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(INDIA)

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CONTENTS

Research Papers

Research Notes

Effect of Additives on the Rheological and Baking Characteristics of Different Extraction Rate Wheat Flours*

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Received 21 *March* 1985; *revised* 25 *July* 1985

Effect of ascorbic acid with and without sodium stearoyl-2-lactylate on rheological and baking characteristics of 70, 75, 80, 85% extraction rate flours from wheat varieties 'WG 357', 'WL 711', 'Jubilar' and 'DNS' was studied. The additives improved to varying extent the maturograph characteristics viz., final proof time, dough elasticity and dough level when tried with different extraction rate flours. Oven rise recorder also showed increase in dough volume, baking volume, oven rise and calculated loaf volume of flours treated with additives. Increase in bread volume, specific volume and overall quality score was observed by the use of additives in different flours. 'Jubilar' and 'DNS' wheat varieties showed good response to the additives; followed by 'WL 711', while 'WG 357' responded poorly. Use of additives showed remarkable improvement in crumb softness of bread made from flours of different extraction rates.

Generally the dough characteristics improve with the addition of oxidants and surfactants. The oxidising agents according to Bloksma[1, 2] affect the rheological properties of dough by interchange reactions of sulphydryl and disulphide groups present in the protein network. Though ascorbic acid is a reducing agent, it exerts the effect of an oxidising agent on the dough properties[3]. The mechanism involves the oxidation-reduction of ascorbic acid by enzymes ascorbic acid oxidase and dehydro ascorbic acid reductase respectively[4-9].

Surfactants are widely used in bread-making for dough strengthening. Sodium stearoyl-2-lactylate complexes with starch and proteins to form a huge aggregate, and increases the dough stability[10-12]. Shogren *et al.*[13] showed that addition of surfactant to the blend of wheat flour, wheat bran and vital gluten substantially improved the loaf volume.

The consumption of bakery products is on the increase in India and the wheat flour requirement by the baking industry is also estimated to increase three-fold by the end of this decade[14].

With the above background, studies carried out using flours of different extraction rates for the assessment of the rheological and bread-making characteristics as affected by the additives are presented in this paper.

Materials and Methods

Flours of extraction rates of 70, 75, 80 and 85 per cent milled[15] from medium strong- 'WG 357', 'WL 711', (India), medium strong- 'Jubilar (West Germany) and strong-'DNS' (USA) quality wheat varieties were used in the studies. The quality characteristics of these flours have already been reported[16].

The effect of additives used at the levels of 20, 40, 60 and 80 ppm ascorbic acid with or without 0.5 per cent sodium stearoyl-2-lactylate (SSL) on the bread-making quality of 70, 75, 80 and 85 per cent extraction rate flours respectively was evaluated. Increasing the level of ascorbic acid with the increase in extraction rate of flour was arrived at on the basis of preliminary studies.

Brabender maturograph: The final proof characteristics of a fermenting dough were studied in a maturograph according to the procedure described in the Instruction Manual[17].

Brabender oven-rise recorder: This instrument was used in combination with maturograph. The baking quality of dough ball was determined according to the procedure described in the Instruction Manual of oven rise recorder[18].

Bread making quality: Breads were prepared according to the Kasten method described in Standard

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Methoden fuer Getreide, Mehl und Brot[19] (Methods for Cereals, Flour and Bread).

Bread evaluation: Bread volume was determined using rapeseed displacement method of Mallock and Cook[20].

Evaluation of breads was carried out after 24 hr by a panel of six judges. The score for the overall quality of bread was calculated[19].

Softness of bread crumb was determined using a penetrometer (SUR-Sommer und Runge KG, Berlin). The penetrometer values were obtained as an average of 10 values expressed in terms of 0.10 mm units, from 100 g bread crumb of 5 cm thickness, using a hemispherical stamp weighing 123 g, with a penetration time of 5 sec.

Statistical analysis: Duncan new multiple range test at 5 per cent level was used for finding out the results of test of significance[21].

Results and Discussion

Brabender maturograph: Seibel[22] reported the use of maturograph for determining the properties of fermenting doughs primarily under the conditions of final proof. Among the wheat samples studied, the minimum and maximum improvement by ascorbic acid for different extraction rate flours ranged between 2-4 and 8-16 min in final proof time, 10-40 and 40-110 BU in elasticity of dough and 65-140 and 130-365 BU in dough level (Table 1). Improvement due to ascorbic acid in combination with SSL ranged between 4 and 10 and 8 and 20 min in final proof time, 5-55 and 50-110 BU/elasticity of dough and 35-210 and 270-430 BU in dough level. However, the effect of additives on proving stability was irregular (Table 1). The flours of 'Jubilar' showed more improvement in dough level as compared to the flours of other wheats. Flours of 'DNS' had the highest dough level values with or without additives (Fig 1).

It can be concluded that the final proof characteristics of the doughs affected adversely with increase in the extraction rate of flour improved to varying extents with the use of ascorbic acid with or without SSL.

Brabender oven-rise recorder: Among the wheats, the minimum and maximum range of improvement due to ascorbic acid treatment of different extraction rate flours were 20-55 and 155-240 ml in baking volume, 25-100 and 50-155 ml in oven-rise (Table 2) and 15-40 and 112-170 ml in calculated loaf volume (Fig 2). Ascorbic

TABLE 1. EFFECT OF ADDITIVES ON THE MATUROGRAPH CHARACTERISTICS OF DIFFERENT EXTRACTION RATE WHEAT* FLOURS

Ascorbic acid	Final proof (min)				Proving stability (min)				Dough elasticity (BU)			
(ppm)	1	2	3	4	1	2	3	4	1	2	3	4
70% Extraction												
—	44	50	28	40	6	10	2	2	210	200	200	275
20	48	50	42	46	4	8	8	6	250	240	245	285
20+	52	48	36	50	4	8	2	10	275	205	250	260
75% Extraction												
—	50	38	28	41	8	4	6	4	210	200	170	275
40	52	48	44	52	4	8	6	12	255	240	245	290
40+	54	54	44	48	4	10	6	8	220	225	270	265
80% Extraction												
—	46	36	28	42	6	6	6	8	210	195	170	260
60	48	50	38	44	4	6	4	8	260	215	280	280
60+	52	52	40	46	4	12	4	6	250	210	280	320
85% Extraction												
—	40	30	22	36	2	10	6	8	210	155	160	255
80	44	32	30	40	4	4	4	6	230	210	200	295
80+	52	40	42	46	8	4	10	6	215	210	240	295

*Varieties: 1—'WG 357'; 2—'WL 711'; 3—'Jubilar' and 4—'DNS'

+Contains 0.5% sodium stearoyl-2-lactylate also.

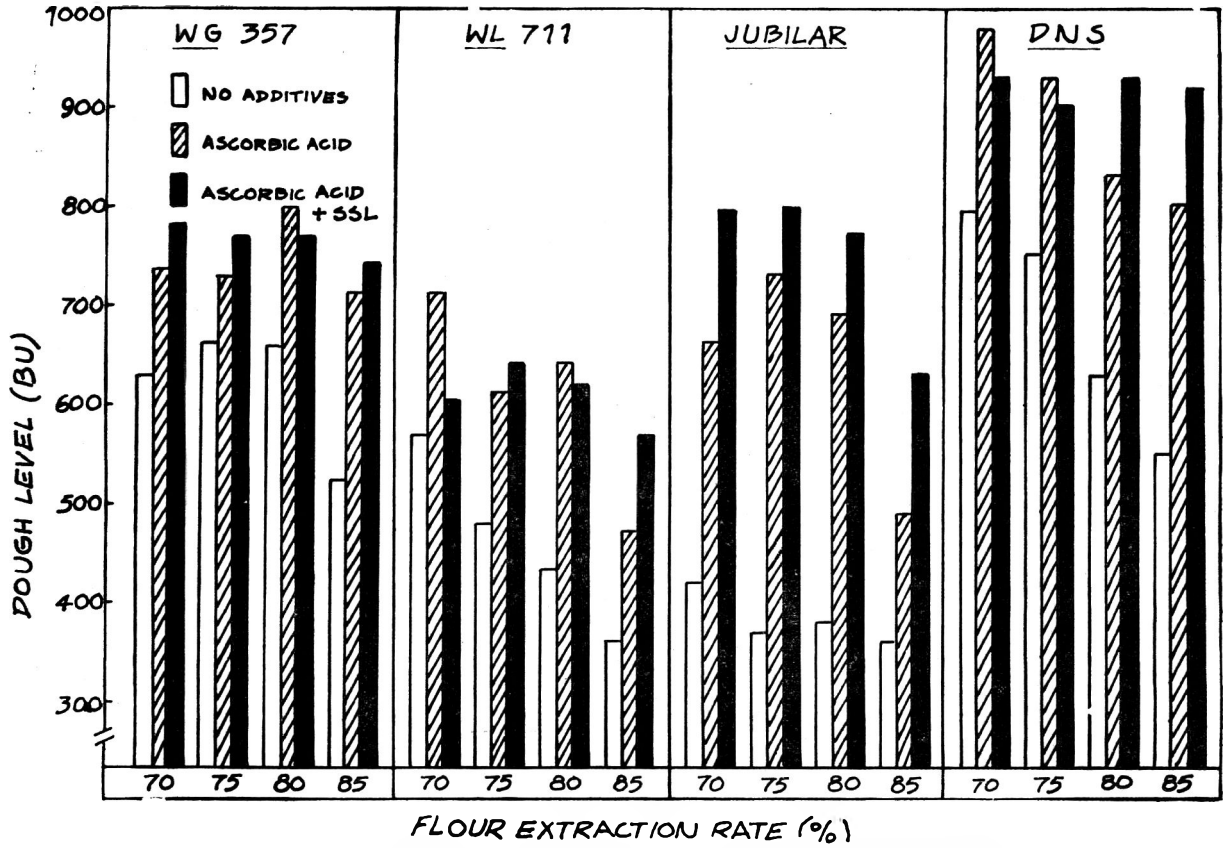

Fig 1. Effect of extraction rate and additives on the maturograph dough level

TABLE 2. EFFECT OF ADDITIVES ON THE OVEN-RISE RECORDER CHARACTERISTICS OF DIFFERENT EXTRACTION RATE WHEAT* FLOURS

Ascorbic acid (ppm)	Dough volume (ml)				Baking volume (ml)				Oven rise (ml)			
	1	2	3	4	1	2	3	4	1	2	3	4
					70% Extraction							
—	400	380	280	430	600	580	480	830	200	200	200	400
20	420	400	410	430	655	580	660	840	235	180	250	410
20+	440	390	370	420	750	660	760	900	310	270	290	480
					75% Extraction							
—	440	350	300	430	590	590	400	730	140	240	100	350
40	440	405	440	450	610	585	610	900	170	180	170	450
40+	480	440	470	440	680	630	750	910	200	190	280	470
					80% Extraction							
—	370	300	295	420	600	595	430	770	230	295	135	350
60	385	380	380	500	640	660	670	920	255	280	290	420
60+	470	430	400	490	760	720	770	920	290	290	370	430
					85% Extraction							
—	365	225	265	400	525	325	375	600	100	100	110	200
80	380	280	350	450	580	370	530	760	200	90	180	310
80+	460	360	500	520	730	570	550	850	270	210	50	330

*Varieties: 1—'WG 357'; 2—WL 711'; 3—'Jubilar' and 4—'DNS'

+Contains 0.5% sodium stearoly-2-lactyate also.

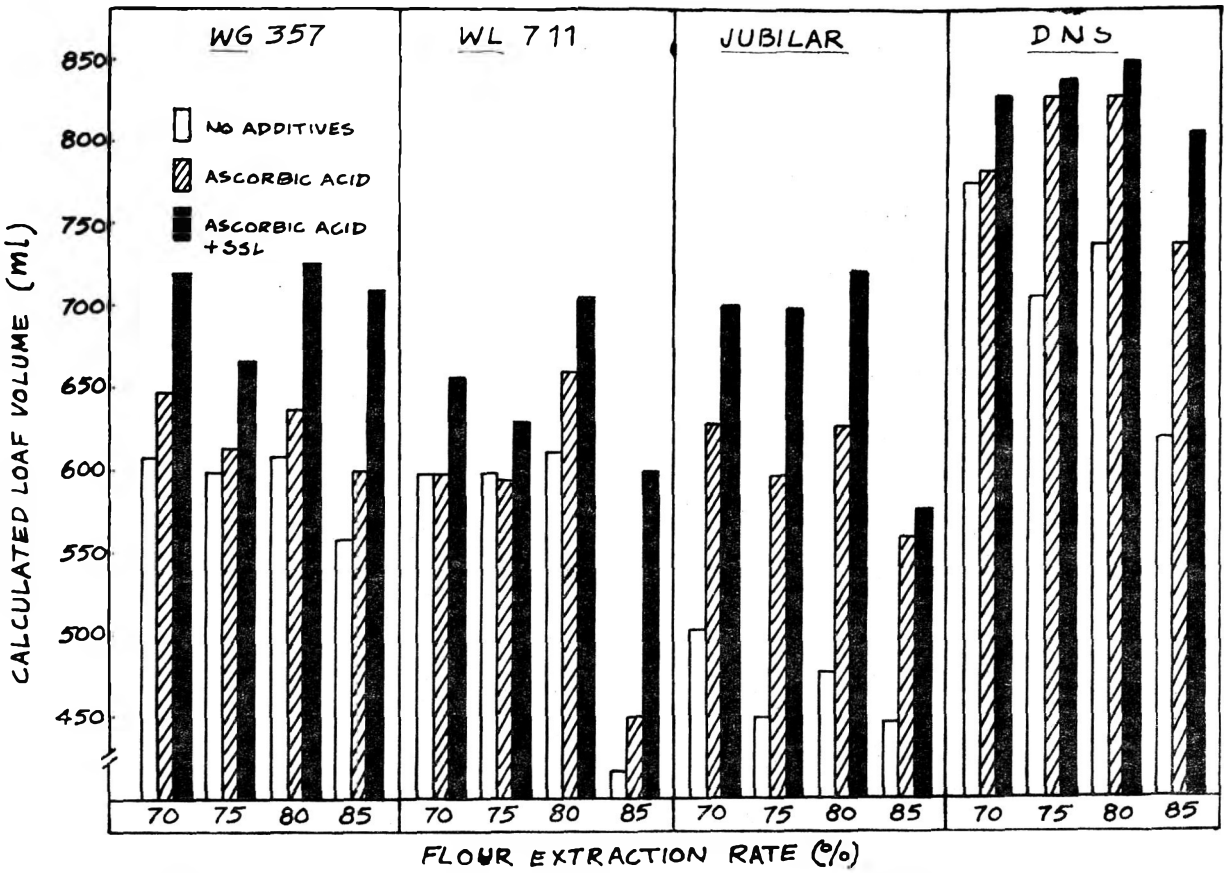

Fig 2. Effect of extraction rate and additives on the oven-rise recorder calculated loaf volume

