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RESEARCH PAPERS

On Some Correlations Between Grain Composition and Physical Characteristics to the Dry Milling Performance in Maize[a]

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Forty samples from twenty German maize varieties were studied for physical characteristics, major chemical constituents and dry milling behaviour. Varietal differences in properties increased in the order—(i) Physical characteristics: bulk density, 1000-kernel weight, number of kernels per liter, percent stress cracked kernels and floaters; (ii) Chemical constituents: starch, protein and fat; and (iii) Product spectrum: total yields (standard semolina), meal I, meal II and flour. Large variations in floaters test helped to classify varieties for hardness (vitreousness). Grain protein content gave high correlation with floaters test and to yield of meal II. Correlations between physical/chemical characteristics and product spectrum indicated high association among bulk density, floaters test and protein and fat content as well as of the above four characteristics with meal II (positive) and for meal I and flour (negative). Significant correlation also existed between stress-crack count and meal I fraction in semolina. Based on yield of aspirated flour fraction in these milling trials, this procedure could be standardized for estimating the floury endosperm fraction in the maize grain.

The uniqueness and many advantages offered by maize in its food, feed and industrial uses led to a progressive increase in its cultivation and utilization in the Federal Republic of Germany (FRG)[1], where in the last ten years over forty maize varieties were officially released[2]. In FRG, dry milling of maize also has been gaining momentum in view of its diversified end-products use[1]. Dry millers insist on a good quality grain as revealed in its wholesomeness, largeness, soundness with a large percentage of horny endosperm and the least counts in broken and stress cracked kernels[3]. A systematic study was undertaken on some German maize varieties with respect to the grain quality and milling performance. In this paper, studies were limited to drawing correlations between grain make-up and its milling performance. The characterization and performance of individual varieties have been described elsewhere[4].

Materials and Methods

Materials: Forty samples of maize belonging to 20 varieties harvested from 1976 crop and comprising of three different maturity periods were procured from four states Baden-Wurttemberg, Bayern, Niedersachsen and Rheinland-Pfalz. The samples after harvest at about 35 ± 5 per cent moisture levels were spread in a room and dried in ambient air (20°C and 65 per cent RH) for 3 to 4 days followed by drying in a laboratory drier (air and material temperatures not more than 60° and 35° respectively) to 15 ± 1 per cent moisture content in the sample, a safe storable moisture level. Moisture contents were measured in a Burrows 700 Digital Moisture Computer. Samples were stored at 15°C and 60 per cent RH. Dry milling was completed in about two months period. Work on physical characteristics and chemical composition was done during the fourth month of storage, when the samples attained 11.9 ± 0.2 per cent (variability among the samples, 1. 93 per cent) moisture, as determined on 10 g duplicate samples heated for 60 min at 130°C in a Brabender oven.

Physical characteristics: 1000-kernel weight was determined in duplicate samples each containing about 800–1200 grains. Bulk density was measured in duplicate samples using a standard hektoliterweight apparatus with 250 ml volume. Number of kernels per liter was obtained by counting the grains in the bulk density measurements with the help of an electronic seed counter. Counts of grains possessing stress cracks were done on duplicate sample weighing approximately 40 g and by viewing them under a $3\times$ magnifying lens, when a focused light beam from below illuminated the grain[5]. Data for the weight of the stress-cracked grains are expressed in per cent. For Floaters Test to classify the varieties as soft, average and hard, method of Wichser[6] was employed by floating about 50 g sample in duplicate in 1.275 specific gravity solution.

Chemical composition: Analysis for starch, fat and protein were done as per standard procedures[7].

Dry milling: Maize was degermed and dry milled

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as per the Flow Sheet (Fig. 1) and machine settings (Table 1)[8].

Five Kilogram samples were adjusted to 20 per cent moisture, tempered overnight (20 hr) and passed twice through Miag Varioroll for degerming. The degermed maize was aspirated in a laboratory aspirator (Wirbelstrom-Siebmaschine) to remove the major portion of germs with hulls on. The endosperm-rich material, which was well mixed up and passed through 3300 μ sieve fitted to the aspirator was then sieved in a Maig purifier and Meal I fraction was sieved out. The overflow (over 1250 μ) was milled in a Buhler Laboratory Mill (MLU 202) using its break roll system and was sieved to obtain Meal II fraction. Flour was directly obtained as a —261 μ fraction from the breaks. The Meal I and II fractions, though do not differ in particle size (1250–261 μ), were differentiated here for process convenience and intrepretations. This fraction was also comparable to regular grits, coarse meal and dusted meal of various particle sizes reported in the literature[9]. The milling yield, standard semolina, was reported as sum total of the three fractions—meal I, meal II and flour, while hulls and germs obtained in various aspirations and as tailings comprised the by-products fraction.

Results and Discussion

Varietal variations: The ranges, the means and the variabilities of the results of different properties are shown in Table 2.

Of the physical properties studied, bulk density exhibited the least variability and the floaters test the highest. This high variation in floaters test was very useful in precisely classifying the varieties to soft, average and hard. Counts of stress-cracked kernels also varied appreciably.

In chemical composition, the variability on the whole was small, the least being in starch and the highest in fat. Total milling yield had the least variability, while the yield of flour had the highest.

Product spectrum: The product in this dry milling of maize for human consumption was standard semolina comprising of the three fractions: meal I, meal II and flour. Sieve analysis of the product indicated that, on an average (n=40), 3.3 per cent of the semolina had a particle size of over 1200 μ and below 250 μ each, followed by 28.3 per cent semolina halted on a 841 μ mesh, a maximum 54.6 per cent halted on a 500 μ sieve and 10.5 per cent halted on a 250 μ sieve (Fig. 2). Statistical treatment of the data indicated that the 500 to 841 μ fraction had the least variability (5.1 per cent) while high variability was shown by the below 250 μ (13.4 per cent) and over 1200 μ (15.1 per cent) fractions.

It is of interest to note here that in our dry milling procedure, flaking grits (over 3360 μ) and coarse grits (over 1410 μ) reported in the literature[9] were never obtained. On the other hand, the yield of regular grits (over 590 μ) was over 70 per cent of the standard semolina or about 36 per cent of the total yields obtained in the milling of maize (Fig. 2). This compared very well with the published product spectrum data[9]. Studies on the utilization of these regular grits (=meal I and II fractions in our milling procedure) for brewing and extrusion cooking have been dealt with elsewhere[4].

Contrary to the similarity of increasing order in the variations among chemical constitutents, viz. starch, protein and fat of maize and semolina (Table 2), the association analysis of these constitutents (Protein 0.98***; fat 0.65*** and starch 0.29^{NS} when $n = 40$) revealed that protein followed by fat were significantly correlated between maize and its milled product-semolina, while starch showed a non-significant correlation. In other words and according to the strongness in these correlations, during milling operation semolina fraction obtained/retained good quantity of protein in it from

TABLE 1. MACHINE SETTINGS FOR MAIZE DRY MILLING FLOW DIAGRAM REFERRED TO IN FIG 1.

Parameter	Miag Varioroll for degerming		Buhler Laboratory Mill MLU 202 using break rolls for dry milling		
	I	II	III (= Break. I)	IV (= Break. II)	V (= Break. III)
Roller:					
Diameter (mm)	250	250	149.6	150	150
Flutes/cm.	4	4	5	7	11
Clearance (mm)	1.7	0.7	0.75	0.45	0.3
Differential velocities	1:7	1:7	1:2	1:2	1:2
Material feed rate (kg/h)	120	120	8		

(rollers operated dull to dull)

TABLE 2. PHYSICAL, CHEMICAL AND MILLING BEHAVIOUR OF MAIZE VARIETIES

Parameter and unit	Range	Mean ± S.D.	Variability
PHYSICAL			
Moisture (%)	11.5 — 12.4	11.9 ± 0.2	1.7
1000-Kernel wt. (g)[a]	209.4 — 305.4	248.6 ± 25.3	10.2
Kernels/lit[b] (nos)	2144 — 3328	2682 ± 289	10.8
Bulk density (g/lit)[b]	702 — 786	745.9 ± 22.8	3.1
Stress-cracked kernels (%)[b]:			
by weight	49.8 — 99.5	81.5 ± 12.9	15.8
by number	46.9 — 98.5	80.4 ± 12.9	16.1
Floaters test (: floaters)[b]	15 — 98	64.2 ± 25.1	39.1
CHEMICAL (%)[a]:			
Whole grain			
Starch	63.7 — 69.8	67.1 ± 2.4	3.6
Protein	10.5 — 14.7	12.0 ± 1.0	8.3
Fat	3.7 — 5.3	4.7 ± 0.4	8.5
Std Semolina:			
Starch	66.7 — 82.7	78.6 ± 4.4	5.6
Protein	9.7 — 14.6	11.8 ± 1.1	9.3
Fat	00.8 — 1.3	1.0 ± 0.1	10.0
MILLING YIELDS (%)[c]:			
Meal I	13.2 — 19.7	16.6 ± 1.5	9.0
Meal II	26.6 — 41.0	34.4 ± 3.7	10.8
Flour	1.2 — 2.0	1.6 ± 0.2	12.5
Std semolina (Total yields)	45.0 — 57.3	52.5 ± 3.0	5.7

[a]Moisture-free basis, [b]11.9±0.2% Moisture basis, [c]Equal Moisture basis

TABLE 3. CLASSIFCATION OF MAIZE VARIETIES BASED ON FLOATERS TEST (INDEX OF VITREOUSNESS)

Soft	Average	Hard
Campo	Blizzard	Anjou 21
Cargil Primeur	Forla	Brillant
Edo	Inrakorn	Limac
Fello	Inraplus	Limagold
Forte	Sigma	Velox
Gabix	Zistron	
Garbo		
Kapio		
Ipho 9		

Soft: >79% floaters; AV: 48-78% floaters; and hard <47% floaters.

TABLE 4. CORRELATIONS BETWEEN GRAIN HARDNESS (LOWER FLOATER SCORES) AND SIEVE ANALYSIS OF STANDARD SEMOLINA (N = 40)

Particle size (μ)	Value of *r*
>1200	−0.25[NS]
<1200—>841	−0.69***
<841—>500	0.72***
<500—>250	0.35*
<250	−0.27[NS]

***Significant at 0.1% level; *Significant at 5.0% level; [NS]Not significant.

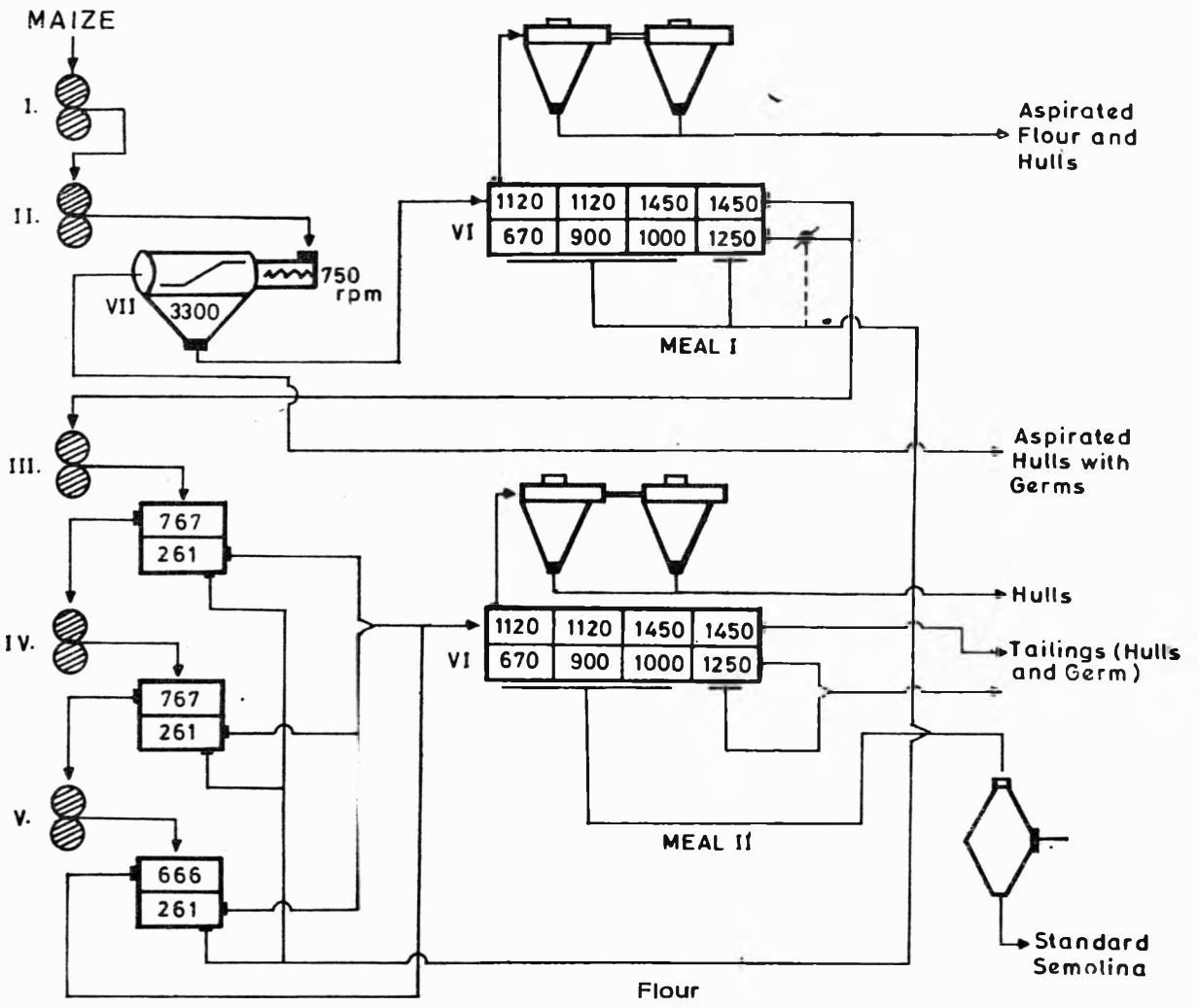

Fig. 1. Maize dry milling process flow-sheet.

I and II Degerming with Miag Varioroll
III to V Break roll milling in Buhler Laboratory Mill MLU 202.
VI Miag purifier
VII Laboratory aspirator (Wirbelstrom-Siebmaschine)

Numbers in arabic script indicate sieve openings in microns.

grain than fat and starch, eventhough starch forms the bulk of chemical constituents in grain and semolina.

Kernel hardness: Corn float test indirectly indicated the horny endosperm content in maize responsible for the yield of grits, a prime product in dry milling[6]. Therefore, floater scores were used to conveniently classify the varieties to soft, average and hard (Table 3) at 11.9 ± 0.2 per cent moisture level in the grains. An analysis for chemical make-up of the grain to its hardness indicated a significant correlation ($r=0.62^{+++}$) with protein than fat and starch.

Statistical analysis with respect to grain hardness (floaters scores) and sieve analysis of standard semolina (Table 4) revealed significant positive correlations with 250–500 μ and 500–841 μ size fractions, a significant negative correlation with semolina of size 841–1200 μ and non significant negative correlations with over 1200 μ and below 250 μ particle size fractions. This indicated the yield of meal having particle size 250–841 μ, which constitutes about 65% of standard semolina (Fig. 2) was dependent on the hardness of kernel.

Correlation of physical and chemical characteristics with milling performance: Amongst physical characteristics bulk density and floaters test and in chemical constitutents protein and fat of the grain revealed high correlations on the yield spectrum. Concerned data are presented in Table 5. 1974 milling studies ($n=15$) also indicated a high association between protein and meal II ($r=0.73$), meal I ($r=-0.83$) and flour ($r=-0.61$)[10].

The yield of meal I and flour was highly significantly

TABLE 5. CORRELATIONS BETWEEN PHYSICAL & CHEMICAL PROPERTIES AND MILLING YIELDS

Mill streams	Bulk density	Floaters test	Stress cracked kernels	Protein	Fat
Meal I	–0.67	–0.67	0.41	–0.59	–0.20
Meal II	0.90	0.70	–0.29	0.71	0.55
Flour	–0.55	–0.57	0.16	–0.59	–0.15
Meal I + Meal II	0.77	0.50	–0.15	0.58	0.57
Std semolina	0.75	0.49	–0.14	0.58	0.57

n = 40 Confidence level r = 0.30 (P = 5%); 0.39 (P = 1%) and 0.49 (P = 0.1%)

and negatively correlated with the above parameters (Table 5) while the yield of meal II was very much positively and significantly correlated. An important role played by meal II fraction is that it converted the negative correlations of meal I to positive, when meal I and II fractions together were considered, and also when total yield (standard semolina) was considered. To interpret these results with respect to our milling procedure, the three components in standard semolina Were looked for their origin in the process flow (Fig. 1). Meal I fraction was obtained as a result of breakage of grain in the initial degerming operation and which passed through the sieves. On the other hand, meal II fraction obtained from the component of over 1250 μ and below 3300 μ (Wirbelstrom-Siebmaschine setting) was progressively milled in the break system and sieved. Therefore, harder the grain, more the over-flows (1250-3300 μ fraction) in the first sieving operation, more the meal II fraction from the breaks and hence the strong positive correlation. The negative correlations for meal I and flour fractions to the hardness of the grain therefore, are self-explanatory. Looking back to the sieve analysis data and kernel hardness (Table 4) and interpreting the negative correlations of fractions 841-1200 μ and over 1200 μ it can be suggested that this fraction might have come from the meal I component. Unfortunately, a sieve analysis of meal I component was not done separately during the milling and sieve analysis of total yield was only attempted. The negative correlations showed by fraction <250 μ could be intrepreted as that of flour component in milling.

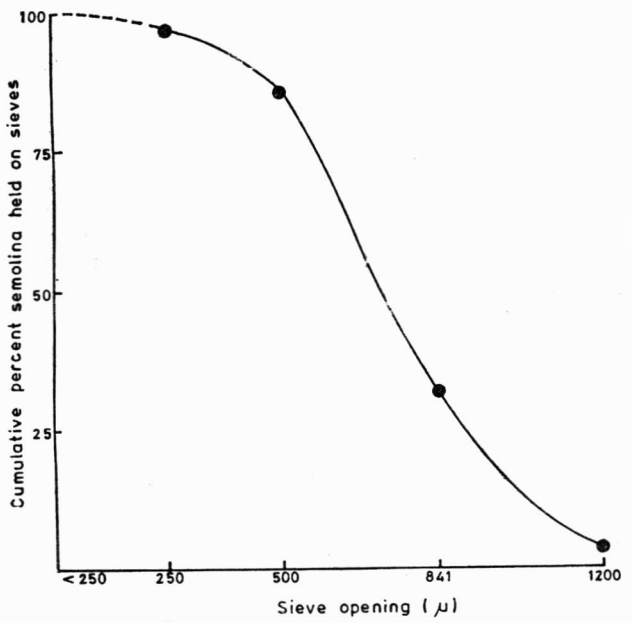

Fig. 2. Sieve Analysis of Standard Semolina.

