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THE NITROGEN METABOLISM OF THE YOUNG PIG. I.—Supplemental Value of Certain Amino-acids when Added to Groundnut Meal Rations

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Young pigs weighing between 25 and 50 lb. live-weight were fed diets consisting of cereals and groundnut meal alone, or with additions of L-lysine monohydrochloride, or DL-methionine, or both. Nitrogen retention was measured over 5-day periods, and a highly significant increase was obtained with the L-lysine supplement at all levels of crude protein. Groundnut + lysine diets were as good as white fish meal diets, providing similar total lysine levels when the protein level was 12 or 15%, but were inferior at 18 and 21% crude protein. No significant response was obtained to DL-methionine except at 18% crude protein, when it depressed nitrogen retention. The greatest nitrogen retentions were obtained either at 18% or 21% of dietary crude protein.

Introduction

Industry is spending much time and effort in producing economically, synthetic lysine and methionine. As these amino-acids have become more available, there has developed an increasing interest in assessing their value as additives to the diet, but before this can be done, fundamental knowledge concerning the nitrogen metabolism of the young pig must be amplified. The view is generally held that the essential amino-acids should be provided in the diet in proportions which reflect the requirement of the animal, but biological response to supplements of these is not always in accordance with the expected benefit.

The efficiency with which dietary protein can support maintenance and growth may be increased, either by the supplementation of one protein with another so that they mutually compensate for their individual amino-acid deficiencies, or by the direct addition of amino-acids believed to be inadequate. Increasing the quantity of a protein concentrate in the rations of young pigs simply to meet the requirement of one deficient amino-acid is wasteful of protein.

The amino-acid composition of a protein concentrate can be estimated chemically but considerable standard errors are associated with such estimates.[1] Before these can be applied to determine how well the concentrate meets the requirement of the animal several factors must be taken into account. The availability of amino-acids may be reduced by excessive heat treatment, a change which is not made apparent by amino-acid assay of acid hydrolysates.[2] Furthermore, the utilisation of essential amino-acids can be affected by antagonisms[3] and toxic effects,[4] or by the specific physiological rôle of individual amino-acids.[5, 6] Little is known of the digestibility coefficients of individual amino-acids, but probably they are high in pigs.

Much work has been done with other species on the interrelationships of protein, energy and amino-acid requirement, and although the underlying principles will undoubtedly apply to the pig, there is little knowledge concerning the nitrogen metabolism of the young pig or of the effect of the addition of supplementary amino-acids on nitrogen retention. It cannot be assumed that protein concentrates of low value to chicks and rats are also of low value to the young pig.

Disproportionate amounts of amino-acids, in relation to the composition of the tissue protein being synthesised, are deaminated and used as a source of energy. The extent of this wasteful use of protein by such deamination is measured by the loss of nitrogen in the urine over and above the normal endogenous loss.

The present study was undertaken to examine the degree of nitrogen balance of the young pig, between 25 and 50 lb. live-weight. Diets containing groundnut meal, which is a protein concentrate of low nutritive value, were compared at varying levels of crude protein with control diets containing white fish meal, a protein concentrate of high nutritive value. The effect of the addition of L-lysine monohydrochloride, and/or DL-methionine, to the protein of groundnut meal was investigated.

Experimental

For the collection of urine and faeces the pigs were housed in battery-type metabolism

cages, which are adjustable in all dimensions and give complete separation of urine and faeces when male pigs are used.

The results reported here refer to four nitrogen-balance experiments where the level of dietary crude protein was 12, 15, 18 or 21% (throughout the text the subscript refers to the experiments in this order) and the mean dry matter content was 86%.

Animals

In each experiment 15 Landrace × Wessex male pigs were weaned at 28 days of age, castrated, dewormed and given the weaners' diet shown in Table I. After satisfactory weaning, ten of the pigs were divided into two groups of five animals according to weight for age. Spare animals were discarded. When the mean weight of a group was 20 lb. the pigs were transferred to the metabolism cages for an acclimatisation period of about 4 days. At a mean group weight of 25 lb. the animals were transferred to individual feeding pens for the first preliminary feeding period and randomly allotted to the experimental diets according to the plan shown in Table II.

Table I

Composition of the weaner ration

	Contribution to diet, %	Crude protein, %		Contribution to diet, %
Ground barley	47·8	5·0	Salt	0·5
Ground maize	12	1·2	Adisco* + B_2	0·3
Ground wheat	8	1·2	Aurofac 2A	0·2
Weatings	8	1·4	Minerals†	0·7
White fish meal	10	6·6		
Soya-bean meal	2·5	1·2	Zinc carbonate 30 g. per 100 lb. as supplement	
Dried skim milk	10	3·5		
		20·1		

* Containing per g. vitamin A 1000 i.u., vitamin D_3 200 i.u., vitamin B_2 500 μg.
† Steam bone flour 1 part and ground limestone 2 parts

Table II

Plan of a single nitrogen-balance experiment

Days	Period	Pig No. 1	2	3	4	5	Period	Pig No. 6	7	8	9	10
0	Prelim. 1	FM	GM	GL	G	GLM						
5	Collection 1						Prelim. 2 / Collection 2	FM	G	GM	GLM	GL
10	Prelim. 3	GL	GLM	G	FM	GM						
15	Collection 3						Prelim. 4 / Collection 4	GLM	GL	G	GM	FM
20	Prelim. 5	GM	G	GLM	GL	FM						
25	Collection 5						Prelim. 6 / Collection 6	G	GM	FM	GL	GLM
30												
35												

Treatments (test protein)

G	Groundnut alone	FM	White fish meal
GL	Groundnut + L-lysine monohydrochloride		
GLM	Groundnut + L-lysine monohydrochloride + DL methionine		
GM	Groundnut + DL methionine		

Design

The factors which determined the design of the experiment were the rapidly changing requirement for crude protein of the young pig,[7, 8] and the limited number of metabolism cages available. It was desired to make the experiment as sensitive as possible, and this was done by arranging that treatment comparisons should be made on a within-pig basis. The experiment was conducted basically as a balanced incomplete block design with restricted randomisation[9] of

the order in which the treatments were applied. Table II shows that every animal received each of its three diets for 10 days, the first 5 of which allowed it to settle, the second 5 constituting the collection period. This experimental pattern was repeated at each level of crude protein.

Diets

The composition of the experimental diets used in each experiment is shown in Table III. The diets are based on a mixture of cereals and the test protein concentrate, the relative amounts of which were adjusted to give the protein level required. In any one experiment the ratio of the protein from cereals to test protein was a constant for all treatments; with increasing crude protein level, however, it was not only necessary to change this ratio but also the ratio of barley protein to miller's offals protein, it being assumed that there is no significant difference in the nutritive values of the proteins of these cereals so far as the young pig is concerned. To ensure a constant crude fibre intake on all treatments, oat feed was included when necessary. The proportions of lard and maize starch were adjusted so that all diets provided the same

Table III

Composition of test diets

Experiment No.	1		2				3				4			
Diet No.	G_1	GL_1	G_2	GL_2	GM_2	GLM_2	G_3	GL_3	GM_3	GLM_3	G_4	GL_4	GM_4	GLM_4
Ground barley	60·0	60·0	69·8	69·8	69·8	69·8	35·4	35·4	35·4	35·4	50·1	50·1	50·1	50·1
Fine miller's offals	9·7	9·7	10·5	10·5	10·5	10·5	33·7	33·7	33·7	33·7	10·0	10·0	10·0	10·0
Groundnut meal	8·4	8·4	10·5	10·5	10·5	10·5	21·0	21·0	21·0	21·0	31·4	31·4	31·4	31·4
Starch (maize)	18·7	18·51	3·9	3·67	3·82	3·59	0·6	0·15	0·44	—	3·70	3·04	3·46	2·80
Lard	—	—	2·0	2·0	2·0	2·0	6·0	6·0	6·0	6·0	1·5	1·5	1·5	1·5
L-Lysine monohydrochloride	—	0·19	—	0·23	—	0·23	—	0·45	—	0·45	—	0·66	—	0·66
DL-Methionine	—	—	—	—	0·08	0·08	—	—	0·15	0·15	—	—	0·24	0·24
Total crude protein	11·9	12·06	14·8	15·0	14·85	15·05	18·07	18·46	18·17	18·63	21·0	21·57	21·15	21·72
Total lysine	0·38	0·52	0·48	0·66	0·48	0·66	0·63	0·98	0·63	0·98	0·73	1·25	0·73	1·25
Total methionine	0·16	0·16	0·21	0·21	0·29	0·29	0·21	0·21	0·36	0·36	0·24	0·24	0·48	0·48
Total methionine + cystine	0·36	0·36	0·45	0·45	0·53	0·53	0·50	0·50	0·65	0·65	0·58	0·58	0·82	0·82
T.D.N.	72·0	72·0	71·4	71·4	71·4	71·4	72·1	72·1	72·1	72·1	72·2	72·2	72·2	72·2

In addition all diets contained Adisco + vitamin B_2 0·5%, Aurofac 0·3%, $Ca_3(PO_4)_2$ 2·0%, salt (NaCl) 0·5%, zinc carbonate 30 g./100 lb. diet, 'Distafeed' (containing 15 μg. of vitamin B_{12}/g.) 125 g./100 lb. diet

Note: Lysine, methionine and cystine based on analysis of concentrates (personal communication G. M. Ellinger, Rowett Institute) and estimates for cereals (De Man & Zwiep[11])

level of Total Digestible Nutrients (T.D.N.). The diets provided the minerals required and all known vitamins in adequate amounts, and chlortetracycline hydrochloride was added to all diets at a rate of 1 g./100 lb. of diet (0·3 lb. of Aurofac 2A per 100 lb. of diet). Fish meals and the groundnut meal used in these experiments were analysed for their lysine and methionine content by Moore & Stein[10] ion-exchange chromatography. At each level of crude protein the diet containing white fish meal was used as the standard or control diet. Groundnut meal was included in the test diets so as to contribute an amount of crude protein equal to that in the control diet. The lysine and methionine contents of the control and test diets were calculated from the analytical values for the fish meal or groundnut meal and average values for the cereal basal portion of the diet taken from the tables of De Man & Zwiep.[11] The composition of each control diet is given in Table IV.

Supplements of L-lysine monohydrochloride and/or DL-methionine were added to the groundnut meal diet to make the total equal to the calculated level in the fish meal diet in respect of the amino-acid concerned. The lysine supplement, obtained from E. I. Du Pont de Nemours & Co. Inc., U.S.A., in 1956, was described as being prepared from agricultural products and was designated as 'Darvyl' L-lysine monohydrochloride containing 95% of L-lysine monohydrochloride and 5% of D-lysine. The DL-methionine was purchased from Light & Co. Ltd., Bucks., England. The amino-acid composition of each diet is compared with the appropriate requirements of the National Research Council[12] in Table V. In each experiment groundnut meal from the same batch was used, but batches of white fish meal differed. The groundnut meal had been prepared from Nigerian nuts by a high-pressure, double expeller process. As white fish meals are known to vary in quality,[13] meals were selected on a quality basis as indicated by their 'available lysine' value[14] (A.L.V.). The 'available lysine' in the four meals used varied only between 6·86 and 6·73 g./16 g. of nitrogen.

Table IV

Composition of control diets

Experiment No.	1		2		3		4	
Diet No.	FM_1		FM_2		FM_3		FM_4	
	% of diet	% crude protein	% of diet	% crude protein	% of diet	% crude protein	% of diet	% crude protein
Ground barley	60·0	6·45	69·8	8·05	33·4	3·04	50·1	4·40
Fine miller's offals	9·7	1·40	10·5	1·75	33·7	5·00	10·0	1·60
White fish meal	6·0	4·0	7·4	5·00	15·7	10·00	23·1	15·00
Oatfeed	1·7	0·10	1·5	0·08	3·0	0·16	4·5	0·25
Starch (maize)	19·7	—	6·1	—	2·4	—	7·34	—
Lard	—	—	2·0	—	7·5	—	3·5	—
Adisco + B_2	0·5	—	0·5	—	0·5	—	0·5	—
Aurofac 2A	0·3	—	0·3	—	0·3	—	0·3	—
Tricalcium phosphate	1·6	—	1·4	—	1·0	—	0·2	—
Salt (NaCl)	0·5	—	0·5	—	0·5	—	0·5	—
Total crude protein	11·95		14·88		18·20		21·25	
Total lysine	0·52		0·66		1·01		1·31	
Total methionine	0·22		0·29		0·36		0·48	
Total methionine + cystine	0·41		0·51		0·61		0·76	
T.D.N.	71·6		71·0		71·90		71·2	
Supplements/100 lb.								
Pantothenic acid	150 mg.		100 mg.		—		—	
Zinc carbonate	30 g.		30 g.		30 g.		30 g.	

Note: Lysine, methionine and cystine based on analysis of concentrates (personal communication G. M. Ellinger, Rowett Institute) and estimates for cereals (DeMan & Zwiep[11])

Table V

Essential amino-acid composition (% of crude protein) of the test and control diets

Experiment No.	1		2		3		4		NRC Recommendation
	G_1	FM_1	G_2	FM_2	G_3	FM_3	G_4	FM_4	
Arginine	7·1	5·3	7·1	5·3	8·6	5·7	9·4	5·6	1·1
Histidine	2·1	2·2	2·1	2·2	2·1	2·4	2·4	2·4	2·2
Isoleucine	4·1	4·6	4·1	4·5	4·2	4·9	6·6	7·4	3·9
Leucine	6·6	6·9	6·6	6·9	7·0	6·4	4·2	5·2	4·4
Lysine	3·2	4·4	3·2	4·5	3·2	5·6	3·1	6·2	5·6
Methionine	1·3	1·9	1·4	2·0	1·2	2·1	1·1	2·3	3·3*
Methionine + cystine	3·0	3·5	3·1	3·5	2·7	3·4	2·8	3·6	
Phenylalanine	4·7	4·5	4·8	4·5	4·5	4·1	7·1	9·6	2·6
Threonine	3·0	3·5	3·0	3·6	2·8	3·0	2·8	3·9	2·2
Tryptophan	1·0	1·0	1·1	1·1	1·1	1·1	1·0	1·1	1·1
Valine	4·6	5·1	4·7	5·2	4·7	5·5	4·7	5·7	2·2
Tyrosine	3·4	3·2	3·3	3·2	3·1	2·9	3·3	3·0	—

* Cystine can replace one-half of the methionine requirement

Note: Amino-acid values taken from the tables of DeMan & Zwiep, except for lysine, methionine and cystine, which were calculated as for Table IV

Method

The experimental diets were offered twice daily in the form of a stiff mash made up with water in a ratio of 1 : 1 by volume. The rate of feeding was fixed at 5% of live-weight, the intake being adjusted at the beginning of each preliminary feeding period. The daily feeds for each period were weighed separately into polythene bags, and the dry matter of a representative sample determined. Water was offered *ad lib.* at noon each day.

Preliminary work with ferric oxide (calcined) as a faeces marker showed that the marker was excreted irregularly by the pigs of this age, and faeces were therefore collected on a time basis at 9 a.m. daily, then stored in bulk at −20°. At the end of each collection period the daily collections were mixed thoroughly in a Peerless industrial mixer, and two 500-g. samples removed for dry matter estimation. A further 500-g. sample was macerated with water in a Waring Blendor, and samples of approximately 30 g. of the macerate were taken for the determination of Kjeldahl nitrogen and dry matter. Urine was allowed to collect in a 10-litre tared

polythene container and kept acid with 5% acetic acid. At the end of each collection period the volume of urine was calculated from weight and specific gravity measurements, and 5-ml. samples removed for Kjeldahl nitrogen determination. All animals were weighed at the beginning and the end of each collection period and throughout the work the temperature in the metabolism room was maintained at 65–70° F.

Results

Table VI shows the percentage of dietary nitrogen retained, the nitrogen retention and nitrogen digestibility coefficients at each level ot crude protein.

Table VI

Nitrogen metabolism data

(each value is the mean of six 5-day balance periods on six unrelated pigs)

Level of crude protein, %	Treatment	FM (control)	G	GL	GM	GLM	Overall signif. of differences between treatments	S.E. of difference between means
Expt. No. 1								
12	% dietary N retained	41·5	31·2	41·6	—	—	***	±1·22
	N-retention g./5 days	19·7	14·9	21·3	—	—	***	±1·43
	N-retention g./kg. live-weight/5 days	1·84	1·39	1·92	—	—	***	±0·06
	Apparent N-digestibility (%)	74·0	73·2	74·3	—	—	NS	±0·73
	True N-digestibility (%)	79·6	78·9	79·5	—	—	*	±0·62
Expt. No. 2								
15	% dietary N retained	41·8	31·1	40·4	32·0	40·7	***	±0·83
	N-retention g./5 days	34·9	26·4	35·5	28·0	35·0	***	±1·79
	N-retention g./kg. live-weight/5 days	2·19	1·68	2·20	1·76	2·21	***	±0·09
	Apparent N-digestibility (%)	77·9	75·2	76·8	76·9	78·3	NS	±1·04
	True N-digestibility (%)	82·1	79·4	80·9	80·9	82·3	NS	±1·05
Expt. No. 3								
18	% dietary N retained	54·2	34·9	45·2	30·2	42·3	***	±0·75
	N-retention g./5 days	56·3	36·4	47·9	32·8	45·0	***	±2·40
	N-retention g./kg. live-weight/5 days	3·53	2·21	3·08	2·10	2·95	***	±0·16
	Apparent N-digestibility (%)	81·5	78·2	79·7	77·3	79·3	NS	±1·62
	True N-digestibility (%)	84·7	81·4	82·8	80·4	82·5	NS	±1·63
Expt No. 4								
21	% dietary N retained	44·4	29·3	38·7	31·3	38·3	***	±1·51
	N-retention g./5 days	54·3	38·1	49·6	38·0	49·2	***	±0·14
	N-retention g./kg. live-weight/5 days	3·29	2·26	2·92	2·35	2·93	***	±0·12
	Apparent N-digestibility (%)	82·9	79·2	82·3	80·4	80·0	**	±0·83
	True N-digestibility (%)	85·8	82·0	85·1	83·4	82·8	**	±0·85

*** $P < 0.001$ ** $P < 0.01$ * $P < 0.05$ NS not significant

The results show that the supplementation of expeller decorticated groundnut meal with L-lysine monohydrochloride produced a highly significant improvement in the percentage of nitrogen retained at all levels of crude protein. At 12 and 15% crude protein the addition of L-lysine to the groundnut meal gave nitrogen retentions equivalent to the values obtained on the white fish meal diet, which provided the same percentage of total lysine. At 18 and 21% crude protein the percentage of dietary nitrogen retained fell short of the value obtained on the control diets. Methionine supplementation was without effect at 15 and 21% crude protein, but at 18% crude protein a highly significant depression in percentage nitrogen retention occurred when methionine was added alone, or together with the L-lysine supplement. On all treatments the percentage of nitrogen retained fell when the dietary protein reached 21%. Except on diet

GM_3 the maximum percentage nitrogen retention occurred at 18% crude protein, and on GM_3 the maximum retention was at 15% crude protein (see Fig. 1).

The results for nitrogen retention per kg. of live-weight are similar to those obtained for percentage nitrogen retention, as indicated in Figs. 1 and 2, but whereas maximum retention per kg. of live-weight on the FM, GL and GLM diets was at 18% crude protein, a maximum on the G and GM diets was not achieved.

Apparent nitrogen digestibility increased with increasing dietary crude protein. True digestibility, calculated using an estimate of metabolic faecal nitrogen (MFN) of 1·14 g./kg. of dry matter intake[15] also increased with increasing protein in the diet, but to a lesser degree.

The daily live-weight gains and food conversion ratios given in Table VII are discussed later in relation to current work.

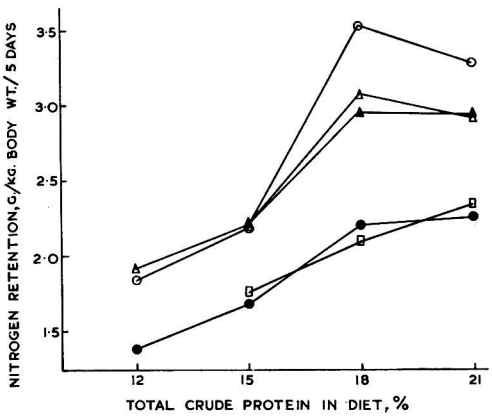

FIG. 1.—*Relationship between dietary crude protein and nitrogen retention by pigs (25–50 lb. liveweight)*

diet containing fish mea ○ groundnut ● ; groundnut and lysine △ ; groundnut + methionine □ ; groundnut + lysine + methionine ▲

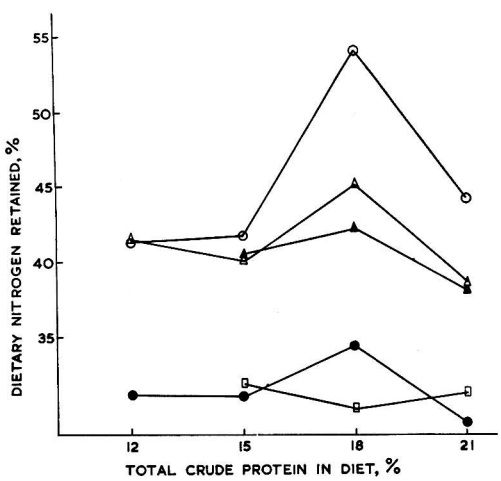

FIG. 2.—*Relationship between % nitrogen retention and dietary crude protein for pigs (25–50 lb. liveweight)*

diet containing fish meal ○ ; groundnut ● ; groundnut and lysine △ ; groundnut + methionine □ groundnut + lysine + methionine ▲

Table VII

Food conversion ratios and daily live-weight increase

Treatment Expt. No.	Protein level, %	G	GL	GM	GLM	FM
		Food conversion ration (lb. feed/lb. live-weight gain)				
1	12	2·51	2·67	3·36	2·81	2·62
2	15	2·55	2·39	2·85	2·45	2·42
3	18	2·32	1·96	2·27	1·87	1·62
4	21	1·97	1·65	2·07	1·80	1·72
		Daily live-weight increase (lb.)				
1	12	0·43	0·43	—	—	0·43
2	15	0·62	0·67	0·56	0·64	0·66
3	18	0·67	0·77	0·71	0·75	0·92
4	21	0·77	0·98	0·80	0·90	0·90

Discussion

Although much is known concerning the effect of amino-acids on growth rate and food conversion ratio, there is little information on their effect on nitrogen metabolism or on carcass quality. As early as 1939 Mitchell[16] concluded that equal weights of gain in young pigs may contain different amounts of protein, in response to different amounts of protein in the diet. It is therefore inadequate to consider only rate of live-weight gain and food conversion ratios when studying the effect of amino-acid supplementation. Nor is it sufficient to consider in addition nitrogen retention, for the distribution of body components is a most important factor when assessing carcass quality. Brooks & Thomas[17] have shown that lysine and methionine or natural sources of these amino-acids, when added to groundnut meal–maize rations, produced highly significant improvements in rate of live-weight gain and muscle development, and furthermore that lysine appeared to have a specific effect in the loin area. Eye muscle (*longissimus dorsi*) defects have been causing concern to the bacon trade for some time, not only in this country but in Denmark. The defects take the form of either a small or misshapen, kidney-shaped eye muscle, or an excessive depth of fat over and beyond the eye muscle. The problem of eye-muscle defect appears to be partly of nutritional and partly of genetic origin.[18] Holme, Coey & Robinson (unpublished results), working with low-protein diets, have been able to produce the defects by inducing rapid growth on diets of low protein content, and also claim that the effect is associated with poor muscle development throughout the carcass.

The pig presents a problem in that, by virtue of its fast growth, it has a rapidly changing protein requirement. Lucas[7] has estimated that the crude protein requirement of the young pig falls from 75 g. of crude protein/1000 kcal. of digestible energy at 10 lb. to 50 g./1000 kcal. of digestible energy at 30 lb. live-weight, while Braude[8] has calculated the requirement of the growing-fattening pig as 17%, falling to 13% crude protein in the later stages of fattening. It is therefore possible that a diet providing adequate protein at 20 lb. live-weight could provide an excess at 60 lb. live-weight. The present authors claim that a nitrogen-balance technique enables research to be carried out over a small increment of live-weight gain and gives an accurate assessment of nitrogen metabolism at various levels of crude protein intake. From such results diets which give maximum nitrogen retention for each range studied can be selected for a large-scale individual feeding trial to assess their effect on rate of live-weight gain, food conversion ratio and carcass quality. The nitrogen-balance technique used by the present authors gives a rapid assessment of treatment effects on nitrogen retention, but has the disadvantage that accurate assessment of food conversion and rate of live-weight gain are not possible owing to the frequent changing of the diet. This is so, partly because pigs changing from groundnut to white fish meal diets were inclined to leave food during the first feeds of the preliminary period, and partly because of the short period over which live-weight gain could be measured.

Table VII shows the daily live-weight gain and food conversion ratios for each level of crude protein. The diets containing 12% crude protein provided inadequate amounts of protein

for maximum growth and consequently live-weight increase during the first experiment was poor. The live-weight increase on all treatments at 18% and 21% crude protein was considered to be good for this range of live-weight. At 15% crude protein the live-weight gain on diets FM2, GL2 and GLM2 was 0·66, 0·67 and 0·64 lb./day respectively. These live-weight gains are lower than those reported by Evans.[19] Calculations from Evans' figures show that pigs fed a cereal-based diet supplemented with 7% white fish meal grew at a rate of 0·77 lb./day over the range 34–50 lb. live-weight. In five other nitrogen-balance studies conducted by the same author, the mean live-weight gain was 0·73 lb./day on a similar diet and over a comparable weight range. Hitherto, Woodman & Evans[20] had considered that young bacon pigs subsisting on a diet composed substantially of barley meal and middlings and containing 7% white fish meal, together with a small quantity of grass or lucerne meal and minerals, were able to display the maximum rate of growth compatible with the net energy content of the diet. However, Evans[19] supplemented such a diet with 0·1% of L-lysine monohydrochloride and reported a live-weight increase of 0·85 lb./day over the range 33–55 lb. live-weight. Reference to Table VII shows that the live-weight gain on diets containing 18% and 21% of protein was comparable to the rates of gain obtained by the above-mentioned workers with pigs fed their standard diet containing 7% of white fish meal, and that the live-weight gain on diets FM_3, FM_4, GL_4 and GLM_4 was even higher; it should be noted that our diets were higher in T.D.N. Lucas *et al.*[21] report a daily live-weight gain of 0·96 lb./day for rapidly growing pigs on their dams, between 25 and 50 lb. live-weight.

At first consideration, the results for food conversion appear abnormally good on the higher levels of protein intake. There is little information in the literature on food conversion by pigs weighing 25–50 lb. Smith & Lucas[22] quote a figure of 1·77 for pigs growing rapidly at 0·96 lb./day between 25 and 40 lb., weaned at a similar age to our own and on a diet providing 74% T.D.N.

Woodman & Evans[20c] have shown that as high a level as 20% of extracted, decorticated groundnut meal is necessary to induce nitrogen retention in young pigs equivalent to that obtained on their standard diet. Reference to Fig. 1 shows that diet FM_2, which contained 7·4% of white fish meal, gave nitrogen retention equivalent to that obtained on diet G_3, which contained 21% of expeller decorticated groundnut meal. The nitrogen retention on these two diets, however, was somewhat lower than that calculated from work reported by Evans[19] (2·78 g./kg. body wt./5 days) for pigs of comparable weight on the standard diet, but our rate of feeding was a little lower and the diets did not include the 3% grass meal supplement. Braude[23] and Duckworth *et al.*[24] have shown that the nutritive value of some leaf protein concentrates can be equivalent to that of white fish meal when fed to growing pigs. Also from its amino-acid composition it is probable that the biological value of the protein of grass is high, and this may in part explain why Evans obtained higher values for nitrogen retention on his standard diet than the present authors did on FM_2 and G_3 diets. The highest retention reported by Evans (2·97 g./kg. body wt./5 days) was obtained on a diet containing 7% of white fish meal and 3% of lucerne meal, supplemented with 0·1% of L-lysine monohydrochloride and supplying 62% T.D.N., while in our studies the maximum nitrogen-retention of 3·53 g./kg. live-weight, was obtained on a diet providing 15·7% white fish meal and 72% T.D.N. It is suggested that the difference in nitrogen-retention is due to the higher percentage of T.D.N. Figs. 1 and 2 show that there was a decrease in both nitrogen retention expressed as g./kg. body weight/5 days and also nitrogen utilisation at 21% crude protein. This may be due to an inadequate supply of non-protein sources of energy.

Reference has already been made to the highly significant response to L-lysine supplements at all levels of crude protein, and to the failure of lysine to equate the nitrogen retention in pigs on diets FM_3 and GL_3. At each level of crude protein the groundnut diets with added lysine contained the same total amount of lysine as the corresponding control diet. It is difficult to account for this failure from the data presented here. It cannot be due to a difference in the availability of the lysine in the protein concentrates, since groundnut meal from the same batch was used in all experiments, and the fish meals had, as mentioned earlier, been selected on their A.L.V.

The exact mechanisms of protein synthesis are by no means fully understood. Although much work has been done on protein absorption, there is still doubt as to the nature of digestion

products and absorption. It is generally accepted that ingested proteins are hydrolysed in the gut to their constituent amino-acids, and that these are absorbed in the free state from the intestine. There is some evidence, however, that proteins can be absorbed as such[25] or as peptides.[26] Newey & Smyth[26c] have shown that peptides are hydrolysed inside the mucosal cells.

It is believed that the absorption of amino-acids is controlled by a simple diffusion mechanism,[27] but in addition the studies of Höber[28] and Gibson[29] indicate the presence of an active absorption mechanism, in that the absorption of some amino-acids was not proportional to their concentration in the intestinal lumen. Since absorbed amino-acids are not stored at the anabolic site,[30] the synthesis of protein will depend on the presence of all the necessary amino-acids at the same time in an available form. Disproportionate amounts of amino-acids are deaminated, and either used as a source of energy or eliminated.[30a, 31]

In the experiments reported here, the free lysine calculated as a percentage of the total dietary lysine increased with increasing crude protein level. It is therefore possible that the lysine supplement was absorbed more rapidly than the constituent amino-acids of the food protein, and that at least some of the lysine supplement was deaminated before the bulk of the amino-acids reached anabolic sites. This would lead to tailing off in the response to lysine as the crude protein increased, and is consistent with the results obtained at the 12, 15 and 18% protein levels. It would also mean that the imbalance due to lysine had not been corrected at the higher protein levels. Further supplementation with the second limiting amino-acid could then be expected to cause a depression in nitrogen retention,[32] as was the case with diets GM_3 and GLM_3. The lack of response to methionine in diets GM_2 and GLM_2 could be due to the low levels of supplementation (0·08%) used. It is also possible that the D-isomer may interfere with the utilisation of the L-form. The effect of the supplements at 21% crude protein are difficult to interpret owing to the protein/energy imbalance at this level. The significance of amino-acid imbalance has been reviewed generally by Salmon[33] and for the rat by Harper.[34]

On the other hand the studies of Crane & Neuberger[35] in which yeast ^{15}N-labelled protein and yeast ^{15}N-labelled protein hydrolysate were given to adult humans, showed that there was only a slight difference in the rate of absorption of ^{15}N and this difference could be accounted for if the enzyme hydrolysis time of whole protein was 10 min. *In vivo* studies with rats[36] have shown that amino-acids fed as intact proteins may pass from the digestive tract into the body as rapidly as those fed in the free form. It would appear, however, that there is some difference in the time of digestion and absorption of some proteins.[37] In such studies it was observed that casein disappeared from the gastrointestinal tract of the rat more rapidly than did zein, but less rapidly than did meat and fish protein.

Altering the relative proportions of cereals and protein concentrate, which is normally done when the protein level in a practical ration is adjusted, can result in an amino-acid which is in sufficient supply to support maximum growth at low protein levels, becoming limiting at higher levels. The effect of change in constituents of chick rations has been discussed by Rosenberg.[38] The order in which amino-acids become limiting can often be changed by increasing the protein level. In the diets used in the present project, the computed histidine levels were sufficient to support the growth rate at the lower protein levels, but as the protein was increased, the histidine in the groundnut meal diets remained constant, while in the control diets it increased. Thus it is possible that the supply of histidine in the groundnut diet was insufficient to allow full expression of the increased growth potential induced by increased protein concentration and lysine supplementation.

While there is some doubt as to the reason for the effects observed in these experiments at the higher levels of dietary protein, the experiments have shown that at the lower levels of protein intake the value of the protein of groundnut meal can be significantly improved by supplementation with lysine. They also indicate some of the dangers that can be encountered by misguided amino-acid supplementation.

Throughout the experiments the rate of feeding was maintained at a constant level of 5% of live-weight. Armstrong & Mitchell[15] working with nitrogen-free diets found that metabolic faecal nitrogen (MFN) in young pigs was 1·14 g./kg. of dry matter intake. Since MFN is a function of dry matter intake, the MFN in these experiments must have remained constant and this, in part, accounts for the observed increase in apparent nitrogen digestibility. The increase in

true digestibility could also be due in part to a difference in nitrogen-digestibility between cereal nitrogen and protein concentrate nitrogen.

The present authors feel that it is important to stress that these results apply to male castrated pigs. Woodman *et al.*[39] report that gilts produce somewhat leaner carcasses than do hogs from the same litter, and their findings pointed to a somewhat more efficient retention of food nitrogen by gilts. Clausen & Thomson[18] have shown that eye muscle defects are more of a problem in hogs than in gilts. This suggests again that nitrogen is more efficiently utilised by gilts. Sex differences in protein utilisation have also been reported for other species.[40]

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STUDIES OF THE SMOKING PROCESS FOR FOODS. I.—The Importance of Vapours

By W. W. FOSTER* and T. H. SIMPSON

Wood smoke consists of minute, light-scattering particles and invisible vapours. The direct deposition of smoke particles makes a negligible contribution to the smoking of fish within the normal range of curing temperatures (32–82°) and for all stages of dryness of the fish up to a pre-smoking weight loss of about 30%. The mode of deposition of smoke on fish appears to be one of vapour absorption, in which the surface and interstitial water of the fish acts as the principal absorbent. Fish ' cured ' in the vapours which remained after visible particles of wood had been electrically precipitated were indistinguishable in colour, flavour and keeping quality from normally-smoked fish.

Analyses of normally- and vapour-smoked bacon suggest that bacon smoking, like fish smoking, mainly involves a vapour absorption process.

Introduction

Although the process of preserving and flavouring of foodstuffs by smoke-curing has been used since prehistoric times[1] it is only in recent years that smoking has been studied in any detail.

When wood is heated a wide range of compounds is generated,[2] the chemical constitution of the smoke depending on many factors such as the type of wood used and the temperature–time cycle. A number of workers have studied the effects of kiln conditions on the rate of deposition of smoke on fish. The rate has been found to increase with the optical density,[3a] the smoke temperature[3b] and the smoke velocity[4] and to decrease as the fish dries.[4a] Further, it has been found[3a, 5, 6] that at high humidities foodstuffs absorb smoke more rapidly than at low, presumably because the material remains wet for a relatively longer time.

Wood smoke consists of light-scattering tarry droplets suspended in a medium of air and invisible vapours. The size of the droplets is dependent on the conditions of smoke generation, the average radius of fresh smoke being about 0·1 μ.[7] Although it appears to have been accepted that the deposition of these visible particles is responsible for the colour, flavour and ' keeping quality ' of smoked products, the basic mechanisms involved in smoking have not hitherto been investigated. Voskresenkii[8] suggested that electrostatic forces cause the deposition of particles on fish. It is presumed that rapidly moving smoke particles suffer distortion in shape which leads to the development of dipolar characteristics and to the consequent attraction to the microelectric zones on the fish surface. The validity of this theory of smoking does not appear to have been tested experimentally and the possibility of vapour absorption being important seems to have been overlooked.

The experiments described in the present communication were designed to elucidate the relative contributions of particle deposition and vapour absorption to the smoking process. Some of the results have already been published in summary form.[9]

Experimental

Apparatus

The Torry kiln and smoke generator.—A diagram of the kiln[10] is shown in Fig. 1. Smoke is provided by burning oak wood sawdust in one or two fire boxes. Each bed of fuel is 120 cm. long and (initially) about 45 cm. deep (front to back) and is built in three layers. The details of the layers are as follows.

	Bottom layer (shavings)	Middle layer (sawdust)	Top layer (sawdust)
Weight of wood, kg.	2·4 ± 0·2	9 ± 0·2	2·7 ± 0·2
Moisture content,* %	13 ± 2	14 ± 2	45 ± 2
Average depth, cm.	6	6	1·5

* loss in weight on drying to constant weight at 110°

* Member of the staff of the Herring Industry Board

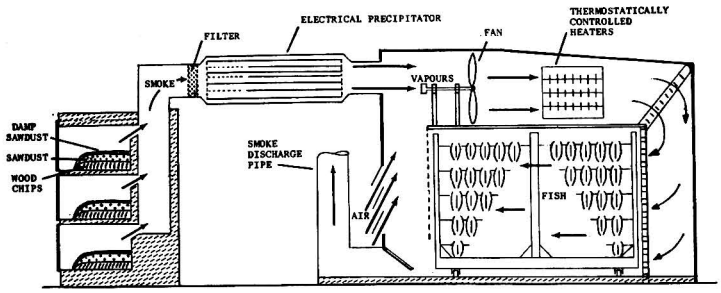

FIG. 1.—*The Torry kiln with electrostatic precipitator*

Apparatus for ' smoking ' in vapours and normal smoke.—The apparatus which was first used for comparing the rates of deposition of normal smoke and vapours is shown diagrammatically in Fig. 2. A stream of smoke was divided into two, one passing through an electrical precipitator and then into a 22-s.w.g. aluminium duct 5 cm. high, 12·5 cm. wide and 138 cm. long, which contained fish or water samples, and the other passing directly into an identical duct containing the reference samples. The precipitator and the ducts were mounted inside the thermostatically controlled smoking chamber of the Torry kiln to minimise differences between deposition rates due to temperature differences between the two smoke streams. Before smoking experiments were started, the flow rates in the two ducts were equalised by adjusting the baffle in the normal smoke duct until the rates of evaporation of water samples were identical.

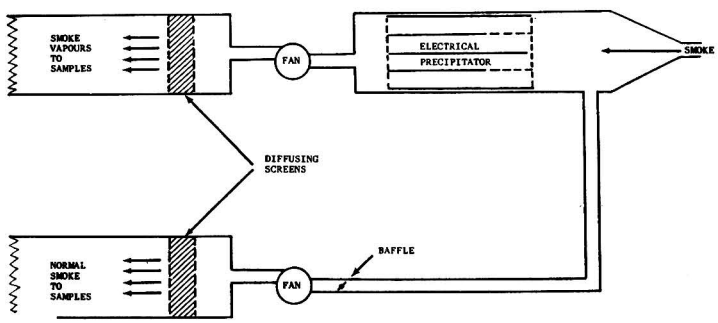

FIG. 2.—*Original apparatus for smoking in vapours and normal smoke*

The other apparatus used for concurrent smoking in normal smoke and vapours consisted (Fig. 3) of an 18-s.w.g. steel duct, 10 cm. high, 10 cm. wide and 180 cm. long, fitted at its centre with an electrical precipitator, through which smoke was drawn by a centrifugal fan. The samples for exposure to smoke and smoke vapours were mounted upstream and downstream of the precipitator, respectively ; the apparatus was placed as before in the smoking chamber of a Torry kiln.

Uniformity of aerodynamic conditions in both forms of apparatus was achieved by mounting diffusing screens consisting of two to five layers of 70-mesh brass wire cloth in the ducts in the positions indicated in Figs. 2 and 3.

A photograph of the two-stage parallel plate electrical precipitators used in these experiments is given in Fig. 4. Each of the charging grids consisted of eight 36-s.w.g. stainless steel wires laced across a frame 18 cm. long and 5·5 cm. high secured in a 2-cm.-thick Perspex cover. The two repulsion electrodes, each 33·5 cm. long and 5·5 cm. high were formed from polished

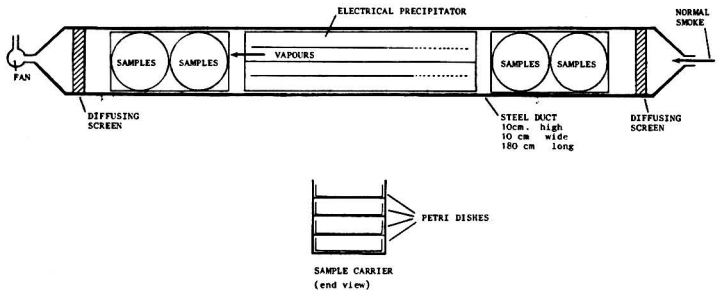

FIG. 3.—*Concurrent smoking in vapours and normal smoke*

20 s.w.g. aluminium and were also mounted in the Perspex cover. The earthed electrode was made of polished 22 s.w.g. aluminium. The distance between this and the charging screen and repulsion electrodes was 2·3 cm. The charging wires and the plates were maintained at about −15 kV and −20 kV respectively, negative corona being preferred to positive because of its greater electrical stability.[11]

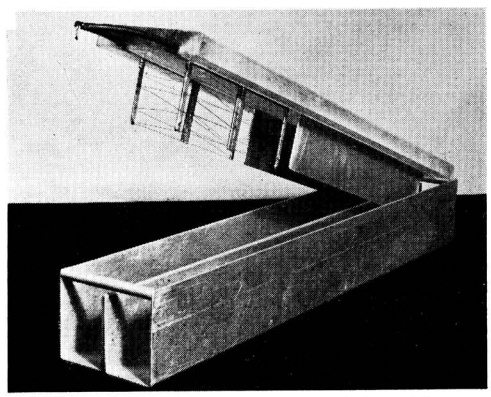

FIG. 4.—*Two-stage parallel-plate electrical precipitator*

Preparation of samples for smoking

Samples of water (25 ml.) were contained in circular aluminium Petri dishes, 9·6 cm. in diameter and 1·2 cm. deep, supported on carriers inserted into the duct as in Fig. 3. Samples of fresh fish were frozen and cut into rectangular blocks 1 cm. thick, 5 cm. wide and 10 cm. long. After being thawed, these were placed on wire mesh trays (no. 7 Tyler screen) to permit the deposition of smoke on all the surfaces of the block. Portions of fat, meat and rind of 'green' bacon were cut into rectangular blocks, 5 cm. long, 5 cm. wide and 1 cm. thick and smoked on the same wire mesh trays.

Analytical methods

(a) *Estimation of smoke deposits*

Since the loss of weight of the water samples by evaporation during smoking is large and since, moreover, wood smoke contains many volatile compounds (including carbon dioxide and carbon monoxide) it was clearly impossible to determine the total amount of smoke in any given sample by direct weighing. It was found however that the relatively non-volatile components of smoke could be estimated with satisfactory reproducibility by freeze-drying the

smoked water samples and weighing the residual tar. Samples of water in tared dishes were exposed to smoke and vapours in the ducts, frozen and then evaporated in a freeze-drying cabinet at a pressure of 1 mm. Hg for 24 h. The tarry residues were then determined by weighing. Estimation of freeze-dried residues are expressed in this paper in the terms weight (mg.) per unit area (100 cm.^{2}) of sample exposed to smoke per unit smoking time (1 h.).

(b) *Examination of the components of smoke deposits*

(i) *Measurement of light absorption spectra.*—Samples of water (each sample 200 ml., contained in eight Petri plates) were exposed to normal smoke and vapours for 3 h. at 32°. The solutions were restored to their original volume by the addition of water, samples were removed for estimation of tar by freeze-drying and the remainders were diluted with methanol (2% by volume). A solution of smoke particles of approximately the same concentration was prepared by dissolving in aqueous methanol (98 : 2) a known weight of tar taken from the precipitator and the light absorption spectra of the three solutions in the region 200–600 mμ were compared in a Unicam S.P.500.

(ii) *Estimation of phenols.*[12]—An appropriate volume of the aqueous solution of phenols was pipetted into a 25-ml. standard flask, made alkaline with aqueous sodium carbonate solution (3 ml., 2% w/v) and a freshly made aqueous solution of 4-aminoantipyrine (2 ml., 1% w/v) added. After dilution of the mixture to 25 ml. with distilled water, aqueous potassium ferricyanide solution (1 ml., 8% w/v) was added and the flask contents thoroughly mixed. The optical density was determined on a ' Spekker ' spectrophotometric colorimeter with Ilford filter No. 603. The control solution was freshly made up for each estimation from the same quantities of sodium carbonate and 4-aminoantipyrine solutions, water (20 ml.) and potassium ferricyanide solution (1 ml.). Unless otherwise stated, the results of phenols estimations are expressed in the figures and text in the terms optical density (1 cm. cell) per unit area (100 cm.^{2}) of sample exposed to smoke, per unit smoking time (1 h.).

(iii) *Counter-current distribution.*—Samples of water (each 100 ml. in four dishes) one of which had been exposed to normal smoke, the other to vapours for 3 h. at 32° were made up to their original volume with distilled water and analysed for ' total phenols ' by the 4-aminoantipyrine method. An aqueous solution of smoke particles, having approximately the same total phenols content, was prepared by dissolving tar from the electrical precipitator in water and diluting appropriately. Portions (19·5 ml.) of the three solutions were then subjected to 20 transfers with light petroleum (b.p. 40–60° ; 20 ml. each transfer) in a Craig counter-current distribution apparatus. The contents of alternate tubes were then transferred to 50-ml. flasks, made alkaline by the addition of sodium carbonate (0·5 g.) and the petrol evaporated by agitation in a gentle stream of air. Aliquots (usually 15 ml.) of the three sets of solutions were then analysed for phenols by the 4-aminoantipyrine method.

(iv) *Fractional steam distillation.—Water.* Samples of water (usually 200 ml., in eight dishes) were smoked, made up to their original volume with distilled water, transferred to 1-l. flasks and steam distilled, the liquid level in the flask being kept steady. After six successive fractions of 100 ml. each had been collected, the steam supply was shut off and the phenols contents of the distillates determined. The residue in the distillation flasks were cooled, made up to a known volume (usually 200 ml.) and the phenols contents determined.

Fish. Samples of fish were disintegrated with distilled water (160 ml.) in a top-drive macerator and the resulting purees transferred to flasks with distilled water (40 ml.), steam distilled as above and the phenols contents of the distillates estimated. The residues were cooled, made up to a known volume and portions centrifuged. Aliquots of the supernatant liquors were then taken for determination of the phenols contents. Since these liquors were not completely clear, it was necessary to apply a turbidity correction. The same aliquot as was used in the estimation was pipetted into a 25-ml. standard flask, mixed with aqueous sodium carbonate (3 ml., 2% w/v) and made up to 26 ml. with distilled water. The turbidity of this solution, relative to aqueous sodium carbonate (water 23 ml., 2% aq. sodium carbonate 3 ml.) was estimated on a ' Spekker ' instrument.

Bacon. Phenols estimations on meat and rind samples of bacon were made exactly as for fish. The aqueous residue from the steam distillation of the fat samples was too turbid to be analysed in this way and the following modified procedure was adopted. The residue was repeatedly

extracted with ether (five portions of 50 ml. each) and the combined ethereal liquors re-extracted with aqueous sodium carbonate solution (1N, seven portions of 30 ml.). An aliquot of this liquor (15 ml.) was then estimated for phenols by the standard method ; further sodium carbonate was not added.

Vapour curing in the Torry kiln

The large quantities of vapour-cured kippers required for tasting and storage experiments were prepared in a Torry kiln, the inlet duct of which had been fitted with an electrical precipitator (Fig. 1) which was basically a scaled-up version of that described above, although the inter-electrode distances were unchanged.

Because certain operational difficulties were encountered, the following minor modifications were made. A coarse filter of metal turnings was fitted in the duct to prevent partially burnt particles of sawdust entering the precipitator and causing arcing. Spacers were inserted at the four corners of the precipitator between the insulated top and the earthed casing ; the clear air admitted through this gap swept the underside of the Perspex top and prevented the accumulation of tar deposits between the electrodes which otherwise caused ' tracking '. The whole precipitator was warmed electrically and slightly tilted so that tar could flow into a removable sump near the smoke inlet. A sectioned photograph of the precipitator is shown in Fig. 5.

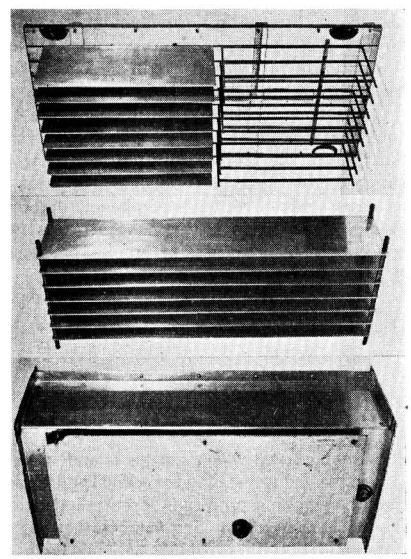

FIG. 5.—*Modified electrical precipitator for large-scale smoking*

Results and discussion

Effect of moisture content of fish

Although earlier workers had shown that smoke is absorbed more rapidly by wet fish than by dry, it seemed desirable to extend these experiments to fish of very low water content. Samples of undried fish (water content about 70%) and of pre-dried fish (water content about 5%) were smoked under the same conditions and the ' cures ' compared by visual assessment of the colours and by measurement of the phenols content. The colour of pre-dried smoked fish was very much less intense than that of the smoked wet fish ; and the rate of deposition of phenols on the former was only 5% of that on the latter. These results suggested that most of the smoke is deposited on or absorbed by the surface and interstitial water of the fish. This was supported by a second series of experiments in which it was shown that when water and wet fish of the same superficial area are smoked under comparable conditions the rates of absorption of smoke phenols were almost identical.

Deposition of smoke on surfaces

Since wet fish are contained within the substantially dry walls of a kiln in the smoking process, the modes of deposition of smoke on wet and dry surfaces were investigated. The rates of deposition of smoke in a Torry kiln at 32° on the upper and lower sides of horizontal sheets of aluminium foil were determined by weighing the freeze-dried deposits. They were found to be about 0·6 mg./100 cm.² h. for the upper surface and about 0·06 mg./cm.² h. for the lower. In another series of experiments the rates of deposition were not affected by the velocity of the smoke over the range of about 2–200 cm./sec. Aerosol particles are known to be deposited on surfaces as a result of Brownian motion[13] and by the action of radiometer,[14] centrifugal and gravitational forces. Since in the above experiments the upper and lower surfaces were at the same temperature (i.e., radiometer forces would be equal) and were exposed to similar aerodynamic conditions (i.e., centrifugal forces would be equal) and since Brownian diffusion is equal in all directions, it is clear that 90% of the deposit on the upper surface arose from the action of gravitational forces.

When water was used as the collecting surface, however, strikingly different results were obtained. Firstly, in normal smoking conditions the rate of deposition was found to be about 10 mg./100 cm.² h., or about 20 times higher than that on a correspondingly dry surface, and secondly, the rate was markedly dependent on the velocity of the smoke, being increased ten-fold by a change of velocity from about 2 to 200 cm./sec.

It seemed possible that this high rate of deposition and its dependence on smoke velocity could have resulted from radiometer forces, greater than those due to gravity, acting on the particles in the temperature gradient near to the evaporatively cooled water. This was not supported by the results of chemical analysis, however. The freeze-dried residue was redissolved in water and its contents of phenols determined by the colorimetric procedure of Gottlieb & Marsh.[12] In Table I, this concentration (expressed in the terms E_1^1) is compared with the concentration of phenols in smoke particles collected in different ways. This shows that, although smoke particles of different size ranges are chemically similar, the deposits on water are quite different. This observation recalled some earlier chromatographic and counter-current separation analyses which showed that particles contained proportionately much more of the polar and much less of the relatively non-polar phenols than does smoked water (see curves a and c of Fig. 6).

Table I

Concentration of phenols in wood smoke deposits

Sample	E_1^1
Smoked water	330
Smoked aluminium foil	40
Tar from small cyclone	41
Tar from electrical precipitator	44

It seemed impossible to reconcile all these observations with the view held by earlier workers that the smoking process is essentially one of particle deposition. It seemed more likely that the mechanism of smoking fish or other wet surfaces is one of absorption of smoke vapours by water and that these smoke vapours have a different chemical composition from that of the particles.

Separate effects of particles and vapours in smoke

To examine directly the parts played by particles and vapours in the normal smoking process, a comparison was made of the rate of deposition of normal smoke with that of isolated smoke vapours and of the chemical compositions of these deposits. An apparatus was required therefore for the removal of particles of smoke without affecting the vapours and also a simple analytical technique for measuring the contributions of particles and vapours in a smoke deposit.

In the early stages of this work counter-current separation analysis was used for comparing the compositions of the smoke deposits. Later it was discovered that advantage could be taken of the difference between the steam volatilities of the phenols in smoked water and those in the particle phase of wood smoke. The fractional steam distillation patterns of smoke deposits were sufficiently characteristic of the source—whether vapour or particle (see curves a and b Fig. 7)—to assess the contribution of particle deposition to the smoking process. A third analytical procedure involving measurement of the light absorption spectra of smoke deposits

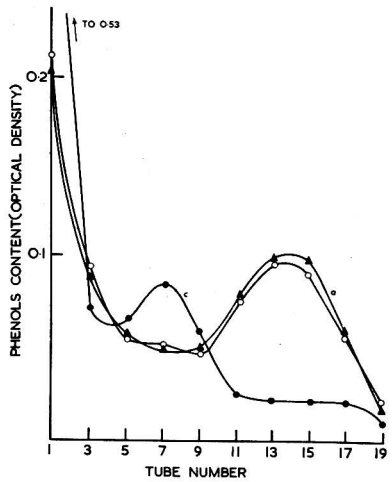

FIG. 6.—*Counter-current distribution, 20 transfers of petroleum and water*

○ deposit of smoke on water △ vapours
● visible particles

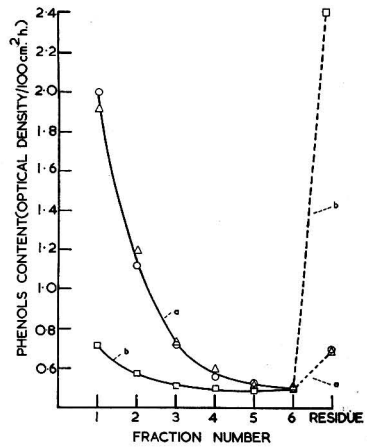

FIG. 7.—*Fractional steam distillation of wood smoke deposits*

Temperature of smoke 32° Velocity 100 cm./sec.
○ normal smoke △ smoke vapours
□ smoke particles

was useful in comparing vapour and normal smoking of water but could not, of course, be used for fish or bacon.

Preliminary study of the problem of removing particles of about 0·1 μ radius from wood smoke without seriously reducing the flow rate or altering the composition of the vapour indicated that of the various known methods only electrostatic precipitation was likely to be effective.

The first procedure used was described above (Fig. 2). Later, when it was discovered that no serious depletion of smoke occurred during its passage over consecutive water samples, a variant of this procedure was adopted (see above and Fig. 3).

Results of counter-current separation analysis of isolated smoke particles and of water smoked at 32° by normal smoke and by vapours are given in Fig. 6. The smoke particle samples were obtained by dissolving tar from the precipitator in water and diluting to give the same total phenol value as the smoked water samples. A second group of similar samples of smoke particles and of normally-smoked and vapour-smoked water was subjected to fractional steam distillation and the concentration of the phenols in each fraction and in the residues was determined colorimetrically. Results are given in Fig. 7. In a third experiment methanol (2% by volume) was added to samples of normally- and vapour-smoked water and the light absorption spectra of the resulting solutions was measured over the range 200–600 mμ. In Fig. 8 these spectra are compared with that of an aqueous methanolic (98 : 2) solution of smoke particles. The superimposability of the vapour and normal smoke curves in Figs. 6–8 and the quite different shapes of the corresponding particle curves shows that the full range of phenolic and light-absorbing components of wood smoke picked up by water during smoking came from the vapour and not from the particle phase.

Further samples of normally- and of vapour-smoked water were freeze-dried and the residues determined by weighing. The weights of the tarry residues which had been absorbed by the water from normal smoke and from vapours agreed within the limits of experimental error.

Although these results showed that vapours are of overriding importance in the smoking of water at 32°, it was desirable to determine whether particles played any more significant a part in the process of deposition under hot smoking conditions. These experiments were

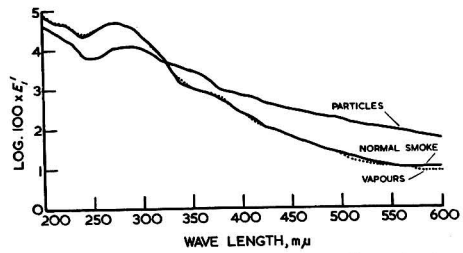

FIG. 8.—*Light absorption spectra of normally- and vapour-smoked water and smoke particles*

therefore repeated at kiln temperatures ranging from 49° to 82°. Once again the steam distillation curves for normally- and vapour-smoked water were superimposable.

It was next necessary to determine whether an upper limit could be set to the contribution of particles. A comparison was therefore made of samples of vapour-smoked water to which smoke particles had been added by subsequent electrostatic deposition. The results are summarised in Table II, from which it appears that when sufficient particles are added to increase by x% the deposit of smoke as determined by freeze-drying then the steam non-volatile phenols increase by about $2x$%.