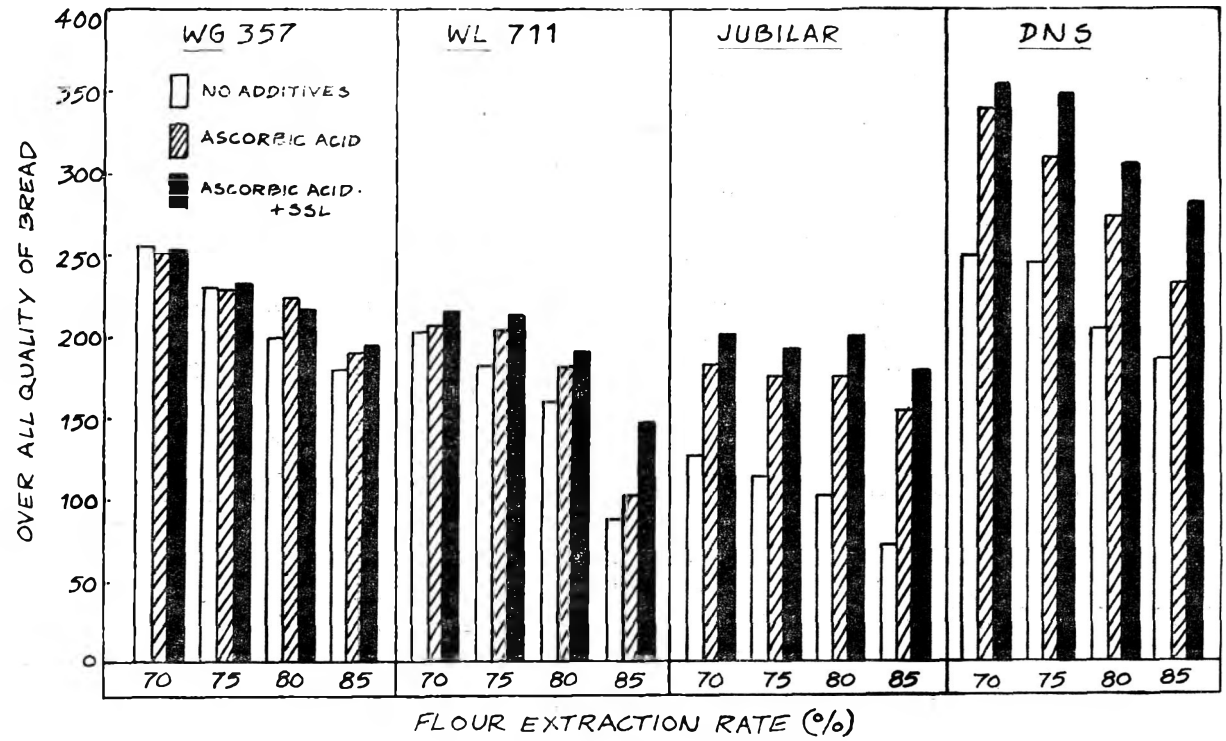

Fig 3. Effect of extraction rate and additives on the overall quality of bread

TABLE 3. EFFECT OF ADDITIVES ON THE BREAD QUALITY OF DIFFERENT EXTRACTION RATE WHEAT* FLOURS

Ascorbic acid	Loaf volume** (ml)					Specific volume** (ml/g)				
(ppm)	1	2	3	4	Mean@	1	2	3	4	Mean@
					70% Extraction					
—	704	644	536	740	656.0^{x}	4.95	4.47	3.73	5.10	4.56^{x}
20	720	670	622	852	716.0^{y}	5.03	4.68	4.33	6.04	5.02^{y}
20+	728	688	668	860	736.0^{y}	5.05	4.74	4.68	6.11	5.14^{y}
SEm					±14.99					±0.13
					75% Extraction					
—	692	620	500	730	635.5^{x}	4.88	4.23	3.43	5.06	4.40^{x}
40	692	662	602	820	694.0^{y}	4.82	4.62	4.17	5.87	4.87^{xy}
40+	706	672	648	850	719.0^{y}	4.92	4.63	4.64	6.02	5.05^{y}
SEm					±16.12					±0.14
					80% Extraction					
—	632	566	466	678	585.5^{x}	4.39	3.82	3.26	4.59	4.02^{x}
60	678	606	596	798	669.5^{y}	4.66	4.11	4.19	5.53	4.62^{y}
60+	680	646	666	862	713.5^{y}	4.67	4.35	4.80	6.12	4.98^{y}
SEm					±19.25					±0.17
					85% Extraction					
—	600	420	424	640	521.0^{x}	4.14	2.75	2.86	4.28	3.51^{x}
80	638	456	542	702	584.5^{y}	4.37	3.18	3.70	4.76	4.00^{y}
80+	650	544	624	804	655.5^{z}	4.46	3.83	4.32	5.46	4.52^{z}
SEm					±17.34					±0.13

*Varieties: 1—'WG 357'; 2—'WL 711'; 3—'Jubilar' and 4—'DNS'

**Values expressed on 100 g flour basis.

+Contains 0.5% sodium stearoyl-2-lactylate also.

@Means of the same column followed by different super scripts differ significantly ($P<0.05$)

acid along with SSL improved these values in the range of 40-245 and 175-350 ml in baking volume, 70-110 and 90-235 ml in oven-rise (Table 2) and 67-151 and 129-248 ml in calculated loaf volume (Fig 2). From Fig 2 it is evident that the performance of 'DNS' flours with or without additives was remarkably better than those of the flours from other wheats.

The results indicated that ascorbic acid alone and in combination with SSL improved to varying extents, the oven-rise recorder characteristics of the different extraction rate flours.

Bread making quality: The decreases in bread volumes based on 100 g flours for 'WG 357', WL 711', 'Jubilar' and 'DNS' with increase in extraction rate of flour from 70 to 85 per cent were 104, 224, 112 and 100 ml, respectively (Table 3). Ascorbic acid alone reduced the difference in baking volume to 82, 214 and 80 ml for 'WG 357', 'WL 711', and 'Jubilar', respectively while increasing the difference to 150 ml in 'DNS' due to the higher improvement in the loaf volume of 70 per cent extraction flour. However, ascorbic acid along with SSL reduced the decrease in loaf volume to 78, 144, 44 and 56 ml in 'WG 357', 'WL 711', 'Jubilar' and 'DNS' respectively.

Improvement in specific volume due to ascorbic acid treatment was in the range of 0.08 to 0.27, 0.21 to 0.43, 0.60 to 0.93 and 0.48 to 0.94 ml/g for 'WG 357', 'WL 711', 'Jubilar' and 'DNS' respectively. While ascorbic acid and SSL increased the same in the above varieties by 0.04 to 0.32, 0.27 to 1.08, 0.95 to 1.54 and 0.96 to 1.53 ml/g respectively (Table 3). The beneficial effect of ascorbic acid and SSL in improving loaf volume and specific volume was significant (Table 3).

As extraction rate of flours increased from 70 to 85 per cent the decrease in overall quality scores of breads for 'WG 357', 'WL 711', 'Jubilar' and 'DNS' were 76,

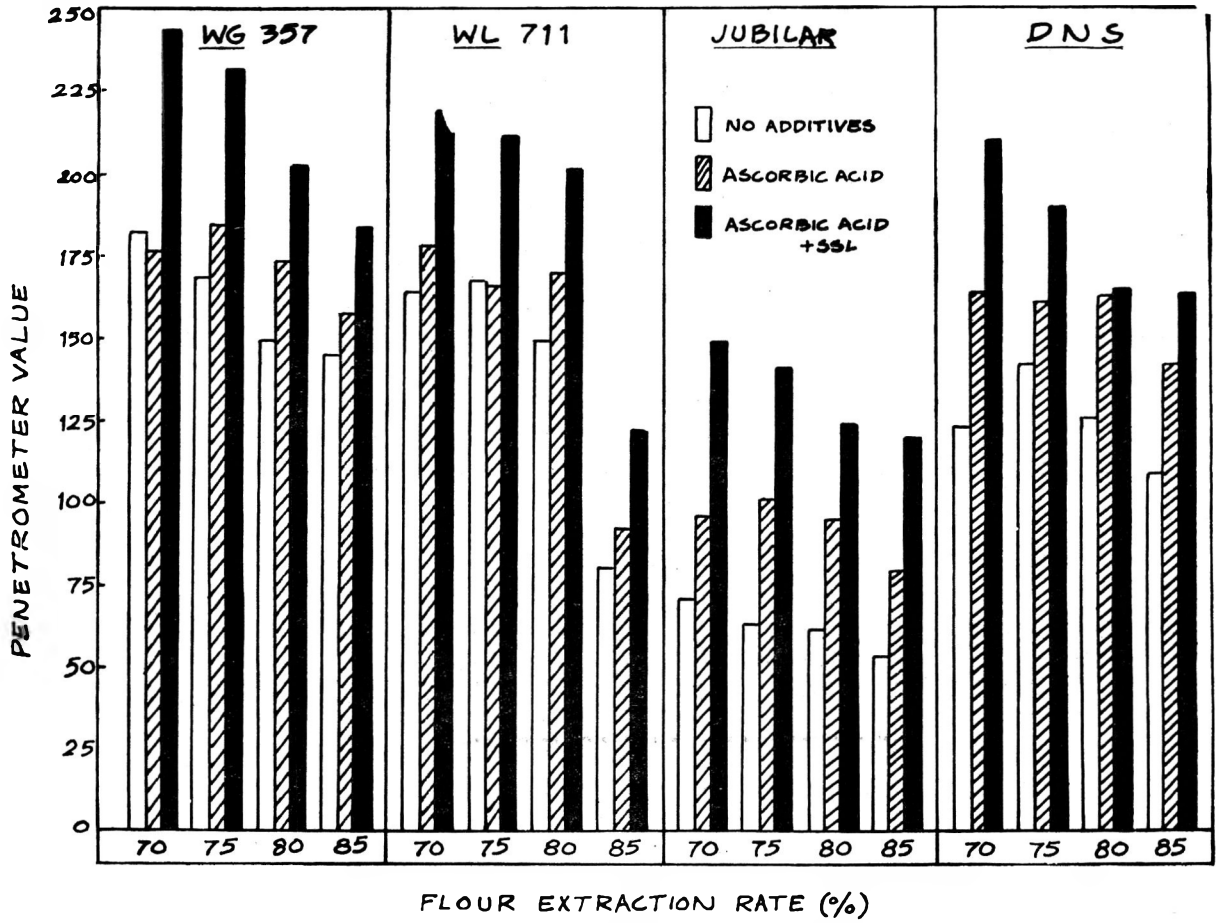

Fig 4. Effect of extraction rate and additives on the penetrometer crumb texture

115, 55 and 64, respectively. These decreases in scores in the above varieties changed to 61, 105, 29 and 107 respectively when both ascorbic acid and SSL were added (Fig 3). Additives improved the bread crumb softness in the four wheat varieties (Fig 4). Increase in the penetrometer values in the range of 12 to 38 due to ascorbic acid and further from 38 to 78 due to ascorbic acid and SSL indicated the improvement in the bread crumb softness of these varieties.

It is evident from the above results that though extraction rates of wheat flour generally adversely alter the original baking qualities, it could be observed that the baking performance and associated qualities of flours could be improved by the addition of ascorbic acid preferably along with sodium stearoyl-2-lactylate.

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Physico-chemical, Milling and Bread Making Quality of Wheats of Uttar Pradesh

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Thirteen varieties of aestivum wheats of Uttar Pradesh were evaluated for their physico-chemical, milling and bread making characteristics. The range of values for physical characteristics was: hectoliter weight 73.1-80.0 kg, 1000 kernel weight 40.3-53.2 g and grain hardness (as crushing resistance) 8.63-12.65 kg/grain. The varieties contained (in per cent) protein (N×5.7) 8.82-15.85, fat 1.53-2.15, ash 1.44-2.05, crude fibre 2.40-4.11 and total carbohydrates (by difference) 80.14-87.93. The values (%) for various physico-chemical parameters of white flour were: flour yield 55.48-72.56. wet gluten 12.77-44.06, ash 0.39-0.78, crude fibre 0.27-0.97, sedimentation value 17-35.3 ml, damaged starch 2.8-5.7%, diastatic activity 171-388 units and Pelshenke value 82-133 min. Specific volume of breads prepared from 100 g of white flour of different varieties ranged from 2.93 to 3.75 cc/g. Variety 'VL-421' showed excellent bread making characteristics.

Recently a good number of wheat varieties have been developed by plant breeders in the country to boost the food grain production further[1]. These varieties are grown in different agro-climatic conditions of the country and some of them have been especially developed for specific regions.

A large number of wheat varieties are being grown in the state of Uttar Pradesh (U.P.). Sufficient information is not available on milling and baking characteristics of these varieties. The present investigation was, therefore, undertaken to evaluate some of the aestivum wheat varieties of U.P. for their physico-chemical, milling and bread making characteristics.

Materials and Methods

Test materials: Thirteen wheat varieties of U.P. namely 'C-306', 'CPAN-1676', 'HD-2204', 'HD-2281', 'HD-2285', 'HS-86', 'Malviya-12', 'Sonalika', 'UP-115', 'UP-262', 'UP-368', 'UP-2003' and 'VL-421' grown at Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar during the rabi season of 1982-83 were used for the study.

Research paper No. 3776 through the Experiment Station, G. B. Pant University of Agriculture and Technology, Pantnagar, Nainital U.P. India.

Physical characteristics: Hectoliter weight and 1000 kernel weight of different wheat varieties was determined according to AACC procedures[2]. Hardness of twenty selected sound kernels of different varieties was determined using a hardness tester (Kiva Seisakusho, Japan) and was recorded as crushing resistance in kg/grain.

Milling quality: For assessing the milling quality, 2 kg sample of each variety was conditioned to 14.5 per cent moisture for 48 hr at room temperature (20-27°C) and milled in a Buhler laboratory mill (Model MLU-202). For calculating the yield of acceptable grade white flour (*maida*), the portion of shorts passing through 10xx sieve was also included. The whiteness of such white flour samples was recorded in a Kent-Jones and Martin flour colour grader.

Chemical characteristics: Moisture, fat, ash, crude fibre, wet gluten, pigments, sedimentation value, diastatic activity and damaged starch in whole wheat flour and/or white flour were determined by AACC procedures[2]. The crude protein (N×5.7) was estimated by micro-Kjeldahl method. Pelshenke value was determined by the procedure of Welsh and Normann[3].

Bread making quality: Bread making quality of different samples was evaluated by standard procedure[4] using 100 g of white flour. After determining the loaf volume[5] and weight, the breads were evaluated organoleptically by a panel of 20 persons. The overall quality of bread was judged by the total score[6] out of 100 which comprised crumb texture 30, crumb colour 20, crust colour and texture 20 and flavour 30.

Results and Discussion

Physical characteristics: The physical characteristics of different varieties of wheat are presented in Table 1. The hectoliter weight of different varieties ranged from 73.1 to 80.0 kg, variety 'C-306' having the highest and 'HD-2281' the lowest. Thousand kernel weight of different varieties varied from 40.3 to 53.2 g. 'CPAN-1676', 'Sonalika' and 'VL-421' exhibited 1000 kernel weight of less than 45 g indicating their comparatively smaller grain size. Only 'HD-2285', 'HS-86', and 'UP-262' had 1000 kernel weight of 50 g or more. Most of the varieties had kernel hardness of more than 10 kg/grain. 'VL-421' exhibited significantly higher crushing resistance than others.

Milling quality: The milling characteristics and colour grade value of flour samples are given in Table 1. Flour (*maida*) yield of only three varieties namely 'HD-2281', 'Malviya-12' and 'UP-2003' was comparable to values of 70-72 per cent generally obtained for hard wheats. Most of the varieties had flour yield of more than 65 per cent. 'C-306' exhibited relatively poor yield of flour upon milling. No correlation was observed between hectoliter weight and flour yield while a

TABLE 1. PHYSICAL CHARACTERISTICS AND MILLING QUALITY OF SOME UTTAR PRADESH WHEATS

Variety	Hectoliter wt (kg)	1000 kernel wt (g)	Crushing resistance (kg/grain)	White flour yield (%)	Shorts (%)	Kent Jones colour grade value
'C-306'	80.0	49.7	8.63	55.48	23.95	2.79
'CPAN-1676'	76.4	43.2	9.75	66.20	18.96	3.45
'HD-2204'	77.2	48.6	10.06	67.02	13.40	1.35
'HD-2281'	73.1	49.3	9.96	69.52	13.18	3.48
'HD-2285'	78.1	53.2	10.50	66.90	13.14	2.10
'HS-86'	74.6	50.0	11.15	66.40	13.34	1.52
'Malviya-12'	74.0	48.2	10.70	72.56	10.56	4.44
'Sonalika'	77.3	42.7	9.80	65.38	13.31	2.56
'UP-115'	75.6	46.7	10.60	65.74	15.49	3.23
'UP-262'	77.0	52.0	12.00	63.90	16.77	3.33
'UP-368'	76.4	48.2	9.98	68.41	13.31	7.17
'UP-2003'	73.7	46.8	10.11	69.65	11.96	2.56
'VL-421'	75.7	40.3	12.56	64.70	17.96	3.45
Mean	76.1	47.6	10.45	66.26	15.02	3.18
SE	±0.19	±0.20	±0.13	±0.24	±0.23	±0.08
CD at 5%	0.57	0.59	0.39	0.71	0.67	0.24

low positive correlation (r=0.02) was observed between 1000 kernel weight and flour yield. The yield of shorts from varieties 'C-306', 'CPAN-1676', 'UP-262' and 'VL-421' was somewhat higher than the normal value of about 16 per cent. Except 'UP-368', the Kent Jones colour grade value denoting the whiteness of flour was less than 5 which is considered to be satisfactory[7]. A positive correlation (r=0.31) between flour yield and colour grade value was seen among different varieties.