The aspirated flour fraction obtained in the sieving-aspiration of degermed product, the fraction supposed to represent major portion of floury endosperm in the grain and which was dislocated during degerming operation, showed highly significant and negative correlation with floater test in these (1976) studies (r = –0.65 when n=40) and with protein in 1974 studies[10] (r = –0.86 when n=15).

Based on the correlations observed, it was inferred that, of the physical properties studied, bulk density appeared to have prime influence on the milling yields followed by floaters test, and in chemical makeup of the grain, protein followed by fat were significantly correlated to high milling yields. Other characteristics studied, viz., 1000-kernel weight, number of kernels per liter and starch content in grain were ignored because of their weak correlations both positive and negative.

Stress-cracked kernels: Content of stress-cracked kernels showed a negative correlation with meal II and a positive significant correlation with meal I (Table 5). This indicated the susceptability of the grain for heavy breakage at the stage of degerming operation, a demerit, causing consequential reduction in meal II and therefore in total yields.

Conclusion: This dry milling procedure can yield semolina (regular grits) suitable for brewing and extrusion cooking processess, while flaking and coarse grits reported in literature[3] were never obtained. Correlation

between floaters test and protein was significant suggesting that hardness of the kernel was related to protein content in the grain. Correlations between physical and chemical characteristics to yield spectrum, especially to meal II fraction, indicated high association in bulk density, floaters test and protein content, which directly or indirectly testify the vitreous nature of the grain and therefore, confirm the dependability of milling yields on the soundness of the grain.

In view of the strong negative correlations observed, the aspirated flour expected from the floury endosperm of grain can be an useful index in predicting the vitreousness nature of the grain. However, more detailed studies are needed to adopt this milling procedure for this purpose.

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On Measurement of Colour of Maize and its Products[a]

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Using a reflectance photometer, colour was measured in eight German maize varieties. The colour in varieties and products, semolina and extrudate was expressed in terms of yellowness, brightness and excitation purity. Particle size distribution in sample, sample size and sample moisture content influenced the colour expressions.

Variety *Forla* recorded the highest yellowness value while *Zistron* the least. Brightness was the least varying amongst varieties. Excitation purity also varied amongst varieties and products. The three colour expressions have behaved independently. There was no change in dominant wavelength in varieties and products, in all their colour was located in the yellow region in chromaticity diagram. Based on near-similarity in colour expressions, the varieties were grouped. Colour diqfferences between the varieties and products were quantitatively evaluated, which inferred an improvement in colour and its purity from maize to semolina during milling and decrease in colour and purity due to extrusion cooking. Statistical analysis revealed significant overall differences amongst varietal and treatment means in yellowness, and significant differences in brightness.

During investigations on the processing of new varieties of maize evolved in Federal Republic of Germany, it was observed that the colour of the different varieties was not the same and that the colour of products prepared from them also differed[1]. Hence, it was of interest to measure the colour of whole grains, and of milled and extrusion products prepared from them.

Literature review revealed no earlier report on the measurement of colour of maize and its products. Objective measurement of colour of major cereal grains and their products have been reported earlier[2-12]. Of relative importance to the present study is the measurement of colour of durum wheat semolina[11-12], as maize milling is very similar to the wheat milling except for

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the initial additional operation of degermination[13]. The extrusion product (extrudate) prepared from maize is also similar to that of spaghetti prepared from durum semolina, except for the treatment with high temperature in short durations during extrusion process.

In this paper, investigations carried out on measurement of colour of maize, its milled product, standard semolina (semolina) and the extrusion product, extrudate from semolina, are presented.

Materials and Methods

Eight varieties of maize (Table 1) grown in the Federal Republic of Germany were employed in these studies. Semolina and extrudate were prepared as described earlier[1]. Samples of maize and extrudate were ground in a Kamas Laboratory Mill provided with a 800 μ sieve. The ground material and semolina as obtained from dry milling were individually sieved to obtain a fraction passing through 710 μ (minus 710) and retained on 250 μ (plus 250) sieves. Samples were stored in dark until used for colour measurement.

Reflectance colour measurement was made in a Carl Zeiss Elrepho Photo Electric Reflectance Photometer which measures the intensities of lights reflected from samples through the three primary colour filters red, green and blue. Instrument was calibrated for 0 per cent reflectance with a black photographic paper (zero point) and then for a 100 per cent reflectance with the magnesium oxide disc for each of the three filters. Samples were compressed in the sample holder and were kept underneath the 35 mm dia. viewing circle of the photometer by means of a spring-loaded holding stage.

Light reflected from the samples was converted into tristimulus values X (red), Y (green) and Z (blue) and making use of these values, trichromatic coordinates x, y and z were calculated. The dominant wave length (λ_d) of the colour, which is analogus to hue, was located on the chromaticity diagram (Fig. 1). by connecting the point representing Illuminant C (x=0.3101 and y=0.3162) to the intercept of the chromaticity coordinates x and y of the sample (S) and further extending the straight line to the locus of the spectral colour (D). Excitation purity (p_e), a measure of saturation was obtained as a percentage of the ratio of distances CS to CD. As all the maize varieties studied were of yellow hue the colour was expressed in yellowness value (b per cent) and also in brightness (L per cent), which were calculated using the following expressions:

$$b\% = 7(Y - Z)/\sqrt{Y} \text{ and } L\% = 10\sqrt{Y}$$

Results and Discussion

Preliminary work done in this laboratory on semolina from US yellow maize revealed that the Z-reflectance readings varied considerably with sample weight, moisture content and particle size. Findings were as follows:

Effect of particle size on colour: Semolina as obtained from the dry milling process was size-graded using sieves ranging from 1000 to 200 μ dimensions. Fraction retained on sieves having openings 200, 300, 400, 500, 600, 750 and 1000 μ was used individually for measurement of colour. Yellowness and brightness values were almost the same when the mesh size varied from 750 to 250 μ (Fig. 2). Below 250 μ and beyond 750 μ, there

TABLE 1. COLOUR EXPRESSIONS IN MAIZE VARIETIES (MEAN VALUES)

Varieties	Maize			Semolina			Expression of Colour in Extrudate			Colour diff. ($\triangle$E)*		
	b%	l%	p_e%	b%	l%	p_e%	b%	l%	p_e%	*i*	*ii*	*iii*
I. Forla	24.17	80.56	40.39	30.70	84.72	42.31	27.25	84.17	42.31	7.35	3.31	4.71
II. Sigma	22.29	79.66	38.46	27.72	82.98	45.19	26.63	83.70	42.31	6.01	1.17	5.78
III. Limac	21.71	78.68	39.42	28.16	83.96	44.23	25.75	83.07	41.35	8.02	2.36	5.89
IV. Fello	21.69	81.67	36.54	27.04	85.65	42.31	26.22	83.22	42.31	6.39	2.62	4.32
V. Edo	21.67	80.84	36.54	27.33	84.68	43.27	24.90	80.90	40.35	6.74	4.78	2.76
VI. Limagold	20.55	80.72	34.62	26.70	84.91	42.31	26.45	83.94	42.31	7.03	5.42	3.39
VII. Zistron	19.11	78.74	34.62	26.18	84.16	41.35	26.79	82.92	42.31	8.48	1.84	8.13
VIII. Campo	19.65	78.93	36.54	26.11	83.85	42.31	24.26	81.70	40.35	7.83	3.11	5.05
Mean	21.36	79.98	37.14	27.49	84.36	42.91	26.03	82.95	41.70	7.23	3.08	5.00
S.E.m.	0.56	0.40	0.75	0.52	0.29	0.44	0.36	0.40	0.32	0.30	0.51	0.59
Coef. Var.	7.44	1.41	5.68	5.38	0.96	2.91	3.88	1.36	2.16	11.76	46.43	33.20

*Colour difference ($\triangle$E) between: *i*) Maize and Semolina; *ii*) Semolina and Extrudate; *iii*) Maize and Extrudate.

TABLE 2. GROUPS OF MAIZE VARIETIES BASED ON COLOUR EXPRESSIONS

Material	Yellowness (b%)			Brightness (L%)			Excitation purity (p_e%)		
Maize	<19.77 VIII, VII	21.36±1.59 V, IV, III. VI, II	>22.95 I	<78.85 III, VII	79.98±1.13 VIII, V, I, VI, II	>81.11 IV	>35.03 VI, VII	37.14±2.11 V, VIII, IV, II	>39.25 I, III
Semolina	<26.01	27.49±1.48 VIII, V, IV, III, VI, II, VII	>28.97 I	<83.55 II	84.36±0.81 VIII, V, I, III, VI, VII	>85.17 IV	<41.66 VII	42.91±1.25 VIII, V, IV, I, VI	>44.16 III, II
Extrudate	<25.02 VIII, V	26.03±1.01 IV, III, VI, II, VII	>27.04 I	<81.82 VIII, V	82.95±1.13 IV, III, VI, II VII	>84.08 I	<40.80 VIII, V	41.7±0.90 IV, I, III, VI, II, VII	>42.60

Names of varieties against numbers: I:Forla; II:Sigma; III:Limac; IV:Fello; V:Edo; VI:Limagold; VII:Zistron and VIII:Campo

was a sharp decrease in yellowness. The plot for brightness showed a progressive fall beyond 750 μ. Based on these data, colour was measured on a fraction having 250 to 710 μ sizes. These two sieves correspond to 60 and 25 numbers of American Standard Sieves (ASTM).

Effect of sample weight on yellowness: The sample cup of instrument Elrepho (diameter 5.5 cm. and effective depth 2 cm.) could hold a maximum 25 g powdered material which has particle size range between 250 and 710 μ. The effect of sample weight on yellowness was shown in Fig. 3. Yellowness progressively decreased when the sample weight was increased from 5 to 25 g. The sample weighing upto 10 g was insufficient to be pressed on to the glass bottom of the sample cup, and samples weighing 20 g was enough to be pressed by the built-in-spring loaded mechanism of the sample cup's lid. Hence the data presented are always with respect to 20 g sample.

Effect of sample moisture on colour: The dry milled product streams, as they come out of the mill, vary in moisture content due to the preliminary tempering and degerming operations and should be dried to a moisture content around 10-12 per cent for safe storage. Colour measurements were made on samples moistened and equilibrated to moisture levels ranging from 10 to 18 per cent. Yellowness decreased gradually as the moisture content increased (Fig. 4). while brightness of the samples almost remained constant. Therefore, colour

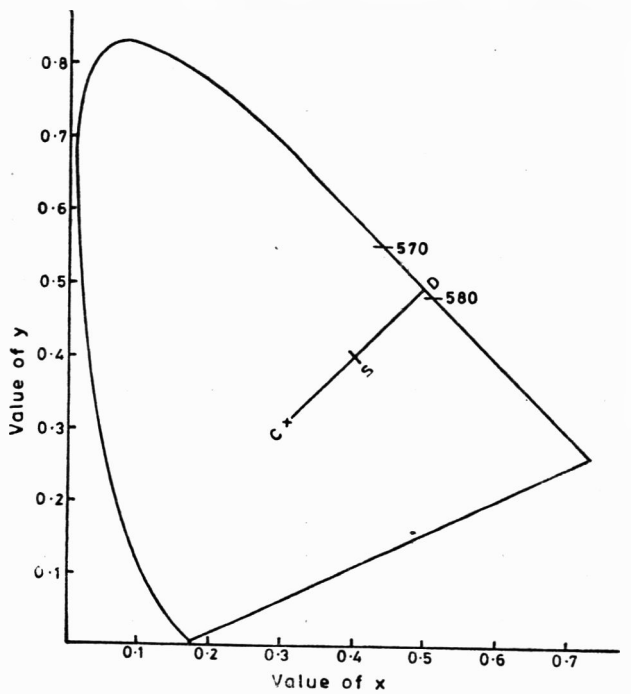

Fig. 1. Graphical determination of dominant wavelength and excitation purity.
C: Position of Illuminant C in CIE chromaticity diagram
S: Stimulus of chromaticity of sample.
D: Point of intercept on the spectral locus = dominant wavelength (λ_d).
p_e: Excitation purity = CS/CD × 100

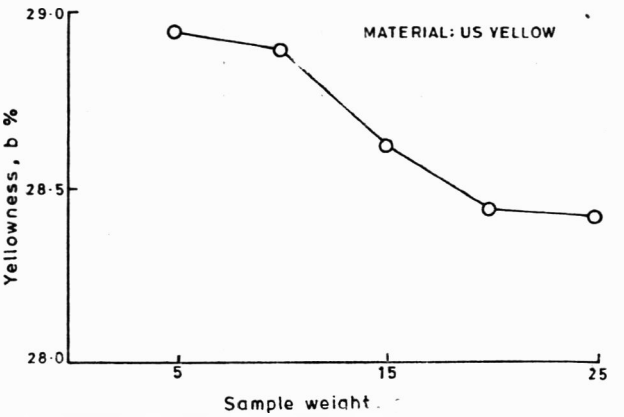

Fig. 2. Effect of sample weight on colour expression.

measurements must be carried out on samples having uniform moisture content. In this investigation, samples were equilibrated to approximately 11 per cent moisture content for colour measurements.

Colour expressions: In the first instance measurement of colour was attempted by pressing 20 g whole maize grains directly in the sample holder cup. Duplicate readings neither agreed nor obtained in normal agreeable error for any colour measurement. Therefore, 50 g whole grains of maize were powdered in a Kamas laboratory mill fitted with 800 μ sieve and the milled product was further sieved out separately to obtain a fraction of −750 to + 250 μ, on which colour measurement was made. It was then observed that the reflectance readings were very consistant in duplicate measurements. Same was the experience with extrudate also, perhaps due to its very uneven surface and hence 50 g of extrudate was milled in a Kamas Laboratory mill, sieved and colour measured as in case of maize. The data on expression of colour of maize and its products in terms of yellowness (b per cent), brightness (L per cent) and excitation purity (p_e per cent) are presented in Table 1.

Characterizations in varieties:

Maize: In general, the three expressions of colour behaved independently and no definite relations could be observed. Variety 'Forla', which scored the highest for yellowness amonst maize also accounted for the highest per cent purity in colour amongst the eight maize varieties studied. Similar trend with respect to the lowest value in yellowness and purity was exhibited by the variety 'Zistron'. Brightness amongst the varieties was the least varying.

Subjective evaluation of yellowness in varieties when observed under a standard light source by a panel of four judges arranged the eight varieties in the following order: 'Forla' > 'Sigma' > 'Fello' > 'Limac' > 'Edo' > 'Limagold' > 'Campo' > 'Zistron.' The evaluation of yellowness by objective method in the experiment rated the varieties in decreasing order: 'Forla' > 'Sigma' > 'Limac' > 'Fello' > 'Edo' > 'Limagold' > 'Campo' > 'Zistron'. Therefore, the trend in subjective and objective evaluation of varieties with respect to maize was near-coinciding except for the order in varieties 'Fello', 'Limac' and 'Edo'.

Semolina: In semolina also, variety 'Forla' had the highest yellowness value but failed to show up the appropriate response in the purity of colour. Even though 'Campo' scored the least value for the yellowness, its purity was comparable to that of 'Forla'. 'Sigma', which recorded middle value in yellowness of semolina, accounted for the highest purity and 'Zistron' the least in purity of colour. Except 'Forla' all the varieties recorded yellowness near to the mean value. Again brightness was the least varying among the varieties.

Comparision of colour between maize and semolina in individual varieties revealed a strong association with respect to yellowness and a significant association with respect to brightness and non-significant association with respect to excitation purity. The colour of semolina milled from different varieties maintained variations amongst the varieties.

Extrudate: 'Forla', which exhibited the highest value in yellowness in maize and semolina also exhibited the highest value in extrudate. 'Campo', which recorded the lowest value in yellowness in semolina, recorded likewise in extrudate. Here again, brightness was the least varying. In excitation purities, five varieties exhibited similar value while three others exhibited lower values.

Extrudate under a standard light source showed a dull yellow colouration with an orange tinge. This was not expressed out in the results of dominant wave length, be-

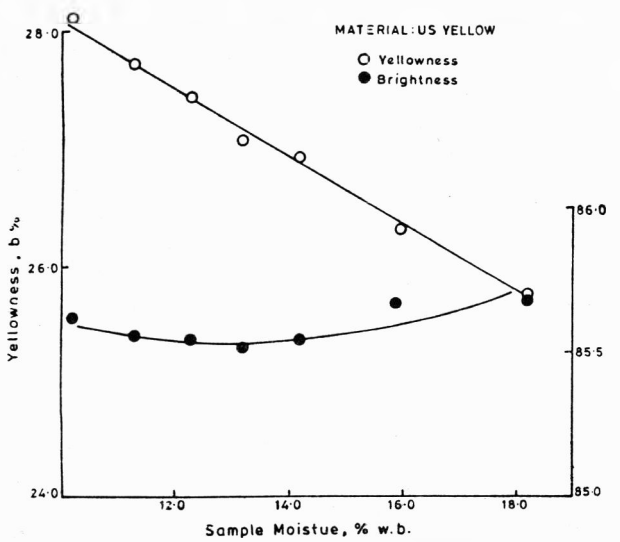

Fig. 3. Effect of sample moisture on colour expression.

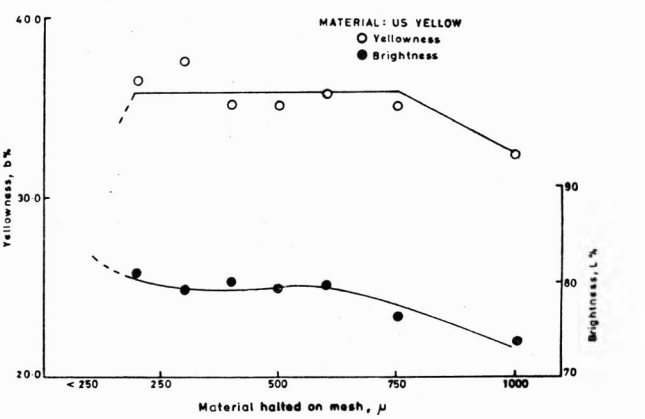

Fig. 4. Effect of sample particle Size on expression of colour.

cause the mean dominant wavelength of maize (577.3λ), semolina (577.4 λ) and extrudate (577.1 λ) did not differ much and all were located in the yellow region in CIE Chromaticity diagramm. However, it was important to note the large variations in the excitation purities between whole maize and semolina, which showed very significant improvement in the purity of colour due to milling process. A reduction in purity, though not significant, could be observed between semolina and extrudate in all the varieties.

Specifications: Specifications for colour in maize (and its products), could not be attempted in the present study in view of limited number of varieties.

II. b. Grouping of varieties:

Based on expression of colour characteristics revealed as yellowness, brightness and excitation purity in individual varieties comprising of three materials in each (maize, semolina and extrudate) and using the parameter mean±standard deviation (S.D.), the eight varieties were grouped into three groups for near-similar expressions in colour characteristics (Table 2). The varieties exhibiting one plus or minus of standard deviation value, which accounts for 68 per cent population in a normal distribution, were grouped to one, while the other two groups constituted a more than or less than the above value respectively.