Table II

Effect of addition of smoke particles on residues, non-volatile and volatile phenols (at 32°)

	Overall rate of deposition (freeze-dried residues)		Steam-volatile phenols (sum of fractions 1–6)		Steam-non-volatile phenols	
	mg./100 cm.² h.	Increase, %	Optical density/cm.² h. (1 cm. cell)	Increase, %	Optical density/100 cm.² h. (1 cm. cell)	Increase, %
Vapour	10·3	0	3·328	0	0·336	0
Vapour + 3-min. electrostatic deposition	15·1	47	3·252	−2·3	0·672	100
Vapour + 6-min. electrostatic deposition	20·4	98	3·348	+0·6	1·104	228

Similar results were obtained at higher smoking temperatures over the range 49–82°. Since determinations of the steam-non-volatile components of normally- and vapour-smoked water have always agreed within about 10% (Table III), it is clear that particles could not be contributing more than about 5% of the weighed smoke deposits over the temperature range investigated. Moreover it is evident that this small contribution by particles could not be responsible for slight differences between the concentration of the steam-volatile compounds in normally- and vapour-smoked water, such as those seen in Fig. 7.

Table III

Steam non-volatile phenols in normally- and vapour-smoked water at 32–83°

Temperature, °C	Steam-non-volatile phenols			
	Normal smoke	Vapours	Difference (Normal − vapour)	Difference, $\frac{\text{Normal} - \text{vapour}}{\text{Normal}} \times 100\%$
	Optical density/100 cm.² h. (1 cm. cell)			
32	0·345	0·336	0·009	2·6
58	0·850	0·731	0·12	14
49–80 (average = 65)	2·00	1·93	0·07	3·5
82	2·07	1·99	0·08	3·9

Rates of deposition of smoke and smoke vapours

It has been noted already that the rate of deposition of smoke on water is affected by smoke velocity. It was desirable therefore to compare the rates of deposition of normal smoke with those of smoke vapours within the range of smoke velocities likely to be encountered in different kilns and in different smoking processes. Smoke deposits were determined as before by weighing the residues after freeze-drying. Since the velocity of smoke or vapour passing over the water surface was difficult to determine, a convenient index of this—the rate of evaporation of water—was measured. In the many separate experiments involved in this study it was impossible to achieve a constant smoke density; due allowance has been made for this by expressing the rates of deposition in the terms weight (mg.) per unit area of surface (100 cm.^{2}) exposed to smoke of unit optical density for unit time (1 h.). The results given in Fig. 9 show that the relationship between smoke velocity and rate of deposition is the same for normal smoke as it is for vapours and that vapour absorption is the dominant mode of deposition over the range of smoke velocities likely to be encountered in practice.

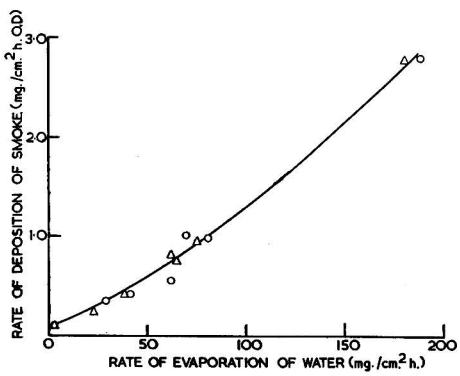

FIG. 9.—*Effect of smoke velocity on rate of deposition of smoke on water*
(temperature 32°)
○ normal smoke △ smoke vapours

Deposition of smoke on fish and bacon

The salient features of the process of smoke deposition on water having been established with some precision, it was now possible to investigate the deposition of smoke on fish and bacon. Rectangular pieces of cod were air-dried for differing periods of time and then smoked in normal smoke and in vapour by the methods already indicated. The vapour- and normally-smoked samples of the same initial weight loss were visually indistinguishable and the fractional steam-distillation patterns were superimposable (Fig. 10). The agreement in their content of the steam-non-volatile phenols is indicated in Table IV.

Table IV

Steam-non-volatile phenols in normally- and vapour-smoked cod

Initial weight loss, %	Final weight loss, %	Temperature of smoke, °C	Steam non-volatile phenols: Optical density/100 cm.^{2} h. Normal	Vapours	Difference (Normal − vapours)	Difference, Normal − vapours / Normal × 100%
0	16	32	0·452	0·431	+0·021	+4·4
21	36	,,	0·411	0·431	−0·02	−4·9
33	48	,,	0·247	0·266	−0·019	−7·7
35	50	,,	0·259	0·248	+0·011	+4·2
50	65	,,	0·231	0·192	+0·039	+16·9
0	23	59	0·810	0·730	+0·080	+9·8

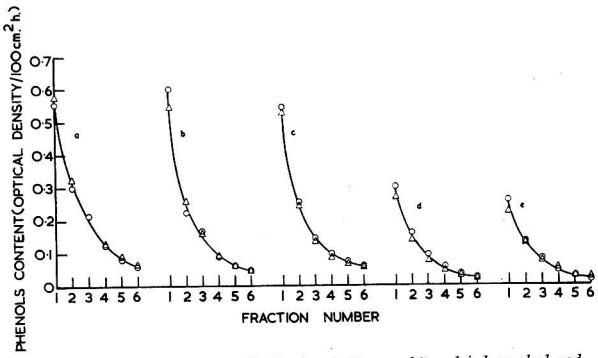

FIG. 10.—*Fractional steam-distillation patterns of pre-dried smoked cod*
Smoke velocity 50 cm./sec. Temperature 32°
○ normal smoke △ smoke vapours
Weight loss (a) 0%, (b) 9%, (c) 14·9%, (d) 35%, (e) 50%

Since it was also found, as in the experiments on the deposition of smoke on water, that the electrostatic addition of particles to vapour-smoked fish caused a disproportionately large increase in the concentration of the steam non-volatile phenols, it is clear that deposition of particles cannot be responsible for more than a small fraction of the total amount of smoke picked up by fish.

Tasting experiments

It was realised, however, that certain components of wood smoke might be found largely or wholly in the particle phase and that if these have strong odours or flavours or powerful antiseptic properties, then the deposit of particles, though small in relation to the total amount of smoke absorbed, might make a profound contribution to the characteristics of smoked fish. Experiments were designed to test this. An electrostatic precipitator was fitted to the inlet duct of the Torry kiln permitting the smoking of large quantities of fish by vapours alone. Three lots of 200 split and gutted fresh herrings were brined and dyed under identical conditions and each lot was smoked at 30° for 3 h. The first and third lots were smoked in normal smoke (N_1 and N_2) and the second in vapours (V). Smoking runs were carried out consecutively in the same Torry kiln operated under identical conditions except that in the second run the electrostatic precipitator was switched on and the optical density of the smoke in the kiln was therefore zero. After storage at 17° for 1, 4, 5 and 6 days the kippers, which were visually indistinguishable, were cooked in casseroles for 40 min. and examined by a panel of 10 to 12 members who were presented with the fish in two groups, each containing one fish from the smoking runs, N_1, N_2 and V. All the fish samples were presented under code and in a random order. The tasters were informed that in each group two kippers had been prepared by one smoking method and that the other had been smoked in a different way; they were asked to pick out the odd sample.

A second tasting experiment, this time on smoked cold-stored herring, was carried out as before except that the three lots of fish were smoked in the order V, N_1, N_2 and that the tasters were able to compare corresponding portions (i.e., bone and boneless) of the fish samples; they were wrapped in aluminium foil and cooked in a Magicook 'infra-red grill'. The assessments of differences in this and the preceding experiment are indicated in Table V.

A large-scale tasting experiment was next conducted. Over 600 people comprising 29 press representatives and 'higher executives', 130 fish trade managers, 218 members of the public and 245 schoolchildren were asked to taste two portions of 'infra-red grilled' kipper. They were informed that one of these portions had been smoked in invisible smoke vapours and the other by the normal process, and were asked firstly to indicate which sample had an unusual

Table V

Tasting comparison of normally- and vapour-smoked kippers

Pre-smoking treatment: fish immersed for 12 min. in 20% (w/w) brine containing 1% (w/w) saturated 'Kipper Brown' solution

Type of herring	Smoking treatment	Weight loss, %	Number of times selected as different on day number				Total selections as different
			1	4	5	6	
Fresh (about 15% fat content)	Normal (N_1)	16·2	8	6	6	8	28
	Vapour (V)	15·7	7	4	9	8	28
	Normal (N_2)	16·4	9	12	5	4	30
Frozen (about 20% fat content)	Vapour (V)	14·5	10	8	7	8	33
	Normal (N_1)	13·9	5	7	11	6	29
	Normal (N_2)	14·7	8	7	4	9	28
			1 recorded 'no difference'	2 recorded 'no difference'	2 recorded 'no difference'	1 recorded 'no difference'	6 recorded 'no difference

flavour and secondly to state their preference. No difference between the samples was found by 375 tasters; 110 found an 'unusual' flavour in the normally-smoked and 89 in the vapour-smoked samples. Of the tasters who expressed preference, 281 preferred the normal-smoked and 257 the vapour-smoked kippers. Analysis of the results failed to reveal any significant differences between the assessments of the various groups of tasters.

Antioxidant property of smoke

Since another useful property of wood smoke is that of delaying oxidative rancidity which would otherwise have developed in kippers as a result of the brining and partial drying treatments, it was desirable to determine whether this too is due to absorption of compounds from the vapour phase. Accordingly two further samples of normally- and vapour-smoked kippers (N and V respectively) were prepared and were then quick-frozen and stored at −28° for 6 months. After being thawed and cooked they were examined for rancid odours and flavours by a taste panel of 14 members. The samples were tasted in two groups of three comprising N, N and V, under code and in random order and the tasters were again instructed to pick out the odd sample. All the panel members reported great difficulty in distinguishing differences in the rancidity levels. There were 11 indications of 'no difference', 13 selections of the normal- and 4 of the vapour-smoked samples. It is concluded, therefore, that normal smoke and vapours do not impart noticeably different levels of protection against the development of oxidative rancidity in cold-stored kippers.

Conclusion

The last four experiments clearly show that there are no significant differences in the appearance, flavour and keeping quality of normally- and vapour-smoked kippers. This supports the conclusion drawn from the chemical and physical studies that although some deposition of particles must be expected to occur during smoking its contribution to the smoking process is negligible.

Application to bacon

It seemed likely that other important food-smoking processes, for instance, bacon curing, might also involve vapour absorption rather than particle deposition. Since the authors are concerned with fish and fish processing it was only possible to carry out one rather limited experiment on bacon. As in the experiments on fish and water, identical portions of the fat, rind and muscle of 'green' bacon were placed upstream and downstream of an electrical precipitator operating in a duct placed inside the Torry kiln and the samples cured for 3 h. at 32°. On visual examination the bacon was found to be well coloured and no difference in the appearance of the normally and vapour treated samples could be detected. The portions were next subjected to fractional steam distillation with the results given in Fig. 11. Although these findings cannot be regarded as being conclusive they suggest that in bacon curing, as in fish smoking, particle deposition is unimportant.

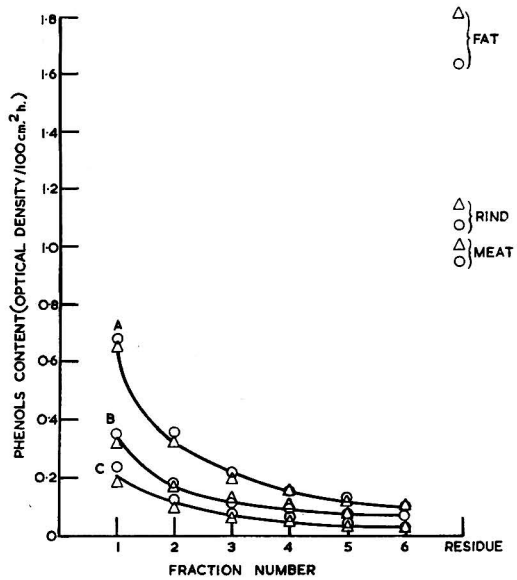

FIG. 11.—*Fractional steam-distillation patterns of normally- and vapour-smoked bacon*
○ normal smoke △ smoke vapours
A, fat B, rind C, meat

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TRANSFORMATION, LEACHING AND UPTAKE OF FERTILISER NITROGEN APPLIED IN AUTUMN AND SPRING TO WINTER WHEAT ON A HEAVY SOIL

By J. K. R. GASSER

The concentrations of ammonium and nitrate in the surface layer (0–6 in.) of a heavy soil with and without fertiliser N were measured from October 1957 to September 1958 on plots growing winter wheat and in bare soil. Ammonium sulphate or 'calcium nitrate' supplying 100 lb. of N/acre was applied in the autumn, in the spring, or half in autumn + half in spring. Both forms of fertiliser applied in the autumn were lost from the surface soil by the following March. Autumn-applied nitrogen was not taken up by the wheat during the autumn or winter. Nitrogen applied in the spring was rapidly taken up by the crop, but remained in the surface soil of the bare plots until June, when prolonged and heavy rain leached the nitrate into the lower soil layer.

At the time the ears emerged, much more mineral nitrogen had been lost from the soil top-dressed with fertiliser in the spring than was accounted for by the increase in nitrogen uptake by the above-ground parts of the wheat.

The yields of grain and straw at harvest were not increased by the nitrogen fertilisers, whenever applied. The nitrogen contents of both grain and straw were increased by applying fertilisers, and there were consistent but small increases in the total nitrogen uptake by the wheat on the fertilised plots. The uptake of the fertiliser nitrogen had its greatest value in the samples taken at ear emergence when on average 27 lb. of N/acre of the 100 lb. applied was recovered. At harvest, wheat from the fertilised plots contained 18 lb. of N/acre less than at ear emergence.

Introduction

Field experiments have shown the effects of nitrogen fertilisers on the final yields of grain and straw of winter wheat,[1, 2] but did not provide information on the relationships between the amount of mineral nitrogen in the soil, nitrogen content of the plant, production of dry matter and total nitrogen uptake during growth. The work now to be described was designed to follow the transformation and movement of fertiliser nitrogen from the surface soil to the subsoil, and to measure the uptake of nitrogen by winter wheat from the surface soil and the recovery from the subsoil.

Experimental

The field experiment was done in Great Field II, Rothamsted, from October 1957 to September 1958 on a heavy clay loam soil (pH 7·0) derived from Clay-with-Flints overlying chalk; the soil contained N 0·149% and C 1·47%. The field had been fallowed in 1957 following beans in 1956. Each plot, 90 ft. long × 14 ft. wide, had 75 ft. drilled with wheat, and 15 ft. at one end kept bare. The fallow ends were marked out and experimental treatments were applied separately.

The treated plots had ammonium sulphate or 'calcium nitrate' supplying 100 lb. of N/acre applied in one dressing in the autumn or in the spring, or half in autumn and half in spring. The ammonium sulphate was normal fertiliser grade material. The 'calcium nitrate' was a granulated fertiliser grade of the double salt $5Ca(NO_3)_2,NH_4NO_3,10H_2O$. Two plots without nitrogen and the six plots treated with nitrogen were arranged in a randomised block; the whole experiment had three blocks. A basal dressing of 5 cwt./acre of compound fertiliser containing P_2O_5 10% and K_2O 20% was broadcast on all plots before the seed was drilled. All nitrogen dressings were broadcast by hand. The autumn dressings of nitrogen and basal PK fertilisers were applied on 5 October. 'Cappelle' wheat was drilled on 7 October at 2·5 bushels per acre. The spring nitrogen was applied on 20 March; the crop and fallow plots were sprayed against weeds on 30 April with CMPP at 6 pints in 40 gal. per acre, and the wheat was combine-harvested on 3 September 1958.

Table I shows the monthly rainfall from September 1957 to September 1958 together with the long-term average, and the amount of rain between sampling dates. After a wet September, rainfall was below average until the end of 1957. January rainfall was a little above average,

and February was much above average. March, April and May were slightly drier than average, with April the driest month. The June rainfall was more than twice the long-term average. July was slightly drier than normal, but August and September were both much wetter. The total summer rainfall was well above average, and the season was marked by a large number of wet and sunless days. The sunshine during the spring and early summer (March to May) was average, but during June, July and August there were only 449 hours compared with the long-term average of 581 hours of sunshine.

Table I

Total monthly rainfall from September 1957 to September 1958 and the long-term average

	Rainfall, in.	
	For 1957	Long-term average
September	3·33	2·38
October	2·51	2·97
November	2·18	2·80
December	2·32	2·57
	For 1958	
January	2·84	2·51
February	3·08	1·93
March	1·85	1·89
April	1·26	1·92
May	2·04	2·15
June	4·67	2·19
July	2·03	2·54
August	3·55	2·60
September	3·61	2·38

Rainfall between sampling dates throughout the experiment

Period	Rainfall, in.
7 Oct.–14 Nov.	4·59
15 Nov.–19 Jan.	5·50
20 Jan.–18 Mar.	4·26
19 Mar.–14 Apr.	2·22
15 Apr.– 2 May	0·45
3 May–20 May	0·87
21 May–12 June	2·54
13 June– 7 Sept.	9·38

A sample of the surface soil (0–6 in.) was taken from each plot on 5 October before any fertilisers were applied. Subsequent samples were taken separately from the bare fallow and from under winter wheat. The experiment was sampled in November, January, at three-week intervals from mid-March to mid-June, and at harvest in early September. Five cores per sample were usually taken, but for the plots receiving spring nitrogen ten cores per sample were taken from the bare fallow from April onwards, and from April to June from under winter wheat. Representative soil samples were difficult to obtain because of the many large flints.

The wheat was sampled from mid-March until June, on the same day as the soil, by removing five 1-yard long rows from each plot (1/4980 acre). (Although larger samples would have represented the plot area more accurately, to remove more plants at each sampling would have interfered too much with the final harvesting.) The plants were pulled out and the roots cut off later; the above-ground part of the plant was weighed, cut into short lengths, and a sub-sample was dried at 85° to determine the dry matter content. At harvest, 60 ft. of the central 16 rows (1/78 acre) were combine-harvested, grain and straw yields were measured and samples were taken for determination of dry matter and analysis. The weight of stubble was estimated by sampling.

The soil samples were extracted by shaking with acidified potassium sulphate solution, the suspension filtered, and the ammonium and nitrate nitrogen contents of the extracts determined by the micro-diffusion method of Bremner & Shaw.[3] The total nitrogen contents of plants, straw, stubble and grain were determined by the Kjeldahl method.

Results

Fig. 1 shows how the dressings of nitrogen fertilisers affected the ammonium and nitrate contents of the bare fallow and the soil under winter wheat. On plots that did not receive fertiliser in the autumn the initial nitrate level of 15 p.p.m. nitrate-N fell to 3–4 p.p.m. by mid-November and remained at this level until March. The bare fallow and soil under winter wheat did not differ during the period October to March, and there was no measurable uptake of nitrogen. Fertilisers broadcast in October increased the mineral nitrogen content of the soil in November, but by January all the nitrogen added as nitrate had been lost from the

surface soil. The ammonium nitrogen applied in October was rapidly nitrified, only 20% remained as ammonium-N in November and nitrification was almost complete by January, so the nitrogen applied as ammonium was also lost from the surface soil during the winter. All plots had similar contents of mineral nitrogen in March ; thereafter plots which had received all their fertiliser in October behaved the same as the unfertilised plots. Fertiliser nitrogen applied in mid-March was taken up rapidly by the wheat. By mid-June, three-quarters of the ammonium sulphate and five-sixths of the ' calcium nitrate ' dressings supplying 100 lb. of N/acre had been removed. The spring portions of the ' split dressings ' were also taken up rapidly. At harvest all the fertiliser nitrogen had been lost from the surface soil under wheat and all plots contained similar amounts of mineral nitrogen.

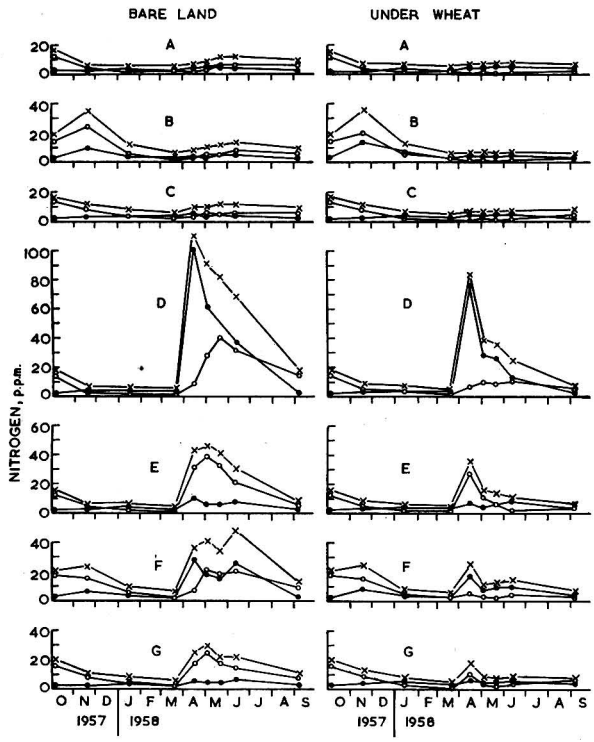

FIG. 1.—*Mineral-N content of bare soil and soil under wheat on plots without fertiliser and with fertiliser supplying* 100 *lb. of N/acre*

A No fertiliser
B Ammonium sulphate, C ' calcium nitrate ', applied all in autumn
D Ammonium sulphate, E ' calcium nitrate ', applied all in spring
F Ammonium sulphate, G ' calcium nitrate ', applied half in autumn + half in spring

NH_4^+-N ●——● NO_3^--N O——O $(NH_4^+ + NO_3^-)$-N ×——×

The ammonium-N content of the unfertilised plots was the same in bare soil and under wheat and averaged 3–4 p.p.m. in the autumn and winter and 5–6 p.p.m. in the spring and summer. Adding either fertiliser increased the ammonium-N content of the soil, but the value returned to the same as for the unfertilised plots after nitrification of the added ammonium.

Under bare fallow not given fertiliser in spring, the ammonium + nitrate-N had its maximum value of 12–14 p.p.m. in June, and had decreased to 9–10 p.p.m. by September.

Fertilisers applied in the spring increased the mineral nitrogen content of the soil and persisted until June, but by September all of the nitrogen applied as ' calcium nitrate ' and most of that applied as ammonium sulphate had been lost from the surface soil.

Tables II–IV show the dry matter produced, nitrogen content and nitrogen uptake for wheat from the unfertilised plots, together with the increases from applying nitrogen fertilisers. The dry matter produced by the plants from the unfertilised plots increased at each sampling, with the maximum weight at harvest (Table II). Nitrogen fertilisers had little effect on the production of dry matter, and there were no significant difference between treatments. The largest increase from fertiliser nitrogen was at ear emergence in June (Table II) ; at harvest the increase was only one-third of this value.

Table II

Dry matter produced by wheat plants without nitrogen fertiliser at different stages of growth and at harvest, and the average increases produced by 100 lb. of N/acre supplied as ammonium sulphate or ' calcium nitrate ' applied all in autumn, all in spring, or half in autumn + half in spring

Sample	Date	Yield with no nitrogen	Increase from 100 lb. of N/acre	S.E. of increase
		Dry matter lb./acre		
1	18 Mar.	310	10*	35
2	14 Apr.	620	40	62
3	2 May	1120	160	148
4	20 May	2360	80	272
5	12 June	6970	700	394
Harvest (total produce)	5 Sept.	8790	240	248

* Excludes plots receiving fertiliser nitrogen all in spring

Table III

Nitrogen contents of wheat plants without nitrogen fertiliser at different stages of growth and of the straw, stubble and grain at harvest, and the increases from 100 lb. of fertiliser N/acre applied all in autumn, all in spring, or half in autumn + half in spring

(Average data for ammonium sulphate and ' calcium nitrate ' are stated)

Sample	Date	No nitrogen	All in autumn	All in spring	Half in autumn half in spring	S.E. of increase
		%N				
		Increase in % N				
1	18 Mar.	4·40	0·10	−0·11	−0·10	0·102
2	14 Apr.	4·06	−0·02	0·08	−0·01	0·131
3	2 May	3·55	−0·04	0·32**	0·16	0·095
4	20 May	2·82	0·26*	0·18	0·12	0·091
5	12 June	1·78	0·22	0·10	0·08	0·104
Harvest	5 Sept.					
Straw		0·64	0·02	0·10*	0·11**	0·033
Stubble		0·47	0·12*	0·20**	0·20**	0·045
Grain		2·20	0·06*	0·07*	0·08*	0·026

* Significance $0{\cdot}05 > P > 0{\cdot}01$ ** $P < 0{\cdot}01$

The nitrogen content of the wheat plants decreased as the crop grew (Table III). Both forms of nitrogen fertiliser behaved similarly and the results are the average for ammonium sulphate and ' calcium nitrate '. The fertiliser nitrogen did not affect the total N content of the wheat until May when it was significantly increased by the dressing applied all in spring and increased by the half of the split dressing applied in spring. In the next sample (late May) all treatments increased the nitrogen content of the wheat and the increase from nitrogen fertilisers applied all in autumn was also significant. In mid-June, at ear emergence, nitrogen fertilisers applied all in spring or all in autumn increased the total N content of the wheat and the latter value approached significance. At harvest, the nitrogen content of the straw was

Table IV

Nitrogen uptake by wheat plants without nitrogen fertiliser at different stages of growth and at harvest, and the average increases from ammonium sulphate or 'calcium nitrate' supplying 100 lb. of N/acre applied in autumn, in spring, or half in autumn + half in spring

Sample	Date	No nitrogen Uptake lb. N/acre	All in autumn	All in spring	Half in autumn half in spring	S.E. of increase
			Increases in uptake, lb. N/acre			
1	18 Mar.	14	0	3	0	1·7
2	14 Apr.	25	1	1	3	3·1
3	2 May	39	2	18*	6	6·4
4	20 May	89	−2	12	13	10·2
5	12 June	120	28	27	25	13·7
Harvest (total produce)	5 Sept.	120	8	9*	9*	3·9

* Significance $0{\cdot}05 > P > 0{\cdot}01$

significantly increased by fertiliser nitrogen applied all in spring or half in autumn and half in spring. The nitrogen contents of the stubble and grain were significantly increased by fertiliser nitrogen applied in all three ways.

Total nitrogen uptakes by the unfertilised wheat, calculated from the yields of dry matter and nitrogen contents (Table IV), increased from March until June and had the same value at harvest as in June. The fertiliser nitrogen did not affect the total nitrogen until early-May, when the dressing applied all in spring significantly increased the amount. In late May, wheat from plots which had received either all or half of their fertiliser nitrogen in spring showed increased uptake of nitrogen. All treatments increased the total uptake in June and at harvest when the values for the latter increases were significant from nitrogen fertiliser applied all in spring or half in autumn and half in spring.

Discussion

The experimental site was fallow during the preceding summer. This was no doubt one reason why the unfertilised yields of straw and grain were high and why the fertiliser nitrogen had only small effect. The unfertilised plots yielded 4180 lb./acre of dry matter (as grain) containing 92 lb. of N. This may be compared with the 2670 lb./acre of dry matter from the unfertilised plots of Widdowson's 1957 experiments[2] where the grain contained 48 lb. of N/acre. The 139 lb. of N/acre applied as fertiliser to the wheat in his experiments increased the average yield of dry matter of the grain to 3450 lb./acre and the nitrogen uptake to 76 lb. of N/acre, values smaller than those given by the unfertilised plots in the present work. Although the nitrogen contents of the growing plants and the grain and straw at harvest were increased by the nitrogen fertilisers applied, the values of the increases in nitrogen content of the grain were only about one-third those found by Widdowson,[2] which again reflects the high nitrogen status of this site. The soil studies show that all the nitrogen applied in the autumn, whether in the ammonium or nitrate form, had been lost from the surface soil by March, when the wheat re-started rapid growth. This mineral nitrogen, which must have been retained in the subsoil, did not increase the nitrogen content of the plants, or total uptake, until May, presumably because the wheat roots did not reach the subsoil containing the leached nitrogen earlier. In contrast, nitrogen applied in the spring was rapidly removed from the surface soil by the wheat and increased the total nitrogen content of the plant.

The maximum recovery of applied nitrogen was found in samples taken at ear emergence in June and averaged 27 lb. of N/acre of the 100 lb. of N/acre applied, with a range from 9 to 41 lb. of N/acre. At harvest the total recovery of fertiliser nitrogen averaged only 9 lb. of N/acre (range 2–15 lb. of N/acre). The average amounts in grain and straw were 2·4 and 6·2 lb. of N/acre respectively. At both these times the unfertilised wheat contained 120 lb. of N/acre, so the total nitrogen uptake by the fertilised wheat decreased by 18 lb. of N/acre between ear emergence and harvest. Therefore, the fertilised wheat plants had accumulated nitrogen during growth which they did not require or were unable to use for producing grain.

The balance of this nitrogen may have been translocated to the roots of the plants when the grain ripened, which would ultimately increase the soil nitrogen, or the excess nitrogen may have been lost by some other means, possibly to the air as gas. There is no information to decide which mechanism is more probable, or if both operate. The loss of mineral nitrogen from the surface soil of fertilised plots under winter wheat was much greater than the increased amounts of nitrogen found in the plants from these plots. The figures given below show that for the plots receiving all their fertiliser nitrogen in the spring only one-third of the amount lost from the surface soil between March and June was recovered in the plant. On the plots which received all their fertiliser nitrogen in the autumn, the increased uptake of nitrogen in June recovered by the wheat from the subsoil was equal to the amount recovered from the plots

	All in spring	Half in autumn half in spring	All in autumn
lb. N/acre applied in spring	100	50	0
lb. N/acre 'lost' from surface soil in spring	80	42	0
lb. N/acre recovered in wheat	27	25	28
Unaccounted for	−53	−17	+28

receiving all in the spring. If the fertiliser nitrogen recovered in the wheat from the plots receiving the split dressing is considered to come equally from the autumn and spring halves, the proportion of the spring dressing unaccounted for is similar to that on the plots receiving all in spring. Although part of the fertiliser nitrogen unaccounted for was undoubtedly in the roots, much is left whose fate is unknown.

The total nitrogen contents of straw and stubble increased less on plots receiving all the fertiliser nitrogen in the autumn than that on plots receiving either split dressings or all in spring. The earlier samplings showed that the wheat did not recover the autumn nitrogen until June, at least 9 weeks after applying spring nitrogen, so that the later recovery affected the composition of the straw less, but increased the nitrogen content of the grain as much as did the spring dressings.

The retention of added fertilisers on the bare fallow confirms previous conclusions that heavy and prolonged rain is required to leach dressings of fertilisers from the surface soil.[4, 5] Some of the nitrate applied in the autumn remained in the surface 6 in. after 4·6 in. of rain had fallen, but all was removed by a total rainfall of 10·1 in. Some of the fertiliser applied as ammonium sulphate still remained at this stage, but was lost after a further 4·3 in. of rain. Even in winter, when the nitrate was most easily leached, considerable rainfall was required to remove the broadcast dressings. The fertiliser applied in March was substantially present in late May after 3·5 in. of rain had fallen. However, a wet spell in late May and early June (which ended with 1·0 in. of rain on 2 June) caused some fertiliser nitrogen to be lost from the surface soil. During the very wet weather from mid-June to September, when 9·4 in. of rain fell, the remainder of the fertiliser applied as nitrate and most of the ammonium nitrogen (which had been nitrified) were lost from the surface soil.

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STUDIES ON EGG QUALITY. I.—Effects of certain Poultry Housing Systems, Age of Bird and Season

By K. BRYCE JONES, T. W. HOUSTON and J. M. HARRIES

The initial quality of eggs from pullets and hens of the same strain under intensive and extensive systems of management have been studied over a twelve-month period. Candling quality, percentage thick white, yolk index, the occurrence of meat and blood spots, and yolk and shell colours were recorded. The eggs were also examined by visual comparison with graded picture charts. The system of management had little effect on the quality of the eggs except that access to range resulted in slightly darker yolks, and in slightly improved appearance of the albumen during the winter months. Changes of quality due to the maturing of pullets were small compared with the effects of season. Different measures of quality were differently affected by season.

Introduction

Modern systems of poultry management have increased productivity. There is a possibility that this gain has been accompanied by changes either in the quality of the egg as laid or in the rate of deterioration during distribution. There are however few data relating to United Kingdom conditions on the internal quality of eggs reaching the consumer by which this hypothesis can be tested. This paper concerns eggs only a few days old.

Orr *et al.*[1] reported that smaller eggs with better quality albumen were obtained from birds reared on range rather than in confinement, but this was not confirmed in later work. Froning & Funk[2] pointed out a conflict of past evidence on the effect of confinement in cages on egg weights and the occurrence of blood and meat spots. In their own experiments comparing caged birds with sister birds on the floor they found that the caged birds gave better quality albumen but more meat spots. Cornford *et al.*[3] found that between April and August eggs from battery hens had distinctly paler yolks, slightly more albumen, and slightly lower Haugh values than eggs from sister birds on free range, but except for the yolk colour the differences were considered unimportant to bakers.

Various authors have reported the influence of the age of birds on the size and composition of eggs but few have studied the effect on quality characteristics. Hunter *et al.*[4] showed that as pullets advance in their production the yolks show a lower yolk index. Greenwood & Bolton[5] found the proportion of thick white increased with the age of the hen.

Egg quality varies seasonally, temperature being probably the most important factor. Hunter and co-workers[4] found a seasonal decline in quality beginning in March or April and continuing through the summer, quality being maximal between November and March. Strain & Johnson[6] found that blood and meat spots were least frequent in October but otherwise the seasonal pattern varied with the strain of bird.

Several American workers have reported that increased productivity is associated with diminished albumen quality,[7, 8] although Knox & Godfrey[9] did not find such a relationship between monthly production and monthly average percentage thick white in a flock of pullets studied throughout 56 weeks.

More recently Johnson & Merritt[10] working on the heritability of albumen height in flocks of White Leghorns and Barred Rocks found significant negative correlations between albumen height and productivity in both breeds but at different levels. They found that in one breed the genetic influence was of opposite sign to the phenotypic influence. Goodman & Godfrey[11] carried out similar work on New Hampshires and obtained negative correlations throughout. Wilcox[12] found that the lysozyme interaction with ovomucin, which may contribute to changes in the thick white, varied more with season than with the age of the bird.

Yolk index has been used as a measure of deterioration during storage or due to short periods of exposure to warmth but is less frequently used as a measure of internal quality than albumen measurements of various kinds.

In 1958 an opportunity arose to study the quality of eggs from groups of Light Sussex pullets and hens withdrawn from a closed flock. The groups were kept under housing systems described as intensive and extensive deep litter, that is, deep litter, and deep litter with access

to open grass range. These groups were also used to test the effects of management system on hatchability. It was arranged that in alternate weeks eggs from each pen would be tested for hatchability and initial egg quality. The results relating to hatchability have been reported by Coles[13] who arranged the field operations associated with the experiment.

Experimental

For this investigation there were four groups of birds housed separately in uninsulated Nissen-type huts, 90 birds in each group. Two of the groups were sister pullets and the other two groups sister hens. One group of pullets (Pen A) and one group of hens (Pen C) were housed intensively without access to range but with additional artificial light; the remaining group of pullets (Pen B) and the remaining group of hens (Pen D) had access to range and artificial lights were not used. There were six cockerels in each pen, these being replaced every six weeks and replacements made immediately a bird died or appeared to be ailing. Female birds which died were not replaced but the date of death was noted in order to relate the group egg production to the number of hen-days per pen. The birds were all fed a commercial breeders' mixture *ad lib.*

The numbers of eggs laid by the four groups were recorded on a daily basis for each group. Commencing on 6th October, 1958, random samples of 90 eggs were drawn from all the eggs laid by each group over the preceding 4 days. These eggs were packed in Keyes trays and transported about 55 miles by road to the laboratory, where they were held at room temperature until the quality examinations were finished. The sampling was repeated fortnightly until the end of September, 1959. The samples are referred to in the text by their serial numbers TE 1–26. The hens in Pen D suffered a marked setback in egg production in December–January and there were insufficient eggs from this pen to provide samples for periods TE 5, 6 and 7.

In this investigation the measures of quality used were expected to be adequate to explore differences due to management treatments. At the same time they represent attributes easily perceptible to the consumer. The laboratory work was planned to give a compromise between speed and accuracy in the study of a sufficiently large number of eggs to cover a wide range of natural variation.

It was not possible to provide sufficient staff to make a full examination of the quality of the eggs every fortnight, so a shorter method of assessment of quality was adopted during alternate fortnightly examination.

On each occasion all eggs were first numbered and then candled. The full examination included the following observations, starting with not less than 80 eggs per pen (except for TE 12, when it was only possible to examine 59 eggs per pen, and for Pen D, TE 5, 6 and 7, when samples were not available):

(i) Weight of the whole egg
(ii) Weights of the separated shell, thick albumen, thin albumen and yolk of each egg
(iii) Yolk index of separated yolk
(iv) The occurrence of meat or blood spots
(v) The colour of shells and yolks.

The short examination was by comparing the appearance of the broken-out egg with graded pictorial charts.

During candling the eggs were classified into four grades, of which grades 1 and 2 corresponded approximately to first-quality eggs by commercial standards, grade 3 to borderline eggs and grade 4 to the equivalent of second-quality eggs or rejects. The occurrence of hair cracks and spots was not taken into account in this assessment, which was concerned with the appearance of the air-cell and the appearance, position and movement of the yolk. All cracks were recorded separately. Most of the candling was done by one operator.

Individual egg weights were recorded to the nearest 0·1 g. Eggs were broken out and separated into shell, thick white, thin white and yolk by a method basically similar to that of Holst & Almquist.[14] Each component of each egg was weighed separately to the nearest 0·1 g. The recorded weights did not strictly represent true values because minor inaccuracies

resulted from the method of separation. In order to maintain an adequate speed the shells were not completely drained and some albumen adhered to the yolk. Thus in general the proportions of shell, yolk and thick white were over-estimated and of thin white under-estimated. These inaccuracies however were found to be relatively constant and were not of importance to the comparisons which were being studied. If the sum of the weights of the separated components was abnormally below that of the original egg weight the result was discarded ; there was almost always a difference of 0·5–0·7 g.

Immediately after separation the yolk was transferred to a sheet of plate glass and the yolk index[15] was measured after 1 min., using a tripod micrometer for measurement of yolk height and vernier calipers for diameter measurements.

Shells and yolks were assessed subjectively for colour using five-point scales ranging from pale to dark.

Pictorial grading was based on a selection from charts* issued by the U.S. Department of Agriculture. These charts were originally intended to give an integrated rating for white and yolk but during the first short examination the observers usually considered that the yolk justified a different grading from the white, making a compromise difficult. Yolks and whites were therefore assessed independently throughout the remainder of the series.

Eggs were received in the laboratory on Mondays, and the assessments of quality were started on Tuesday morning. The full examination usually took until Friday to complete. During the investigation it was noted that the quality measurements made on the fourth day differed appreciably from those on the first day of examination. The experimental procedure was regulated from TE 14 onwards so that 20 eggs from each pen were examined each day. The short examination took only two days to complete.

Results

(i) *Candling*

The data obtained on candling were compared with the observations made on breaking out the eggs. This comparison is not reported here as it did not provide any additional information on the subject of this paper.

(ii) *Yolk index*

Yolk index averages for each pen for successive periods are presented in Table I. Owing to breakages and the fact that for certain periods the full quota of eggs was not obtainable the number of eggs contributing to each average was not constant.

Table I

Yolk index (Y) and % of thick white (T)

(period averages)

Period No.		Pullets				Hens			
		Intensive Pen A		Extensive Pen B		Intensive Pen C		Extensive Pen D	
		Y	T	Y	T	Y	T	Y	T
Oct. 1958	TE 1	0·425	55·6	0·428	55·8	0·415	55·7	0·417	54·8
	3	0·425	55·6	0·430	56·0	0·418	55·4	0·427	52·0
	5	0·431	59·5	0·444	58·8	0·433	59·8	—	—
Jan. 1959	8	0·432	58·8	0·440	59·9	0·434	59·6	0·440	64·3
	10	0·432	57·2	0·427	57·0	0·429	56·0	0·425	62·0
	12	0·449	55·2	0·435	56·8	0·441	57·3	0·454	60·4
	14	0·446	54·9	0·434	52·7	0·435	55·1	0·438	56·9
May 1959	16	0·431	54·3	0·416	51·8	0·438	57·7	0·420	56·3
	18	0·416	49·7	0·413	48·9	0·419	53·4	0·413	51·4
	20	0·401	46·1	0·403	45·5	0·412	49·1	0·400	47·5
	22	0·398	42·6	0·407	44·5	0·400	47·7	0·387	47·5
	24	0·365	43·2	0·381	44·1	0·327	42·1	0·378	46·1
Sept. 1959	26	0·410	49·8	0·417	52·5	0·409	50·5	0·411	51·9

* The charts used were Nos. 2, 5, 6, 7, 8, 10 and 12 of the U.S.D.A. series, corresponding to Average AA, Average A, Low A, High B, Average B, High C and Low C grades, respectively.

Thick white as a percentage of total white.—Table I also shows the average values for thick white as a percentage of total white. As the investigation was concerned with the incidence of poor-quality eggs as well as with the general average, percentage frequency distributions are given in Table II, showing the proportions of eggs in 8% groupings for the whole range of values observed. A further breakdown of the lower tails of these distributions is given in Table III, showing the actual numbers of eggs in each group.

Table II

Thick white as % of total white
(% frequency distribution)

	6–14%	14–22%	22–30%	30–38%	38–46%	46–54%	54–62%	62–70%	70–78%	78–86%	86–94%	Total no. eggs
Intensive pullets Pen A	0·3	1·4	4·0	7·2	11·8	25·5	29·0	15·1	5·2	0·5	0·1	1056
Extensive pullets Pen B	0·2	0·9	1·8	6·5	14·9	25·9	30·6	15·5	3·4	0·3	—	1055
Intensive hens Pen C	—	0·7	2·5	7·3	14·3	22·7	28·2	16·5	6·1	1·4	0·4	1054
Extensive hens Pen D	0·5	1·2	3·9	6·2	11·8	21·0	27·4	18·7	6·1	2·2	1·0	916
No. of eggs	10	42	123	279	541	973	1117	668	211	43	14	4081

Table III

Thick white as % of total white
(total no. of eggs in % groups below 30%)

		6–10%	10–14%	14–18%	18–22%	22–26%	26–30%	Total
Oct.	TE 1					4	5	9
1958	3					1	2	3
	5		1					1
Jan.	8						3	3
1959	10							0
	12					2	1	3
	14				1	1		2
May	16				1		2	3
1959	18				4	4	9	17
	20			2	4	6	16	28
	22	2	2	3	6	9	17	39
Sept.	24	1	2	8	8	10	17	46
1959	26		1	2	3	8	6	20
Totals		3	6	15	27	45	78	174
Cumulative totals		3	9	24	51	96	174	

(iii) *Pictorial grading*

This was assessed by two observers and the scorings of both were taken into account in calculating a pictorial grade index to characterise each monthly pen sample. An index was calculated for albumen and yolk separately by using weighting factors 1 to 7 for each of the pictorial grades ranging from good to poor quality. The total score for each pen sample was expressed as a percentage of seven times the number of observations and this subtracted from 100 gave the index. Thus the higher the index the better was the quality by pictorial grading. The monthly index values for whites and yolks are given in Table IV. The variation in appearance of the whites was greater than that of the yolks. The percentages of eggs which were placed in grades 6 and 7 for whites, and in grades 4 and 5 for yolks, for each pen and in each month, are recorded in Table V. No yolks were placed in grades 6 or 7.

(iv) *Meat and blood spots*

The incidence of meat and blood spots, observed on breaking out, is shown in Table VI. The majority of the spots were meat spots and many of them were only small.

Table IV

Pictorial values for yolk and albumen

Period		Yolks					Albumen				
		Pullets		Hens		All	Pullets		Hens		All
		Int. A	Ext. B	Int. C	Ext. D	birds	Int. A	Ext. B	Int. C	Ext. D	birds
Nov. 1958	TE 4	67	63	61	—	64	45	51	39	—	45
	6	60	63	61	71	64	37	55	44	50	47
	7	59	58	59	58	58	43	47	40	47	44
Jan. 1959	9	67	66	66	69	67	48	55	49	53	51
	11	67	74	69	73	71	40	50	44	49	46
	13	72	69	72	69	71	59	53	50	52	54
Apr. 1959	15	75	74	72	73	74	58	56	56	55	56
	17	62	64	63	63	63	51	42	41	40	44
	19	72	73	73	72	73	54	52	57	53	54
	21	74	72	71	71	72	52	51	45	49	49
Aug. 1959	23	73	65	68	68	68	42	47	45	49	46
	25	69	70	66	68	69	52	44	39	42	44
Average		68	67	67	69	68	48	50	46	40	48

Int. = intensive system Ext. = extensive system

(Data for TE 2 not available)

Table V

% of eggs in low pictorial grades

Period		Albumen grades 6 and 7					Yolk grades 4 and 5				
		Pen A	Pen B	Pen C	Pen D	All pens	Pen A	Pen B	Pen C	Pen D	All pens
Nov. 1958	TE 4	16	3	22	—	14	5	8	9	—	7
	6	23	2	7	5	9	18	7	14	4	11
	7	18	2	20	13	13	27	24	12	20	21
	9	11	3	11	6	8	1	3	7	3	3
Feb. 1959	11	23	8	15	9	14	14	2	4	3	6
	13	0	4	4	0	2	2	7	3	3	4
	15	0	1	3	0	1	2	0	1	0	1
	17	4	16	16	18	14	10	7	3	8	7
June 1959	19	1	4	4	2	3	1	1	0	0	1
	21	2	3	10	2	4	1	0	0	0	0
	23	5	7	4	1	4	0	4	0	1	1
Sept. 1959	25	5	11	15	13	11	0	0	3	0	1
Average		9	5	11	6	8	7	5	5	4	5

Table VI

Incidence of meat and blood spots (%)

Period		Pullets		Hens	
		Intensive Pen A	Extensive Pen B	Intensive Pen C	Extensive Pen D
Oct. 1958	TE 1	17	8	10	12
	3	28	29	38	47
	5	29	39	34	—
Jan. 1959	8	36	50	37	50
	10	34	47	37	44
	12	23	30	24	40
	14	37	19	32	36
May 1959	16	27	20	27	22
	18	27	22	31	32
	20	31	20	31	24
	22	20	14	21	27
	24	22	15	37	27
Sept. 1959	26	29	26	29	34
Averages		28	26	30	33

(v) *Colour of yolk and shell*

The observations of yolk and shell colour were converted into numerical values by giving weightings of 5, 4, 3, 2 and 1, respectively, to the descriptions dark, dark-medium, medium,

medium-pale, and pale, adding the score for each pen and expressing the result as a percentage of 5 times the number of eggs examined. Thus the higher the percentage the darker were the yolks or shells as a group. The colour values for yolks and shells are given separately for each pen and period in Table VII.

Table VII

Colour values for yolks and shells

Period		Yolks					Shells				
		Pullets		Hens		All	Pullets		Hens		All
		Int. A	Ext. B	Int. C	Ext. D	birds	Int. A	Ext. B	Int. C	Ext. D	birds
Nov. TE	3	44	51	58	63	56	43	56	63	52	54
1958	5	57	62	54	—	58	43	50	52	—	49
	8	58	62	59	65	60	42	51	53	52	49
Feb.	10	58	61	61	66	62	40	48	40	53	45
1959	12	58	71	66	69	66	38	43	44	52	44
	14	61	56	63	59	60	44	41	51	48	46
	16	58	65	58	68	62	45	40	53	50	47
June	18	59	61	58	61	60	42	37	53	45	47
1959	20	57	59	61	60	59	45	43	54	51	48
	22	58	61	55	63	59	41	31	50	46	42
	24	59	62	57	71	62	42	34	46	46	42
Sept.	26	60	62	59	66	62	52	39	45	47	46
1959 Averages		57	61	59	65	61	43	43	50	49	47

The assessments of colour and pictorial grade are liable to observer bias, and, in the case of colour, an error due to a lack of absolute standards. However, despite these reservations the data for these assessments were useful for comparing effects due to management, season or age of bird.

(vi) *Productivity*

The weekly productivity of each pen was expressed in terms of eggs per hen per day, and the results are illustrated in Fig. 1.

(vii) *Analysis of results*

The data quoted have been examined by appropriate statistical techniques. Chi-squared tests were used to assess the significance of factor effects when the results were in the form of proportional counts, as in the records of meat and blood spots, pictorial grading, colour of yolk and shell, and candling categories. For the yolk index data, since the numbers of eggs contributing to the average values were not constant owing to breakages of the membrane before the measurements were completed, separate estimations have been made of the standard errors for each of the means given in Table I. An analysis of variance was made on the results for percentage thick white from periods TE 14 onwards when the number of eggs per pen per period was constant.

No stress has been laid on those statistically significant differences that are attributable to interactive effects apparently irrelevant to the purposes of the enquiry, such as the difference between yolk index averages in Table I. A difference of 0·01 between any two of these averages is statistically significant in most instances ($P < 0{\cdot}05$), but the pattern of change is complex and only the seasonal trend can be interpreted constructively.

The statistical analyses are not quoted in full but an estimate of significance (probability value) is given, where appropriate, in discussing the effects of the main factors.

Discussion

(a) *General*

This study has reflected the changes in quality of eggs from pullets and hens of one breed under two systems of management throughout a season.

FIG. 1.—*Egg productivity*

× ——— × Pullets on intensive system A
○ ——— ○ „ „ extensive „ B
× - - - - - × Hens „ intensive „ C
○ - - - - - ○ „ „ extensive „ D

An outstanding feature of the results is the difference in the apparent quality when estimated by more than one method of assessment. There were seasonal changes which on the whole were greater than those directly attributable to management, but the pattern of variation was different for the separate assessments. Throughout the year changes in pictorial grading of whites and yolks did not agree with those observed in the quantitative measurements made on these components.

This lack of agreement between different assessments of apparent quality has been noted by other workers. Pennington *et al.*[16] found little difference in the percentage thick white in different candling grades but reported a small progressive decline in yolk index in the lower candling grades. Lorenz *et al.*[17] found that yolk position *per se* was not highly correlated with albumen quality in 24-h.-old eggs. Stewart and co-workers[18] found no correlation between percentage thick white and yolk index, and showed that candlers did not detect changes in quality until considerable deterioration of the thick white and yolk index had occurred. Sauter *et al.*[19] obtained highly significant correlations between albumen index, yolk colour, albumen score and pH, but this was in a comparison between one-day-old and stored eggs.

In this trial the relationship between percentage thick white and yolk index is illustrated in Table VIII which gives the frequencies with which eggs in groups of yolk index values coincided with groups of certain percentages of thick white. There is evidence of the expected general association between yolk index values and the proportion of thick white, but there is nevertheless a number of eggs which have a relatively low yolk index and a high proportion of thick white or a relatively high yolk index and a low proportion of thick white.

Various separate factors contribute to quality in eggs. An ideal egg may be characterised by optimum values for each factor. In practice there is a natural variation in the quality of eggs as laid, and some factors may be nearer to the optimum than others. The relative importance of individual factors varies with the way in which the egg is to be prepared for eating and it is not possible therefore to integrate all factors into an overall index of quality. But

Table VIII

Frequency distribution of eggs by proportion of thick white and yolk index (all pens)

% thick white	Yolk index								Total eggs	Group %
	0·32–0·34	0·34–0·36	0·36–0·38	0·38–0·40	0·40–0·42	0·42–0·44	0·44–0·46	Over 0·46		
10–20%	4	3	6	5					18	0·5
20–30%	10	13	13	26	24	7	4	1	98	2·9
30–40%	16	22	54	69	73	53	19	11	317	9·4
40–50%	13	21	68	114	169	161	90	35	671	19·8
50–60%	8	22	60	149	286	335	225	135	1220	36·1
>60%	1	10	28	118	238	275	227	162	1059	31·3
Total eggs	52	91	229	481	790	831	565	344	3383	
Group %	1·5	2·7	6·8	14·2	23·3	24·6	16·7	10·2		100

eggs may justly be deemed defective if they are noticeably deficient in any one quality important to a consumer. It is of interest to note the proportion of eggs in this study found lacking in any one quality factor. There are no established minimum quality standards for eggs less than one week old, and this study is certainly not comprehensive enough to establish such standards. Nevertheless the authors are of the opinion that of the eggs examined in this investigation about 4% had too little thick white, about 8% were too low in pictorial grade, and about 4% were too low in yolk index, to be considered exempt from serious criticism. Pictorial grading, and measurements of the proportion of thick white and separated yolk index were not done on the same eggs so that the overlap between these grounds for rejection is uncertain. We have no information on the tolerance of British consumers to the presence of meat and blood spots, but it seems reasonable to assume that some customers would object to spots smaller than those identifiable by routine candling. Taking these several points into account we think it fair to conclude that, at a conservative estimate, at least 10% of the eggs examined might reasonably be criticised as being of poor internal quality. Some of the worst of these eggs would no doubt have been rejected by commercial candling had they been passed through the normal marketing avenues to a packing station, but in our opinion the majority would have escaped detection.

It is possible that the results on internal quality may have been affected by the fact that the food given to these birds was a breeders' mixture rather than a laying mixture. If cool storage conditions had been employed from the time of laying until the quality examination was completed it is probable that fewer eggs would have been found lacking in quality.

The system of pictorial grading used can probably be improved. Some American authors[20] have found pictorial grading a useful and time-saving substitute for the measurement of Haugh units and yolk indices. Although the method was rapid it was found that the American standard illustrations used were not wholly suitable to the range of eggs studied. The implied correlation between the condition of the yolks and the whites for the U.S.D.A. charts was not borne out. This may be because the American illustrations were planned to illustrate deterioration on storage or in distribution rather than the natural variation in fresh eggs before deterioration has become a dominant factor.

(b) *Effects of management*

The four pens from which eggs were derived included two systems of management and two age levels of birds. The primary object of the field trial was to obtain data on the effects of management and age of bird on hatchability, and the investigation of the general quality of the eggs was incidental. The more intensive system was expected to give greater productivity, but marked differences in productivity between the two systems of management are only evident in the pens of pullets and only for part of the year (see Fig. 1). The results on quality can be interpreted either in terms of management over the whole year, or more specifically in relation to the period between October and March when the difference in productivity between the two pens of pullets was greatest.

Over the whole year and for all pens the only substantial and continuous difference attributable to management appears to be the colour of the yolk. The yolks from eggs produced under intensive management were paler than their counterparts under extensive management. The difference in colour was statistically significant ($P < 0.001$) but the variation between individual eggs was such that the effect of management was not obvious to the observers during their examination.

If comparisons are limited to the period between November and March, the pictorial grading of albumen and the yolk and shell colours of the eggs from Pen A are consistently different from those of Pen B. The pullets in the extensive system, which were of lower productivity during this period, gave better albumen quality and darker yolks and shells. Subsequently, however, when the difference in productivity became less marked, the pictorial grading of the albumen was sometimes higher for the intensive than the extensive pullets and the shell colour difference was also reversed, but the yolk colour remained darker in the eggs from the extensive pullets. The average percentage thick white, average yolk index and the pictorial values for the yolk were approximately the same for both these pens and were apparently unaffected by productivity. During the period November to March the number of eggs with less than 30% thick white was minimal as shown in Table III. The hens in the intensive system were credited with lower pictorial values than those in the extensive system during the winter months, and produced a greater proportion of eggs having lower percentages of albumen, but the records do not prove any association of this with productivity at this period.

(c) *Effects due to season*

There were significant variations from period to period in all separate assessments of quality but the pattern of change was by no means constant. Effects on quality due to the ageing of the birds, particularly of the pullets, occur concurrently with change of season and can only be differentiated by comparing the results for hens with those for pullets. Differences attributable to ageing, such as weight of egg and the proportions of components, were observed, but are not reported in this paper which is concerned only with quality.

As the measurements of percentage thick white and yolk index occupied a period of 4 days on each occasion, part of the changes recorded are attributable to deterioration during storage at room temperatures, and this varied with the time of year. The shorter process of pictorial grading was less susceptible to this influence.

The average values for percentage thick white and yolk index both follow similar trends over the whole period of the investigation but were not at their maxima at the same time. The proportion of thick white was generally highest in December and subsequently declined to a minimum in July or August, whereas the yolk index showed only minor fluctuations between November and February and then decreased steadily until August. The differences between maximum and minimum average values were quite large, from about 60 to 45% for the proportion of thick white and from about 0·43 to about 0·36 for the yolk index. These differences are probably large enough to be noticed by some consumers.

The period averages for the pictorial grading were erratic. The results for period TE 17 were abnormal for both yolk and albumen. They are of particular interest as a demonstration of the effect on quality of a delay in distribution due to a national holiday, a particularly warm Whit-Monday.

Wolk *et al.*[21] calculated regression equations for the effect of time and temperature on yolk index. From eggs with an initial yolk index of 0·468 (as measured with the yolk standing in the white) they would expect an average yolk index of 0·440 after 7 days at 59° F, 0·403 after 5 days at 77° F and 0·367 after 8 days at 77° F. The average yolk index (measured with yolk separated from white) at period TE 24 in this investigation was 0·36. The temperature of storage was 75–80° F during the 4 days of this examination.

Table IV shows that during the winter a relatively large proportion of eggs, when graded pictorially, had albumen which only justified ' C ' grading according to the American egg chart standards. There was no parallel indication of this in the records of percentage thick white during the winter months although later in the year, in August and September, both the pictorial

grading and the percentage thick white tended to be low. Van Wagenen & Wilgus[22] found no correlation between the observed condition of firm albumen and its relative quantity. On the other hand Brooks & Hale[23] found that as the proportion of thick white decreased from 40 to 20% so did its rigidity, and that the thin white was almost devoid of elastic properties. These apparently conflicting observations may reflect differences between the natural variation in fresh eggs and the deterioration due to storage.