Chemical characteristics: The composition of whole wheat flour of different varieties is given in Table 2. 'UP-262' and 'VL-421' had more than 14 per cent protein. The ash content of varieties ranged from 1.44 to 2.05 per cent. Only 'VL-421' contained more than 2 per cent ash. However, the white flour of all varieties obtained from Buhler mill contained less than 0.6 per cent ash (Table 3). The crude fibre in whole wheat flour was relatively higher in 'HD-2204', 'HD-2285' and 'UP-368' than others.

The data on chemical characteristics of white flour (*maida*) are presented in Table 3. Wet gluten content in different varieties ranged from 12.77 to 44.06 per cent. The poor quality of 'C-306' was indicated by its low protein content (Table 2). 'VL-421' had highest protein as well as wet gluten contents. The crude fibre was less than 1 per cent in all the samples. The pigment content expressed as β-carotene in different varieties

TABLE 2. PROXIMATE COMPOSITION OF SOME UTTAR PRADESH WHEATS[1]

Variety	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrates[2] (%)
'C-306'	8.82	1.62	1.63	2.58	87.93
'CPAN-1676'	11.52	1.53	1.67	3.32	85.28
'HD-2204'	12.27	1.65	1.55	4.11	84.53
'HD-2281'	12.05	1.62	1.56	2.67	84.77
'HD-2285'	12.51	1.66	1.66	4.09	84.17
'HS-86'	13.32	1.73	1.61	3.13	83.34
'Malviya-12'	13.24	1.56	1.44	2.81	83.76
'Sonalika'	11.99	2.07	1.63	2.82	84.31
'UP-115'	13.00	1.72	1.80	3.12	83.48
'UP-262'	14.37	2.15	1.67	2.40	81.81
'UP-368'	12.37	1.90	1.68	4.10	84.05
'UP-2003'	12.69	1.89	1.91	3.44	83.55
'VL-421'	13.85	1.96	2.05	3.66	80.14
Mean	12.61	1.77	1.68	3.25	83.85
SE	±0.18	±0.05	±0.04	±0.05	±0.42
CD at 5%	0.52	0.15	0.12	0.14	1.23

[1]Values expressed on dry weight basis
[2]Calculated by difference.

TABLE 3. CHEMICAL CHARACTERISTICS OF WHITE FLOUR OF UTTAR PRADESH WHEATS

Variety	Wet gluten* (%)	Ash** (%)	Crude fibre** (%)	Pigments as β-carotene** (ppm)	Sedimentation value (ml)	Diastatic activity*‡	Damaged starch* (%)	Pelshenke value* (min)
'C-306'	12.77	0.59	0.87	2.49	17.0	201	4.5	82
'CPAN-1676'	33.84	0.39	0.49	2.08	29.4	214	5.2	104
'HD-2204'	29.08	0.68	0.45	1.01	20.7	191	3.6	89
'HD-2281'	31.32	0.49	0.55	1.26	28.5	270	2.8	92
'HD-2285'	30.29	0.64	0.41	1.51	24.0	177	3.2	94
'HS-86'	35.08	0.66	0.81	0.46	34.1	273	5.1	118
'Malviya-12'	35.51	0.44	0.85	1.08	27.5	372	5.7	105
'Sonalika'	27.14	0.66	0.87	1.43	19.8	171	5.3	86
'UP-115'	40.72	0.48	0.95	1.38	34.6	158	3.5	125
'UP-262'	39.23	0.70	0.97	1.62	34.6	354	4.3	127
'UP-368'	38.40	0.45	0.76	1.49	28.7	332	3.4	119
'UP-2003'	32.18	0.58	0.27	3.39	33.0	207	3.3	111
'VL-421'	44.06	0.78	0.86	1.42	35.3	388	3.9	133
Mean	33.05	0.58	0.70	1.58	28.2	254	4.13	106
SE	±0.28	±0.02	±0.02	±0.03	±0.19	±2.70	±0.08	±2.28
CD at 5%	0.82	0.05	0.05	0.08	0.55	7.90	0.23	6.67

*On 14% moisture basis, **On dry weight basis, ‡Values expressed as mg maltose per 10g flour.

ranged from 0.46 to 3.40 ppm which was similar to that reported for aestivum wheats[7] but lower than durum wheats[8].

The sedimentation value of different varieties ranged from 17 to 35.3 ml. With the exception of 'C-306', 'HD-2204', 'HD-2285' and 'Sonalika', all varieties had sedimentation value of more than 25 ml. 'VL-421' exhibited maximum sedimentation value indicating its superiority over other varieties for bread making. Only four varieties had diastatic activity in the desirable range of 225-350 units. 'UP-262' and 'VL-421' exhibited higher value of diastatic activity and therefore these can be used for blending with other aestivum wheats. 'HD-2204', 'HD-2285', 'Sonalika' and 'UP-115' had relatively poor diastatic activity. All varieties had normal damaged starch content of less than 9 per cent.

The Pelshenke value observed for different varieties in the present study is in conformity with earlier reports[9-11]. On account of its highest protein content and sedimentation value, 'VL-421' exhibited maximum Pelshenke value.

Bread quality: Breads prepared from flour of various varieties differed in their loaf volume and weight. The specific volume of varieties ranged from 2.93 to 3.75 cc/g with an average of 3.29 cc/g. 'VL-421' exhibited the highest (3.75 cc/g) while 'C-306' showed the lowest (2.93 cc/g) specific volume. All other varieties exhibited specific volume between 3.20 and 3.45 cc/g. Highest specific volume of 'VL-421 appeared on account of its highest gluten content, sedimentation value and Pelshenke value.

Organoleptic characteristics of breads revealed differences among various varieties (Table 4). 'C-306' was adjudged to be poor whereas 'VL-421' was rated as having excellent bread making characteristics. Based on sensory evaluation data, variety 'UP-262' was rated as good whereas 'HD-2281', 'HS-86', 'Malviya-12', 'UP-368' and 'UP-2003' were satisfactory in their bread making characteristics. The overall superiority of 'VL-421' may be attributed to its highest gluten content, sedimentation value, Pelshenke value and good diastatic activity.

It may be concluded that variety 'VL-421' is excellent for bread making. Variety 'UP-262' is good whereas 'HD-2281', 'HS-86', 'Malviya-12', 'UP-368' and 'UP-2003' are satisfactory.

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TABLE 4. SENSORY CHARACTERISTICS OF BREADS PREPARED FROM DIFFERENT VARIETIES* OF WHEATS

Variety	Crumb texture (30)	Crumb colour (20)	Crust colour (20)	Flavour (30)	Overall acceptance (100)	Grade**
'C-306'	13.3	13.3	11.1	20.0	57.7	P
'CPAN-1676'	23.3	13.3	11.1	20.0	67.7	F
'HD-2204'	16.3	13.3	15.5	23.3	68.4	F
'HD-2281'	26.6	13.3	11.1	20.0	71.0	S
'HD-2285'	20.0	13.3	13.3	20.0	70.0	F
'HS-86'	20.0	15.5	13.3	26.6	75.4	S
'Malviya-12'	20.0	15.5	15.5	23.3	74.3	S
'Sonalika'	16.3	13.3	13.3	23.3	66.2	F
'UP-115'	16.3	13.3	15.5	20.0	65.1	F
'UP-262'	26.6	17.7	15.5	23.3	83.3	G
'UP-368'	23.3	17.7	13.3	20.0	74.3	S
UP-2003'	23.3	13.3	17.7	23.3	77.6	S
'VL-421'	30.0	20.0	20.0	26.6	96.6	E
Mean	21.15	14.83	14.32	22.28	72.89	—
SE	±1.35	±0.63	±0.74	±0.70	±2.65	—
CD at 5%	1.20	1.77	0.65	1.95	7.39	—

*Average score given by panel members out of maximum score indicated in the parenthesis.

**E: Excellent (91-100), G: Good (81-90), S: Satisfactory (71-80), F: Fair (61-70) and P: Poor (51-60).

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A Small Scale Process for Milling of Wheat. Part II. A Process for Coarse Grit *(Dalia)* Milling

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A process has been developed for obtaining 84–88% yields of *dalia* of improved quality by using indigenously available low cost machinery—huller, *chakki*, sifter with suitable modifications in the grinding technique and sieving system. A comparative study of *dalia* thus processed with that of the market samples has shown that the total and acid insoluble ash contents ranged from 1.33 to 2.10% and 0.05 to 0.14% for market samples, while milled *dalia* has values of 1.22-1.59 and 0.03-0.07% respectively. Market samples required longer cooking time (9-12 min), as compared to 6–8 min of the samples obtained by the improved process developed. The water uptake was high (316-410%) in the case of *dalia* samples obtained from the above process as compared to low uptake (226-348%) of market samples. Medium hard wheat was found to be better for processing into *dalia* than soft white wheat in getting the higher yields and good texture of cooked product.

With the increasing annual production of wheat there is a need and considerable scope for diversified methods of processing and utilisation of wheat. *Dalia* (coarse grits of wheat grain) is commonly consumed in many States of northern India as well as in Tamil Nadu in the South. It is generally cooked and used in the form of sweet or spiced preparations according to traditional recipes. However, *dalia* is being processed from wheat according to traditional and emperical methods and very little scientific information is available on the production of *dalia* of desired quality.

Using indigenously available low cost machinery-huller, *chakki*, sifter, a simple process has been developed earlier for obtaining bakery flour and chapati *atta*, which has considerable scope for adoption in rural and semi-urban areas as even unskilled labour can manage the production[1]. *Dalia* is marketed at a relatively higher price than other milled products such as *atta*, *soji* and *maida*. With this background, studies were undertaken to examine whether the simple wheat milling process reported earlier[1] could be modified for the production of *dalia* of improved quality.

The results of a comparative study of milling and cooking quality of *dalia* produced by the improved process with available market samples are reported in this paper.

Materials and Methods

Wheat samples: Different types of wheat samples were procured from local market. The samples were: *T. aestivum* (Punjab, 'Bhojan Samrat' and Soft White), *T. durum* 'Bijaga yellow' and *T. dicoccum* ('Jave').

Dalia *samples*: Six commercial samples of *dalia* were obtained from Lucknow and Mysore markets.

Dalia *milling process:* Different samples of wheat were cleaned and polished to the extent of 5-7 per cent in a No. I rice huller, according to the process developed at this Institute[1, 2]. Polished wheat was fed into a 12 in vertical metallic disc grinder (*chakki*) wherein wheat gets ground between the stationary and the rotating discs. The particle size of the ground material was regulated by manually adjusting the clearance between the two discs of the *chakki*, in such a way that the ground material retained on a 12 mesh sieve (mesh opening 1680 μ) ranged between 80 and 85 per cent. The ground material was passed over a set of three standard sieves (12, 15 and 40 mesh) placed in a sifter box. The overs of 12 mesh were passed through the *chakki* again to further reduce the coarse fractions. The fractions of +12; —12, +15; —15; and +40 mesh together formed the *dalia*, while throughs of 40 mesh was processed to wheat flour (*atta*).

Physical characteristics of wheat and dalia: Pearling index was determined according to the procedure of McCluggage using Corcoran Barley Pearler[3]. The hardness of the wheat grain was determined in a hardness tester (M/s Kiya Seisa Kusha Ltd., Tokyo) after exposing the grains placed in petri dishes to relative humidity of 75 per cent at 30°C for 48 hr in desiccators. The average of 20 values recorded for each wheat sample is given as hardness in kg/grain.

For determining the particle size distribution, a 200 g sample of *dalia* was passed through a set of standard (US) sieves of 12, 20, 25, 30 and 40 mesh and agitated in a mechanical shaker for 5 min. The percentages of different fractions retained on each sieve were calculated and average of three replications are reported.

Chemical characteristics: The moisture, ash, gluten, pigment (as β-carotene) and falling number of different wheat and *dalia* samples were determined by Standard AACC methods[4].

Cooking test of dalia: Fifty gram sample was transferred to 250 ml boiling water in a beaker and the contents were allowed to simmer After 5 min, *dalia* granules were removed at intervals of one minute for examination to arrive at optimum cooking time, which was considered as time required for complete gelatinisation of starch. The cooked sample was drained over a 30 mesh sieve and water uptake was calculated. The appearance of cooked *dalia* was evaluated by a panel of six trained judges by observing colour, discreteness of granules and consistency (sticky/mashy).

Results and Discussion

The optimum conditions for the desired degree of grinding and use of set of sieves (12, 15 and 40 mesh) for obtaining maximum yield of *dalia* were established by preliminary trials.

Results of the physical and chemical characteristics of the five varieties of wheat and their relation to *dalia* milling time and yield are indicated in Tables 1 and 2. Pearling index did not differ much except in extra hard 'Bijaga yellow' wheat which had a higher value; this may partly be attributed to its lower moisture content. As compared to other varieties, 'Jave'

TABLE 1. RELATIONSHIP BETWEEN PEARLING INDEX, HARDNESS AND YIELDS IN *DALIA* MILLING

Variety/type	Pearling index	Grain hardness (kg/grain)	Cleaning time (min)	Degree of polish** (%)	*Dalia* milling* time (min)	*Dalia* yield (%)
'Punjab'	16.5	12.3	14.4	6.0	35	87.6
'Bhojan Samrat'	16.0	13.0	12.0	6.5	36	84.0
'Soft white'	16.0	8.2	18.0	8.0	30	82.0
'Bijaga yellow'	18.5	13.4	15.0	6.0	32	88.0
'Jave'	16.5	6.7	18.5	8.0	24	90.0

*Batch-size—100 kg; values are averages of 3 batches.

**Polishing time ranged between 49 and 51 min.

TABLE 2. SOME CHEMICAL CHARACTERISTICS OF WHEATS USED FOR *DALIA* MILLING

Variety/type	Moisture (%)	Ash (dry wt basis) Total (%)	Acid insoluble (%)	Pigments (dry wt basis) (ppm)	Falling number* (sec)
'Punjab'	12.9	1.46	0.08	2.6	478
'Bhojan Samrat'	12.8	1.41	0.08	3.6	489
'White'	12.5	1.51	0.06	3.3	542
'Bijaga yellow'	10.7	1.69	0.09	4.0	471
'Jave'	12.4	1.80	0.14	3.8	445

*On 14% moisture basis.

TABLE 3. COMPOSITION OF *DALIA* SAMPLES*

Sample No.	Moisture (%)	Ash (%) (dry wt bais) Total	Insouble	Dry gluten (dry wt basis) (%)	Pigments (dry wt basis) (ppm)
		Lucknow market			
1.	10.0	1.71	0.14	8.8	3.0
2.	10.1	1.65	0.10	8.4	3.8
3.	10.1	1.59	0.08	8.5	3.2
4.	8.2	1.33	0.05	10.0	2.9
		Mysore market			
5.	11.2	2.10	0.07	14.4	4.6
6.	10.9	1.88	0.05	14.9	4.6
		Milling trials			
7.	9.9	1.27	0.07	10.8	3.3
8.	11.4	1.22	0.03	11.1	3.9
9.	10.1	1.44	0.06	8.2	3.4
10.	10.2	1.46	0.06	12.7	5.4
11.	10.1	1.59	0.07	13.6	3.9

*Samples 1, 2, 3 and 4 were from aestivum wheats
Samples 5 and 6 from dicoccum 'Jave' wheats
Samples 7, 8 and 9 from aestivum (Punjab, 'Bhojan Samrat and Soft White respectively) wheats
Sample 10 from durum 'Bijaga yellow' wheat
Sample 11 from dicoccum 'Jave' wheat.

and soft white wheats had lower grain hardness values (6.7-8.2 kg/grain) and required shorter duration (24-30 min) for milling into *dalia*. These are probably due to the slender and longer nature of grains and the vitreous but brittle endosperm of 'Jave' wheat and the slightly chalky nature of white wheat. The time required for cleaning 100 kg wheat (12-18.5 min) and polishing (49-51 min) did not vary much among the different varieties.