Yellowness Irrespective of the material, variety 'Forla' possessed the highest yellowness value, and hence grouped as one. Varieties 'Fello', 'Limac', 'Limagold' and 'Sigma' were grouped together in view of their nearness to the mean value. Varieties 'Zistron' and 'Campo[2] though possessed lower values' yellowness improved after being milled to semolina. 'Campo' possessed the least value in yellowness and therfore grouped separately. 'Edo' had yellowness value within one SD in whole maize and semolina, however, showed a decrease in extrudate.

Brightness: Grouping varieties for brightness revealed non-consistency in groups amongst materials when compared to yellowness value groupings, eventhough brightness has recorded the least coefficient of variability than that of yellowness. Variety 'Fello', which showed the highest values for brightness in maize and semolina failed to show in extrudate, while Forla showed an improvement in extrudate. 'Limagold', however, remained in the middle group always for all the materials thus indicating a consistency for grouping amongst the varieties. 'Limac' and 'Zistron' which possessed lower values in maize had improvements in brightness in semolina and extrudate. A lower brightness value with respect to 'Sigma' was noted in semolina compared to maize and extrudate and a fall in brightness in case of 'Edo' in extrudate compared to its maize and semolina.

Excitation purity: Excitation purity also showed considerable non-consistency in grouping of varieties. Variety 'Fello' was always in the group classified near to the mean value. 'Campo' and 'Edo' had lower values in extrudate while 'Zistron' had in maize and semolina. Improvement in excitation purity was noted in 'Limagold' from maize to semolina and extrudate. 'Limac' which had the highest purity in maize showed a decrease in extrudate, which was also the case with 'Forla' and 'Sigma.'

II. c. Evaluation of Colour differences:

Colour differences existing between maize, semolina and extrudate were evaluated quantitatively making use of the formula: $\triangle E=(\triangle L^2+\triangle a^2+\triangle b^2)^{1/2}$. From the basic reflectance data, the calculated CIE tristimulus values X, Y and Z were converted to a, b coordinates and L was obtained from Y-reflection[14]. The data are given in Table 1.

The data revealed higher colour differences between maize and semolina than semolina and extrudate. In fact, extrudate colour was always lower to its raw material semolina, but higher to maize. Therefore milling had remarkably improved the colour, but extrusion cooking lowered the colour. The difference between maize and extrudate was higher compared to semolina and extrudate. Variety's Sigma' showed the least difference. 'Forla, 'Limac', 'Fello' and 'Campo' were grouped together in view of their values near to the mean. The colour differences in 'Edo' and 'Limagold' for semolina and extrudate to maize and extrudate were conspicuous.

III. Statistical analysis and interpretations

The calculated coefficient of variabilities (Table 1) indicate that in varieties irrespective of the material (treatments), yellowness varied more to excitation purity to brightness. In an Analysis of Variance, the interactions between treatments and varieties (error) revealed significant differences even at 0.1 per cent probability level, strongly indicating the existance of overall differences amongst treatment means and varietal means in yellowness and significant differences with respect to brightness.

The data were further analysed through the application of tests of significance in terms of Least Significant Difference (LSD), and also in terms of Studentized Range Test to obtain the difference D between two means that is required for 5 per cent significance as $Q_{0.05}$ times standard error of the mean[15]. As value D always resulted in a higher value, a better parameter for evaluation compared to LSD, it was made use of in precisely identifying the varieties between whom a significant difference existed with respect to colour attributes and materials.

It was proved that the differences in treatment (materials) means for yellowness, brightness and excitation purity were significant as far as maize and semolina were concerned; however, it failed to indicate the similar nature for all varieties between semolina and extrudate. For example, in yellowness, varieties: 'Fello', 'Limagold', 'Sigma' and 'Zistron', in 'brightness, varieties[1] 'Forla', 'Limac', 'Sigma' and 'Zistron', and in excitation, purity varieties. 'Fello', 'Forla', 'Limagold' and 'Zistron' did not differ significantly between semolina and extrudate.

Correlation coefficients revealed high association in yellowness ($r=0.93^{+++}$) and brightness ($r=0.76^{+}$) between maize and its semolina. But between semolina and extrudate it was non-significant. The negative tendencies in correlations between semolina and extrudate with respect to brightness and excitation purity, though not significant, are of interest to note, which are indicative of a reduction in colour, brightness and purity during the extrusion process. The reasons for this reduction in colour during extrusion should be investigated in further work.

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Bread, Biscuit and Chapati Making Quality of Indian Triticales

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Studies on the possibilities of utilising triticale-wheat blends in bakery products have shown relatively poor water absorption and dough stability of triticale flours. Use of 20 ppm potassium bromate and 0.5% SSL improved the baking quality of triticale *maida*. The loaf volume and overall acceptability of triticale breads, which were inferior to those of wheat breads, improved significantly on either blending with equal quantity of wheat *maida* or 2% gluten. The biscuits prepared from the different triticale *maida* samples were found to be as good as the soft wheat biscuits in respect of their acceptability and had the desired spread ratio. As compared to wheat chapatis, those prepared from most of the triticale varieties were just acceptable.

Development of man-made cereal triticale (*Triticum secale*) in the last decade is gaining increasing attention of several agricultural and cereal scientists, mainly because of its higher protein content and better amino acid balance, as compared to wheat. Srivastava[1], Tsen[2], Lorenz and Welsh[3] have reported the possibilities of using triticales in bakery products.

Recent studies (unpublished data) have shown that some of the Indian triticales compared favourably with American as well as Candian triticales on which extensive work has been reported[4]. Suitability of Indian triticales for the preparation of commercially important bakery products such as bread and biscuits and also in the staple food item such as chapati are reported in this paper.

Materials and Methods

Test materials: Ten varieties of Indian triticales (*Armadillo PM*-4, *Triticale No.* 4, *Bromco*-90, *MSN*-372 -1, *Armadillo* PPV-13, *JNK* 6*T*001-*A*, *JNK* 6*T*200, *JNK* 6*T*206-*B*, *JNK* 6*T*090 and *PC*-202) two American (6-*TA*-204 and 6-*TA*-206) and one Canadian (*Rosner*) varieties were used. Commercial varieties of Punjab and soft white wheats purchased locally were used as controls.

The *maida* (refined flour) samples used for bread and biscuit making trials were obtained by milling triticales in a Buhler Laboratory Mill (model MLU-202).

Different triticale varieties were ground in Laboratory Kamas Mill (Swedish model: SLAGY 200A) using a sieve with an aperture of 0.8 mm diameter. The ground *atta* (flour) passing through 40 mesh Buhler sieve (aperture width 0.42 mm) and having 93-95 per cent extraction rate was used for studying the chapati making quality. The wheat samples were milled similarly, and used as controls in the various baking trials.

Dough characteristics: Brabender Farinograph was used to assess the different dough characteristics such as water absorption, dough development time, stability and mixing tolerance according to AACC procedures[5].

Bread making quality: Malt-phosphate - bromate method[6] was used for test baking trials. However, malt was not included in the recipe of triticale breads in view of high α-amylase activity. Also, based on preliminary trials a fermentation time of only 2 hr for triticales as compared to $2\frac{1}{2}$ hr for wheat bread, was used.

Effect of additive: The optimum level of bromate was arrived at by test baking experiments using 10, 20, 30, 40 and 50 ppm of potassium bromate in the recipe, based on *maida* from *Armadillo PM*-4. The influence of optimum level of potassium bromate in conjunction with sodium stearoyl lactylate (SSL) was studied in case of the varieties *Rosner* and *PC*-202.

Effect of blending with wheat: Based on the observation of relatively unsatisfactory quality of triticale bread, the effects of blending triticale *maida* with different levels of wheat *maida* were studied to arrive at the desired level (*Armadillo PM*-4). Consequently, all the triticale varieties as such or 50:50 and 75:25 blends of triticale-wheat were assessed for their bread making quality.

Effect of blending with wheat gluten: Gluten used in this study was prepared by washing the dough of wheat *maida* free of starch, and subsequently drying at 45-50°C in a vacuum shelf drier. Blends of triticale flours with 2 and 3 per cent of the finely ground gluten were used in the preparation of bread as described above.

Evaluation. The loaf volume of bread was determined by rape seed displacement method using loaf-volume meter. In bread evaluation, criteria followed by a panel of six judges were the general appearance, the loaf volume, crust and crumb colour, crumb softness, fineness and uniformity of crumb grain, as well as flavour and eating quality.

Biscuit making quality: The suitability of different triticale varieties for preparation of biscuits was assessed by using the recipe (on 100 g basis): triticale/wheat *maida* 64 g; sugar 18 g; fat 16 g; non-fat milk solids 1.0 g; glucose 1.0 g; common salt 0.4 g; baking powder 0.2 g; ammonium bicarbonate 0.5 g; sodium bicarbonate 0.2 g; vanillin 0.05 g; and water 13-15 ml. Sugar, fat and vanillin were creamed in a Hobart mixer for 2 min. To this, a well mixed blend of the flour, non-fat milk solids and baking powder were added along with water containing glucose, common salt, ammonium bicarbonate and sodium bicarbonate and mixed for further 2 min. Using a wooden rolling pin the dough thus obtained was sheeted on a specially fabricated aluminium platform to an uniform thickness of 2.5 mm. Circular biscuits of 5.1 cm in diameter were cut and baked for 8-10 min at 250°C.

Evaluation: Diameter and thickness of five biscuits were recorded for calculating the spread ratio. In addition, the colour, crispness, eating quality and overall acceptability were assessed by a panel of six judges. Biscuits based on soft white wheat *maida* were used as control.

Chapati making quality: Chapatis were prepared from *atta* samples according to method described by Shurpalekar and Prabhavathi.[7] Chapatis were then assessed by a panel of six judges. The main criteria considered for evaluation were the appearance, the texture, the number of discrete layers, the chewing quality and the taste and flavour.

Results and Discussion

Dough characteristics: The data presented in Table 1 on the different dough characteristics indicate significantly low values for farinograph water absorption (52.8 to 57.8 percent), and dough development time (0.75 to 1.25 min except for the variety *JNK*-6*T*090). The dough stability of triticale varieties (except *MSN*-372-1 and *JNK* 6*T*200) ranged between 0 and 3.5 min. The blending of triticale *maida* with equal quantity of wheat *maida* improved the dough characteristics partially. These observations further confirmed that triticale proteins lack in quality, as indicated by their low sedimentation value and wet gluten contents (Unpublished data). Tsen[2] as well as Ahmed and McDonald[8] have also reported similar findings on the mixing characteristics and bread making quality of trticale doughs.

Effect of additives: The results in Table 2 show that 20 ppm of potassium bromate was optimum for giving maximum loaf volume and improved crumb texture. SSL at 0.5 per cent level, along with 20 ppm of potassium

TABLE 1. FARINOGRAPH DATA FOR TRITICALES AND TRITICALE-WHEAT BLENDS

	Water absorption (%)	Dough development t me (min.)	Dough stability (min.)	Mixing tolerance index (B.U.[a])
Triticales				
Armadillo PM-4	55.6	1.00	3.00	80
Triticale No. 4	57.8	1.25	1.75	140
Bromco-90	57.8	1.00	nil	220
MSN-372-1	53.8	1.00	5.50	20
Armadillo PPY-13	54.8	0.75	nil	170
JNK 6T001A	57.4	1.00	3.00	110
JNK 6T200	53.0	0.75	4.25	80
JNK 6T206-B	54.4	1.25	1.50	140
JNK 6T090	52.8	4.00	1.00	50
PC-202	57.2	1.25	2.75	100
Rosner	54.2	1.00	nil	140
6-*TA*-204	55.3	1.00	3.50	140
6-*TA*-206	55.3	1.00	3.00	190
Punjab Wheat triticale blends (1:1)				
Armadillo PM-4	58.8	3.50	1.50	80
Triticale No. 4	58.4	3.50	1.50	80
JNK 6T001-A	61.6	4.00	2.00	100
PC-202	59.6	3.00	1.50	60
Wheat				
Punjab wheat (control)	63.8	4.50	1.50	60

a–Brabender units.

TABLE 2. EFFECT OF ADDITIVES ON THE QUALITY OF TRITICALE BREADS

Variety	Additives: Pot. bromate (ppm)	Additives: SSL (%)	Loaf volume (ml)	Crumb texture score[a]
Armadillo PM-4	Nil	—	360	—
,,	10	—	410	,,
,,	20	—	425	,,
,,	30	—	410	,,
,,	40	—	395	,,
,,	50	—	375	
Rosner	Nil	—	350	,,
,,	20	—	360	A
,,	—	0.5	355	,,
,,	20	0.5	385	SB
PC-202	Nil	—	290	—
,,	20	—	300	A
,,	—	0.5	330	SB
,,	20	0.5	330	,,

a–Graded as compared to Triticale control without additives: SB–Slightly better; A–As good as.

TABLE 3. EFFECT OF LEVEL OF BLENDING WITH PUNJAB WHEAT ON THE BREAD MAKING QUALITY OF *Armadillo* PM-4

Armadillo PM-4—Wheat	Loaf volume (ml)	Acceptability[a]
100 : 0	385	I
90 : 10	410	I
80 : 20	420	I
70 : 30	420	I
60 : 40	455	I
50 : 50	475	SWI
40 : 60	470	SWI
30 : 70	475	SWI
20 : 80	485	SWI
0 : 100 (Control)	570	Excellent

a–Graded as compared to control: A–as good as; SI–slightly inferior; SWI–Somewhat inferior and I–Inferior.

bromate improved the loaf volume as well as crumb texture, as compared to control. Tsen *et al.*[9] also have reported beneficial effect of SSL.

Effect of blending: Triticale breads (Tables 3 and 4) had of dense crumb with open textured grains and were less spongy to handfeel. Triticale breads had a sticky mouth feel, normally absent in wheat bread. This may be attributed to dextrinisation of starch due to high α-amylase activity of the triticales. Further, during the preliminary experiments, it was observed that the triticale dough had poor gas retention capacity. As such, the fermentation time of only 2 hr had to be used in the different baking trails, as compared to $2\frac{1}{2}$ hr needed for wheat dough.

Among the different triticale-wheat *maida* blends tried, it was observed (Table 3) that atleast 50 per cent of wheat *maida* was essential for bringing about an appreciable improvement in the loaf volume as well as the acceptability of bread. However, the triticale-wheat bread was inferior, when compared to the control wheat bread. Although these findings corroborated with the earlier observations of Rooney *et al.*,[10] they disagreed with those of Unrau and Jenkins[11], who observed no marked deleterious change in the bread quality even when the wheat *maida* was blended with 30 to 40 percent of triticale *maida*.

Based on the above observations, breads were prepared from 100:0, 50:50 and 75:25 blends of triticale and wheat *maida* (Table 4). The triticale wheat blends were significantly superior in their bread making quality, as compared to triticale alone. The varieties *Bromco*–90, *MSN*-372-1, *Armadillo PPV*-13, *JNK*-6*T*001-*A* and *JNK*-6*T*090 indicated no difference in their acceptability as well as in the loaf volume of breads when prepared

TABLE 4. BREAD MAKING QUALITY[a] OF BLENDS OF DIFFERENT VARIETIES OF TRITICALES WITH PUNJAB WHEAT AND ITS GLUTEN

Variety	Triticale: Wheat[b] blends 100:0 Loaf volume (ml)	Acceptability[c]	75:25 Loaf volume (ml)	Acceptability[c]	50:50 Loaf volume (ml)	Acceptability[c]	Gluten added (%) 2 Loaf volume (ml)	Acceptability[d]	3 Loaf volume (ml)	Acceptability[d]
Triticale No. 4	275	I	325	I	365	I	—	—	350	S
Bromco–90	300	I	385	SWI	400	SWI	400	S	410	S
MSN–372–1	335	I	400	SWI	405	SWI	—	—	435	S
Armadillo PPV–13	310	I	390	SWI	405	SWI	390	S	405	S
JNK 6T001–A	325	I	410	SWI	410	SWI	430	S	435	S
JNK 6T200	290	I	355	I	390	SWI	370	S	—	—
JNK 6T206–B	340	I	420	SWI	425	SI	425	S	430	S
JNK 6T090	320	I	380	SWI	390	SWI	415	S	—	—
PC–202	330	I	390	SWI	420	SI	—	—	—	—
Rosner	385	SWI	405	SWI	465	A	—	—	435	S
6–*TA*–204	400	SWI	385	SWI	425	SI	—	—	—	—
6–*TA*–206	390	SWI	375	SWI	430	SI	—	—	—	—

a–All recipes contained 20 ppm potassium bromate and 0.5% SSL.

b–The bread from wheat flour (control) had a loaf volume of 480 ml and its acceptability was graded as good.

c–Breads based on Triticale-Wheat blends were compared with wheat bread (control) and their acceptability graded as: A–as good as; SI–slightly inferior; SWI–somewhat inferior, and I–inferior.

d–Breads based on Triticale–Gluten blends were compared with the respective 100% triticale breads and their acceptability graded as: A–as good as; SS–slightly superior; SWS–somewhat superior, and S–superior.

TABLE 5. BISCUIT MAKING QUALITY OF TRITICALES

Variety	Dia. (W) (mm)	Raise (T) (mm)	Spread ratio (W/T)	Spread factor	Crispness[a]	Acceptability[a]
Armadillo PM–4	53.0	3.1	9.46	130.3	SI	A
Triticale No. 4	52.5	2.9	9.55	131.5	I	I
Bromco–90	52.5	2.7	10.10	139.1	SI	A
MSN–372–1	51.6	3.3	8.90	122.6	SWI	SI
Armadillo PPV–13	52.4	3.0	9.53	131.3	SI	A
JNK 6T001–A	52.0	3.3	8.96	123.4	SWI	A
JNK 6T200	54.0	2.5	10.80	148.7	SI	A
JNK 6T206–B	52.4	3.5	8.73	120.2	SWI	SI
JNK 6T090	52.0	2.1	11.30	155.6	SWI	SI
PC–202	52.5	3.5	8.75	120.5	A	A
Rosner	53.0	3.3	9.14	125.9	SI	A
6–*TA*–204	51.0	3.5	8.30	114.3	A	A
6–*TA*–206	52.0	2.7	10.00	137.7	A	A
Soft wheat (control)	53.0	4.8	7.26	100.0	Excellent	Excellent

a–Graded as compared to control: A–As good as; SI–Slightly inferior; SWI–Somewhat inferior; and I–Inferior.