Seasonal variations in the incidence of meat and blood spots is only apparent for the birds in the extensive system, for which higher levels were observed in winter and spring than during the summer or autumn. The proportion of eggs containing spots observed on breaking out appears very high in comparison with normal candling returns but this is not unexpected since many of the spots were small. Other workers have found that from 5 to 15% of spots present are likely to be detected by candling.

(d) *Effect of age of bird*

It is known that as birds mature the weight of their eggs tends to approach a maximum, and that when pullets first come into lay their eggs are slightly different in composition from those laid by older birds. There appears to be little recorded knowledge of differences in quality as distinct from composition. This study does not confirm the findings of Hunter *et al.*[4] concerning the effect of age on the yolk index of eggs from pullets, perhaps because they had begun to lay some 3 months before these trials began. The pullets in the extensive system reached a maximum value for yolk index much earlier than did any of the other flocks.

In this study there is evidence that hens laid eggs with a slightly higher proportion of thick white than did pullets, particularly during the period March to July, and over this period this effect was significant ($P = 0.05$). The mean values from TE 16 to 26 inclusive were 47·7% for pullets and 50·3% for hens. Age of bird does not appear to have influenced the proportion of eggs with a markedly low percentage of thick white. There is however an indication in Table II that the older birds may provide a few more eggs with a very high percentage of thick white. Holst & Almquist[14] showed that the percentage of thick white is a characteristic of individual birds. It is probable that the eggs which appear at the extreme ends of the frequency distribution in Table II may have been due to one or two birds in each pen.

Neither in yolk index nor in pictorial grading did age appear to have any long-standing effect.

It is unfortunate that the hens of Pen D suffered a setback in egg production in November and December. This may have some bearing on the quality of their eggs just before and just after this period, as the percentage of thick white was rather low before laying stopped and was exceptionally high for these birds in January and February when laying was resumed.

Conclusions

This investigation has demonstrated that the two systems of management had little overall effect on quality beyond a slight effect on yolk colour, and a small effect on pictorial grade during the winter. There was a marked difference in the productivity of the pens of pullets during the winter but not of the pens of hens. Information has also been gained on the frequency of occurrence of eggs detectably deficient in quality when less than seven days old and kept at room temperature. The results showed that neither the measurement of the percentage of thick white by weight nor pictorial grading could be used satisfactorily as sole measures of internal quality. Measurement of the proportion of thick white by weight does not indicate the quality of that thick white.

As a measure of consumer reaction to eggs a pictorial grading may prove to be more realistic, but the indexes based on physical measurements are more suitable when the elimination of the subjective element and the reduction of experimental error are important.

Studies by other workers have shown that many characteristics of internal quality are heritable. This study suggests that there may be a need to eliminate from breeding flocks hens which lay eggs of defective quality. Some of the wide variation in quality which was observed in this study might have been restricted by eliminating such birds.

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THE DAMAGE TO WHEAT KERNELS CAUSED BY THE WHEAT BLOSSOM MIDGE (*SITODIPLOSIS MOSELLANA*)

By BYRON S. MILLER* and P. HALTON

Attack by *Sitodiplosis mosellana* decreased germination capacity, bushel weight and flour yield of wheat. The ash of the flour increased slightly and its maltose and colour grade values increased greatly. α-Amylase and protease increased only in proportion to the decrease of kernel weight and was not related to the extremely large increase in number of fungi and bacteria occurring on and in attacked grains.

The water absorption, Extensometer resistance and Extensometer extensibility values all decreased greatly in doughs made from flour milled from attacked grain. The loaves made from such flour were inferior to others in outside colour, nature of the crumb, and loaf volume. Blending the flour milled from attacked grain with flour from a good-quality wheat lowered the bread-making quality of the latter.

Experimental evidence indicated that increased α-amylase and protease activities were not the causes of the poor quality of infested grain, which seem likely to result from the failure of protein to develop properly.

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Introduction

The Wheat Blossom midges, *Contarinia tritici* Kirby and *Sitodiplosis mosellana* Gehin, are important insect pests in the wheat-producing areas of Europe, China and Japan. *S. mosellana* also occurs in certain areas of Canada and the United States of America. Detailed information concerning them recorded by Barnes[1] includes descriptions of the insects and their life history, and discussions on their distribution, diagnostic character, the damage they cause, methods for assessing infestation and damage, how to predict outbreaks, and control measures.

The damage caused by Wheat Blossom midges varies greatly with year and place. The adult insects are short-lived and inconspicuous, and lay their eggs mainly in the evening only during flowering of the wheat, and the larvae leave the grain after causing damage but before harvest, so that farmers are unlikely to be aware of the presence of midges or larvae or the damage they cause.

The egg laying habits of *C. tritici* and *S. mosellana* on wheat plants differ, but if infestation by either species occurs the adults must emerge from their pupae in the soil and oviposit during the time of earburst. Usually the timing of these two conditions is strongly correlated. The female *C. tritici* frequently lays ten or more eggs in a floret, and the resulting larvae consume all of the juices normally used by the developing wheat kernel. As a result, infested kernels do not develop and are not present in the harvested grains. Thus *C. tritici* may reduce the yield, but has little effect on the quality of the wheat harvested. The female *S. mosellana*, however, usually lays a solitary egg and seldom more than four eggs per floret. Only a part of the plant juice is therefore used by the feeding larvae and the infested kernels are shrivelled.[1] Fritzsche & Wolffgang[2] picture the damage sustained by attacked wheat and show shrivelling, the extent of which depends on how many larvae fed on the kernel during its development. They also picture another type of damage, in which kernels appear normal over much of their surface but have sunken or collapsed areas. In our opinion this damage is not caused by *S. mosellana* but rather by the chafing of thrips, which are often found when ears are examined for infestation by the Wheat Blossom midges.

The most damaged kernels are very light in weight and, therefore, are removed during mechanical cleaning of the grain, while those less damaged remain with the ' sound ' grain. The primary result of an attack by *S. mosellana* is to increase the quantity of shrivelled kernels, but there are sometimes secondary effects. The nature of the damage is not fully understood, but some workers think that infestation permits fungi and bacteria to develop. Fritzsche & Wolffgang[2] reported that infestation of wheat with Blossom midges decreases sprouting vigour, germination capacity and speed, and weight of seeds. The baking quality also decreased with increasing infestation. The degree of infestation was correlated positively with ash and gluten content, and negatively with content of starch, crude fibre and reducing sugars and with gluten quality of the seed.

The purpose of this investigation was to obtain further information on the nature of the grain damage caused by *Sitodiplosis mosellana*.

Experimental

Squareheads Master wheat representing the 1958 and 1959 crops was harvested by combine from five Broadbalk plots. Data obtained by examining 50 ears of wheat from each plot showed that the degree of infestation with *S. mosellana* was similar for the two years. On average 6·3% of the kernels were infested with 1·3 larvae in 1958 and 6·4% with 1·3 in 1959. Fig. 1 shows the effect of attack by *S. mosellana*.

The grain from the very wet 1958 harvest was cleaned on the farm and 100 lb. each of sound and of shrivelled grain representing the five plots were dried from the initial 20% to a final 14% moisture content by spreading the samples thinly on paper in a glasshouse. The grain (13% moisture) from the dry 1959 harvest was cleaned on the farm without subsequent drying. All the samples were further cleaned with Kvarnmaskiner laboratory cleaning machinery. The 1958 grain was sieved and sorted into the three samples : (*a*) plump grain hand-picked to remove broken and discoloured kernels and weed seeds ; (*b*) shrivelled grain hand-picked to

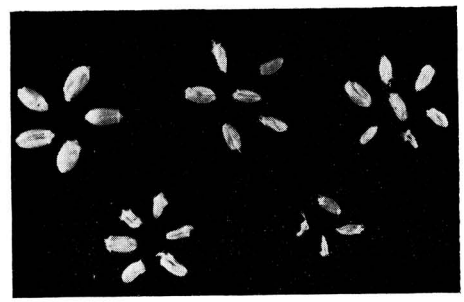

FIG. 1.—*Effect on kernels of attack by* S. mosellana

top left unattacked kernels
,, centre kernels attacked by 1 larva
,, right ,, ,, by 2 larvae
bottom left ,, ,, by 3 ,,
,, right ,, ,, by 4 ,,

remove broken and discoloured kernels ; (*c*) shrivelled grain as it came from the laboratory cleaning machine without subsequent hand picking.

The 1959 grain was separated by hand sieving and sorting into three samples : (*a*) plump grain hand-picked to remove damaged kernels ; (*b*) grain which passed through a 2·75-mm. sieve and over a 2·25-mm. sieve and then hand-picked to leave only shrivelled kernels which, judged from visual appearance, had been attacked and (*c*) grain which passed through a 2·25-mm. sieve and was hand-picked to leave only kernels which had been attacked by *S. mosellana*. All samples were dampened to 15% moisture and milled on a Bühler experimental mill.

The following analyses were made : ash, protein, gas production and maltose by methods of the A.A.C.C. ;[3] moisture by heating the samples overnight at 100° ; colour grade values with the Kent-Jones & Martin Colour Grader ;[4] vitamin B_1 by the method of Ridyard ;[5] mould counts by the method of Barton-Wright[6] except that Difco malt extract was used instead of the Thornton medium ; bacteria counts by the method of Barton-Wright ;[6] α-amylase by the method of Jongh[7] with 0·2% calcium chloride to stabilise the enzyme ; protease by the method of Miller ;[8] water-soluble nitrogen by measuring the amount of nitrogen in a filtered extract of flour ; water absorption from the rate of extrusion of dough after 3 h. fermentation at 80° F ;[9] extensometer curves by the method of Halton[9] for doughs which had been made with predetermined water absorptions and fermented for 3 h.

Doughs for baking were made from 140 g. of flour, 2·0% yeast, 1·5% salt, 2% sugar, 0·3% malt extract, 0·1% ammonium phosphate and various amounts of potassium bromate. All doughs were fermented at 80° F for 2 h., punched, fermented for 1 h., moulded, tinned, proofed at 95° F for 60 min., and baked at 425° F for 24 min. Loaf volumes were measured after 16 h.

Results and discussion

The samples from the dry 1959 harvest were much more suitable for study than were those from the wet 1958 harvest, when many grains germinated before harvest. Nevertheless, results with the two sets of samples (Table I) are similar and are included for comparison.

Analytical data for wheat and flour samples

Table I shows that damage by midge (samples B and C) decreased germination capacity, bushel weight and flour yield, and increased ash and colour-grade value of milled flour. These results confirm those of Fritzsche & Wolffgang.[2] Midge attack increased the protein content in 1958 but not in 1959, which suggests that the effect on protein depends on growing conditions.

The α-amylase values for the 1958 sprout-damaged samples were, as expected, much higher than for the 1959 samples. The most damaged sample for both years, however, contained five times as much α-amylase as the corresponding plump sample. The α-amylase activities of the 1958 samples amounted to 1·6, 3·5 and 7·8 Jongh units, respectively. This is in reverse order of their kernel weights.

The α-amylase and protease activities of immature kernels obtained at the time the *S. mosellana* midges were feeding are shown in Table II. Although the enzyme activities of

Table I

Results of the examination of samples of sound wheat, wheat attacked in the field by Sitodiplosis mosellana *and the flours milled from them*

Harvest year	1958			1959		
Code	A	B	C	A	B	C
Sample	Selected plump kernels	Selected shrivelled kernels	Unselected shrivelled kernels	Selected plump kernels	Selected shrivelled kernels, 2·25–2·75 mm.	Selected shrivelled kernels, under 2·25 mm.
Wheat						
Bushel weight, g./l.	745	646	646	803	745	635
Protein,* %	10·8	12·4	12·0	12·2	12·8	12·5
Flour yield, %	66·8	56·6	57·7	69·8	67·0	57·0
Mould count, thousands of spores/g.	0·5	1·8	21·8	—	—	—
Bacteria count, thousands/g.	437	519	1000	—	—	—
Germination, % in 8 days, room temp.	—	—	—	99	92	—
Flour						
Ash,* %	0·35	0·44	0·60	0·42	0·45	0·46
Colour grade value	6·0	10·0	14·0	4·0	6·5	10·9
Protein,* %	8·8	9·9	9·5	10·6	10·5	10·5
Vitamin B_1, mg./100 g.	0·14	0·19	0·18	—	—	—
Maltose, mg./10 g.	185	223	287	130	210	200
Gas production, mg. Hg at 5 h.	282	342	382	—	—	—
α-Amylase,* Jongh units/g.	1·6	3·5	7·8	0·22	0·67	1·02
Protease, haemoglobin units/g.	4·94	8·30	10·70	1·44	1·98	1·44
Water-soluble N, mg./g. flour	2·10	2·35	2·75	4·8	5·1	5·8
Mould count, thousands of spores/g.	1·7	5	14	<1	28	6
Bacteria count, thousands/g.	34	86	145	2	25	168
Water absorption,* %	48·2	46·2	43·9	49·6	45·0	39·3
Extensometer resistance, R	300	240	200	190	180	140
Extensometer extensibility, E	21	22	17	26	20	11
R × E/100	63	53	34	49	36	15

* 14% flour moisture basis

Table II

Enzyme activities of immature kernels when the S. mosellana *midges were feeding*

Sample	No. of damaged grains analysed	Wt. of grain analysed, g.	α-Amylase activity, Jongh units/g.	Protease activity, haemoglobin units/g.
Attacked kernels	30	0·131	—	130
Plump kernels	30	0·900	—	28
Attacked kernels	150	1·65	44·0	—
Plump kernels	150	4·08	22·6	—

attacked immature kernels are higher than for plump immature kernels when expressed on a weight basis, they are similar on the basis of an equivalent number of kernels. The generally high level in all of the samples is to be expected because protease and α-amylase activity is high in immature wheat and decreases to a minimum at maturation of the grain.

The 1959 samples had approximately 1/4 the protease activities of the 1958 samples. The differences between the protease activities in mature plump and mature shrivelled samples, however, were no more than would be expected for unattacked mature samples with comparable physical characteristics and would not cause the differences in Extensometer readings shown in Table I. The larvae themselves contributed little to the protease activity of the attacked kernels, because the protease activities in macerated *C. tritici* and *S. mosellana* larvae were negligible (see below).

The big differences in maltose values for the 1958 samples might be explained by a concentration of sprouted kernels in the shrivelled samples. In the 1959 samples there was a similar large difference in maltose values among the flour samples, but little or none of the wheat had sprouted as reflected by the general low level of both maltose and α-amylase values. The

vitamin B_1 content was the same for samples B and C grown in 1958 so the higher maltose values of the attacked samples were not due to germinated wheat or because they contained more of the aleurone layer. Furthermore, the method of Jongh[7] showed that the macerated young feeding larvae of *C. tritici* or *S. mosellana* contained little α-amylase. Macerated larvae of *C. tritici* (1032 at 0·28 mg. each) contained only 0·46 Jongh units/g. and of *S. mosellana* (210 at 0·43 mg. each) contained 2·68 Jongh units/g. of α-amylase activity.

The shrivelled samples contained some discoloured kernels, so moulds and bacteria were counted on all samples. The shrivelled grains contained many more organisms than the plump kernels, which suggested that the inferior quality of the damaged kernels might be caused by enzymes elaborated by the moulds or bacteria. Results obtained by the method of Knight[10] for distinguishing between fungal and cereal amylase did not confirm the presence of a significant amount of fungal amylase in the flour, however, and those obtained by a method adapted from the work of Miller *et al.*[11] revealed neither bacterial nor fungal α-amylase. It must be concluded, therefore, that the presence of fungi and bacteria was merely incidental to the real damage caused by attack by *S. mosellana*.

Measurement of gas production indicated that the sample contained nothing that inhibits the action of yeast.

Physical properties of doughs and breadmaking quality of the samples

The stretching behaviour of the doughs, their Extensometer curves (Figs. 2 and 3) and values (Table I) revealed differences between the flours milled from sound and attacked wheat

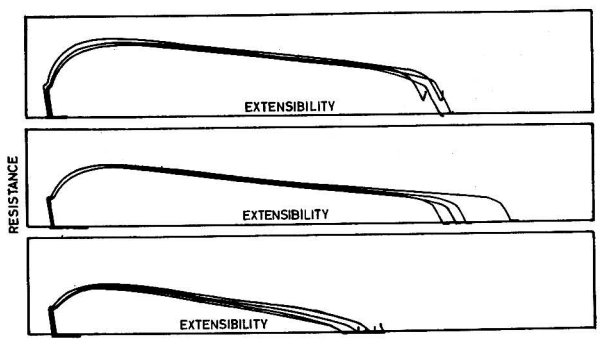

FIG. 2

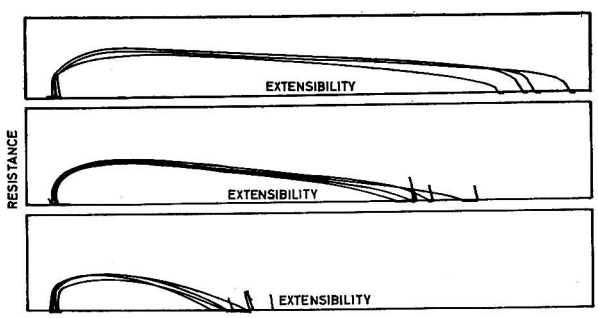

FIG. 3

Extensometer curves for (FIG. 2) 1958 *flours*, (FIG. 3) 1959 *flours*
top sample A middle sample B bottom sample C

such as could have resulted from excess proteolytic activity. The decrease in water absorption (Table I) could also have resulted from high enzyme activity. However, differences in dough properties probably had other causes because the enzyme activities of the flours were not high (Table I) and, of even more significance, the pattern of the Extensometer curves for the 1959 and the 1958 samples were similar despite the much lower level of enzyme activity in the former.

The loaves shown in Figs. 4 and 5 show the outsides and crumbs of the loaves baked from the 1958 flours and, for comparison, from flour milled from Svenno wheat, one of the better breadmaking varieties grown in England.

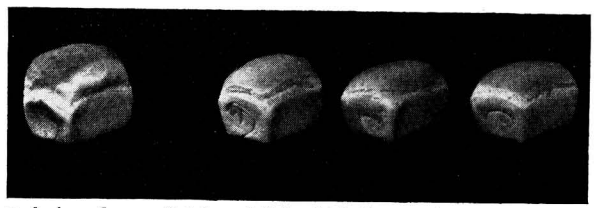

FIG. 4.—*Loaves made from flours milled from* (left to right) *Svenno wheat and from the Squarehead master samples A, B and C harvested in* 1958

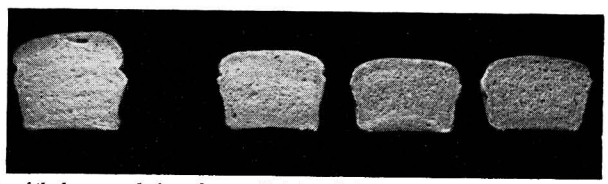

FIG. 5.—*Crumbs of the loaves made from flours milled from* (left to right) *Svenno wheat and from the Squarehead master samples A, B and C harvested in* 1958

The volumes (c.c.) of the loaves baked with the addition of 10 p.p.m. of potassium bromate, the quantity found to be optimum from a preliminary bake, were:

Svenno	A	B	C
760	615	565	560

The loaf made from the C flours had the darkest exterior, smoothest sides and sharpest edges. Its crumb was the darkest, most open in grain, coarsest and firmest.

Blends of the Svenno flour with the A, B and C flours in the ratios 1 : 4 and 1 : 2 were also baked. The loaves from the Svenno–A blends were the best and those from the Svenno–C blends the poorest. The same trends in colour and crumb structure were apparent, although to a lesser degree, as when the A, B and C flours were baked by themselves.

The loaves shown in Figs. 6 and 7 were baked from the 1959 A and B flours. There was insufficient of C for baking tests.

The loaf volumes (c.c.) were:

	A	B
With 0 p.p.m. bromate	555	530
,, 10 ,, ,,	645	580
,, 20 ,, ,,	710	590

The differences were similar to those found between the loaves baked from the 1958 flours. The B loaves were the smaller, poorer in colour and inferior in outside appearance and in crumb quality.

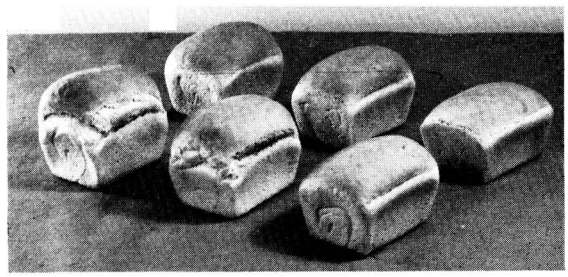

FIG. 6.—*Loaves baked from the Squarehead master samples A and B harvested in* 1959
Front row (right to left) sample A baked with 0, 10 and 20 p.p.m. bromate
Back row (right to left) sample B baked with 0, 10 and 20 p.p.m. bromate

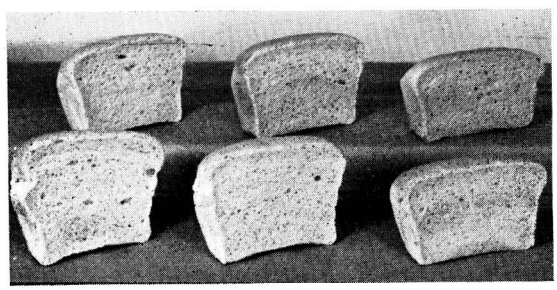

FIG. 7.—*Crumbs of loaves baked from the Squarehead master samples A and B harvested in* 1959
Front row (right to left) sample A baked with 0, 10 and 20 p.p.m. bromate
Back row right to left) sample B baked with 0, 10 and 20 p.p.m. bromate

Conclusions

It is difficult to evaluate accurately the inherent baking properties of flour when the protein contents are as low as those for the samples tested. Nevertheless, it is clear from the analytical data, baking scores and load-extension curves for doughs, that the quality of the attacked samples was inferior to that of the unattacked samples. The poor quality seemed to correlate positively with degree of insect attack as evidenced by the degree of shrivelling of the attacked kernels. The fact that Extensometer and baking tests showed similar differences between the sound and the attacked wheat flours in the 1959 as in the 1958 samples, despite the much lower enzyme activity of the former, is strong evidence that increased enzyme activity does not cause the deterioration produced by insect attack.

The damage to wheat by *S. mosellana* may be associated with the immaturity of attacked grains. This is indicated in part by an increase in soluble proteins in flour from attacked wheat, but particularly by the nature of the Extensometer curves for the damaged flour. That attacked grains should be inferior is not surprising because the larvae feed on the plant juice which would otherwise be used to develop the grains fully.

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EFFECTS OF SALT AND OTHER FERTILISERS ON YIELD AND MINERAL COMPOSITION OF FORAGE CROPS. III.*—Herbage

By R. G. HEMINGWAY†

Salt did not increase the yields of herbage in four experiments, two of which were responsive to muriate of potash. There were, however, consistent negative interactions between salt and potash. Salt in finely powdered form may scorch clover severely if applied in dry weather. Salt and ammonium sulphate, providing the nitrogen, increased yields, greatly increased sodium contents of both grass and clover, whilst muriate of potash markedly depressed sodium contents. Salt did not alter the potassium concentrations in either grass or clover but muriate of potash had consistently large incremental effects. Repeated application of ammonium sulphate reduced potassium concentrations. Fertilisers did not in any way alter calcium contents of either grass or clover and, apart from superphosphate, there were no effects on phosphorus concentrations.

Three cwt. of ammonium sulphate increased the percentage concentration of magnesium by an average of 14% for grass and 4% for clover, while 2 cwt. of muriate of potash or 4 cwt. of salt depressed the grass and clover magnesium contents by 7·5% and 4% respectively. Much the greatest reductions in herbage magnesium due to muriate of potash were in the late-season samples. A small dressing of magnesium sulphate increased herbage magnesium in one of two experiments.

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Introduction

Salt has been used for many years on grass by some farmers in those areas adjacent to the sources of production in Cheshire and Staffordshire. In addition to the possible effects on yield it is reported to preserve the freshness of the vegetation in dry weather and to increase the palatability of older and coarser material. There have, however, been no recorded experiments in this country to assess the effect of sodium chloride on either the yield or mineral composition of herbage and its interactions with other nutrients. There is an equal lack of information on the factors which control the amount of sodium in herbage.

Lynch,[1a] Bell[1b] and During[1c] have all indicated that in New Zealand there may be useful responses to salt, more particularly under conditions of potassium deficiency. Frequently there was more uniform and closer grazing and better development of wild white clover. Potassium uptake was frequently increased by applications of salt. Gammon[2] found in pot experiments that pangola grass (which has a high potassium requirement) could have two-thirds of this need replaced by sodium without loss of crop, but that other grasses with a lower demand for potassium did not respond nearly so well to salt.

Many workers (e.g. [3, 4]) have reported favourably on the effects of salt on cereal crops such as oats, barley and wheat, while others[5] have obtained increases in yield of clover from applications of sodium. Lucerne was found to respond by Wallace *et al.*,[6] York *et al.*[7] and Truog *et al.*[4] Pizer[8] reported that ryegrass, rye and barley are amongst those crops with the highest degree of resistance to the adverse effects of flooding by sea water. On the other hand, red and white clovers, wheat and timothy are very susceptible to damage whilst oats and lucerne are intermediate in sensitivity.

It would thus appear that there are reasonable grounds for supposing that herbage might respond to application of sodium chloride. This present paper describes the effects of salt and other fertilisers on the yield and mineral composition of herbage cut several times during a single grazing season. A further communication will describe the effects over a longer period when soil potassium is reduced to very low levels by the continued removal of herbage.

Experimental

Two field experiments were carried out in 1956 (Expts. 1 and 2) and a further two in 1957 (Expts. 3 and 4). In the 1956 experiments there were four treatments, the layout being a 2^4 factorial arrangement of four blocks of eight plots each, the four-factor interaction being confounded between each of the two complete replicates. The fertiliser dressings were 0 and 3 cwt. of ammonium sulphate, 0 and 3 cwt. of superphosphate, 0 and 2 cwt. of muriate of potash, and 0 and 4 cwt. of sodium chloride. These dressings were applied at the end of February. It had been intended to top-dress the nitrogen-treated plots with further quantities of ammonium sulphate after each cut, but as both the nitrogen and salt had such adverse effects on clover growth, it was subsequently decided not to do so.

In 1957, a further treatment of 2 cwt. of magnesium sulphate ($MgSO_4,7H_2O$, equivalent to 22·5 lb. of Mg) was introduced and in consequence the layouts of Expts. 3 and 4 were 2^5 factorials of 32 plots arranged in four blocks of eight plots with one four-factor and two of the three-factor interactions confounded between blocks. In 1957 also, 3 cwt. of ammonium sulphate was applied for each of the cuts taken, the initial nitrogen treatment and all the other fertilisers being given at the end of February.

Sward composition

The treatments were applied to herbage which had been undersown the previous year with a basal NPK fertiliser. In Expts. 2 and 4 there was a complete absence of clover, the herbage being predominantly a ryegrass/cocksfoot mixture. In Expts. 1 and 3 there were initially good clover contents combined with ryegrass and cocksfoot. Red clover predominated in the first cuts, but white clover was subsequently of greater importance. The weed content at each site was negligible.

Plot size, harvesting and sampling

The plots were each of 0·005 acre, being 4 ft. wide and 54 ft. long. The herbage was cut, generally at the silage stage, by means of an Allen Autoscythe, having a 3 ft. cut. Samples

were taken by bulking 25 handfuls of herbage obtained at random from the full length of each plot. These were divided by hand in the laboratory into grass and clover for separate determinations of dry matter and chemical analyses. The respective yields of dry matter of grass and clover can thus be calculated from the total fresh weight of each plot.

Soil analyses

Table I details the soil analyses. In each case the soils were heavy loams and in Expts. 2 and 4 the sites were poorly drained. Two of the sites (Expts. 1 and 3) could be described as satisfactory with regard to readily soluble phosphorus and potassium, but the other two (Expts. 2 and 4) with no clover were low in both respects.

Table I

Soil analyses

Expt. no.	pH	1% citric soluble (mg.-%) Phosphorus	Potassium
1	6·5	12·5 (satisfactory)	12·5 (satisfactory)
2	6·4	7·5 (low)	8·0 (low)
3	6·8	13·0 (satisfactory)	12·5 (satisfactory)
4	5·7	7·0 (low)	9·5 (low)

Sampling dates

Table II summarises the times of sampling and the growth stages. In Expts. 1 and 2, Sample A in each case refers to a sample of herbage collected by hand at the grazing stage in advance of Sample B which represents the first cut at the silage stage when the same grass was more mature. In Expts. 2 and 4 on the poor soils with swards containing no clover, it was not possible to take samples after the end of August as there was no further growth.

Herbage analyses

The dried samples of grass and clover were analysed for sodium, potassium, calcium, magnesium and phosphorus by the rapid scheme of analysis described in Part I.[9]

Table II

Sampling dates and growth stages

Sample	Experiment 1 1956		Experiment 2 1956		Experiment 3 1957		Experiment 4 1957	
A	May 5	No yield data Grazing stage	May 10	No yield data Grazing stage	June 3	First cut Early hay stage	May 30	First cut Early hay stage
B	May 30	First cut Silage stage	June 2	First cut Silage stage	July 16	Second cut Silage stage	July 20	Second cut Silage stage
C	July 21	Second cut Silage stage	Aug. 24	Second cut Silage stage	Aug. 18	Third cut Silage stage	Aug. 23	Third cut Grazing stage
D	Aug. 21	Third cut Silage stage		— No further growth	Sept. 24	Fourth cut Grazing stage		— No further growth

Results

The mean effects of the fertiliser treatments on yield and mineral composition are given in Tables III–VIII. Only those interactions which were consistent or of significance have been tabulated, the remainder being both small and irregular.

Yields (Table III)

Salt increased the yield of grass in Expts. 2 and 4, but by very small amounts. These swards contained no clover and both gave significant increases in yield to muriate of potash.

In Expt. 1 the clover was severely scorched by the salt and the yield of total dry matter suffered in consequence. Other observations have shown that this is frequently the case when fine, crystalline salt is used, but the risk may well be less if it were included in a granulated compound. In this particular case, no rain fell for several days after the salt application, but in Expt. 3 it was spread by hand during wet weather and there was no attendant scorch. Apart from this, salt had little effect on yield in Expts. 1 and 3 where there were no responses to muriate of potash. Of the 19 possible interactions between salt and potash 16 were negative, indicating the possibility of similar function for the plant. Expt. 3 has been continued over a period of 3 years in order to allow potassium deficiency to become seriously acute. Results (to be published) indicate that even under these conditions, the responses to salt do not increase as the capacity of the soil to supply potassium progressively falls.

Ammonium sulphate consistently increased yields by large amounts. The effect was a net one in that clover was consistently depressed and the grass increased. In the first two experiments where there was only one application of ammonium sulphate, there was little residual effect on total yield after the first cut.

Superphosphate did not materially influence the yields although the soils were generally not well supplied with readily soluble phosphorus.

Muriate of potash significantly increased yields in Expts. 2 and 4 where the soils were low in readily soluble potassium. The tendency to depress the clover yield in Expt. 1 can be attributed to some leaf scorch occurring at the time of application. The small significant yield increment in the last cut of Expt. 3 is a reflection of the drain in soil-potassium caused by frequent cutting and by repeated nitrogen application.

Magnesium sulphate in the two experiments where it was used had little effect on yield.

Plant composition

(1) *Sodium* (Table IV).—A feature of these experiments and those reported earlier[9, 10] for turnips and kale has been the very great variability in the sodium contents. Salt and ammonium sulphate have increased the % concentrations of sodium in all experiments whereas muriate of potash has depressed them. Table IV details the main effects of the fertilisers on sodium contents, but does not fully reflect the large differences between individual plots. In all four experiments the minimum values found (i.e., on the treated plots with muriate of potash) were in the order of 0·015—0·030% Na. The highest concentrations ranged from 0·75–1·00% Na, and were associated with the salt plus ammonium sulphate treatments. In Expts. 1 and 2 which had a single spring application of ammonium sulphate, the mean sodium concentrations fell after the first two cuts, but in Expts. 3 and 4, with repeated nitrogen applications, the % Na in the grass continued to increase with each sampling throughout the season.

Salt itself had large and significant incremental effects on sodium uptake in both grass and clover. In virtually every sampling the increases reached significance at the 1% level and were generally at least 50% of the respective overall means. Its influence tended to be reduced at the later samplings.

Ammonium sulphate also had significant stimulating effects on sodium uptake and frequently it raised levels to a greater degree than did salt. There was no effect on the sodium content of the clover in Expt. 1, and in Expt. 3 the clover was influenced proportionately less than the grass. It seems clear that this effect of ammonium sulphate on sodium uptake is in some way connected with its growth-promoting properties. In Expts. 1 and 2 where the nitrogen was no longer affecting growth after Sample B, the effects on the sodium contents of subsequent samples were very small. On the other hand, in Expts. 3 and 4, with repeated nitrogen applications after each cut, the increases in sodium uptake continued on an expanding scale over the whole season. Entirely comparable results have been obtained with kale[10] and it must be concluded that growth stimulation with nitrogen will very frequently increase sodium uptake, and that to a marked degree.

Muriate of potash very significantly reduced sodium uptake in all experiments and at each sampling. There were also consistent and significant negative NK interactions whereby potassium exerted its greatest influence in the presence of added nitrogen. Broadly speaking, the opposing effects of salt or ammonium sulphate on the one hand, and of muriate of potash on

Table III

Dry matter yields (cwt.)

Sample			Experiment 1			Experiment 2		Experiment 3				Experiment 4		
Cut			B 1	C 2	D 3	B 1	C 2	A 1	B 2	C 3	D 4	A 1	B 2	C 3
Mean yield		Grass	16·41	15·00	8·21	16·91	7·98	27·84	8·53	10·58	5·29	12·11	10·23	8·68
		Clover	5·23	8·24	6·34	—	—	4·31	3·97	3·46	0·80	—	—	—
Response to Salt	4 cwt.	Grass	0·54	0·19	0·25	1·39	0·46*	−1·16	−0·01	−0·16	−0·09	−0·08	1·24*	0·38
		Clover	−2·26*	−2·36*	−2·55*	—	—	−0·70	−0·15	−0·11	−0·04	—	—	—
Muriate of potash	2 cwt.	Grass	−0·15	−0·12	0·22	2·18*	0·37*	−0·14	−0·04	0·73	0·51*	1·00	2·08**	3·28**
		Clover	−1·22	−1·04	0·10	—	—	0·16	−0·24	0·18	0·20*	—	—	—
Superphosphate	3 cwt.	Grass	0·76	0·54	0·20	0·49	−0·26	1·36	−0·09	0·66	0·07	0·05	0·81	0·34
		Clover	0·44	0·68	0·70	—	—	0·24	−0·06	−0·06	0·02	—	—	—
Ammonium sulphate†	3 cwt.	Grass	14·50**	7·84**	1·20	7·84**	0·09	15·08**	9·17**	11·86**	4·08**	15·39**	9·95**	6·00**
		Clover	−2·58*	−6·51*	−4·40*	—	—	−2·14**	−4·48**	−4·89**	−1·08**	—	—	—
Magnesium sulphate	2 cwt.	Grass	—	—	—	—	—	−0·76	−0·19	0·46	0·08	0·70	0·06	0·52*
		Clover	—	—	—	—	—	−0·06	0·38	0·21	−0·01	—	—	—
Standard error±		Grass	0·96	0·87	0·60	0·79	0·17	1·34	0·45	0·63	0·25	0·73	0·45	0·20
		Clover	0·91	1·08	0·90	—	—	0·34	0·28	0·22	0·07	—	—	—
Consistent interactions K/salt		Grass	−0·98	−0·18	−0·22	−0·94	−0·24	−0·66	0·14	−0·98	−0·72*	−0·25	−1·42**	−0·72*
		Clover	−0·92	−1·21	−0·98	—	—	−0·24	−0·03	0·26	0·06	—	—	—
Standard error±		Grass	1·29	1·24	0·85	1·11	0·24	1·89	0·64	0·89	0·36	1·03	0·63	0·28
		Clover	1·28	1·53	1·28	—	—	0·48	0·40	0·31	0·10	—	—	—

† 3 cwt. for each cut in Expts. 3 and

Table IV

% sodium in dry matter

Sample			Experiment 1				Experiment 2			Experiment 3				Experiment 4		
			A	B	C	D	A	B		A	B	C	D	A	B	
Mean % Na		Grass	0·266	0·177	0·076	0·062	0·290	0·217	0·073	0·144	0·224	0·371	0·446	0·181	0·182	0·252
		Clover	0·101	0·064	0·093	0·092	—	—	—	0·273	0·265	0·231	0·248	—	—	—
Response to Salt	4 cwt.	Grass	0·167**	0·134**	0·053**	0·022*	0·132**	0·116**	0·020	0·070**	0·105**	0·136**	0·035	0·083**	0·027	0·041*
		Clover	0·102**	0·069**	0·083**	0·033**	—	—	—	0·196**	0·108**	0·112**	0·088**	—	—	—
Muriate of potash	2 cwt.	Grass	−0·105**	−0·075**	−0·040**	−0·047**	−0·143**	−0·091**	−0·054**	−0·062**	−0·097**	−0·163**	−0·158**	−0·159**	−0·090**	−0·217**
		Clover	−0·017	−0·019**	−0·059*	−0·056**	—	—	—	−0·029	−0·082**	−0·094**	−0·114**	—	—	—
Superphosphate	3 cwt.	Grass	−0·055*	−0·046	−0·017	0·003	0·023	−0·009	−0·001	−0·005	−0·021	−0·016	−0·039	0·015	0·028	0·034
		Clover	−0·005	−0·009	−0·029	−0·022*	—	—	—	0·004	0·002	0·024	−0·010	—	—	—
Ammonium sulphate†	3 cwt.	Grass	0·148**	0·179**	0·039**	0·006	0·268**	0·239**	0·035*	0·087**	0·248**	0·432**	0·392**	0·146**	0·257**	0·352**
		Clover	−0·030	−0·007	0·030	0·000	—	—	—	0·065*	0·066**	0·111**	0·088**	—	—	—
Magnesium sulphate	2 cwt.	Grass	—	—	—	—	—	—	—	−0·006	−0·042*	−0·050	−0·068*	0·007	0·009	−0·001
		Clover	—	—	—	—	—	—	—	−0·012	−0·027	−0·013	−0·027	—	—	—
Standard error±		Grass	0·024	0·023	0·006	0·008	0·027	0·018	0·013	0·018	0·019	0·034	0·029	0·009	0·017	0·016
		Clover	0·018	0·005	0·020	0·010	—	—	—	0·024	0·015	0·021	0·018	—	—	—
Consistent interaction NK		Grass	−0·106**	−0·048*	−0·025*	−0·007	−0·101**	−0·045*	−0·028	0·000	−0·058**	−0·077*	−0·118**	−0·089**	−0·069**	−0·179**
		Clover	−0·013	−0·015	−0·037	−0·033**	—	—	—	0·026	0·018	−0·009	−0·003	—	—	—
Standard error±		Grass	0·034	0·032	0·008	0·011	0·038	0·026	0·019	0·025	0·027	0·048	0·041	0·013	0·024	0·023
		Clover	0·026	0·008	0·029	0·012	—	—	—	0·034	0·021	0·028	0·025	—	—	—

† 3 cwt. for each cut in Expts. 3 and 4

the other, are about equal. Use of nitrogen and potassium fertilisers together, therefore, should have no serious effect on normal sodium uptake, but heavy application of either of them alone can lead to very substantial changes in sodium content.

Superphosphate had no effect on the sodium content of either grass or clover, but in none of the experiments did it affect the yield of herbage. The small application of magnesium sulphate tended to reduce the sodium concentrations in Expt. 3.

(2) *Potassium* (Table V).—Salt had no detectable effect on potassium uptake by either grass or clover. Apart from small increases in Expt. 1, superphosphate also had no influence on potassium levels.

Muriate of potash consistently and significantly increased the potassium contents of both grass and clover and at all cuts by amounts ranging from 0·20 to 0·55% K.

Ammonium sulphate tended to increase potassium uptake during the early part of the season but thereafter caused marked depressions in both grass and clover, particularly in Expts. 1 and 3. This is associated with the effects on yield and the consequent increased depletion of soil potassium. By the time of the fourth sampling in Expt. 3, the herbage on the nitrogen-treated plots receiving no potassium was showing some symptoms of potassium deficiency. There were frequent and significant positive NK interactions.

The small dressing of magnesium sulphate did not alter potassium uptake.

(3) *Calcium* (Table VI).—Fertilisers have had remarkably little influence on the uptake of calcium by either grass or clover. In the great majority of cases the mean differences were under $\pm$0·05% Ca. The large changes which salt and muriate of potash bring about in the % Na and % K are not reflected in any compensating change in the calcium contents.

The most important factor involved in the assessment of fertiliser treatment on herbage calcium is therefore that involving a change in grass/clover ratio. Whilst fertilisers have only small effects on individual plants, any increase or reduction in clover will manifestly be the determining factor.

(4) *Magnesium* (Table VII).—In each of the experiments there has been a tendency for the magnesium content of the grass to increase at each sampling throughout the season. This was most marked in Expt. 3 where the initial concentration was doubled. On the other hand, the content in the clover showed a tendency to fall. Clover generally contained about twice as much magnesium as did grass, but it should be remembered that the yield of clover dry matter, especially in the early season, was small relative to that of the grass (Table III). In contrast to these species differences and the seasonal changes, the effects of fertilisers at the rates used have been rather small.

Salt and muriate of potash have both consistently reduced the % Mg in grass and clover alike by amounts which frequently reached significance. In most cases the reductions were in the order of 0·010% Mg or less, but in Expt. 3 depressions of 0·020% Mg were generally found. It would be reasonable to suppose that 0·5 or 1·0 cwt. of muriate of potash which are more typical rates of application under farm conditions than the 2 cwt. used here, would have correspondingly smaller effects. The K/salt interactions were always positive, indicating that their separate effects are more than additive. There is a very marked tendency for the depressive effects of salt and muriate of potash to be much greater for both grass and clover during the later part of the season. Indeed, these experiments would appear to indicate that there has been no appreciable reduction in herbage magnesium at the first sampling. Expt. 3 has been continued for a further 2 years with the same annual fertiliser treatments. In both years, 2 cwt. of muriate of potash applied in late February reduced magnesium concentrations in grass and clover to a considerably greater degree at the time of the fourth cut in September than at the first cut in late May. Other more recent experiments have also shown only very small depressive effects from an early March application of 2 cwt. of muriate of potash on the magnesium concentrations in herbage over a period of grazing in May. These observations do not agree with the often quoted opinions on the alleged detrimental effects of spring potash applications on the uptake of magnesium by herbage and the incidence of hypomagnesaemia.

Ammonium sulphate invariably increased the magnesium contents of both grass and clover. In Expts. 1 and 2 these reached significance ($P = 0·01$) at around 0·030% Mg at the first sampling, but in Expts. 3 and 4 the greatest effects were in the later cuts. This may be due

Table V

% potassium in dry matter

Sample			Experiment 1 A	Experiment 1 B	Experiment 1 C	Experiment 1 D	Experiment 2 A	Experiment 2 B	Experiment 2 C	Experiment 3 A	Experiment 3 B	Experiment 3 C	Experiment 3 D	Experiment 4 A	Experiment 4 B	Experiment 4 C
Mean % K		Grass	3·36	2·25	1·87	2·40	2·23	1·55	1·76	1·63	1·96	2·43	2·09	1·09	1·05	1·03
		Clover	3·12	2·85	1·90	1·86	—	—	—	1·85	1·65	1·86	1·55	—	—	—
Response to Salt	4 cwt.	Grass	0·13	0·11	−0·11*	−0·02	0·12	0·00	−0·08	0·01	0·02	−0·04	−0·04	−0·01	0·03	0·06
		Clover	0·10	−0·38*	−0·16	0·17	—	—	—	0·06	0·02	0·05	0·01	—	—	—
Muriate of potash	2 cwt.	Grass	0·48**	0·40**	0·20**	0·29**	0·58**	0·33*	0·21*	0·24**	0·24**	0·59**	0·53**	0·44**	0·38**	0·41**
		Clover	0·37**	0·51**	0·33**	0·42**	—	—	—	0·53**	0·44**	0·55**	0·47**	—	—	—
Superphosphate	3 cwt.	Grass	0·30*	0·19*	0·06	0·05	−0·01	0·02	0·05	−0·13	−0·03	0·04	−0·11	−0·06	−0·02	−0·03
		Clover	0·27**	0·24	0·32**	0·14	—	—	—	−0·05	−0·05	0·01	0·00	—	—	—
Ammonium sulphate†	3 cwt.	Grass	0·74**	0·22*	−0·46**	−0·28**	0·33	0·17	−0·15	0·06	−0·15*	−0·75**	−0·71**	−0·09*	0·04	0·00
		Clover	0·19	−0·13	−0·22*	−0·25**	—	—	—	0·08	−0·05	−0·22**	−0·26*	—	—	—
Magnesium sulphate	3 cwt.	Grass	—	—	—	—	—	—	—	−0·01	0·05	−0·04	0·09	0·03	0·06	−0·01
		Clover	—	—	—	—	—	—	—	−0·07	0·11	0·08	0·11	—	—	—
Standard error±		Grass	0·07	0·08	0·05	0·08	0·16	0·12	0·08	0·06	0·06	0·10	0·08	0·03	0·03	0·05
		Clover	0·06	0·13	0·08	0·07	—	—	—	0·07	0·07	0·07	0·07	—	—	—
Consistent interactions K/salt		Grass	−0·42**	−0·25**	−0·09	−0·09	−0·23	−0·24	−0·12	−0·07	−0·13*	−0·01	0·10	−0·03	−0·03	−0·14**
		Clover	−0·30**	−0·30**	−0·07	0·17*	—	—	—	0·00	−0·10	0·11	−0·03	—	—	—
NK		Grass	0·51**	0·52**	0·21**	0·26**	0·38*	0·09	0·15	0·06	0·21**	0·13	0·09	0·22**	0·18**	0·11**
		Clover	0·25**	0·30**	0·03	0·20*	—	—	—	−0·14	−0·03	0·00	−0·09	—	—	—
Standard error±		Grass	0·09	0·11	0·07	0·12	0·23	0·17	0·11	0·08	0·08	0·14	0·12	0·04	0·05	0·07
		Clover	0·08	0·19	0·12	0·10	—	—	—	0·10	0·10	0·10	0·10	—	—	—

† 3 cwt. for each cut in Expts. 3 and 4

Table VI

% calcium in dry matter

Sample			Experiment 1 A	Experiment 1 B	Experiment 1 C	Experiment 1 D	Experiment 2 A	Experiment 2 B	Experiment 2 C	Experiment 3 A	Experiment 3 B	Experiment 3 C	Experiment 3 D	Experiment 4 A	Experiment 4 B	Experiment 4 C
Mean % Ca		Grass	0·63	0·51	0·49	0·57	0·42	0·33	0·41	0·45	0·63	0·69	0·74	0·36	0·46	0·62
		Clover	2·03	1·82	1·85	2·19	—	—	—	2·03	1·70	1·85	1·83	—	—	—
Response to Salt	4 cwt.	Grass	−0·05**	−0·01	0·00	0·0	−0·02	−0·02	−0·05**	−0·01	0·04	0·00	−0·04	−0·04**	−0·05*	0·01
		Clover	−0·06	−0·04	0·06	0·08*	—	—	—	−0·12	−0·06	−0·01	0·03	—	—	—
Muriate of potash	2 cwt.	Grass	−0·03*	−0·02	−0·03	−0·01	0·00	0·01	−0·03	−0·02	0·03	−0·04	0·00	−0·01	0·01	−0·01
		Clover	−0·06	0·00	0·06	−0·03	—	—	—	0·01	0·01	−0·06	−0·07	—	—	—
Superphosphate	3 cwt.	Grass	0·02	0·00	−0·01	0·00	0·03	0·02	0·02	−0·01	−0·02	0·02	0·01	0·01	0·01	0·02
		Clover	−0·02	−0·01	0·01	0·06	—	—	—	−0·02	0·00	0·04	−0·05	—	—	—
Ammonium sulphate†	3 cwt.	Grass	−0·02	0·01	−0·02	−0·02	0·03	0·05*	−0·04*	0·04*	0·03	0·00	0·08**	0·01	0·01	0·02
		Clover	−0·22*	−0·34*	0·07	0·13**	—	—	—	−0·14	−0·03	−0·02	0·04	—	—	—
Magnesium sulphate	2 cwt.	Grass	—	—	—	—	—	—	—	−0·02	−0·07**	−0·04	−0·01	0·00	0·01	0·00
		Clover	—	—	—	—	—	—	—	0·00	0·00	0·05	−0·01	—	—	—
Standard error±		Grass	0·01	0·01	0·03	0·02	0·02	0·02	0·02	0·02	0·02	0·03	0·02	0·01	0·02	0·01
		Clover	0·04	0·06	0·04	0·03	—	—	—	0·07	0·04	0·03	0·06	—	—	—

† 3 cwt. for each cut in Expts. 3 and 4

Table VII

% magnesium in dry matter

Sample			Experiment 1 A	Experiment 1 B	Experiment 1 C	Experiment 1 D	Experiment 2 A	Experiment 2 B	Experiment 2 C	Experiment 3 A	Experiment 3 B	Experiment 3 C	Experiment 3 D	Experiment 4 A	Experiment 4 B	Experiment 4 C
Mean % Mg		Grass	0·115	0·092	0·097	0·129	0·095	0·078	0·105	0·090	0·134	0·180	0·177	0·091	0·119	0·135
		Clover	0·260	0·227	0·229	0·218	—	—	—	0·221	0·229	0·259	0·207	—	—	—
Response to Salt	4 cwt.	Grass	−0·003	0·001	−0·008*	−0·017*	−0·006	−0·009	−0·013**	−0·006	−0·005	−0·005	−0·013*	−0·003	−0·013*	−0·026*
		Clover	−0·028*	−0·006	0·003	−0·005	—	—	—	−0·007	−0·012*	0·003	−0·001	—	—	—
Muriate of potash	2 cwt.	Grass	−0·005	−0·001	−0·009**	−0·001	0·000	−0·004	−0·008*	−0·004	−0·023**	−0·023**	−0·019**	−0·003	−0·009	−0·030*
		Clover	−0·009	−0·001	−0·006	−0·001	—	—	—	−0·014*	−0·019**	−0·024**	−0·010**	—	—	—
Superphosphate	3 cwt.	Grass	−0·010*	−0·008*	−0·007*	−0·003	0·007	0·002	0·003	−0·002	−0·007	−0·002	0·007	−0·007	−0·002	−0·006
		Clover	−0·003	−0·020**	−0·014	−0·019	—	—	—	−0·002	−0·005	−0·006	−0·002	—	—	—
Ammonium sulphate†	3 cwt.	Grass	0·030**	0·015**	−0·003	−0·002	0·028**	0·015*	−0·004	0·002	0·016*	0·015*	0·043**	0·001	0·038**	0·048**
		Clover	0·025	−0·002	0·020	0·017	—	—	—	−0·021**	0·014**	0·019**	0·006	—	—	—
Magnesium sulphate	2 cwt.	Grass	—	—	—	—	—	—	—	0·001	−0·008	−0·003	−0·001	0·013*	0·014*	0·025*
		Clover	—	—	—	—	—	—	—	0·017*	0·000	0·006	0·005*	—	—	—
Standard error ±		Grass	0·004	0·003	0·003	0·006	0·004	0·005	0·004	0·004	0·006	0·006	0·005	0·006	0·005	0·010
		Clover	0·013	0·005	0·010	0·011	—	—	—	0·006	0·004	0·007	0·002	—	—	—
Consistent interactions K/salt		Grass	0·006	−0·002	0·004	0·013*	−0·002	−0·009	0·002	0·008	0·009	0·022**	0·011*	−0·005	0·023**	−0·004
		Clover	0·010	0·006	0·012	0·017	—	—	—	0·001	0·012*	0·025**	−0·004	—	—	—
NK		Grass	−0·016*	0·004	0·000	0·002	−0·011*	−0·002	−0·008*	0·004	0·007	−0·006	0·000	−0·001	−0·012*	−0·024**
		Clover	0·004	−0·004	−0·007	0·013	—	—	—	0·006	−0·007	0·004	−0·006*	—	—	—
Standard error ±		Grass	0·006	0·005	0·004	0·008	0·006	0·007	0·006	0·006	0·009	0·009	0·008	0·008	0·007	0·014
		Clover	0·019	0·007	0·014	0·015	—	—	—	0·008	0·006	0·009	0·004	—	—	—

† 3 cwt. for each cut in Expts. 3 and 4

Table VIII

% phosphorus in dry matter

Sample			Experiment 1 A	Experiment 1 B	Experiment 1 C	Experiment 1 D	Experiment 2 A	Experiment 2 B	Experiment 2 C	Experiment 3 A	Experiment 3 B	Experiment 3 C	Experiment 3 D	Experiment 4 A	Experiment 4 B	Experiment 4 C
Mean % P		Grass	0·280	0·256	0·219	0·264	0·272	0·171	0·183	0·175	0·193	0·246	0·238	0·160	0·177	0·163
		Clover	0·320	0·222	0·137	0·163	—	—	—	0·162	0·188	0·194	0·223	—	—	—
Response to Salt	4 cwt.	Grass	0·002	0·007	0·005	0·021	0·008	−0·001	0·000	0·000	0·008	0·012	0·009	0·007	0·008	0·004
		Clover	−0·016	−0·010	−0·006	−0·014	—	—	—	−0·020**	0·000	−0·025*	0·006	—	—	—
Muriate of potash	2 cwt.	Grass	−0·010	−0·016	−0·005	−0·012	−0·008	−0·004	0·011	0·002	−0·005	−0·003	0·004	0·006	0·011	−0·004
		Clover	−0·016	−0·015	0·000	0·007	—	—	—	0·009	−0·003	0·010	0·035**	—	—	—
Superphosphate	3 cwt.	Grass	0·022*	0·023	0·004	−0·019	0·026	0·025*	0·011	0·013	0·010	0·014	0·009	0·013*	0·026**	0·019**
		Clover	0·038**	0·017	0·000	−0·016*	—	—	—	0·013*	0·009	0·003	0·005	—	—	—
Ammonium sulphate†	3 cwt.	Grass	0·000	0·005	−0·049**	−0·039**	0·046**	0·037**	0·001	0·000	−0·012	−0·071**	−0·051**	0·005	0·005	0·001
		Clover	0·027*	0·032*	−0·025*	−0·027**	—	—	—	−0·018**	−0·001	−0·006	−0·004	—	—	—
Magnesium sulphate	2 cwt.	Grass	—	—	—	—	—	—	—	−0·007	0·003	−0·001	−0·006	−0·007	−0·003	0·014
		Clover	—	—	—	—	—	—	—	−0·005	0·000	−0·021*	−0·009	—	—	—
Standard error ±		Grass	0·010	0·013	0·007	0·013	0·015	0·010	0·009	0·010	0·007	0·012	0·013	0·005	0·007	0·006
		Clover	0·011	0·011	0·009	0·006	—	—	—	0·005	0·007	0·009	0·010	—	—	—

† 3 cwt. for each cut in Expts. 3 and 4

to the more drastic fall in herbage potassium in Expts. 3 and 4 which received repeated nitrogen applications. The NK interactions were generally negative.

Superphosphate reduced the percentage concentrations of magnesium in three of the four experiments. These reductions reached significance for both grass and clover in Expt. 1, but otherwise they were quite small.

Two cwt. of magnesium sulphate (≡22·5 lb. of Mg/acre) significantly increased the magnesium concentrations in the grass for each of the three cuts in Expt. 4. It did not increase the grass magnesium at any stage in Expt. 3, but it enhanced the magnesium content of the clover for all cuts except the second.

When expressed on a % basis with regard to their respective means and averaged over the whole season, the alterations in the magnesium uptake for the grasses were: −7·5% for 4 cwt. of salt, −7·5% for 2 cwt. of muriate of potash, and +14% for 3 cwt. of ammonium sulphate. For clover the respective figures were −3·2%, −4·8% and +4·0%. On average, therefore, balanced dressings of nitrogen and potassium applied at normal rates should not have any appreciable effect on herbage magnesium.

(5) *Phosphorus* (Table VIII).—Superphosphate generally increased the phosphorus contents of both grass and clover by about 0·010–0·020% P. The effects were most obvious in the early-season samples.

Salt, muriate of potash and magnesium sulphate had no regular influence, but ammonium sulphate significantly depressed phosphorus contents in the third and fourth samples from Expts. 1 and 3. On the other hand, it significantly increased the phosphorus content in the first two samples of Expt. 2.

Apart therefore from superphosphate, fertilisers have had no consistent effect on phosphate content.

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THE ASSESSMENT OF NUTRITIVE VALUE IN PROTEIN CONCENTRATES BY THE GROSS PROTEIN VALUE METHOD

By (the late) J. DUCKWORTH, A. A. WOODHAM and I. McDONALD

The Gross Protein Value technique, modified in certain particulars, has been used to evaluate 171 samples of protein concentrates, obtained from world-wide sources, and including a number of animal by-products and oilseed meals.

The assessments demonstrated that in nearly all these classes of concentrate the samples on the market differ widely in nutritive value. The work reported indicates the need for rapid laboratory tests which will predict the value of different protein concentrates and the range of samples should provide useful reference standards for this purpose.