'Jave' wheat had relatively higher values for total ash (1.88 per cent) as well as acid insoluble ash (0.14 per cent). The contents of pigments, influencing the colour of cooked *dalia* ranged from 2.6 to 4 ppm. The values for falling number ranging between 445 and 542 are indicative of low alpha amylase activity, which has indirect influence on the pasting characteristics during cooking of *dalia*.

Dalia *samples*: From the data presented in Table 3 it may be observed that only in case of market sample 4, moisture was lesser (8.2 per cent) than the remaining samples (9.9 to 11.4 per cent). The ash values of samples 5 and 6 from Mysore market were higher (1.88-2.10 per cent) than most other samples (1.22 to 1.71 per cent).

TABLE 4. PARTICLE SIZE (PER CENT OVERTAILINGS) DISTRIBUTION OF *DALIA* SAMPLES*

Sieve		Lucknow market				Mysore market		Milling trials				
Mesh	Opening (μ)	1	2	3	4	5	6	7	8	9	10	11
12	1680	46.5	48.0	22.0	46.0	49.0	62.3	19.5	27.6	23.5	7.6	16.7
20	840	46.5	46.5	77.0	52.0	44.8	34.0	67.5	61.7	58.8	66.2	70.5
25	700	3.0	3.0	0.8	1.5	5.0	2.0	5.9	4.8	5.2	9.8	6.1
30	590	1.0	1.5	0.1	0.2	1.1	1.0	2.2	1.6	4.7	6.8	3.1
40	420	2.7	0.9	0.1	0.3	0.1	0.6	4.4	3.9	7.1	8.6	3.3
Pan	—	0.3	0.1	—	—	—	0.1	0.5	0.4	0.7	1.0	0.3

*Details same as in Table 3.

TABLE 5. COOKING QUALITY OF *DALIA* SAMPLES

Dalia sample No.*	Cooking time (min)	Water uptake (%)	Appearance on cooking	
			Colour	Grain texture
		Lucknow market		
1	9.5	320	Brownish	Slightly mashy
2	12.0	348	Brownish	,, ,,
3	10.0	314	Brownish	,, ,,
4	9.0	328	Slightly brownish	Somewhat discrete
		Mysore market		
5	11.0	296	Brownish	Highly discrete
6	10.5	226	Brownish	,, ,,
		Milling trials		
7	7.5	352	Creamy	Slightly mashy
8	7.0	372	Creamy	Slightly mashy
9	6.0	410	Creamy	Highly mashy and sticky
10	7.0	390	Creamy	Highly discrete
11	8.0	316	Brownish	,, ,,

*Details same as in Table 3

Only in commercial Lucknow samples (1 and 2), acid insoluble ash was higher (0.10-0.14 per cent) than other market samples. Lucknow samples (1, 2 and 3) had much lower gluten content (8.4-8.8 per cent) than those from Mysore ('Jave' samples) (14.4 and 15.9 per cent) indicating that mostly medium hard aestivum types of wheat are used for commercial *dalia* milling in the northern states. The pigment values of 2.9 to 3.8 ppm for Lucknow samples were comparable to those for milled *dalia* samples 7, 8 and 9 (3.3–3.9 ppm).

Particle size distribution of dalia *samples*: Maximum retention of *dalia* (82–90 per cent) was observed over 12 and 20 mesh sieves together for all *dalia* samples except for the low value of about 74 per cent for 'Bijiga yellow' *dalia* (Table 4). Further it may be noted that the milled *dalia* had lower percentage (7.6–27.6) of overtails of 12 mesh as compared to (46.0–62.3) for commercial samples with the exception of sample 3 which has only 22.0 per cent. This difference in the pattern of particle size distribution is likely to influence both the cooking time and the water uptake of *dalia*, as could be observed from data presented in Table 5.

Cooking quality of dalia: Commercial samples required longer cooking time of 9–12 min as compared to 6–8 min for milled *dalia*. Further, except for sample 11, water uptake by milled *dalia* (352–410 per cent) was also higher than that for commercial samples (226–348 per cent). 'Jave' *dalia* in general had lowest water uptake. Except 'Jave' *dalia*, all milled samples had more attractive creamy colour unlike commercial samples which were brownish. This may be attributed to polishing of wheat resulting in lowering of total ash content. The commercial as well as milled *dalia* from aestivum wheats (1, 2, 3, 7 and 8) had a desirable slightly mashy texture on cooking. However *dalia* from soft white wheat (9) was highly mashy and sticky. The *dalia* from 'Jave' and 'Bijaga yellow' had highly discrete grains, which could be attributed to the hard endosperm.

It is concluded that the small scale wheat milling process developed earlier for obtaining bakery flour and chapati *atta* using low cost machinery could be used for *dalia* milling. Medium hard wheats like 'Punjab' and 'Bhojan Samrat' were suited well for *dalia* milling. In view of their high cost, hard endosperm and discrete grain texture on cooking, 'Jave' and 'Bijaga yellow' wheats were more suited for milling of semolina than *dalia*. Soft white wheat was least suited for *dalia* milling.

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Studies on Puffed Rice. I. Effect of Processing Conditions

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Puffed rice is traditionally made by subjecting paddy to high-temperature, short-time treatment, usually with heated sand. The effect of various processing conditions on puffing has been studied using (a) a small laboratory coffee roaster and (b) a small hot-air puffing system, using 25 g paddy in each experiment. The sand grade, sand-to-paddy ratio and roaster rpm did not affect puffing significantly. The optimum conditions were: (*i*) grain moisture of 14% (wet basis) in either system, and (*ii*) sand puffing at about 200°C, air puffing at 225°C at an air-flow rate of 1.5 m^3/min. Immature kernels did not puff well but cracked grains showed slightly increased puffed volume. Parboiling reduced puffing. Addition of salt increased puffed volume appreciably and also shifted the optimum moisture content to 17%. Sun-drying of paddy before moisture adjustment substantially increased the puffed volume.

In the Indian sub-continent flaked rice (*Avalakki, Aval, Poha, Chira*), expanded rice (*Murmura, Puri, Muri*) and puffed rice (*Aralu, Nel puri, Kheel, Khoi*) are popular snack foods and have been widely produced for centuries. Ghose *et al.*[1] estimated that 10 per cent of rice produced in India was converted into these three products. Both expanded rice and puffed rice are prepared by puffing the grain by a high-temperature, short-time (HTST) treatment. But while expanded rice is made by puffing milled parboiled rice, puffed rice is made by direct puffing of raw paddy:

Paddy→parboil→dry→mill→puff→Expanded rice

Paddy→adjust moisture→puff→Puffed rice.

A photograph of the products is shown in Fig 1.

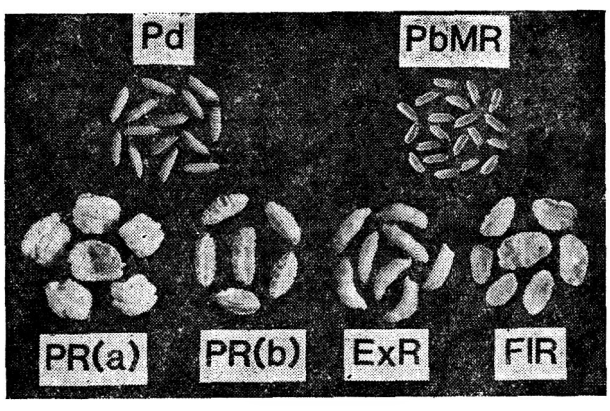


Fig 1. Photograph of paddy (Pd); parboiled milled rice (PbMR); puffed rice, fully opened (PR(*a*); puffed rice, not fully opened (PR(*b*); expanded rice (ExR); and flaked rice (FlR)

The traditional method of making puffed rice in India has been described by Narayanswami[2] and Ghose *et al*[1]. The practice seems to vary from region to region. In some cases the paddy is puffed simply after adjustment of its moisture. But more elaborate procedures are also adopted. For example, Narayanswami[2] states that in one method paddy is exposed to sun for varying periods of time depending upon the season (4 hr in summer and 8–12 hr in winter). It is then filled in earthen jars and treated with hot water for 2–3 min. Water is drained out and the jar is kept in an inverted position overnight. Next morning the paddy is again dried in the sun for a short period and then puffed while it is still moist.

Why such elaborate procedures are adopted is not known. Mottern *et al.*[3] studied the puffing characteristics of various US varieties and the method of making puffed rice using hot air. Srinivas and associates[4,5] studied the effect of temperature, sand grade, varietal differences and other related factors. Results of a study of various processing factors affecting puffing quality are reported here.

Materials and Methods

Materials: Eight varieties of paddy were used. 'Intan', 'IR20', 'Prakash' and 'Jaya' were procured from the market, cleaned, fumigated and stored in metal containers in the laboratory under ambient conditions. 'Taichung 65', 'Madhu', 'Co 25' and 'NlOB' were obtained from the University of Agricultural Sciences Experiment Station at Mandya, cleaned, dried, fumigated and stored at 4–5°C. All

samples had been aged at ambient temperatures for 3–10 months at the time of the experiment.

For studying the effect of moisture content, paddy was soaked in water at ambient temperature for 3 days and dried in the shade, samples being drawn at intervals and kept in closed bottles for 2 days for equilibration. To study the effect of salt, paddy was soaked in salt solutions of different concentrations for 3 days, after which the above procedure was followed.

After determining the effect of moisture content of paddy on its puffing, all other experiments were done after adjusting moisture to the optimum level of 14 per cent (wet basis, w. b.). This was carried out initially by adding the calculated amount of water to the paddy, followed by equilibration in a closed bottle. Subsequently, moisture adjustment was done by exposing the paddy in a tray in a humidity chamber at 30°C in which the relative humidity was maintained at 75 per cent using a saturated solution of sodium chloride.

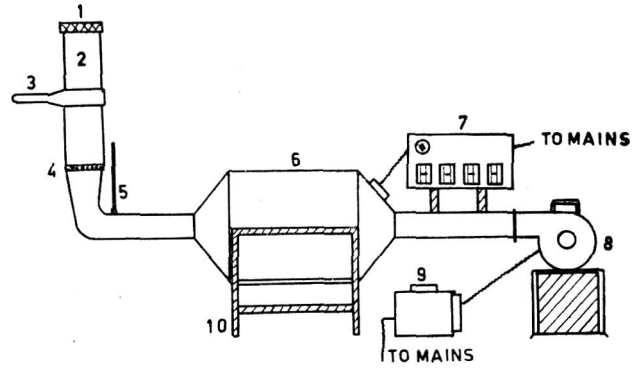
For studying the effect of cracks, sound grains and those having: (*i*) a single transverse crack (STC), (*ii*) double transverse cracks (DTC) and (*iii*) multiple cracks (MC)[6] each were separated from composite paddy samples using a paddy crack detector[7] and puffed separately.

To study the effect of sun-drying, paddy was exposed in trays to the sun, samples being drawn at intervals. The moisture content of the samples was determined, after which they were exposed under ambient conditions for 2–3 days and cracks were determined with a crack detector. The moisture content was readjusted to the optimum level (14 per cent, w. b.) as described above, following which the cracked kernels were again determined before puffing.

Paddy was parboiled by: (*i*) pressure parboiling, by washing the paddy in water followed by steaming under a pressure of 2.5 kg/cm^2 for 20 min[8], and (*ii*) dry-heat parboiling, by sand heating of soaked paddy at 250°C for 1 min[9]. The parboiled samples were dried in shade. All grains showing split husk were removed by hand picking. Normal parboling (soaking, then steaming) was not tried, as the husk invariably split in these grains.

To study the effect of immature grains, two samples of paddy with relatively large quantities of immature grains were aspirated by a Bates laboratory aspirator to obtain in each case a fraction high in immature grains and another poor, and the two fractions were puffed separately. The immature kernels were estimated in each after shelling 200 grains with a Satake laboratory sheller and examining them in transmitted light in a microbiological colony counter[6].

Sand was washed with acid and water and dried, followed by sieving through different mesh-size screens.



1 Wire-net cover
2 Glass jar sample holder
3 Handle
4 Perforated sheet
5 Thermometer
6 Heater
7 Heater control
8 Air blower
9 Variac
10 Stand

Fig 2. Schematic diagram of laboratory air-puffing set up.

Methods: Puffing was carried out initially with hot sand as done by Chinnaswamy and Bhattacharya[10] for making expanded rice. Paddy (25 g) was poured into an electrically heated, manually rotated, small coffee roaster containing heated sand. As soon as the popping sound ceased, the material was poured out on to a sieve to separate the sand.

Subsequently all experiments were carried out by hot-air puffing because of its convenience. A schematic diagram of the device used is shown in Fig 2. The heater consisted of four 2kw coils, fitted with a thermostatic control. The air was blown by a Wolf blower (capacity 60 cfm) connected through a variable transformer (Dimmerstat, 0–270 V) to control the airflow rate, which was measured with an anemometer. For puffing, the air flow and the heating were started, and when the temperature had stabilized at the desired level, 25 g raw paddy was poured into the glass sample-holder jar and the jar covered with a wire mesh. As soon as the popping sound ceased, the jar was removed and the puffed rice and hulls were poured out.

The puffed volume and the puffing expansion were measured as follows: The hulls were removed from the puffed material by sieving through a 4-mesh seive; in a few grains the hulls remained attached to the kernels and were removed manually. Separately 25 g of raw paddy was shelled with a Satake laboratory sheller; the broken grains were removed and weighed and then replaced by an equal weight of whole brown rice kernels. The bulk volumes of the above puffed rice and unpuffed brown rice were then measured in cylinders as described for expanded rice[10] and expansion ratio calculated.

Moisture was determined by drying whole grains at 105°C for 24 hr, and adding a correction factor of 1 per cent (dry basis) to the per cent loss in weight[11].

All moisture data reported are on wet basis (w. b.). All experiments were performed at least in duplicate and mean values are reported.

Results and Discussion

Effect of sand grade, sand quantity and roaster rpm in sand puffing: Sand particle size (mesh sizes of −4+16 to −60+85 as well as fine earth), sand-to-paddy ratio (20:1 to 0:1 by weight) and roaster rpm (0 to 100) were varied, but none of these factors seemed to influence the puffing expansion a great deal. A sand grade of −44+60 mesh, a sand-to-paddy ratio of 4:1 and a roaster rpm of about 50 seemed optimal and convenient. Too little or too much sand tended to cause charring and a slight reduction in expansion. Too coarse sand had the same effect, while too fine sand or earth tended to stick to puffed rice. Low roaster rpm increased puffing time, too low values also causing charring. These results are broadly similar to those for making expanded rice[10].

Effect of temperature: The optimal temperature was 190–210°C for sand puffing and 215–235°C for air puffing (Fig 3), as compared to reported values of 275°C[4] and 240°C[3] for the respective procedures. The time needed for puffing also varied with the temperature: it took 40–45 sec for the puffing to be completed at the optimum temperature, 100 sec at 150–180°C, and about 20 sec at 300°C. There was tendency to charring at too high temperatures; besides, the puffed kernels tended to remain cylindrical in shape with random splitting on the surface [PR (*b*) in Fig 1], rather than opening out from inside as in good puffing.

Effect of air-flow rate: Mottern *et al.*[3] had observed that puffing was affected by the air speed and that the kernels were not sufficiently agitated at slow air speeds. In the present work, maximum puffed volume was obtained at an air velocity of about 3.6 m/sec (1.5 m³/min) or more (Fig 4). Besides, the time needed for puffing increased as the air-flow rate decreased (85, 60, 40 and 36 sec at 1, 2, 3.5 and 4 m/sec, respectively). High air speeds also facilitated the separation of hulls from the puffed material.