TABLE 6. CHAPATI MAKING QUALITY OF TRITICALES

Variety	Water absorption[a] (%)	Acceptability[b]
Armadillo PM-4	56.5	I
Triticale No. 4	65.4	I
Bromco-90	53.0	SWI
MSN-372-1	63.0	SWI
Armadillo-PPV-13	56.3	SWI
JNK 6*T*001-*A*	60.8	I
JNK 6*T*200	57.0	SWI
JNK 6*T*206-*B*	57.7	SWI
JNK 6*T*090	56.9	I
PC-202	58.7	I
Rosner	59.0	SWI
6-*TA*-204	53.2	A
6-*TA*-206	53.5	SWI
Punjab Wheat (Control)	50.3	Excellent

a–On 14% moisture basis.

b–Graded as compared to control; A–as good as; SI–Slightly inferior; SWI–somewhat inferior, and I–Inferior.

from blends with 50:50 or 75:25 of triticale and wheat *maida*.

Among the different breads based on 50:50 blends, the blend based on Canadian variety *Rosner* had the maximum volume of 465 ml as compared to 480 ml for the control wheat bread, and had the best acceptability among triticales. The bread based on only Canadian or American triticales gave significantly higher loaf volume and is better acceptable.

Effect of blending with gluten: Incorporation of even 2 per cent gluten (on the basis of *maida* weight) gave significant increase in the loaf volume of triticale breads (Table 4), and compared favourably with those breads based on 1:1 blend of triticale and wheat. This indicates the deficiency in quality and quantity of gluten-forming proteins as an important factor responsible for the unsuitability of triticales for bread making.

Biscuit making quality: The results presented in Table 5 indicate that majority of Indian varieties of triticales gave acceptable quality biscuits, comparable to that of Canadian *Rosner* or American varieties. These biscuits were almost as good as the biscuits based on soft white wheat. Only the variety *Triticale* No.4 was found to be unsuitable for biscuit preparation. These findings corroborated with castics observation (unpublished data) that the triticales resemble more with soft wheat in many respects.

Chapati making quality: Unlike the *maida*, the water absorption of the triticale *atta* showed a wide range (53.2 to 65.4 per cent), which was considerably higher than that of Punjab wheat (50.3 percent) (Table 6).

Majority of triticale varieties were graded as either inferior or somewhat inferior when compared to excellent chapati making quality of Punjab wheat. It is interesting to note that American variety 6-TA-204 was as good as the control in respect of different quality attributes. The triticale chapatis were darker in colour and most of them had somewhat tough and leathery texture as well as poor chewing quality. Their flavour was distinctly different from that of wheat chapatis.

To summarise, the farinograph characteristics as well as the significant improvement in the loaf volume and overall acceptability of the breads based on blends of triticale *maida* with either equal quantity of wheat or 2 percent wheat gluten clearly bring out the fact that triticales are not good for bread making. The observation regarding the behaviour of triticales as soft wheat and their suitability for biscuit making as indicated by the spread ratio and acceptability can possibly open a new avenue for the utilisation of triticales in the near future.

Foregoing results thus highlight the possibility of using triticales in bakery products of acceptable quality, especially during the times of wheat shortage.

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A Study of Lipids in Different Varieties of Wheat *(Triticum aestivum)**

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The polar and neutral lipid contents and patterns in seven varieties of wheat (K'—227', 'S-308', 'C-273', 'K-68', 'S-413', 'Argelto' and 'Sharbati Sanora') were examined by thin layer chromatography. All the samples showed varied amounts of free fatty acids indicating the presence of lipase activity in the stored wheat grains. Among the neutral lipids, glycerides formed the major component whereas among the phospholipids and glycolipids, phosphatidyl choline and galactosyl diglyceride formed the major component. On the basis of lipid composition, variety 'S-308' appears to have better baking qualities and likely to possess better retention power of its flour.

The content of lipids in wheat is low, yet they are important in the baking and aging of wheat flour, crumb softening and staling phenomenon, and also a source of essential fatty acids[1]. During the last decade a number of high yielding varieties of wheat have been evolved in India. This study was conducted to determine the lipid patterns of a number of important varieties of wheat and to correlate with the baking qualities. Such data will also be useful in the cross breeding programme to evolve new varities possessing good baking qualities.

Materials and Methods

Seven varieties of wheat viz. 'K-227', 'S-308', 'C-273', 'K-68', 'S-413, 'Argelto' and 'Sharbati Sanora were procured from the Department of Genetics, Punjab Agricultural University, Ludhiana. The total lipids were extracted[2] from wheat grains and purified by the method of Folch *et al*[3]. and fractionated into polar and neutral lipids by the solvent partition method of Nichols[4]. This did not effect complete separation. Of the polar fraction, 13.2 to 26.0 per cent lipids were represented by neutral lipids (Table 2). The components of the polar and neutral lipids were separated by thin layer chromatography (TLC) on silica gel G using solvent systems consisting of chloroform: methanol: 7N ammonia (75:25:4, v/v/v) for polar lipids and petroleum ether: solvent ether: acetic acid (80:20:1, V/V/V) for neutral lipids. The lipid components separated by TLC were visualised with iodine vapours and cupric acetate reagent[5]. The identification of the lipid components was done by specific spray reagents[6-11] and by comparison of their Rf values with standard reference compounds. The lipid components separated on TLC and visualised by cupric acetate reagent were quantitated by desnsitometery[5] on Densicord photodensitometer, Model 542, U.S.A. Crude protein contents were determined by microkjeldahal method of Mckenzie and Wallace[12].

Results and Discussion

The range of total lipids, polar lipids, neutral lipids and crude protein contents in the sample was 1.4-2.2, 0.5-0.8, 0.9-1.6 and 13.1-16.8 per cent, respectively (Table 1). The variation in total lipid content may be due to variation in the kernel size[13], method of extraction of lipids[14], and environment and genetic make up of the variety[15]. A non significant negative correlation (r=0.246) between total lipid content and the number

Table 1. Comparison of lipids and protein content of different varieties of wheat

Variety	No. of kernels/g.	Crude protein (%)	Lipids (%)		
			Total	Polar	Neutral
K-227	38	14.9	1.7	0.6	1.1
S-308	26	15.8	2.0	0.8	1.2
C-273	19	16.8	1.4	0.5	0.9
K-68	26	16.8	2.2	0.6	1.6
Sharbati Sanora	31	13.1	1.6	0.5	1.1
Argelto	24	16.1	2.0	0.8	1.2
S-413	28	16.5	1.8	0.6	1.2

*This work forms a part of thesis submitted by the first author to Punjab Agricultural University, Ludhiana, in partial fulfilment of the requirements for M.Sc. degree in Biochemistry in 1975.

TABLE 2. ABSOLUTE (MG %) AMOUNTS OF POLAR LIPIDS IN SAMPLES OF WHEAT GRAINS

Lipid/sample component	K–227	S–308	C–273	K–68	Sharbati Sanora	S–413	Argelto
Phosphatidic acid	11	24	15	18	16	23	16
LPE	16	30	12	21	21	15	26
P. inositol	16	31	19	27	13	19	30
P. serine	24	44	18	29	28	30	43
P. choline	58	83	51	88	52	56	77
P. ethanolamine	37	56	38	36	41	46	52
Unknown phospholipid	35	44	25	31	30	29	47
Total phospholipids	197	312	178	250	201	218	291
DGDG	79	102	62	86	69	68	92
MGDG	61	72	49	55	48	55	66
Cerebrosides	53	67	38	51	47	46	64
Sterol glycosides	54	54	46	44	38	39	52
Unknown glycolipid	48	55	34	52	49	44	44
Total glycolipids	295	350	229	288	251	252	318
Neutral lipids	145	120	95	103	89	119	157

MGDG, Monogalactosyl diglycerides; DGDG, Digalactosyl diglycerides; LPE, Lysophosphatidyl ethanolamine; P. Phosphatidyl.

of kernels per gram was observed. Since all the varieties were grown and extracted under identical conditions, the variations observed during the study may be due to variation in the genetic make up alone. 'S-308' and 'Argelto' had higher polar lipid content, while 'K-68' had the highest neutral lipid content. Among the polar lipid fractions, total glycolipids content was higher than the total phospholipids in all the wheat varieties. Variety 'S-308' had the highest content of phospholipids followed, in order, by 'Argelto', 'K-68', 'S-413', 'Sharabati Sanora', 'K-273' and 'C-273'. Almost similar pattern in the glycolipids content was also observed in all these varieties. In all the samples galatosyl diglycerides and phosphatidyl choline were the major glyco- and phospolipids, respectively. Variety 'S-308' contained highest amount of phosphatidyl choline and digalatosyl diglyceride followed by 'Argelto' and 'K-68' (Table 2). Similar results in wheat have been reported by Lin, *et al*[16] and Kinsell *et al*[17]. Wheat varieties rich in polar lipids have good baking qualities[1,17]. The level of phosphatidyl choline[18] and galatosyl diglycerides[1] have been reported to determine the baking qualities of wheat grains. Due to lack of sufficient quantity of samples, the direct baking quality measurement could not be made. However, on the basis of polar lipid contents, variety 'S-308' is likely to possess better baking and cooking qualities. 'Argelto' and 'K-68' come next in the order.

TABLE 3. ABSOLUTE (MG %) AMOUNTS OF NEUTRAL LIPIDS IN SAMPLES OF WHEAT GRAINS

Variety	Partial glycerides	Triglycerides	Free fatty acids	Sterols	
				Free	Esterified
K–227*	129	478	189	64	116
S–308	185	560	173	80	150
C–273*	151	500	66	72	81
K–68*	305	517	238	161	170
Sharbati Sanora*	225	430	233	67	96
S–413	145	523	243	84	143
Argelto*	221	438	253	94	129

*The samples other than these showed variable amounts of an unidentified component.

Among the neutral lipids, triglycerides formed the major component in all the varieties (Table 3). Variety 'S-308' had the highest amounts of triglycerides followed by 'S-413', 'K-68', 'C-273', 'K-227', 'Agrelto' and 'Sharabati Sanora' in that order. The wheat flour from varieties 'S-308' and 'S-314' is likely to possess better retention power due to higher triglyceride contents. Similar results have been reported by Pomeranz[13]. The neutral lipid fraction from all the varieties showed variable amounts (upto 24.5 per cent of neutral lipids, Table 3) of free fatty acids. The presence of such high concentration of free fatty acids in this fraction indicated that wheat lipids undergo hydrolysis during storage of wheat grains. Similar lipase activities have been reported in rice-grains[19].

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Physico-Thermal Properties of Rice Bran

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Physico-thermal properties of rice-bran ('Ratna' variety) such as bulk density, particle density bed porosity, specific heat and thermal conductivity were determined at 10 and 12% moisture contents (wet basis). All properties except particle density were found to be moisture dependent.

Rice bran is a by-product of rice milling industry and is gaining considerable importance as an oil bearing material in the present context of the edible oil shortage. Physico-thermal properties are useful in the design of rice bran processing systems. Very little information is available on bulk density and none on other physical properties. Bulk density of rice bran is reported[1] to vary from 0.368 to 0.40 g/cc. The work was, therefore, undertaken to determine physico-thermal properties which are required for standardizing the rice bran processing operations and design of related equipments.

Materials and Methods

Rice bran for this study was obtained by milling and polishing 'Ratna' variety of paddy in the laboratory models of Kissan paddy dehusker and polisher. Degree of polishing was kept constant at about 6 per cent. Moisture content of bran when obtained from the polisher was 12 per cent (w.b.). A part of this bran was dried to 10 per cent (w.b.) moisture content in hot air oven at 30°C. Samples at both these moisture levels were sealed in polyethylene bags and stored at room temperature. All the measurements were made at these two moisture levels.

Bulk density was determined by measuring the volume of a known weight of bran. Bran, weighed accurately was poured into a 500 ml graduated cylinder through a funnel to give a reasonably uniform degree of packing; tapping was not done to avoid compaction of bran. Toluene displacement method suggested by Means *et al*[2], was adopted for measurement of particle density. The weight of the bran for the experiments ranged from 9.5 to 14.4 g. Average porosity was calculated by using the measured values of bulk and true density.

Method of mixtures was used for measurements of specific heat. A 33 g sample was taken in a thermos flask of half litre capacity, provided with a stirrer and insulated cover which was used as a calorimeter. The calorimeter was filled with 150 g of water at room temperature. The mixture was thoroughly stirred to ensure complete submergence of bran particles. Stabilized temperature of cold mixture (approximately equal to room temperature) was measured with a precision thermometer having a least count of 0.1°C. Hundred grams of hot water at a stabilized temperature of 47°C was then poured into the calorimeter rapidly. The mixture temperature got stabilized within 1-2 min and was noted. Average specific heat in the temperature range of 24-33°C (representing initial and final values of mixture temperature) was calculated using heat balance equation[3].

Thermal conductivity was determined with the help of a concentric cylinder steady state apparatus as described by Singh *et al*[4]. using the equation.

$$K = \frac{Q\, l_n \left(\frac{r_0}{r_1} \right)}{2\pi L \triangle T}$$

Where, K, Q, r_0, r_1 L and $\triangle$T stand for thermal conductivity, heat flow rate, radius of outer cylinder, radius of inner cylinder, length of heat flow path and temperature drop respectively.

Results and Discussion

Physico-thermal properties of rice bran are given in Table 1.

TABLE 1. PHYSICO-THERMAL PROPERTIES OF RICE BRAN

Properties	Moisture content (w. b.) 10%	12%
Bulk density (g/cc)	0.303	0.277
Particle density (g/cc)	1.220	1.220
Porosity (%)	75. 35	77.29
Specific heat* $\left(\frac{\text{cal}}{\text{g}-^{\circ}\text{c}} \right)$	0.413	0.429
Thermal conductivity $\left(\frac{\text{watt}}{\text{m.}^{\circ}\text{k}} \right)$	0.164	0.192

*Mean experimental temperature 28.8° and 24.2°C, for the two samples respectively.

The average bulk density of rice bran decreased slightly as the moisture content increased from 10 to 12 per cent. The decrease might be attributed to change in bed porosity arising out of swelling of particles due to absorption of moisture. For granular foods the coefficient of friction is known to increase with moisture content[5]. It is possible that the fall in bulk density might have also been caused by an increase in coefficient of friction.

Particle density was found to be constant and independant of moisture content. The same was found[6] for wheat, paddy, pigeon pea and soybean over a moisture range of 8.5 to 12.5 per cent.

The porosity increased with increase in moisture content. This increase may be attributed to the change in shape of the particle due to absorption of moisture, which in turn might have caused the change in particle arrangement and thereby in volume of voids.

The specific heat of rice bran increased with moisture content. This is in agreement with the findings of other workers[3,7-10], determined for other food products.

The thermal conductivity of rice bran increased with moisture content. This may be due to the fact that rice bran is essentially a low thermal conductivity material and when its moisture content is increased the thermal conductivity increases due to higher conductivity value of water (moisture).

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Studies on Selection of Starter Cultures for the Manufacture of Yoghurt

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Successful preparation of yoghurt depends upon proper symbiotic growth between *S. thermophilus* and *L. bulgaricus*. Three strains each of *S. thermophilus* and *L. bulgaricus* were examined in various combinations for their symbiotic growth and production of good quality yoghurt. Yoghurt samples were assessed for curdling time, acidity, body. characteristics, diacetyl content and microscopic ratio of the two organisms. The combination of *S. thermophilus* (H) and *L. bulgaricus* (W) in the ratio of 1:2 and *S. thermophilus* 489 and *L. bulgaricus* (W) in the ratio of 1:1 gave the best products.

Yoghurt is a *dahi* like product with curative properties[1] and is obtained by the fermentation of milk with a mixture of *S. thermophilus* and *L. bulgaricus*. Successful preparation of the product depends upon a symbiotic relationship between the two organisms and all combinations possible from pairing strains of *S. thermophilus* and *L. bulgaricus* will not produce a high quality product[2,3]. According to the Davis *et al*[4] a satisfactory combination is one which will be amenable for growth under manufacturing conditions[5] and produce a product with good body, texture, taste, flavour, etc. and contains equal proportion of the two organisms.

Nikolvin[6] observed that good quality yoghurt of typical flavour could be obtained where the mixed culture contains equal proportion of *S. thermophilus* and *L. bulgaricus* during coagulation. In the present study, 3 strains of *S. thermophilus* and 4 strains of *L. bulgaricus* were tested in pairs for their suitability in the preparation of yoghurt.

Materials and Methods

Milk: Good buffalo milk from the Experimental Dairy standardized to a fat content 2.0-2.5 per cent was used throughout the study.

Cultures: The following cultures were taken from the National Culture Collection of dairy organisms of National Dairy Research Institute, Karnal.

S. thermophilus (W), *S. thermophilus* (489), *S. thermophilus* (H), *L. bulgaricus* (W), *L. bulgaricus* (1373), *L. bulgaricus* (Yb), *L. bulgaricus* (RTS).

Study of symbiosis among pairs and preparation of yoghurt: Standardized milk (100 ml) in 150 ml conical flasks were steamed for 30 min and after cooling to 40-42°C was inoculated at 2 per cent level (18 hr old) with the two cultures mixed in different proportions. They were incubated at 42±1°C for $3\frac{1}{2}$ hr and coagulation of milk, if any, was noted. The flasks were then cooled immediately and tested for titratable acidity as per standard procedure[7]. Using cultures selected on the basis of symbiotic relationship, yoghurt was prepared but the

TABLE 1. ASSOCIATIVE ACTION BETWEEN *S. Thermophilus* AND *L. Bulgaricus*

Culture combinations	Ratio	Acidity as % lactic acid	Final product after $3\frac{1}{2}$ hr.
S. thermophilus (H)	0:2	0.35	Not curdled
L. bulgaricus (W)	2:0	0.27	,,
	1:1	0.47	Partially curdled
	1:2	0.72	Curdled
	2:1	0.46	Partially curdled
S. thermophilus (H)	0:2	0.41	Not curdled
L. bulgaricus (1373)	2:0	0.27	,,
	1:1	0.45	Partially curdled
	1:2	0.67	Curdled
	2:1	0.50	Partially curdled
S. thermophilus (W)	0:2	0.19	Not curdled
L. bulgaricus (W)	2:0	0.36	,,
	1:1	0.49	Partially curdled
	1:2	0.51	Curdled
	2:1	0.54	,,
S. thermophilus (489)	0:2	0.29	Not curdled
L. bulgaricus (W)	2:0	0.28	,,
	1:1	0.51	Partially curdled
	1:2	0.56	Curdled
	2:1	0.52	,,
S. thermophilus (H)	0:2	0.39	Not curdled
L. bulgaricus (RTS)	2:0	0.55	Partially curdled
	1:1	0.75	Curdled
	1:2	0.81	,,
	2:1	0.74	,,
S. thermophilus (H)	0:2	0.46	Not curdled
L. bulgaricus (Yb)	2:0	0.56	,,
	1:1	0.68	Partially curdled
	1:2	0.81	Curdled
	2:1	0.80	,,

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TABLE 2. SELECTION OF BEST COMBINATIONS OF STRAINS OF *S. Thermophilus L. Bulgaricus*

Culture combinations	Initial ratio	Curdling time (hr-min.)	Final microscopic ratio	Acidity (% Lactic acid)	Diacetyl acetoin (ppm)
S. thermophilus (H) *L. bulgaricus* (W)	1:2	3-15	1:1	1.00	47
S. thermophilus (W) *L. bulgaricus* (W)	1:2	3-10	2:1	0.98	78
S. thermophilus (H) *L. bulgaricus* (Y_b)	1:3	3-30	1:1	0.89	78
S. thermophilus (H) *L. bulgaricus* (1373)	1:2	3-20	3:1	0.90	74
S. thermophilus (H) *L. bulgaricus* (RTS)	1:1	3-20	1:1	1.05	76
S. thermophilus (489) *L. bulgaricus* (W)	1:1	4.00	2:1	1.45	72

proportion of the *Streptococci* and *Lactobacilli* were varied. The curdling time was noted in each case. The product obtained from each combination was tested for acidity[7], texture, diacetyl content[8] and ratio of the two organisms by microscopic examination. The final product was graded according to score card developed for yoghurt by Futschik[9].