Introduction

The problem of devising rations for non-ruminant farm animals in the United Kingdom in which the protein is adequate in both quantity and quality, is complicated by the diversity of materials on the market. The bulk of the feed may be composed of one or several cereals providing energy and some protein. To this must be added one or more concentrates in order to increase the protein content and to provide a sufficiency of essential amino-acids, some of which will be in short supply in the cereals. These protein concentrates include animal by-products such as meat and bone meal, fish meal, and dried skimmed milk, and vegetable materials such as groundnut meal and soya-bean meal.

In practice several concentrates may be used together and at present the choice depends largely upon the availability and prevailing price of materials. For example groundnut meal may be replaced by sunflower seed meal if the economic conditions dictate, and at another time both may be replaced by soya-bean meal. Such manipulation is permissible if the various mixtures are equivalent in nutritive value. In view of the differing amino-acid compositions and energy contents of the various types of protein concentrate this equivalence is unlikely, and the difficulty is surmounted by the inclusion of larger quantities of supplementary protein than necessary, in order to provide a ' margin of safety '. Information on ' replacement values ' for individual concentrates would permit the safety margin to be cut down, thereby reducing the price of the product and also ensuring that these valuable commodities be used to their best advantage. Recognised deficiencies in quality with respect to a particular component of a mixture could be remedied either by increasing its level, or by adding another material capable of complementing the effect of the first.

The biological evaluation of even a proportion of the possible combinations of cereals and concentrates would be a formidable task. Further the variation in quality between different specimens of the same material would seriously detract from the usefulness of the results obtained. The value of a mixture of two concentrates fed with a cereal basal ration may well be greater than that of an equivalent quantity of either.[1] In consequence deductions from evaluations of single concentrates must be made with care. In addition, the value of a particular concentrate will be affected by the cereal components present in the diet. Despite these drawbacks it was felt that evaluation of a series of individual concentrates was a necessary first step towards assessing their performance under practical conditions.

The work which is described here represents an attempt to discover how great is the variation in nutritive value of the principal types of protein concentrate available on the British market for use in the feeding of pigs and poultry. Previous papers have emphasised the increasing extent to which our animal feeding industry is dependent upon imports of raw materials, and the necessity for making the best possible use of them.[2, 3] This might be achieved partially at least by diverting best quality materials into feeding stuffs for non-ruminants which are more discriminating in their requirements, and using the poorer materials for ruminants which can use them to the best advantage.[2]

A further reason for carrying out this work was the need for a range of materials of known quality for use in studies aimed at evolving rapid predictive laboratory tests of protein quality. This formed part of a collaborative effort involving 13 laboratories and carried out under the aegis of the Agricultural Research Council.

Choice of method

A variety of biological procedures has been used in previous studies of protein quality and in choosing the most suitable one for this work various considerations were borne in mind. The ideal test had to be capable of evaluating some 170 samples within a reasonable period of time. The experimental animals would preferably be chicks in order that the results would be directly applicable to an industry which consumes a very large proportion of the protein concentrates used in this country. For a similar reason it was decided that the most suitable test would be one in which the protein source was tested as a supplement to cereals, rather than as the sole source of protein. Ideally the ratio of supplementary protein and cereal protein should be similar to that used commercially. Provision should be made for comparison of results obtained at different times and this could best be done by including a series of parallel tests on a standard reference protein. The test should be designed to measure differences in protein quality only. A constant cereal basal diet should be used throughout and this would require to be flexible enough to allow for the testing of a wide variety of concentrates.

The Gross Protein Value test described by Heiman *et al.*[4] in 1939, with certain modifications, had been used in the Rowett Research Institute for some years previously, and it did in fact fulfil most of the requirements mentioned above. The only major exception was the level of supplementary protein used and this did fall considerably below the level used in practical rations. Nevertheless it was felt that the method was the most suitable established technique for our purpose. The necessary equipment, housing and an adequate regular supply of chicks were all available and sufficient experience had been gained with the method to allow an immediate start.

The modified Gross Protein Value method

Before 1939, the protein evaluation procedures in use lacked uniformity as regards the composition of the basal diets, the levels of protein used, the age and species of experimental animals, and the methods of interpreting the data. The Gross Protein Value test was designed to supply information of practical value to the poultry industry and, naturally, diets were evolved with the commercial American rations in mind. Modifications were therefore introduced by workers in this Institute to make the test more applicable to British conditions.[5, 6]

For the present series of trials further modifications were introduced with the principal object of making possible the testing of extreme types of protein concentrate. It was necessary, for example, to fix a level of crude fibre for all diets which would allow high-fibre sunflower seed meals to be tested, and allowance had at the same time to be made for high phosphorus levels in some meat and bone meals.

Experimental

Description of method used

Six hundred day-old R.I.R. × W.L. cockerels were housed in electrically heated hovers fitted with wire floors. For 3 days a diet consisting of equal parts of cracked wheat and maize was fed and for the following 10 days all birds received a depletion diet containing 8% of protein of which 6·5% was provided by cereals and the remainder by yeast and whey. On the 14th day each chick was weighed to the nearest g. and a sufficient number of the heavier and lighter birds discarded to leave 320 as similar in weight as possible. Any bird which seemed in any way inferior to the others in general condition was excluded. The chosen birds were then divided into 32 groups of 10 by a randomisation procedure which ensured the greatest possible similarity between groups. Each group was allocated at random to one of 32 single tier cages and to one of eight diets. To minimise the contribution of local environmental differences to apparent treatment differences, the distribution was effected in such a manner that each one of the four groups on a given diet was situated in a different quarter of the house.

During the subsequent 14-day test period food and water was provided *ad libitum*. Chicks were weighed on the 4th, 7th, 11th, 13th and 14th days of the test period, as was residual food, the intermediate weighings being designed to make possible corrections for birds dying during the period.

Diets

(a) *The basal mix.*—This was made up (160 kg.) for each experiment and contained 12–13% crude protein.

	kg.		kg.
Millers offals	40·0	Whey	13·4
Maize meal	28·0	Yeast	8·0
Barley meal	40·0	Salt	1·2
Sussex ground oats	26·6	Vitamin supplement*	2·8
		Total	160·0

* contained 1000 i.u. of vitamin A and 200 i.u. of vitamin D_3 per g.

(b) *The depletion diet.*—This consisted of the basal mix diluted with starch and adjusted to contain a definite level of crude protein, fibre, calcium and phosphorus by the incorporation of suitable quantities of oatfeed, calcium phosphate and calcium carbonate, as follows:

Basal mix, Oatfeed	quantities calculated to contribute 8% of crude protein and 7% of crude fibre in the final diet
$Ca_3(PO_4)_2$	sufficient to raise the phosphorus level of diet to 0·72%
$CaCO_3$	sufficient to raise the calcium level of diet to 1·10%
Vitamin E	360 mg.
Starch	to give 120 kg. of total diet

(c) *The control diet.*—19·8 kg. of the depletion diet were remixed with 0·2 kg. of starch on which was distributed 60 mg. of vitamin E.

(d) *The test diets.*—These were made by adjustment of the basal diet as already described for (*b*) and consisted essentially of the control diet supplemented with 3% of test protein. In every experiment, one test diet incorporated 3% of protein provided by casein, the reference protein.

Test protein concentrate or casein	to contribute 3% of crude protein to the final diet
Basal mix, Oatfeed	quantities calculated to contribute 8% of crude protein to the final diet, and to raise the crude fibre level to 7%
$Ca_3(PO_4)_2$	sufficient to raise the phosphorus level of the diet to 0·72%
$CaCO_3$	sufficient to raise the calcium level of the diet to 1·10%
Vitamin E	60 mg.
Starch	to give 20 kg. of total diet

Diets (*b*), (*c*) and (*d*) all varied slightly from trial to trial owing to differences in the raw materials used for making up the basal diets. It is therefore impossible to give a rigid weight composition for the experimental diets.

Calculation of Gross Protein Value (G.P.V.)

$$\text{Wt. gain/g. of supplementary protein} = \frac{\text{Extra wt. gain (g.)*}}{\text{Food eaten/head (g).}} \times \frac{100}{\%\ \text{supplementary protein}\dagger}$$

$$\text{G.P.V.} = \frac{\text{Wt. gain/g. of supplementary protein in test diet (g.)}}{\text{Wt. gain/g. of supplementary protein in casein diet (g.)}} \times 100$$

It will be observed that the method of calculation makes no allowance for the feed consumption of the control groups. An alternative method of calculation taking this into account has been devised and this will be the subject of another communication. In the meantime it can be stated that while the theoretical accuracy of the final figure is improved there is no significant difference in the resultant rankings of the individual meals when the modified form of calculation is used.

* Extra wt. gain = Wt. gain/head of test group − wt. gain/head of corresponding control group.

† % supplementary protein = Crude protein content of test diet by analysis − crude protein content of control diet by analysis.

Sample collection

Importers and compounders of animal feeds, seed-crushers, manufacturers of meat, whale and fish meals, creameries, etc. were approached and invariably proved helpful and co-operative in providing the bulk of the samples needed. Some samples, however, were bought on the open market through the usual commercial channels. All the cottonseed meals were donated by the Oilseeds Division of the U.S. Department of Agriculture Southern Regional Research Laboratory. Sample size varied somewhat but normally ranged from 56 to 112 lb. In each series with the exception of cottonseed, every attempt was made to draw samples from sources as diverse as possible and the success of this depended to some extent upon the materials which were on the market at the time that the collection was made. The large size of the sample was necessary to ensure that it was truly representative, and also to provide material for the Collaborative investigation already mentioned.

Each sample after thorough mixing was transferred to internally lacquered metal cans which were then sealed in an atmosphere of nitrogen and stored at −10° until required.

Results

The Gross Protein Values for all of the 171 samples are set out in Tables I–IX. Individual replicates are given as well as the mean value, and the samples of each type of concentrate are listed in order of G.P.V. The country of origin is shown where this is known as well as the crude protein content of the sample, found by analysis, and the description of the material given by the supplier. In some cases information was available on processing and this is briefly indicated in the tables.

Table I

Meat meals and meat/bone meals

Sample no.	Country of origin	Description of sample	Crude protein content, %	Gross Protein Value: Individual results	Mean
MM 23	Argentina	Meat meal	56·8	91 91	91
MM 18	U.K.	Meat meal	56·9	90 89 83	87
MM 25	Uruguay	Meat & bone meal	49·7	77 83	80
MM 14	U.K.	Meat & bone meal, from pig waste	53·0	86 74 69 74	76
MM 13	U.K.	Meat & bone meal, from pig waste	47·9	80 86 68 67	75
MM 6	Australia	Meat & bone meal	49·4	72 73	73
MM 11	U.K.	Meat & bone meal	48·3	71 73	72
MM 1	U.K.	Meat meal, from mixed raw material	59·3	70 72	71
MM 2	U.K.	Meat meal, from mixed raw material	57·8	74 65	70
MM 24	Argentina	Meat & bone meal	42·6	74 66 75 69 62	69
MM 15	Foreign*	Meat & bone meal	49·2	80 60 61 70 74	69
MM 5	New Zealand	Meat meal	86·0	71 71 72 64 63	68
MM 27	Australia	Meat & bone meal	39·3	66 71	68
MM 4	U.K.	Meat meal, from mixed raw material	56·6	66 65	66
MM 28	Australia	Meat meal	55·6	66 67	66
MM 21	U.S.A.	Meat meal	56·3	56 74	65
MM 10	U.K.	Meat & bone meal	47·1	61 68	64
MM 3	New Zealand	Meat meal	87·1	69 67 62 58	64
MM 26	Australia	Meat meal	56·4	61 65	63
MM 7	U.K.	Meat & bone meal, from mixed raw material	48·9	62 62	62
MM 12	U.S.A.	Meat & bone meal	52·8	55 64 64	61
MM 8	U.K.	Meat & bone meal, from mixed raw material	43·3	46 73	59
MM 30	U.S.A.	Meat & bone meal	48·3	54 64	59
MM 22	U.S.A.	Meat & bone meal	49·2	51 63	57
MM 29	Australia	Meat & bone meal	49·4	52 59	56
MM 9	U.K.	Meat & bone meal, from mixed raw material	51·2	60 53	56
MM 19	U.S.A.	Meat meal	60·0	51 60	56
MM 17	Foreign*	Meat & bone meal	52·7	44 63 45	51
MM 16	Foreign*	Meat meal	60·0	46 35 38 36	39

* Country not known

Table II

Fish meals

Sample no.	Country of origin	Description of sample	Crude protein content, %	Gross Protein Value — Individual results	Mean
FM 7	S. Africa	Fish meal (probably pilchard)	67·0	121 125 118	121
FM 5	Norway	Herring meal	74·7	120 118	119
FM 8	Denmark	Herring meal	70·8	121 125 120 114 105	117
FM 6	Norway	Herring meal	75·6	125 124 98	116
FM 9	S.W. Africa	Fish meal	63·9	118 113	116
FM 14	Norway	Herring meal	70·6	115 107 124	115
FM 23	U.K.	White fish meal	57·2	115 115	115
FM 11	Norway	Herring meal	73·5	112 114	113
FM 12	Norway	Herring meal	73·2	108 119	113
FM 1	Norway	Herring meal	70·0	115 121 103 111	112
FM 10	Norway	Herring meal	71·7	106 119	112
FM 18	Iceland	Redfish meal	60·5	103 105 126 113 112 113	112
FM 15	Iceland	Cod meal	74·5	110 109 123 113 95 108 109	110
FM 13	Norway	Herring meal	73·2	111 104	108
FM 2	Norway	Herring meal	71·9	111 101	106
FM 16	Iceland	Cod meal	58·2	100 111	106
FM 19	U.K.	White fish meal	64·8	100 102 104 95	100
FM 21	U.K.	White fish meal	63·9	89 106	98
FM 20	U.K.	White fish meal	63·3	97 88	93
FM 22	U.K.	White fish meal	65·9	92 92	92

Table III

Whale meals and dried whale solubles

Sample no.	Country of origin	Description of sample	Crude protein content, %	Gross Protein Value — Individual results	Mean
WM 9	U.K.	Whale fillet meal—mixed fin and sperm	88·1	112 117	114
WM 11	U.K.	Whale meat meal—mixed fin and sperm	84·4	99 114 110 96 102	104
WM 6	U.K.	Whale meat meal	81·0	90 124 99	104
WM 4	U.K.	Whale meat meal	78·9	102 113 84 95	99
WM 5	U.K.	Whale meat meal—sperm	71·1	89 117 90	99
WM 13	Norway	Whale meat meal	84·7	97 100	98
WM 3	Unknown	Whale meat meal	85·9	104 93 86	94
WM 10	U.K.	Grax meal	82·4	82 92	87
WM 2	Unknown	Whale meat meal	68·4	87 86	86
WM 12	Norway	Whale meat meal	59·2	89 84	86
WM 1	Unknown	Whale meat & bone meal	59·6	72 81	77
WM 14	Peru	Whale meat meal	60·6	67 76	72
WM 7	U.K.	Whale meat meal	87·0	48 56 55 45 61	53
WS 2	Norway	Dried whale solubles	77·2	66 70	68
WS 4	U.K.	Dried whale solubles	82·4	47 56	52
WS 1	U.K.	Dried whale solubles	87·1	68 42 40 45 53	50
WS 3	U.K.	Dried whale solubles	86·4	38 42	40

Table IV

Dried milk powders

Sample no.	Country of origin	Description of sample*	Crude protein content, %	Gross Protein Value — Individual results	Mean
SM 13	U.K.	Spray dried	34·2	111 98 96	102
SM 18	U.K.	Spray dried	33·6	101 94	97
SM 29	New Zealand	Roller dried	30·6	92 101	97
SM 17	U.K.	Spray dried	33·7	101 89 96	95
SM 5	U.K.	Spray dried	34·6	82 101 98	94
SM 16	U.K.	Roller dried	32·8	101 81 96	93
SM 19	U.K.	Roller dried	32·2	88 91	90
SM 3	U.K.	Spray dried	34·9	85 90 92	89
SM 6	U.K.	Spray dried	35·0	88 89	89
SM 31	New Zealand	Spray dried	36·1	89 89	89

* All skimmed milk powder, except SM 29 which was buttermilk powder

Table IV (*cont.*)

Sample no.	Country of origin	Description of sample*	Crude protein content, %	Gross Protein Value Individual results	Mean
SM 1	U.K.	Spray dried	34·7	93 86 86	88
SM 14	U.K.	Roller dried	33·1	85 90	88
SM 21	U.K.	Roller dried ' separated siftings '	33·1	91 86	88
SM 26	New Zealand	Roller dried	33·7	87 83 94	88
SM 4	U.K.	Roller dried	36·2	79 87 92	86
SM 2	U.K.	Roller dried	35·2	86 84 83	84
SM 9	U.K.	Roller dried	32·6	85 81 79 90	84
SM 11	U.K.	Roller dried	32·4	82 85	84
SM 15	U.K.	Roller dried	32·2	89 80	84
SM 7	U.K.	Spray dried	32·5	79 82	80
SM 12	U.K.	Spray dried	29·8	76 81	78
SM 8	U.K.	Roller dried	32·4	69 64 70	68
SM 10	U.K.	Roller dried	32·3	69 61	65

Table V

Soya-bean meals

Sample no.	Country of origin	Description of sample	Crude protein content, %	Gross Protein Value Individual results	Mean
SB 1	Canada	S.E.	44·9	95 100 92 87 90 91	93
SB 7	U.S.	S.E.	40·1	92 82	87
SB 9	Canada	S.E.	43·9	87 86	86
SB 13	U.K.	S.E.	48·4	91 82	86
SB 15	U.S.	S.E.	45·0	89 82	86
SB 8	Canada	S.E.	42·9	85 84	84
SB 12	U.K.	S.E.	42·5	80 88	84
SB 16	U.K.	S.E.	44·5	85 79	82
SB 5	Canada	Expeller	43·8	82 78	80
SB 10	Canada	S.E.	38·0	86 75	80
SB 14	Canada	S.E.	45·7	86 75	80
SB 6	Canada	S.E.	42·7	82 75	79
SB 18	Canada	S.E.	45·3	88 66	77
SB 11	Canada	Expeller	40·8	84 75 64 71	74
SB 19	U.K.	S.E.	45·2	72 72	72
SB 4	U.K.	S.E.	44·1	75 62 76 57 72 77	70
SB 17	U.K.	S.E.	44·9	67 59	63
SB 21	U.S.S.R.	S.E.	47·0	55 64	60
SB 3	U.K.	Expeller	45·7	53 57 56 70	59

Table VI

Sunflower seed meals

Sample no.	Country of origin	Description of sample	Crude protein content, %	Gross Protein Value Individual results	Mean
SF 11	Argentina	S.E.	37·2	90 92	91
SF 8	Argentina	S.E.	45·7	72 68	70
SF 13	Argentina	S.E.	34·2	66 74	70
SF 10	U.K.	S.E.	35·2	63 70	66
SF 9	U.K.	S.E.	40·5	54 74	64
SF 12	U.K.	Process unspecified	40·4	64 65	64
SF 16	Unknown	Process unspecified	41·0	58 64	61
SF 14	Argentina	Expeller	38·3	66 52	59
SF 19	Chile	S.E.	29·5	57 61	59
SF 6	Argentina	S.E.	39·7	52 59	56
SF 2	Argentina	Expeller	32·8	54 53	54
SF 15	Argentina	S.E.	39·0	49 59	54
SF 20	U.S.S.R.	S.E.	45·6	60 47	54
SF 18	Argentina/Uruguay	S.E.	40·4	57 49	53
SF 5	Argentina/Uruguay	Process unspecified	35·4	57 46	52
SF 4	Argentina	S.E.	37·1	53 49	51
SF 17	Unknown	Process unspecified	42·7	42 57	50
SF 7	Argentina/Uruguay	S.E.	38·5	48 46	47
SF 3	Argentina/Uruguay	S.E.	37·4	45 46	46
SF 1	Argentina	S.E.	37·1	33 34	34

S.E. = solvent extracted meal

Table VII

Cottonseed meals

Sample no.	Country of origin	Description of sample	Crude protein content, %	Gross Protein Value: Individual results	Gross Protein Value: Mean
CM 49	U.S.	Solvent extracted meal (chemically degossypolised)	44·0	95 81	88
CM 19	U.S.	Solvent extracted meal	40·5	72 58	65
CM 6	U.S.	Pre-press solvent extracted meal	39·6	71 56	64
CM 54	U.S.	Process unspecified	39·7	56 57	56
CM 56	U.S.	Process unspecified	40·1	65 48 54	56
CM 58	U.S.	Process unspecified	40·5	46 58 57	54
CM 55	U.S.	Process unspecified	41·6	56 50	53
CM 53	U.S.	Process unspecified	40·7	55 46	50
CM 61	U.S.	Process unspecified	39·9	43 55	49
CM 60	U.S.	Process unspecified	40·2	32 55 57	48
CM 57	U.S.	Process unspecified	40·8	55 40 46	47
CM 59	U.S.	Process unspecified	41·9	34 41	38
CM 36	U.S.	Low-speed expeller meal	43·3	37 26	32
CM 13	U.S.	High-speed expeller meal	39·5	35 27	31
CM 66	U.S.	Process unspecified	45·0	26 31	28
CM 52	U.S.	Process unspecified	41·6	28 26	27
CM 65	U.S.	Process unspecified	46·3	19 17 20	19

Table VIII

Groundnut meals

Sample no.	Country of origin	Description of sample	Crude protein content, %	Gross Protein Value: Individual results	Gross Protein Value: Mean
GN 12	U.K.	Double expeller meal from Nigerian groundnuts	46·4	64 63	64
GN 16	U.K.	Solvent extracted meal from Nigerian groundnuts	48·7	60 61	60
GN 7	U.K.	Expeller meal from Nigerian groundnuts	43·2	51 60	56
GN 9	U.K.	Solvent extracted meal from Nigerian groundnuts	47·9	45 60 55 57	54
GN 6	U.K.	Solvent extracted meal	48·3	55 47	51
GN 18	India	Expeller meal	51·3	57 45	51
GN 5	U.K.	Solvent extracted meal	50·3	47 54	50
GN 13	India	Solvent extracted meal	45·5	50 33 62 50	49
GN 1	Unknown	Process unspecified	45·5	42 53	48
GN 10	U.K.	Solvent extracted meal from South African groundnuts	43·1	41 62 47 42	48
GN 3	France	Solvent extracted meal	49·8	42 52	47
GN 17	French West Africa	Process unspecified	49·4	51 25 44 57	44
GN 8	Burma	Expeller meal	38·7	28 51 45 38 51	42
GN 15	Paraguay	Process unspecified	42·9	49 24 51 35	40
GN 14	Iraq	Process unspecified	51·8	31 43 28 29 43 41	36
GN 11	Burma	Jungle cake	47·0	27 27 48 31 41 39	36
GN 19	U.K.	Solvent extracted meal	50·4	37 36	36
GN 20	U.K.	Solvent extracted meal	50·6	38 34	36
GN 2	U.S.A.	Process unspecified	48·2	36 29	32
GN 4	Nigeria	Expeller meal	46·8	28 37	32

Table IX

Miscellaneous samples

Sample no.	Country of origin	Description of sample	Crude protein content, %	Gross Protein Value Individual results	Mean
MM 20	U.S.A.	Feather tankage	78·7	13 11	12
MM 31	New Zealand	Liver meal	63·2	73 54	64
FM 3	India	Fish meal	40·9	84 71 71 71	74
FM 4	Unknown	Crayfish meal	41·9	65 54 64 66	62
FM 17	Iceland	Cod bone meal	39·8	77 84	81
SB 2	U.K.	High-fat processed soya-bean flour	38·7	67 70 76	71

Fig. 1 illustrates diagrammatically the spread of mean G.P.V. for each type of material, and allows comparison between them.

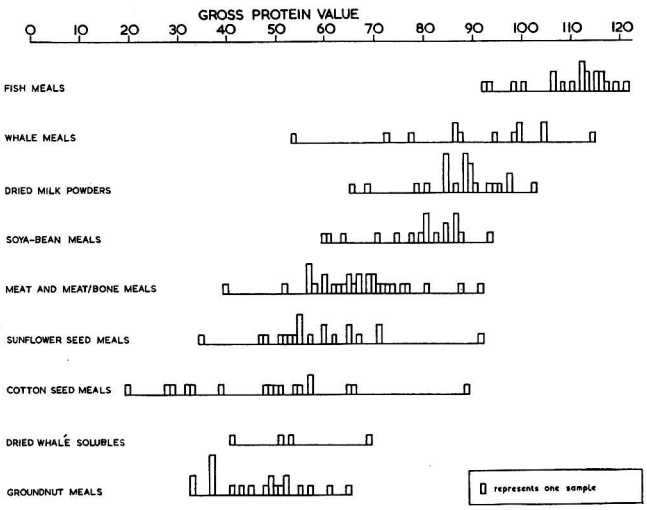

FIG. 1.—*Gross protein value distribution of all samples*
(rectangles indicate 1–4 samples according to height)

Each individual G.P.V. is the mean result from the four replicates included in each trial and each sample was included in at least two trials. Thus each mean G.P.V. reported originates from at least eight figures. Where only two results are given for a particular sample, each was obtained in a different house, and generally in successive experiments.

In the course of the work five different batches of casein were used, all obtained from Glaxo Laboratories Ltd. and described as ' lactic casein—unextracted '. These batches were compared with each other, directly by including two caseins in one or more trials at the time of the change-over, and indirectly by comparing the unadjusted individual G.P.V. of samples tested with different caseins at different times. On the basis of these comparisons, the following five correction factors were applied to the initial results, according to the particular batch of standard casein used: 1·01, 1·07, 0·92, 0·95 and 1·01. The mean of these values, weighted by the numbers of trials in which each casein was used, was arbitrarily fixed as unity.

The precision of the final mean G.P.V.s has been estimated from comparisons between the individual G.P.V.s for each sample. Comparisons between individual results obtained in consecutive experiments have been excluded, as the differences tended to be less, and there

must have been some variable factors which did not affect these short-term comparisons. The standard deviation of an individual G.P.V. was estimated as ± 8, and hence approximate 95% confidence limits for the mean of two individual figures are $\pm 1{\cdot}96 \times 8/\sqrt{2} = \pm 11$. This estimate was based on 89 independent comparisons (degrees of freedom).

In Table X the results are compared with those reported previously for corresponding materials. Extreme ranges are shown and, where adequate information is available, the classes have been broken down in order that major processing differences may be examined.

Discussion

It is clear from an examination of the Tables that each series of samples collected covers a wide range in quality as measured by the Gross Protein Value method. The range is nearly always considerably greater than that exhibited by all the samples tested previously elsewhere even though results from several laboratories have been included in the totals in Table X. The principal exception is fish meal and here the range has not included a sufficient number of poor-quality materials. The majority of these samples originated either in the United Kingdom or in Scandinavia where processing control is known to be well organised. Since the completion of the sample collection, poor-quality fish meals have appeared on the market which have come from parts of the world where fish meal production is not a traditional activity.

Table X

Gross Protein Values of the various classes of protein concentrate examined in the present work, compared with results obtained by other workers

Materials	Samples used in present work				Similar samples reported previously			
	Table	No. of samples	Range of G.P.V.	Mean	No. of samples	Range of G.P.V.	Mean	References
Meat meals and meat/bone meals—complete range	I	29	39–91	66	11	32–60	52	1, 7, 8, 9
Meat meals only	,,	12	39–91	67	8	43–60	53	1, 7
Meat/bone meals only	,,	17	51–80	65	3	32–57	47	7, 8, 9
Fish meals—complete range	II	20	92–119	110	31	72–112	96	1, 4, 5, 7, 8, 9, 10, 11, 12
Herring meals only	,,	10	106–119	113	16	90–112	100	1, 4, 7, 8, 9, 10, 11
White fish meals only	,,	7	92–115	102	9	85–95	91	5, 9, 12
Pilchard meals only	,,	1	—	121	5	84–111	96	1
Whale meat meals	III	12	53–114	90	2	97–105	101	6
Grax meal	,,	1	—	87	1	—	96	6
Dried whale solubles	,,	4	40–68	53	2	56–58	57	6
Dried skimmed milk—complete range	IV	23	65–102	87	5	78–92	87	1, 4, 7
Dried skimmed milk—roller-dried samples only	,,	12	65–93	83	—	—	—	
Dried skimmed milk—spray-dried samples only	,,	10	78–102	90	—	—	—	
Dried buttermilk	,,	1	—	97	2	91–92	92	1, 7
Soya-bean meals—complete range	V	19	59–93	78	13	46–85	72	1, 7, 8, 9, 10
Soya-bean meals—solvent extracted only	,,	16	60–93	79	—	—	—	
Soya-bean meals—expeller only	,,	3	59–80	71	3	46–85	72	1, 7
Sunflower seed meals—complete range	VI	20	34–91	58	2	45–47	46	8
Sunflower seed meals—solvent extracted only	,,	14	34–91	58	—	—	—	
Sunflower seed meals—expeller only	,,	2	54–59	56	—	—	—	
Cottonseed meals—complete range	VII	17	19–88	47	2	13–46	30	8, 10
Cottonseed meals—solvent extracted only	,,	2	65–88	77	—	—	—	
Cottonseed meals—expeller only	,,	2	31–32	32	1	—	46	8
Groundnut meals—complete range	VIII	20	32–64	46	8	33–50	40	5, 9, 13
Groundnut meals—solvent extracted only	,,	9	36–60	48	—	—	—	
Groundnut meals—expeller only	,,	5	32–64	49	1	—	39	13

It must be borne in mind that these wide ranges do reflect in some measure the limited precision of the G.P.V. measurement. That there is indeed a true residual difference in quality between samples can be seen by reference to the standard deviation which is estimated as ± 8. It is even more obvious from the original detailed results, since comparisons between G.P.V. obtained in the same trials are considerably more precise than is implied by this standard deviation, including as it does between-trials variability.

Turning to Fig. 1 a general pattern can be seen in which fish meal as a class exhibits the highest nutritive value as assessed by the Gross Protein Value method, and this is followed in order by whale meal, dried skimmed milk, soya-bean meal, meat meal, sunflower seed meal, cottonseed meal, dried whale solubles and finally groundnut meal. This general picture is in good agreement with theoretical assessments of nutritive value based on amino-acid content and digestibility. Nevertheless the fact that the range of meat meals, sunflower seed meals

and cottonseed meals each contain individuals with G.P.V. of the order of 90 and therefore equivalent to some of the white fish meals, suggests that the potential for these materials is not being realised. With meat meals the choice of raw materials may well be chiefly responsible for the variation in quality, but with the oilseed meals it seems likely that quality is largely dependent upon the method of processing and there is room for hope that technological developments will eventually produce a considerable improvement in the average quality of these meals.

It will be noted also that for each class of material, samples tend to be concentrated at a particular part of the range. With the highest ranking materials, namely fish meals, whale meals, dried skimmed milk and soya-bean meals, the focal point is near the higher end ; with materials of intermediate overall value, the meat meals and sunflower seed meals, the maximum concentration occurs about the middle of the range, and with the poorer materials the majority of samples tend to fall nearer to the lower end of the scale. A given fish meal, therefore, is more likely to be a good fish meal than a bad one while the reverse holds for groundnut meals.

Comparison of the absolute figures obtained in the present work with those reported previously for corresponding materials (Table X) suggests that there is a slight tendency towards a uniform upward shift in Gross Protein Value. Despite this, the agreement is in fact closer than was expected considering the experimental modifications which have been adopted and the unlikelihood that the reference casein was nutritionally equivalent to that used by others. In general the total ranges were wider than those previously reported, but this was to be expected from the fact that more samples were involved.

Some comments may now be made on individual points arising from the tables. Meat meals, differentiated from meat and bone meals only by the fact that they contain more than 55% of crude protein, are somewhat more variable in quality than the latter. This may be an accidental sampling effect, as it is not in agreement with the earlier work based on a smaller number of samples. The superiority of herring meals over white fish meals is marked and confirms the finding of earlier workers. Dried whale solubles are lower in nutritive value than ordinary whale meals and this also agrees with precedent. Spray-dried skimmed milk appears to be superior on average to roller-dried material and this might be attributed to the lower temperatures involved in the former process. However the difference just fails to reach the 5% level of statistical significance. Hardly enough information is available to permit rigid conclusions as to the respective merits of solvent-extracted and screw-pressed oilseed meal samples. The indication from a limited number of meals is that solvent extraction may be preferable for soya-bean and cottonseed meals, while with sunflower seed and groundnut meals this process produces concentrates which are of much the same value as those produced by screw-pressing.

The variability in nutritive value shown by the samples used in this work emphasises the need for rapid tests designed to predict quality in such materials. Biological tests such as the Gross Protein Value are not ideal for routine use, particularly where time is an important factor, and the range of materials available now upon which this particular assessment has been carried out forms a useful starting point for work already in progress aimed at the development of simple laboratory tests.

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All of the samples used in this work are identical with those distributed to laboratories participating in the Agricultural Research Council collaborative trial of protein quality tests, and the code letters and numbers are unchanged.

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TREATMENT OF MEATS WITH IONISING RADIATIONS. VI.*—Changes in Quality during Storage of Sterilised Raw Beef and Pork

By B. COLEBY, M. INGRAM and H. J. SHEPHERD

Radiation-sterilised raw beef and pork were stored at temperatures from −20° to +37°, and changes in appearance, odour, texture and flavour, during several months, were assessed by a panel using ranking and hedonic scores.

The changes in appearance were deleterious, but of minor importance save at the highest temperatures. There was a softening of texture and loss of fluid, presumed due to autolytic changes, also greater at the higher temperatures; but, even after several months at 37°, the fibrous texture of the meat remained intact during cooking. The initial 'irradiation' odour and flavour gradually changed to stale and bitter flavours and, though there were minor fluctuations, the general trend was a marked deterioration, again more rapid the higher the temperature.

Meat irradiated with 5 Mrads at −75° was preferred to that with 2 Mrads at 18°, confirming the protective effect of freezing; but, on storage under similar conditions, the former deteriorated like the latter. Occasional samples, in both series, were not sterilised.

It is concluded that for the radiation-preservation of raw meat at normal temperatures, the storage changes represent as serious an obstacle as the initial effect of irradiation.

Introduction

The changes in appearance, odour and flavour of meats directly resulting from the absorption of a sterilising dose of radiation are a major obstacle in preventing application of the technique. Though some procedures are partially successful in preventing these changes[1–4] a fully satisfactory process has yet to be developed; and the problem has been increased by the wider recognition that a commercially acceptable sterilising dose of radiation for meats is about 4·5 Mrads,[4, 5] rather than the previously accepted value of about 2 Mrads.

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Furthermore, a successful method of food preservation must minimise undesired changes in quality during storage. In this respect, irradiation seems defective, especially if not supplemented by other processing. Several publications have reported quality changes in raw meats during storage after sterilisation by irradiation: most,[6–9] though not all,[10] report a gradual deterioration. For these reasons, changes during storage have usually been followed in our experiments, and the present paper gives a general view of the nature of the changes with irradiated beef and pork, the quality being judged from the responses of a taste panel. Most samples were irradiated to a dose of 5 Mrads. To reduce the severe quality changes normally observed with such doses, some samples were irradiated at −75°, a procedure which affords considerable immediate benefit.[4] A direct comparison has therefore also been made between the behaviour during a storage of samples receiving 5 Mrads at −75° or 2 Mrads at room temperature.

Experimental

Materials

Beef was purchased locally, usually 2–3 days after slaughter of the animal. Rump steak, trimmed free of excess fat, or the *longissimus dorsi* muscle, was minced and packed anaerobically in shallow aluminium cans, as described earlier.[11] For some experiments slices of meat, 1 cm. in thickness, were cut consecutively along the length of the *longissimus dorsi* muscle, and packed anaerobically. The cans were kept at 0° overnight before irradiation to allow for the removal of any residual oxygen by metabolic processes. Pork was purchased locally, usually 1–2 days after slaughter. Fillet, trimmed free of excess fat, or the *longissimus dorsi* muscle, was used, being handled in a similar fashion to the beef.

Irradiation

The cans were irradiated successively from opposing sides with the scanned electron beam from a 2 MeV Van de Graaff generator, the dose rate being about 1 Mrad per second. Samples to be irradiated in the frozen condition were placed in powdered solid carbon dioxide at least 2 h. before being irradiated while embedded in solid carbon dioxide. Such samples were thawed immediately after irradiation by immersing in water at about 15°.

After irradiation, and thawing if necessary, samples were placed at appropriate temperatures for storage. Unirradiated samples for controls were stored at −20°.

Quality assessment

The taste panel technique has been described previously.[12] The panel usually had 10 members who were discriminating, though not especially accustomed to irradiation flavours. A few people who showed inconsistency in their judgments were excluded from the panel.

Bacteriological examinations

All samples which had been stored at temperatures higher than 5° were examined for pathogenic micro-organisms.

Results

Assessments of the appearance, odour and taste of pork given 5 Mrads at −75° and stored subsequently at various temperatures are recorded in Table I and the corresponding data for beef in Table II. Comparisons of the effects on pork of either 5 Mrads at −75° or 2 Mrads at room temperature are shown in Tables III–V.

Quality changes in pork

(1) *Appearance.*—Irradiation of pork under anaerobic conditions produces a pink or red colour, which some panel members preferred to the greyish appearance of untreated pork. On average, therefore, irradiated pork was often ranked better than the control, since panel members were not instructed to regard a red appearance as undesirable. The results in Table I indicate that after storage for 3 months or even a year, samples held at 15°, 0° or −20° were preferred

Table I

Panel assessments of pork samples during storage at various temperatures after receiving 5 Mrads at −75°

R = average rank S = average hedonic score

Storage time, days	Temperature during storage	Appearance	Odour	Flavour	
		R	R	R	S
6	Control		1·0	2·3	7·2
	−20°		2·7	2·9	5·5
	0°		3·4	3·6	5·2
	15°		3·9	4·1	5·0
	25°		4·0	3·4	5·0
	37°		6·0	4·7	4·8
	Significance†		***	*	
30	Control		1·0	1·4	6·5
	−20°		2·7	2·9	4·2
	0°		3·8	3·3	3·9
	15°		4·0	4·3	3·6
	25°		3·5	3·8	3·3
	37°		6·0	5·3	2·3
	Significance		***	***	
93	Control	3·5	1·0	1·2	6·6
	−20°	2·8	2·7	1·9	5·3
	0°	1·5	2·9	3·0	3·8
	15°	2·8	3·8	4·1	2·6
	25°	4·5	5·0	4·8	2·0
	37°	6·0	5·6	6·0	1·3
	Significance	***	***	***	
183	Control	2·0	1·0	1·1	6·5
	−20°	2·9	3·6	2·4	4·3
	0°	2·9	2·7	3·0	3·3
	15°	2·6	3·3	3·5	2·8
	25°	4·6	4·8	5·3	1·4
	37°	6·0	5·6	5·7	1·1
	Significance	***	***	***	
365	Control	4·0	1·0	1·1	6·2
	−20°	2·5	2·2	2·3	4·1
	0°	1·0	2·8	2·6	3·9
	15°	2·5	4·0	4·0	1·6
	Significance	***	***	***	

Table II

Panel assessments of beef samples during storage at various temperatures after receiving 5 Mrads at −75°

Storage time, days	Temperature during storage	Appearance	Odour	Flavour	
		R	R	R	S
7	Control	1·0	1·0	1·4	6·5
	−20°	3·3	4·0	2·3	4·8
	0°	3·2	3·6	4·0	3·8
	15°	2·6	4·5	4·9	3·5
	25°	4·9	3·9	4·6	3·5
	37°	6·0	4·0	3·8	4·2
	Significance†	***	***	***	
34	Control	1·0	1·0	2·2	5·7
	−20°	3·6	3·5	2·9	4·3
	0°	2·0	2·0	3·9	3·9
	15°	3·4	3·8	3·4	4·4
	25°	5·2	4·8	3·1	4·5
	37°	5·8	6·0	5·5	2·1
	Significance	***	***	***	
93	Control	1·0	1·0	1·2	6·3
	−20°	3·5	4·1	2·3	4·7
	0°	3·1	2·9	3·5	4·1
	15°	2·5	2·4	3·8	2·5
	25°	4·9	5·5	4·6	2·1
	37°	6·0	5·1	5·6	1·3
	Significance	***	***	***	
183	Control	1·2	1·0	1·1	6·7
	−20°	3·0	3·0	2·0	5·2
	0°	1·8	2·0	2·9	3·9
	15°	4·0	4·0	4·0	2·3
	Significance	***	***	***	

† The assessment of statistical significance of ranking data in this and other Tables was made using the procedure described by Kendall.[25]

n.s. = not significant * = significant at 5% level ** = significant at 1% level
*** = significant at 0·1% level

to the control. At 25° and 37°, however, the pink colour tended to fade or turn pale brown, and such samples were least preferred.

The comparison in Table III between samples receiving 5 Mrads at −75° or 2 Mrads at room temperature indicate that, in nearly all cases, the samples irradiated while frozen were preferred, although the control was preferred to both irradiated samples. During storage at 37°, there was little difference between the irradiated samples, both showing marked deterioration, but the separate comparisons at other storage temperatures, between samples irradiated either frozen or unfrozen, reveal interesting differences (Table III). These results differ from those in Table I; this may be due to variations in different samples of meat or, more probably, to differences in the responses of panel members on different occasions.

(2) *Odour.*—As seen in Tables I and IV, irradiation of pork invariably produced deleterious changes at once, hence there was always a decided preference for the control samples. During storage, moreover, the general tendency was that the odours became progressively more unpleasant, the samples least preferred being those stored at the higher temperatures. Within

Table III

Comparisons of appearance made by laboratory panel between pork samples which received either 5 Mrads at −75° or 2 Mrads at room temperature (18°) and stored afterwards at various temperatures

Storage conditions	Time of storage, days: 0	7	30	93
	R	*R*	*R*	*R*
At 0°				
Control	1·6	2·0	1·4	1·5
2 Mrads (18°)	2·9	2·4	2·8	2·5
5 Mrads (−75°)	1·6	1·6	1·8	2·0
Significance	*	n.s.	n.s.	n.s.
At 15°				
Control		1·5	1·2	1·0
2 Mrads (18°)		1·9	3·0	3·0
5 Mrads (−75°)		2·6	1·8	2·0
Significance		n.s.	***	***
At 25°				
Control		1·9	1·0	1·0
2 Mrads (18°)		2·9	2·8	3·0
5 Mrads (−75°)		1·2	2·2	2·0
Significance		**	***	***
At 37°				
Control		1·0	1·0	1·0
2 Mrads (18°)		2·4	2·4	2·7
5 Mrads (−75°)		2·6	2·6	2·3
Significance		***	***	**
2 *Mrads* (18°)				
Control		2·3		1·8
−20°		2·9		1·2
0°		2·9		3·0
15°		2·0		4·0
25°		5·0		—
37°		6·0		—
Significance		***		***
5 *Mrads* (−75°)				
Control		1·0		1·3
−20°		3·1		1·7
0°		4·9		3·0
15°		5·6		4·0
25°		4·1		—
37°		2·3		—
Significance		***		***

Table IV

Comparisons of odour made by laboratory panel between pork samples which received either 5 Mrads at −75° or 2 Mrads at room temperature (18°) and stored afterwards at various temperatures

R = average rank

Storage conditions	Time of storage, days: 0	7	30	93
	R	*R*	*R*	*R*
At 0°				
Control	1·0	1·0	1·0	1·0
2 Mrads (18°)	2·7	3·0	3·0	3·0
5 Mrads (−75°)	2·3	2·0	2·0	2·0
Significance	***	***	***	***
At 15°				
Control		1·0	1·0	1·0
2 Mrads (18°)		2·9	3·0	3·0
5 Mrads (−75°)		2·1	2·0	2·0
Significance		***	***	***
At 25°				
Control		1·0	1·0	1·0
2 Mrads (18°)		2·75	3·0	3·0
5 Mrads (−75°)		2·25	2·0	2·0
Significance		***	***	***
At 37°				
Control		1·0	1·0	1·0
2 Mrads (18°)		2·75	2·8	2·0
5 Mrads (−75°)		2·25	2·2	3·0
Significance		***	***	***
2 *Mrads* (18°)				
Control		1·0		1·0
−20°		4·1		2·7
0°		3·3		3·3
15°		2·6		3·0
25°		4·1		—
37°		5·9		—
Significance		***		**
5 *Mrads* (−75°)				
Control		1·0		1·2
−20°		5·1		2·2
0°		4·0		2·7
15°		4·6		4·0
25°		3·6		—
37°		2·6		—
Significance		***		***

this general framework, however, some slight transitory improvements occurred on storage: thus in Table IV among samples receiving 5 Mrads at −75°, after 1 week that stored at 37° was preferred, followed by that held at 25°; among samples given 2 Mrads at room temperature, the preference was for samples stored at 15°, followed by those stored at 0°; and again in Table I, the sample stored at 0° for 6 months showed a slight improvement in relation to the other irradiated samples.

The results in Table IV indicate that, with the single exception of samples stored at 37° for 3 months, the samples receiving 5 Mrads at −75° were significantly preferred to those receiving 2 Mrads at room temperature.

Table V

Comparisons of flavour made by laboratory panel between pork samples which received either 5 Mrads at −75° or 2 Mrads at room temperature (18°) and stored afterwards at various temperatures

R = average rank S = average hedonic score

Storage conditions	Time of storage, days							
	0		7		30		93	
	R	S	R	S	R	S	R	S
At 0°								
Control	1·2	7·2	1·6	6·1	1·3	6·7	1·1	6·7
2 Mrads (18°)	2·7	4·7	2·3	5·0	2·6	4·2	2·7	3·7
5 Mrads (−75°)	2·1	5·5	2·1	5·5	2·1	5·2	2·2	4·7
Significance	***		n.s.		**		***	
At 15°								
Control			1·3	6·3	1·0	7·6	1·0	6·3
2 Mrads (18°)			2·6	3·6	2·7	3·9	2·8	3·1
5 Mrads (−75°)			2·1	4·9	2·3	4·5	2·2	4·1
Significance			***		***		***	
At 25°								
Control			1·1	7·2	1·0	6·5	1·0	6·0
2 Mrads (18°)			2·5	4·1	2·6	3·2	2·5	2·0
5 Mrads (−75°)			2·4	4·6	2·4	3·2	2·5	2·2
Significance			***		***		***	
At 37°								
Control			1·0	7·4	1·0	6·3	1·0	6·1
2 Mrads (18°)			2·8	3·6	2·5	2·2	2·5	1·5
5 Mrads (−75°)			2·2	4·3	2·5	2·4	2·5	1·6
Significance			***		***		**	
2 Mrads (18°)								
Control			1·9	6·2			1·3	6·4
−20°			2·8	5·5			2·3	4·3
0°			3·3	4·9			3·3	2·9
15°			3·7	4·0			3·0	3·8
25°			4·9	4·0			—	—
37°			4·4	4·1			—	—
Significance			**				***	
5 Mrads (−75°)								
Control			1·4	6·8			1·0	5·9
−20°			3·7	4·8			2·1	4·6
0°			4·2	4·6			3·1	3·6
15°			3·5	4·7			3·8	3·0
25°			4·1	4·4			—	—
37°			4·1	4·3			—	—
Significance			**				***	

(3) *Taste.*—From the results shown in Tables I and V, in both cases it is clear that the unirradiated control samples were much preferred, while the average hedonic scores show that the irradiated samples were, in general, of low quality, and became progressively worse during storage, more rapidly at the higher temperatures. The results in Table V show that the irradiated samples improved slightly during storage for 1 week at 0°, a conclusion substantiated by the results in Table I where distinctions between samples were least marked after storage for 1 week.

From Table V, it is apparent that samples given 5 Mrads at −75° were considerably better than those given 2 Mrads at room temperature, during storage for up to 3 months at 0° and 15°; if stored at 25° or 37°, samples irradiated by either method became so distasteful that little distinction could be made between them.

Quality changes in beef

(1) *Appearance.*—Irradiation of beef, even when carried out at −75°, results in a transformation of the red colour to brown. This was the reason for the clear discrimination against irradiated samples shown in Table II. Some slight improvement occurred on storage at 0° or 15° for varying periods; but storage at 25° and 37° caused adverse changes, the brown colour becoming deeper, in places tinged with green.

(2) *Odour.*—There was a unanimous preference for the odour of control samples, as shown in Table II. Among the irradiated samples, after 1 week there was some slight preference for that stored at 0°; on subsequent examinations some preference was shown for those stored at 0° or 15°. After 1 month or longer, samples stored at 25° and 37° were easily ranked as worst.

(3) *Taste.*—A decided preference was always shown for the unirradiated control samples, the samples next preferred being those stored at −20°. Storage for 1 week at 37° or 1 month at 25° effected some slight relative improvement, which, however, was insufficient to offset the general decline in quality during continued storage. After 3 months or longer at 25° or 37°, the samples tasted extremely offensive.

Microbiological examinations

Samples stored at temperatures higher than 5° were routinely examined for sterility. Sixty-five cans which had received 2 Mrads at room temperature were tested; of these one which had been stored at 25° and four which had been stored at 37°, were not sterile. Tests were made on 140 cans which had received 5 Mrads at −75°, and one, which had been stored at 37°, was not sterile. All these non-sterile cans contained pork.

Of the five cans showing signs of contamination after irradiation with 2 Mrads at room temperature, four were blown. Three of these were examined, and two contained very large Gram-positive round-ended rods, which grew anaerobically, and one of which formed terminal swollen spores. These were probably *Clostridia*. No bacteria could be seen in smears from the third can examined, although considerable digestion of the meat had taken place, and no viable bacteria were recovered by subculturing. The can which was not blown contained Gram-positive rods resembling *Clostridia*.

The can containing viable organisms after irradiation with 5 Mrads in the frozen state was blown, had a putrid smell and the meat was disintegrating at the surface. Two organisms were seen in large numbers in smears—a Gram-positive coccoid rod, in short chains, and a very small Gram-positive rod. The former organism grew anaerobically, and was thought to be a *Streptococcus*, while the latter failed to grow on subculture.

Discussion

The quality changes in the beef and pork soon after irradiation were easily detectable and of considerable magnitude, as has frequently been observed before. The only change not considered deleterious was the red colour produced in pork. Otherwise, the immediate changes were so adverse that there seems little prospect of using radiation, unsupplemented by other processing, to sterilise beef or pork.

During storage, moreover, the predominant feature was a further decline in quality, which proceeded more rapidly and extensively at higher temperatures. With pork, the colour only deteriorated when the samples were stored at 25° or 37°, becoming an unattractive pale pink; with beef, a darkening of the brown colour occurred at these temperatures. Some exudation of fluid was noticed during storage; other similar experiments with slices of beef and pork (not described here) have shown that this exudate may amount to 10–15% of the weight of the meat. No systematic observations of texture were made, but panel members commented that a softening was noticeable immediately after irradiation, and further breakdown occurred during storage at the higher temperatures—though not to the extent suggested by Radouco-Thomas.[13] If it is assumed that irradiated samples stored at −20° do not change substantially in quality, slight improvements in odour were apparent in samples of beef held at higher temperatures for particular periods, some temperatures and storage periods being more effective than others; with pork, the improvement was quite pronounced after one week. However, such improvements appear transitory and insufficient to offset the overall loss of quality during

storage. The experiments therefore confirm earlier reports that some benefit arises through short-term high-temperature storage,[14] but that deterioration occurs after longer periods.[6–9, 15]

No attempt was made to characterise the changes in odour and flavour, which others have done.[16] It was noticed, however, that during storage at 25° or 37°, the characteristic 'irradiation' flavour of the meats disappeared, to be replaced by a more nauseating, bitter flavour. Free tyrosine appeared in crystalline clumps on the surface of the meats after prolonged storage, indicating proteolysis which is known to occur during the storage of raw irradiated meats and to which flavour changes have usually been ascribed;[6, 8, 9, 13, 15, 17, 18] in autolysing lambs' liver, however, the appearance of a bitter flavour was not related to the release of free amino-acids.[26] Because of this, most recent investigations have been with meats in which enzymes have been inactivated by heating: but, even with these, there has been deterioration during storage[15, 19] particularly in respect of texture;[20] and evidence of proteolysis has been noticed with meats in which enzymes have been regarded as inactivated.[6, 19, 21] Hence it is reasonable to suppose that even with raw meats, some deterioration may be due to purely chemical, as distinct from enzymic, processes.

Reports on the advantages of irradiating meats while in a frozen condition have been conflicting; some[1, 4, 11] record a beneficial effect, but others do not.[6, 7, 22–24] The results in Tables III–V show a very marked benefit by irradiation at −75°: individually, the separate panel comparisons are characterised by a high degree of statistical significance, and collectively the data afford a striking illustration of the benefit of irradiating pork in a frozen condition. It has been asserted[23] that samples irradiated in a frozen condition deteriorate more rapidly afterwards, particularly in colour, but the results in Tables III–V do not support that view. Elsewhere[4, 11] it has been shown that the degree of protection afforded to meats by irradiation at −75° instead of room temperature may vary between factors of 2·5 and 10, depending on the criteria used in judging quality. In the present experiments, the samples given 2 Mrads at room temperature were generally inferior to those receiving 5 Mrads at −75°, so that the gain due to freezing is obviously by a factor greater than 2·5, in agreement with the earlier work.

The microbiological examinations, which were made for reasons of safety on samples stored at temperatures higher than 5°, showed that about 7% of the samples receiving nominally 2 Mrads at room temperature were not sterile. With the electron source used, the radiation energy was not absorbed uniformly, and the dose deficiency in some parts of the samples may have been as high as 25%. Even allowing for this, however, the high proportion of non-sterile samples found in such a small number of examinations confirms that the first-suggested 'sterilising' dose of 2 Mrads is insufficient. The observation of one non-sterile sample (0·7%) among those receiving 5 Mrads at −75° should not occasion alarm, in view of the non-uniform distribution of absorbed radiation, mentioned above; but it does serve to emphasise the need for rigidly defining radiation processing conditions. It suggests moreover that, if sterilisation is to be attempted at such low temperatures as we have suggested elsewhere,[4] the troublesome micro-organisms may no longer be the spore-forming species but those which have a high radiation resistance in the vegetative state, for example some faecal streptococci.

The various storage changes here described have, in our view, different degrees of importance. The changes of colour, though certainly significant commercially, seem insufficient to make the meats wholly unacceptable. The change in texture, too, is not of a catastrophic nature: there is nothing approaching total liquefaction, as might be expected from prolonged proteolytic changes; and, even after several months under warm conditions, the meat retains sufficient coherence to be cut after cooking. The really serious alterations appear to be those in odour and flavour: because after only a few weeks, they become so marked as to lead to the almost unanimous verdict of increasing degrees of dislike, the flavours being stale and bitter; and with longer storage, they become extremely unpleasant, as the hedonic scores show.

The principal objective of the radiation sterilising process, with meats, has been to make it possible to store fresh meat for long periods under normal warm conditions. The foregoing observations confirm that radiation alone cannot attain this: perhaps even more because of deterioration during subsequent storage, than because of the immediate damaging effects of irradiation, which are now well known. These storage changes in meats are usually ascribed to proteolysis, but it is by no means firmly established that the most deleterious storage change

—that in flavour—is wholly or even mainly due to this cause. At any rate, it is generally agreed that enzymic changes are important, and that they might be obviated by heating. Interest has therefore veered towards the sterilisation of cooked meats, in the expectation that they may deteriorate less during storage, but this does not represent a complete answer.[15, 19, 20] This is, moreover, to relinquish a primary aim of the radiation process, the long preservation under normal conditions of fresh food, and to admit that it cannot at present be achieved by irradiation in the case of raw meat. The alternative is to seek means other than heating for preventing the enzymic changes, for example, pre-slaughter injection of adrenaline, as suggested by the Battelle workers.[13]

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The authors are grateful to Dr. M. J. Thornley and Mr. J. Barlow for the microbiological examinations; to Tube Investments Research Laboratories for providing radiation facilities; and to Dr. R. S. Hannan whose earlier experiments formed the basis for the present investigations.

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JOURNAL OF THE SCIENCE OF FOOD AND AGRICULTURE

ABSTRACTS

MAY, 1961

The general arrangement of the abstracts is as follows: 1.—AGRICULTURE AND HORTICULTURE. 2.—FOOD; also appropriate Microbiological Processes; Essential Oils. 3.—SANITATION, including Water; Sewage; Atmospheric Pollution, etc. 4.—APPARATUS AND UNCLASSIFIED.

INDEX OF AUTHORS' NAMES

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JOURNAL OF THE SCIENCE OF FOOD AND AGRICULTURE

ABSTRACTS

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I.—AGRICULTURE AND HORTICULTURE

General: Soils and Fertilisers

Clay mineral distribution in some rendzinas, red-brown soils, and terra rossas on limestones of different geologic ages. D. H. Khan (*Soil Sci.*, 1960, **90**, 312—319).—Clay minerals were identified and estimated by *X*-ray methods. Rendzina clays are essentially montmorillonitic whilst those of the terra rossas are micaceous. Red-brown soil clays are characterised by a high vermiculite content, the order of abundance of clay minerals being vermiculite > mica > kaolin. Clays from intergrade soils have more kaolin than any others, vermiculite being least abundant. The chlorite content of the clays distinguishes rendzinas from red-brown soils, being absent from the former and present in the latter. In the clays examined, goethite was the only Fe oxide mineral found. Weathering was appreciable in the micaceous materials and was more marked in red-brown soils and terra rossas than in rendzinas. Kaolin minerals have formed in all soils. Decomposition of montmorillonites was not observed in rendzinas but occurred in the others. All soils except rendzinas contained vermiculite minerals.
T. G. MORRIS.