Effect of moisture content: The optimum moisture content for expansion lay between 13.5 and 14.5 per cent (wet basis) both for sand and air puffing (Fig 5), which compared with 14 per cent[4] and 15 per cent[3] for the two methods, respectively, reported earlier. Interestingly, at too low moisture contents, most of the puffed kernels remained cylindrical in shape without opening up [PR (*b*) in Fig 1], probably indicating lack of adequate steam pressure needed for bursting.

Effect of immature grains: Immature grains lowered puffing volume (Table 1), for most of them did not

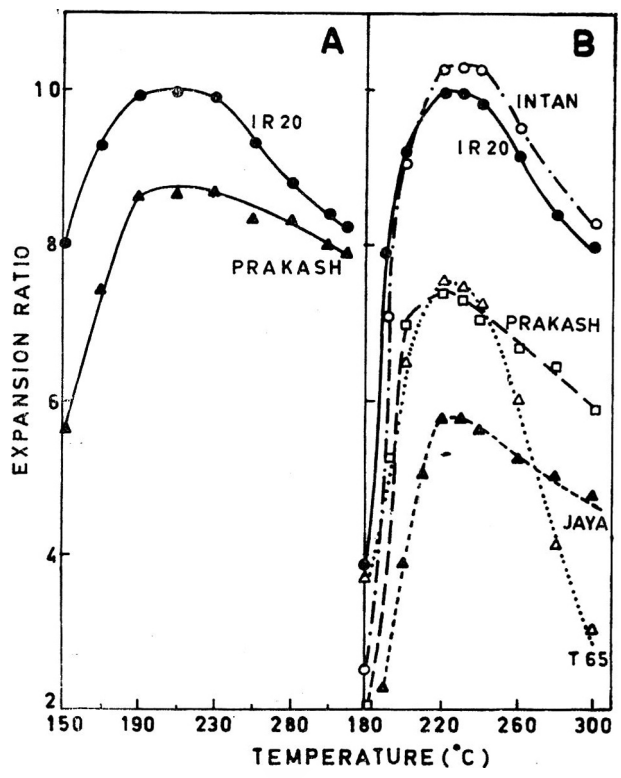


Fig 3. Optimum temperature for the puffing of paddy by sand heating (A) and air heating (B). Moisture content of samples was adjusted to 14 per cent before puffing.

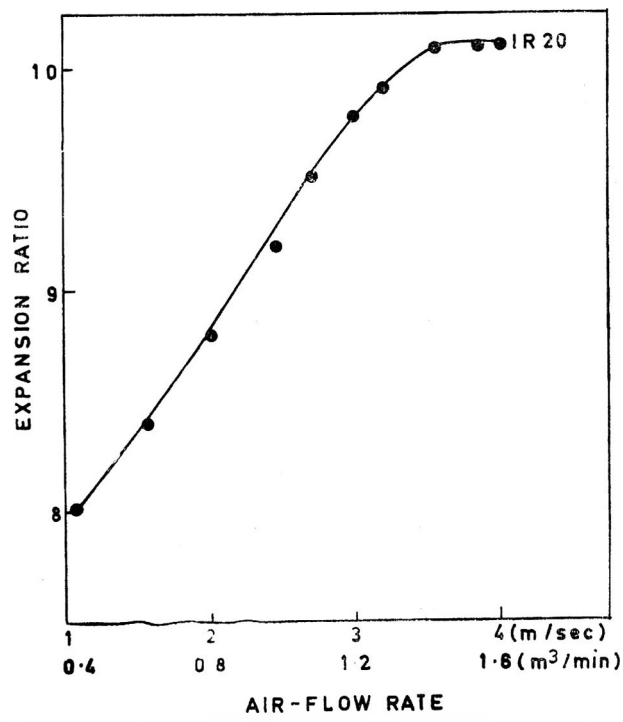


Fig 4. Effect of air-flow rate on puffing expansion during hot-air puffing of 'IR 20' paddy at 225°C.

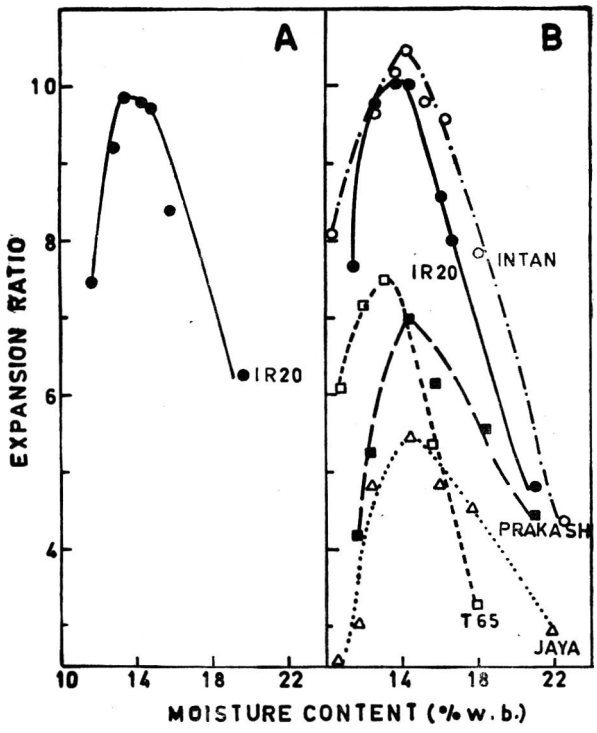


Fig 5. Optimum paddy moisture for puffing of paddy by sand heating (A) and air heating (B).

puff at all, and even those which did, tended to get charred by the time the process was completed. Srinivas and Desikachar[4] had earlier noted that too early harvest adversely affected puffing.

Effect of cracks: Grains with a single transverse crack (STC) and double transverse cracks (DTC) gave a slightly higher puffed volume than sound grains and grains having multiple cracks (MC) (Table 2). While tapping the cylinder with puffed grains for measuring their bulk volume[10], those obtained from highly cracked grains tended to break, which could be one reason for the slightly lower expansion ratio shown by MC kernels. Srinivas and coworkers[4,5] on the other hand reported that cracked grains reduced puffing expansion (they used composite samples and not separated cracked grains as here). The reasons for this difference in results are not known in the case of expanded rice, which is made by puffing of milled parboiled rice, cracks in kernel definitely reduce expansion[10]. In any case the present results show that cracks are not a significant defect for making puffed rice.

TABLE 1. EFFECT OF IMMATURE PADDY AND OF PARBOILING ON PUFFING (IN AIR-PUFFING SYSTEM)

Variety	Type of paddy	Expansion ratio	
		1-3% immature	40-50% immature
'Intan'	Raw	11.2	7.0
'Co 25'	Raw	5.0	2.5
'IR 20'	Raw	10.3	—
'IR 20'	PP*	3.8	—
'IR 20'	DHP+	3.5	—

*PP: Pressure parboiled; +DHP: Dry-heat parboiled

TABLE 2. EFFECT OF DIFFERENT TYPES OF CRACKS IN PADDY ON PUFFING EXPANSION (IN AIR-PUFFING SYSTEM)

Variety	Expansion ratio of grains[a]			
	Sound	STC	DTC	MC
'Intan'	12.0	13.3	13.3	12.0
'Madhu'	5.4	7.8	7.8	6.3
'N10 B'	2.8	2.0	3.0	2.8

[a]STC - grains with a single transverse crack,
DTC - grains with double transverse cracks,
MC - grains with multiple cracks.

Effect of parboiling: Expanded rice is made by puffing milled parboiled rice, where parboiling, *i.e.*, gelatinization, imparts the power to expand, for raw milled rice hardly expands upon heating[10]. It was therefore felt that if paddy is first parboiled and then subjected to HTST treatment, perhaps it would puff better. Surprisingly, puffing expansion actually decreased (Table 1). This was true even when the parboiled paddy was carefully screened to remove all grains showing incipient splitting of the husk. The reasons for this peculiar behaviour are not known. Further, puffed rice obtained from parboiled paddy resembled expanded rice in appearance, but with a blistered surface, unlike normal puffed rice.

Effect of salt: Chinnaswamy and Bhattacharya[10] reported that addition of common salt increases the expansion of expanded rice. Salt is indeed regularly used in the preparation of expanded rice. Whether salt has any effect on the puffing of paddy was tested by soaking the paddy in different salt solutions, drying and puffing. It was found that even here salt increased puffing expansion substantially. Interestingly, the optimal moisture content was simultaneously shifted from about 14 per cent without salt to about 17 per

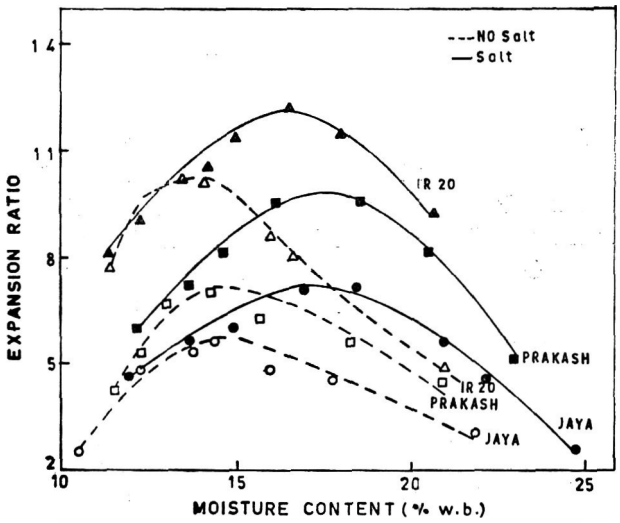


Fig 6. Effect of common salt on puffing expansion of paddy and its optimum moisture content for puffing. Paddy soaked in 2 per cent salt solution, dried to different moisture contents, and hot-air puffed.

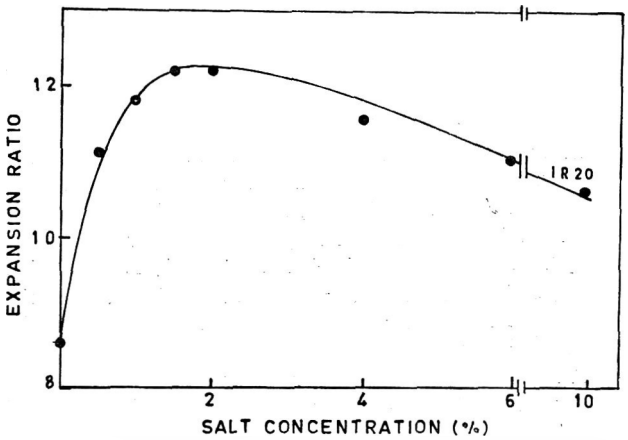


Fig 7. Optimum salt concentration for best puffing of 'IR 20' paddy. Samples were hot-air puffed at 17 per cent moisture.

TABLE 3. EFFECT OF VARIOUS SALTS ON EXPANSION RATIO OF PUFFED RICE[a]

Salt	Concn (%)	Optimum moisture content (%)	Expansion ratio
Nil	—	14	10.1
NaCl	2	17	12.1
$CaCl_2$	2	17	12.3
K_2SO_4	2	17	12.0

[a]'IR 20' paddy soaked in the respective salt solution for 3 days, dried in air to the optimum moisture and hot-air puffed.

cent with salt (Fig 6). The optimum salt concentration (concentration in water used for soaking) was about 2 per cent (Fig 7). Other salts too had similar effects (Table 3), as indeed observed for expanded rice as well[10]. The reasons for better puffing and especially for the shift in optimum moisture content by salt are not known. Use of salt has not been reported for the preparation of puffed rice in the traditional process, but the present results show that it should be further explored.

Effect of sun-drying: In certain traditional processes the paddy is passed through an elaborate cycle of drying and wetting before puffing. To examine this aspect, several samples were dried in the sun to different moisture contents and then expanded after adjustment of moisture to the optimum level. The results showed (Fig 8) that sun-drying before moisture adjustment indeed greatly helped the puffing expansion upto an optimum level after which the expansion again decreased somewhat. The samples moisture-adjusted in the humidity chamber rather than by water addition following sun-drying gave better expansion. Srinivas and Desikachar[4] in contrast noted that severe sun-drying caused a reduction in puffing volume.

Why sun-drying helps expansion so appreciably is not clear. Sun-drying no doubt led to extensive cracking

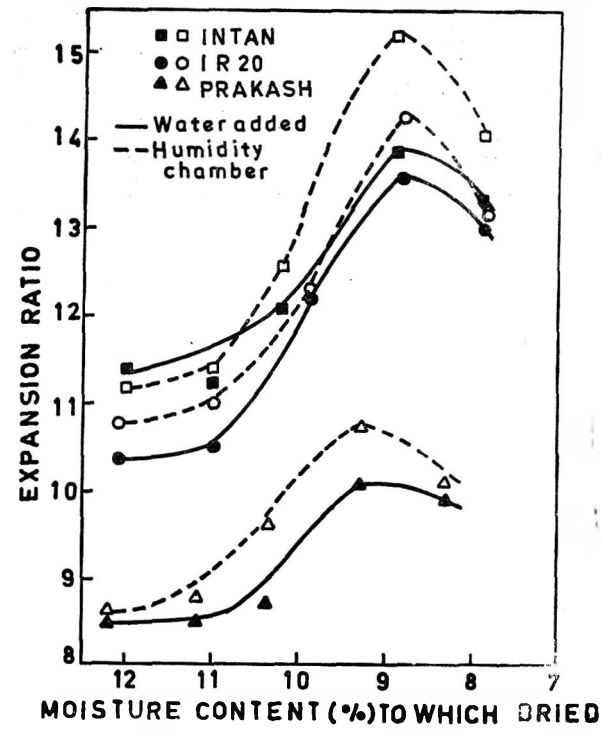


Fig 8. Effect of drying paddy in sun to different moisture contents on its puffing expansion. Paddy adjusted to 14 per cent moisture content before puffing by addition of water (continuous lines,————)and by exposure to humidity chamber (broken lines, — — — — —).

TABLE 4. EFFECT OF SUN-DRYING AND REMOISTENING ON FORMATION OF CRACKS IN PADDY[a]

Moisture content after sun-drying (% w.b.)	Cracked grains (%)		
	After sun-drying[b]	After remoistening to 14% moisture	
		By exposure in humidity chamber	By water addition
12.1[c]	5	6	17
11.0	6	6	41
9.9	10	8	49
8.8	21	18	61
7.9	72	75	81

[a]Variety: 'IR 20'. Similar data were obtained with 'Intan' and and 'Prakash'.

[b]Cracks estimated after exposure to laboratory atmosphere after sun-drying.

[c]Initial moisture content of paddy before sun-drying.

of the grains. Further cracks were formed in the samples when their moisture contents were adjusted by adding water, but not when this was done in the humidity chamber (Table 4). But, as mentioned earlier (Table 2), cracks in paddy do not seem to seriously affect puffing. Preliminary examination showed that neither the clearance between the husk and the kernel nor the extent of kernel chalkiness was affected by the process of sundrying and subsequent wetting. Further experiments with controlled drying using hot air might help to clarify this aspect.

These results suggest that controlled hot-air drying coupled with salting could perhaps be used to devise an improved process for making puffed rice. A suitable device to replace the current manual system of sand heating on a burning hearth (*bhatti*) is also needed.

Acknowledgement

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Changes in the Chemical Composition of Coconut Water During Maturation

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Coconut water collected from the nuts at eight progressive stages of maturity were analysed for titratable acidity, pH, total solids, total and reducing sugars, total and non-protein nitrogen, fat and fatty acid composition and ash and mineral constituents. Marked reduction in the volume of water accompanied by significant changes in the chemical composition were observed during maturation. On per nut water basis, drastic reduction in the contents of total solids, sugars and ash and mineral constituents was noticed whereas fat and protein contents were found to increase on maturation. Changes in the chemical composition of coconut water during maturation are indicative of quality changes.