Results and Discussion

Table 1 shows the symbiotic relationship in 6 out of 12 pairs tried. It is seen that in all cases, there was improved acid production when both the organisms were present. The titrable acidity in the paired culture was more than 0.5 per cent (as lactic acid) which is considered as minimum for use in yoghurt preparation. In general, the acid production was more in pairs containing *S. thermophilus* (H) than the other two. Acid production was also higher when the ratio of *Streptococcus* to *Lactobacillus* was 1:2 in the inoculum. The data obtained for the other six pairs (not reported) were similar to these 6 pairs.

TABLE 3. SCORE CARD FOR YOGHURT PREPARED FROM DIFFERENT CULTURE COMBINATIONS

Culture combinations	Appearance	Consistency	Taste	Flavour	Total
Max. score	2	3	4	6	15
S. thermophilus (H) + *L. bulgaricus* (W)	2	2	3	5	12
S. thermophilus (W) + *L. bulgaricus* (W)	2	1	2	5	10
S. thermophilus (H) + *L. bulgaricus* (1372)	2	1	1	4	8
S. thermophilus (489) + *L. bulgaricus* (W)	2	2	3	5	12
S. thermophilus (H) + *L. bulgaricus* (RTS)	1	2	2	3	8
S. thermophilus (H) + *L. bulgaricus* (Yb)	2	1	2	4	9

Excellent = 12–15; Very good = 9–11; Good = 6–8.

Table 2 shows the selection of best combination of *Streptococci* and *Lactobacilli* for grading the product with reference to body, texture, flavour and taste, among different combinations (1:1; 1:2; 1:3; 2:1 and 3:1) tried. It was observed that in all cases the coagulation was obtained within 3 to 4 hr, the curdling time being more than $3\frac{1}{2}$ hr in respect of the pair *S. thermophilus* 489 and *L. bulgaricus* (W). Overnight storing the samples at low temperatures showed significant changes in the proportion of organisms and production of acidity in the product. The data indicate that *Streptococci* show the tendency of dominance in the final product. No effort was made to improve the proportion of *Lactobacilli* in the final product by prolonging the incubation period as it resulted in increased acid production beyond the desirable level. Although all the four *Lactobacilli* used in the study had antibiotic actions against *B. subtills*, *E. coli* and *A. aerogenes* but the yoghurt samples had no inhibitory action against these test organisms. This is probably due to the low numbers of *Lactobacilli* present in the final product.

The detailed score card of the best product from each combination is shown in Table 3. It was observed that the combination of *S. thermophilus* H and *L. bulgaricus* (W) in the ratio 1:2 and *S. thermophilus* 489 and *L. bulgaricus* (W) in the ratio off 1:1 gave the best products.

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Comparative Changes in Chemical Constituents of Some Special Milks and Dahi Obtained from them

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Comparative changes in total solids, lactose total nitrogen and non-protein nitrogen contents of special milks, pasteurised and boiled, and *dahi* prepared therefrom were investigated. No definite trend in the total solids contents of *dahi* prepared from such milks was observed when compared with the original milk. The decrease in lactose content of such *dahi* ranged from 13 to 16 per cent. Statistically no significant change in total nitrogen and non-protein nitrogen content was observed. The decrease in total nitrogen in *dahi* ranged between 0.005 and 0.30 per cent, the range of increase of non-protein nitrogen was 0.007 to 0.9 per cent.

For augmenting market milk supply, special milks like toned milk, double toned milk, recombined milk and standardised milk have been introduced in Indian markets. Since *dahi* is commonly consumed in most of the houses, a portion of special milk is utilised in the preparation of *dahi*. *Dahi* from special milk being comparatively a new product, no published data are available on it, unlike the one prepared from normal cow or buffalo milk. Several workers[1,2] have reported a reduction in total solids and lactose content of *dahi* when compared with the values of original milk used for *dahi* making. Khambatta and Dastur[1] reported no changes in the total nitrogen content of *dahi*., Ranganathan and Narasimhamurthy[2] observed slight reduction in the total nitrogen when fermentation of milk was prolonged. Khambatta and Dastur[1] reported increase in non-protein nitrogen in *dahi* prepared from cow or buffalo milk. This paper reports the changes in the total solids, lactose, total nitrogen and non-protein nitrogen contents of *dahi* prepared from such special milks subjected to pasteurisation, boiling and on using *Streptococcus diacetilactis* culture.

Materials and Methods

Raw materials: Fresh clarified cow and buffalo milk, low heat spray dried skim milk powder and unsalted butter were procured from the Experimental Dairy, NDRI, Karnal, for the preparation of special milks. DRC culture (*Streptococcus diacetilactis*) was obtained from the Microbiology Division of the Institute.

Preparation of toned and double toned milk: By adopting the routine technology, toned milk having fat, 3 and SNF, 8.5 per cent and double toned milk having fat, 1.5 and SNF, 9.0 per cent conforming to Health Services requirements[3] were prepared by utilising low heat skim milk powder and water in 5 l. quantities at a time.

Preparation of recombined milk: At a time, 5 l. of recombined milk having fat, 4 and SNF 9 per cent were prepared as follows:

Reconstituted skim milk was prepared from low heat skim milk powder and water at 37°C. On attaining a temperature of 60°C, calculated quantity of butter was added. This was then homogenised at 105 kg/cm^2 pressure with Rannie Piston type homogeniser. Later, it was pasteurised at 71.5°C for 15 sec under laboratory conditions and cooled to room temperature.

Preparation of standardised milk: At a time, 5 l. of standardised milk having fat, 4 and SNF 8.5 per cent were prepared by mixing cow and buffalo milk samples in required quantities. High temperature heating to 71.5°C for 15 sec was adopted under laboratory conditions and cooled to room tempwrature.

Pasteurisation: Milk was pasterurised as described above.

Boiling: Milk was brought just to boil and cooled to room temperature.

Preparation of dahi: All the batches of milk were inoculated with DRC culture (*Streptococcus diacetilactis*) at 1.5 per cent level at room temperature and incubated at 22°C for 18 hr. *Dahi* obtained was stored at 4°C for analytical purpose.

Analytical: Cow milk, buffalo milk, toned milk, double toned milk, standardised milk and recombined milk were tested for fat and SNF contents as per ISI methods[4]. Total solids of milk and *dahi* were determined by gravimetric method[5]; total nitrogen and non-protein nitrogen contents of milk and *dahi* were determined by Kjeldahl method as per ISI[6]. Lactose of milk and *dahi* were determined by Lane Eynon's method as adopted by ISI[6].

The data were analysed statistically by analysis of covariance for various parameters of *dahi* taking milk

TABLE 1. THE AVERAGES OF SEVEN SAMPLES SHOWING PERCENTAGE OF TOTAL SOLIDS, LACTOSE, TOTAL NITROGEN AND NON PROTEIN NITROGEN OF DIFFERENT TYPES OF MILK AND DAHI

Treatment to milk	*Toned*		*Double Toned*		*Recombined*		*Standardised*	
	Milk	Dahi	Milk	Dahi	Milk	Dahi	Milk	Dahi
			Total Solids					
Pasteurised	12.38	12.43	11.58	11.57	14.03	13.73	13.84	14.17
Boiled	13.17	12.89	11.62	11.95	13.97	14.01	13.97	13.78
			Lactose					
Pasteurised	4.68	4.05	4.87	4.17	4.82	4.08	4.76	4.04
Boiled	4.91	4.11	5.07	4.42	4.97	4.23	4.89	4.21
			Total Nitrogen					
Pasteurised	0.54	0.52	0.50	0.48	0.53	0.51	0.53	0.52
Boiled	0.54	0.52	0.54	0.51	0.52	0.51	0.56	0.53
			Non Protein Nitrogen					
Pasturised	0.03	0.05	0.03	0.04	0.02	0.05	0.03	0.05
Boiled	0.03	0.04	0.03	0.04	0.03	0.04	0.03	0.05

Differences are not significant between types of milk as well as between treatments in all cases.

as auxillary variate. The number of observations for type of milk and treatment subclass was the same and equal to seven (two way factorial design—for orthogonal).

Results and Discussion

Total solids: From the data in Table 1, it is clear that there is no definite trend in the change of total solids of *dahi*, when compared to the total solids of different types of milk subjected to different treatments from which it was prepared. Whereas contrary to this, Ranganathan and Narasimhamurthy[2] and Khambatta and Dastur[1] have reported decrease in total solid contents of *dahi*. Khambatta and Dastur[1] reported an average loss of 4 per cent in the total solids after 24 hr and 6.6 per cent after seven days storage at 37°C in *dahi* prepared from raw cow milk. Corresponding values of reduction were 5.3 and 9.2 per cent in case of buffalo milk *dahi*. They also reported average reduction of 6.6 and 4.2 per cent in total solids of *dahi* prepared from boiled cow and boiled buffalo-milk respectively after 24 hr storage. Khambatta snd Dastur[1] used 3 per cent culture of house hold *dahi*.

Lactose: The results in Table 1 show that there were no significant differences in the decline in the lactose content of *dahi* prepared from milk under different heat treatments for all four types of milk when compared to the initial lactose contents of different types of milk. The percentage reduction amounted to 13.5, 14.34, 15.31 and 15.01 for *dahi* prepared from toned, double toned, recombined and standardised milk when compared to the respective types of pasteurised milks. The corresponding values of reduction for *dahi* were 16.3, 13.0, 14.9 and 14.02 per cent when prepared from such boiled lots. The reduction in lactose content is attributed to the lactose fermenting organisms. Khambatta and Dastur[1] observed a decrease of 53.1 and 37.4 per cent in lactose content of *dahi* prepared from raw buffalo milk and raw cow milk respectively after 24 hr incubation. For *dahi* prepared from boiled buffalo milk and boiled cow milk they reported 35.8 and 39.4 per cent loss respectively under similar conditions. These workers used 3 per cent culture of household *dahi*.

Total nitrogen: From Table 1 it is clear that there is no significant difference in total nitrogen content of different types of *dahi* made from different types of milk. Slight decrease in total nitrogen, however, was observed in *dahi* of all types except in the case of *dahi* prepared from boiled recombined milk which showed an increase of 0.005 units. In the case of pasteurised milk, *dahi* prepared from different types of milk, the decrease in nitrogen content ranged from 0.024 to 0.069 units, maximum being in case of standardised milk (0.069 units) followed by double toned (0.0255) single toned (0.0249) and recombined milk (0.0241).

The decrease for *dahi* prepared from boiled lots of special milks, ranged from 0.0017 to 0.0306 units, the decrease for standardised, double toned and single toned was 0.0306, 0.0307, 0.0207 units respectively, whereas the increase in the case of recombined milk *dahi* was 0.005 units. Khambatta and Dastur[1] observed no change in total nitrogen content of *dahi*.

Ranganathan and Narasimhamurhty[2] observed slight loss of nitrogen in *dahi*.

Non-Protein nitrogen: The results in Table 1 show that there was no significant difference in non-protein nitrogen content of *dahi* prepared from special milks subjected to pasteurisation and boiling. *Dahi* prepared from pasteurised lots of special milks showed an increase of 0.02451 for recombined milk *dahi*, followed by single toned *dahi* 0.01318, standardised milk *dahi* 0.0105 and double toned milk *dahi* 0.0081 units. For *dahi* prepared from boiled lots of special milks, the increase of non-protein nitrogen content was 0.01930 for standardised milk *dahi*, 0.0079 for recombined milk *dahi*. 0.0078 for single toned milk *dahi* and 0.00691 units for double toned *dahi*. Khambatta and Dastur[1] also observed an increase in non-protein nitrogen content of *dahi* by 0.024 units after 24 hr of incubation in the case of both raw cow and buffalo milk.

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Composition of Ghee-Residue

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Ghee-residues obtained by cream, creamery-butter and *desi*-butter methods showed that the moisture, protein and ash contents were more in butter ghee-residues than in cream ghee-residues. Butter ghee-residues contained more phospholipids than cream ghee-residues. As the period of heating increased, there were decreases in all the major phospholipids and a slight increase in lyso-phospholipids.

In an earlier study we have found that ghee-residue has antioxidant properties depending upon the method of preparation of ghee[1]. In the present communication the composition of ghee-residue obtained by different methods of preparation of ghee is presented.

Materials and Methods

Ghee was prepared by heating cream (unripened or ripened) creamery-butter or *desi* (indigenous)-butter momentarily to 120°C, unless otherwise mentioned, and the ghee-residues obtained were used for further analysis.

These were analysed for moisture by drying in an oven, fat by Rose-Gottlieb method, protein by micro-Kjeldahl method, lactose by Lane-Enon method and ash by incinerating the residue in a Muffle furnace; all essentially by the methods described in A.O.A.C.[2]. The phospholipid content of ghee-residue was determined as described earlier[3].

For fractionation of individual phospolipids, total lipids were extracted from ghee-residue by the method of Folch *et al.*[4] and they were subsequently fractionated by thin layer chromatography[5]. Individual phospholipid fractions were identified by spraying specific reagents[6] and were estimated quantitatively after charring them[7]. Butter-serum obtained by melting butter at 50-60°C was fractionated for individual phospholipids for the purpose of comparision.

Results and Discussion

Yield of ghee-residue: The yield of ghee-residue obtained by different methods of preparation of ghee, namely direct-cream (both ripened and unripened), creamery-butter and *desi*-butter methods was deter-

TABLE 1. EFFECT OF METHOD OF PREPARATION ON THE PROXIMATE COMPOSITION OF GHEE-RESIDUE

Type of ghee-residue	Moisture % Mean±S.D.	Fat % Mean±S.D.	Protein % Mean±S.D.	Lactose % Mean±S.D.	Ash % Mean±S.D.
Unripened cream ghee-residue*	14.1±5.43	59.5±10.26	18.6±6.15	7.9±2.36	1.3±0.64
Ripened cream ghee-residue*	13.6±6.06	57.0± 6.13	19.8±3.14	7.1±4.99	2.2±0.37
Creamery-butter ghee-reisdue**	25.5±4.89	36.2± 5.83	27.5±2.75	5.5±1.58	4.6±1.41
Desi-butter ghee-residue*	17.0±3.62	36.8± 4.38	33.5±5.21	10.4±4.03	3.1±2.26

*Average of 6 samples
**Average of 10 samples.

mined. The amount of ghee-residue was found to depend upon the method of preparation of ghee. This was due to the variation of the non-fatty serum constitutents of the different raw materials used for the preparation of ghee. The yield of ghee-residue was observed to be maximum in the case of direct-cream method, and it ranged from 9.6 to 14.7 per cent with a mean of 12 per cent. Both creamery-butter and *desi*-butter methods gave almost the same yield of ghee-residue which ranged from 2.8 to 5.2 per cent with an average of 3.7 per cent. Ripening of cream prior to clarification of cream reduced the yield of ghee-residue.

Proximate composition of ghee-residue: Ghee-residues obtained by the 3 different methods were analysed for their proximate composition and the results are shown in Table 1. It was observed that there were considerable variations in the composition of ghee-residues depending upon the method of preparation of ghee. Moisture, protein and ash contents were more in creamery-butter and *desi*-butter ghee-residues than in cream ghee-residues. Fat content was higher in cream ghee-residues than in butter ghee-residues. The maximum value for lactose was observed in the case of residue from *desi*-butter, while residue from creamery-butter showed the minimum value for the same. From this study it is seen that the composition of ghee-residue is dependent upon the raw materials used for the manufacture of ghee. Similar results have also been reported by others[8,9].

Total phospholipid content of ghee-residue: The total phospholipid contents of ghee-residues obtained by the different methods of preparation of ghee, namely direct-cream (both unripened and ripened), creamery-butter and *desi*-butter methods, were estimated and the results are shown in Table 2. It was observed that the phospholipid contents of ghee-residues were dependent upon the method of preparation. It is now clear that in unripened and ripened cream ghee-residues, the phospholipids amounted to about 1.57 and 1.10 per cent respectively of their total fat contents. These differences are statistically significant ($P < 0.05$). In creamery-butter ghee-residue and *desi*-butter ghee-residue the phospholipids were found to contribute to about 17.39 and 4.9 per cent respectively of their total fat. This showed that the phospolipid content was maximum in creamery-butter ghee-residue and minimum in ripened cream ghee-residue.

The differences observed in the phospholipid contents of different types of ghee-residues may be explained on the basis of initial phospholipid content of the raw materials and the out-turn (yield per cent) of the ghee-residues in the preparation of ghee. The low phospholipid contents observed in the case of cream ghee-residues may be due to the larger out-turn of ghee-residue during the preparation of ghee. The ripening of cream prior to clarification was found to decrease the phospholipid content of ghee-residue. This may be due to the greater removal of moisture from the residue and the subsequent transfer of phospholipid to ghee during the clarification of ripened cream[10]. The higher phospholipid contents obtained in the case of butter ghee-residues may be due to the lesser out-turn of ghee-residue. Among the two types of butter ghee-residues

TABLE 2. EFFECT OF METHOD OF PREPARATION ON PHOSPHOLIPIDS CONTENT OF GHEE RESIDUE

Type of ghee-residue	Phospholipids % Mean±S.D.	Phospholipids content of fat (%) Mean±S.D.
Unripened cream ghee-residue[a]	0.92±0.21[c]	1.57±0.40[c]
Ripened cream ghee-residue[a]	0.62±0.26[c]	1.10±0.47[c]
Creamery-butter ghee-residue[b]	6.27±2.60	17.39±6.81
Desi-butter ghee-residue[c]	1.78±0.56	4.95±1.85

[a]Average of 6 samples
[b]Average of 10 samples
[c]Statistically significant ($P < 0.05$)

TABLE 3. COMPOSITION OF PHOSPHOLIPIDS OF DIFFERENT TYPES OF GHEE-RESIDUES

Source of phospholipids	Phosphatidyl choline	Phosphatidyl ethanolamine	Phosphatidyl serine	Sphingomyelin	Phosphatidyl inositol	LPC+ LPE	Unidentified
			Wt%				
*Unripened cream ghee-residue	28.7	23.3	4.5	29.1	4.8	5.6	4.0
*Ripened cream ghee-residue	28.6	24.3	4.8	29.3	5.1	4.2	3.7
**Creamerty-butter ghee-residue	28.2	23.0	4.1	30.0	5.1	6.2	3.4
**Desi*-butter ghee-residue	28.6	20.4	4.0	29.5	5.0	6.8	5.7
*Butter-serum	29.3	26.9	5.0	31.3	5.9	1.6	—

* Average of 3 samples

** Average of 5 samples

LPC: Lysophosphatidyl Choline; LPE: Lysophosphatidyl ethanolamine.

studied, *desi*-butter ghee-residue had lesser phospholipid content and it can be attributed to the lesser inital phospholipid content of *desi*-butter compared to creamery butter[3,10,11]. This study clearly shows that the phospholipid content of ghee-residue is dependent upon the method of preparation of ghee.