[Electrical] conductivity of clay systems. C. Dakshinamurti (*Soil Sci.*, 1960, **90**, 302—305).—Five clays were converted into the Ca or the K form and suspended in aq. $CaCl_2$ of a concn. suitable for the formation of a thixotropic gel. The gel was concentrated by centrifuging and then by repeated washings with a given electrolyte it was brought to equilibrium with it. The conductivity of the gel so formed (c_g) was compared with that of the equilibrium electrolyte (c_e); their ratio is the relative conductivity c_g/c_e. With a given c_e the c_g/c_e was proportional to the % clay content. At a certain critical concn. the c_g/c_e was 1 at all percentages of clays studied. This concn. varied with the clay. For all c_e above the critical value the c_e/c_g varied directly with the concn. of electrolyte. The relationship between the critical concn. values and the respective cation-exchange capacities of the clays was linear over the range (8—100 mequiv.) of cation-exchange capacity studied.
T. G. MORRIS.

Mull and mor in relation to the soil-water regime of a forest. G. Minderman (*Plant & Soil*, 1960, **13**, 1—27).—In an area covered mainly with oak and birch two types of mull and three types of mor were distinguished. Chemical characteristics of the different forest-floor types are presented and discussed in relation to soil colour and texture, topography and drainage. A. H. CORNFIELD.

Use of tritium from spent uranium fuel elements as a ground-water tracer. J. H. Horton and D. I. Ross (*Soil Sci.*, 1960, **90**, 267—271).—The disposal of radioactive waste by means of seepage basins is discussed. The use of tritium, present in the waste material from reactor fuel processing, is examined as a tracer for the movement of soil water: it affords a satisfactory method to monitor ground-water movements. T. G. MORRIS.

Soil temperature variation (1952—6) at Lexington, Kentucky. E. B. Penrod, J. M. Elliott and W. K. Brown (*Soil Sci.*, 1960, **90**, 275—283).—The amount of solar energy falling on the soil and the soil temp. at depths of 2—10 ft. have been recorded over the period. Soil temp. were taken by thermocouple and readings were taken at intervals of 2 h. The results have been analysed mathematically.
T. G. MORRIS.

Chemical and intake-rate changes with various treatments on Sebree-Chilcott soil series association (slick spots). C. H. Pair and G. C. Lewis (*Soil Sci.*, 1960, **90**, 306—311).—The reclamation of "slick spots" (alkaline Na clay) is discussed. Gypsum at various rates was applied to the soil contained in cylinders driven into the ground, the intake of water being used to measure the conversion of Na- to a Ca-clay. Ten tons of gypsum per acre increased the water intake ten-fold. The max. increase was obtained when the soil profile, which contained gypsum, to a depth of 4 ft. was all mixed together. Both treatments reduced the exchangeable Na but mixing was more effective in facilitating the leaching of sol. salts.
T. G. MORRIS.

Negative and positive adsorption of chloride by kaolinite. J. P. Quirk (*Nature, Lond.*, 1960, **188**, 253—254).—Negative adsorption of Cl^- at pH 9 is less than the theoretical with KCl, but when treated with Na polymetaphosphate adsorption is close to theoretical. When $CaCl_2$ is used positive adsorption predominates, Cl^- adsorption being proportional to concn. at pH >7. Max. adsorption (at pH 3) is 3 mequiv./100 g. and represents a surface area 6 sq.m./g. of kaolinite. A. C.

Loss of [soil-] nitrogen by volatilisation of ammonia. R. Vanstallen (*J. Dairy Sci.*, 1960, **8**, 91—102).—Losses from $(NH_4)_2SO_4$ (0·7%) in loams varying only in pH are negligible at pH 6·2, and (after 3 weeks) are 16% at pH 7·8. Losses increase with the concn. of $(NH_4)_2SO_4$, the % saturation of the soil moisture, and the % of sand in the loam; they are (after 3 weeks) for NH_4NO_3 ~50% less than those from $(NH_4)_2SO_4$. P. S. ARUP.

Variations in [soil-] nitrogen as influenced by crop rotation. J. Livens (*Agricultura*, 1960, **8**, 61—76).—Current methods for determining soil-N are discussed with reference to the author's method. Wheat + clover in comparison with wheat alone, results in considerably more residual soil-N, which remains available to a following oat crop during a large part of the second year. The N from barley or flax remains available only up to the harvest of the first year. The residue of N from flax is greater than that from barley. (15 references.) P. S. ARUP.

Dominant rôle of nitrogen in leaching losses from soils in humid regions. W. A. Raney (*Agron. J.*, 1960, **52**, 563—566).—The extent of loss of Ca + Mg + K (all in mequiv.) through leaching of a sandy soil was very highly correlated with loss of nitrate over 5—7 years at both high and low fertility levels. Loss of bases was poorly correlated with SO_4^{2-} and Cl^- contents of the leachates. The extent of leaching of both N and bases was only roughly correlated with the amount of percolating water. A. H. CORNFIELD.

Recovery of available soil nitrogen by annual fodder crops at Katherine, Northern Territory. R. Wetselaar and M. J. T. Norman (*Aust. J. agric. Res.*, 1960, **11**, 693—704).—After 6 years of an all-grass ley, available soil N at all soil levels to 5 ft. remained low throughout the cropping season and N yield from the fodder crops, fodder sorghum, Sudan grass and bulrush millet, averaged only 17 lb. per acre. After a 7-year ley of Townsville lucerne, available soil N was low at the start of the season, but mineralisation was rapid and on fallowed soil, leachates showed a peak concn. of NO_3^--N at 2—3 ft. The average recovery of N in the three crops was 75 lb. per acre. After 5 years of clean fallow, soil N had been mineralised and leached to a considerable depth, giving 260 lb. of nitrate-N per acre in the 0—5 ft. layer. Bulrush millet depleted soil N throughout the 0—5 ft. layer, and was the most efficient crop for the recovery of deep nitrate-N and its conversion to fodder protein. M. D. ANDERSON.

Forms of phosphate in the soil and their distribution amongst the particle size fractions. F. Scheffer, A. Kloke and K. Hempler (*Z. PflErnähr. Düng.*, 1960, **91**, 240—252).—Calcium phosphate is the predominant form of phosphate in calcareous soils, whilst Fe phosphate and org. P predominate in acid soils. Al phosphate is found in the Fe phosphate fraction but is generally insignificant. The org. P content is decided by the humus content. The Ca phosphate content rises with increasing particle size and reaches max. in the sand fractions, whilst the reverse holds for the Fe and Al phosphates. Org. P is found mainly in the <2μ, 2—6μ and 6—20μ fractions. M. LONG.

Evaluation of laboratory indexes of absorption of soil phosphorus by plants. II. E. J. Thompson, A. L. F. Oliveira, U. S. Moser and C. A. Black (*Plant & Soil*, 1960, **13**, 28—38).—Total P uptake by sorghum in pot tests with 22 soils from different parts of the U.S.A. was compared with various chemical methods of assessing soil P status. The efficiency of the chemical methods for indicating soil P status was in the order, extraction with 0·01N-lactic acid–0·01N-Ca lactate ⩽ 2% citric acid < 0·03N-NH_4F–0·025N-HCl < the "% P saturation" (100 × labile P by isotopic dilution ÷ P adsorption capacity ⩽ labile P by isotopic dilution ⩽ water extraction.
A. H. CORNFIELD.

Effect of water-stress on the absorption of soil phosphorus by wheat plants. R. G. Fawcett and J. P. Quirk (*Nature, Lond.*, 1960, **188**, 687—688).—Rate of uptake of P by young wheat plants on a lateritic podsolic soil, measured with ^{32}P as a tracer, increased with increase of soil content of P in the range 50—600 p.p.m., and was not affected by decreasing soil content of water until the level at which wilting occurred (about 8 p.p.m.). Wilting is associated with damage to the roots. Available soil P is mainly held in fine pores,

which may remain full of water even when the plant is wilting; concn. of available P in these fine pores may be higher than is indicated by displacement techniques. M. D. ANDERSON.

Availability of potassium in some Tasmanian soils. I. Variability of soil potassium in the field and its fractionation. A. M. Graley, K. D. Nicolls and C. S. Piper. **II. Exhaustive cropping in relation to potassium reserves in soil.** C. S. Piper and M. P. C. de Vries (*Aust. J. agric. Res.*, 1960, **11**, 750—773, 774—804).—I. Soils in which difficulties arise after initial increases in productivity following application of superphosphate are regarded as deficient in K. Variations in exchangeable K were very large. About 35% of the exchangeable K was water-sol. The amount of additional K released by boiling with N-HNO_3 for 10 min. was about 90% of that in the exchangeable fraction. Conc. HCl dissolved on the average a further 0·6—0·7 mequiv. per 100 g. In B horizons much of the total K was in the coarser fractions. (25 references.)

II. Samples of five Tasmanian sandy loam soils were used in pots to grow four successive crops. Uptake of K by alternate crops of rye-grass and clover was greatest from soils with highest exchangeable K; applied K was also rapidly taken up by the crops. Applications of K gave no increase in yield until exchangeable K had fallen to 0·10—0·15 mequiv. per 100 g. After the four crops, exchangeable K had fallen to 0·05—0·14 mequiv. per 100 g. Clover showing severe K-deficiency leaf necrosis contained 0·55—0·63% of K; plants with 1·2% of K were free from symptoms. Only small amounts of non-exchangeable K were taken up from these sandy loam soils, but the same crops on an illitic soil with a much higher content of non-exchangeable K took slightly more than half their K from non-exchangeable sources, and exchangeable K did not fall below 0·33 mequiv, per 100 g. When sol. K was added to the former soil, kept moist, all the added K was recovered in exchangeable form after 4 weeks, but when the soils were drier, a small amount of K was fixed in a less available state. Fixation was considerably greater in the illitic soil. (19 references.) M. D. ANDERSON.

Principles and problems of the chemical estimation of the supply of available soil manganese. A. Finck (*Plant & Soil*, 1960, **13**, 39—46).—A critical review and discussion. A. H. CORNFIELD.

Quantitative relationships between content of organic matter in soil and climate. H. Laudelout, J. Meyer and A. Peeters (*Agricultura*, 1960, **8**, 103—140).—Available data show that the relationship expressed by Jenny's exponential equation for soils in temperate climates cannot be applied to soils in tropical climates. A similar equation, but with different parameters, is applicable to the latter, under which the rates of synthesis and decomposition of org. matter are much higher than those under temperate conditions. The causes underlying these differences are considered in detail. (45 references.) P. S. ARUP.

Investigations with radioactively labelled humic acids and precursors. II. H. W. Sharpenseel (*Z. PflErnähr. Düng.*, 1960, **91**, 193—202).—The conversion of pyrogallol-5-carboxylic acid (**I**) into purpurogallin can be detected, the rate being appreciably higher in the presence of mushroom dehydrogenase than in that of diphosphopyridinenucleotadase (DPN). In the soil the formation of brown humic acids from ^{14}C-**I** is similarly affected, and the formation of the former from the latter is proved. M. LONG.

Rôle of mineralisation and leaching of organic deposits from [the leaves] of trees and shrubs in plant nutrition. V. I. Slovikovskii (*Dokl. Akad. Nauk SSSR*, 1960, **132**, 223—226).—Leaching into soil of the P_2O_5, N and the raw ash from leaf deposits of 30 different plants was investigated. From these deposits 20—50% of the P_2O_5 was removed in the first 4 months; the rate was little affected by the degree of leaf decomposition. The leaching of N proceeded at a slower rate, but the total amount of N in the leaf deposits increased due to fixation of atm. N by the micro-organisms. The rate and degree of N removal from leaf deposits by natural ammonification varied considerably, being low in the white beech (*Carpinus betulus*) and very high in the European elder (*Sambucus nigra*) and the Siberian acacia (*Carafana arborescens*). The yields of the raw ash from the deposits exceeded the initial content in all cases, especially in leaves containing the higher contents of alkali and alkaline metals. A. L. GROCHOWSKI.

Chemical constituents of some local weeds. I. Humification of arousa (*Justicia adhotoda*) leaves under constant moisture level and variations in the amounts of carbohydrates. H. K. Jain and A. K. Bhattacharya (*Z. PflErnähr. Düng.*, 1960, **91**, 233—240).—Since mineral N in the soil increases on humification of arousa, this plant is a potential green manure, although non-leguminous. The decomposition of the leaves occurs with the preferential oxidation of carbon compared with that of N. M. LONG.

Gains and losses of nitrogen and depth distribution of nitrogen and organic carbon in the soil of a lysimeter investigation. P. F. Pratt, H. D. Chapman and M. J. Garber (*Soil Sci.*, 1960, **90**, 293—297).—Lysimeters were filled in 1926, left fallow until 1933 and then the soil was sampled and the first crop taken in 1934. Treatments consisted of cereal straw with and without N as $Ca(NO_3)_2$, applied in the winter, and vetch, mustard or melilotus was grown. Over the 20 years of the test there were significant amounts of N fixed when annual legumes were grown in the winter. However, where $Ca(NO_3)_2$ was applied, the amount of N fixed decreased with increasing amounts of applied N. Losses of N by volatilisation when straw was added were insignificant. Over the period, org. C and total N in the top 6 in. increased, but at all other depths there was a decrease initially, followed by an increase (for the 6—12 in. depth) or the attainment of a steady level. T. G. MORRIS.

Use of loamless composts for the propagation of antirrhinums and tomatoes. P. J. Sutton (*Annu. Rep. Glasshouse Crops Res. Inst., 1959*, 1960, 89—98).—Sand–peat mixtures containing a basal fertiliser were at least as effective as John Innes compost (J.I.) in respect of germination of antirrhinum and tomato. Subsequent growth was in most cases as good as in J.I. provided a suitable nutrient solution was used. Growth under conditions of high intensity and long duration of sunlight needs further investigation. It is unlikely that sand–peat composts would need sterilisation before use. A. G. POLLARD.

Plant containers and moulded blocks, with special reference to the porosity of pots. A. C. Bunt (*Annu. Rep. Glasshouse Crops Res. Inst., 1959*, 1960, 116—125).—A review with 37 references. A. G. POLLARD.

A Warburg vessel for soil samples. J. Drobník (*Nature, Lond.*, 1960, **188**, 686).—A Warburg vessel for use with samples of damp soil has a central well for KOH, and supports for an oblong sample-dish of plastic or Al foil. An aperture above communicates with the manometer, and one at the side admits the dish. Samples are weighed directly on the dish, which can easily be removed from the vessel and returned to it. M. D. ANDERSON.

Soil sterilisation: preliminary comparison between Metham-sodium, steam and chloropicrin. W. H. Read (*Annu. Rep. Glasshouse Crops Res. Inst., 1959*, 1960, 105—107).—Steam sterilisation, treatment with Metham-Na (Na *N*-methyldithiocarbamate) (as 50% w/v solution diluted 1 : 200, at 4·5 gal./sq. yd.) and fumigation with chloropicrin (injections of 3·5 ml. at 6 in. depth and 12 in. staggered spacing) were equally effective, crop yields being highly significantly increased in all cases. A. G. POLLARD.

Methods and samplers for obtaining undisturbed soil samples in the forest. H. van Groenewoud (*Soil Sci.*, 1960, **90**, 272—274).—Methods and types of soil samplers for obtaining "undisturbed" samples are briefly discussed. The instrument described is primarily for forest soils. T. G. MORRIS.

Determination of sodium in soil solutions with the glass electrode. J. di Gleria and K. Darab (*Z. PflErnähr. Düng.*, 1960, **91**, 202—205).—The concn. of Na in soil solutions is given by $e = A - k_t \log (C_{Na} \cdot f_{Na})$, where e is the potential of the electrode in the solution, A is the asymmetry potential of the electrode, k_t is a temp.-dependant constant and $\log (C_{Na} \cdot f_{Na})$ is the Brigg's log of the activity of Na in solution. Anions affecting the potential are removed prior to the determination with Dowex 2 resin. The results, so obtained, agree well those from flame-photometric determinations. M. LONG.

Non-burning fertiliser. Anon. (*Farm Chemicals*, 1961, **124**, No. 2, 26—27).—The new fertiliser consists essentially of a $MgNH_4$ phosphate (N, 8; available PO_4^{3-}, 40; MgO, 24%). It causes no injury when applied directly to roots or foliage and was developed primarily for the forestry industry. Field experimental results are briefly recorded. A. G. POLLARD.

Potassium nitrate in mixed fertilisers. J. O. Hardesty, G. F. Dickie and B. M. Olive (*Farm Chemicals*, 1961, **124**, No. 2, 32—38).—Uses of KNO_3 in the production of fertiliser mixtures are discussed with particular reference to their hygroscopicity, caking and granulation. A. G. POLLARD.

By-product wool as a source of fertiliser nitrogen. E. J. Rubins, A. Hawkins and B. A. Brown (*Soil Sci.*, 1960, **90**, 290—292).—By-product wool shreds and dust have been compared with cottonseed meal, castor pomace and N salts as sources of N. In nitrification studies with a fine sandy loam and a loam–sand mixture (1 : 1), wool shreds and dust were nitrified as quickly as was castor pomace on the loam alone, but more slowly on the loam–sand mixture. In greenhouse trials with oats on soil receiving CaO, P, K, Mg and B the yield from wool dust was the same as from cottonseed meal but less than from castor pomace or urea. Field experiments using potatoes showed that wool was equal to castor pomace in N-supplying power when up to 33% of the N was supplied in these forms.

On lawns, wool fibre was more slowly utilised but its effect was more prolonged than that of either urea or castor pomace.
T. G. MORRIS.

Influence of biuret and urea fertilisers containing biuret on maize plant growth and development. S. R. Wilkinson and A. J. Ohlrogge (*Agron. J.*, 1960, **52**, 560—562).—Toxicity symptoms in maize seedlings due to biuret damage are described and illustrated. No toxic symptoms occurred when pure urea was used. The extent of damage increased with level of biuret in the applied urea and was less when the fertiliser was placed a few in. away from the seed than when drilled with the seed. A. H. CORNFIELD.

Determination of ammonia nitrogen in mixed commercial fertilisers by titration with sodium hypochlorite solution. Z. Rezáč and M. Figarova (*Z. anal. Chem.*, 1960, **176**, 115—118).—The sample is treated with Calgon S to keep phosphates in solution and to the neutral solution (pH 7—8) are added $NaHCO_3$ and KBr, and the end-point of the titration with NaOCl is detected by the dead-stop method. The whole procedure can be completed within 15 min. Results are reported and compared with those by the distillation and potentiometric methods. B. B. BAUMINGER.

Comparison between greenhouse and field procedures in phosphate-fertiliser testing. R. L. Hausenbuiller and W. H. Weaver (*Soil Sci.*, 1960, **90**, 298—301).—Ladino clover was grown in the greenhouse on soil taken from the field plots before fertilisation and lucerne was grown in the field on these plots, P being applied in each case. There were highly significant correlations for the relative yields of dry matter and P uptake between greenhouse and field; the greenhouse tests were the more sensitive. T. G. MORRIS.

Manganese oxide and manganese sulphate as fertiliser sources for correcting manganese deficiency in soya-beans. H. J. Mederski, D. J. Hoff and J. H. Wilson (*Agron. J.*, 1960, **52**, 667).—Application of Mn (6 lb. per acre) as $MnSO_4$ to a clay loam was more effective in increasing the uptake of Mn by soya-bean plants (harvested 3 weeks after emergence) than was application as MnO. Combination of the Mn sources with NP, PK or NPK was especially effective in increasing Mn uptake by the plant. Neither source of Mn had any effect on yields. A. H. CORNFIELD.

Plant Physiology, Nutrition and Biochemistry

Phototropy and light-conditioned lengthening of hypocotyl of *Sinapis alba*, L. H. Mohr and E. Peters (*Planta*, 1960, **55**, 637—646).—Inhibition of lengthening, whether in dark red or white illumination, is due to corresponding reductions in cell-length. A theory is advanced to explain the observed failure of unilateral visible long-λ, as opposed to short-λ radiation to produce curvature. (39 references.) P. S. ARUP.

Light dosage and phototropic responses of maize and oat coleoptiles. W. R. Briggs (*Plant Physiol.*, 1960, **35**, 951—962).—The Bunsen–Roscoe reciprocity law is valid only for light dosages of 1000 metre-candle-sec. or less. Negative curvature of oat coleoptiles is interpreted in terms of failure of the reciprocity law. Reciprocity failure in maize coleoptiles is the result of pigment inactivation rather than of a limit imposed by a thermochemical dark reaction.
E. G. BRICKELL.

Activity of enzymes in resting and germinating seeds of *Pinus nigra*, Arn. H. Bartels (*Planta*, 1960, **55**, 573—597).—The activity of glyceraldehyde-phosphate-, lactate, and ethanol-dehydrases in the embryo and endosperm gradually decreases as germination proceeds, whilst that of diphosphofructose-aldolase, phosphotriose-isomerase, malate-dehydrogenase and glutamate-aspartate-transaminase increases; the activity of glutamate-alanine-transaminase increases in the embryo. The relative proportions of most of the enzymes are approx. the same in the resting as in the freshly-germinating seeds. Enzyme activity is a function of embryo-development rather than of time. (39 references.)
P. S. ARUP.

Action of amino-acids, vitamins and other compounds on the germination of lettuce seeds. P. L. Verona (*Ric. sci.*, 1960, **30**, 1391—1396).—Germination tests on lettuce seeds in darkness show that the state of dormancy in lettuce seed can be broken by a wide variety of chemicals, e.g., DL-alanine, L-arginine, cystine and L-glutamic acid, biotin and riboflavin (but not ascorbic acid), desthiobiotin, pepsin, H_2O_2, boric acid and urea, but not by histamine, nicotinic acid, anthranilic acid or quinoline. L. A. O'NEILL.

Acceleration of the mobilisation of carbohydrate from germinating rye seedlings by citrate. W. Rathje (*Z. PflErnähr. Düng.*, 1960, **91**, 205—208).—Citrate accelerates the mobilisation of carbohydrate from the endosperm of germinating rye seedlings, causing increased shoot growth. M. LONG.

Transpiration of wheat plants cultivated under different environmental conditions. C. Florell and H. Rufelt (*Physiol. Plant.*, 1960, **13**, 482—486).—Oscillations in transpiration are marked at 20°, but are non-existent at 15° and much weaker at 25°. Light intensity has effect only at 20°, the lowest light intensity producing the most marked oscillations. Light λ has no effect. M. LONG.

Theory of osmotic water movement. P. M. Roy (*Plant Physiol.*, 1960, **35**, 783—795).—The mechanism of osmotic water movement and the factors which determine its rate are re-examined from a quant. point of view. Osmosis is not strictly a diffusion process and it is suggested that it occurs by bulk flow of water through pores in the membrane, the flow being due to pressure gradients induced within the pores by diffusion at pore apertures.
E. G. BRICKELL.

Field studies of internal moisture relations of the maize plant. L. N. Namken and E. R. Lemon (*Agron. J.*, 1960, **52**, 643—646).—The electrical conductivity of maize stem tissue was primarily related to hydration of the cell wall. Plant stem resistance measurements taken before 8.00 a.m. showed a carry-over effect of moisture stress experienced by the plant during the preceding 24-h. period or longer. Relative turgidity measurements of the leaves showed much less carry-over effect on moisture stress.
A. H. CORNFIELD.

Variations in mineral content of storage tissue disks maintained in tap water. I. R. Macdonald, P. C. DeKock and A. H. Knight (*Physiol. Plant.*, 1960, **13**, 76—89).—After continuous washing during several days in aerated tap water, disks of red and sugar beet, carrot and swedes show evidence of considerable and often selective absorption of cations; the accumulation rates (ratio of internal to external concn.) of Na^+ by red beet and of K^+ by swede tissue reach 2300 and 14,000, respectively. Potato disks, however, show considerable overall decreases, due entirely to losses of K^+. Minor losses of K^+ occur in red beet. Absorption of cations occurs at comparatively lower levels. In the beet, the balance is maintained by increases in oxalic and other org. acids. (19 references.)
P. S. ARUP.

Cation-exchange properties and pectin content of storage-tissue disks. W. M. Crooke, A. H. Knight and I. R. MacDonald (*Plant & Soil*, 1960, **13**, 55—67).—The cation-exchange capacity (C.E.C.) of disks of storage tissue of sugar beet, red beet, potato, carrot and swede turnip kept in running water at constant temp. was measured by an acid-washing technique. There was quant. agreement between C.E.C. and pectin content (CO_2 evolved on decarboxylation) of the disks provided the former was measured on a tissue vol. basis and also providing that in assessing the latter, the substances yielding CO_2 not yet participating in cation-exchange were first removed from the tissue by boiling with water. Both C.E.C. and pectin content of the disks increased with time and reached a max. 3—4 days after the disks were cut from the parent tissue.
A. H. CORNFIELD.

Uptake and utilisation of L-glutamic acid by radish root slices. A. E. Young (*Physiol. Plant.*, 1960, **13**, 104—111).—Max. uptake of amino-N from solutions of the acid, and output of NH_3 (recovered from the solution after 48 h.) occur at concn. ~5·7%. Max. amounts of peptide-N and CO_2 are recovered at concn. ~8·6. (18 references.) P. S. ARUP.

Ion uptake by tissue slices. II. Effect of 2,4-dinitrophenol [DNP] on uptake of calcium by potato slices. R. M. Chasson (*Physiol. Plant.*, 1960, **13**, 124—132).—At 5·9M, DNP increases the uptake of Ca at 20° by potato slices, but decreases that of Rb by potato and carrot slices. Increased uptake of Ca by potato is also observed at 2°. At higher concn. of DNP, the uptake of Ca is further increased, but accumulation of Ca into the vacuoles is reduced. A theory is proposed to account for this dual effect. (14 references.)
P. S. ARUP.

Growth of excised roots. X. Individual amino-acids and acid-hydrolysed casein as nitrogen sources for growth of excised tomato roots. H. E. Street, J. C. Hughes and J. S. Lewis (*New Phytol.*, 1960, **59**, 273—287).—Of 25 amino-acids tested only L- and D-cystine stimulated root growth. The remainder were more or less inhibitory although L-arginine stimulated growth at low pH (4·8). Acid-hydrolysed casein was more effective than NH_4^+ as a N source over a wide pH range, but was as effective as NO_3^- only near to neutrality. When NH_4^+ was the source of N an amino-acid mixture stimulated growth at pH >5·3. L. G. G. WARNE.

Studies of rest period. II. Nitrogen and phosphorus changes in embryonic organs of after-ripening cherry seed. III. Respiratory changes in leaf primordia of maple buds during chilling. H. O. Olney and B. Pollock (*Plant Physiol.*, 1960, **35**, 970—975, 975—977).—II. During after-ripening at 5°, N and P are translocated from the storage to the potentially growing organs of the cherry seed. N remains constant in the cells but P increases. Rest

period may therefore be associated with a block in the phosphate metabolism of the cells.

III. The efficiency of utilisation of the respiratory enzyme system always remains higher in organs approaching growth than in those in which the rest period is not broken (i.e., chilled buds).

E. G. BRICKELL.

Effects of ammonia on plant metabolism and a possible mechanism for ammonium toxicity. H. M. Vines and R. T. Wedding (*Plant Physiol.*, 1960, **35**, 820—825).—The O_2 uptake in a Warburg respirometer was used as an indication of the effect of gaseous NH_3 and NH_4^+ salts on respiration of excised barley roots, garden beetroot disks, as well as leaf disks of spinach and sugar beets, and garden beetroot mitochondria. Gaseous NH_3 and undissociated NH_4^+ in equal concn. inhibited respiration to the same degree; the pH level was important. The site of NH_4^+ toxicity appears to be located in the electron transport system, specifically on the DPNH → DPN reaction. E. G. BRICKELL.

Assimilation of ammonium nitrate introduced by capillary method into tomato plants. E. Macovschi, O. Zaharia and L. Buzilă (*Rev. Chim., Bucharest*, 1960, **5**, 49—56).—Aq. NH_4NO_3 (1%) or distilled water was introduced by a cotton wick to stems of tomato plants (*a*) under normal conditions at 4 weeks old in May or (*b*) in greenhouses at 3 months old in Dec. Rates of uptake of NH_3 and of formation of amino-acids and protein are examined. (22 references.)

A. G. COOPER.

Metabolic and non-metabolic uptake of sodium in roots of *Zea mays*. R. Handley, R. D. Vidal and R. Overstreet (*Plant Physiol.*, 1960, **35**, 907—912).—Meristematic tissue of maize roots possesses little if any ability to absorb Na metabolically, but this develops rather rapidly during maturation. Also because of the relatively long time required for isotopic equilibrium between Na of non-vacuolated tissue and Na in the culture medium, it is concluded that at least part of the cytoplasm is involved in the non-metabolic uptake of that element. E. G. BRICKELL.

Accumulation of potassium, caesium-137 and rubidium-86 in plants grown in nutrient solutions. J. F. Cline and F. P. Hungate (*Plant Physiol.*, 1960, **35**, 826—829).—Adding K to the nutrient substrate reduced ^{137}Cs and ^{86}Rb uptake in bean plants less than expected. Plants discriminated against Cs at low K concn., likewise with Rb. Some toxicity was noted when significant quantities of non-radioactive Cs were in the nutrient solution.

E. G. BRICKELL.

Relative uptake and translocation of potassium and caesium in barley. L. J. Middleton, R. Handley and R. Overstreet (*Plant Physiol.*, 1960, **35**, 913—918).—Results are expressed as the observed ratio (O.R.) of $^{137}Cs/^{42}K$ in the plant and the solution. In excised roots (K up to 1·0 mequiv./l.) O.R. was in the range 0·15—0·25 but in a higher concn. (K up to 10 mequiv./l.) it was approx. 0·4 indicating a lower selectivity for K at this level. When the rate of K uptake was low or when water movement was restricted, the O.R. in the shoots was >1, showing a greater transference of ^{137}Cs.

E. G. BRICKELL.

Strontium in higher plants. II. Distribution and bonding in the plant. G. Schilling (*Z. PflErnähr. Düng.*, 1960, **91**, 212—224).—Both Sr and Ca are similarly distributed in the pea (more in leaves than in stem) due to being carried along in the transpiration stream and left in the leaves after evaporation. Both exist as water-sol. ionised compounds. Sr cannot replace Ca in oxalate excretion of peas. M. LONG.

Manganese deficiency and toxicity in agricultural plants. D. Stenuit and R. Piot (*Agricultura*, 1960, **8**, 141—172).—Visible symptoms are described; agricultural and horticultural plants are classified according to their sensitivity to both influences. Deficiency increases mineral uptake and decreases the production of org. matter; at the same time, the content of Ca, P, Na and MnO in the ash is decreased, that of K is increased, whilst the MgO is unaffected. Poisoning occurs on very acid soils only; the symptoms resemble those of deficiency except for the appearance of black spots consisting of MnO_2 in the midribs. P. S. ARUP.

Competition between chelating agents and roots as factors affecting absorption of iron and other ions by plant species. J. C. Brown, L. O. Tiffin and R. S. Holmes (*Plant Physiol.*, 1960, **35**, 878—886).—*In vitro* experiments demonstrated a competition between chelating agents for Fe; *in vivo* experiments showed that roots react like chelating agents in their capacity to compete for Fe in a growth medium. The competitive effect was overcome by adding more Fe to the nutrient solution. E. G. BRICKELL.

Phosphorus compound metabolism in tissues of different organs of wheat plant. L. A. Zuev and Yu Chun-Byao (*Dokl. Akad. Nauk SSSR*, 1960, **132**, 1434—1437).—Wheat plants were supplied with ^{32}P for periods of 0·5, 1, 2, 4, 6 and 30 h. Phosphorus was present as inorg. phosphates, sugar-phosphates, ribonucleic acid and deoxyribonucleic acid. T. P. BOR.

Ion absorption in young sunflower plants. I. Uptake and transport mechanisms for sulphate. S. Pettersson (*Physiol. Plant.*, 1960, **13**, 133—147).—A rapid uptake of $^{35}SO_4^{2-}$ (which has been added to a nutrient solution) during the first few min. is followed by a constant slow uptake by the roots and shoots. A direct relationship is established between the uptake of the ions and water transport. The influx coeff. decreases with increasing concn. of $^{35}SO_4^{2-}$. The possibility of active and passive transport mechanisms is considered. (23 references.) P. S. ARUP.

Influence of external osmotic conditions upon accumulation of sulphate in leaves. A. Kylin (*Physiol. Plant.*, 1960, **13**, 148—154).—Increased uptake of $^{35}SO_4^{2-}$ with increasing (0—0·8M) concn. of mannitol in the nutrient solution is observed for *Crassula* leaves under illumination, whilst decreases are observed in darkness. Similar differences are observed for *Thuidium* and *Vallisneria* leaves. Differences between the mechanisms of light- and dark-uptake are considered. (15 references.) P. S. ARUP.

Effect of sucrose sprays on growth of tomatoes. A. M. M. Berrie (*Physiol. Plant.*, 1960, **13**, 9—19).—The sprays produce max. responses under conditions in which photosynthesis is limited by day length, and especially when the rate of respiration is high and that of photosynthesis low. P. S. ARUP.

Accumulation and transformation of sugars in sugar cane stalks. K. T. Glaziou (*Plant Physiol.*, 1960, **35**, 895—901).—The rates of accumulation for glucose and sucrose in tissues from very young internodes were 6 and 15 times higher respectively than from tissues from mature internodes; the ratio varied from 3·4 to 9·7. Immature tissues were 8—10 times more permeable to reducing sugars than to sucrose. The latter may act as a source of glucose and fructose. Efflux of sugars from tissues in water is not closely correlated with the sugar content of the tissue. A working hypothesis is presented entailing a carrier which mediates the accumulation process and is located in a permeability barrier (tonoplast membrane) separating the outer and inner space of the tissue.

E. G. BRICKELL.

Rôle of the grain coat in wheat-grain development. A. H. G. C. Rijven and C. A. Banbury (*Nature, Lond.*, 1960, **188**, 546—547).—The thin grain coat exerts a strong metabolic influence on the developing wheat-grain, the early peak in glutamyl transferase activity being associated with the early development of the coat. The distribution of phosphatase in the developing grain is examined. (14 references.) W. J. BAKER.

Polyphenols and polyphenol-oxidases in leaves of *Solidago virgaurea*. O. Björkman and P. Holmgren (*Physiol. Plant.*, 1960, **13**, 582—594).—Chlorogenic acid, a chlorogenic isomer, rutin and a kaempferol glucoside are the most abundant phenolic constituents of the leaves and increase with age. Flavol contents are lower and only an alpine form is found to contain appreciable amounts of anthocyanin. Monohydric phenols are not oxidised by crude polyphenol-oxidase prep., but the oxidation of several *o*-dihydric phenols is stimulated. Chlorogenic and caffeic acids are the most easily oxidised whilst rutin is hardly affected. M. LONG.

Relative penetrating ability of different plant roots. H. M. Taylor and H. R. Gardner (*Agron. J.*, 1960, **52**, 579—581).—The penetrating ability of plant roots was studied using wax substrates of varying rigidity. Although root-penetrating ability varied with species, the penetrating ability of legume roots was not significantly different from that of non-legume roots. A. H. CORNFIELD.

Removal of heavy metal and halide contamination from macronutrient salts. D. N. Munns and C. M. Johnson (*Plant Physiol.*, 1960, **35**, 978—981).—Heavy cations are co-precipitated with $Mg(OH)_2$, and the halides are removed by wetting the dry salt with conc. HNO_3 and evaporating it to dryness. E. G. BRICKELL.

Determination of calcium, magnesium, potassium and sodium in plant material. A. Henriksen (*Tidsskr. Planteavl*, 1960, **64**, 530—552).—Recently published rapid methods are examined and applied to the analysis of the HNO_3 extract of plant ash. Phosphate is accurately determined by the vanadate-molybdate colorimetric method. After removal of PO_4^{3-} by pptn. with $FeCl_3$ or $ZrOCl_2$ at pH 4, Ca and Mg are determined by complexometric titration and Na and K by flame-photometry. The max. range of error is 1·5% for Ca, K and Na, and 2·3% for Mg. The results agree well with those obtained by previously used methods.

P. S. ARUP.

Biochemistry and physiological development of sprouting and flower initiation in sugar beet. I. Experimental influencing of flower initiation, and chemical detection of free β-indolylacetic acid.

G. Schneider (*Planta*, 1960, **55**, 669—686).—No morphological differentiation between flowering and non-flowering shoots is detectable earlier than two weeks after vernalisation. The impulse to flower initiation is not transmitted to neighbouring shoots. Vernalisation cannot induce flower initiation in N-starved plants. Short irradiation with u.v. light inhibits flower initiation. Spraying with β-indolylacetic acid (**I**) or tri-iodobenzoic acid does not affect flower initiation. No free **I** is detectable in extracts of the leaves; aq. extracts contain a substance capable of decomposing synthetic **I**. (47 references.) P. S. ARUP.

Active state of auxin in wheat roots. P. Fransson (*Physiol. Plant.*, 1960, **13**, 398—428).—Wheat roots contain a factor inhibiting the germination of cress seeds; this action is countered by the anti-auxin, *p*-chlorophenoxyisobutyric acid (**I**), but is restored by indolylacetic acid (**II**). The free form of **II** in aq. extracts of the roots increases after addition of **I**. The inhibitory factor is probably a complex of **II** of which a peptide is a possible component. (50 references.) A. G. POLLARD.

Changes in acid growth substances in terminal buds of longleaf pine saplings during the breaking of winter dormancy. R. M. Allen (*Physiol. Plant.*, 1960, **13**, 555—558).—The greatest changes are an increase in a promoter whose R_F value is similar to that of indolylacetic acid and a decrease in an inhibitor whose R_F value is similar to that of inhibitor β. M. LONG.

Auxin production by mycorrhizal fungi. J. M. Ulrich (*Physiol. Plant.*, 1960, **13**, 429—443).—Mycorrhizal fungi fall into three groups based on their indole metabolism. All species of *Boletus*, except *B. badius*, produce indolylacetic acid (IAA) and generally no other indole. *B. badius* produces IAA initially but this disappears after a few days, its place taken by unidentified indole compounds. *Coprinus comatus* behaves similarly, having an active IAA oxidase system. The *Amanita* species produce many unidentified indole compounds, as well as IAA. M. LONG.

Dissociation of the effects of auxin on metabolism and growth of cultured tobacco pith. E. H. Newcomb (*Physiol. Plant.*, 1960, **13**, 459—467).—At 5—15.10^{-4}M, phenylthiourea normally completely inhibits ascorbic oxidase activity and growth, but permits a large respiratory increase in presence of auxin and does not greatly reduce respiration in the absence of auxin. M. LONG.

Effect of mycorrhizal fungi and auxins on root development of sugar pine seedlings (*Pinus lambertiana*, Dougl.). J. M. Ulrich (*Physiol. Plant.*, 1960, **13**, 493—504).—A mycorrhizal association forms between sugar pine roots and either *Boletus badius* or *B. variegatus* which has no effect on root development. Dichotomously branched shoot roots are not caused by indolylacetic acid concn. up to 10^{-4}M, but with higher concn. root elongation is inhibited. Roots destroy the compound. Indolylacetonitrile at 10^{-6}M causes dichotomy after 2 weeks. M. LONG.

Effect of indolylacetic acid [IAA] on rate of elongation of root hairs of *Agrostis alba*, L. W. T. Jackson (*Physiol. Plant.*, 1960, **13**, 36—45).—The rate of elongation of root hairs is immediately increased by IAA at 10^{-13}M in an inorg. culture solution, and inhibited at concn. 10^{-6}—10^{-3}M; the rates show no correlation with the rates of cytoplasmic streaming. No effect is observed on the elongation of the root itself. The significance of these findings is considered. P. S. ARUP.

Antagonism of auxin and kinetin in apical dominance. II. Transport of indolylacetic acid in pea stems in relation to apical dominance. M. Wickson and K. V. Thimann (*Physiol. Plant.*, 1960, **13**, 539—554).—Excised pea stems transport ^{14}C-labelled IAA without loss of biological activity, sections cut just below the apex transporting at a greater rate than older sections. Transport is largely basipetal but acropetal movement takes place in both stem and lateral buds. Conditions favouring bud growth, e.g., light, kinetin treatment or decapitation some days before excision, reduces the radioactivity of the tissue. The content of ^{14}C in a developing lateral bud after treating stem with labelled IAA is related to the inhibition thus re-established. Hence, IAA applied to the stem does reach the lateral buds. M. LONG.

Effects of kinetin on growth of excised tomato roots. D. N. Butcher and H. E. Street (*Physiol. Plant.*, 1960, **13**, 46—55).—Growth of the excised roots in media containing $\geq 1{\cdot}5\%$ of sucrose was inhibited by kinetin ($6{\cdot}25$ and $12{\cdot}5 \times 10^{-9}$ g./ml.). With 3% of sucrose in the medium kinetin increased linear growth, extended the duration of meristematic activity in the main root and counteracted the "ageing" effects of gibberellin and of naphthylacetic acid. A. G. POLLARD.

Changes in nitrogen in pea stem sections under action of kinetin. K. V. Thimann and M. M. Laloraya (*Physiol. Plant.*, 1960, **13**, 165—178).—The presence of kinetin and IAA in a nutrient sucrose solution doubles the rate of protein synthesis in the bud and stem within 5 days. The effect of externally applied kinetin is localised. The kinetin is probably incorporated in a biologically active nucleic acid. Uptake of ^{14}C-labelled leucine by wounded surfaces and its subsequent decarboxylation is scarcely affected by the presence of kinetin. P. S. ARUP.

Effect of adenine and kinetin on growth and differentiation of lupinus. N. Fries (*Physiol. Plant.*, 1960, **13**, 468—481).—Both adenine and kinetin strongly stimulate growth in lupin seedlings in total darkness, but only very slightly if the roots are in light. Kinetin causes great increases in shoot and lateral root growth rates, as well as in dry wt. of all plant organs. Higher concn. inhibit mean root elongation; still higher concn. cause abnormal growth. If decotylised, shoot and lateral root growth are not stimulated. M. LONG.

Growth response of wheat roots to antiauxins and 2,3,5-tri-iodobenzoic acid. L. Eliasson (*Physiol. Plant.*, 1960, **13**, 505—512).—The concn. of endogenous auxin is held at an optimum for wheat roots grown in narrow glass tubes through which fresh nutrient solution flows continuously. Only slight, if any, increases in growth occur in the presence of anti-auxin; 2,3,5-tri-iodobenzoic acid at low concn. does not inhibit growth. Anti-auxins have a time-dependent stimulatory action on root elongation, apparent after 2 or more days, treatment. M. LONG.

Nature of growth-promoting action of coumarin. J. Neumann (*Physiol. Plant.*, 1960, **13**, 328—341).—Coumarin (**I**) stimulates the elongation of the hypocotyls of sunflowers, peas, beans and oats. The effect of **I** at 50 mg./l. together with IAA in various concn. is additive, but at higher concn. of **I**, less than additive. Pretreatment of the hypocotyls with **I** 3 h. before treatment with IAA produces a synergistic effect which is not reproducible with reversal of the treatments. The results of these and other experiments suggest differences between the sites of action of **I** and IAA. (17 references.) P. S. ARUP.

Growth-regulating properties of root extract of water hyacinth (*Eichhornia speciosa*, Kunth.). S. M. Sircar and M. Kundu (*Physiol. Plant.*, 1960, **13**, 56—63).—The (cold water) extract accelerates shoot growth and retards root growth in seedlings of cereals and other plants. The effects differ in some respects from those produced by gibberellic acid or IAA. (12 references.) P. S. ARUP.

Effect of streptomycin on flowering of two *Xanthium* species. A. K. Khudairi (*Physiol. Plant.*, 1960, **13**, 1—8).—Treatment of the upper surface of growing leaves with aq. $0{\cdot}2\%$ streptomycin prevents the development of chloroplasts. Plants with a single green expanded leaf respond to photoperiodic flower initiation, whilst plants with a single treated leaf fail to do so. Mature leaves are not affected by the treatment. Similar treatment with gibberellin solution promotes floral development, but does not neutralise the effect of streptomycin when applied to leaves which have already been bleached. (15 references.) P. S. ARUP.

2-Chloroethyltrimethylammonium chloride and related compounds as plant growth substances. V. Growth, flowering and fruiting responses as related to those induced by auxin and gibberellin. S. H. Wittwer and N. E. Tolbert (*Plant Physiol.*, 1960, **35**, 871—877).—2-Chloroethyltrimethylammonium chloride suppressed the gibberellin- and light-induced germination of lettuce seed, vegetative extensions of genetically dwarf and normal plants, elongation of plants in light and dark, and flowering of lettuce. With Biloxi soya-beans flowering was not affected but vegetative growth was induced under long days. Elongation of *Avena* coleoptile sections was suppressed both in the presence and absence of indolyl-3-ylacetic acid. E. G. BRICKELL.

Action of plant growth regulators. III. Adsorption of aromatic acids to oat monolayers. R. C. Brian (*Plant Physiol.*, 1960, **35**, 773—782).—The measurement of adsorption values of a series of chloro- and methyl-phenoxy- and phenyl-acetic acids and benzoic acids to monolayers from oat leaves is reported. The results indicate how the acids are adsorbed and in what relative quantities. E. G. BRICKELL.

Metabolism of plants treated with 3-amino-1,2,4-triazole. C. G. McWhorter and W. K. Porter (*Physiol. Plant.*, 1960, **13**, 444—449).—3-Amino-1,2,4-triazole produces chlorotic tissue in maize and the seeds from such plants have a more active lipoxidase system and a higher fat content than those from untreated plants which, however, have less total carbohydrate and a greater aldolase activity. NaF causes the same amount of inhibition, but iodoacetate and malonic acid cause more in the chlorotic tissue. Chlorotic plants metabolise fats, whilst untreated plants metabolise carbohydrates. M. LONG.

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Physiological effects of gibberellic acid. II. On starch hydrolysing enzymes of barley endosperm. L. G. Paleg (*Plant Physiol.*, 1960, **35,** 902—906).—A substantial increase in β-amylase activity as well as the initiation of α-amylase activity and a third enzyme (*E*), similar to α-amylase, occur in the endosperm as a response to gibberellic acid. *E* is capable of causing, in conjunction with β-amylase, the hydrolysis of more than 60% of the starch present in the amylolytic assays. E. G. BRICKELL.

Effect of pre-harvest foliar sprays of gibberellin on yield and storage breakdown of celery. M. J. Bukovac, S. H. Wittwer and J. A. Cook (*Mich. agric. Exp. Sta. Quart. Bull.*, 1960, **42,** 764—770).—When applied as foliage spray to celery 2—3 weeks before harvesting gibberellin (50 and 100 p.p.m.) increased the length of petioles and, frequently, the fresh wt. of trimmed stalks. Treated plants showed a tendency toward some twisting of petioles, production of seed stems, a shorter harvest period and accelerated breakdown in storage. A. G. POLLARD.

Effect of gibberellin on mineral composition of year-old Montmorency cherry trees. L. N. Lewis and J. Hull, jun. (*Mich. agric. Exp. Sta. Quart. Bull.*, 1960, **42,** 784—786).—Foliar sprays of gibberellin (100—1000 p.p.m.) lowered the Ca and B and increased the N % in the leaves (dry basis). The % of P, K, Mg, Mn, Fe and Cu were unaffected. A. G. POLLARD.

Effects of gibberellic acid on safflower. D. M. Yermanos and P. F. Knowles (*Agron. J.*, 1960, **52,** 596—598).—Foliar applications of gibberellic acid (10—100 p.p.m.) to five varieties of safflower depressed seed yields and % of oil in the seed, but had no effect on seed wt. and I val. of the oil. The treatments also induced earliness, internode elongation, sterility and chlorosis and increased the incidence of *Phytophthora* root rot. A. H. CORNFIELD.

Fruit-setting of apples using gibberellic acid. R. M. Davison (*Nature, Lond.*, 1960, **188,** 681—682).—When gibberellic acid was applied as a 1% lanolin paste to the cut surfaces of apple flowers from which petals, stamens and style had been removed, most of the flowers (but none of the controls) appeared to have set. There was a heavy drop of fruit 5—7 weeks later. Of the treated flowers of three varieties 8—40% developed into mature fruits, slightly smaller, on an average, than normal fruit. With normal pollination, fruit was harvested from 10—15% of flowers. The colour, time of ripening and general quality of the treated fruits were normal, but a no. of them developed lopsidedly.
M. D. ANDERSON.

Influence of iron and gibberellic acid on the light sensitivity of roots. H. Burström (*Physiol. Plant.*, 1960, **13,** 597—615).—Light inhibition of meristematic activity and cell elongation are independent. The latter depends on the supply of Fe and gibberellic acid. Fe inhibition of cell elongation is reversed by gibberellic acid in light but not in darkness. Gibberellic acid also reduces chlorophyll formation and meristematic activity particularly in darkness.
M. LONG.

Interaction of gibberellin and auxins in lamina joints of excised rice leaves. E. Maeda (*Physiol. Plant.*, 1960, **13,** 214—225; cf. *ibid.*, 204).—Gibberellin alone (100 mg./l.) and IAA, IBA, NAA or 2,4-D alone (at 10 mg./l.) caused slight increases in the angles between the lamina and shoot axis of the previously soaked leaves, floating on water. The effect of gibberellin was slightly synergistic with low concn. but antagonistic towards optimum of higher concn. of the above growth substances. The combined effects of gibberellin and TCBA differed, as regards operative concn., from those found for gibberellin together with the other growth substances. (17 references.) P. S. ARUP.

Enhancement of gibberellin growth-promoting activity by hydrangenol isolated from leaves of *Hydrangea macrophylla*. S. Asen, H. M. Cathey and N. W. Stuart (*Plant Physiol.*, 1960, **35,** 816—819).—The aglycone of hydrangenol (8,4′-dihydroxy-3,4-dihydroisocoumarin) by itself possessed little or no biological activity but when applied to several test species it enhanced the activity of low concn. of applied gibberellin. E. G. BRICKELL.

Crops and Cropping

Carbohydrate relationships in the wheat plant and wheat starch extracted from mottled and unmottled grain. H. L. Wood (*Aust. J. agric. Res.*, 1960, **11,** 673—685).—In some areas of Queensland the ears of wheat contain a proportion of yellow opaque grains. This "mottled" grain contains less protein and more starch than does normal unmottled wheat of the same variety; flour from mottled wheat is unsatisfactory for bread-making. Irrespective of variety and mottling, starches extracted from mature grain contained 22·4% of amylose, and no differences were detected between them. Amylose in young developing grain had a shorter polysaccharide chain than that from mature grain. Sucrose was the main carbohydrate in the developing wheat plant, increasing markedly when the ears were developing on the tillers (11 to 13 weeks after emergence), and decreasing as the content of starch in the ears increased (14th to 19th weeks). Reducing sugars never accumulated to any extent in any part of the plant. (34 references.) M. D. ANDERSON.

Effect of clipping and nitrogen fertilisation on forage and grain yields of spring oats. F. P. Gardner and S. C. Wiggans (*Agron. J.*, 1960, **52,** 566—568).—Clipping oats at the 4-, 5- and 7-leaf stage gave respectively 100, 350 and 2600 lb. of dry forage per acre and reduced grain yields by 9, 28 and 98% respectively. Grain yields were reduced by 40% and 100% with two and four additional clippings respectively following the initial clipping at the 4-leaf stage. Repeated clippings sharply reduced test wt., whereas single clippings at the 4- or 5-leaf stage had no effect on test wt. The clipping effects were similar at both levels of N and for the two varieties studied. A. H. CORNFIELD.

Increasing the initial growth of rye plants by coating the seed with calcium nitrate. W. Rathje (*Z. PflErnähr. Düng.*, 1960, **91,** 208—211).—Coating the seed with 3% of their wt. of $Ca(NO_3)_2$ causes an increase of growth similar to that by the optimal concn. of $Ca(NO_3)_2$ in solution. This increase is significant statistically after 34 days. Yield may also be favourably affected. M. LONG.

Evaluation of dry-subsurface and wet-surface ammonium sulphate application for rice. F. Amer (*Plant & Soil*, 1960, **13,** 47—54).—A comparison of dry-subsurface application of $(NH_4)_2SO_4$ (**I**) (ploughed into the soil prior to flooding) with wet-surface application (50% of applied **I** broadcast at tillering and the rest before heading) was made for waterlogged rice. Rice yields were higher at all levels of applied N (10—40 kg. N per feddan) with the dry subsurface than with the wet-surface method of application. The apparent recovery of applied N by the crop ranged from 53 to 84% with dry-subsurface and from 38—49% with the wet-surface application. The % recovery of N decreased with rate of application.
A. H. CORNFIELD.

Relative absorption of phosphorus by rice plants from native and additive sources, using radioactive phosphorus as a tracer. Maung Mya Thaung (*Soil Sci.*, 1960, **90,** 284—289).—Rice plants were treated at different intervals of time after transplanting with ammonium dihydrogen phosphate labelled with ^{32}P. Plants were removed weekly and analysed for total P and ^{32} P. During the first 7—9 weeks the plants receiving P 9 days after transplanting absorbed more and more added P. Plants supplied with P 54 days and 80 days after transplanting preferentially derived more of their P from the soil. The highest response in yield, the largest no. of panicles and the tallest plants were in those receiving their P 9 days after transplanting. T. G. MORRIS.

Chemical composition of kernel fractions of maize samples varying in amylose content. M. S. Zuber, W. L. Deatherage, C. O. Grogan and M. M. MacMasters (*Agron. J.*, 1960, **52,** 572—575).—Kernel fractions of maize samples varying widely in amylose content showed that amylose % was negatively correlated with endosperm wt. and starch % and positively correlated with pericarp wt., germ wt., endosperm protein % and endosperm oil %.
A. H. CORNFIELD.

Maleic hydrazide, a sprout-inhibiting medium for potatoes. F. Hansen (*Tidsskr. Planteavl*, 1960, **64,** 417—448).—No useful results are produced by sprayings during or after flowering. (22 references.) P. S. ARUP.

Response of orchard grass, *Dactylis glomerata* L., to nitrogen fertilisation and time of cutting. J. M. Scholl, T. H. McIntosh and L. R. Frederick (*Agron. J.*, 1960, **52,** 587—589).—The effect of application of N (40—80 lb. per acre) as NH_4NO_3 (**I**) or aq. NH_3 (**II**) to the grass sown 4 years previously on a silty clay loam was studied. Dry matter yields were increased to a greater extent by **I** than by **II** at the first cutting, but the reverse was true by the third cutting. The total seasonal yield was greater with **I** than with **II**. There was a fair residual effect on yields in the year following application of N. The apparent recovery of applied N was greater from **I** than from **II**. Dry matter yields were somewhat higher when the first cutting was made on May 30 than when made earlier in the month during the year following N application. Total uptake of N was little affected by time of first cutting. A. H. CORNFIELD.

Root development of Coastal Bermuda-grass with high nitrogen fertilisation. E. C. Holt and F. L. Fisher (*Agron. J.*, 1960, **52,** 593—596).—Root wt. per acre of the grass established 2—3 years previously was little affected by application of N. (0—1600 lb. per acre), even though forage yields were greatly increased. There was a tendency towards deeper root distribution with increasing level of

applied N. Root-N% increased with N application, particularly near the surface. Over 5 years the % of org. matter in the 0—4 in. soil layer increased to a greater extent where N was applied than where no N was applied. A. H. CORNFIELD.

Salt tolerance of twenty-five strains of *Agropyron*. D. R. Dewey (*Agron. J.*, 1960, **52**, 631—635).—The salt tolerance of 25 strains, representing 14 species, of *Agropyron* was measured in the field and laboratory. In general forage yields decreased with increasing salinity (0—18,000 p.p.m. NaCl + $CaCl_2$) of the irrigation water. There were considerable differences in salt tolerance due to variety and strain. *A. elongatum* was the most, and *A. inerme* and *A. spicatum* were the least, tolerant. Germination % decreased and germination time increased with increasing salinity and there were differences due to variety and strain at all salinity levels. A. H. CORNFIELD.

Effect of soil moisture regime on root distribution of warm season forage species. B. D. Doss, D. A. Ashley and O. L. Bennett (*Agron. J.*, 1960, **52**, 569—572).—The depth of rooting of five species of grasses decreased with increasing soil moisture regime. Sericea and dallis grass showed the least and common and coastal Bermudagrasses and Bahia grass the greatest rooting depths with all moisture regimes. A. H. CORNFIELD.

Effect of nitrogen fertiliser on yield and protein content of lucerne and companion crops. C. R. Carter and H. D. Foth (*Mich. agric. Exp. Sta. Quart. Bull.*, 1960, **42**, 737—743).—Application of N fertilisers [$(NH_4)_2SO_4$, NH_4NO_3, urea] increased the yield and protein content of lucerne under glasshouse conditions but not when applied with the seed sown with a companion crop (oats, barley), in the field. Under these conditions the companion crop increased in yield and protein content. When applied as a top-dressing to an established stand of lucerne the fertilisers did not affect the yield or protein content of the forage. Spring top-dressings of N on lucerne established in wheat lowered the yield of lucerne at the first cutting. A. G. POLLARD.

Establishment and fertilisation of legume–bromegrass hay. H. D. Foth, R. M. Swenson and R. L. Cook (*Mich. agric. Exp. Sta. Quart. Bull.*, 1960, **42**, 744—746).—Effects of time of sowing, soil moisture level, the nature of the accompanying cereal crop and fertiliser treatment on the yield and botanical composition of the herbage cut twice annually over 2 or 4 years are recorded. A. G. POLLARD.