Coconut (*Cocos nucifera*) water is the liquid endosperm that fills the central cavity enclosed by a solid endosperm protected by the hard shell and husk. Tender coconut water is a delicious and nutritious drink. In its natural state, it is sterile and is used as an oral rehydration medium for children suffering from gastro-enteritis. Coconut water is also reported to contain substances capable of inducing rapid proliferation of plant tissues[1-3]. It has also been used as a bacterial and plant tissue culture medium. Vinegar and *Nata decoco*, a fermented drink popular in the Philippines, are also prepared using coconut water as base. Coconut water plays an important role in the ripening of the fruit and in germination.

At its tender stage, a large nut may contain about 600 ml water with 30 g sugar and 2 g potassium. Towards the end of maturation, the volume of water decreases considerably, accompanied by changes in the chemical composition and palatability. Water from ripe nut is bland in taste and flavour and therefore is a waste product in the desiccated coconut and coconut oil industries. Studies on the chemical changes of coconut water related to maturity are very limited and are confined to certain constituents. Nathanael[4] reported the changes in the sugar content. Tuleck *et al.*[5] compared free amino acids and organic acid contents of mature and tender nut water. A systematic study on the changes in the chemical composition of coconut water has not been reported to this date. The present work is a report on the major and minor constituents of coconut water and their changes at different stages of maturity of the coconut fruit.

Materials and Methods

Coconut bunches were harvested from a healthy tree (West Coast tall variety) grown in the laboratory campus. The bunches were numbered I to VIII separately in the order of increasing maturity. Thus, I represents the earliest stage studied and stage VIII represents fully mature nuts. Water collected from the nuts of the respective bunches was pooled and the volume was recorded. The number of nuts per bunch varied from 10 to 15. The values recorded are average of two replications.

Total solids, crude fat (ether extract), pH, titratable acidity, ash, chlorine and sulfur were determined according to AOAC methods[6]. Sodium and potassium were estimated by flame photometry[6]. Iron and copper were determined by atomic absorption spectrophotometry (Pye Unicam, SP 2900). Phosphorus was estimated following a micro colorimetric method[7]. Calcium and magnesium were estimated by complexometric titration using EDTA[8].

Total and non protein nitrogen (NPN) were determined by Kjeldahl's procedure; for NPN analysis, the protein was precipitated with 10 per cent TCA and the filtrate used. Protein nitrogen was calculated by subtracting NPN from total nitrogen. Total and reducing sugars were estimated by the methods of Roe[9] and Somogyi[10] respectively.

Methyl esters of the fatty acids were prepared by trans-esterification using sodium methoxide. They were separated in a Hewlett Packard 5840 A gas chromatograph equipped with a FID; S.S. column 6′×1/8″ packed with 10 per cent DEGS on 100–120 mesh

TABLE 1. CHANGES IN TOTAL SOLIDS AND ACIDITY OF COCONUT WATER DURING MATURATION

Maturity stage	Amount of water/nut (g)	pH	Acidity as citric acid (mg/nut)	Acidity as citric acid (mg/100g water)	Total solids (g/nut)	Total solids (g/100g water)
I	250	4.80	280	112	14.55	5.82
II	216	4.95	255	118	14.23	6.50
III	179	5.09	211	118	11.74	6.56
IV	126	4.50	181	144	7.60	6.03
V	84	4.45	121	144	4.64	5.52
VI	53	4.55	76	144	3.14	5.92
VII(M)	53	4.65	42	80	3.01	5.68
VIII(M)	55	5.10	35	64	2.97	5.40

M: Mature nuts

chromosorb, temperature 100–180°C, programme 5°C/min, injector at 250°C; detector, 300°C, carrier gas nitrogen, 20 ml/min; hydrogen at 1.5 kg/cm^2, slope sensitivity 0.5. Identification was by comparison with authentic standards (Sigma Chemicals Co.) and peaks were quantitated by digital integration.

Results and Discussion

Coconut takes about 12 to 13 months on an average to reach full maturity[11]. Stages I to VIII presented here, roughtly correspond to 6 to 13 months of maturity with an interval of one month between two consecutive bunches. The first four can be considered as tender and the last two (VII and VIII) as mature stages. The amount of water per nut decreased steadily with increasing maturity (Table 1). The volume reduction of water could be attributed to absorption by the developing endosperm and also to evaporation. However, there are no reports on the exact nature of the loss of water from the cavity. The titratable acidity (Table 1) was comparatively low at the first three stages from which it increased to the maximum during the subsequent three stages, followed by a significant drop during the last two stages. The pH increased in the first two stages and dropped in the subsequent two stages followed by an increase during the final stages to the maximum value (Table 1). The acidity of the water might be due to organic acids, free amino acids, etc. Dissolved CO_2 evolved during tissue respiration as also fatty acids could contribute to acidity. Tender coconut water is reported to be under hydrostatic pressure which might facilitate the dissolution of CO_2 in water[12]. It is a common observation that effervescence appears in the water on opening a tender nut.

TABLE 2. CHANGES IN SUGAR CONTENT OF COCONUT WATER DURING MATURATION

Maturity stage	Total sugar (g/nut)	Total sugar (g/100g water)	Reducing sugar (g/nut)	Reducing sugar (g/100g water)	Non reducing sugar (% of total)	Reducing sugar (% of total)
I	12.00	4.8	10.00	4.0	16.7	83.3
II	12.33	5.7	9.50	4.4	22.9	77.1
III	8.23	4.6	5.73	3.2	30.4	69.6
IV	4.79	3.8	3.03	2.4	36.5	63.4
V	2.52	3.1	1.68	2.0	35.5	64.5
VI	1.48	2.8	0.32	0.6	78.6	21.4
VII(M)	1.06	2.0	0.11	0.2	90.0	10.0
VIII(M)	1.10	2.0	0.11	0.2	90.0	10.0

M: Mature nuts

Depletion of water on maturation causes an empty space into which the gases escape and therefore effervescence is usually not observed in the matured nut water. Total solids showed very little variations on percentage basis (Table 1). However, the changes in the total solids per nut recorded a steep decline on maturation. This could be partly attributed to the conversion of some components to endosperm constituents.

Total and reducing sugars showed a progressive reduction during maturation, the rate of reduction being much higher for reducing sugars (Table 2). The two major changes in the profile of sugars were the steep fall of total sugars per nut by more than 90 per cent and the disappearance of reducing sugars. The trend is similar to what Child and Nathanael[4] had reported earlier. Changes in the sugars were more marked than any other constituent. The fall in the sugar content of the nut water and accompanying rise in the fat accumulated in the endosperm in the process of maturation, reflects the intense biochemical activity involved. The developing endosperm might, therefore, be utilizing these sugars as precursors for fat synthesis. The physiological significance of conversion of reducing sugars into sucrose on maturation is not clearly understood. The fall in sugar content can be directly correlated with the loss of sweetness on maturation.

Unlike sugars, total nitrogen and nonprotein nitrogen (NPN) content registered a progressive increase with increasing maturity (Table 3). However, on 'per nut basis' both these constituents showed slight reduction. Protein content also showed a sharp increase on maturation. NPN constituted more than 60 per cent at any stage of maturity and its proportion was higher at the earlier stages. NPN is reported to be derived from amino acids, nucleic acids[5,13] and some growth stimulating factors[14], the major contribution being from free amino acids.

Total fat also increased steeply with increasing maturity both on percentage and per nut basis (Table 4). Fatty acid composition of fat extracted at various stages of maturity showed pronounced changes in certain fatty acids (Table 4). On the whole, increase in the relative proportion of fatty acids up to 14:0 and corresponding decrease in the higher unsaturated fatty acids were the major changes observed. Hexanoic acid which was absent in the first three stages appeared later on. Other acids (8:0, 10:0, 12:0 and 14:0) progressively increased with maturity, 12:0 being more pronounced as the most abundant acid. Fat extracted at early stages contained very high levels of 18:2, 18:3 which declined significantly at later stages. In early stages relatively greater amounts of higher saturated acids (20:0 and 22:0) were present which on maturation decreased to insignificant levels. Presence of 15:0, 17:0, 14:1 and 16:1 in the early stages and their total absence in the later stages were noteworthy. There are a few reports on the changes in the fat and fatty acid composition of the endosperm from the commercial point of view[15,16]. However, the changes in the fat and fatty acid composition of coconut water during maturation are reported for the first time in this paper. Changes in the fatty acid composition of coconut water is similar to those reported for the endosperm but with significant deviations in relative abundance.

On percentage basis the total ash content showed very little variation. But ash content per nut decreased substantially with maturation (Table 5). Among the minerals, potassium was the most abundant, which

TABLE 3. CHANGES IN NITROGEN CONTENT OF COCONUT WATER DURING MATURATION

Maturity stage	Total nitrogen (mg/nut)	Total nitrogen (mg/100g water)	Non protein N (mg/nut)	Non protein N (mg/100g water)	Protein (mg/nut)	Protein (mg/100g water)	NPN (%of total N)	Protein N (%of total N)
I	27.0	10.8	22.5	9.0	28.3	11.3	83.3	16.7
II	23.5	10.9	17.3	8.0	39.1	18.1	73.4	26.6
III	25.6	14.3	19.2	10.7	40.3	22.5	74.8	25.2
IV	27.0	21.4	19.0	15.1	49.6	39.4	70.6	29.4
V	25.3	30.1	19.2	22.8	38.3	45.6	75.7	24.3
VI	19.0	35.9	12.3	23.2	42.1	79.4	64.6	35.4
VII(M)	19.7	37.2	12.7	24.0	43.7	82.5	64.5	35.5
VIII(M)	20.7	37.6	14.0	25.5	41.6	75.6	67.8	32.2

M: Mature nuts

TABLE 4. CHANGES IN FAT CONTENT AND FATTY ACID COMPOSITION (AREA%) OF COCONUT WATER DURING MATURATION

	Stage of maturity						
	I	II	III	IV	V	VI	VIII(M)
Fat (mg/nut)	11.3	3.2	12.9	15.9	24.1	28.4	45.7
	(4.5)	(1.5)	(7.2)	(12.6)	(28.7)	(53.6)	(83.0)
Fatty acid							
6:0	Nil	Nil	Nil	0.3	0.5	0.2	0.5
8:0	0.8	1.4	3.0	6.7	7.1	6.5	9.5
10:0	0.5	1.1	1.9	4.1	4.6	4.5	5.4
12:0	7.9	15.3	25.0	41.3	43.4	47.1	46.9
14:0	2.5	8.8	13.2	20.4	18.8	19.4	18.7
14:1	2.2	Nil	Nil	Nil	Nil	Nil	Nil
15:0	2.3	0.6	0.8	Nil	Nil	Nil	Nil
16:0	4.7	14.4	10.2	10.1	8.1	7.2	7.0
16:1	4.7	Nil	Nil	Nil	Nil	Nil	Nil
17:0	4.2	2.5	1.7	Nil	Nil	Nil	Nil
18:0	1.1	2.2	2.0	1.4	1.1	1.8	1.6
18:1	14.3	13.4	10.4	8.5	7.7	5.9	4.2
18:2	7.5	9.4	7.2	4.0	2.2	1.8	1.5
20:0	15.2	10.9	8.3	1.9	2.4	3.3	3.0
18:3	26.2	16.4	13.6	0.9	3.3	2.1	1.4
22:0	5.9	3.6	2.7	0.4	0.8	0.2	0.2

Figures in parentheses indicate fat content in mg/100g water.

M: Mature nuts

TABLE 5. CHANGES IN MINERAL CONTENT OF COCONUT WATER DURING MATURATION

Maturity stage	Ash		Mineral content (mg/100g water)								
	(mg/nut)	(mg/100g water)	K	Na	Cl	Ca	Mg	S	P	Fe (μg)	Cu (μg)
I	1450	580	324	21	100	48	16	58	9.2	106	26
II	1145	530	291	42	75	44	10	58	9.2	106	26
III	1002	560	290	42	91	53	11	60	9.6	105	26
IV	693	550	272	52	85	54	11	65	8.3	132	26
V	470	560	282	52	72	57	17	70	7.1	79	26
VI	345	650	275	52	130	51	15	90	8.9	79	26
VII(M)	297	540	247	48	108	40	15	80	6.3	79	26

M: Mature nuts

accounted for more than half of the mineral matter. Whereas potassium decreased on maturation, sodium showed an increase. Calcium, magnesium, chloride, iron and copper content in coconut water did not exhibit any particular trend during maturation. Sulphur showed a slight increase and phosphorus a decrease.

Though the mineral composition of tender and mature coconut water was compared earlier[17-19] there are no reports on changes during progressive stages of maturation.

The major chemical constituents of coconut water, are sugars and minerals and minor ones are fat, and nitrogenous substances. The pleasant taste of tender coconut water could be attributed mainly to the sugar and mineral matter. The minor constituents such as fat, free amino acids, nucleic acids, organic acids and dissolved gases might also contribute to the overall flavour and mouth feel. Changes in their concentration on maturity render the nut water bland and less relishing. From the physiological point of view, coconut water functions as a reservoir of precursors for the developing endosperm constituents. As a result the total amount of nutrients in the nut water is substantially reduced except those that are leached into the water from the endosperm.

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Studies on the Consistency of Biscuit Doughs Using "Research" Water Absorption Meter

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A "Research" water absorption meter (RWAM) has been successfully used for evaluating the changes in consistency of soft doughs for biscuit as influenced by process variables like resting and mixing time and some of the major ingredients like sugar and shortening. The results of laboratory trials have indicated that RWAM extrusion time can serve as a reliable index in predicting the overall quality of soft dough biscuits. Dough consistency corresponding to an extrusion time of 64±10 sec were optimum for preparing quality biscuits. Resting the dough for 90 min did not affect biscuit quality. Reduction in the cost of ingredients could be achieved by reducing the requirement of shortening by 3% by replacement with 2% extra sugar in the formulation.

In view of the wide variations in the qualities of major raw materials used in India, a need has been felt to standardise the consistency of biscuit doughs using simple tools for obtaining uniformly good quality biscuits consistently. The mixed dough possesses specific characteristics of elasticity, resilience and moulding which contribute to the consistency of the dough. The dough forming machinery is highly sensitive to changes in consistency of dough and hence, for process control, uniformity in consistency is very important.

Different rheological tests and instruments have been mainly designed for simple flour-water-salt systems like those of bread. These methods are not suitable for biscuit formulations, which have in addition to the above mentioned ingredients significant quantities of sugar and shortening which affect flour hydration and hence the consistency. It is therefore better to evaluate the finished doughs.

Studies carried out by Muller and Barron[1] and Steele[2] have indicated the use of "Research" water absorption meter (RWAM) in consistency measurement of different doughs. This is an extrusion meter where a sample of dough is extruded at constant pressure. It is simple in design, not so costly and could be widely adopted.

In biscuits, there exists a wide spectrum of formulations with variations mainly in the quantities of sugar, shortening and water. Each biscuit manufacturer has his own formulation suited best to his set-up. Standardisation of the consistency for soft doughs to obtain excellent quality biscuits and the effect of some of the major ingredients and processing conditions on the consistency and hence the biscuit quality have been dealt with in this paper.

Materials and Methods

Wheat flour: Commercial soft wheat was milled to 69 per cent extraction in the Buhler laboratory mill (MLU-202). The flour packed in air-tight moisture proof containers was stored in the cold (0–4°C) for further study. Flour samples drawn from the cold were allowed to come to room temperature before use in different experiments.

Shortening, sugar and chemicals: Commercial brand of aerated bakery shortening "Marvo" suited for biscuits was used in the study. Crystal sugar was pulverised in the Kamas hammer mill to pass through B.S. 100 mesh sieve and stored in moisture proof containers before use. Dextrose monohydrate, sodium bicarbonate, sodium chloride, ammonium bicarbonate and vanillin of "chemically pure" grade were used in the study. Commercial brand of double acting baking powder "Rex" and commercial non-fat dry milk were used in the formulation. Distilled water was used for the preparation of the dough.