Composition of ghee-residue phospholipids: The distribution pattern of individual phospholipids of unripened and ripened cream ghee-residues, creamery-butter and *desi*-butter ghee-residues in relation to butter-serum phospholipids are shown in Table 3. The thin layer chromatographic separation of the ghee-residue showed that it contained all the phospholipids which are normally present in butter-serum. In addition to these, it was found that the ghee-residues also gave one unidentified spot (Un.) containing phosphorus at the place of application in TLC. This may be a decomposition product of phospholipids formed during the heat treatment in the manufacture of ghee. In ghee-residues the average values for the percentages of individual phospholipids showed that the percentages of phosphatidyl chloine (PC), phosphatidyl ethanolamine (PE), phosphatidyl serine (PS), spihngomyelin (Sph) and phosphatidyl inositol (PI) were slightly less and that of lyso-phospholipids were more as compared to those of butter-serum phospholipids. No significant differences were noticed in the composition of phospholipids of different ghee-residues.

TABLE 4. EFFECT OF PERIOD OF HEATING ON THE PHOSPHOLIPID CONTENT OF CREAMERY-BUTTER GHEE-RESIDUE

Heating period at 120°C (min.)	Phospholipid content %	% reduction of phospholipid
0	4.2	—
10	3.3	21
20	2.2	48
30	1.6	62

Average of 3 samples

Effect of period of heating on the phospholipid content of ghee-residue: For studying the effect of period of heating on the phospholipid content of ghee-residue, creamery-butter was heated at 120°C for 0, 10, 20 and 30 min and the residues obtained were used for analysis. The effect of period of heating on the phospholipid content of ghee-residue is shown in Table 4. From the results obtained, it is clear that the phospholipid content of ghee-residue decreased as the period of heating increased. The average decreases of phospholipid contents in ghee-residue by heating creamery-butter to 120°C for 10, 20 and 30 min are about 21, 48 and 62 per cent respectively as compared to that heated just to 120°C. This is in conformity with earlier observations[10,12]. This is because of the fact that the ghee-residue obtained during the preparation of ghee by heating butter to 120°C without holding contained large amounts of moisture, and phospholipids, because of their surface active properties, remained mostly in the ghee-residue. It may also be possible that during heating, protein of phospholipid-protein complexes in the residue might get denatured and removal of moisture help to dissolve the phospholipids partly in the oil phase as suggested by El-Rafey *et al*[13].

The average compositions (as weight percentage) of the ghee-residue phospholipids obtained by heating creamery-butter at 120°C for 0, 10, 20 and 30 min were estimated after the separation of the phospholipids on TLC. The results are shown in Table 5. It can be seen

TABLE 5. EFFECT OF PERIOD OF HEATING ON THE COMPOSITION OF CREAMERY-BUTTER GHEE-RESIDUE PHOSPHOLIPIDS

Heating period at 120°C (min.)	Phosphatidyl choline	Phosphatidyl ethanolamine	Phosphatidyl serine	Sphingomyelin	Phosphatidyl inositol	LPC+LPE	Unidentified
				Wt%			
0	28.0 (24.0–30.3)	23.2 (17.3–26.0)	4.3 (3.1–5.9)	29.0 (28.0–30.0)	5.1 (4.5–5.9)	7.4 (5.1–8.3)	3.0 (0.5–9.6)
10	27.7 (23.6–30.0)	20.0 (15.5–22.0)	3.9 (3.0–4.8)	28.5 (27.5–29.2)	4.7 (3.7–5.1)	11.2 (10.1–12.3)	4.0 (2.0–12.7)
20	27.3 (23.1–29.6)	15.3 (12.2–18.0)	3.1 (2.2–4.4)	28.2 (27.2–29.2)	4.3 (3.0–5.1)	15.0 (12.0–16.6)	6.8 (2.1–12.7)
30	26.9 (22.9–29.0)	13.8 (10.3–17.7)	2.6 (2.0–4.4)	28.0 (27.1–29.0)	4.0 (3.3–5.2)	17.8 (15.5–18.8)	6.9 (2.4–13.7)

Average of 5 samples; Values in the parenthesis indicate the range
LPC: Lysophosphatidyl Choline; LPE: Lysophosphatidyl ethanolamine.

that there was decrease in percentage of PC, PE, PS, Sph and PI, and an increase in lyso-phospholipid as the period of heating at 120°C increased. The maximum decrease was found in the case of PE, followed by PS, PI, Sph and PC. On heating cream or butter to longer periods it was also observed that the ghee as well as the ghee-residue had turned dark brown and also imparted cooked like flavour. This colour and flavour changes as a result of continued heating may be due to the non-enzymatic browning reaction, caramelization of sugar etc. The differences observed in the antioxidant properties of ghee-residue obtained by the various method of preparation of ghee in the earlier study[1] may partly be explained from this investigation on the basis of their phospholipid contents, as they are known to have antioxidant properties[12,13].

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Preparation of Sodium Stearoyl-2-Lactylate and its Evaluation in Bread Making

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A simple 'one-pot' procedure has been developed for the preparation of sodium stearoyl-2-lactylate, which involves partial neutralization of lactic acid followed by simultaneous polymerization and esterification with stearic acid. The product conforms to the FDA specification. Baking studies showed the utility of the product in facilitating the incorporation (upto 10%) of soya flour into bread without affecting the physical quality of the bread loaf.

One way of enhancing the protein level of diets is through the fortification of bread with high quality oilseed proteins. However, incorporation of oilseed protein flour to wheat flour in appreciable proportion has adverse effects on the physical properties of bread,[1-3] which can be overcome with the help of sodium stearoyl-2-lactylate (SSL). SSL is believed to form a complex with gluten to stabilize the gluten net-work in dough[4]. SSL is not manufactured in India at present.

One patent[5] describes the preparation of salts of stearoyl lactylates by reacting stearic acid, alkali carbonates and lactylic acid at 200°C. Another patent[6] describes the preparation of acyl polylactic acids by reacting polylactic acid (eq. wt., 212.27; degree of polymerization, 2.69) with stearoyl chloride and its conversion to various metallic salts. There is no Indian patent on the preparation of SSL. However, one patent[7] describes the use of SSL in making high-protein bread.

Materials and Methods

Three makes of lactic acid, one imported (reagent grade) and two indigenous (I. P. grade), were used in this investigation. Their characteristics are given in Table 1. Two grades of technical stearic acid (ISI Types I & II—Indian Standards Specification: 1675-1971) were used. Sodium carbonate (reagent grade) and commercial sodium hydroxide flakes were used.

ADCS methods[8] were used for the determination of acid number, saponification number and melting pont. Free and total lactic acids were determined according to Fetzer and Jones[9]. GLC analysis was carried out on an F & M unit equipped with a thermal conductivity detector and a column (2 ft $\times \frac{1}{4}$ in) of SE-30 (5 per cent) on Chromosorb P (45-60 mesh) maintained at 200°C. Injection Port and detector temperatures were maintained at 300°C. Carrier gas was hydrogen (60 ml/min).

Initially, SSL was prepared by esterification of polylactic acid with stearoyl chloride. Though a light coloured product was obtained, this is a costly 4-step procedure. Hence, an one-step procedure was developed. This involves partial neutralization of lactic acid and esterification with stearic acid at elevated temperatures. Nitrogen or carbon dioxide was bubbled through during the reaction. Several batches (2 kg/batch) were made, the details of which are given in Table 2, and the results were consistent. A few pilot-plant runs (20 kg/batch) were also carried out. Lactic acid (Make 1) was bleached with 1 per cent activated carbon or 30 per cent hydrogen peroxide. Dark coloured SSL was bleached twice in ethanol using 1 per cent carbon, followed by 30 per cent hydrogen peroxide after removal of ethanol. The process know-how is available through the National Research Development Corporation, New Delhi.

Baking performance evaluation of SSL was carried out. Conditions of baking are as follows:

Method of baking: Sponge and Dough method. Sponge consisting of 60 per cent of the total quantity of wheat flour was used. The remaining 40 per cent of the flour was added in the dough stage after initial fermentation.

Fermentation time: 2.5 hr.

Other ingredients: Sugar, 1.55; salt, 1.75; yeast, 1.0; and glycerol monostearate in groundnut oil, 1.2 percent.

Mixing time for sponge: 1 min at high speed and 3 min at low speed.

Mixing time for dough: 1 min at high speed and 4.5 min at low speed.

Proof time: 1 hr.

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Baking temperature: 232°C.
Baking time: 27 min.

TABLE 1. ANALYSIS OF LACTIC ACID

Grade	Colour	Sp. gr.	Lactic acid (%) Free	Total
Reagent	Colourless	1.206	73.2	91.5
I.P. (Make I)	Yellow	1.209	68.3	85.4
I.P. (Make II)	Pale Yellow	1.192	71.4	88.5

Results and Discussion

SSL conforming to the FDA specification could be prepared from all the grades of lactic acid used. However, SSL (No. 5 in Table 2) from one make of indigenous lactic acid (Make 1 in Table 1) was very dark and required bleaching. Initial bleaching of lactic acid with activated carbon or hydrogen peroxide did not improve the colour of the product greatly; the dark coloured SSL after bleaching became yellow (No. 6 in Table 2). Bleaching enhanced the acid number of the product beyond the limit specified by the FDA. SSL (No. 3 & 4 in Table 2) made from reagent grade lactic acid was white while that made from another make of indigenous lactic acid (Make 2 in Table 1) was of light tan colour (SSL No. 7 in Table 2). Light tan colour will not affect the quality of bread since only 0.5 per cent of SSL is generally used. The SSL samples made from ISI Type I stearic acid generally had lower melting points than those made from ISI Type II stearic acid because of higher content of palmitic acid in the former. However, this did not adversely affect the baking performance. Sodium carbonate was preferred to sodium hydroxide from the point of view of cost and also baking performance of the product: The gas used for bubbling had an effect on the colour of the product, carbon dioxide imparted a lighter colour compared to nitrogen.

Analytical characteristics of SSL prepared from different lactic acids are given in Table 2. SSL (No. 7 in Table 2) was also analysed by gas-liquid chromatography after esterification of free acids with diazomethane and also after acidification with dil. hydrochloric acid and subsequent esterification. When analysed before acidification three peaks were observed corresponding to methyl palmitate, methyl stearate and an unidentified component, presumably a polymer of lactic acid. After acidification and esterification the chromatogram showed four peaks corresponding to methyl palmitate, methyl stearate and presumably palmitoyl lactylate and stearoyl lactylate. The chromatogram was superimposable with that obtained from an imported sample of SSL ('Emplex' of Patco Products, Kansas City, USA). The weight percentage composition of the components eluted was calculated from the area percentages of the peaks (Table 3).

When analysed after adding a known amount of methyl palmitate it was found that only about 60 per cent of the SSL or 'Emplex' could be accounted for on the basis of eluted components, indicating that there are some lesser volatile polymeric compounds which were retained on the column. Free stearic acid was estimated to be 13.4 per cent from the gas chromatogram. Using this value and the acid number of the product, free

TABLE 2. ANALYSIS OF SODIUM STEAROYL-2-LACTYLATE PREPARED UNDER DIFFERENT CONDITIONS

SSL No.		Process description	Colour	Acid no.	Saponification no.	Ester no.	M.pt. (°C)
	I	Reagent grade lactic acid, sodium carbonate, stearic acid (ISI-Type I), N_2 bubbling					
1.		*a*) Unbleached	Dark brown	78.5	227.6	149.1	46
2.		*b*) Bleached	Light brown	97.0	228.6	131.6	42
3.		As in I but CO_2 bubbling, unbleached	White	61.4	229.0	167.6	40
4.		As in I but caustic soda, unbleached	White	71.4	229.0	157.0	40
	II	Indigenous lactic acid (Make I), stearic acid (ISI-Type I), caustic soda flakes, CO_2 bubbling					
5.		*a*) Unbleached	Very dark	55.0	198.0	143.0	—
6.		*b*) Bleached	Yellow	99.5	198.0	98.5	42.5
7.		As in II indigenous lactic acid (Make 2), stearic acid (ISI-Type II), unbleached	Tan	70.6	220.4	149.8	46
		FDA specifications	—	60–80	210–270	150-190	46–52

TABLE 3. WEIGHT PERCENTAGE COMPOSITION OF THE ELUTED COMPONENTS FROM SSL AND 'EMPLEX'

	Relative retention time	Composition, (wt. %)	
		SSL*	'EMPLEX'
Methyl palmitate	1.0	1.1	2.4
Methyl stearate	1.2	32.9	30.2
Methyl palmitoyl-2-lactylate (?)	4.3	5.1	7.5
Methyl steraroyl-2-lactylate (?)	7.7	60.8	59.8

*No. 7 in Table 2.

TABLE 4. COMPARISON OF INDIGENOUS AND IMPORTED SODIUM STEAROYL-2-LACTYLATE (SSL) FOR 8% SOYA FLOUR INCORPORATION IN BREAD

SSL in wheat flour* (wt. %)	Vol./wt. ratio of loaf	
	Indigenous**	Imported ('Emplex')
0.0	5.73	5.78
0.3	5.95	5.95
0.5	6.03	6.01
0.75	6.01	6.00
1.0	6.20	6.20

*Gluten (medium strong) content, 11.7%
**See No. 7 in Table 2.

TABLE 5. COMPARISON OF INDIGENOUS AND IMPORTED SODIUM STEAROYL-2-LACTYLATES (SSL-0.5%) AT DIFFERENT LEVELS OF SOYA INCORPORATION IN BREAD

Soya flour in wheat flour* (wt. %)	Vol./wt. ratio of loaf	
	Indigenous**	Imported ('Emplex')
8	6.03	6.17
10	6.19	6.10
12	4.10	4.33

*Gluten (medium strong) content 12.5%
**See No. 7 in Table 2.

lactyllactic acid (dimer) was computed to be 13 per cent.

Baking performance of SSL was compared with 'Emplex'. Table 4 gives the volume/wt ratio of the loaves at various levels of SSL and 'Emplex' and at 8 per cent level of soya flour. SSL compared very well with 'Emplex' at all the levels studied.

The staling in the control samples started on the 3rd day, whereas the samples with SSL and 'Emplex' remained soft till the fourth day when they became fungus infested.

The performance of SSL is compared in Table 5 with that of 'Emplex' (0.5 per cent by weight) at 8 and 10 per cent levels of soya flour incorporation. Again, SSL was found to perform well in comparison with 'Emplex'. Above 10 per cent level of incorporation, the loaf volume was unsatisfactory.

Thus, SSL comparable to imported material in specification and baking performance can be prepared from light coloured indigenous lactic acid (I.P.), stearic acid (ISI-Type II) and sodium carbonate (reagent grade).

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RESEARCH NOTES

STORAGE BEHAVIOUR OF PRE-COOKED DEHYDRATED RICE

Pre-cooked dehydrated rice samples prepared in the laboratory and packed in different packaging material were assessed for shelf-stability. The results of the storage studies indicated that the samples packed in aluminium laminate pouches could be stored at room temperature upto 18 months as against the samples packed in polycell or polyethylene bags upto 6 months without appreciable changes in quality attributes.

Quick cooking or precooked dehydrated rice, having short reconstitution time and storage life are likely to be of value for specifilized purposes or under conditions of emergency[1-5]. In situations where a saving in time is desired (convenience of preparation) or for those situated at very high altitudes (army personnel), such precooked rice is of great value. The paper describes the results of storage behaviour of the precooked dehydrated rice (Basmati) employing various types of packaging materials for the stability of the processed product. Milled and cleaned 'Basmati' variety of rice (50 kg) confirming to ASC specifications[4] and containing 10-12 per cent moisture was used in the present studies.

'Basmati' rice (100 g. each out of a mixed representative sample made up of 10 portions and selected at random from 10 kg lots) was roasted at 90±2°C for 3 min in a shallow aluminium pan (32 cm. diameter ×70 cm. height with cover) to produce fissures (cracks) in the grains making it easier for gelatinization of rice to render it quick cooking. After roasting it was soaked in equal amount of water for 15 min. This process provides sufficient moisture for the gelatinisation process and also the grains are provided with a layer of gelatinised starch which retains the integrity of grains during subsequent pressure cooking[1]. Soaked rice was then cooked in a laboratory scale pressure cooker for 7 min at a pressure of 0.35 kg/sq.cm. Rice after pressure cooking (moisture content 80 per cent) was dehydrated to a final moisture content of 6 per cent in 3 hr using a indigenously fabricated recirculation system air dryer maintaining the temperature of 60±2°C. Rapid drying was thus carried out to ensure enlarged grain condition and porous structure in the final product to make it quick cooking.

On the basis of these results, a flow diagram for the process has been evolved (Fig. 1). The method of producing precooked dehydrated rice as modified in this laboratory (Fig. 1) was further tried with two commercial varieties of rice (25 kg batches) viz. 'Dehradun Basmati' and 'Kaisipichodi'. The products obtained were of high organoleptic quality and were found to cook in 6½ to 7 min in boiling water as compared to 30 min required for cooking ordinary rice without any treatment, indicating the applicability of the process to different commercial varieties of rice.

The precooked dehydrated rice thus prepared was packed suitably and stored at room temperature (26± 2°C) and at 45 per cent RH. For storage of the final product (*i*) polycell and polyethylene bags (700 gauge); (*ii*) aluminium laminate pouches (paper/polyethylene/ aluminium/polyethylene) (400 gauge); and (*iii*) moisture sealable transparent (MST) cellophane (300 gauge) followed by an outer wrap of kraft paper (60 B.C.)/ aluminium foil (0.02 mm) /polyethylene (150 gauge) laminated pouches were used for packaging. Quality of stored product was assessed at regular intervals by a taste panel consisting of 12 members of the staff. Nine point hedonic scale was used for appearance, flavour, texture and overall acceptance.