Effect of varying row spacing and seeding density within rows of the perennial grass component of a mixed sward. W. D. Andrew (*Aust. J. agric. Res.*, 1960, **11**, 686—692).—The perennial grass *Phalaris tuberosa* was sown in rows 7, 21 and 35 in. apart, and the annual legume *Trifolium subterraneum* was oversown in rows 7 in. apart at right angles to the grass rows. Superphosphate was applied annually, and the grass was not allowed to produce seed. N was applied in the 5th, 6th and 7th years of the experiment; response decreased with increasing distance between the rows of grass. In most years yields of forage were greater from the plots with the more widely spaced rows of grass. The response of the legume is attributed to greater development in the extra space available, and that of the grass to increased symbiotic fixation of N by the legume. Doubling the number of grass seeds sown in the rows had no effect on the yields of grass or legume. (11 references.) M. D. ANDERSON.

Effects of harvesting an oat companion crop at four stages of maturity on the yield of oats, on light near the soil surface, on soil moisture and on the establishment of lucerne. L. J. Klebesadel and D. Smith (*Agron. J.*, 1960, **52**, 627—630).—Dry matter yields of an oat companion crop, sown with lucerne during April–May, were highest when harvested at the late milk–early dough stage and lowest when cut at the 12—16 in. height stage. Protein yields were highest when the crop was cut at either of these stages, intermediate when cut at the boot stage and lowest when cut at maturity. Soil moisture was depleted to the greatest extent when the crop was allowed to mature before cutting. Lucerne suffered from lack of light through screening by the oat companion crop only when harvesting of the latter was delayed until the late milk stage or beyond. Although harvesting the oat crop at maturity resulted in thinner lucerne stands than at the immature stages, yields of lucerne the following year were little affected by time of harvesting of the oats the previous year. A. H. CORNFIELD.

Time and rate of application of Nitro-chalk for strawberries. A. Henriksen (*Tidsskr. Planteavl*, 1960, **64**, 449—454).—Max. increases in yields (~30%) are obtained with 400 kg. of Nitro-chalk per hectare on heavy loam. Nitro-chalk is much less effective on lighter soils, and can decrease yields on sandy soil. The rate or time of application has no effect on the size of the berries. The no. of runners increases with increasing applications. P. S. ARUP.

Growth and mineral content of carrots and beans as related to varying osmotic and ionic-composition effects in saline-sodic sand cultures. J. V. Lagerwerff and J. P. Holland (*Agron. J.*, 1960, **52**, 603—608).—Sand culture tests on carrots and red kidney beans at varying levels of salinity and Na adsorption ratio were carried out. The tolerance of the plants for Na depended on the level of salinity, and the tolerance for salinity on the Na level of the growth medium. The effect of the treatments on the uptake of the major elements is also reported. A. H. CORNFIELD.

Effect of plant spacing, fertility and irrigation managements on grain sorghum production. D. W. Grimes and J. T. Musick (*Agron. J.*, 1960, **52**, 647—650).—Trials over 7 years on a clay loam showed that narrow rows produced considerably higher grain sorghum yields than did wider rows with identical plant populations. Plant populations ranging from 56,000 to 224,000 per acre did not materially influence yields although with high level of irrigation max. yields were usually obtained with 100,000 plants per acre. Slight yield increases were obtained by application of 80—100 lb. N per acre in two years. A. H. CORNFIELD.

Nutrition of forest tree seedlings. III. Mineral nutrition of pine. T. Ingestad (*Physiol. Plant.*, 1960, **13**, 513—533).—Deficiency symptoms appearing at low levels of supply of N, P, K, Mg, Ca and Fe, are not specific. Needle analysis is more reliable as an index of nutrient status. Optimum nutritional levels lead to the following needle analyses: N, 2·4—3·1; P, 0·13—0·28; K, 0·7—1·6; Ca, 0·05—0·24; and Mg, 0·12—0·2%. Nutritional requirements of pine at max. growth are less than those of birch but higher than those of spruce. M. LONG.

Soil disinfection and nutrient status of spruce seedlings. T. Ingestad and N. Molin (*Physiol. Plant.*, 1960, **13**, 90—103).—Improvements in the condition of the seedlings observed after fumigation (with MeBr or formaldehyde) of the soil (comparatively free from parasites) can be only partly attributed to possible improvement of the nutritive capacity of the soil. Direct or indirect effects of changes in the soil micro-flora are considered to be the most likely operative factors. (49 references.) P. S. ARUP.

Nitrogenous fertilisation of cotton: effect of the secondary ions of various fertilisers. R. Aguirre (*Chil. Nitrate agric. Serv.*, 1960).—The ratio of base : cation in a fertiliser determines its effect on soil pH, and $NaNO_3$ has more than sufficient base to neutralise acidity introduced by utilisation of its N content. For cotton, Na^+, if present in sufficient quantity, can diminish losses of K^+ by irrigation and drainage. (13 references.) L. G. L. UNSTEAD-JOSS.

Mineral deficiency and organic constituents in tobacco plants, I. Alkaloids, sugars and organic acids. II. Amino-acids. T. C. Tso, J. E. McMurtrey, jun., and T. Sorokin (*Plant Physiol.*, 1960, **35**, 860—864, 865—870).—I. The relative differences in alkaloids, sugars and org. acids due to deficiencies of N, P, K, Ca, Mg, S or B are reported and the important effect of each element on the plant is clearly indicated.

II. Relative changes of amino-acids due to deficiencies of N, P, K, Ca, Mg, S and B are reported. In general, with the exception of N, deficiencies caused an increase in free amino-acids in the plants. E. G. BRICKELL.

Physical and chemical properties of Michigan peppermint oil. W. M. Laughlin (*Mich. agric. Exp. Sta. Quart. Bull.*, 1960, **42**, 787—793).—With advancing age of the plants the sp. optical rotation, % of esters and total menthol contents increased and the % of menthone diminished. Application of Zn, Cu, I_2, SiO_2 or Cr to the soil did not affect the yield or characteristics of the oil. A. G. POLLARD.

Pest Control

Protection of crops by seed coating. J. Lhoste (*Chim. et Industr.*, 1960, **84**, 557—570).—A review. (74 references.) A. C.

Pesticide effects in soils on nitrification and plant growth. W. M. Shaw and B. Robinson (*Soil Sci.*, 1960, **90**, 320—323).—Lysimeter tests were made on a silt loam of good fertility treated with aldrin, heptachlor, 2,4-D (low volatile ester) at rates of 1—8 lb. per acre of active ingredient or chlordane at 3—24 lb. per acre. The lysimeters were exposed to weather for 6 months and the leachates analysed. No significant effect was observed in the NO_3^- outgo due to any treatment. Growth of grass and tomato was unaffected by aldrin or heptachlor at low rates of application but suffered small depressions with 120 and 180 lb. per acre of 40% chlordane and was severely decreased by 300 lb. All plants died with 2,4-D. Soil nitrification was unaffected by any treatment. In another soil the pesticides were incubated with the soil. Aldrin, dieldrin, chlordane, heptachlor, DDT and Simazin did not decrease nitrification and, except

for dieldrin, stimulated it. Growth of maize and tomato was decreased by high rates (>150 lb.) of the pesticides used except for Simazin which depressed growth at <10 lb. per acre of 50% wettable powder. T. G. MORRIS.

Conversion of sodium N-methyldithiocarbamate (Metham-sodium) to methyl isothiocyanate in soil. J. T. Hughes (*Annu. Rep. Glasshouse Crops Res. Inst., 1959*, 1960, 108—111).—The transformation of the dithiocarbamate into methyl isothiocyanate in soil occurs rapidly, the solid components of the soil rather than the sol. matter being more concerned in the changes. A. G. POLLARD.

Persistence of Trithion, an organophosphorus insecticide, in soil. J. J. Menn, G. G. Patchett and G. H. Batchelder (*J. econ. Ent.*, 1960, **53**, 1080—1082).—Degradation of Trithion was greatest in soils with a high clay content being fastest in a silty clay loam, intermediate in a loamy sand and slowest in a loam. The amount of org. matter present was not significant. Trithion degrades only slowly in water. Breakdown was reduced in autoclaved soils indicating the importance of micro-organisms in the process. Fumigation with Vapam also reduced the breakdown rate when 10 p.p.m. emulsion was used but not when 10 p.p.m. granular formulations were used. C. M. HARDWICK.

Systemic insecticidal properties of certain carbamates. W. A. L. David, R. L. Metcalf and M. Winton (*J. econ. Ent.*, 1960, **53**, 1021—1025).—The relative toxicity of Isolan, Sevin and seven other carbamates to *Estigmena acrea* when placed in drops on bean leaves, varied greatly. No difference in toxicity was found between leaves from bean plants on the first and third days after being placed in insecticidal solutions. Application of solutions to older leaves did not affect larvae feeding on young untreated leaves. *m*-Isopropylphenyl *N*-methylcarbamate reached a steady max. in root and stem while the amount in the leaves increased further. C. M. HARDWICK.

Analogue synergism of several carbamate insecticides. H. T. Gordon and M. E. Elderfrawl (*J. econ. Ent.*, 1960, **53**, 1004—1009).—The toxicity of combinations of Pyrolan, Dimetilan and Isolan applied topically to various insects is given. Dimetilan synergised the more potent *in vitro* cholinesterase inhibitors, Sevin and Pyrolan, in *Blatella germanica* and *Musca domestica*. Partial inhibition of a detoxifying enzyme " carbamate esterase " was suggested as an explanation of the synergistic action with other carbamate insecticides which were easily broken down. No such reaction was found in *Oncopeltus fasciatis*. (16 references.) C. M. HARDWICK.

Sampling experimental plots of lucerne for insecticidal residues. E. W. Huddleston, K. H. Thompson, G. G. Gyrisco, D. J. Lisk, T. W. Kerr, jun., and C. E. Olney (*J. econ. Ent.*, 1960, **53**, 1078—1080).—A procedure was developed combining both random and systematic methods. A single chemical analysis made from a 20-composite sample taken from a 20 × 40-ft. plot was best for residue determination. Methods are given in detail. C. M. HARDWICK.

DDT residues on New York dairy farms following the gypsy moth eradication programme. E. W. Huddleston, G. G. Gyrisco and D. J. Lisk (*J. econ. Ent.*, 1960, **53**, 1019—1021).—No loss of residues following the aerial application of DDT–oil over a wide area was attributable to weathering but new growth produced great reductions. When applied to hay near harvest time residues persisted for 120 days. Residues in milk persisted for 1 year. Eggs had DDT residues after 1 month. C. M. HARDWICK.

Bee poisoning versus clover aphid control in red clover grown for seed. C. Johansen (*J. econ. Ent.*, 1960, **53**, 1012—1015).—Of 20 compounds Trithion, Phosphamidon, Phorate and methyl Trithion + Trithion gave greatest aphid control without appreciable damage to bees, predators and parasites. Guthion and Sevin were appreciably toxic to bees for 4 and 7 days respectively. Sprays were most effective 4 or 5 weeks after hay cutting. 60% of seed loss was attributable to reduction in seed wt. and 40% to seed no. C. M. HARDWICK.

Bee repellant combined with dieldrin or Sevin in bee poisoning tests in lucerne. C. Johansen (*J. econ. Ent.*, 1960, **53**, 1010—1012).—The addition of R874 (2-hydroxyethyl n-octyl sulphide) to sprays of dieldrin or Sevin applied to blooming lucerne, protected bees against poisoning. *Apis mellifera* and *Bombus* spp. were repelled for 6—8 days when max. temp. were ~71°F but only 3—4 days when max. temp. were ~87°F. The Sevin combination was slightly more repellent than that with dieldrin. Evening spraying was less toxic than morning application. C. M. HARDWICK.

DDT-resistant codling moths on pears in California. H. F. Madsen and L. A. Falcon (*J. econ. Ent.*, 1960, **53**, 1083—1085).—The high percentage of infested fruit showed that DDT was ineffective in three orchards and parathion + DDT no more effective than parathion alone. Guthion and ethyl Guthion gave excellent control and Sevin treatments resulted in <1% infested fruit. Kepone, Trithion and diazinon were not satisfactory. C. M. HARDWICK.

Relation between silica in wheat plants and resistance to hessian fly attack. B. S. Miller, R. J. Robinson, J. A. Johnson, E. T. Jones and B. W. X. Ponnaiya (*J. econ. Ent.*, 1960, **53**, 995—999).—Spodograms (ash prep.) were prepared from second leaf sheaths. One hessian fly resistant variety of oats and five of wheat showed relatively dense, grainy coverings of silica over the whole sheath. Susceptible varieties of wheat showed silica with rod-shaped masses in widely spaced rows. Silica deposits increased with age. Most varieties with silicified hairs on the surface were susceptible to attack. C. M. HARDWICK.

Development of chlordane and malathion resistance in German cockroaches. G. S. Burden, C. S. Lofgren and C. N. Smith (*J. econ. Ent.*, 1960, **53**, 1138—1139).—Dosages giving 50—75% mortality were used on three colonies. Alternate or combined use of chlordane and malathion may retard but will not prevent the development of resistance to both insecticides. C. M. HARDWICK.

Infra-red determination of aldrin and dieldrin in aldrin-treated soil. R. C. Blinn, F. A. Gunther and M. S. Mulla (*J. econ. Ent.*, 1960, **53**, 1129—1131).—Sample prep. is described. The peak for aldrin was taken at 1250 $cm.^{-1}$ giving 92% recovery and 910 $cm.^{-1}$ for dieldrin giving 75%. The colorimetric and i.r. values are compared. C. M. HARDWICK.

Micro-determination of endrin. E. J. Skerrett and E. A. Baker (*Analyst*, 1960, **85**, 606—607).—A solution of endrin in benzene is evaporated under reduced pressure and the residue is heated at 60° with AcOH–H_2SO_4. The liquid is made alkaline and extracted with benzene, the extract is evaporated under reduced pressure, the residue dissolved in ethanol and 2,4-dinitrophenylhydrazine reagent is added. To the washed mixture dissolved in benzene, tetraethyl ammonium hydroxide reagent is added and the extinction is measured at 440 mμ. Recovery of 200 μg. added to an extract of unsprayed blackcurrant flower buds was 91%, but blank values were high. A. O. JONES.

Paper chromatography of ferbam, maneb, nabam, thiram, zineb and ziram. W. P. McKinley and S. A. Magarvey (*J. Ass. off. agric. Chem., Wash.*, 1960, **43**, 717—720).—Chromatographic procedure for the resolution of the compounds with two groups is described; formamide in acetone is used as the immobile solvent and $CHCl_3$ as the mobile solvent, when ferbam, thiram and ziram move to the solvent front. Feigl's sodium azide–iodine reaction catalysed by thioketones is used for development. A. A. ELDRIDGE.

Quantitative paper chromatography of chlorinated insecticides in soils. J. P. San Antonio (*J. Ass. off. agric. Chem., Wash.*, 1960, **43**, 721—724).—A method previously studied (cf. J.S.F.A. Abstr., 1959, ii, 204) was modified, to afford an accuracy of about ±10%. Some results for heptachlor, dieldrin, *pp'*-DDT, lindane and aldrin are recorded. A. A. ELDRIDGE.

Distributions of phosphorus in tissues of host plants during fungus attack. E. K. Grabrielson and A. Madsen (*Physiol. Plant.*, 1960, **13**, 595—596).—Radiograms of infected tissue indicate that fungi tend to collect P from cells of host plants. M. LONG.

Control of *Oligonychus pratensis* attacking winter wheat in Western Kansas. L. J. DePew (*J. econ. Ent.*, 1960, **53**, 1061—1063).—When used as autumn sprays demeton and Trithion gave the best results but no acaricide gave 14 days' control. In spring, Trithion, parathion and Kelthane were better than demeton. Aerial spraying with parathion at 1 lb./acre was satisfactory after 14 days and gave substantially increased yields. C. M. HARDWICK.

Relation of moisture content and temperature of stored grain to the effectiveness of grain fumigants under forced circulation. D. L. Lindgren and L. E. Vincent (*J. econ. Ent.*, 1960, **53**, 1071—1077).—The mortality of adult *Tribolium confusum* and *Sitophilus oryza* after 5 h. exposure to CCl_4, HCN and MeBr with no load, with wheat or maize at 10%, 12·5% and 15% moisture content and at 50°, 70° and 90°F is given together with the concn. of fumigant under these conditions. C. M. HARDWICK.

Maize earworm oviposition and the effect of DDT on the egg predator complex in maize silk. F. P. Harrison (*J. econ. Ent.*, 1960, **53**, 1088—1094).—The no. of eggs of *Heliothis zea* was greatest late in the season. Their main predators are listed. DDT–oil emulsion sprays decreased the predators and increased the survival of *H. zea*. C. M. HARDWICK.

Comparison of effectiveness of aldrin seed treatment for rice water weevil control on water- and drill-seeded rice. C. C. Bowling (*J. econ. Ent.*, 1960, **53**, 1135—1137).—Aldrin (4 and 8 oz./100 lb. seed) reduced no. of *Lissorhoptrus oryzophilus* significantly. Both dosages increased yields to a similar amount but yields from water-seeded rice were higher than from drill-seeded. C. M. HARDWICK.

Control of the south-western maize borer. H. C. Wall and W. H. Whitcomb (*Ark. Farm Res.*, 1960, **9**, No. 4, 5).—Satisfactory control was obtained with endrin (20% granules) or Thiodan emulsion applied at several intervals to destroy second and third generations. The correct timing of the applications (2—4) is essential. A. G. POLLARD.

Control of sugar-beet moth, *Phthorimaea ocellatella*, Boyd. F. J. Löcher (*Z. PflKrankh.*, 1960, **66**, 589—598).—Although the caterpillars removed from their webs were readily killed by BHC, DDT, dieldrin and parazinon, concn. far exceeding those in normal use were used in the field, even in early stages when the webs were still weak. A. G. POLLARD.

Influence of mercury dips on germination and early growth of sugar beet, with special reference to their selective action on the microflora present on the seed. L. Ebner (*Phytopath. Z.*, 1960, **39**, 297—320).—With increase in the amount of rainfall during seed ripening the germinative capacity diminished and the no. of microorganisms on the seed increased. The germination of undressed seed under poor conditions declined more rapidly in sterile soil than in an unsterilised medium. Dry Hg seed-dressings affected the seed directly and also modified the microflora. Under unfavourable storage conditions dressing with Hg prep. did not eliminate *Aspergillus* spp. which might ultimately destroy the seed. A. G. POLLARD.

Incidence of pink snowmould, *Fusarium nivale*, (Fr.) Ces., on bentgrass as affected by irrigation and fertiliser treatment. J. H. Madison, L. J. Petersen and T. K. Hodges (*Agron. J.*, 1960, **52**, 591—592).—The incidence of pink snowmould on Highland bentgrass was greater after irrigation in the morning than after that in the evening, and was greater when carried out daily than when every 3—7 days. Disease incidence was not affected by rate of application of N, but was greater where urea–formaldehyde resin fertiliser was applied than where urea was applied. The incidence of the disease on Seaside bentgrass increased with level of applied N, but was not related to type of irrigation or source of N. A. H. CORNFIELD.

Bacterial wilt of lucerne. H. J. Walters (*Ark. Farm Res.*, 1960, **9**, 8).—The susceptibility of two varieties of lucerne (Buffalo, Grimm) in sand cultures to infection by wilt was high when the nutrient solution was of the type, high N and P–low K, and low when it was low N and P–medium-to-high K. A. G. POLLARD.

Effect of heptachlor and toxaphene on stand of ladino clover. H. A. Fribourg and W. W. Stanley (*J. econ. Ent.*, 1960, **53**, 1134—1135).—No increase in clover resulted from heptachlor application in 1956 and 1957 but clover increased by 50% in 1958 and this continued the following year. Demeton, toxaphene and Disyston did not affect the stand in 1958 but increases occurred in 1959 following toxaphene treatment. No increases occurred in forage production. C. M. HARDWICK.

Apple and pear canker. W. Porreye (*Agricultura*, 1960, **8**, 43—50).—Observations on infections by the spores of *Nectria galligena*, Bres. through natural and fortuitous wounds reveal the importance of wounds due to leaf-fall. Spore distribution occurs chiefly during spring and autumn. Promising results have been obtained for control by spraying with captan, TMTD, or Cu oxychloride at leaf-fall. (11 references.) P. S. ARUP.

Bitter pit in the apple variety Cleopatra in Tasmania in relation to calcium and magnesium. D. Martin, T. L. Lewis and J. Cerny (*Aust. J. agric. Res.*, 1960, **11**, 742—749).—Cleopatra apple-trees with a history of high susceptibility to bitter pit were treated by spraying half trees with KNO_3, $Ca(NO_3)_2$ or $Ca(H_2PO_4)_2$, with or without borax. $Ca(NO_3)_2$ decreased the incidence of bitter pit; KNO_3 increased it; $Ca(H_2PO_4)_2$ was without effect. Borax tended to decrease the effectiveness of $Ca(NO_3)_2$. $Ca(NO_3)_2$ and KNO_3, with or without borax, did not affect the K, Mg, P or N contents of the flesh of the fruit (excluding peel and core). K, Mg and P contents were similar in 1958 and 1959, but Ca content was three times as high in 1958, a year of low incidence of pit, as in the following year of high incidence. Spraying with $Ca(NO_3)_2$ increased Ca content in 1959; KNO_3 did not affect Ca content. Sound and pitted fruits did not differ in contents of K, Mg, P or Ca. (34 references.) M. D. ANDERSON.

Insecticidal control of San Jose scale on stone fruits. E. W. Anthon (*J. econ. Ent.*, 1960, **53**, 1085—1087).—The dormant type oil—lime-sulphur spray in the delayed dormant stage caused injury to cherry trees if temp. were low. Volek Supreme oil was not phytotoxic and in combination with malathion, Trithion, Ethion or parathion gave good control of *Aspidiotus perniciosus*. C. M. HARDWICK.

Black-headed fireworm of cranberry—a pest of the evergreen huckleberry in western Washington. E. P. Breakey (*J. econ. Ent.*, 1960, **53**, 1097—1099).—The life history, host plants, identification and synonymy of *Rhopabota naevana* are described. 50% TDE at 2 lb./100 gal. reduced infestations greatly. *Horogenes* sp. and *Eulasonia* sp. may be important in biological control. C. M. HARDWICK.

Control of cranberry fruitworm, *Acrobasis vaccinii*. W. E. Tomlinson, jun. (*J. econ. Ent.*, 1960, **53**, 1116—1119).—As high gallonage sprays, malathion, diazinon, Guthion, rotenone, Sevin and Thiodan gave >90% control for two seasons, and Dibrom, Trithion and endrin for one season. Gyolite was ineffective. As conc. and semi-conc. sprays, parathion and Trithion were better than parathion, diazinon and malathion. All compounds had some ovicidal action and several systemics killed a no. of larvae feeding on the fruit. C. M. HARDWICK.

Drosophila control in tomato fields. A. C. Davis (*J. econ. Ent.*, 1960, **53**, 1107—1110).—The extent of infestation was determined by oviposition in trap tomatoes over 3 years. Diazinon (0·5 lb./acre) was effective for 5 days as a spray and for a longer period as granules. Malathion–Phosdrin had a short residual action. Ronnel and Dibrom were promising. C. M. HARDWICK.

Comparison of Sevin with DDT and rotenone on tomatoes under tropical conditions. G. W. Miskimen (*J. econ. Ent.*, 1960, **53**, 1128—1129).—Under the warm, dry conditions of the Virgin Islands application of 50% Sevin wettable powder to tomatoes gave 183·2% more fruit than those treated with DDT and 457·1% more than those untreated or treated with rotenone. C. M. HARDWICK.

Prevention of basal attacks of tomato stem rot (*Didymella lycopersici*) with captan. W. H. Read (*Annu. Rep. Glasshouse Crops Res. Inst. 1959*, 1960, 112—115).—Application of captan (4 fl. oz. of 0·25% solution per plant) to the lower parts of the stem and the surrounding soil, 1 day after planting-out, and a second treatment (5 fl. oz.) 25 days later gave better results than when the first treatment was given in the pots 1 day before planting-out. Probably, captan does not act systemically under these conditions. A. G. POLLARD.

Vascular necrosis of tomato roots. W. S. Sutton (*J. Aust. Inst. agric. Sci.*, 1960, **26**, 278—280).—The virus causing "drop head wilt" was purified and its physical properties are described. S. G. AYERST.

Laboratory tests of insecticides against eggs and larvae of the cabbage looper. W. P. Kerr and J. R. Brazzel (*J. econ. Ent.*, 1960, **53**, 991—992).—When sprayed on cotton terminals, Phosdrin gave the highest egg mortality with Sevin nearly as effective. DDT, except at 2 lb./acre, toxaphene–DDT, Thiodan and endrin gave <50% mortality. All sprays except Sevin and Phosdrin gave >70% control of first instar larvae, Thiodan and endrin being most effective. The same pattern of effectiveness was found for second and third instar larvae but with a general decrease in effectiveness as larval size increased so that fourth and fifth instar larvae were not adequately controlled. C. M. HARDWICK.

Systemic insecticidal action in cortical tissues of elm twigs. D. M. Norris, jun. (*J. econ. Ent.*, 1960, **53**, 1034—1036).—Shell 3562 (2-dimethylcarbamoyl-1-methylvinyl phosphate) and Phosphamidon gave high mortality of *Scolytus multistriatus* and reduced niche length when implanted in tree-trunks. Protection lasted 15 and 29 days after dosages of 6 and 18 g. The action was attributed to high water solubility and phosphate or phosphorthiolate rather than phosphorodithioate groups. C. M. HARDWICK.

Chemical control of the Eastern spruce gall aphid with observations on host preference and population increase. J. W. Butcher and D. L. Haynes (*J. econ. Ent.*, 1960, **53**, 979—982).—Lindane spray reduced the no. of galls caused by *Chermes abietis*; Sevin gave some control but Dimethoate, malathion and Phosdrin sprays had little effect. Application time was not significant if between last freeze and gall formation. In a mixed plantation ~15% more White than Norway spruce were attacked. A great reduction in infested trees could be obtained by harvesting attacked trees. No foundation was found for theory that some trees are resistant to attack. C. M. HARDWICK.

Brush control with a tree injector. F. M. Meade (*Ark. Farm. Res.*, 1960, **9**, No. 3, 11).—Application of 2,4,5-T (4 lb./gal. as low volatility ester) by injection into the sap wood of trees close to ground level killed 95% of hardwoods. Diesel oil was superior to water as a carrier. Sprouting of treated stumps was <1%. A. G. POLLARD.

Early-season control of green peach aphids on tobacco.—C. B. Dominick (*J. econ. Ent.*, 1960, **53**, 1099—1101).—Phorate and demeton in transplanting water gave excellent control of *Myzus persicae* for 6 weeks, but Dimethoate and Am. Cyanamid 18706 (*S*-*N*-ethylcarbamoylmethyl *OO*-dimethyl phosphorodithioate) were less satisfactory. As foliage sprays, Guthion, Thiodan, endrin and Shell SD4402 (1,3,4,5,6,7,8,8-octachloro-3a,4,7,7a-tetrahydro-4,7-methanophthalan) reduced aphid build-up. Dipterex, TDE, Sevin

and Kepone were poor. Thiodan, Guthion and endrin were also effective as dusts. C. M. HARDWICK.

Cockchafers, *Melolontha melolontha*, L. and *M. hippocastani*, Fabr. J. Jörgensen (*Tidsskr Planteavl.*, 1960, **64**, 614—685).—Considerable kills of the insects have been achieved by spraying with DDT and lindane. Aldrin and chlordane at 4—5 kg. per hectare applied in autumn are very effective against the larvae in the soil; lindane is effective, but toxic to conifer and strawberry roots. The larvae of *M. melolontha* can easily be lethally infected by suspensions on the spores of *B. popilliae* injected into the haemolymph, but not *per os*. (12 references.) P. S. ARUP.

Organophosphorus and carbamate insecticides as soil treatments against the eye gnat, *Hippelates collusor*, in the laboratory. M. S. Mulla (*J. econ. Ent.*, 1960, **53**, 1102—1107).—The compounds are listed in order of initial effectiveness as soil sprays. Of the 24 org. P compounds, CoRal, Bayer 25141 (*OO*-diethyl *O*-*p*-methylsulphinylphenyl phosphorothioate) and E.N. 18133 (*OO*-diethyl *O*-2-pyrazinyl phosphorothioate) were the most effective. None of the three carbamates was appreciably toxic, nor was Thiodan. In general the methyl analogues were less effective than those containing ethyl groups. C. M. HARDWICK.

Effect of colchicine on screw-worms. W. F. Chamberlain and D. E. Hopkins (*J. econ. Ent.*, 1960, **53**, 1133—1134).—*Callitroga hominivorax* became more susceptible to colchicine during its development. The reduction in no. of viable eggs was slight. Four- and 8-day old flies from larvae treated in first and second instars showed morphological retardation of sexual development at 0·0002% dosage. C. M. HARDWICK.

Interference with the biological control of cottony-cushion scale by insecticides and attempts to re-establish a favourable natural balance. B. R. Bartlett and C. F. Lagace (*J. econ. Ent.*, 1960, **53**, 1055—1058).—Increased populations of *Icerya purchasi* have resulted from the effect of insecticidal drift on *Rodolia cardinalis*. The relative toxicity of 50 insecticides to this beetle in laboratory tests is given. Several applications at intervals may be more drastic than the dosage would indicate. Methods of overwintering vedalia beetles are discussed. *Cryptochaetum iceryae* may be introduced to give winter control. (12 references.) C. M. HARDWICK.

Biology and control of morning-glory leaf miner, *Bedellia somnulentella*, on sweet potatoes. H. H. Shorey and L. D. Anderson (*J. econ. Ent.*, 1960, **53**, 1119—1122).—The insect is parasitised by *Apanteles bedelliae*. Toxaphene, Dylox, parathion, malathion, DDT and diazinon sprays gave initial control but reinfestation was fast. Diazinon dust (2%) gave almost complete larval control and no reinfestation in one field. C. M. HARDWICK.

Control of several early-season cotton pests with insecticides. C. R. Parencia, jun., C. B. Cowan, jun., and J. W. Davis (*J. econ. Ent.*, 1960, **53**, 1051—1054).—The effects of chlorinated hydrocarbon and org. P sprays against *Psallus seriatus*, overwintered *Anthonomus grandis* and *Frankliniella* spp. are given. C. M. HARDWICK.

Soil insects in Hokkaido, Japan, with special reference to the effects of some chlorinated hydrocarbons. S. Kuwayama, K. Sakurai and K. Endo (*J. econ. Ent.*, 1960, **53**, 1015—1018).—Heptachlor and aldrin were the most generally effective treatments against *Hylemya cilicrura*, *H. antiqua* and *H. floralis*, cutworms, chafers, wireworms and a mole cricket. C. M. HARDWICK.

Effect of chemical weed control ("chemical fallow") on soil moisture storage. A. F. Wiese and T. J. Army (*Agron. J.*, 1960, **52**, 612—613).—The moisture content of the top 4 ft. of a silty clay loam was maintained at a higher level during 7 months of fallow, following a wheat crop, where weed control by tillage or chemical (naphtha base oil) was practised than where weeds were not controlled. A. H. CORNFIELD.

New herbicide for pre-emergence control of weeds in beet and vegetable crops. A. Fisher (*Z. PflKrankh.*, 1960, **66**, 577—588).—Highly selective effects were obtained with OMU (*N*-cyclo-octyldimethylurea) applied as a pre-emergence spray (0·4—1·0 kg. of active material per hectare). In light soils OMU is less persistent than were CMU (*N*-*p*-chlorophenyl-*N'*-dimethylurea) or CDT [2-chloro-4,6-bis(ethylamino)-*s*-triazine], but its action may be prolonged and the range of weed species which it controls can be extended by admixture with small amounts of BIPC (butynol *m*-chlorocarbanilate). A. G. POLLARD.

Determination of α-(4-chloro-2-methylphenoxy)propionic acid in chloromethylphenoxypropionic acids [in herbicides] by gas–liquid chromatography with an internal standard. H. G. Higson and D. Butler (*Analyst*, 1960, **85**, 657—663).—The acids, extracted from acid solution with $CHCl_3$, are converted into their butyl esters. The chromatographic apparatus is described and dimethyl phthalate is used as internal standard. A modification in which an internal standard is not required is described. A. O. JONES.

Pesticidal compositions. Lunevale Products Ltd. and M. Fitzgibbon (B.P. 831,790, 2.8.56 and 17.4.57).—There is claimed a pesticidal composition comprising a dispersion in aq. medium of solid particles of an emulsion polymer containing dissolved pesticide. Such a composition is better tolerated by plants than is an oil emulsion. In an example, DDT (5) is dissolved in styrene (95), and the resulting solution is heated with water (200), $C_{12}H_{25}O{\cdot}SO_3Na$ (5), carboxymethylcellulose (3) and $(NH_4)_2S_2O_8$ (3 pt.) at 80° until polymerisation is complete. The resulting emulsion is then diluted with water—ready for use. F. R. BASFORD.

Pest-combating preparations. CIBA Ltd. (B.P. 831,075, 12.6.56. Switz., 17.6.55 and 25.4.56).—A composition for combating pests, especially fungi and moulds (e.g., *Septoria apii*, *Oidium* on grapes and apples, *Aspergillus niger*) comprises a liquid or solid carrier and a salt of a diformamidine disulphide, viz., $NRR^{I}(:NR^{II})\cdot C\cdot S_n\cdot C(:NR^{III})\cdot NR^{IV}R^{V}$ (R—R^{V} are H or aliphatic hydrocarbon radicals of 1—4 C, or R^{I} and R^{II}, or R^{III} and R^{IV} may together with N form a heterocyclic radical; *n* is 1 or 2). Compounds where *n* is 2 may be obtained by treating a thiourea with an oxidising agent (H_2O_2 or halogen) in presence of an acid or with an acid chloride, e.g., SO_2Cl_2, or by subjecting it to electrolysis. The monosulphides may be prepared from a cyanamide and a thiourea in the presence of anhyd. H halide. F. R. BASFORD.

Agricultural chemical compositions. Fisons Pest Control Ltd. (Inventor: C. H. Barker) (B.P. 831,344, 6.2.57).—A composition, for use as fungicide, pesticide, herbicide, plant growth regulant or plant nutrient, comprises a mixture of two or more such agents and (to prevent pptn. thereof on dilution with hard water) 0·01—2 wt.-% of a vinylpyrrolidone polymer or copolymer, mol. wt. 10,000—100,000. In an example, a solution of DDT in xylene is emulsified with an aq. solution of polyvinylpyrrolidone, mol. wt. 25,000 Na lauryl sulphate and water, to provide a concentrate which (for use as an insecticidal spray) may be diluted with water to form a storage-stable emulsion. F. R. BASFORD.

Dry seed-dressing compositions. Shell Research Ltd. (Inventors: J. K. Eaton and J. Bromilow) (B.P. 833,180, 29.7.58).—A composition for protection of seed against insect pests, soil- and seed-borne fungi, bacterial and virus diseases, comprises a biocidal agent, e.g., insecticide, fungicide, bactericide, and/or viricide (15—95 wt.-%, of which 50—99% is a bactericide, and a solid carrier of sorptive capacity ⩽20 and with ⩽90% of the particles having an effective diameter of <15μ. The preferred carrier is attapulgite clay, china clay, Spanish clay or synthetic Ca or Mg silicate. The preferred insecticide is a halogenated polynuclear condensed ring system containing at least one (halogeno)endomethylene group, e.g., dieldrin. F. R. BASFORD.

Halogenated bicyclo[2,2,1]heptenes. Farbwerke Hoechst A.-G. (B.P. 832,226, 20.7.56. Ger., 21.7.55).—Halogenated bicyclo-[2,2,1]heptenes substituted in the 5- and 6-positions by CH_2X (X is halogen) and elsewhere by ⩽4 halogen atoms are obtained by interaction of a halogenated cyclopentadiene with a *cis*-1,4-dihalogenobut-2-ene. The compounds are useful as insecticides. In an example, 1,4-dichlorobut-2-ene (mainly *cis*) is heated with hexachlorocyclopentadiene (at 180—200° for 48 h.), then the product is distilled, to give crude *1,2,3,4,7,7-hexachloro-5,6-di(chloromethyl)bicyclo[2,2,1]heptene*, b.p. 172—176°/2 mm. F. R. BASFORD.

Compounding of insecticidal compositions. Associated Fumigators Ltd. (Inventors: M. A. Phillips and C. L. J. Chapman) (B.P. 833,632, 26.8.55).—The toxicity of fluoroacetamide to mammals is reduced without loss in insecticidal activity by compounding with, e.g., a substance containing 2 linked C, such as acetamide, chloroacetamide, EtOH or an ester of a monohydric or polyhydric alcohol (glycerol monoacetate) (⩽2 pt. per pt. of fluoroacetamide). F. R. BASFORD.

Thiophosphoric acid esters. Farbenfabriken Bayer A.-G. (B.P. 833,244, 3.9.56. Ger., 3.9.55).—Compounds $(OR)_2PO{\cdot}S{\cdot}A{\cdot}Y$ (R is alkyl of ⩽5 C, aryl, cycloalkyl or aralkyl; A is alkylene of 2—5 C; Y is Cl or Br in the β-position of A), useful as insecticides, acaricides and miticides, are obtained by interaction of Br·A·Y with a salt of $(OR)_2PO{\cdot}SH$. The prep. is described of *OO-diethyl S-2-bromoethyl phosphorothiolate*, b.p. 75°/0·02 mm. F. R. BASFORD.

Phosphorus-containing insecticides. Norddeutsche Affinerie and P. Spiess (C. F. Spiess & Sohn) (B.P. 833,863, 16.6.58. Ger., 18.7.57).—Compounds $OR(OR'){\cdot}PX{\cdot}NR''{\cdot}SO_2R'''$ are claimed (R and R' are alkyl of 1—4 C; R'' is alkyl or cycloalkyl of 1—12 C; R''' is alkyl of 1—12 C, halogenoalkyl of 1—4 C, or Ph optionally

substituted by halogen ; X is O or S). They are useful as pesticides (especially active against sucking insects, e.g., aphids and tetranychids) and may be obtained by a variety of methods. In one example, *dimethyl (isopropylamino)phosphonate* (prep. described), m.p. 42°, b.p. 107—109°/1 mm., is converted into Me_2 *N-methylsulphonyl-N-isopropylphosphoroamidate*, b.p. 100—102°/0·5 mm. F. R. BASFORD.

Phosphorus-containing keto-esters. Union Carbide Corp., Assee of W. M. Lanham (B.P. 831,149, 29.6.56. U.S., 1.7.55).—Compounds useful, *inter alia*, as insecticides and fungicides are obtained by interaction of a compound CRR'CH·COR'' with a 2-mercapto-2-thiono-1,3,2-dioxaphosphorinane optionally substituted in the 4-, 5- or 6-positions by 1—2 alkyl of 1—20 C (R and R' are H or hydrocarbon groups ; R'' is hydrocarbon group or CH_2·CRR'·SR''' where R''' is another 2-thiono-1,3,2- dioxaphosphorinane residue in which SR''' is attached to R. The prep. of 2-(*2-acetyl-1-phenylethylthio*)-5-*ethyl*-4-*propyl*-2-*thiono*-1,3,2-*dioxaphosphorinane* is described. H. S. R.

Phosphonic acid esters. C. H. Boehringer Sohn (B.P. 830,774, 30.4.58. Ger., 6.5.57).—An *OO*-dimethyl *O*-arylmercaptoethyl phosphite (aryl is phenyl optionally substituted by Cl or alkyl) is treated with chloral to give an *O*-methyl *O*-arylmercaptoethyl *O*-ββ-dichlorovinyl phosphate, useful as an insecticide or acaricide. E. ENOS JONES.

New basic ester of phosphorothiolic acid and pesticidal compositions containing it. Imperial Chemical Industries Ltd. (Inventors : A. Calderbank and R. Ghosh) (B.P. 832,990, 19.10.56).—The compound OO-*diethyl* S-2-*dimethylamino*-2-*methylpropyl phosphorothiolate* (**I**) and its acid addition salts are claimed. They are characterised by pesticidal properties superior to those of previously made compounds (J.S.F.A. Abstr., 1956, ii, 168 ; 1958, ii, 172). **I** is obtained by a conventional process. F. R. BASFORD.

O-Aryl phosphoroamidohydrazidothioates. Dow Chemical Co. (Inventor : E. H. Blair) (B.P. 833,156, 25.4.58).—Compounds OX·P(S)(NRR')·NH·NR''R''' are claimed (X is aryl, optionally substituted by Cl, Br, low-mol. alkyl, cyclohexyl, benzyl, alkoxy, or NO_2 ; R and R'' are H or alkyl of 1—4 C ; R' is alkyl of 1—4 C or *cyclo*hexyl ; R''' is H, Ph or alkyl of 1—4 C). They are active against fungi (e.g., *Alternaria solani*), parasites, household and agricultural pests. As an example, O-2,4,5-*trichlorophenyl* N-*methylphosphonamidohydrazidothioate*, m.p. 104—105°, is prepared from the corresponding chloridate and hydrazine. F. R. BASFORD.

Thiocyanic esters and pesticidal compositions containing them. Société des Usines Chimiques Rhône-Poulenc (B.P. 831,420, 21.8.58. Fr., 20.11.57).—Compounds R·CH_2·SCN are claimed (R is benzoxazol-2-yl or benzthiazol-2-yl radical, optionally substituted by halogen, alkyl or alkoxy of 1—4 C, or NO_2) ; they may be obtained by condensing R·CH_2X (X is acid residue of a reactive ester) with a metal thiocyanate in an inert solvent. The compounds are useful as pesticides and especially fungicides, and compositions containing them (0·005—5 wt.-%) for such purposes are also claimed. In an example, the prep. of 2-thiocyanatomethylbenzthiazole, m.p. 88—89°, is detailed. F. R. BASFORD.

Glycoluril derivatives. Diamond Alkali Co., Assee of F. R. Slezaki and I. Rosen (B.P. 831,853, 21.1.58. U.S., 23.1.57).—Compounds obtained by direct chlorination of glycoluril (2,4,6,8-tetra-azabicyclo[3,3,0]octa-3,7-dione (**I**) and their 1,5-dimethyl deriv. are claimed as fungicides, nematocides, etc. (they have Cl combined in easily available form, but are stable). The 2,4,6,8-*tetrachloro* deriv. of **I** is prepared. H. S. R.

Sterilants. Ben Venue Laboratories Inc. (B.P. 832,659, 2.4.58. U.S., 10.4.57).—A non-flammable, non-explosive volatile composition for use in destroying all types of micro-organisms (viruses, rickettsiae, bacteria, spores, fungi) and insects comprises a flammable volatile sterilising agent, viz., an epoxide (ethylene oxide) and an inert flammability-suppressant mixture consisting of one component of lower b.p. and higher v.p. than the epoxide and one component of higher b.p. and lower v.p. than the epoxide. A preferred composition contains ethylene oxide, dichlorodifluoromethane and trichlorofluoromethane. F. R. BASFORD.

2,3,5,6-Tetrachlorobenzoyl halides and their derivatives for herbicidal compositions. Hooker Electrochemical Co. (B.P. 833,218, 8.2.56. U.S., 29.4.55).—A benzoyl halide (chloride or fluoride) is treated with Cl_2 at 100—230° in presence of a catalyst to give a product, d_4^{25} 1·55—1·72, containing at least some 2,3,5,6-tetrachlorobenzoyl halide, useful in the production of herbicidal compositions (containing the corresponding acid, or a salt or ester thereof). F. R. BASFORD.

Fluoroaromatic compounds. Dow Chemical Co. (Inventors : E. C. Britton and T. R. Keil) (B.P. 833,163, 22.5.58).—Fluoroaromatic compounds are obtained in good yield by decomposition of a corresponding aromatic diazonium fluoroborate in anhyd. inert fluid solvent (chlorinated aromatic hydrocarbon, e.g., 1,2,4,-trichlorobenzene) in presence of alkali metal fluoride or alkali metal H fluoride, e.g., NaF or NaH fluoride (1—2 mol. per mol. of BF_3 theoretically evolved). Especially claimed are (*5-fluorodiphenyl-2-yloxy*)*acetic acid* and (*4-fluoro-2,5-xylyloxy*)*acetic acid*, both useful as herbicides. F. R. BASFORD.

Animal Husbandry

Iodine and animal production. (*Iodine Inf.*, 1960, No. 54).—The effects of iodine deficiency on animal growth, milk yield, milk quality, production of wool and eggs and reproduction are reviewed. (98 references.) A. C.

Comparison between measured and calculated gross calorific values of foods. A. de Vuyst, W. Vervack, M. Vanbelle, R. Arnould, A. Moreels and R. Vanderpoorten (*Agricultura*, 1960, **8**, 3—20).—The following new coeff. based on bomb-calorimetric determinations and chemical analyses are presented : for proteins 6200, crude fibre 5250, fat 10,180, carbohydrates 4150, and mineral matter 0 g.-cal. per g. These coeff. permit the determination of gross calorific values with a standard error of ≯3%, as against that of 9·5% incurred with the use of the Rubner coeff. The new coeff. are consistently higher than the Rubner figures ; a mathematical analysis of the results points to the existence of an undetermined constituent of high calorific value. P. S. ARUP.

Comparison of the conventional, silica- and chromium oxide-index methods in digestibility studies. K. Pujszo, S. Seidler, A. Ziolecka and A. Zólkiewski (*Roczn. Nauk rol.*, 1959, **74, B,** 591—602).—Use of SiO_2 and of Cr_2O_3 as indicators in feeding trials with sheep or pigs yielded similar results provided that, in the former case, access to extraneous sources of SiO_2 is prevented. In the determination of digestibility coeff. with sheep, using Cr_2O_3 some divergent results may be attributed to poor dispersion of the indicator with the ration. A. G. POLLARD.

Rapid test for chromic oxide in faeces. H. M. Cunningham (*Canad. J. Anim. Sci.*, 1960, **40,** 35).—Wet faeces (e.g., 1 g. from digestibility trials) with 1 ml. of ethanol are ignited in a Parr oxygen bomb. Small translucent beads occurring in the ash contain the Cr, the green colour being proportional to the Cr content. The procedure is completed in 5 min. and detects 0·02 mg. of Cr_2O_3 per g. of wet or dry faeces. A. G. POLLARD.

Experimental technique of *in vitro* forage cellulose fermentation with a new artificial microrumen. G. Geri (*Ric. sci.*, 1960, **30,** 1284—1305).—An *in vitro* fermentation technique for the determination of forage cellulose digestibility, using a new synthetic microrumen, has been developed. Applications of the method are discussed. (80 references.) L. A. O'NEILL.

Factors affecting ratios of CO_2/CH_4 in bovine rumen gas. W. O. Nelson, R. E. Brown and R. G. Kingwill (*J. Dairy Sci.*, 1960, **43,** 1654—1655).—Max. ratios (3 or 2 : 1) are found in the gas 1 h. after feeding roughage or concentrates, respectively. Subsequent, but lower max. occur ~4 h. later. The ratio is not significantly altered by sparging the rumen ingesta with H_2 during 6 h. or by the administration of *d*-limonene in amounts toxic to acetate-fermenting methane bacteria. P. S. ARUP.

Synthesis of amino-nitrogen and free amino-acids by rumen bacteria. L. Feliński and S. Baranow-Baranowski (*Roczn. Nauk rol.*, 1959, **75, B,** 1—19).—Bacteria isolated from sheep rumen readily hydrolysed urea (88% in 2·5 h.). Organisms from sheep on pasture + concentrates produced less amino-N than did those given hay + concentrates. No differences between aerobic and anaerobic conditions in respect of the synthesis were apparent. The protein content of the medium was increased. A. G. POLLARD.

Urea concentration in milk as an index of nitrogen changes in the rumen. R. Ryś (*Roczn. Nauk rol.*, 1959, **74, B,** 413—418).—High contents of NH_3 in the rumen are associated with high concn. of urea in the milk. The latter value is a simple index of the transfer of rumen-NH_3 into the blood stream. A. G. POLLARD.

Effect of fine grinding of hay on ration digestibility, rate of passage and on fat content of milk. C. B. Rodrigue and N. N. Allen (*Canad. J. Anim. Sci.*, 1960, **40,** 23—29).—In a ration for lactating cows (hay + concentrate, 2 : 1 pt.) grinding the hay hastened the initial excretion and increased the rate of excretion of hay residues. The digestibility of fibre and/or cellulose in the ration was lowered by grinding causing a highly significant diminution in dry matter digestion ; the digestibility of protein, ether extract and N-free extract was also lowered. The depression in digestibility and the increase in rate of excretion rose with the fineness of grinding of the

hay. The lowered digestibility of cellulose wall material was associated with a decline in % milk fat. A. G. POLLARD.

Further study of a turbidity test for quality in hay. J. G. Archibald, E. Bennett and D. F. Owen, jun. (*J. Dairy Sci.*, 1960, **43**, 1628—1631).—Additional statistical confirmation is obtained of the high correlation between the turbidity of aq. suspensions of ground hay and the composition of the hay. The method has still, however, limitations as regards the evaluation of single samples. P. S. ARUP.

Yield and chemical composition of oats for forage with advance in maturity. D. Smith (*Agron. J.*, 1960, **52**, 637—639).—The % of protein, fat, ash, P, Ca, K and NO_3^- in oat forage declined from the 4-leaf to the ripe stage, whilst the % of N-free extract and dry matter increased. The % fibre increased until the heads emerged from the boot and then decreased slightly. A. H. CORNFIELD.

Appraisal of various ensiling practices in Belgium. A. Devuyst, M. Vanbelle, R. Arnould, W. Vervack and A. Moreels (*Agricultura*, 1960, **8**, 27—42).—A report with advice on necessary improvements. P. S. ARUP.

Grass silage quality as affected by additives. J. G. Archibald, J. W. Kuzmeski and S. Russell (*J. Dairy Sci.*, 1960, **43**, 1648—1653).—A moisture content of ∢75—80% in the crop is closely correlated with the production of poor silage of relatively low lactic acid content, containing butyric acid and volatile bases (NH_3 etc.). Chemical additives (e.g., Na metabisulphite or Ca formate + $NaNO_3$) can prevent deterioration due to high moisture, but do not reduce losses due to run-off. Quality is favoured by a high sugar content in the crop (accumulated during cool dry weather) or by additives containing fermentable carbohydrates, e.g., molasses, ground cereals, or citrus pulp. (12 references.) P. S. ARUP.

Types and sequence change of bacteria in orchard grass and lucerne silages. C. W. Langston and C. Bouma (*J. Dairy Sci.*, 1960, **43**, 1575—1584).—Examination of 3142 strains reveals, in good silages, an initial predominance of cocci, most of which are subsequently replaced by lactobacilli (notably *L. brevis* and *L. plantarum*) and pediococci. In poor silages *L. casei* tends to predominate over the other lactobacilli, and an attenuated strain of *Lactobacillus* of low acid-forming capacity is found in relatively large numbers. Aeration and high temp. appear to favour the undesirable types. (22 references.) P. S. ARUP.

Use of ammoniated feeding stuffs for ruminants. I. Ammoniated sugar-beet pulp for feeding wethers. M. Chomyszyn, A. Ziolecka and K. Bieliński. **II. Use of different levels of ammonia in rations for wethers.** M. Chomyszyn and K. Bieliński. **III. Digestibility of the diet and nitrogen balance when feeding a high ration of ammonia. IV. Use of dried ammoniated sugar-beet pulp in feeding wethers.** M. Chomyszyn, A. Ziolecka, M. Kuzdowicz and K. Bieliński. **V. Fattening of growing wethers.** M. Chomyszyn, K. Bieliński and L. Kielisz (*Roczn. Nauk rol.*, 1959, **74, B**, 509—526, 527—536, 537—546, 547—556, 557—566).—I. Sugar-beet pulp was soaked in aq. 1·36% NH_3 for 24 h. and used to replace part of the wheat bran in a hay–bran–potato–sugar-beet pulp ration, the NH_3-N providing 7 and 17% of the total N. With the larger proportion of NH_3-N the protein digestibility increased significantly. The digestibility of the NH_3-N averaged 67 and 71% respectively for the two levels of supply. N retention was greatest with the high-level supply of NH_3. Blood-urea and -NH_3 were normal during the experimental period; urinary-total N increased slightly and -urea increased considerably.

II. No evidence of NH_3-toxicity to the sheep was apparent with feeding levels up to 40 g./day although feed consumption was restricted by the odour of rations containing the higher proportions of NH_3. Digestibility coeff. were not greatly affected by the ammoniated feed.

III. Inclusion of NH_3 (23 g./kg. live-wt. daily) to the ration increased the digestibility of the protein (by 14%) without affecting that of the other nutrients and increased the N balance. Retention of NH_3-N was 10% (18% from ammoniated beet pulp) and the digestibility of NH_3-N averaged 64%.

IV. Addition of ammoniated sugar-beet pulp to the ration increased the digestibility coeff. of the protein from 55 to 77% but urinary-N was increased 4-fold.

V. Replacement of part of the protein in the ration by aq. NH_3 increased the gain in wt. of sheep and improved the utilisation of nutrients without affecting the digestibility of the ration or the quality of the carcasses. A. G. POLLARD.

Fodder value of yeast grown on waste sulphite lye and sulphite mash for pig feeding. Z. Ruszczyc and J. Glapś (*Roczn. Nauk rol.*, 1959, **74, B**, 137—144).—The yeasts used to replace meat-and-bone meal in fattening rations did not affect the rates of gain in wt., feed utilisation (except for a slight decline in the case of protein) or carcass quality. A. G. POLLARD.

Nutritive value of *Lathyrus tingitanus* in feeding ruminants. A. Zolkiewski, M. Chomyszyn, K. Bieliński and L. Kielisz (*Roczn. Nauk rol.*, 1959, **74, B**, 579—590).—In trials with sheep, *L. tingitanus* feed, green or as hay, showed useful nutritive values, optimum yields of food units and digestible protein being obtained by cutting at the late bloom stage. A. G. POLLARD.

Unidentified growth factor(s) in soya-bean oil-meal. R. A. Wilcox (*Dissert. Abstr.*, 1960, **21**, 284).—The protein of soya-bean oil-meal supported faster growth of poults than did isolated soya-bean protein. Growth-promoting activity was present in aq. extracts of soya-bean oil-meal made at pH 4·7, but not in 100% acetone- or 100% ethanol-extracts. The aq. extract appeared to have org. and inorg. growth-promoting components, not impaired by high concn. of ethanol or pH between 1 and 10. There may be an interaction between maize oil and the growth-promoting activity of the aq. extracts. M. D. ANDERSON.

Effect of supplementary digestive enzymes on growth of dairy heifers. J. M. Wing and C. J. Wilcox (*J. Dairy Sci.*, 1960, **43**, 1655—1656).—With normal feeding levels of hay, silage and concentrates, the heifers do not benefit significantly by the administration of a prep. containing protease, diastase and a gum-splitting enzyme. P. S. ARUP.

Vitamin A and carotenoid interrelationships in bovine plasma and liver. R. H. Diven, O. F. Pahnish, C. B. Roubicek, E. S. Erwin and H. M. Page (*J. Dairy Sci.*, 1960, **43**, 1632—1638).—The mutual correlations found are variable and not close enough to have any predictive value. (15 references.) P. S. ARUP.

Measuring selective grazing with fistulated steers. A. L. Lesperance, E. H. Jensen, V. R. Bohman and R. A. Madsen (*J. Dairy Sci.*, 1960, **43**, 1615—1622).—Selective grazing was observed on mixed clover–grass pastures, with initial preference for clovers, and subsequent increases in the proportion of grass consumed. No agreement was found between the composition of fistula samples and that of samples hand-harvested under the cages on the same day. (29 references.) P. S. ARUP.

Effect of feeding urea to dairy cows on the serum-magnesium level. R. Ryś (*Roczn. Nauk rol.*, 1959, **74, B**, 229—234).—Use of urea as a N supplement in rations for cows did not lower the serum-Mg. A. G. POLLARD.

Effects of isoniazide and chlorotetracycline in diet of young calves. J. M. Wing and P. T. D. Arnold (*J. Dairy Sci.*, 1960, **43**, 1656—1657).—Feeding experiments in which the additives are used singly and in combination show the combined effect to be purely additive. P. S. ARUP.

Effect of brewer's yeast on the fat content of cow's milk. J. Okoński, B. Pachelska and A. Wierny (*Roczn. Nauk rol.*, 1959, **74, B**, 407—412).—Feeding brewer's yeast to milch cows tended to increase the milk-fat content though not significantly in a short-term experiment. A. G. POLLARD.

Effect on milk production of chopping meadow crop once and twice daily. A. D. Pratt, R. R. Davis and H. R. Conrad (*J. Dairy Sci.*, 1960, **43**, 1623—1627).—In spite of heating effects observed in the soilage during the intervals between meals, no undesirable effects as regards dry matter uptake or milk production are incurred by chopping once instead of twice daily. "Half rate" grain feeding is justified in comparison with "zero" or "quarter rate" with respect to milk production. P. S. ARUP.

Effect of a modified sulphite waste liquor and of calcium gluconate on milk production. R. S. Emery, C. K. Smith, T. R. Lewis, J. De Hate and L. D. Brown (*J. Dairy Sci.*, 1960, **43**, 1643—1647).—The production is increased by 0·6—1·9 lb. of milk per day by daily supplementation with the dried product (0·25 lb.) or with Ca gluconate (0·125 lb.). The gluconate (obtained from this product) is fairly resistant to fermentation in the rumen. P. S. ARUP.

Efficiency of conversion of food to wool. I. Correlated response to selection for high and low clean wool weight per head. C. H. S. Dolling and R. W. Moore (*Aust. J. agric. Res.*, 1960, **11**, 836—844).—The offspring of two families of medium Peppin Merino sheep, selected respectively for high and low clean-wool wt. differed in the ratio of wool produced to food eaten, when they were fed in individual pens on a ration of lucerne chaff slightly above maintenance requirement. These ratios can be taken to reflect a difference in net efficiency of conversion of food to wool. M. D. ANDERSON.