Preparation of the dough: For different studies, soft doughs based on 100 g wheat flour were prepared in triplicate according to the traditional "creaming" method. The other ingredients included in the dough were: 24 g shortening, 27 g sugar, 1.5 g dextrose monohydrate, 0.3 g sodium bicarbonate, 0.6 g sodium chloride, 0.8 g ammonium bicarbonate, 0.6 g baking powder, 1.5 g non-fat dry milk solids, 0.01 g vanillin and varying quantities of water.

Mixing was done in a Hobart planetary mixer (N-50) with the beater attachment. Care was taken to minimise the loss of ammonia by minimising the time lapse between weighing and mixing. Skinning of the dough was prevented by covering it with a damp cloth.

Consistency measurement using RWAM: Three 45 g test dough pieces scaled from the lot were relaxed for 1 hr at 30°C in a bowl kept covered with a damp cloth. The doughs were then moulded and extruded in the RWAM according to the method described in the manual for the instrument for unyeasted system[3]. The time taken for extrusion is directly related to consistency.

Biscuit making quality: The dough prepared as explained above, was sheeted on a specially fabricated aluminium platform using a wooden rolling pin to obtain a sheet of uniform thickness of 3.5 mm. The sheet was cut into circular dough pieces of 5.1 cm diameter with a biscuit cutter and baked for 13 min at 205°C with an average load of 8 biscuits per tray, equally distributed. Biscuits so obtained were cooled to room temperature, packed suitably and stored in air-tight tins.

All analyses were carried out in triplicate and the means are given.

Evaluation: Diameter and thickness of 6 biscuits were measured by placing them edge-to-edge and by stacking one above the other. Measurements by re-arranging and restacking were done to obtain the average.

Crust and crumb colour, flavour, texture and eating quality were scored by a panel of 6 experienced judges on a maximum of 100 score with the weightages given for different parameters according to AACC[4], with the exception, that weightage given for flavour and spread factor was modified to 30 per cent each instead of the recommended 20 and 40 per cent respectively. Different biscuits were graded on the basis of a total score obtained as follows: Excellent (E) 91–100; Good (G) 81–90; Satisfactory (S) 66–80; Fair (F) 51–65; Poor (P) 50 or less.

Results and Discussion

RWAM extrusion times with conventional soft biscuit doughs: Preliminary trials with some of the biscuit doughs made in the laboratory showed that extrusion times were in the range of 50 to 100 sec suggesting that *RWAM* could be conveniently used to measure the consistency of biscuit doughs.

Physico-chemical characteristics of the wheat flour: As shown in Table 1 wheat flour with the low protein content of 8.87 per cent as well as a sedimentation value of just 18 ml is ideally suited for preparation of biscuits.

TABLE 1. PHYSICO-CHEMICAL CHARACTERISTICS OF WHEAT FLOUR*

Crude protein (N×5.7) (%)	8.87
Total ash (%)	0.58
Ether extractives (%)	1.15
Crude fibre (%)	0.24
Carbohydrates (by diff) (%)	89.16
Sedimentation value (ml)	18
Kent-Jones colour grade value	4.1

*Values are on moisture-free basis; moisture in wheat flour: 12.71%

Effect of resting: Resting the biscuit dough upto a period of 3 hr increased the extrusion time from 58 to 99 sec indicating thereby, increased stiffness of the dough (Fig 1). This increase may be due to the proper hydration of the flour. However, resting the dough beyond 3 hr reduced the consistency, possibly due to softening by the enzymes present in it.

Resting of the dough upto 90 min after mixing, did not influence biscuit quality. Doughs rested for longer durations, however yielded biscuits of inferior quality with lesser raise and excessive spread; the biscuits also tended to become harder.

Effect of water: As expected, with increase in added water from 15 to 20 per cent, extrusion time decreased

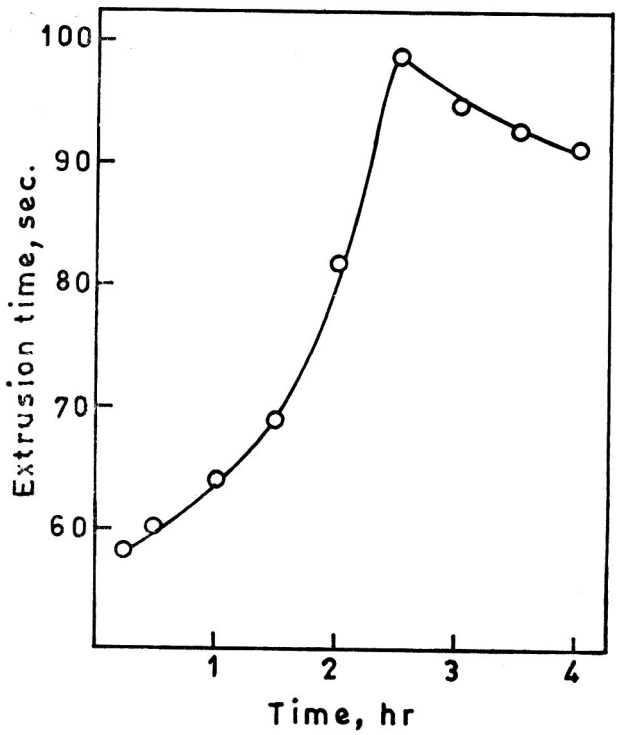

Fig 1. Relaxation curve with RWAM for soft biscuit dough

TABLE 2. EFFECT OF WATER ON EXTRUSION TIME OF THE DOUGH AND OVERALL QUALITY OF BISCUITS

Level of water (%)	Dough extrusion time (sec)	Biscuit			
		Width (W) (cm)	Thickness (T) (cm)	Spread factor*	Overall quality**
14		No dough formation in 5 min mixing			
15	97	5.40	0.73	94	F
16	70	5.44	0.71	98	G
17‡	64	5.49	0.70	100	E
18	49	5.54	0.68	104	F
19	38	5.58	0.67	106	P
20	31	5.60	0.66	108	P

*$\frac{\text{W/T for test sample}}{\text{W/T for control}} \times 100$

**Based on crust and crumb characteristics and spread factor.
E-Excellent, G-Good, S-Satisfactory, F-Fair, P-Poor.

‡Control.

from 97 to 31 sec. An increase in the spread with a corresponding decrease in thickness was also observed with increasing water additions (Table 2) With 14 per cent water, dough of the expected consistency was not formed in 5 min mixing. On the other hand, the dough made with 19 to 20 per cent water was very soft. In the range of 16 to 17 per cent added water, dough mixed for 5 min and sheeted resulted in biscuits of superior quality characteristics; 17 per cent water gave excellent results. Hence, in further studies dough with 17 per cent water and mixed for 5 min was taken to be the standard. In terms of consistency measured on RWAM, the dough exhibited an extrusion time of 64 sec.

Effect of mixing time: Data presented in Table 3 indicate that mixing for shorter period of 3–4 min resulted in a stiff, inconsistent lumpy dough with high extrusion time ranging from 121 to 161 sec. Further mixing for upto 7 min rendered the dough softer and more homogeneous resulting in a marked decrease in the extrusion time to 62 sec. However, continuation of mixing upto 15 min toughened the gluten, with the consequent stiffening of the dough, leading to marginal increase in the extrusion time to 78 sec.

Over-mixing was not as detrimental to consistency and biscuit quality as under-mixing which resulted in poor quality biscuits with transverse cracks, distorted shapes and poor glaze. In the narrow range of 5 to 7 min mixing, with no apparent change in the consistency of the dough from the standard value, excellent quality biscuits could be obtained. Dough consistency as affected by mixing and overall quality of biscuits closely paralleled each other.

Effect of shortening: Shortening was found to have a profound influence on the dough consistency (Table 4).

TABLE 3. EFFECT OF MIXING TIME ON EXTRUSION TIME OF THE DOUGH AND OVERALL QUALITY OF BISCUITS

Mixing period (min)	Dough extrusion time (sec)	Biscuit			
		Width (cm)	Thickness (cm)	Spread factor	Overall quality
3	161	5.40	0.78	88	P
4	121	5.49	0.71	99	F
5*	64	5.53	0.70	100	E
7	62	5.69	0.69	105	E
9	73	5.64	0.70	103	G
12	75	5.60	0.71	101	G
15	78	5.60	0.71	101	G

*Control

TABLE 4. EFFECT OF SHORTENING ON EXTRUSION TIME OF THE DOUGH AND OVERALL QUALITY OF BISCUITS

Level of shortening (%)	Dough extrusion time (sec)	Biscuit			
		Width (cm)	Thickness (cm)	Spread factor	Overall quality
12	—	5.38	0.84	82	P
23	150	5.43	0.72	96	F
24*	64	5.49	0.70	100	E
25	60	5.57	0.70	102	G
36	15	5.78	0.69	107	P

*Control.

The dough with half the quantity of shortening normally used (24 per cent) was so stiff that it could not be extruded while, the one with one and half times the normally used level extruded readily in 15 sec. Manley[5] is of the opinion that at high levels of shortening, the lubricating action on the dough is highly pronounced requiring very little water to achieve the desired consistency. Also, gluten formation and gelatinisation of starch are reduced, in view of the competition between the aqueous phase and the shortening for the flour surface ultimately to give a soft dough.

As contrasted with its effect on dough consistency, the shortening had negligible effect on spread and raise in biscuits. Studies carried out by Finney *et al.*[6] point out that, shortening did not materially affect cookie diameter, but did alter the top grain in certain cases. In the initial stages of baking, shortening may help in the retention of gas and water vapour to give the raise and firming up of the tender structure thereby not allowing the biscuits to spread.

Formulations either with high or low levels of shortening pose machining problems as they are sensitive to changes in consistency. Further, colour, texture and surface characteristics of biscuits baked with such formulations were not acceptable.

Effect of sugar: Increasing the level of sugar from 13.5 to 40.5 per cent increased the spread from 5.07 to 5.67 cm as well as spread factor from 83 to 121 but did not exert as much of an influence on consistency as shortening did (Table 5). Sugar has been reported to decrease the dough consistency by Muller and Barron[1] and described to induce spread by Whiteley[7] and Manley[6] when present in excess or in too fine a particle size. Studies of Finney *et al.*[6] pointed out that at constant level of ammonium bicarbonate in the formulation, spreading of cookies during baking was directly proportional to the quantity of sugar added. Sugar competes with the gluten for the available water which may induce the spread seen in the biscuits.

Effect of varying levels of shortening and sugar: Next to flour, sugar and shortening are the major ingredients in soft dough biscuit formulations. Shortening and sugar decrease the consistency of the dough; on the other hand, the spread factor is increased to different degrees with increase in their levels in the formulation (Tables 4 and 5). In view of shortening being a costly ingredient,

TABLE 5. EFFECT OF SUGAR ON EXTRUSION TIME OF THE DOUGH AND OVERALL QUALITY OF BISCUITS

Level of sugar (%)	Dough extrusion time (sec)	Biscuit			
		Width (cm)	Thickness (cm)	Spread factor	Overall quality
13.5	597	5.07	0.78	83	P
25.0	70	5.30	0.77	88	S
27.0*	64	5.49	0.70	100	E
29.0	54	5.55	0.65	109	G
40.5	40	5.67	0.60	121	P

*Control

TABLE 6. EFFECT OF SHORTENING AND SUGAR LEVELS ON EXTRUSION TIME OF THE DOUGH AND OVERALL QUALITY OF BISCUITS

Trial no.	Shortening (%)	Sugar (%)	Dough extrusion time (sec)	Biscuit			
				Width (cm)	Thickness (cm)	Spread factor	Overall quality
1	25	27	60	5.57	0.70	102	G
2*	24	27	64	5.49	0.70	100	E
3	23	27	150	5.43	0.72	96	F
4	24	25	70	5.30	0.77	88	S
5	24	29	54	5.55	0.65	109	G
6	23	28	70	5.49	0.70	100	G
7	22	29	68	5.49	0.70	100	G
8	21	30	150	5.40	0.73	94	F

*Control

the biscuit manufacturer tends to limit its incorporation to the minimum without significantly impairing the quality of biscuits and the role of emulsifiers in this context is worth mentioning[8].

Trials carried out to study the effect of using different combinations of shortening and sugar on the dough consistency as well as quality of biscuits (Table 6) showed that desired consistency could be obtained by varying sugar-shortening levels in the formulation. Also, it was interesting to note that those formulations which conformed to the desired consistency range yielded good quality biscuits. Any variations in sugar and shortening levels in biscuit formulations did not pose any problem with the machinability of the dough or the baking operations. The results also indicated that by increasing sugar by 2 per cent in the formulations 3 per cent shortening could be reduced, thus considerably saving in the raw material costs.

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Some Toxicological Aspects of Casein and Ghee Prepared from Spoilt Milk*

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Multiplication of *Staphylococcus aureus* and *Escherichia coli* and likely production of heat-stable toxin during spoilage was studied in raw buffalo milk sold in Karnal town. No heat-stable toxin could be detected during spoilage of milk till initiation of curdling. Feeding ghee prepared by direct churning of curdled milk to rats for 6 months showed no adverse effect on the growth and organs of the rat. However, ghee made from neutralized (with sodium bicarbonate) curdled milk or milk with 0.5% acidity, and casein prepared from milk with 0.2, 0.3 and 0.4% acidity promoted lower growth rate as compared to controls. Inflammation of oviduct was observed in 40% of rats fed ghee made from neutralized curdled milk or 0.5% acidity milk, and in 10% and 40% of rats fed casein from 0.3 and 0.4% acidity milk, respectively.

In India, spoilage of large quantities of milk is not uncommon during summer and monsoon. Such milk is not considered fit for human consumption. This huge wastage can be prevented if spoilt milk is converted into ghee (moisture free clarified butter fat) and casein suitable for human consumption. The present investigation was, therefore, undertaken to study in rats the effect of casein and ghee prepared from spoilt buffalo milk.

Materials and Methods

Bacteriological analysis of milk: Twenty five samples of buffalo milk collected from different places in Karnal town were allowed to sour at 37°C till initiation of curdling. The bacterial counts were estimated by standard methods[1]. The coliforms were enumerated on eosine methylene blue agar (Hi-Media, Hindustan Dehydrated Media, Bombay) and *Escherichia coli* colonies distinguished from others by their characteristic greenish metallic sheen. *Staphylococci* produced black colonies surrounded by a zone of opalescence on Baird-Parker medium (Hi-Media) supplemented with egg yolk (2.4 per cent) and potassium tellurite (0.1 per cent). These black colonies were tested[2] for thermostable DNase production using toluidine blue DNA agar and confirmed as *S. aureus*.

Evaluation of toxins: Twenty five spoilt milk samples at 0.4 per cent acidity and at initiation of curdling were tested for heat-stable toxins. *E. coli* toxins from milk samples were extracted by the procedure of Glatz and Brudvig[3] and tested on 1–3 days old mice by the procedure as described by Dean *et al.*[4] The extract was injected intragastrically and the intestine examined for inflammation after 3 hr. For comparison, entero toxigenic strain (F 9/2) of *E. coli* (obtained from Dairy Bacteriology Division of the Institute) was grown at 37°C for 18 hr in casamino acid-yeast extract medium (without glucose) for the production of heat-stable toxins, the cell free supernatant was concentrated at 70°C using a thin film rotary evaporator and tested for toxins as described above.

Thermostable DNase test of Lachica *et al.*[2] was followed to detect the pressence of heat-stable toxins of *S. aureus*. DNase was extracted according to the method of Tatini *et al*[5]. boiled for 15 min and assayed on toluidine blue DNA agar plates. Enzyme extract (10 μl) was transferred to each well (7 mm dia.) and the petri plates were incubated for 4 to 5 hr at 37°C. Pink zones around the well indicated the presence of thermostable DNase. For comparison, 196E strain of *S. aureus* (obtained from Dairy Bacteriology Division of the Institute) was grown in BHI broth (Hi-Media), the supernatant (centrifugation at 20,000 $\times g$ for 15 min) boiled for 15 min and tested as above.

Feeding trials: The following casein and ghee samples from spoilt milk samples (prepared by Mr. V. K. Gupta, Dairy Technology and Engineering Division of the Institute) were studied.

*M.Sc. Thesis submitted by the senior author.