Results of sensory evaluation and storage stability of precooked dehydrated rice are included in Table 1. The freshly prepared sample, samples stored for 6, 12, 15 and 18 months in polycell bags and aluminium pouches after cooking scored 7 and more on 9 point hedonic scale. This indicated the overall quality of the product in very good to good range of acceptance. There was no substantial loss of flavour or colour on pre-processing

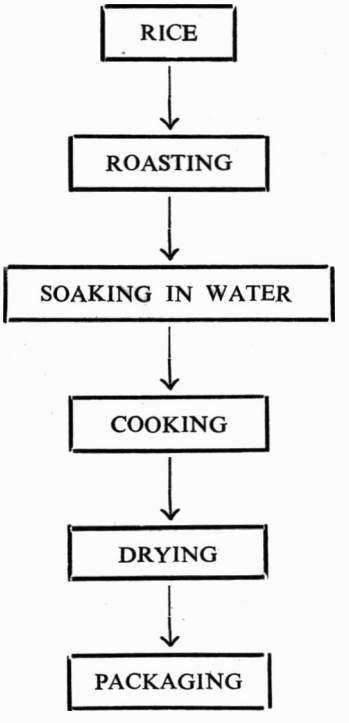

Fig. 1. Flow diagram of the process for quick cooking rice

TABLE 1. ACCEPTABILITY AND STORAGE STABILITY OF PRECOOKED DEHYDRATED RICE

Packaging material	Cooking time (mn.)	Moisture content %	*Organoleptic score of stored product (based on hedonic scale)* Freshly prepared	6 month	12 month	15 month	18 month
Polyethylene pouches	7.0	6.0	8*	—	—	—	—
(700 gauge)	7.5	7.0	—	7*	—	—	—
Polycell pouches	7.0	6.0	8	—	—	—	—
(700 gauge)	7.8	7.1	—	7	—	—	—
Aluminium pouches	7.0	6.0	8	—	—	—	—
(paper/polyethylene/	7.0	6.0	—	8	—	—	—
aluminium/polyethylene)	7.0	6.0	—	—	8	—	—
	7.5	6.8	—	—	—	7	—
Moisture sealable transparent (MST)	7.0	6.0	8	—	—	—	—
cellophane (300 gauge)	7.0	6.0	—	8	—	—	—
followed by an outer	7.0	6.0	—	—	8	—	—
wraper of kraft paper	7.0	6.0	—	—	—	8	—
(60 B.C.)/aluminium foil	7.4	6.7	—	—	—	—	7
(0.02 mm)/polyethylene							
(150 gauge) laminate							
pouches							

*Organoleptic scores of 8 and 7 indicate the quality of the product as very good and good respectively.

the rice to render it quick cooking. Nutritional losses, however, may be expected[2]. The precooked dehydrated rice samples packed in polyethylene or polycell bags or in aluminium pouches were found to be acceptable when evaluated after 6 months and 15 months of storage, respectively, under ambient temperature conditions (Table 1). After 6 months, moisture content of the rice packed in polyethylene or polycell bags increased slightly and cooking time was also slightly affected. There was, however, no increase in moisture content of the product stored in aluminium pouches for 1 year when cooking time remained same. No substantial loss of flavour or colour in processed rice sample during storage at room temperature was noticed. Therefore, less costly packaging materials like polyethylene or polycell bags are adequate for storage upto six months. For storage beyond six months, aluminium pouches and MST cellophane laminate pouches which give storage stability upto 18 months are suitable. For reducing the percentage of broken grain and preventing the packages from scratches or pinholes during transportation of precooked dehydrated rice, it is advisable to pack these small bags in paper cartons or corrugated boxes prior to transport. The secondary package will give additional protection to the final quality of the product.

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PROCESSING AND FERMENTATION OF COCONUT TODDY

Coconut toddy fermented for 12 hr after collection contains maximum number of bacteria and yeasts compared to the fresh and 24 hr fermented samples. Processing of toddy was done by mixing with carbon granules, followed by clarification by centrifugation, pasteurisation and bottling. Processed toddy did not contain any viable cells of bacteria or yeasts. Processed samples were clear and retained the natural colour and appearance. Significant difference was observed in the total sugar content between fresh and fermented toddy. Preservation did not substantially alter the alcohol content. Protein content of processed toddy was higher.

Coconut toddy is a popular alcoholic beverage for the lower socio-economic classes in India. The method of obtaining toddy consists a series of operations in the spathe of the coconut palm, that result in oozing of

TABLE 1. INFLUENCE OF THE PROGRESS OF FERMENTATION AND PROCESSING IN COCONUT TODDY*

Treatment to toddy	Optical density	Conductivity (μ mho)	Titratable acidity (ml of 0.1 N KOH/100 ml)	Free sugars (% w/v)	Total sugars (% w/v)	Alcohol (% w/v)	Protein (mg/100 ml)
Fresh	1.73	0.65	15.33	2.73	9.19	2.87	189.6
Fresh (processed)	0.56	0.76	12.26	3.13	9.57	2.52	101.4
12 hr fermented	1.67	0.71	18.85	2.51	3.51	4.21	160.8
12 hr fermented (processed)	0.64	0.85	15.01	2.76	3.86	3.61	83.6
24 hr fermented	1.41	0.77	24.31	1.57	2.23	7.42	154.3
24 hr fermented (processed)	0.68	0.89	22.74	1.81	2.44	6.31	81.4
Period of collection							
Fresh	1.14	0.70	13.79	2.93	9.38	2.69	145.5
12 hr fermented	1.16	0.78	16.90	2.64	3.68	3.91	122.2
24 hr fermented	1.04	0.83	23.53	1.68	2.34	6.86	117.9
Significance	H.S.	H.S.	H.S.	H.S.	H.S.	H.S.	H.S.
C.D.	0.04	0.02	1.11	0.13	0.56	0.30	14.0
Effect of treatment							
Pre-treated	1.60	0.71	19.48	2.27	4.97	4.83	168.2
Post-treated	0.63	0.83	16.67	2.57	5.28	4.14	88.8
Significance	H.S.	H.S.	H.S.	H.S.	N.S.	N.S.	N.S.
C.D.	0.04	0.012	0.90	0.102	—	—	—

H.S. = Highly significant; *Mean values of 14 samples

sweet toddy from the cut surface. Commercial toddy available in the market has an undesirable odour. Under natural conditions, toddy is fermented by native microflora consisting of yeasts and bacteria. Some of them produce ethyl alcohol while others produce aldehydes, higher alcohols and acetic acid[1]. A process has been developed for removing the undesirable odours and for controlling the fermentation. Details of the process with the results of the investigations on the influence of processing and fermentation of coconut toddy are presented in this report.

In the pretreatment of the process, toddy was mixed with activated carbon granules at 5 per cent level in a tank and kept gently mixed for a period of 30 min. The carbon mixed toddy was clarified in a solid bowl basket centrifuge at 1000 g and pasteurised in a double pipe heat exchanger at a temperature of 80-82°C. The hot toddy was bottled either directly or collected in a balance tank and bottled subsequently. The sealed bottles were again processed in an autoclave for 30 min with steam at atmospheric pressure. Coconut toddy collected in the early morning was considered as fresh toddy which was allowed to ferment at room temperature for 12 and 24 hr. Total bacterial and yeast counts in the processed and unprocessed samples were determined by plating on nutrient agar and glucose yeast extract agar media respectively. The pH was determined using a pH meter (Systronics). The absorbance was determined at 430 mμ using a Beckman DU 2—Spectrophotometer. The conductivity was measured with a Mullard Conductivity Bridge. Titratable acidity was determined by titration against 0.1 N potassium hydroxide. Free and total sugars were estimated by Hane's method[2]. The alcohol content was determined by the method described in AOAC[3]. For estimating the ash content, aliquots were evaporated to dryness before igniting in a muffle furnace to constant weights at 450°C. Protein was determined by Micro kjeldhal method[4]. The removal of odour of the toddy was judged on the basis of sensory evaluation. The group of individuals from the station who evaluated the toddy were selected on the basis of aptitude. The scores for the extent of odour were 1-3, 4-6 and 7-9 for slight, strong and very strong odours, respectively.

The number of bacteria and yeasts was comparatively highest in samples of toddy fermented for 12 hr. In ten samples the number of bacteria in millions/ml ranged from 28 to 134 (mean 96) in fresh toddy, 84 to 291 (mean 179) after 12 hr fermentation and 30 to 173 (mean 115) after 24 hr fermentation. The number of yeasts ranged from 29 to 64 (mean 48) in fresh toddy, 99 to 273 (mean 198) after 12 hr fermentation and 26 to 80 (mean 54) after 24 hr fermentation. The processed samples of toddy did not contain any viable cells of either yeast or bacteria. There was a reduction in pH with the progress of fermentation, but there was no difference between the

processed and unprocessed samples (pH range, 3.74-3.42).

The difference in the clarity as determined by absorbance between the processed and unprocessed toddy was high which can be attributed to the removal of microorganisms during processing. A relatively low optical density was recorded with the 24 hr fermented toddy compared to the fresh and 12 hr fermented samples (Table 1) which may be the result of a shift in the absorption maximum due to formation of certain by products. The increase in conductivity observed as a result of fermentation or processing of toddy (Table 1) may be either due to the release of ionizable matter otherwise bound by organic substances or due to the mineralization of organic substances as a result of fermentation.

The significant increase in the titratable acidity during the course of fermentation (Table 1) is suggestive of the presence of acids formed possibly as byproducts. Processing of toddy on the other hand resulted in the decrease of titratable acidity attributable to the removal of part of these acids during processing. Free and total sugars gradually decreased as the fermentation progressed (Table 1) with a concomitant increase in alcohol content. The conversion of sugar to alcohol beyond the theoritical limit may be attributed to the presence of polysaccharides in toddy which get converted to alcohol. The higher content of free sugar noticed in the processed toddy compared to the unprocessed samples (Table 1) may be the result of hydrolysis of certain constituents during the processing of toddy.

The fall in protein content was noticed as a result of fermentation and processing (Table 1). While this decrease during fermentation is the result of microbial activity the influence of the process may also chemically alter the protein content. The score of sensory evaluation of unprocessed toddy was significantly higher than the processed toddy at each intervals (mean score range 1.20-1.30 for processed toddy and 5.75-6.10 for the preprocessed toddy). Within the processed samples or within the unprocessed samples panelists were unable to find out significant differences.

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PROXIMATE COMPOSITION AND NUTRITIVE VALUE OF *PHASEOLUS MUNGOREOUS*, A CROSS BETWEEN *PHASEOLUS MUNGO* AND *PHASEOLUSAUREUS*

A comparative study of biochemical composition of *Phaseolus mungoreous*, a cross between *Phaseolus mungo* (M_{1-1}) and Phaseolus aureus (T_1) was carried out. These pulses were analysed for proximate composition and essential amino acid content. The amphidiploid contained a maximum of 27.93% protein as compared to its parents. Nutritive value based on amino acid contents indicated that pulse grains are a good source of lysine, but are deficient in tryptophan followed by sulphur amino acids.

Legumes are of importance as a chief source of protein food. They are characterised by a relatively high content of protein, an even greater content of carbohydrates and low level of oil[1].

Singh and Singh[2] reported the protein content of the hybrids, the crosses between 24-2 × hybrid-4 and P. 23-67 × Jalgaon 781. The results of Rao and Subramanian[3] indicate that pulses are good source of lysine, valine and aromatic amino acids but are deficient with respect to tryptophan and sulphur amino acids. Pulse breeders of this University have developed a cross, *Phaseolus mungoreous* between *Phaseolus mungo* (var. M_{1-1}) and *Phaseolus aureus* (var. T_1). In the present investigation this cross has been examined for its biochemical composition and nutritional quality.

Samples of the parents viz. *Phaseolus mungo* (M_{1-1}) and *Phaseolus aureus* (T_1) and the cross *Phaseolus mungoreous* (amphidiploid) for this study were obtained from the Department of Genetics, Haryana Agricultural University, Hissar.

The samples were analysed for moisture, ash, crude protein, true protein, crude fibre, ether extract and calcium according to AOAC methods[4], and phosphorus was determined by the modified method of Bartlett[5]. Tryptophan was determined by the colorimetric method[6] and methionine according to the method of Horn *et al.*[7] Other amino acids viz. leucine, isoleucine, valine, threonine and tyrosine were determined by paper

TABLE 1. PROXIMATE CHEMICAL CONSTITUENTS OF PULSES ON MOISTURE-FREE BASIS

Variety	Moisture %	Ash %	Ether extract %	Crude fibre %	Crude protein %	Nirogen free extract* %	True protein %	Calcium %	Phosphorus %
P. mungo (M_{1-1})	5.48	3.60	1.25	4.04	23.3	67.8	20.6	0.12	0.21
P. aureus (T_1)	4.93	3.74	1.12	4.83	22.3	68.3	17.0	0.10	0.24
P. mungoreous	4.92	4.19	2.37	5.89	27.9	59.6	22.4	0.13	0.30

*% NFE = 100-(CP% + CF% + Ash% + EE%)

chromatography according to the method of Rao and Subramanian[3]. Two dimensional descending chromatography was employed for all these determinations and the concentration of amino acid was determined colorimetrically at 540 nm according to the method of Giri *et al.*[8]

Proximate composition of *Phaseolus mungoreous* (amphidiploid), *Phaseolus aureus* (T_1) and *Phaselous mungo* (M_{1-1}) is given in Table 1. The protein content in amphidiploid (cross) is highest (27.9 per cent) as compared to its parents *Phaseolus aureus* (T_1) (22.3 per cent) and *Phaseolus mungo* (M_{1-1}) (23.3 per cent). The protein content of the hybrid variety is higher as compared to that of the parents. The variation in moisture, crude fibre, NFE, ash and ether extractives is very small (Table 1). There is little difference in the calcium content of these varieties, however, phosphorus content is more in the case of cross as compared to that of its parents. The differences in proximate composition may be attributed to genome differences. High protein and phosphorus in amphidiploid suggests hybrid vigour for these characters.

The amino acid composition (methionine, tryptophan, threonine, lysine, tyrosine, valine, leucine and isoleucine) of the three varieties of pulses are given in Table 2.

TABLE 2. AMINO ACID COMPOSITION OF PULSES AND THEIR CROSS (g/16 g.N. basis)

Amino acids	*P. mungo* (M_{1-1})	*P. aureus* (T_1)	*P. mungoreous*	*Hen's egg*[8]
Lysine	9.24	8.68	7.24	6.4
Tyrosine	3.15	3.01	3.64	4.2
valine	5.33	5.16	4.97	7.3
Isoleucine	5.46	6.63	4.90	6.6
Leucine	11.68	11.00	9.92	8.8
Threonine	2.52	2.22	2.27	5.1
Tryptophan	0.71	0.69	0.59	1.6
Methionine	1.51	1.42	1.30	3.1

Tyrosine content is high in the cross as compared to that of the parents; whereas parents (*Phaseolus mungo* and *Phaseolus aureus*) had a slight superiority over the cross (*Phaseolus mungoreous*) in relation to valine, isoleucine, leucine and lysine. The variation in tryptophan, methionine, and threonine were not specific to these two groups of pure strains and hybrid. Nutritive value of *Phaseolus mungo* is highest, while it is lowest in case of *Phaseolus mungoreous* and intermediate in *Phaseolus aureus*. From the data on amino acid contents, it is concluded that there is a partial dominance of low amino acid content over high amino acid content. This is in agreement with the findings of Leleji *et al*,[9] who brought out the dominance of low over high available methionine in the F_1 and F_2 seeds. It can be concluded that the major deficiency in these pulse varieties is that of tryptophan followed by methionine and threonine.

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BOOK REVIEWS

Monograph on the MARKETING OF FOODS FOR CHILDREN THROUGH THE PUBLIC DISTRIBUTION SYSTEM: NEW DELHI WORKSHOP, published by the Protein Foods and Nutrition Development Association of India, 63 pages.

Shri Mohan Dharia, Union Minister of Commerce, Civil Supplies and Co-operation, inaugurated the Workshop which was held in New Delhi on 9th and 10th July 1977. A number of topics such as 'Target Groups and Food Types', 'Components of Distribution' and other 'Elements of the Operation' have been discussed in detail. Further, an invited panel of experts consisting of Mr. R. Balasubramaniam, Mr. S. Ramaswamy, Mr. N. P. Singh, Dr. D. V. S. K. Rao and Dr. S. V. Pingale have given interesting contributions on the topic based on their experience.

What are the target groups and how can they be reached? Should there be selection of beneficiaries? Are our target groups disenabled to use our public distribution system? Should nutritional intervention be considered as feeding programmes for relief operations, subsidized operations for selected vulnerable groups for a continuing period or substantial investments by Government on food for the needy?

Is cost the major determinant in the efficacy of the programme? What consistutes 'fair price'?

Is public distribution basically required for this type of operation? Are people better served by existing public and private distribution systems or do we require new strategies of distribution? Is the problem solved by making available higher quantities of food commodities people are used to or should presentation to the consumer be in the form of mixed commodities in terms of nutritional principles or should it be as processed foods? If the latter, what type of processing is most convenient, effective and economic? What proportions of the total cost of the food delivery can be allottedfor manufacture, packaging, distribution and selling of the product? Do processed foods play any significant role at all in alleviating malnutrition or promoting better nutrition to the under-privileged high-risk target groups subsisting below the poverty line? Indeed should cost be considered paramount in considerations of food which should be the Government's obligation and social concern, since adequate food relative to the purchasing power of large segments of our population is probably not achievable in the foreseeable future. In such a case what priority should we give to nutritional problems, and should we forge a national policy on foods on the basis of Government as the real consumer, subsidising foods with a view to meet the needs of the poor?

These and other questions have been asked and answered by specialists in the respective areas. PFNDAI under the direction of Dr. K. T. Achaya had previously arranged a number of Workshops to discuss matters related to foods in their nutritional context. The New Delhi Workshop has examined key aspects of nutritional issues involved and generated information to determine steps to be taken for putting nutritional data into food practice.

The only criticism the reviewer has is, that there has not been enough stress on modalities of constituting food products suited to various regions in India based on their dietary practices and nutritional needs. Nevertheless, I would strongly recommend this monograph to everybody involved in nutrition and foods in India.

Dr. K. K. G. MENON
HINDUSTAN LEVER LTD. BOMBAY

ENERGY-SAVING TECHNIQUES FOR THE FOOD INDUSTRY 1977" Ed: M. E. Casper—Pages: 657. Noyes Data Corporation Park Ridge, New Jersey, U.S.A.

This book is based on two reports written for assisting the Federal Energy Administration in USA to set targets for energy saving by different food industries. While it lists the techniques available for energy saving, in 4 pages—it is by no means a manual or guide book for those who are looking for methods of energy saving. To the extent the title of the book is misleading.

On the other hand, the book is full of data on various (47 Nos) food industries relating to the existing pattern of energy consumption and targets considered feasible. For us in India, this data can only be of use for comparison with our own energy consumption patterns and the book is, therefore, of only limited use.

The most interesting part of the book appeared to me. to be the methodology followed and the structure of the report on each industry.

First of all they have derived the weighted average pattern for each industry to tabulate the source of energy (electricity, gas, coal, etc.) as per cent of the total for the total production. To give the per cent, all energy consumption has been expressed as heat units, viz: BTUs. Then the intermediate use distribution and end

use distribution are tabulated. Thus the fuel used for generating steam and the steam being used to generate electricity are shown schematically in a quantitative way along with improvements possible by specified techniques. This tabulated/schematic representation is most helpful

Another good feature of the methodology is the precise & logical definition of every term used in the final conclusions. For example, to define what technique is considered feasible technologically and economically, very rational criteria have been derived.