Selective consumption of dry pasture by sheep as affected by spraying with urea or molasses or both. W. M. Willougby and A. Axelsen (*Aust. J. agric. Res.*, 1960, **11**, 827—835).—Spraying low-quality dry summer pasture with urea, or molasses, or both, increased the consumption of the pasture by sheep. Sheep on the pastures sprayed with molasses lost wt. less rapidly than those on unsprayed pastures.

Urea lessened loss of wt. only in the latter part of the experimental period. Sheep with free access to larger areas of unsprayed pasture lost less wt. than those on the smaller unsprayed areas available to the control animals, suggesting that the non-preferred plants were less nutritious than the preferred plants. M. D. ANDERSON.

Toxic effect of urea on lambs. L. Feliński (*Roczn. Nauk rol.*, 1959, **74, B,** 165—177).—When urea was fed to lambs via cannulae the toxic effects varied with the site of introduction into the digestive system in the order, rumen > duodenum > large intestine. A. G. POLLARD.

Effect of oestradiol and testosterone injections and thyroidectomy on wool growth in shearling sheep. S. B. Slen and R. Connell (*Canad. J. Anim. Sci.*, 1960, **40,** 15—22).—Intramuscular injections of oestradiol (5 mg. biweekly) in normal ewes lowered the wt. of clean wool and its fibre length and increased the thyroid, pituitary and adrenal wt. Similar treatment of thyroidectomised ewes resulted in still less clean wool. There was no effect on wethers. Testosterone (175 mg. weekly) did not affect wool yields from normal ewes or wethers but lowered those from thyroidectomised ewes. A. G. POLLARD.

Ability of pigs to digest the components of crude fibre (lignin, cellulose, pentosans). C. Laurentowska (*Roczn. Nauk rol.*, 1959, **74, B,** 567—578).—The chemical composition of the crude fibre in a ration characterises the carbohydrate fraction better than do conventional methods of analysis, notably in respect of the N-free extract. Considerable differences in ability to digest crude fibre are shown between individual pigs and between breeds. The digestibility coeff. of the components of the crude fibre were in the order, pentosans > cellulose > lignin. A. G. POLLARD.

Substitution of potatoes and barley by maize cob silage in fattening bacon pigs. H. Duniec (*Roczn. Nauk rol.*, 1959, **74, B,** 97—117).—Fattening pigs refused a considerable proportion of the maize cob silage included in the ration. With rise in the portion of the silage fed the amounts rejected increased, the fattening period was lengthened, the total food units and amount of protein consumed per unit gain in wt. increased and carcasses became leaner. A. G. POLLARD.

Maize ear silage for feeding bacon hogs. I. Nutritive value of maize in various stages of maturity. II. Maize ear silage for fattening bacon pigs. III. Influence of maize ear silage on fat and meat quality. M. Janicki, M. Chomyszyn and K. Bieliński (*Roczn. Nauk rol.*, 1959, **74, B,** 84—95).—I. Highest yields of dry matter and of digestible protein from maize were obtained by harvesting at the " glassy " milk stage. Silages made from the ears cut at this stage used alone and that from a 1 : 1 mixture with sugar-beet leaves were of similar composition. The product from maize ears + lucerne (1 : 1) contained about double the protein content but much more fibre than that from maize alone.

II. In trials with pigs of about 50 kg. live-wt. inclusion in the ration of silage from maize ears alone or mixed with sugar-beet leaves did not lower the digestibility of the ration or the average daily gain in wt., but diminished the efficiency of food utilisation.

III. Feeding the above silage had no ill-effects on the proportions of fat and lean tissue of the carcass but the use of sugar-beet leaves lowered the m.p. of the fat. A. G. POLLARD.

New method for calculating the gross value of proteins. A. Anwar (*Poultry Sci.*, 1960, **39,** 1406—1408).—The new method of calculating the gross value of proteins (*Wash. agric. Exp. Sta.*, 1940, Bull. 338) allows for variation in the amount of food consumed by control birds between different tests. Gross protein values as calculated by the old and new methods are presented for several common protein supplements. A. H. CORNFIELD.

Short-term procedure for determining the amino-acid requirements of laying hens. E. C. Miller, J. S. O'Barr and C. A. Denton (*Poultry Sci.*, 1960, **39,** 1438—1442).—Whereas a long-term (8-month) study showed that a basal diet was deficient in lysine, as indicated by increased body wt. and egg production where lysine was added, a short-term (3-week) study using ^{35}S-labelled lysine did not detect lysine deficiency in the same basal diet. It was necessary to restrict feed intake to 70—80% of normal before the tracer method was able to show lysine deficiency in the basal diet. A. H. CORNFIELD.

Effect of vitamin-A level of diet on feed conversion and utilisation of energy by growing chickens. T. E. Shellenberger, D. B. Parrish and P. E. Sanford (*Poultry Sci.*, 1960, **39,** 1413—1417).—The growth of chicks to 9 weeks of age was satisfactory with diets containing 600 units or more of vitamin A per lb. of feed (lucerne meal). Feed efficiency was similar at all vitamin intakes >400 units per lb. for both low- and high-energy feeds, although it was higher for birds fed low-energy than for those fed high-energy diets. *Ad libitum* consumption of productive energy per lb. gain was similar for broiler-strain chicks receiving both high- and low-energy diets containing 400 units or more of vitamin A per lb. With egg-strain chicks the intake of productive energy per lb. gain was higher than with broiler-strain chicks at levels of vitamin A ranging from 500 to 2000 units per lb. feed. Quantities of vitamin A which may be satisfactory for optimum feed intake and energy utilisation may not be high enough to support max. growth or normal health. A. H. CORNFIELD.

Effect of animal fat and mixtures of animal and vegetable fats containing varying amounts of free fatty acids on performance of caged birds. C. M. Treat, B. L. Reid, R. E. Davies and J. R. Couch (*Poultry Sci.*, 1960, **39,** 1550—1555).—Addition of 2·5—5·0% of animal fat (containing 14% free fatty acids) or mixed animal–vegetable fats (54—91% free fatty acids) to the diet of caged layers had no effect on egg production over 32 weeks but improved feed efficiency. Egg wt. was improved by most of the treatments, whilst the cholesterol levels in the serum, liver and aorta were little affected. A. H. CORNFIELD.

Performance of laying pullets fed rations differing in cereal component and protein supplement. D. Cooper, B. March and J. Biely (*Poultry Sci.*, 1960, **39,** 1395—1400).—There was little difference in egg production, egg wt. and interior egg quality over 48 weeks due to type of cereal component (wheat vs. screenings) or type of protein supplement (soya-bean oil-meal vs. mixtures of soya-bean oil-meal, fish meal and meat meal) in the rations. Inclusion of the animal meals brought the birds into production somewhat more rapidly. During the first 20 weeks of production the progeny of a strain-cross laid at a similar rate with all rations, whilst the progeny of a pure strain laid the fastest with the diets containing the animal meals. A. H. CORNFIELD.

Maize–soya-bean oil-meal laying diets. I. Amino-acid supplementation of low-protein diets. D. J. Bray and J. D. Garlich. **II. Optimum combinations of maize and soya-bean proteins.** D. J. Bray (*Poultry Sci.*, 1960, **39,** 1346—1349, 1541—1546).—I. Birds on a diet containing maize 71·6% and soya-bean oil-meal 19·2% (16% protein) maintained a high rate of egg production over 12 weeks. On a diet containing maize 87·3% and oil-meal 3·5% (9% protein) egg production fell off after 3 weeks. Addition of extra lysine, tryptophan, methionine, isoleucine and valine to the 9%-protein diet to bring the requirements of these amino-acids to a theoretically adequate level resulted in a reduced fall-off in egg production with time, but was not as satisfactory as egg production from birds receiving the 16%-protein diet.

II. A 16%-protein diet in which soya-bean oil-meal (SOM) contributed 58% of the protein and maize the rest maintained a high rate of egg production over 13 weeks. Diets containing 10% of protein, with SOM contributing 58% or 22% of the protein, resulted in a decline in the rate of egg production over the 13 weeks, the rate of decline being greater with the latter diet. Further trials with diets containing 9% and 10% of protein showed that the least decline in rate of egg production over 13 weeks occurred when 50·5% and 55·5% respectively of the protein was contributed by SOM. A. H. CORNFIELD.

Influence of dietary fat and choline on serum- and egg yolk-cholesterol in the laying chicken. N. J. Daghir, W. W. Marion and S. L. Balloun (*Poultry Sci.*, 1960, **39,** 1479—1466).—Addition of 12% of soya-bean oil to the diet of laying hens reduced serum-cholesterol level, whilst 12% of animal fat (white grease) had no effect. Varying the dietary choline from 0·4 to 1·0 g. per lb. of feed had no effect on serum cholesterol level. None of the treatments affected egg yolk cholesterol levels. Neither of the fats affected egg production or feed efficiency with respect to egg production. Egg production was at a max. with 0·7 g. of choline per lb. of feed. The treatments had no effect on egg wt., shell quality and Haugh unit scores. A. H. CORNFIELD.

Radionuclide mineral studies. II. Effect of dietary constituents, including protein and vitamin B_{12} on the metabolism of ^{35}S-sulphate in the chick. W. G. Martin and H. Patrick (*Poultry Sci.*, 1960, **39,** 1501—1510).—Vitamin B_{12} increased the absorption and retention of ^{35}S-labelled SO_4^{2-} by skeletal tissue of the chick. Bone deposition of added SO_4^{2-} was greater with soya-bean oil-meal than with casein as a source of protein. Vitamin B_{12} increases retention of SO_4^{2-} possibly through the relationship of the SO_4-fixing enzyme system. A. H. CORNFIELD.

Source of chick growth stimulus in maize fermentation condensed solubles. J. M. Russo, S. A. Watson and V. Heiman (*Poultry Sci.*, 1960, **39,** 1408—1412).—The extent of chick growth stimulation was similar whether fermented or unfermented maize solubles were added to the A.N.R.C. basal diet free of fish and whey. Feed efficiency was slightly higher with the fermented solubles. Addition to the diet of ground maize which had been steeped to remove the water-sol. fraction resulted in significantly poorer wt. gains and feed efficiency when compared with the addition of unsteeped ground maize. The origin of the chick growth stimulating component in maize fermentation solubles is the maize grain itself. A. H. CORNFIELD.

Heat inactivation of substances in crude cottonseed oil causing pink whites and large discoloured yolks in stored eggs. R. J. Evans, S. L. Bandemer and J. A. Davidson (*Poultry Sci.*, 1960, **39**, 1478—1483).—Eggs from hens fed 2·5% of crude cottonseed oil in the ration developed pink whites and salmon yolks after 6 months' cold storage. Crude cottonseed oil gave a strong Halphen test. Crude cottonseed oil heated at 150° for 4 h. or 200° for 1 h. no longer gave this test, but still produced egg discoloration. No discoloration occurred when oil heated at 200° for 8 h. or at 240° for 1 h. was fed to the dams. A. H. CORNFIELD.

Feeding stuffs. J. Kruss (B.P. 832,918, 4.12.56. Ger., 14.12.55).—Fish solubles, which have been freed from oil and concentrated to a solids content of at least 40% by wt., are intimately mixed with the carbohydrate materials, and the mixture is subjected to aerobic fermentation. E. ENOS JONES.

Compositions for treating animals to eliminate hookworms and ascarids. American Cyanamid Co. (B.P. 830,868, 6.3.58. U.S., 1.5.57).—A composition for combating hookworm and ascarid infections in animals comprises a mixture of 1-phenyl-4-(dichloroacetyl)piperazine (2·5—200) and 1-diethylcarbamoyl-4-methylpiperazine (0·5—8 mg. per kg. of body wt.). F. R. BASFORD.

Cyanoacethydrazide derivatives and compositions containing them. Imperial Chemical Industries Ltd. (Inventor: N. Greenhalgh) (B.P. 831,096, 20.12.56).—Compounds $CN{\cdot}CH_2{\cdot}CO{\cdot}NH{\cdot}NH{\cdot}CO_2R$ (R is hydrocarbon radical of >2 C) are claimed; they are useful as therapeutic agents in the control of lungworm infestations in domestic livestock (cattle, sheep, goats, pigs, poultry) and in the treatment of tuberculosis. As an example, the method of prep. is detailed for N-2-*butoxycarbonylcyanoacethydrazide*, m.p. 88—89° (from water). F. R. BASFORD.

Organic phosphorus compounds and preparations containing them. CIBA Ltd. (B.P. 829,576, 2.11.56. Switz., 3.11.55 and 4.10.56).—Compounds of the structural formula $NRR^{I}{\cdot}CO{\cdot}CR^{II}R^{III}{\cdot}P(:Z)R^{IV}R^{V}$ or $NRR^{I}{\cdot}CO{\cdot}CR^{II}{:}CR^{VI}O{\cdot}P(:Z){\cdot}R^{IV}R^{V}$ are claimed (R and R^I are H, alkyl, cycloalkyl, aryl, aralkyl or heterocyclyl, or together form part of a cyclic system; R^{II} is H, alkyl or halogen; R^{III} is CN, COR^{VI}, CO_2R^{VI} or $CONRR^{I}$; R^{VI} is alkyl, aryl or heterocyclyl; R^{IV} is $X_{n-2}R^{VII}$; Z is O or S; R^{V} is $Y_{m-1}{\cdot}R^{VIII}$; X and Y are O, S, NH or NR; R^{VII} and R^{VIII} are alkyl, *cyclo*alkyl, aryl, aralkyl, heterocyclyl or together form part of a cyclic system; *m* and *n* are 1–2). They may be obtained by interaction of $NRR^{I}{\cdot}CO{\cdot}CR^{II}R^{III}B$ (B is halogen) with $PR^{IV}R^{V}{\cdot}Z{\cdot}R^{IX}$ (R^{IX} is alkyl of 1—4 C). Thus, a mixture of Et_3PO_3 and $CHCl_2{\cdot}CO{\cdot}NEt_2$ is heated to 90° (violent reaction, temp. rising to 160°), then at 95° *in vacuo*: the product is distilled, to give a substance b.p. 144°/0·1 mm., analysing for $C_{12}H_{23}O_5NClP$. The compounds are of use in combating pests, especially animal pests, and are effective against various stages of development thereof. F. R. BASFORD.

2.—FOODS

Carbohydrate Materials

Cereals, flours, starches, baking

Note on the determination of gelatinisation temperatures of rice varieties. J. V. Halick, H. M. Beachell, J. W. Stansel and H. H. Kramer (*Cereal Chem.*, 1960, **37**, 670—672).—Gelatinisation temp. determined microscopically and with the Brabender Amylograph, are reported for 21 varieties of rice, together with their amylose contents. No relation was found between gelatinisation temp. and amylose content. E. C. APLING.

Size of sample for maturity determination of canning maize. H. B. Cannon, E. A. Asselbergs and W. P. Mohr (*Food Technol.*, 1960, **14**, 619—621).—Of two factors influencing variability in a field of maize, position in the field was more important than ear-to-ear variation. Increasing the no. of positions in the field at which ears were harvested improved the accuracy more than increasing the no. of ears at any one position. E. M. J.

Maize wet-milling. Process and progress. J. W. Evans (*Cereal Sci.*, 1960, **5**, 243—244).—The major purpose in maize refining is to obtain pure starch containing a min. amount of protein and other impurities. The various processes of steeping, degerminating, separation of hull and fibre, centrifugal separation of starch from protein, starch washing and drying are described. I. DICKINSON.

Subsieve-size fractions of a hard red spring wheat flour produced by air classification. R. Gracza (*Cereal Chem.*, 1960, **37**, 579—593).—Results of analysis and physical dough testing (Farinograph and Extensograph) are reported for seven flour fractions separated by air classification from an 86% extraction flour prepared from Montana hard spring wheat. Protein contents of the fractions varied from 20·3 to 8·8%, compared with 13·8% in the parent flour, but the degree of protein shift between fractions was much smaller than when soft red winter wheat flour was similarly treated (cf. J.S.F.A. Abstr., 1960, i, 294). The coarser fractions (44·5 to 48·0 SED μ) showed the physical dough characteristics of good bread flours, while the finer fractions (from 23 to 39 SED μ) amounting to 17% of the total flour, were characteristic of a soft wheat pastry flour. (17 references.) E. C. APLING.

Milling properties of wheat in relation to pearling, scouring and impaction. G. M. Grosh, J. A. Shellenberger and E. P. Farrell (*Cereal Chem.*, 1960, **37**, 593—602).—The effect of pearling, scouring and prebreak impaction was studied in experimental millings of soft and hard wheats. Pearling and scouring adversely affected milling, but prebreak impaction of tempered wheat on a 27-in. Entoleter at 2400 r.p.m. gave 60% extraction of flour of reduced ash content. Prebreak impaction gave no significant improvement with soft wheat. (19 references.) E. C. APLING.

Changes in ash content of endosperm during hydrothermal treatment of wheat. E. D. Kazakov and I. A. Sakharova (*Dokl. Akad. Nauk SSSR*, 1960, **132**, 1438—1440).—Ash content in the grain is important because the value of flour is determined by it. Four series of hydrothermal treatments (conditioning) were carried out followed by the analysis of the mineral content by incineration. It is concluded that a partial migration of the mineral materials takes place from the endosperm into the zone of embryo owing to the intensified biochemical processes. T. P. BOR.

Turbidity of wheat gluten solutions: interaction with phosphate ions. R. T. Bottle and J. Sizer (*Chem. & Ind.*, 1960, 1530—1531).—Samples of gluten powder (untreated and preheated) were dissolved in 0·01M-NaOH, diluted to 0·125%. 2 ml. of the diluted solution were added to 20 ml. of citrate or phosphate buffer solutions and the turbidity measured colorimetrically. On a turbidity/pH curve the untreated gluten gives a max. at pH 8 possibly due to aggregation of protein molecules through formation of a PO_4^{3-} complex. (11 references.) A. C.

Gluten in dietetic products. J. Sarazin and R. Perard (*Bull. Centre Form. tech. Perfectionnement de l'Union des Fabricants de Biscuits*, 1/60, pp. 1—8).—Dietetic rusks were made with flour to which different glutens were added to give 20% of protein, and the effects of the quality of the gluten on fermentation rate and loaf vol. are reported. Good vol. cannot be obtained with a "short" gluten, however consistency, proving time, flour strength, etc., are varied. A "short" gluten mixed with at least 50% of an elastic gluten gives satisfactory results. M. D. ANDERSON.

Low-temperature extraction of wheat flour lipids and gradient elution from silicic acid. J. J. Wren and S. C. Elliston (*Chem. & Ind.*, 1961, 80—81).—The N-, P- and sugar-containing lipids of white flour are being investigated by extraction with $CHCl_3$–MeOH at −23°. The elution curve obtained by gradient elution from silicic acid is given. A. C.

Presence and probable rôle of thioctic acid in wheat flour. L. Dahle and B. Sullivan (*Cereal Chem.*, 1960, **37**, 679—682).—The identification of thioctic acid in the acid-hydrolysed extract of wheat flour is reported and its possible rôle in the maturing of flour is discussed. E. C. APLING.

Improved method for detection and approximate estimation of fungal amylase supplementation of wheat flour. K. J. Hayden (*J. Sci. Fd Agric.*, 1961, **12**, 123—127).—A simple technique based on treatment of flour extracts with bentonite under suitable conditions of pH, in presence of NaOAc is described; cereal α- and β-amylases are inactivated almost completely with little or no action on the fungal enzymes. The fungal amylase is detected by a cup-plate technique with a starch–agar substrate. (12 references.) E. M. J.

Characteristics of flours intended for the manufacture of wafers. M. P. Bourreau (*Bull. Centre Form. tech. Perfectionnement de l'Union des Fabricants de Biscuits*, 1/59, pp. 1—3).—Dough for wafers contains more water than doughs for bread or biscuits, and consists of a suspension of starch and gluten grains in water. Flour for wafers should contain 15 to 15·5% of water, and be very finely ground, perfectly homogeneous, and of low protein content (6—7% dry wt.) to avoid agglomeration of protein particles; the stability of the dough is increased by addition of lecithin or egg yolk, or of solutions of gum, starch, or sugar. $NaHCO_3$ is sometimes added to improve the consistency of doughs made from flours of too high protein content, but it tends to damage the structure and

colour of the product. A judicious addition of $MgCO_3$ makes the wafer lighter, more friable, less hydrophilic, and more easily separable from the metal surface on which it is moulded.
M. D. ANDERSON.

Accelerated browning in starch pastes containing various bread ingredients. R. J. Stenberg and W. F. Geddes (*Cereal Chem.*, 1960, **37**, 623—637).—The effect of additions of gluten, sucrose, glucose, lactose, fat and dried skimmed milk on the browning of wheat starch pastes (10%) stored at 75° for 25 days was assessed by reflectance measurements made on the dried pastes at 600 mμ. Additions of sugars had the major effect on browning, which was accompanied in all cases by increases in reducing substances. Extracts of stored pastes showed strongly increased absorption at 275 mμ due to carbonyl compounds, at present unidentified. (22 references.)
E. C. APLING.

Particle size in aqueous starch dispersions. G. E. Babcock, R. Tobin, R. J. Dimler and F. R. Senti (*Cereal Chem.*, 1960, **37**, 645—655).—Starch dispersions prepared by heating, alkali treatment or by high shear treatments were studied by ultracentrifugal and light-scattering methods. High rates of mechanical shear produced marked reductions in dispersed particle size, but the amount of free amylose was little affected and was from 60 to 75% of the total amylose of the starch. (10 references.) E. C. APLING.

Preparation and properties of hydroxyethylated high-amylose maize starch. J. C. Rankin, J. G. Rall, C. R. Russell and F. R. Senti (*Cereal Chem.*, 1960, **37**, 656—670).—Paste viscosity studies with Corn Industries Viscometer and the Brabender Amylograph on maize starch of 50% amylose content, hydroxyethylated to contain between 1% and 27% combined ethylene oxide are reported. The modified high-amylose starch gave lower cooking–cooling curves and less translucent pastes than similarly modified waxy and normal maize starches, but viscosity, clarity and colour of the pasted starch is also dependent on pH and on the % of alkali catalyst used in its prep. The microscopical appearance and film-forming properties of the pastes are discussed. (18 references.) E. C. APLING.

Cooling starch-thickened foods with cold tube agitation. K. Longhee, L. Moragne and J. C. White (*J. Milk Tech.*, 1960, **23**, 330—336).—In the production of white sauces 4-gal. batches were cooled by agitation using a rotary tube agitator through which refrigerated water flowed. Relative viscosity (**I**), density, whiteness and acceptability (**II**) were studied using the following variables: flour, 4, 6, 12 oz./gal.; milk fat, 4, 6, 12 oz./gal.; rate of agitation 6, 12, 18 r.p.m. Cooling took place from 140 to 60°F in 5 h., but half of these cooled within 3 h.; those with high fat content cooled more slowly. Changes in **I** were small and, except in two cases, **II** was not affected. C. V.

Keeping quality of tapioca and nutro-macaroni. N. Rajasekharan, N. Gopalakrishna Rao, N. S. Kapur, D. S. Bhatia and V. Subrahmanyan (*Food Sci., Mysore*, 1960, **9**, 240—243).—Steamed and roasted tapioca macaroni rice and nutro-macaroni were stored in polythene bags, brown paper and in cloth at room temp. and at 37°, R.H. 70%. Samples were examined every month for one year. Results are given. All samples kept well for one year under normal conditions. I. DICKINSON.

Sedimentation value as an index of dough-mixing characteristics in early-generation wheat selections. L. Zeleny, W. T. Greenaway, G. M. Gurney, C. C. Fifield and K. Lebsock (*Cereal Chem.*, 1960, **37**, 673—678).—Mixogram curves and sedimentation values determined on 159 samples of F_3 lines resulting from a cross between two wheat varieties showed highly significant correlations between sedimentation values and mixogram data. The use of the sedimentation test may provide a more reliable guide for wheat selections than does the mixograph or any other recording dough mixer. The test also has the advantage of requiring only a small sample, 20 g. for the normal technique and only 2 g. for a proposed semi-micro technique.
E. C. APLING.

New possibility of research into dough ripening processes. H. Wutzel (*Brot u. Gebäck*, 1960, **14**, 215—223).—Using a new apparatus which measures simultaneously gas production and rate of rising of a dough, the effects of quantity of yeast, dough temp., kneading time and H^+ concn. on the gas retention of doughs are studied. For wheat doughs the pH for optimal gas retention was about 5·0. The working of the dough at lower temp. resulted in more favourable dough properties than those obtained at a higher temp. (23 references.) J. V. RUSSO.

Effect of dough processing on the freshness and keeping quality of mixed bread. H. Stephen (*Brot u. Gebäck*, 1960, **14**, 224—232).—The effects of flour type, acidity of dough and methods of dough processing on the keeping quality of the resultant bread are assessed by physical measurements on the breadcrumb after storage of the bread for 2—48 h. and by mould counts. J. V. RUSSO.

Oxidation of cysteine, glutathione and thioglycollate by iodate, bromate, persulphate and air. F. J. R. Hird and J. R. Yates (*J. Sci. Fd Agric.*, 1961, **12**, 89—95).—The action of the oxidising agents on thiols at concn., pH and temp. appropriate to dough prep. was studied. The oxidations at 28° were followed by reaction with *p*-chloromercuribenzoate (spectrophotometric), methylmercuric iodide (polarographic) and, in the case of cysteine, chromatographically and manometrically. Thiol groups (**I**) on adjacent protein mol. may be oxidised to produce an intermol. disulphide bond, increasing strength of dough; **I** on the same mol. may be oxidised to produce an intramol. disulphide bond; or **I** may be oxidised to the sulphinic or the sulphonic acid and prevent formation of intermol. disulphide bond by oxidation or by disulphide-thiol exchange. (25 references.) E. M. J.

Instant bread mix. I. Dehydration of flavouring materials. C. O. Chichester, N. Sharrah and M. Simone. **II. Consumer evaluation of prepared bread.** M. Simone, N. Sharrah and C. O. Chichester (*Food Technol.*, 1960, **14**, 653—656, 657—661).—I. The application of three drying principles—freeze, spray and drum—to a fermented broth (which when combined with an instant mix resulted in a baked product with good sensory characteristics) and the evaluation of these processes in the production of a dried flavouring medium from the standpoint of bread flavour are discussed. Dried bread-flavouring materials from cell-free liquid broths gave bread results differing slightly in bread flavour intensity, but not in preference as ranked by laboratory panel and had a storage stability over a period of 2 months.

II. The acceptability with regard to appearance, texture and flavour of instant-mix bread made with four flavour prep. was evaluated by a laboratory panel and a consumer panel. No significant differences were indicated by either panel among the three dried flavour prep. E. M. J.

Possibilities for the use of air-separated flour fractions in the manufacture of fine and stored bakery products. A. Rotsch and E. Tessmer (*Brot u. Gebäck*, 1960, **14**, 209—215).—The effects of using whole flour, and high and low protein fractions of flour, on the appearance, taste, colour and texture of various types of bread and cakes are studied. J. V. RUSSO.

Moisture determination in baked goods and doughs by automatic titration with Karl Fischer reagent. P. F. Pelshenke, W. Seibel and H. Bolling (*Dtsch. LebensmittRdsch.*, 1960, **56**, 293—296).—The application of automatic titration by the dead stop end-point technique with Karl Fischer reagent to the rapid determination of moisture in doughs and freshly baked goods is described. Results obtained are somewhat higher than by oven-drying methods, but these differences are probably due to incomplete removal of moisture in normal drying. E. C. APLING.

Identification of carbonyl compounds in an ethanol extract of fresh white bread. H. Ng, D. J. Reed and J. W. Pence (*Cereal Chem.*, 1960, **37**, 638—645).—Acetaldehyde, ethyl pyruvate, furfural, hexanal, 2-methylbutanal, acetone, methyl ethyl ketone and formaldehyde were isolated and identified in the ethanolic extract of fresh white bread. Isobutyraldehyde and n-valeraldehyde were identified in oven vapour condensates but not in the ethanolic extract of bread. The methods used are briefly described. (12 references.) E. C. APLING.

Rôle and importance of enzymes in commercial bread production. G. Dalby (*Cereal Sci.*, 1960, **5**, 270, 272).—The addition of wheat or barley α-amylase to unmalted flour gives bread with gummy crumb and loaf fragility. The use of fungal enzymes instead reduces these faults, provides loaf softness similar to that given by cereal malt, and also provides protease supplementation. S. G. AYERST.

"Remix" baking test. G. N. Irvine and M. E. McMullan (*Cereal Chem.*, 1960, **37**, 603—613).—The baking test described is designed to measure strength. A malt–phosphate–bromate formula is used and times and conditions of mixing, fermentation, re-mixing, recovery, moulding, proof and baking are prescribed. Typical parallel baking test and physical dough test (Farinograph and Extensograph) results are tabulated. The Remix method detects extreme strength more readily and discriminates more widely between strong and weak flour than does the straight dough method of the A.A.C.C. ("Cereal Laboratory Methods," 1957, 6th edn.). (11 references.)
E. C. APLING.

Chemical changes which accompany the browning of canned bread during storage. R. J. Stenberg and W. F. Geddes (*Cereal Chem.*, 1960, **37**, 614—632).—Canned bread was stored at temp. of −15, 25, 35, 50 and 75° for periods up to 120 days and the extent of browning was assessed by reflectance measurements on the air-dried crumb at 600 mμ, and analyses were made of total sol. N, free amino-N, titratable acidity, lysine, reducing substances and pH. At 25° there was only very slight browning after 120 days, but

browning was appreciable at 35° and more rapid at 50° and 75°. Changes in acidity and pH suggest that org. acids play a rôle in the browning of bread. Further storage studies may conveniently be carried out at 75°. (22 references.) E. C. APLING.

White mineral oil in the baking industry. R. T. Bohn (*Cereal Sci.*, 1960, **5**, 234—238).—Determination of mineral oil, often used as lubricant for dough dividers, a release agent for bread and cake pans and as a component of trough grease, was carried out on bread and buns. The method is described. In one bakery the mineral oil content of bread varied from 120 to 2100 p.p.m. Bread purchased in stores supplied by 17 different companies varied from 117 to 3360 p.p.m. Analyses of buns made in 62 bakeries showed a variation from 300 to 1200 p.p.m. The age and condition of the dough divider affected the mineral oil migration into the dough. (11 references.) I. DICKINSON.

Irradiation of starch. Union Carbide Corp. (B.P. 832,746, 8.11.55. U.S., 1.2.55).—A starch product, which has increased water-solubility, and is a very useful protective agent against drying or atm. influences when applied as a protective layer (from 1 to 2% aq. solution) to foodstuffs, tobacco, wood, metal, etc., is obtained by irradiating maize or potato starch with 10^6—200^6 r. per g., preferably in presence of a small amount of water and an oxidation catalyst (V_2O_5). H. L. WHITEHEAD.

Sugars and confectionery

Browning of sugar solutions. IV. Effect of pH on volatile products of reducing sugars. V. Effect of pH on browning of trioses. H. G. Lento, J. C. Underwood and C. O. Willits (*Food Res.*, 1960, **25**, 750—756, 757—763).—IV. By a bisulphite ion-exchange procedure for the quant. separation of acetol (**I**), methylglyoxal (**II**) and diacetyl (**III**), the factors which influence their formation are shown to be related to the reducing sugar involved and to the pH of the solution. Increasing acidity favoured the production of **II** from dihydroxyacetone with little or no **I** or **III** being formed from fructose, glucose and dihydroxyacetone in acid solution. In solutions at pH 10—12 **I** and **III** were produced from the three sugars; at pH 8—9 smaller amounts of **I**, **III** and **II** were formed from fructose and dihydroxyacetone but not from glucose. The production or not of **I**, **II** and **III** is probably related to the ease with which heated sugar solutions enolise, fragment or rearrange under different conditions of pH. (23 references.)

V. The intermediates formed in the browning of the trioses, dihydroxyacetone and glyceraldehyde were studied in solutions of pH 4—11. Triose reductone in heated deoxygenated solutions produced no colour over the pH range 4—11. At the highest pH most browning occurred with solutions of **II** and least with those of dihydroxyacetone. At pH 4 and 5 amounts of colour produced by glyceraldehyde and dihydroxyacetone were 0·02 absorbance after 75 min. at 100°, but when these solutions were heated for 2 h. rate of colour production was linear. The curve for **I** showed the most rapid change in colour with pH increase, as shown by the curve rate constants for colour production versus pH. The curve for **II** indicated the least increase in reactivity with increasing pH. (19 references.) E. M. J.

Bread aromatics from browning systems. P. J. Kiely, A. C. Nowlin and J. H. Moriarty (*Cereal Sci.*, 1960, **5**, 273—274).—Aromas resulting from reactions between 20 amino-acids and 8 sugars at several pH levels and temp. were investigated. Typical bread-like aromas were produced consistently by leucine, histidine and arginine. Other interesting aromas were noted. S. G. AYERST.

Chemistry of non-enzymic browning. XI. Reactions of bisulphite with reducing sugars. D. L. Ingles (*Aust. J. Chem.*, 1960, **13**, 404—410).—At temp. up to 100° reducing sugars promoted autoxidation of HSO_3^- to S and SO_4^{2-}; the ketoses were more effective than the aldoses. During the autoxidation the aldoses were partly oxidised to the corresponding aldonic acids. The ketoses reacted more rapidly, only 32% of unchanged fructose was recovered after 8 h. at 100°. Oxidation of ketoses probably occurred via osone and resulted in a complex mixture of keto acids. Ascorbic acid was converted to dehydroascorbic acid and an unidentified acid. These reactions may be an explanation for the formation of SO_4^{2-} and the loss of HSO_3^- in foods treated with SO_2. An oxidative mechanism is suggested for the inhibition of non-enzymic browning by SO_2. (19 references.) I. DICKINSON.

Behaviour of sugars and their part in the manufacture of rusks. J. Sarazin and R. Calvel (*Bull. Centre Form. tech. Perfectionnement de l'Union des Fabricants de Biscuits*, 1/59, pp. 5—11).—Doughs containing 0 to 10% of added sucrose reached max. vol. with 2·5% of sugar. In general, vol. increased with fermentation temp. in the range 22° to 28°. The loaves had max. vol. with 5% sugar, the fermentation time chosen being apparently too long for 2·5% sugar. The vol. of loaves with 5% of added sugar was little affected by fermentation temp. Too little sugar in the dough results in rusks with heterogeneous pores. Sugar in excess affects the quality of the dough, and reacts with the gluten to give less friable rusks. About 5% of sugar gives rusks with optimum texture, colour and flavour. The quality of the flour, and the fermentation time and baking conditions, are also important. M. D. ANDERSON.

Maple syrup. XVII. Prevention of mould and yeast growth in maple syrup by chemical inhibitors. H. A. Frank and C. O. Willits (*Food Technol.*, 1961, **15**, 1—3).—Low concn. of esters of *p*-hydroxybenzoic acid (PHBA) were more effective than the mould inhibitors propionate, sorbate, benzoate. Na propyl PHBA at concn. <0·02% inhibited the growth of four yeast and eight mould strains inoculated into maple syrup. (19 references.) E. M. J.

Quantitative estimation of carbohydrates by paper partition chromatography. S. B. Misra and V. K. Mohan Rao (*J. sci. industr. Res.*, 1960, **19C**, 173—176).—A simple micromethod for the quant. estimation of aniline hydrogen phthalate stained sugar spots is described. Formamide, HOAc, MeOH, EtOH and acetone are suitable eluants at 50—80% concn. Overall error does not exceed ±6%. (19 references.) J.A.C. ABSTR.

Instability and formation of 5-hydroxymethylfurfural. W. Diemair and E. Jury (*Z. LebensmittUntersuch.*, 1960, **113**, 189—197).—The difference between the absorptions at 245 mμ and 284 mμ was used to determine 5-hydroxymethylfurfural (**I**) in studies of factors affecting its stability. Neither aeration for 4 h. nor exposure to diffused daylight for 21 days caused destruction. At pH 5·7 and 22°, destruction was complete in 48 h., was very much slower at 8°, 48° and 70°, but very rapid at 98°. Exposure to a temp. of 70° for 15 days protected **I** from destruction when then held at 22°. These effects are ascribed to polycondensation at higher temp. Lowering the pH caused a progressive increase in stability at 22° down to pH 1·0. The formation of **I** from glucose, fructose and sucrose and its dependence on concn., time, pH and temp. was studied, and was related to the chemical structure of the hexoses. The reactions involved in **I** formation from glucose can be explained on the basis of the spectrophotometric changes observed. (22 references.) C. L. HINTON.

Improvement to lead tetra-acetate detection of sugar alcohols in paper electrophoresis. K. Sampson, F. Schild and R. J. Wicker (*Chem. & Ind.*, 1961, 82).—Sensitivity and permanence of electrograms of sugars and sugar alcohols in borax buffer are improved by addition of rosaniline base in AcOH–acetone. Red spots on a pink–grey ground are obtained. A. C.

Bacteriostatic action of honey. J. Stomfay-Stitz and S. D. Kominos (*Z. LebensmittUntersuch.*, 1960, **113**, 304—309).—The bacteriostatic effect against *Streptococcus faecalis* and *Shigella dysenteriae* of 16 honeys of North American and European origin was examined in concn. of 5—25%. All showed inhibitory action, varying in extent. The activity was lost on heating above 56° and on ultrafiltration, but not on filtration through paper. The bacteriostatic action does not depend on the high sugar concn. or the weak acidity of the honey. Its basis is the presence of the still unknown "inhibins." C. L. HINTON.

Fermentation and Alcoholic Beverages

Detection of added invert sugar in grape juices and wines. F. H. Mühlberger (*Z. LebensmittUntersuch.*, 1960, **113**, 265—277).—A reliable method is described for the detection of added artificial invert sugar in grape juice and table wine by paper-chromatographic identification of the hydroxymethylfurfural and two specific reversion products derived from the invert sugar. The ordinary conditions and processes of wine-making do not interfere. With heavy wines, where atm. conc. grape juice may have been added, results are less positive. Added invert sugar was found in a no. of imported table and white dessert wines. (16 references.) C. L. HINTON.

Influence of sulphurous acid and L-ascorbic acid in winemaking I. Combination of sulphurous acid with acetaldehyde and glucose. W. Diemair, J. Koch and D. Hess (*Z. LebensmittUntersuch.*, 1960, **113**, 277—289).—Sulphurous acid was produced in the fermentation of model solutions and of grape juices, presumably from the reducing action of the yeast on sulphates. When found in fermented SO_4^{2-} free media, the necessary S must be provided by the yeast. The course of production of CH_3CHO during fermentation was followed in relation to the changes in SO_2 (free and combined) content. In wines more CH_3CHO was found than can be bound by the H_2SO_3 present. The excess must be dealt with by adequate sulphuring

after fermentation to prevent adverse effects on odour and taste of the wine. Equilibrium constants for the combination of SO_2 with CH_3CHO and glucose were determined. In wine, combination with glucose from residual sugar is much less than with CH_3CHO. Wines prepared by interrupted fermentation contain other SO_2-binding substances; to keep the total SO_2 requirement low, the fermentation should be allowed to die away naturally. (33 references.) C. L. HINTON.

Studies of the determination of hydrogen cyanide in wines treated with ferrocyanide. P. Joulmes and R. Mestres. Additions I and II, G. Brockelt and R. Pohlovdek-Fabini (*Ann. Falsif. Paris*, 1960, **53**, 455—475).—Extractions of " free " HCN from wines by entrainment in a current of air, by diffusion and by vac. distillation, and of " total " HCN by distillation in an acid medium with the addition of $CuCl_2$ are described in detail. A method for the simultaneous extraction of free and combined HCN is also described. Colorimetric methods for the determination of microquantities of HCN in solution, viz.: Epstein's pyrazolone, phenophthalin, benzidine and guaiacum resin methods are compared and contrasted. (26 references.) J. V. RUSSO.

Saccharification of potato mash in agricultural plants with a preparation of waste mycelium from the production of citric acid. K. Bevan, N. Burger and Z. Fencl (*Nahrung*, 1960, **4**, 719—737).—Comparative analyses of potato mashes saccharified with malt alone and with a mixture of malt and mycelium prep. are tabulated. Chromatographic analyses of the variously treated mashes are also illustrated. (32 references.) J. V. RUSSO.

Continuous brewing process. J. R. A. Pollock (*Rev. Ferment.*, 1960, **15**, 136—141).—The three stages of a continuous brewing process: rotary masher, wort boiler and extractor and fermentation plant, are described and illustrated. J. V. RUSSO.

Variety characteristics of malting properties of brewing barley. D. Lau and W. Piratzky (*Nahrung*, 1960, **4**, 250—273).—In small-scale malting tests over the years 1954—58 analysis of variance showed that significant differences in quality existed in a large no. of quality coeff. The varieties Elsa and Saale were of about equal value but Freya was inferior in enzymic activity. Elsa gave the highest yield of malt extract and had a high protein content. The quality of the barley depended on the local cultivation as well as on atm. conditions. The cool temp. and heavy rainfall of the 5 years influenced the grain formation, protein content and yield of extract and stability of the barleys. The enzyme activity during ear forming until yellow ripeness was greater than average. Increase in the dormant period of the grain after a cool, wet summer suggests an intravarietal relationship between germ inaction and enzyme activity. (32 references.) E. M. J.

Chemical aspects of malting. IX. Anthocyanogens in barley and other cereals and their fate during malting. J. R. A. Pollock, A. A. Pool and T. Reynolds (*J. Inst. Brew.*, 1960, **66** [New Ser. **57**], 389—394).—Anthocyanogens (leucoanthocyanins) were found in barley, rye-grass, and meadow fescue but are absent from wheat, oats, rye, maize, rice, millet, kaffircorn, timothy grass and cocksfoot. In the normal malting process the anthocyanogens of barley remain unaffected. If decorticated barley is malted, however, they are lost through steeping and by enzyme processes. C. A. SLATER.

Rapid method for the determination of the husk content of barley and oats. E. T. Whitmore (*J. Inst. Brew.*, 1960, **66** [New Ser. **57**], 407—408).—Husk may be detached by a short boiling treatment with alkaline hypochlorite. Results correlate well with those from older methods. C. A. SLATER.

Influence of hop oil constituents on the flavour and aroma of beer. F. V. Harold, R. P. Hildebrand, A. S. Morieson and P. J. Murray (*J. Inst. Brew.*, 1960, **66** [New Ser. **57**], 395—398).—A no. of hop oil constituents, including sesquiterpenes, have been extracted from beer. Their influence on flavour is discussed. C. A. SLATER.

Influence of metal ions on beer properties, with special reference to foam. J. M. M. Luykx (*J. Inst. Brew.*, **66** [New Ser. **57**], 399—407).—A study was made of the effect of metal–isohumulone complexes, particularly the Ni complex, on beer. The influence of Ni^{2+} (5 p.p.m.) on isohumulone content, brilliance, taste and gushing of stored beer is reported. Co^{2+} can induce gushing but is less effective than Ni^{2+}. (12 references.) C. A. SLATER.

Adaptation of high-yield strains of pentose-assimilating yeasts. Chien Tswen-Rou and Fang Hsing-Fang (*Scientia Sinica*, 1959, **8**, 61—82).—Forty-three strains of *Candida*, *Torula* and *Oidium* were studied to improve the species. In adaptation to higher temp., it was found that when there was a return to normal temp. the metabolic rate is greatly increased, this being shown by rate of multiplication, efficiency of sugar and N-assimilation and rate of O_2 consumption. With three strains of yeast it was shown that the longer the period of adaptation, the more stable were the characteristics, those after the 190th being more marked than after the 88th. (13 references.) (In English.) C. V.

Fruits, Vegetables, etc.

Natural coating of apples. V. Unsaturated and minor saturated acids of the cuticle oil. J. B. Davenport (*Aust. J. Chem.*, 1960, **13**, 411—415).—Fatty acids sol. in acetone at −18° comprised 48·5% of the cuticle oil of ripe Granny Smith apples. The composition of this fraction was: oleic acid 28, linoleic 49, linolenic 5, palmitic 1 and myristic 1%. Lauric acid was identified. Traces of caprylic, œnanthic and caproic acids were found by gas chromatography. (14 references.) I. DICKINSON.

Penetration and localisation of paraffin oil in orange peel. E. Laville (*Fruits d'outre mer*, 1960, **15**, 357—360).—The extent of the penetration of the mineral oil (paraffin) into orange peel is discussed and the contrast with the penetration of animal and vegetable oils is noted. The paraffin oil, as illustrated by photomicrographs of stained sections, penetrates the external epidermis, the hypodermis into the external mesocarp, where it is localised, between the cells. By contrast, animal or vegetable oils penetrate the cell membrane. J. V. RUSSO.

Factors contributing to breakdown of frozen sliced strawberries. W. A. Sistrunk, R. F. Cain, E. K. Vaughan and H. B. Lagerstedt (*Food Technol.*, 1960, **14**, 640—644).—Percentages of mushy slices in the frozen product were lower and shear-press measurements of firmness were higher in " Northwest " than in other varieties. In fruit harvested beyond mid season, % of mushy slices and water-sol. pectin content in the frozen product increased and in the thawed frozen product η of syrup and shear press measurements of firmness decreased. In the " Siletz " variety, when fresh fruit was held at 34°F or at room temp. prior to processing, % of mushy slices increased. If held up to 24 h. syrup η decreased. (14 references.) E. M. J.

Inhibition of polygalacturonase in brined cherries. H. Y. Yang, W. F. Steele and D. J. Graham (*Food Technol.*, 1960, **14**, 644—647).—Severe softening occurred by degradation of the pectin, the enzyme being active at a pH >1·6. When $CaCl_2$ was used instead of $Ca(OH)_2$ as the firming agent in SO_2 brine, the low pH was obtained but the cherries tended to crack and the skin was injured easily. Polygalacturonase can be inhibited by a cherry brine with the following formulation: SO_2 1·25, $Ca(OH)_2$ 0·7% and commercial 40%-active alkyl aryl sulphonate 0·02%. (15 references.) E. M. J.

Effect of post-harvest treatment with growth regulators on the ripening of mangoes. W. B. Date and P. B. Mathur (*Food Sci., Mysore*, 1960, **9**, 248—249).—Growth regulators 2,4,5-trichlorophenoxyacetic acid (NH_4 salt) (2,4,5-T) and the Na salt of 1,2-dihydropyridazine-3-6,dione (MH-40) were used in two concn., i.e., 1000 and 1500 p.p.m. of active ingredient. Tween-20 at 0·5% level was incorporated as a surface-active agent. The fruits were dipped for 2 min., dried in a current of warm air, then stored at 65—85°F and 45 to 85% R.H. and examined after 10 days. Results of the organoleptic tests and the determination of % total sol. solids, % citric acid before and after treatment are given. Fruits having received 2,4,5-T treatment at 1000 p.p.m. level were favoured in respect of their taste qualities. Post-harvest and pre-storage treatment could extend the storage life of mangoes. I. DICKINSON.

Carboxylase in carrots and potatoes. W. O. James and A. M. Richens (*New Phytol.*, 1960, **59**, 292—297).—The carboxylase of carrots can be extracted with water. There is normally little carboxylase in potatoes but their ability to decarboxylate pyruvic acid increases when the tubers are stored in N_2. L. G. G. WARNE.

Infra-red spectroscopic method for the determination of residues of pentachloronitrobenzene. G. Paulig (*Dtsch. LebensmittRdsch.*, 1960, **56**, 296—298).—The method is based on reduction of pentachloronitrobenzene to pentachloroaniline with Zn and AcOH and measurement of its i.r. absorption in the 7·23 μ band using CCl_4 as solvent. Procedures for extraction of the residues, reduction, and isolation of the pentachloroaniline formed are described in detail. The method will determine 0·1 p.p.m. of pentachloronitrobenzene in cabbage with a max. error of about 15%. E. C. APLING.

English (Persian) walnuts, *Juglans regia*. II. Dehydration of kernels with the belt-trough dryer. L. B. Rockland, E. Lowe, D. M. Swarthout and R. A. Johnson (*Food Technol.*, 1960, **14**, 615—618).—Kernel moistures were reduced to the optimum moisture range (3·5 ± 0·3%) from 15—20% within 65 min. during single-stage drying at 190°F and within 50 min. in two equal stages at 180° and 210°F, respectively, and no significant off-flavours developed. The kernels developed a slight polish although kernel abrasion was minimised. (12 references.) E. M. J.

Effect of ripeness level on consistency of canned tomato juice. B. S. Luh, F. Villarreal, S. J. Leonard and M. Yamaguchi (*Food Technol.*, 1960, **14**, 635—639).—Total pectin decreased with ripening; protopectin decreased in proportion to an increase in water-sol. pectin indicating solubilisation of protopectin as the fruit matured. Juices made from firm-ripe tomatoes were thicker in consistency than those made from canning ripe or soft ripe tomatoes. (30 references.) E. M. J.

Non-alcoholic beverages

Molecular distillation apparatus for the concentration of juices and more difficult evaporations. O. Pimazzoni (*Olii min.*, 1960, **37**, 387—388).—The requirements of apparatus for the concn. of fruit juices without loss of flavour are discussed. L. A. O'Neill.

Pasteurised mixtures of fruit juice and milk intended for prolonged storage. J. J. Doesburg and L. de Vos (*Fruits d'outre mer*, 1960, **15**, 375—377).—Methods of pasteurising fruit juice/milk mixtures at high temp. and low pH without causing coagulation of the casein, utilising pectin as a stabiliser are described. Literature from 1934 is briefly reviewed. (14 references.) J. V. Russo.

Tea, coffee, cocoa

Rheology of cocoa butter. III. Crystalline changes during storage at various temperatures. C. Sterling (*Food Res.*, 1960, **25**, 770—776).—Purified cocoa butter undergoes oxidative polymerisation during storage proportional to the time and temp. resulting in decreased crystalline organisation and increased amorphous fraction (β most stable crystal, β' less stable and α least stable). At a stage involving large amounts of dimer formation, the crystalline pattern changes and a new type of crystal ω is produced. This is followed by the formation of a less crystalline gel-like structure. (21 references.) E. M. J.

Concentrating aqueous brews of beverages. General Aniline and Film Corp. (B.P. 832,299, 21.1.58).—The concentration of aqueous brews of beverages, such as coffee and tea, is facilitated by incorporating polyvinylpyrrolidone before evaporation. O. M. Whitton.

Chocolate. T. Friis-Andersen (B.P. 832,343, 28.7.55).—Formation of bloom on the surface of chocolate is retarded or prevented by admixing the chocolate mass (in non-aq. condition) with 5 wt.-% of a mixture of oil-free glycerides of the fatty acids of animal butter fat (preferably hardened butter-fat oil), unhydrogenated vegetable fat (cacao butter), and vegetable emulsifying agent (lecithin). F. R. Basford.

Milk, Dairy Products, Eggs

Physico-chemical properties of cow and buffalo milk. VIII. Electrometric titration of milk. S. Parkash and B. R. Puri (*Indian J. Dairy Sci.*, 1960, **13**, 97—103).—A large no. of samples of milk were titrated electrometrically with dil. aq. NaOH. The point of inflection in each case was in the pH range 8·3—8·4. A simple relationship between the amount of alkali required for neutralisation and the protein content of the milk was found. The buffer indices decreased continuously with rise in pH value. S. G. Ayerst.

Lactoperoxidase. IV. Inactivation of lactoperoxidase by micro-organisms. F. Kiermeier and C. Kayser (*Z. LebensmittUntersuch.*, 1960, **113**, 203—213).—The diminution of lactoperoxidase activity which occurs in milk treated with cultures of mixed organisms from acid curd or from yoghurt was found to occur also in milk treated with pure cultures of *Streptococcus thermophilus, Lactobacillus bulgaricus, Bacterium coli* and an unidentified *Micrococcus* growing but slowly in milk and producing very little acid. A close correlation was found between inactivation of enzyme and growth of organism. The lactic acid formed in the development of the organisms (i.e., the souring of the milk) was not responsible for the inactivation, but the enzyme (presumably within the framework of the metabolic system of the organism) was irreversibly destroyed. The importance of the results in relation to the reliability of the qual. peroxidase test for milk is discussed. (13 references.) C. L. Hinton.

Mathematical evaluation of the significance of small changes in the phosphatase activity of milk. J. B. Mickle and R. D. Morrison (*Food Technol.*, 1961, **15**, 6—7).—Milk samples were tested for phosphatase content by the method of Sanders and Sager. Colour intensities were converted into phenol units by a single standard curve calculated from data of phenol solutions of known concn. and by a statistical procedure known as a "biological assay" technique, which had more precision. E. M. J.

Cyanocobalamin-binding capacity of yoghurt, *Lactobacillus bulgaricus* and *Lactobacillus thermophilus*. D. A. Callieri (*Ark. Kem.*, 1960, **16**, 197—201).—*L. bulgaricus* (**I**) and *L. thermophilus* (**II**) suspended in saline exhibit a cyanocobalamin-binding capacity which increases on adding further cyanocobalamin. Binding capacity of **I** increases with no. of cells in suspension; that of **II** is little affected. Capacity of **II** and yoghurt in saline varies little at temp. 20—60° but decreases sharply at higher temp. (>90°). On heating **I** to 70—80° its binding capacity is decreased to ~10% of that at 20°. C. A. Slater.

Fat globule membrane materials of cows' milk. V. Interaction between milk proteins and lecithin in emulsification. VI. Properties of membrane phosphatase. S. Koyama (*Nippon Nôgei Kagaku Kaishi*, 1960, **34**, 510—514, 514—517).—V. The emulsifying power of Na caseinate, lactalbumin and lactoglobulin in butterfat–phosphate buffer emulsion was measured (1) when only each one of these proteins was added, (2) when each protein mixed with lecithin was added, and (3) when each protein was added after previous dissolution of lecithin in butterfat. The emulsifying power of Na caseinate was the same in all cases, that of lactoglobulin was highest in (3) and lowest in (1), and that of lactalbumin was highest in (1) and lowest in (2). Lecithin showed little emulsifying power. Thus the contribution of lecithin to emulsification of milk is mainly in making more close adsorption of lactoglobulin on the surface of fat globule.

VI. It was previously reported that both fractions (supernatant and precipitate) prepared from the fat-globule membrane materials by ultracentrifugation had alkaline phosphatase activity. The effect of pH was similar on the enzymes in the supernatant and the precipitate. After treatment of both fractions with ethanol–ether mixture, the lipid-free protein residues were submitted to solubility test and paper electrophoresis. The phosphatase in the supernatant was mostly sol. in 0·08M-NaCl solution, but that in the precipitate was mostly insol. The former easily migrated on paper electrophoresis, whereas the latter did not. S. Kawamura.

Determination of iodine-131, caesium-137 and barium-140 in fluid milk by γ-spectroscopy. G. R. Haggee, G. J. Karches and A. S. Goldin (*Talanta*, 1960, **5**, 36—43).—The nucleides present together in milk can be determined individually in concn. down to 10 $\mu\mu$c./l. with an accuracy within 10% at concn. >100 $\mu\mu$c./l. The milk is placed in an Al beaker in a scintillation spectrometer and the spectrum is recorded over the energy range 0—1·9 MeV in 95 20-keV channels. No prep. of the sample is required. G. Burger.

Stability of vitamins of milk in pasteurisation, sterilisation and in preparation of condensed milk. W. Wodsak (*Nahrung*, 1960, **4**, 209—224).—By short-time pasteurisation, 10—20 sec. at 71—74°, losses of vitamins A, C, B_1, B_2 and B_6 were 10—16, 9—12, 20—27, 5—10 and 5%, respectively; and by autoclaving 60 min. at 115°, 25, 22—40, 16—28, 0—3 and 11—16%, respectively; nicotinic acid remained stable in both processes. By sterilisation 60 min. at 115° and homogenisation, losses of vitamins A, C, B_1, were 30—35, 22—25 and 22—25%, respectively; by boiling, losses of vitamins A, C, B_1, B_2, B_6 and nicotinic acid were 18—22, 10—15, 10—20, 0—5, 5—12 and 0—5%. By prep. of condensed milk losses of vitamins A, C, B_1 and B_2 were 22—25, 7·3—21·7, 2·2—35·4 and 0·5—5%, respectively. Nicotinic acid was stable. If milk is stored before heating, losses of vitamins A and C increase. (32 references.) E. M. J.

Organic acids of milk and milk products. J. Schormüller and H. Langner (*Z. LebensmittUntersuch.*, 1960, **113**, 197—203).—The org. acids of cow's and mare's milk and of sour milk, yoghurt, kephir, kumiss and cottage cheese were determined by previously described methods (*ibid.*, 1960, **113**, 104). In fresh milk of both kinds citric is the chief acid; in naturally soured milk lactic and acetic acids become more important, although with little diminution in the absolute amount of citric acid. Yoghurt shows a large content of lactic acid but the citric acid again is unchanged. In kephir and kumiss still larger amounts of lactic acid are produced, along with some increase of acetic acid, but the citric acid mostly disappears (entirely so in "strong" kumiss). Lactic acid, with some acetic acid, is the main acid of cottage cheese. Data are included for other acids present in trace amounts in the various products. (14 references.) C. L. Hinton.

Formation of acetoin and diacetyl by souring cream cultures. K. Täufel and U. Behnke (*Nahrung*, 1960, **4**, 197—208).—According to the discussion the splitting of citric acid into acetic and oxalic acids is due to the activity of the ferment citricase. The oxalic acid is decarboxylated into pyruvic acid. Glucose in the culture is also converted into pyruvic acid and this by hydrogenation is mainly converted into lactic acid, but small quantities are changed into α-acetolactic acid and finally into acetoin and diacetyl. Glucose or citric acid alone is incapable of producing this change; the presence of glucose promotes the reaction. (25 references.) E. M. J.

Effect of storage on *deshi* butter. S. N. Mitra, P. N. Sengupta, B. R. Roy, T. V. Mathew and A. K. Mallik (*J. Instn Chem. India*, 1960, **32**, 232—234).—Stored samples of butter were examined every month for a period of one year. The free fatty acid content increased from 2·1% to 15·5% and the sap. val. fell slightly but the moisture content, refractometer reading at 40°, Reichert value of extracted fat and the Kirschner value of butyric acid content did not show any appreciable change. S. A. BROOKS.

[Factors] influencing the consistency of butter. J. M. de Man (*Dairy Industries*, 1961, **26**, 37—41).—A brief review. (27 references.) C. V.

Organic acids of various cheeses. J. Schormüller and H. Langner (*Z. LebensmittUntersuch.*, 1960, **113**, 289—298).—The org. acid balance was followed by methods used in earlier work (*Z. Lebensmitt-Untersuch.*, 1960, **113**, 197) during the 3—4 weeks ripening period of sour-milk cheese. Lactic and citric acids disappeared entirely, while there were notable increases in succinic, acetic, propionic and higher volatile fatty acids. The acid balances of other cheeses as obtained from a commercial source (Romadur, Emmental, Tilsit, Edam, Parmesan, Gorgonzola, Roquefort, Camembert and two processed cheeses) were determined. Considerable differences in the amounts of the dominant acids were found. Acids present in minor quantity often contribute decisively to the flavour of particular cheeses. The development of acid by *Penicillium camemberti* on synthetic and milk media was examined. The addition of milk markedly stimulated growth, the most positive effects on the acid balance being the diminution in α-ketoglutaric acid and the increase in pyruvic acid. (24 references.) C. L. HINTON.

Changes in milk proteins by *Penicillium roqueforti*. II. Proteolysis by enzyme preparations and effects of lactic acid bacteria. III. Effects of rennet. T. Imamura (*Nippon Nôgei Kagaku Kaishi*, 1960, **34**, 375—378, 379—383).—II. In order to obtain some basic knowledge on the decomposition of casein by *P. roqueforti* (*P. r.*) and other starter organisms, changes in the amounts of tyrosine formed in substrates by enzyme prep. were determined. Max. proteolysis was observed at pH 5·5 and 42°. Proteolytic activity of the cell extract from a fungus mat increased with growth of the mould until the growth had reached a max. after 7 days. Thereafter the proteolytic activity of the cell extract decreased and that of the cell-free medium increased, as the protease became an extracellular enzyme. In this extracellular state, the activity was rapidly lost at 25°. At the ripening temp. (4·5—10°) of Roquefort cheese the growth of the moulds and casein decomposition are slow but the protease activity is retained for a long time. Starter organisms such as *Streptococcus lactis*, *S. cremoris* and *Lactobacillus bulgaricus* also had proteolytic action, but their activities were negligibly low in comparison with that of *P. r.* These starters accelerated the proteolytic action of *P. r.* by decomposition of lactose and formation of lactic acid.

III. The effects of rennet on the decomposition of casein by *P. r.* were studied by the changes of amount of tyrosine formed, electrophoretic patterns, and paper chromatograms of free amino-acids. Rennet accelerated the decomposition of casein by *P. r.*, owing to the pepsin present in the rennet. Rennin showed no peptide-decomposing action, but had some effect on liberation of lysine and arginine from casein. Pepsin also was effective in accelerating the liberation of amino-acids. S. KAWAMURA.

Changes of milk fat by *Penicillium roqueforti*. II. Lipolysis by enzyme preparations. III. Accumulation of volatile fatty acids and the effect of sodium chloride. T. Imamura (*Nippon Nôgei Kagaku Kaishi*, 1960, **34**, 383—387, 387—393).—II. The enzyme prep. used were cell extract (**I**) and cell-free medium (**II**) of *P. roqueforti*. The degree of lipolysis during incubation of moulds increased with the growth of the moulds and gradually decreased in the stationary phase. The sp. activity (activity per g. of mould) was high in the growing period and decreased suddenly at the beginning of stationary phase. Lipolytic activity of **I** was only shown on the normal Czapek medium if butter fat were added, and also on bread medium. The lipolysis of **I** was optimal at pH 7·0 and 30—35°, and that of **II** showed lower max. at the same pH and temp. Of the fatty acids liberated by **I** and **II**, 1/4—1/3 and 1/2 were volatile, respectively. The presence of two different types of lipase was assumed in the supernatant and the insol. matter of **I**; optimal pH were 7·5 and 6·5, respectively. The activity of **I** and **II** was lowered by addition of more than 3% of NaCl.

III. The lack of O_2 supply was not sufficient to explain the accumulation of volatile fatty acids in cheese, since it was found that *P. roqueforti* could grow under such anaerobic condition as within Roquefort cheese. Volatile acids accumulated in the medium on addition of 4% NaCl to the milk, since the pH was lowered, and the mould growth was suppressed. At the optimum pH of mould growth, addition of less than 4% NaCl accelerated the growth of *P. roqueforti* and retarded the consumption of volatile fatty acids. This tendency was pronounced for fatty acids of higher mol. wt. The consumption level of acetic acid reduced to 1/2, of butyric acid to 1/3, of caproic acid to 1/5, and of caprylic to 1/6 on addition of 4% NaCl. This was attributed to loss of buffer action or liberation of H^+, which was adsorbed on protein particles. Accumulation of volatile fatty acids in skim milk was not observed, but the decomposition of residual milk fat contributed to the volatile acid production more than did lactose or amino-acids. S. KAWAMURA.

Vegetable cheese from groundnut milk. M. A. Krishnaswamy and D. S. Johar (*Food Sci., Mysore*, 1960, **9**, 235—240).—The possibility of manufacturing a hard-type cheese from groundnut milk was investigated. *Ficus carica* (Linn.) was used as a clotting agent. The prep. of the enzyme ficin and the manufacturing process of the cheese is described. Milk cheese and cheese made from groundnut milk mixed with milk were made and used as comparison. The curds from pure groundnut milk cheese and the mixed milks were very weak, which resulted in incomplete removal of moisture, therefore only semi-hard cheeses could be obtained. The curds were difficult to handle and an appreciable amount of solids was lost. The flavour was slightly nutty, which impaired the quality as a Cheddar type cheese. (17 references.) I. DICKINSON.

Ripening of cream. J. Masek, J. Haskovec and M. Vedlich (B.P. 832,539, 24.1.57).—To control the biological ripening of cream before churning, the cream is cooled to a predetermined temp., when a desired acidity has been reached, as determined by the electrical conductivity or the pH of the cream. H. S. R.

Preparation of milk products such as sour milk by use of static cultures. A. Schmidt-Burbach (B.P. 831,797, 19.9.56. Ger., 22.9.55).—A process for preparing milk products, e.g., sour milk (yoghurt), curd or cottage cheese, comprises inoculating high-temp.-pasteurised milk with 2—5% of a starter, optionally in presence of $CoCl_2$, pantothenic acid, and/or *p*-aminobenzoic acid. The starter is specifically material obtained by cultivating the intestinal form of *Lactobacillus acidophilus* and/or the intestinal form of *L. bifidus* with a specified yeast, *Streptococcus* or propionic acid bacteria. F. R. BASFORD.

Butter-like spread. J. G. Roberts (B.P. 833,116, 24.12.57. U.S., 31.12.56).—A butter-like spread, pH 6—6·2, comprises butterfat 22—28, non-fat milk solids (containing 3·5—4·5% of lactose) 15—16, NaCl 0—2%, and water (⩾60%). F. R. BASFORD.

Edible Oils and Fats

Vegetable oils. IX. Application of reversed-phase chromatography to the analysis of seed oils. F. D. Gunstone and P. J. Sykes (*J. Sci. Fd Agric.*, 1961, **12**, 115—123).—By reversed-phase partition chromatography in columns, a quant. study was made of mixtures of saturated, unsaturated and oxygenated fatty acids from four seed oils: *Gmelina asiatica*, *Cephalocroton pueschelii*, *Vernonia camporum* and *Jatropha cureas*. (39 references.) E. M. J.

Manufacture of modern edible fats and their analysis. W. Wachs (*Z. LebensmittUntersuch.*, 1960, **113**, 213—222).—The chemical and physical changes involved in the technical conversion of natural oils and fats into edible fats are reviewed. Hydrogenation, position- and stereo(*cis-trans*)-isomerism, interesterification, fractional crystallisation and combined procedures are dealt with. Special reference is made to chromatographic methods for determining lauric acid in examining chocolate fats for small amounts of palm-kernel fats, for detecting palmitic acid esterified in a hardened fat, and for separating the mixture of mono- and dicarboxylic acids obtained on oxidation of mono-unsaturated acids in the detection of hydrogenated or elaidinised constituents. The desirability on physiological grounds of giving preference to hardening procedures involving as little change as possible in the natural fatty acids is pointed out. (37 references.) C. L. HINTON.

Effect of autoxidation prior to deodorisation on oxidative and flavour stability of soya-bean oil. C. D. Evans, E. N. Frankel, P. M. Cooney and H. A. Moser (*J. Amer. Oil Chem. Soc.*, 1960, **37**, 452—456).—Oxidation prior to deodorisation was detrimental to the flavour and oxidative stability of soya-bean oil. The increase in non-volatile carbonyl content of freshly deodorised oils was proportional to the peroxide value before deodorising; rate of loss of flavour and oxidative stability were related to the extent of carbonyl development. All oils contained some non-volatile carbonyls (**I**). Oxidised soya-bean oil methyl esters developed **I** on heating at deodorisation temp. Addition of isolated methyl ester peroxide decomposition products to deodorised soya-bean oil reduced its flavour and oxidative stability in proportion to the amount added.

The oxidatively derived **I**, of unknown structure, probably contribute to flavour instability and quality deterioration. The importance of minimising autoxidation in soya-bean oil, before deodorisation, is stressed. (25 references.) E. S. LANE.

Frying life of fat. M. E. Rust and D. L. Harrison (*Food Technol.*, 1960, **14**, 605—609).—A hydrogenated vegetable fat processed for deep-fat frying of foods was studied. It was (**I**) filtered, stored in a covered metal container at 2—5° and 20% of original wt. fresh fat added each 8-h. frying period; (**II**) filtered, stored in a cleaned fryer at 20—25° and 20% fresh fat added each frying period; (**III**) filtered, stored in a cleaned fryer at 20—25° and fresh fat added to replace that lost during each 8-h. frying period; (**IV**) skimmed, stored in a fryer at 20—25° and fresh fat added to replace that lost at each frying period. Fat treated as **I** and **II** had a frying life twice that of **III** and **IV** (e.g., in frying 100-g. samples of potatoes) and **I** and **II** also required approx. twice as much fat. There was a significant negative correlation between the acid no. of the fat and the acceptability of French fried potatoes. E. M. J.

Use of antioxidants of the type BHT in the conservation of expressed olive oil. G. Petruccioli and U. Amicucci (*Olii min.*, 1960, **36**, 369—380).—Olive oil containing various proportions of 2-6-di-t-butyl-4-methylphenol was stored for 7 months in glass bottles, open and closed, in light and in darkness, and development of rancidity followed by changes in acid val., I val., peroxide val., sap. val. and *n*, by Kreis and by Watts and Major colour tests, by examination in Wood's light, and organoleptically. Adequate stabilisation of the oil was given by a concn. of antioxidant of 22·5 mg./100 g. (70 references.) L. A. O'NEILL.

Essential fatty acid action of some geometrical isomers of unsaturated fatty acids. F. H. Mattson (*J. Nutr.*, 1960, **71**, 366—370).—An essential fatty acid deficiency was developed in weanling male rats (130) over a 12-week period; these were divided into groups, and given supplements of *cis-cis-*, *cis-trans-* and *trans-trans-*linoleate (**I**), oleate or elaidate either alone or in addition to the *cis-cis-***I** variety. Increase in body wt. showed that only the *cis-cis-***I** compound possessed the necessary fatty acid activity; the inactive ones did not however interfere in any way. Spermatogenesis was normal even in the case of the inactive acids. (17 references.) C. V.

Direct conversion of lipid components to their fatty acid methyl esters. F. E. Luddy, R. A. Barford and R. W. Riemenschneider (*J. Amer. Oil Chem. Soc.*, 1960, **37**, 447—451).—Substantially quant. yields of Me esters are prepared from cholesteryl esters, phospholipids and glycerides by methanolysis with a large excess of Na or K methoxide in MeOH. A silicic acid chromatographic adsorption column for separating Me esters from unsaponifiables is described. Conditions for complete methanolysis of glyceride fats and oils requiring only 5 min. reflux are given. Fatty acids are quant. converted into Me esters using MeOH containing 4% HCl or H_2SO_4 and by methylation with diazomethane. E. S. LANE.

Isolation and analysis of phosphatides and glycolipids. H. Wagner (*Fette Seif. Anstrichm.*, 1960, **62**, 1115—1123).—Published methods for the paper-chromatographic separation of ox-brain phosphatides and sphingolipids, pig heart muscle and retinal lipid extracts and commercial lecithin are discussed together with the application of the thin-layer chromatographic technique. A scheme for the separation of ox-brain sphingolipids is outlined which incorporates solvent extraction, alkaline hydrolysis, Craig distribution and i.r. spectroscopy methods for identification of new compounds. G. R. WHALLEY.

Tertiary butyl-substituted *p*-phenylphenols. Imperial Chemical Industries Ltd. (Inventor: R. W. G. Preston) (B.P. 833,022, 1.3.57).—Compounds *p*-R·C_6H_4·C_6H_2R′R″·OH-1,3,5,4 (R is H or Bu^t; R′ is Bu^t; R″ is H or is Bu^t when R is Bu^t), useful as antioxidants (especially in fats, fatty oils and soaps), are obtained by interaction of *p*-phenylphenol (**I**) with isobutene in presence of a catalyst (H_2SO_4) in solution in another phenol, e.g., 3,5-dimethylphenol, at $\gtrsim$150°. Details of the method of prep. are given. F. R. BASFORD.

Stabilisation of emulsions. Channel Islands Fine Distillers Ltd. (Inventor: A. Orley) (B.P. 833,018, 21.2.57).—Oil-in-water emulsions, especially an emulsion consisting of dairy cream (8), egg yolk (5), sugar (40), EtOH (17·1%) and water, is stabilised (against separation of oil) by keeping in contact with rubber latex (~1 wt.-%) for $\lesssim$1 (7) day. F. R. BASFORD.

Margarine. T. Hedley & Co. Ltd. (Inventors: J. J. Devlin and A. P. Walker) (B.P. 832,377, 27.3.57).—An oil, solid content index val. 24·5—37 at 50°F, 5·5—10 at 80°F and 0—3·5 at 92°F, suitable for use in the production of margarine, is obtained by co-randomising (inter-esterifying) palm oil (30—50) and coconut oil (50—70%), or palm oil (40—50) and palm-kernel oil (50—60 wt.-%). The product is used for the prep. of margarine with the physical characteristics of butter. F. R. BASFORD.

Meat and Poultry

Relationship between pork leanness and moisture content. E. Karmas, J. E. Thompson and H. E. Wistreich (*Food Technol.*, 1961, **15**, 8—12).—The relationship between moisture content and leanness of pork was expressed by the equation $L = 1{\cdot}5M - 11{\cdot}5$ where L is the % of lean and M is the % of moisture. The equation can be used for quant. determination of lean in the meat industry where commercial cuts of meat usually contain >40% of lean. E. M. J.

Effect of cure on pork with watery structure. I. Binding of salt and water to meat. II. Effect on quality of canned hams. J. Wismer-Pedersen (*Food Res.*, 1960, **25**, 789—798, 799—801).—I. The low water-binding capacity of the meat proteins in ground watery pork occurred near the isoelectric point, i.e., in the pH range of 5·1—5·5. Whole cuts of watery meat, when covered, absorbed more pickle than normal meat. The diffusion of salt into and of N compounds out of the meat was higher for watery meat than for that with normal structure. The flow of K, Na and deoxypentose nucleic acid indicated a more thorough penetration of the pickle into the meat cells of the watery meat compared with normal meat. (14 references.)

II. In pasteurised hams from meat with watery structure, colour (generally paler), taste and texture were inferior. When hams were cooked to commercial sterility, there was no difference between those processed from normal and those from watery meat. E. M. J.

Radiation resistance of the natural bacterial flora of cured ham. W. L. Brown, C. Vinton and C. E. Gross (*Food Technol.*, 1960, **14**, 622—625).—Most bacterial strains were very sensitive to irradiation but small no. of spores were able to survive high levels of radiation in cans of cured ham. These spores were identified as the S-2 strain of PA 3679. If curing salts (NaCl, sugar, NO_3^-, NO_2^-) were present in normal amounts the ground ham was not spoiled in cans given 0·5 Mrad irradiation when incubated for 2 months at 86°F. When no curing salts were present and 1 Mrad irradiation was given, after incubation, the spores grew and produced spoilage. Destruction of bacteria was similar whether the source of irradiation was γ-rays or an electron beam. (10 references.) E. M. J.

Polarographic studies on storage of meat. IX. Influence of γ-ray irradiation on organic acids and free amino-acids of beef. T. Obara and Y. Ogasawara (*Nippon Nôgei Kagaku Kaishi*, 1960, **34**, 397—403).—Irradiated beef vacuum-packed in polyethylene–Cellophane bags was stored at 20° for 52 days. Before storage, there was an increase in the lactic acid content with increasing dosages of γ-rays, but there was a decrease with dosages $>240 \times 10^4$ r. There was a decrease in free creatinine and creatine with increasing dosages of γ-rays. Amino-acid contents of irradiated beef were almost independent of the dosages. With beef irradiated by $<148 \times 10^4$ r., there was a decrease in lactic acid content with increasing time of storage. With dosages of $>200 \times 10^4$ r, there was a decrease in lactic acid content up to 21 days, but thereafter there was an increase with time of storage. Creatine decreased on storage, but creatinine did not. Free amino-acids increased during storage. As lactic acid and free amino-acids in stored, irradiated beef were present only in small amounts, they were not likely to affect the protein wave on the polarogram. S. KAWAMURA.

Reaction of cooked, stored meats with 2-thiobarbituric acid (TBA). I. Changes of TBA values of cooked meats during storage. M. Fujimaki and F. Yoshimatsu (*Nippon Nôgei Kagaku Kaishi*, 1960, **34**, 518—523).—Cooked, stored meat showed much increased TBA values, compared with raw meat or cooked, stored meat with added polyphosphate. TBA values and peroxide no. of fats extracted from cooked, stored meats with ether as solvent showed little change from the original low level, but TBA values of defatted, cooked, stored meats showed much increase during storage for 2 weeks. The substances in cooked, stored meats reacting with TBA were little extracted by such org. solvents as ether, chloroform, or ethanol, but were mostly extracted by trichloroacetic acid solution. S. KAWAMURA.

Volatile carbonyl compounds of cooked chicken. II. Compounds volatilised with steam during cooking. E. L. Pippen and M. Nonaka (*Food Res.*, 1960, **25**, 764—769).—Raw cut-up chicken and water were boiled and the steam was passed into 2,4-dinitrophenylhydrazine; 56 kg. of chicken yielded 651 mg. of 2,4-dinitrophenylhydrazones. The carbonyl compounds unequivocally identified included diacetyl and/or acetoin, acetaldehyde, n-hexanal and n-deca-2,4-dienal; 16 others occurring in lesser amount were tentatively identified and there was evidence of others not identified. None of the identified carbonyl compounds had flavour

characteristics resembling the flavour of cooked chicken but the concn. of total carbonyl found in chicken broth suggests that one or more carbonyl compounds contribute significantly to the over-all flavour. (11 references.) E. M. J.

Treatment of meat, meat-containing products and blood. Chemische Fabrik Budenheim A.-G. (B.P. 831,132 22.6.56. Ger., 27.6.55).—Meat, meat-containing product or blood is protected against coagulation, and the keeping properties are improved by treatment with a condensed alkali metal phosphate, mol. wt. 200—1600, characterised by bulk wt. <600 g. (preferably <400 g.) per litre and obtained in very voluminous and readily sol. form by a direct or indirect spraying process. F. R. BASFORD.

Composition and method for coating foodstuffs. Dow Chemical Co. (B.P. 832,449, 24.4.58. U.S., 29.8.57).—A thin, tightly adhering protective coating (which is subsequently readily removed by stripping) is obtained on foodstuffs (especially meat and meat products) by applying thereto (in frozen state) a molten composition consisting of an ethylcellulose (of ethoxy content 47·5—50 wt.-%; η 6—200 centipoises in 5% solution in 80 : 20 vol. toluene–EtOH) 19—70, refined mineral oil (η^{38} 80—400 Saybolt) 15—65, and colourless, odourless, non-toxic plasticiser 5—30 wt.-%. F. R. BASFORD.

Canning bacon. M. Ingram (B.P. 833,987, 16.7.55).—Before canning, bacon is cut into small pieces (rashers), then air-dried (on a strip of regenerated cellulosic material) until the water/salt content ratio is <5 : 1 (the final salt content of the bacon being preferably >4 wt.-%). The product, after winding into a spiral and canning, may then be sterilised at a lower temp. than usual, e.g., at 75° for 140 min., to give a superior material. F. R. BASFORD.

Fish

Formation of acetoin in cod and other bottom-fish fillets during refrigerated storage. H. S. Groninger (*Food Technol.*, 1961, **15**, 10—12).—The content of acetoin increased from <1 to 7—10 mg./100 g. after storage for 4—8 days at 34°F. This increase occurs just before the time that the sample would be considered unacceptable. As a measure of quality it is of very limited use. E. M. J.

Antibiotic ice in the conservation of fish. C. Matéu and G. Varela (*An. Bromatologia*, 1960, **12**, 271—333).—The structure of tetracyclines and methods of application of antibiotics to the catch are reviewed. Methods of judging fish quality are based on: organoleptic tests, alteration in pH, fat and N and, additionally, the volatile amines content, tyrosine index and Walkiewicz tests. Oxytetracycline is used as the antibiotic. The fish examined was bought (far from the catch point) in Madrid, but antibiotic ice (compared with ordinary ice) postponed the onset of decomposition by up to 6 days. (160 references.) L. G. L. UNSTEAD-JOSS.

Spices, Flavours, etc.

Non-enzymic browning in garlic powder during storage. J. S. Pruthi, L. J. Singh and Girdhari Lal (*Food Sci., Mysore*, 1960, **9**, 243—247).—The effects of packaging, moisture content and storage temp. were investigated. The extent of non-enzymic browning was studied by measuring % light absorption in 2% filtered aq. extracts in a Lumetron photo-electric colorimeter at 420 mμ (blue filter). The results were expressed as optical density at 420 mμ. The browning was also measured quant. in a Lovibond tintometer and expressed in terms of the red, yellow and blue units. Browning was max. at 37° and min. at 0—2°. Less browning occurred in polythene bags than under any other conditions. (13 references.) I. DICKINSON.

Semi-chemical soya sauce. IV. Isolation and identification of volatile sulphur components. V. Some factors affecting the occurrence of volatile sulphur components. T. Ueno and A. Nobuhara (*Nippon Nôgei Kagaku Kaishi*, 1960, **34**, 566—569, 569—572).—IV. In order to recover the volatile S components in semi-chemical and chemical soya sauce, the gases from aerated neutralisates of defatted soya-bean hydrolysate were passed through a train of absorption traps consisting of anhyd. $CaCl_2$, $Pb(OAc)_2$, 4% $Hg(CN)_2$ and 3% $HgCl_2$. Three l. of the neutralisate were boiled under reflux and aerated with N_2 for 10 h. at the rate of 200 ml./min. by applying a vacuum at the end of the train. H_2S was identified in the $Pb(OAc)_2$ trap. From the white ppt. which appeared in the $Hg(CN)_2$ trap, MeSH was identified as $(MeS)_2Hg$. From the white ppt. which appeared in the $HgCl_2$ trap, Me_2S was identified as its Hg salt, $2Me_2S,3HgCl_2$, also from the infra-red spectrum. A trace of Me_2S_2 was presumed to be present. The characteristic unpleasant flavour formed by acid hydrolysis of soya-beans was attributed to a complex mixture of these volatile S compounds, carbonyls and acidic substances.

V. Below 85° the amount of these volatile S compounds was low, but at 100° much larger amounts were evolved, especially Me_2S. The occurrence of H_2S and MeSH increased in proportion to the heating time, but that of Me_2S became almost constant in 2—4 h. after boiling. H_2S was more readily evolved in strong acid solution and diminished in proportion to the rise of pH, but it increased gradually above pH 5. MeSH and Me_2S occurred only slightly in strong acid solution and increased remarkably in proportion to the rise of pH. The occurrence of these volatile S compounds in various soya sauces was compared. There were no differences in H_2S and MeOH between naturally brewed soya sauce and chemical soya sauce. Naturally brewed soya sauce evolved only a trace of Me_2S, but chemical soya sauce evolved much larger amounts. Thus Me_2S is one of the characteristic constituents of soya sauce which undergoes acid hydrolysis. S. KAWAMURA.

Adsorption indicators in the determination of sodium chloride in soya sauce and miso. I. Argentometry with bromophenol blue as an adsorption indicator. II. Argentometric determination with some sulphonphthalein dyes. III. Argentometric determination by the use of Fe^{3+} (or Ce^{4+} or VO_3^-)–*o*-tolidine system as an oxi-adsorption indicator. IV. Determination with some sulphonphthalein dyes as adsorption indicators in mercurometry. V. Determination with diphenylcarbazone as an indicator in mercurometry. K. Sato (*Nippon Nôgei Kagaku Kaishi*, 1960, **34**, 630—634, 634—637, 638—644, 713—716, 716—720).—I. A rapid, accurate determination of Cl^- in soya sauce and miso is very difficult. Mohr's method is unsuitable, because org. substances present mask the colour change of reagents, as the colour of the sauce and miso resembles that of Ag_2CrO_4, the results are too high by 2—4%. Volhard's method is also unsuitable. In the direct titration of Cl^- in soya sauce and miso with $AgNO_3$, satisfactory results are obtained in acid solution (optimum pH, 2·7—3·4) with bromophenol blue as adsorption indicator. Deproteination of the fluid is not necessary. The results are accurate in the presence of considerable amounts of protein, amino-acids and other org. compounds. Metanil yellow, Tropaeolin OO, fluorescein, dichlorofluorescein, Congo red, etc., cannot be used owing to the interference of proteins and their hydrolysis or fermentation products.

II. Chlorophenol blue (**I**) and chlorobromophenol blue (**II**) are new argentometric adsorption indicators for titrating Cl^-, Br^- and I^-. These indicators are reversible and the colour changes at the end-points are from yellow to blue in all cases. The titration is possible up to a concentration of 0·02N-Cl^-, -Br^- and -I^- with **I** and 0·02N-Cl^-, 0·01N-Br^- and 0·01N-I^- with **II** in a weakly acidic solution (pH 3·0—4·0), but neither can be applied to soya sauce and miso. In the volumetric analysis of Cl^- in soya sauce and miso with $AgNO_3$, testing of 13 kinds of sulphonphthalein indicators shows that titration is successful with tetrabromophenol blue as an adsorption indicator. The pH should be adjusted to 3·6—2·8. In this case, phenol red, cresol red, thymol blue, bromophenol red, bromocresol purple, chlorophenol red, iodophenol blue, **I**, and **II** cannot be applied owing to the protein interference, and it is explained theoretically from the view of chemical structure that bromophenol blue and tetrabromophenol blue are applicable to soya sauce and miso.

III. In the argentometric determination of Cl^- in soya sauce and miso, diphenylamine, *N*-methyldiphenylamine red, benzidine, *o*-dianisidine, *o*-tolidine, methyl violet (or Acid violet, Crystal violet), Brilliant green, Malachite green are suitable as adsorption indicators. Also Fe^{3+}–benzidine, Fe^{3+}–*o*-tolidine oxi-adsorption indicators are excellent. The last-mentioned is recommended as being more sensitive than bromophenol blue in the argentometry of Cl^- in soya sauce and miso. When Cl^- is in excess, the tolidine-meriquinoid is adsorbed by AgCl, giving a purple colour. At the end-point a yellow colour is obtained very sharply. The titration with Fe^{3+}–*o*-tolidine is successful in solutions containing excess of protein and by using Ce^{4+}– or VO_3^-–*o*-tolidine system, high concn. of H_3PO_4 up to 30% can be tolerated. The evaluation of Cl^- with Fe^{3+}–*o*-tolidine gives satisfactory results in solutions containing 0·003N-Cl^- and in EtOH solvent as little as 0·001N-Cl^-, and showed acid resistance up to 2·7N-, 0·8N- and 0·07N-H_2SO_4 in concn. for 0·1, 0·02 and 0·003N-Cl^- solutions, respectively. In strongly acidic solution, Malachite green and Brilliant green can be used as adsorption indicators for titrating Cl^-, Br^- and I^- with $AgNO_3$.

IV. Chlorophenol blue (**I**) and chlorobromophenol blue (**II**) are new adsorption indicators for titrating halide ions with $Hg_2(NO_3)_2$. **I** is suitable for the analysis of Br^- and **II** for Cl^- and Br^-. **I** can be used up to 0·01N-Br^- and **II** up to 0·01N-Br^- and 0·1N-Cl^- with colour change from yellow to violet, when 0·1N-$Hg_2(NO_3)_2$ solution is employed. In the volumetric analysis of Cl^- in soya sauce and miso by mercurometry, of 12 sulphonphthalein adsorption indicators, bromophenol blue is recommended as the most suitable. Gelatin,

peptone, glucose, furfural, etc. do not interfere. It can be used with up to 0·6N-HNO_3 before titration.

V. A new adsorption indicator, *p*-dimethylaminobenzylidenerhodanine in acetone solution, is used for the mercurometric titration of halide ions. The indicator is suitable for the analysis of Br^- and the ppt. changes from red to deep violet at the end-point. A method for the mercurometric determination of Cl^- in soya sauce and miso is described as being more simple and more accurate than the ordinary $AgNO_3$ titration. Diphenylcarbazone (**I**) is suitable as an indicator and the mechanism of colour change is discussed. This method gives satisfactory results in the presence of excess protein, carbohydrate, amino-acids and other org. compounds, but Fe^{3+} should be less than 1·2 mg./ml. The interference of higher Fe^{3+} contents can be avoided by adding KF or H_3PO_4 solution. The tested solution must be adjusted to pH 1·7 at the end-point. **I** should be added near the end-point, preferably before the last 1—2 ml. of the titrant. The ppt. is white and turns to blue violet as the end-point is reached. A preliminary titration (35—60°) is desirable. Diphenylcarbazide is unsuitable as an indicator for Cl^- analysis. S. KAWAMURA.

Effect of number of judgements in test on flavour evaluations for preference. L. A. Sather and L. D. Calvin (*Food Technol.*, 1960, **14,** 613—615).—Samples (20) of each product (canned peaches, hamburger, tomato juice and green beans) were assigned to four trays and judged in one continuous test period. For mild products such as these, 20 samples may be included in one test period with no decrease in the judges' ability to discriminate flavour preferences among samples. (10 references.) E. M. J.

A new model in consumer testing. G. E. Ferris (*Food Res.*, 1960, **25,** 802—809).—The analysis described enables the estimation of preference proportions for products A and B, corrected for pseudo-preferences. E. M. J.

Non-specificity of differences in taste testing for preference. G. A. Baker, M. A. Amerine, E. B. Roessler and A. Filipello (*Food Res.*, 1960, **25,** 810—816).—A taste-preference experiment with raisins is described which emphasises the distinction between difference testing and preference ratings based on organoleptic examinations of foods, beverages, etc. E. M. J.

Colouring matters

Polyene compounds. F. Hoffmann-La Roche & Co. A.-G. (B.P. 831,901, 20.8.57. Switz., 21.8.56).—Colouring matters for foods comprise crocetin and bixin deriv., especially all-*trans*-1,14-di-(alkoxycarbonyl)-5,10-dimethyltetradeca-1,3,5,7,9,11-heptaenes and 1,18-di(alkoxycarbonyl)-3,7,12,16-tetramethyloctadeca-1,3,5,7,9,11,-13,15,17-nonaenes (and their deriv. with Me groups in the 1,14- and 1,18-positions respectively), the prep. of which is described in detail. H. S. R.

Preservatives

Experimental preservation of fresh beef with antibiotics and radiation. A. W. Phillips, H. R. Newcomb, T. Robinson, F. Bach, W. L. Clark and A. R. Whitehill (*Food Technol.*, 1961, **15,** 13—15).—The application of 7 p.p.m. of chlortetracycline to the surface of beef followed by irradiation with 0·1 megarad inhibited microbial growth during storage at 34°F for 30 days, more effectively than antibiotic or irradiation alone. The most useful limits of chlortetracycline concn. were 0·5—10 p.p.m. and the most suitable radiation dose was 200 krads. Storage temp. of 34° was better than 40°F. Microbial counts were lower in treated meat packed in Saran film than in Cellophane and polyethylene. (15 references.) E. M. J.

Effectiveness of Acronize chlortetracycline in poultry preservation following long-term commercial use. A. Abbey, A. R. Kohler and P. F. Hopper (*Food Technol.*, 1960, **14,** 609—612).—Since Nov. 30, 1955, when 7 p.p.m. for residues of chlortetracycline in and on uncooked poultry were permitted, Acronize chlortetracycline has been used effectively in the poultry processing industry to retard bacterial spoilage. After 5 years of continued commercial use Acronize remained effective (75% average shelf-life extension). When Acronized birds were held under ice or stored in polyethylene bags, the average shelf life over that of controls was 48 and 77% respectively. Increase in insensitive micro-organisms in a developing spoilage population on Acronized poultry is caused by "selection" rather than development. (19 references.) E. M. J.

Food Processing, Refrigeration

Possibilities of the use of certain new disinfectants in the fruit and vegetable processing industry. I. Kalačević (*Kem. u Industr., Zagreb,* 1960, **9,** 216—225).—Of the liquid and powder detergents, "Biostat" antibiotic, "Neocitin" preservative and "Sorbistat" stabiliser investigated, "Saponia" detergent powder was the most effective washing agent with least organoleptic ill-effects, but all tested detergents were suitable for the washing of glass and wooden vessels and plant. The addition of >50 p.p.m. Biostat (21·6% oxytetracycline) followed by heating to 100° resulted in complete elimination of microflora. Neocitin B (a benzyl ester of monobromoacetic acid) (1 mg. per l.) was effective for fruit and vegetable preservation, but this agent is prohibited by the German food regulations. Sorbistat was a highly effective anti-mould additive. Pending official decisions, washing the processing plant with water chlorinated to 20 mg. active Cl per l., to give an effective concn. of ~5 mg./l. is suggested. (16 references.) A. L. GROCHOWSKI.

Physical and biochemical alterations of frozen foods. J. Kuprianoff (*Kältetechnik,* 1960, **12,** 284—290).—Physical and biochemical alterations of food, which may be caused by the actual freezing process and which may limit the storage time on account of protein denaturation and rancidity of the fatty substances are discussed. The problem of reversibility is dealt with. Although the course of such alterations and measures of prevention are well known in practice, knowledge of the reactions taking place is still incomplete. (13 references.) W. H. KEMP.

Deep freeze and the processing of baked goods. J. T. Herbert (*Mod. Refrig.,* 1960, **63,** 1169, 1258).—A brief review. C. V.

Sterilisation and protection of articles. A. Charlesby (B.P. 832,076, 30.10.56).—Foodstuffs and other articles are heat sterilised, generally by heating at 100—150° for 1—60 min., after heat sealing in a container formed from flexible sheet or film of polymer plastic, e.g., polyethylene. This plastic is irradiated previously with a dosage of *X*-rays, *γ*-rays, high-energy electrons, etc. so that sufficient is cross-linked to withstand the heat of sterilisation and enough is left unaffected for heat sealing. O. M. WHITTON.

Packaging

[Correct] package for fresh fruit. N. F. Sommer and D. A. Luvis (*Pack. Engng,* 1960, **5,** No. 12, 37—43, 116).—A general review. No universal type of package would appear possible. Each must be considered in terms of the type of fruit, the form of natural deterioration and the rigors of handling and transit. (18 references.) C. V.

Effect of packaging films and storage temperatures on ripening mature green tomatoes. J. C. Ayres and L. C. Peirce (*Food Technol.,* 1960, **14,** 647—653).—Tomatoes stored at 5° did not ripen normally, but were pre-disposed to decay; rate of ripening proceeded in the order: ambient room temp. > 25 > 20 > 15 > 10°. Of fruit kept in storage, for 2·5 months at 10°, 2 months at 15°, etc., that at 20° spoiled in <1·5 months and at 25° or ambient temp., in a few days. Shear press values are useful in assessing stage of maturity (ripeness). Trays of the fruit overwrapped with the more impermeable polyethylene, Pliofilm, Saran and Cryovac rotted and had an undesirable taste. Wt. losses were min. in these trays and greatest in those overwrapped with cellulose acetate. (12 references.) E. M. J.

Miscellaneous

Nutrition, proteins, amino-acids, vitamins

Chemical composition and nutritive value of *jowar* (kaffir corn—*Sorghum vulgare*) and Jowar diets. P. P. Kurien, M. Narayana Rao, M. Swaminathan and V. Subrahmanyan (*Food Sci., Mysore,* 1960, **9,** 205—210).—*Jowar,* a staple food consumed as grains like rice or as flour in India, is reviewed covering the chemical composition, distribution of protein, Ca and P in the husk and endosperm, availability of Ca and P, effect of milling on the nutritive value, the nutritive value of poor *jowar* diets, metabolism of N, Ca and P in children on *jowar* diet and the utilisation for production of malt and malt foods. (40 references.) I. DICKINSON.

Nitrogen and essential amino-acid contents of various varieties of maize. R. Bressani, L. G. Elías, M. Santos, D. Navarrete and N. S. Scrimshaw (*Arch. venezol. Nutr.,* 1960, **10,** 85—100).—Results for total N content of the germ, endosperm and husk; the % of acid-sol., alcohol-sol. (zein), alkali-sol. and insol. protein, and the essential amino-acid contents are tabulated for 10 varieties of maize from Vera Cruz, Mexico and four from Guatemala. Compared with the FAO reference protein, maize protein from all the samples examined was deficient in lysine, tryptophan, methionine and threonine. Selection of maize varieties for higher proportion of germ would lead to improvement in the nutritive value of the protein of whole maize. (26 references.) E. C. APLING.

Biological value of pea protein with respect to essential amino-acids. W. Schuphan and W. Postel (*Z. LebensmittUntersuch.*, 1960, **113**, 223—229).—Essential amino-acids (EAA) were determined microbiologically in the protein of fresh and dried peas. The biological value of the protein of dried peas, as indicated by the EAA index, was higher than that of fresh peas. Changes in composition of the protein of fresh peas with increase of size (virtually equivalent to degree of ripeness) were followed; the biological value increased with size, although not to the value shown by the dried peas. Changes in the content of individual amino-acids with increase of size of fresh peas and as between fresh and dried peas are indicated and discussed. Improvement in the quality of pea protein should be sought through the breeding of varieties with higher methionine (and cystine) content. (31 references.) C. L. HINTON.

Nutritive value of beans from Central America. III. Variations in protein, methionine, tryptophan, thiamine, riboflavin and niacin contents of samples of *Phaseolus vulgaris* cultivated in Costa Rica, El Salvador and Honduras. R. Bressani, J. Méndez and N. S. Scrimshaw (*Arch. venezol. Nutr.*, 1960, **10**, 71—84).—Analytical results for 11 varieties from El Salvador, 20 from Honduras and 7 from Costa Rica are tabulated and their significance in nutrition is discussed. Considerable variations in protein contents between varieties were found, e.g., Honduras-grown varieties varied from 16·6 to 25·9% protein, but there was significant correlation between N and lysine content and between N and methionine. The bean is an excellent source of lysine (580—600 mg. lysine per g. N), but a poor source of methionine (54—61 mg. per g. N) and of tryptophan (40 mg. per g. N) compared with the levels in the FAO reference protein of 270, 270 and 90 mg. per g. N, respectively. (22 references.)
E. C. APLING.

Tempeh, an Indonesian fermented soya-bean food. K. H. Steinkraus, Yap Bwee Hwa, J. P. van Buren, M. I. Provvidenti and D. B. Hand (*Food Res.*, 1960, **25**, 777—788).—Tempeh produced by growing the mould *Rhizopus oryzae* on soya-beans is suggested as a possible source of low-cost protein in child-feeding programmes in undeveloped countries. The product is probably more easily digested than the original soya-bean. The yield, by procedures described, was ~72·5 g. (dry substance)/100 g. of starting soya-beans (dry wt.). E. M. J.

Methods for the study of digestion and absorption. III. Movement of barium sulphate and chromic oxide in the large intestine. I. Yoshihara, A. Sugisaki and M. Kandatsu (*Nippon Nôgei Kagaku Kaishi*, 1960, **34**, 563—566).—A mixture of ^{35}S–$BaSO_4$ and Cr_2O_3 was injected into the cecum of the rabbit with abdominal window and the radioactivity and the Cr_2O_3 and $BaSO_4$ in the ash of the faeces were assayed. Count per min./Cr_2O_3 per 100 mg. of faecal ash was different in the samples of faeces showing a regular tendency pattern based on the compositional differences in ash of faeces. Definite evidence of the parallel movement of $BaSO_4$ and Cr_2O_3 in the large intestine was noted. S. KAWAMURA.

Concentration of tocopherols. Vitamins Ltd. (Inventors: J. Green and S. Z. Marcinkiewicz) (B.P. 832,572, 9.4.57).—A natural tocopherol concentrate containing non-tocopherol hydroxylic substances is freed from the latter by dissolving in an inert solvent (light petroleum), adding $ZnCl_2$, heating for a few min., then separating off pptd. $ZnCl_2$–impurity complex. F. R. BASFORD.

Vitaminised products. Institut National de la Recherche Agronomique and Société Protector (B.P. 831,258, 15.11.57. Fr., 16.11.56).—An aq. dispersion of protein containing homogeneously-distributed vitamin-active material is (prior to coagulation of the protein) absorbed under vacuum by grains of a previously degassed, edible animal or vegetable absorbent (e.g., cacao pods), so that the finished grains contain and are coated individually with a film of coagulated protein (preferably gelatin). If desired, the grains may be coated with a supplementary layer of a derivative of an edible glucide, e.g., alkali metal alginate. Absorption treatment is best effected at 40—80%/10—20 mm., and the preferred coagulant is tannin. F. R. BASFORD.

Unclassified

Production and application of enzyme preparations in food manufacture. (*Soc. chem. Ind. Monogr.*, 1961, No. 11, 180 pp., Symp. iv sessions.)—(i) **General introduction.** M. Dixon. (pp. 3—14.) In a general survey of enzymes, types of reaction which they catalyse, with special reference to foods, and effects produced are discussed. The enzymes (~700) may be broadly divided into groups: hydrolysing (~200), transferring (~370), adding (or removing) (~70), isomerising (~25) and synthesing (~25). The general properties of enzymes important for prep. and addition of desirable and the prevention of undesirable reactions are reviewed.

Production of fungal amylase and its use in supplementation of bread flour. A. R. Lockwood. (pp. 15—24.) A description is given of an established process for producing α-amylase by submerged culture and the present use of fungal α-amylase in milling and baking technology is discussed.

Invertase: its manufacture and uses. A. L. Cochrane. (pp. 25—31.) The two enzymes, β-h-fructosidase (present in yeast) and α-n-glucosidoinvertase (excreted by *Aspergillus oryzae*), capable of hydrolysing sucrose are discussed. In general a suitable strain of yeast is grown in deep aerobic fermentation; the yeast is then "conditioned" by treatment with molasses under aeration, to produce max. invertase secretion. Yeast invertase is most active at pH 3—6, pH 4·5 being the optimum value. The use of invertase concentrate in sweetening matter and the incorporation of invertase in fondant for chocolates are described. (12 references.)

(ii) **Preparation, properties and assay of pectin-degrading enzymes.** W. W. Reid. (pp. 35—47.) The properties of pectin and pectin enzymes are reviewed. (31 references.)

Production and applications of plant and microbial proteinases. L. A. Underkofler. (pp. 48—63.) The method of production of plant proteinases: papain, bromelain and ficin, and microbial proteinases from *Aspergillus oryzae* and *Bacillus subtilis* are briefly discussed. In commercial application knowledge of optimum pH range, thermal inactivation rates and temp. optima is important. Specific applications to baking, brewing, cereal foods, dairy and meat products and protein hydrolysate (e.g., for special diets and animal feeds) industries are discussed. (14 references.)

Manufacture, purification and properties of rennin. N. J. Berridge. (pp. 64—70.) The extraction and isolation, sterilisation, pptn. and use in cheese-making are briefly reviewed. A patented method of prep. without separation of the enzyme is described. Reference is made to the recent work on κ-casein. (13 references.)

Collagenases and elastases. J. Thomas. (p. 71.)

Glucose oxidase: production, properties, present and potential applications. L. A. Underkofler. (pp. 72—86.) The specificity, optimum pH range, rate of glucose oxidation, thermal stability and rate of O_2 uptake are discussed. The uses of glucose oxidase in the protection of foods include removal of glucose, removal of O_2, use in beverages, in mayonnaise, and in packaged dried foods. (17 references.)

General discussion. Future potentialities for application of enzymes. S. W. F. Hanson. (pp. 87—90.)

(iii) **Innate enzymes: their action and control. Enzymes concerned in the ripening of fruits.** A. C. Hulme. (pp. 93—106.) Fruits studied were banana, avocado pear and temperate-zone fruits, e.g., tomato, apple and pear in relation to the newer knowledge of the enzyme-mediated changes occurring during the early critical changes of ripening associated directly with the period of respiration climacteric. Small amounts of ethylene in the atm. surrounding fruits produce changes in the overall enzymic reactions, in ordered sequence, without imbalance and physiological injury, whereas present methods, e.g., use of low temp. supernormal CO_2, etc., if used in excess cause physiological injury. (20 references.)

Use of enzymes in processing and storage of juices and other products. V. L. S. Charley. (pp. 107—117.) Apart from oxidising systems inactivated at 85—95°, in 10—30 sec., the innate enzymes pectinesterases (PE) and polygalacturonases (PG) degrade pectin and clarify the juice. The use of such enzymes for juice production and clarification and the suppression of PE in citrus juices are reviewed. (19 references.)

Oxidation of ascorbic acid and phenolic constituents. L. W. Mapson and T. Swain. (pp. 121—133.) The enzymes ascorbic acid oxidase (**I**) and phenolase (**II**) are Cu proteinates. **I** produces undesirable nutritional effects, but no off-flavours or discoloration such as occur when **II** is active on phenolic compounds. The enzymic browning of potato slices is discussed. (49 references.)

(iv) **Hydrolysis of lipids in cereals and cereal products.** J. B. Hutchinson. (pp. 137—149.) Deterioration changes in stored grain, loss of viability, increase in fat acidity and decrease in non-reducing sugars, etc., are reviewed. Changes in fat acidity and sugars have been examined as indices of deterioration in wheat, maize and rice but not in oats or barley. When grain is milled or crushed the speed of lipolysis is greatly increased. (22 references.)

Unsaturated fat oxidase activity of plant extracts. J. A. Blain and E. C. C. Styles. (pp. 150—159.) In processing and storage of foods oxidation of naturally occurring unsaturated lipids may cause unpleasant flavours and destruction, e.g., of vitamin A, carotenoids and other substances. Fatty acids most readily oxidised, viz., linoleic, linolenic and arachidonic, have the pentadiene group, and certain factors in plant and animal tissues catalyse the oxidation of these acids. The destruction of β-carotene by haematin compounds is due to their action on linoleate hydroperoxide. (50 references.)

Oxidation of carotenoids in green plant tissue. J. Friend. (pp. 160—167.) Carotene is destroyed enzymically after damage or cutting of fresh green tissue. If damage is avoided and the chopped or sliced green vegetables are blanched the enzymes are inactivated and oxidation is decreased. Loss of carotene in dried peas or animal feeding stuffs is due to a non-enzymic process and losses were reduced by gas- or vac.-packing, by controlling the moisture content, by keeping at low temp. during storage or by adding antioxidants (**I**). Commercial use of **I** is not recommended. (18 references.)

Enzymic deterioration of lipids. I. Animal lipids. C. H. Lea. (pp. 169—177.)

II. Vegetable oils and oilseeds. W. D. Raymond. (pp. 177—180.)

I. The main deteriorative actions of tissue enzymes on food lipids are either hydrolytic or oxidative. Of interest in food preservation is the activation of lipid-splitting enzymes by freezing. Enzyme activity in liver, fatty tissues of meat animals, poultry, eggs, fish and milk is discussed. (36 references.)

II. In vegetable and seed oils the proportion of free acidity affects cost of refining for edible purposes. The oil-rich seeds contain lipases the activity of which decreases with a reduction in moisture content. Max. for safe storage is 14% calculated on the non-oleaginous portion of the seed. Oil seeds may also be attacked by enzymes from insects or moulds. Differences in Malayan and Nigerian palm oils are discussed. E. M. J.

War gases: the impregnation of, and removal from, foodstuffs and water. A. Sanchez Capuchino (*An. Bromatologia*, 1960, **12**, 253—264).—Iperite, hydrolysed and nitrogenised iperite, $COCl_2$, HCN, halogens and cyanhydrides, and organophosphorus compounds are considered, together with their means of detection in water and foodstuffs, forages and cereals. A list is given of solid chemicals and apparatus needed for the detection of the poisons listed.
L. G. L. Unstead-Joss.

Food chemistry and spectrography. K. Pfeilsticker (*Dtsch. LebensmittRdsch.*, 1960, **56**, 285—289).—A review of recent advances in spectrographic detection and determination of trace elements in food chemistry and toxicology. (12 references.) E. C. Apling.

Zinc-65 and zirconium-95 in food. M. A. van Dilla (*Science*, 1960, **131**, 659—660).—^{65}Zn has been found in small amounts in beef liver and beef muscle in cattle raised in Nevada and New Mexico; ^{95}Nb and ^{95}Zr occurred in liver. Traces of ^{65}Zn were also found in milk from areas of high fall-out; this milk also had elevated ^{137}Cs levels.
T. G. Morris.

Anthocyanins. II. Action of anthocyanin pigments and related compounds on growth of micro-organisms. J. J. Powers, D. Somaatmadja, D. E. Pratt and M. K. Hamdy (*Food Technol.*, 1960, **14**, 626—632; cf. J.S.F.A. Abstr., 1960, i, 318).—The 3-monoglucosides of pelargonidin and delphinidin inhibited the growth of *Bacterium coli*. Malvidin-3,5-diglucoside (**I**) stimulated growth at some stages. Delphinidin and malvidin (**II**) stimulated growth. *Lactobacillus casei* was stimulated by **I** and **II**. Of five synthetic compounds (**III**) three were inhibitory towards *Staphylococcus aureus* but not to *B. coli* or *L. casei*; two had no effect on any of the organisms. Heating of **III** caused loss of activity in some cases and gain in others. (38 references.) E. M. J.

Effect of γ-rays on food micro-organisms. VI. Effect on *Bacterium coli* in components of varied meats. VII. Effect on food bacteria under some conditions. W. Watanabe (*Bull. agric. chem. Soc. Japan*, 1960, **24**, 673—681, 681—684).—VI. A series of studies was made on the effects of various conditions on the survival of *B. coli* irradiated with ^{60}Co γ-rays. This report deals with the survivals of the strain irradiated in the medium containing each of the components of various types of fish-meats and meats.

VII. The effects of irradiation on *B. coli* and other food bacteria (in pure and nutrient agar medium) are compared.
S. Kawamura.

Effect of chlorine on spores of *Bacillus coagulans*. T. R. La Bree, M. L. Fields and N. W. Desrosier (*Food Technol.*, 1960, **14**, 632—634).—The sporicidal effect of Cl on spores of *B. coagulans* was influenced by pH, temp. and Cl concn. At a concn. of 20 p.p.m. of Cl and at 60° the sporicidal effect was in the range of practical use in a cannery. (14 references.) E. M. J.

Vosges–Proskauer test using 1-naphthol purified by steam distillation. M. Fulton, D. Halkias and D. A. Yarashus (*Appl. Microbiol.*, 1960, **8**, 361—362).—This purification resulted in greater stability and freedom from interfering colour. (12 references.) C. V.

3.—SANITATION

Residues in wheat and wheat products after fumigation with ethylene dibromide. S. G. Heuser (*J. Sci. Fd Agric.*, 1961, **12**, 103—115).—In studying the nature and amount of the residues which may be present in foodstuffs after commercial-scale fumigation with ethylene bromide (EDB) analytical procedures are required which will differentiate between unreacted EDB physically sorbed on the material and the water-sol. inorg. bromide which may result from the decomposition of the EDB or its reaction with the material. The effects of duration of treatment, temp., moisture content and milling of wheat on sorption and desorption were determined. Recommended procedures for determination of total bromide, reacted bromide (and free EDB) in fumigated cereal products are described. (17 references.) E. M. J.

Stability of insecticide-resistance in mosquitoes. L. L. Lewallen (*J. econ. Ent.*, 1960, **53**, 1122—1124).—In laboratory tests, DDT-resistance declined fairly rapidly when pressure was relaxed going from 165× to 14·5× in 5½ months at LC_{50} level. Malathion-resistance declined to a low level in 1959 after being high in 3 previous years in a pasture. Parathion resistance also declined when insecticide applications were less frequent in field tests.
C. M. Hardwick.

Pollution effects on the fungus population of a stream. W. B. Cooke (*Ecology*, 1961, **42**, 1—17).—The fungal population of a stream was depressed near the outfall of a sewage treatment plant but increased down stream and finally surpassed the population of the zone above the outfall. L. G. G. Warne.

Cleansing and sterilising compositions. V. J. Albericci (B.P. 832,105, 30.8.57).—A solid cleansing and sterilising composition, e.g., for dairy equipment, surgical instruments, etc., comprises a solid, water-sol. bromide or iodide of an alkali or alkaline earth metal, a solid chlorine-releasing compound (e.g., trichloroisocyanuric acid) and a solid surface-active agent. There should be sufficient chlorine-releasing compound to decompose at least a large part of halogen salt. Preferably, sufficient solid acid or acid-reacting salt (e.g., sulphamic acid, NaH_2PO_4) is incorporated to produce pH 4—7 when the composition is dissolved in water. O. M. Whitton.

4.—APPARATUS AND UNCLASSIFIED

Determination of magnesium in plant material with Titan yellow E. G. Bradfield (*Analyst*, 1960, **85**, 666—670).—To ensure adequate concn. of the component of Titan yellow that precipitates Mg, the solution of the reagent in 0·1% polyvinyl alcohol is standardised spectrophotometrically at 550 mμ. The ground, dried plant material is digested with HNO_3 with subsequent addition of $HClO_4$. An aliquot of the diluted residue is adjusted to pH 3 to 4 and applied to an ion exchange column of De-Acidite E (Cl^- form) which is eluted with water. To an aliquot of the eluate and to a series of standards (0 to 100 μg. of Mg) a compensating solution containing $CaCl_2$, $AlCl_3$, hydroxylamine hydrochloride and triethanolamine is added, the mixtures are treated with the Titan yellow–polyvinyl alcohol reagent and NaOH solution. After 30 min. the extinction is measured at 550 mμ. Results with some plant materials are quoted and compared with those found by the 8-hydroxyquinoline method. A. O. Jones.

Limits of interference by iron, manganese, aluminium and sulphate in the EDTA determination of calcium in presence of magnesium using Cal-red as indicator. P. Moss (*J. Sci. Fd Agric.*, 1961, **12**, 30—34).—Under the conditions described, the titration of Ca by EDTA can tolerate in 50 ml. of an equimolar solution of Ca and Mg up to 2 mg. of Fe, 1 mg. of Mn, 3 mg. of Al and up to 6 mg. of PO_4^{3-}.
E. M. J.

Iron chelates in plant extracts. D. G. Hill-Cottingham and C. P. Lloyd-Jones (*J. Sci. Fd Agric.*, 1961, **12**, 69—74).—Methods were studied for extracting and identifying ethylenediaminetetra-acetic acid (EDTA) and 1,2-diaminocyclohexanetetra-acetic acid (CDTA) or their Fe chelates from plants; concentrating these substances (**I**), separating them from salts, sugars, etc., in the aq. extracts so that **I** could be examined by paper chromatography. Separation is effected by retaining the EDTA or CDTA on cation-exchange resin, at pH 2, and elution with dil.aq. NH_3 or adsorbing the Fe chelates from aq. solutions on activated C; salts and sugars are eluted with water and 5% aq. ethanol, the Fe chelates with 25 or 50% ethanol. When chromatographed on paper with 4 : 1 w/v phenol–water solvent the EDTA and CDTA are located by staining with Ni dimethylglyoxime and the Fe chelates by viewing under u.v. light. (11 references.) E. M. J.

Lettuce (le·tis): genus *Lactuca*. 1. A hardy annual of which mainly four varieties are cultivated, the most important being var. *capitata*, the head or cabbage lettuce. 2. Subject to attack by aphids, cabbage loopers and other pests, particularly in the days immediately before harvest when generally the use of insecticides is prohibited because of risk of harmful residue. 3. Complete crop protection against insects during this period is ensured *only* by Phosdrin, a systemic insecticide which can be used on all edible crops to within 48 hours of harvesting without risk of residue. Control is achieved within a few hours. 4. Phosdrin is part of the complete range of chemicals for crop protection offered by Shell (see also aldrin, dieldrin, endrin, D-D and Nemagon). **Phosdrin** *Trade*.

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CONTENTS