While the actual figures and targets in this book may be of limited relevance to our food technologists, the methodology and the approach to the problem of collection of energy data is equally relevant in all countries. This book will, therefore, be of interest to some of our industrial engineers working in food and allied industries, who will appreciate the rigorous approach developed for the purpose of the reports on which this data book is based.

DR. S. S. KALBAG
HINDUSTAN LEVER LTD. BOMBAY

FORTIFIED AND SOFT DRINKS by M. H. Gutcho, Noyes Data Corporation, Park Ridge, New Jersey, USA, 1977—pp. 420.

This is the Review in Food Technology No. 43 put out by the Publishers and is covered under two parts, the US Patent literature about 186 in all from 1966 to 1977.

In Part I the patents on Nutritive and Fortified drinks from soyabean, whey, dairy drink, chocolate, cocoa beverages, fortified soft drinks using proteins and vitamins are covered. In Part II the coverage is on carbonated and non-carbonated soft drinks like dry beverage mixes, low calorie drinks, citrus drinks, slush beverages, acidulants, flavours and liquid carbonated beverages.

Soy drinks: Destroying trypsin by microorganisms, beany taste removal by lactic fermentation and protease action, use of carragenin as stabiliser, soy-sesame and coconut meal powder are some aspects detailed.

Whey: Removal of albumin to improve flavour and use of whey to mask flavour of soybean and eggs are covered.

Dairy Drink: Viscosity control in refrigerated liquid milk, debittered naval orange juice are interesting.

Chocolate and cocoa: Use of cellulase to improve solubility and surfacactants or enzyme to improve dispersal are significant developments.

Fortifiers: Deamidised glutens, enzyme treated soybean, cysteine and amino acids to stablise vitamin 'C' and iron are narrated under fortification of drinks.

Carbonated and non-carbonated soft drinks: Patents on various types of carbonators like use of supersonic vibration, continuous carbonation under low pressure, carbonation near freezing point using solid CO_2 and concentrated carbonated aqueous beverage are noteworthy.

Preparation of dry beverage mix using calcium carbonate with acid and other additives, dextrin coated acid and carbonates, carbondioxide containing molecular sieves, rigid crystalline zeolite body are examples in dry beverage mixes.

Sugar crystals impregnated with colour and desiccating agents, improving stability by non-alkali orthophosphate in mixes containing phosphoric acid are areas covered in a number of patents.

Citrus drinks: Use of flavylium salts as colorants and caramel as an emulsifier for water insoluble flavour, 2-ethylidine cis-3 hexanol as flavour augumentor and cellulose ester adsorbants for debittering juices are interesting patents.

Slush beverages: Recently slush beverages are becoming popular and the problems to control the crystal structure to give creamy smooth textures has been solved using pectin in combination with other gums.

Various apparatus for preparation of frozen carbonated beverages are described with diagrams.

Several formula for non-carbonated slushes are also narrated.

Acidulants: Fumaric and Adipic acid with improved solubility and stability have been achieved using surfactants and flow conditioning agents. Agglomeration after impregnation with aqueous propylene glycol, and pelletizing with syrup of malic acid are patents mentioned. Amino trymethylene phosphonic acid has been reported to have high solubility in water and to achieve lower pH in the range 2.5 to 3.0 at low concentration—0.009 to 0.05 per cent only.

Flavors: Number of formulations using synthetic compounds to give enhanced or typical flavors are given for flavors like coumarin, citrus, straberry, grape etc.

Several synthetic flavor enhancers for grapes and strawberry flavors are reported.

In the other part, the aspects covered are: pulping agent (collagen) for juice like beverage, calcium insolubilised algin with calcium insensitive modifier, water soluble gum from Irish Moss, maple beverage and packaging

fruit drinks in polystyrene to retard oxidative browning, use of different types of containers, apparatus for autoclaving bottled soft drinks have been covered.

The compilation is very useful for all those engaged in the preparation of carbonated and other soft drinks. The patents are described in an easy manner. It would have been useful if mention had been made on which of the patents are now exploited by trade and which chemicals are now permitted by Food regulations.

C. P. NATARAJAN
C.F.T.R.I., MYSORE

FOOD HYGIENE IN CATERING ESTABLISHMENTS: LEGISLATION AND MODEL REGULATIONS: WHO, 1211 Geneva 27 Switzerland, 1977, $ 2.40/ Sw. Fr. 6/-., pp. 16.

This brochure on existing practice of Food Hygiene in catering Establishments and covering a reasonably representative cross section of food legislations of member states of W.H.O. and F.A.O. is a long overdue handbook. The treatment is comprehensive. From a survey of current legislation related to food hygiene in catering establishments, the authors have proceeded to model regulations which can be effectively used in introducing food legislations, in training food handlers and in promulgating house policies on sanitation by catering establishments. The presentation of this very significant material in concise and usable form is credit worthy.

The need for high standards of food hygiene and for adequate control measures to ensure its implementation in public catering houses cannot be overstressed. Here is a book that I confidently recommend to all teachers, training food handlers, students under training in foods and sanitation to all personnel involved in Food Services and those responsible for introducing and implementing legislation measures to ensure that food served to the public is safe, clean and wholesome.

MISS. THANGAM E. PHILIP
INSTITUTE OF HOTEL MANAGEMENT, CATERING TECHNOLOGY AND APPLIED NUTRITION, BOMBAY

ASSOCIATION NEWS

Southern Regional Branch, Madras

Lecture delivered by Dr. T. S. Santhanakrishnan on 17th March 1978, on Colour Additives in Food.

"Colours have been the sign and stimulus of the most furious passions that have rent the Nations"—said Ruskin. It is perhaps one of the first characteristics perceived by the senses and is indispensible to the modern day consumer as a means for the rapid identification and ultimate acceptance of food. Almost all foods, from raw agricultural commodities to finished products have an associated colour acceptable to the consumer on the basis of social, geographic, ethnic and historical backgrounds. Deviations from this norm often precipitates drastic consequences. Subtle changes in colour shades are often associated with poor and first-rate food items. For example, the colour of fresh orange juice is quite precise and manufacturers of orange soft drinks almost always attempt to match this colour. From ancient times, the colours of nature-vegetable or animal origin such as saffron, turmeric, chlorophyll or cochineal, annatto etc. have been used by man but only over the last century or so; non natural colours—one of the products of modern organic chemistry, have been added to the list of colourings used by the food industry. These are the synthetic dyes and pigments. The present talk will deal mostly on the synthetic colours, these have now become a "hot subject". These synthetic dyes are broadly termed as coal tar dyes and these became popular due to their easy availability in wider ranges and in greater brilliance. For convenience, we may devide these coal tar dyes into the following classes:

(*a*) A series of mono-di and tri-sulphonated colours whose basic naphthalene ring is azo-linked to either a second naphthalene ring or a benzene ring. e.g. Sunset Yellow FCF, Amaranth, Fast Red E, Carmoisine and Ponceau 4R.

(*b*) Azopyrazolene colours: The best example is Tartrazine, the yellow due.

(*c*) Triphenyl methane colours: Brilliant Blue FCF and Green S.

(*d*) Indigoid colours: Indigo Carmine.

(*e*) Xanthene colours: Erythrosine.

Thus we have for red colour, Ponceau 4R, Carmoisine, Fast Red E, Amaranth and Erythrosine, for yellow, Tartrazine and Sunset Yellow FCF, for blue, Indigo Carmine, Brilliant Blue FCF and for green, Green S, or Fast Green FCF.

Colour additives for food represent a unique and special category of food additives. These have historically been so considered in legislature and regulations. As early as 1900 some 80 dyes were being used in U.S.A. for colouring food. But by 1938 the Food Drug & Cosmetic Act was passed in U.S.A. by which the colours were certified, colour prefixes and numbers introduced and certification became mandatory. The colours were scrutinized for their toxicological effects and by 1938 about 15 colours were certified and permitted to be used in foods. In U.K. the permitted food colour list dwindled from 80 before 1955, to 30 in 1957, 25 by 1966 and 23 by 1973. These are further dwindling fast today. Thus we could see that even in such a developed society with a high literacy percentages as in U.S.A./U.K. the certification and listing of permitted food colours became necessary. FAO/WHO Expert Committee at Rome took up these problems and these food colours attracted the attention of the leading physiologist, toxicologist and other food scientists and this were hence put under rigorous tests. Generally the toxicological studies were carried out on laboratory animals especially rats and they studied their toxicity, short term toxicity and long term toxicity. On this basis WHO classified food colours under six categories viz., Category A, Category, B. Category C_1, Category C_2, Category C_3, and Category D.

In our country, under the Prevention of Food Adulteration Act 1954 at first, 8 food colours viz. Ponceau 4R, Carmoisine, Fast Red E, Amaranth, Erythrosine, Tartrazine, Sunset Yellow FCF and Indigo Carmine were permitted and another three viz. Brilliant Blue FCF, Green S and Fast Green FCF have now been added. I.S.I. then prepared 24 standards for these permitted food colours, 11 for (coaltar) food colours, 10 for natural colours and 3 for testing, common names and food colour boxes. These are mainly based on FAO/WHO findings.

Although these are documented in PFA and ISI still the indiscriminate use of non-permitted colours like Matenil Yellow, Blue VRS etc. and other cheap textile dyes came to light and a survey by toxicological research centre at Lucknow showed that 70 per cent of the food items tested were found to be coured with Matenil Yellow colour which causes damage to the liver and kidney on prolonged use and also cancer. These compelled the Government of India to bring in compulsory certification of "food colours", "Coal tar food colour preparations and mixtures".

The Compulsory certification came to effect from

21.2.1975. As per the amended PF.A. Rules, the "coal dyes and their preparations or mixtures permitted for use in certain foods shall be sold only under I.SI. Certification Mark"—perhaps the first instance a food item has come under both I.S.I. Certification as well as under Government of India Food Laws (P.F.A. Rules).

"Coal tar food colour preparations" are mixtures of permitted food colours with or without permitted diluents and are available in powder and liquid forms. In the case of coal tar food colour prepartions, FAO/WHO have not prepared any standards and as such I.S.I. Technical Comittee prepared a specification and this includes the determination of the total dye content, water insoluble matter, Arsenic and lead. As per this specification, a limit of 1 per cent has been prescribed for water insoluble matter, 3 ppm for Arsenic and 10 ppm for lead. The analysis for the determination of total dye content of these coal tar food colour preparations is yet another challenge and although I.S.I. at first permitted a tolerence of ± 15 per cent for both powder and liquid coal tar food colour preprations, this tolerance was required as the standardization of the methods for these analyses posed many practical problems for the chemists. Further the non-availability of standard food colour boxes for standardization purposes enhanced the gravity of the analytical problems. After a year or so the tolerance limit was brought down to ± 7.5 per cent for powder preprations and + 15 per cent to 10 per cent for liquid preparations. The situation as it stands today is not that gloomy as it was in the beginning and the analytical problems appear to be under control as seen by the fact that I.S.I. have not pulled many of I.S.I. Licensees. Still the Food Colour Boxes—a "must" for standardization purposes, have not seen the light of the day.

In spite of all these regulations, still instances have come to our notice that Matenil Yellow is being sold as Kesari powder etc. Perhaps the Government machinery has still to be tightened up and the public must suitably be enlightened—a lacuna that still exists and needs rectification.

Next, let us see what our P.F.A. Act says on the use of colour additives in food. In India, in the P.F.A. Act, Rule 26 clearly specifies the natural colouring matter that may be used in Food and Rule 28 specifies the coal tar dyes (mentioned earlier) which may be used in food. Further rule 29 gives a list of food items wherein coal tar dyes are permitted to be used. Again rule 30 prescribes a maximum limit of permitted colurs. It says "the maximum limit of any permitted coal tar colours or mixtures of permitted coal tar colours which may be added to any food (as enumerated in rule 29) shall not exceed 0.2 gram per kilogram of the final food or beverage for consumption. Thus the amount of the colour additives that is being consumed by man at a time is infinitestimally small. This, I am stressing now as today there is a heated debate going on in India as well as abroad on the subject of "Consumer concern about the effects of these syntetic food colours on their health"—a controversial but important subject.

Thus by a comparison with most other food additives these synthetic colours have been extensively tested and when viewed in perspective, any conceivable impact of the great majority of food colours on consumer health is likely to be small in comparison with that often associated with various food contaminants or even with natural constituents for which the margin of safety is uncomfortably low.

As mentioned earlier under Rule 26 in the P.F.A. Act the following natural colouring matters (isolated from natural colours or produced synthetically) are permitted to be used in or upon any article of food:

> Beta-carotene, Beta-apo-8'-carotenal, Methylester of Beta-apo-8'- carotenoic acid, Ethylester of Beta-apo-8'-carotenoic acid, Canthaxanthin, Chlorophyll, Riboflavin (Lactoflavin), Caramel, Annatto, Ratanjot, Saffron and Curcumin (or Turmeric).

Today, only Caramel is being systematically used as a colouring and flavour additive and regarding the rest, it is too early to say how far these will eventually go as a good substitute for the synthetic colours as these are known to be pH sensitive and as Dr. Counsell of Roche Products Ltd. U.K. mentioned in one of his papers "the real problem lies in finding adequate supplies and a considerable work load of finding which one to use and how to use it".

Thus good stability to a wide range of processing availability in bulk quantities with high purity, high tinctorial values enabling them to be used at levels of usually not more than 100 ppm and the wide range of shades available with their use are some of the distinct advantages in the use of synthetic food colours over natural colours.

As a new development in this field, the "non-absorbable polymeric food colours", from Dynapol, California, U.S.A. may be cited here. The rational underlying the development stems from the hitherto conceptual basis that functional ingredients which are absorbed intact or metabolised may interact with target organs and tissues and can constitute a potential toxic risk. This toxic risk to man can be considerably reduced if ingredients such as food dyes were rendered non-absorbable and restricted to transient passage from the gastrointestinal tract with elimination via feces[1]. Dynapol have prepared a series of non-absor-

bable polymeric dyes and these are undergoing long term safety tests and they are very hopeful to market these in U.S.A. with F.D.A., FAO/WHO blessings.

In conclusion, eating should be enjoyable and not an anxiety provoking activity and as Mark Twin said "Part of success in life is to eat what you like and let the foods fight it out inside".

Eastern Zone

Mr. P. Chakraborti, Jadavpur University, Calcutta, delivered a lecture on "Legume based imitation and blended milk products", on 21st February 1978.

Dr. T. S. Banerjee of Central Food Laboratory, Calcutta, delivered a talk on "Certain aspects of food dyes", on 18th March 1978.

Dr. Dipak Das of the State University of New York, U.S.A., gave a talk on "Bio-engineering aspects of transport of nucleoside in lung" on 31st March 1978.

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Ordinary members:

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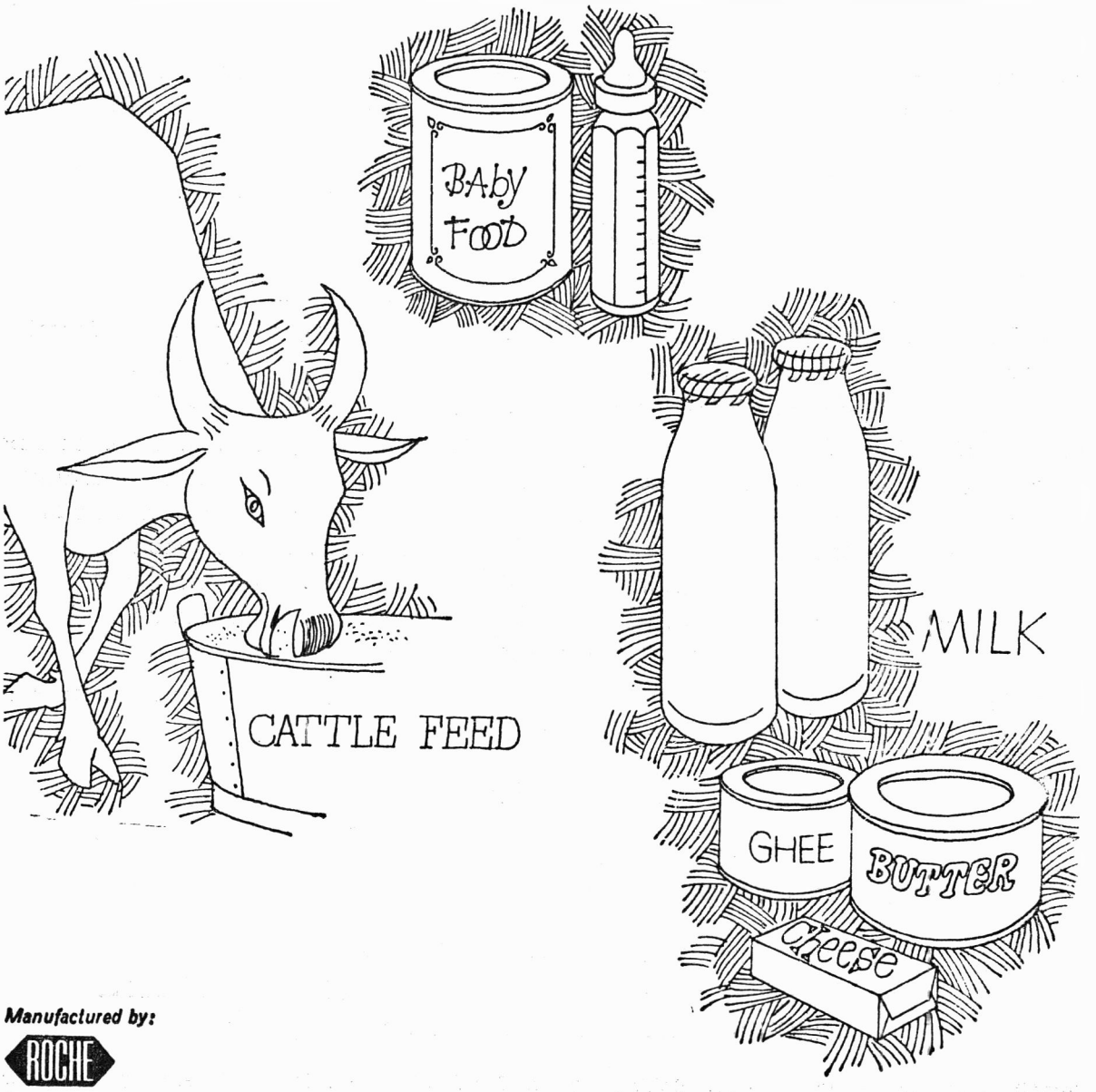

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2. Short communications in the nature of Research Notes should clearly indicate the scope of the investigation and the salient features of the results.

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   (*f*) *Unpublished Work:* Rao, G., unpublished, Central Food Technological Research Institute, Mysore, India.

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