—Casein from milk samples with 0.2, 0.3 and 0.4 per cent acidity which was neutralized with sodium bicarbonate.
—Ghee prepared from milk with 0.5 per cent acidity and curdled milk (~0.65 per cent acidity), after neutralizing with sodium bicarbonate.
—Ghee prepared by direct churning of curdled milk.

Each product was fed for six months to a group of 10 female rats (Wistar), weighing 40-48 g, housed in suspended wire bottomed cages. The diets prepared as described by AOAC[6] were supplemented with experimental ghee at 7 per cent level and casein to provide 10 per cent protein. The control diet was supplemented with casein and ghee from fresh milk. Other constituents of the diet were salt mixture (USP XIX), 4 per cent; sesame oil, 2 per cent; vitamin mixture, 1 per cent; cellulose, 1 per cent and starch to make 100 per cent. The food intake was recorded every day and the animals were weighed fortnightly. After the experimental period the blood was analysed for haemoglobin[7], and viscera examined for abnormality, if any.

The data on organ weights and haemoglobin level were subjected to analysis of variance, and the comparisons tested by Duncan's new multiple-range test[8].

Results and Discussion

The data on multiplication of bacteria in market milk during spoilage are presented in Table 1. As per the limits of total bacterial counts prescribed by ISI[9], raw milk samples from Karnal town can be graded as follows: 20 per cent, very good; 20 per cent, good; 40 per cent fair and 20 per cent, poor. Only 3 out of 25 samples tested were within the standard limits prescribed by ISI[9] for coliform counts in raw milk. Coliforms increased by about four fold and *S. aureus* by two fold at 0.4 per cent acidity. The viable cells of these organisms diminished considerably at the curdling stage which might be due to the antagonistic effect of other organisms[10-13] like *Lactobacilli* and *Streptococci.*

All pathogenic organisms (except spores of clostridia) and heat labile toxins are presumed to be destroyed during the heat treatment (75–80°C for 2 min) given to the spoilt milk after neutralizing its acidity. The only bacteria known to produce heat-stable toxins are *S. aureus*[14] and *E. coli*[15], but toxin production is expected only if the milk is heavily contaminated with enterotoxigenic strains of these organisms. Donnelly *et al.*[16] observed that the enterotoxin was detected only in those milk samples inoculated initially with 10^6 *S. aureus* cells per ml and incubated at 35°C. Generally, a concentration of 5×10^7 *S. aureus* cells per ml was reached before enterotoxin was detected. Hains and Harmon[13] examined 15 species of lactic acid bacteria for their ability to influence the growth of *S. aureus* and production of enterotoxin. Among the organisms used *Streptococci* were the most inhibitory, and enterotoxin could be detected only in those samples in which population of *S. aureus* reached 8×10^8/ml. We observed that highest population of *S. aureus* in spoilt milk was 12×10^4, much below the concentration at which enterotoxin has been detected. Further, none of the 25 spoilt milk samples showed thermostable DNase activity

Mehlman *et al.*[17] suggested that an infectious dose of 10^8-10^9 viable *E. coli* cells must be present in contaminated food to cause intoxication. The highest *E. coli* population observed in the spoilt milk samples tested was 10×10^4 cells/ml (Table 1). Further, no inflammation was observed in the intestine of infant mice on intragastric injection of extracts from spoilt milk samples. The ratio of intestinal weight to carcass

TABLE 1. BACTERIAL COUNTS (PER ML) OF MARKET MILK SAMPLES DURING SPOILAGE

	Fresh milk	At 0.4% acidity	At initiation of curdling
Total counts	15×10^3–78×10^6 (70×10^5)	14×10^5–15×10^7 (42×10^6)	17×10^6–84×10^7 (24×10^7)
Coliforms	65×10^0–49×10^3 (70×10^2)	14×10^1–15×10^4 (27×10^3)	27×10^0–68×10^3 (10×10^3)
Escherichia coli	42×10^0–39×10^3 (43×10^2)	98×10^0–80×10^3 (16×10^3)	18×10^0–69×10^3 (89×10^2)
Staphylococcus aureus	62×10^0–64×10^3 (83×10^2)	14×10^1–12×10^4 (18×10^3)	26×10^0–49×10^3 (61×10^2)

Figures in the parentheses indicate the mean values of 25 samples.

TABLE 2. EVALUATION OF HEAT-STABLE TOXINS FROM *E. COLI*

Samples	Intestinal wt/ Carcass wt
Control (no toxin)	0.026—0.035
E. coli (strain F 9/2)	0.080—0.083*
Pasteurized milk	0.029—0.035
Sour milk (0.4% acidity)	0.024—0.039
Curdled milk (curdling initiation)	0.022—0.037

*Positive response for *E. coli* heat-stable toxin.

weight ranged from 0.022 to 0.039 (Table 2) after the extracts from spoilt milk samples were injected, while with *E. coli* toxins, this ratio was about 0.080. Therefore, *E. coli* heat-stable toxins were not observed in any of the 25 spoilt milk samples.

The data on food intake, weight gain and haemoglobin level in rats fed the products from fresh/spoilt milk are shown in Table 3. The average food intake was similar in different groups. However, the food intake of rats fed casein from 0.4 per cent acidity milk was relatively lower during the first 30 days. The growth rate and haemoglobin level in rats fed casein from 0.2 per cent acidity milk were comparable to that in control rats. The weight gain was significantly lower in

TABLE 3. FOOD INTAKE, WEIGHT GAIN AND HAEMOGLOBIN LEVEL IN RATS FED CASEIN/GHEE FROM FRESH/SPOILT BUFFALO MILK

Sample	Acidity of milk (%)	Method of preparation	Food intake (g)	Wt. gain (g)	Haemoglobin level (g/100ml)
Control	—	—	1539±56	173±5	14.85±0.05
Casein	0.2	Neutrazliation	1516±48	169±4	13.99±0.04
Casein	0.3	Neutralization	1530±59	152±4*	13.82±0.06
Casein	0.4	Neutralization	1503±62	151±5*	13.51±0.10*
Ghee	0.5	Neutralization	1545±37	163±5	13.90±0.05
Ghee	0.65[c]	Neutralization	1504±49	155±2*	13.64±0.13*
Ghee	0.65[c]	Direct churning	1518±62	171±4	13.97±0.04

c = Curdled; Control = casein + ghee from fresh milk. Values are mean±SEM from 10 rats
*The values are significantly different ($P<0.05$) from others.

TABLE 4. AVERAGE WEIGHTS (G/100G BODY WEIGHT) OF VISCERAL ORGANS IN RATS FED CASEIN/GHEE FROM FRESH/SPOILT BUFFALO MILK

Sample	Acidity of milk (%)	Method of preparation	Liver	Spleen	Heart	Kidneys	Lungs	Gastrointestinal tract
Control	—	—	3.7±0.1*	0.26±0.03	0.35±0.04	0.78±0.03	0.62±0.02	3.7±0.1
Casein	0.2	Neutralization	3.6±0.1	0.27±0.01	0.34±0.04	0.84±0.05	0.65±0.03	3.8±0.1
Casein	0.3	Neutralization	3.8±0.1	0.30±0.01	0.36±0.04	0.88±0.03	0.66±0.02	3.9±0.2
Casein	0.4	Neutralization	3.7±0.1	0.29±0.02	0.37±0.04	0.87±0.03	0.67±0.03	3.5±0.1
Ghee	0.5	Neutralization	3.8±0.1	0.27±0.01	0.35±0.01	0.78±0.01	0.70±0.01	3.7±0.1
Ghee	0.65[c]	Neutralization	3.4±0.1	0.25±0.01	0.32±0.04	0.71±0.07	0.64±0.05	2.9±0.1[a]
Ghee	0.65[c]	Direct churning	3.7±0.2	0.27±0.04	0.33±0.04	0.79±0.04	0.66±0.07	3.9±0.1

Control = casein + ghee from fresh milk; *c* = curdled.
*Values are mean±SEM from 10 rats.
a Significantly different ($P<0.05$) from the values of other groups.

rats fed casein from 0.3 or 0.4 per cent acidity milk. The haemoglobin level was also lower in rats fed casein from 0.4 per cent acidity milk. In a short term experiment, Kansal *et al.*[18] observed lower biological value and net protein utilization for casein prepared from 0.3 or 0.4 per cent acidity milk.

The haemoglobin level and growth rate in rats fed ghee prepared by direct churning of spoilt milk were comparable to that in control rats. The rats fed ghee prepared from neutralized spoilt milk had lower growth rate and haemoglobin level.

Except for the lower weight of the gastro-intestinal tract in rats fed the ghee prepared from curdled milk after neutralization, there was no significant difference in organ weights of rats fed different samples of casein or ghee (Table 4). Examination of viscera revealed no abnormality in any organ in any group except inflammation of the oviduct in some of the rats. Fifty per cent of the rats exhibited swollen oviduct in groups given the ghee prepared from milk with 0.5 per cent acidity/curdled milk after neutralization. Inflammation of oviduct was not observed in rats fed the casein from 0.2 per cent acidity milk. One animal in the group given casein from 0.3 per cent acidity milk and four in the group given the casein from 0.4 per cent acidity milk exhibited swollen oviduct.

No abnormality was seen in rats fed ghee prepared by direct churning of spoilt milk, while the intake of ghee prepared from spoilt milk after neutralization caused diminution in growth rate, haemoglobin level and the weight of gastro-intestinal tract, and inflammation of oviduct. This adverse effect could be due to some antimetabolite produced as a result of the treatment of milk with sodium bicarbonate. Detailed studies on histopathological and biochemical aspects are needed to confirm the safety of ghee prepared by direct churning of spoilt milk and to understand the toxicity caused by ghee prepared from neutralized spoilt milk.

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Effect of Raw Materials, Deboning Methods and Chemical Additives on Microbial Quality of Mechanically Deboned Poultry Meat During Frozen Storage

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Microbial quality of spent hens' whole carcasses, mechanically deboned poultry meat (MDPM) from spent hens' whole carcasses deboned on Beehive deboner at two different settings namely 'a' (setting commercially used for deboning chicken racks), and 'b' (setting giving about 10% less yield than 'a') and MDPM from chicken racks such as 'c' (deboned on Beehive deboner) and 'd' (deboned on Protocon MPD-30) were studied. The effects of propyl gallate and sodium tripolyphosphate on the shelf-life of MDPM during frozen storage at -18°C for 4 months were also investigated.

The log counts of different bacteria present on fresh spent hens' whole carcasses were, total counts (5.46), coliforms (3.43), *Staphylococcus aureus* (3.48), and faecal *Streptococcus* (2.00). However, *Salmonella* was absent. Amongst the MDPM groups, 'a' was the best in overall microbial quality. Between the MDPM from chicken racks, 'd' was better than 'c'. Freezing was observed to reduce bacterial counts (total counts, coliforms and haemolytic counts) in all the MDPM groups studied. Treatments with propyl gallate and sodium tripolyphosphate had little beneficial effect on the shelf-life of MDPM groups during frozen storage.

Mechanically deboned poultry meat (MDPM) due to its highly comminuted nature is liable to high microbial contamination[1]. During deboning process, the microbial contamination may be easily blended throughout the deboned tissues. The tissue maceration also results in the release of cellular fluids rich in nutrients, which provide a suitable medium for bacterial growth. In addition, frictional heat generated during deboning may enhance bacterial growth. As a result, the product has a short shelf-life under refrigeration[2], which is a serious problem in using MDPM for further processing into meat products.

Attempts have been made to improve the keeping quality of MDPM by heat pasteurization[3], storage under 100 per cent carbon dioxide atmosphere[4], using resting cells of starter cultures of *Pediococcus cerevisiae* and *Lactobacillus plantarum*[5], rosemary spice extract, butylated hydroxy anisole (BHA) and citric acid[6]. Most of these studies relate to the MDPM from chicken racks. However, very little work has been done on MDPM from spent hens. Hence, the present study was undertaken to provide information on microbial quality of MDPM from spent hens vis-a-vis chicken racks during frozen storage and the effect of raw material, deboning methods and chemical additives on their shelf-life.

Materials and Methods

Raw material: Fresh chilled spent hens' whole carcasses (SHWC) without giblets, slaughtered under commercial conditions at 74°C scald temperature and chicken racks (broiler backs) were used in the present study.

Deboning methods:

1. MDPM from spent hens' whole carcasses deboned on Beehive deboner was designated as 'a'. The deboner setting was similar to that of deboning chicken racks under commercial conditions.
2. MDPM from spent hens' whole carcasses deboned on Beehive deboner at reduced pressure so as to give about 10 per cent less yield than 'a' was designated as 'b'.
3. MDPM from chicken racks deboned on Beehive deboner under commercial conditions was designated as 'c'.

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4. MDPM from chicken racks deboned on Protecon MPD-30 deboner under commercial conditions was designated as 'd'.

Sample preparation: To assess the initial quality of fresh spent hens whole carcasses prior to deboning, at random 10 samples of neck skin from different carcasses were collected immediately after chilling, from the dressing line of the plant. The samples were analysed on the same day.

For initial microbial profile of different MDPM groups, 250 g of sample was drawn on the same day and subjected to microbiological analysis

Treatments: MDPM from spent hens' carcasses ('a' group) and chicken racks ('c' group) were treated with different levels of propyl gallate (50 and 100 ppm) and sodium tripolyphosphate (0.25 and 0.50 per cent) individually and in combination. The propyl gallate (PG) treatment was imparted by gradually adding 4 and 8 ml solution containing 250 mg PG/ml distilled water to 2 kg MDPM, while mixing in a Kenwood mixer, for 50 and 100 ppm, respectively. The sodium tripolyphosphate (TPP) treatment was performed by dissolving 250 g TPP per litre of hot distilled water. The measured volume of 20 and 40 ml hot solution was slowly added to 2 kg MDPM while mixing, for 0.25 and 0.50 per cent TPP level respectively. There were nine treatments (Tr), as follows:

Tr 1 = Control
Tr 2 = 50 ppm PG.
Tr 3 = 100 ppm PG.
Tr 4 = 0 ppm PG+0.25% TPP.
Tr 5 = 50 ppm PG+0.25% TPP.
Tr 6 = 100 ppm PG+0.25% TPP.
Tr 7 = 0 ppm PG+0.50% TPP.
Tr 8 = 50 ppm PG+0.50% TPP.
Tr 9 = 100 ppm PG+0.50% TPP.

Storage: Each of the treated sample was divided into four portions and packed separately in double layer of polyethylene films and stored at -18°C alongwith the control. Samples were analysed after 0, 1, 2 and 4 months storage in triplicate.

Microbiological analysis: The neck skin samples of spent hens carcasses were analysed for total counts, coliforms, faecal *streptococcus*, *Staphylococcus aureus* and *Salmonella*. MDPM samples were analysed for the above mentioned organisms besides *Clostridium* and haemolytic counts. Haemolytic counts were done in view of the fact that there are certain known pathogens which cause haemolysis in the blood agar plates.

The frozen storage studies were carried out on treated and un-treated samples of 'a' and 'c' MDPM groups and were analysed for total counts, coliforms and haemolytic counts.

TABLE 1. SUBSTRATE, TEMPERATURE AND TIME OF INCUBATION FOR DIFFERENT ORGANISMS STUDIED

Organism	Substrate	Temp (°C)	Incubation period (days)
Total counts	Plate count agar	20	2
Coliforms	Violet red bile agar	37	1
Faecal *Streptococcus* sp.	Slanetz agar	37	2
Staphylococcus aureus	Baird Parker agar	37	1 or 2
Salmonella	MacConkey agar	37	1 or 2
Clostridium	Iron sulfite	37	1
Haemolytic count	Blood agar	37	1

The microbiological analysis was carried out as described in the Commission of the European Communities Study Report[7]. However, the media used, time and temperature of incubation for different organisms are given in Table 1. All bacterial counts were converted to log 10 value.

Results and Discussion

Microbiological quality of fresh spent hens whole carcasses (SHWC): The summary of microbiological analysis of SHWC presented in Table 2, indicate that their total count of 5.46/g was lower than that of broiler carcasses (5.75 to 6.50/g) reported earlier by others[7]. The possible reason for such lower counts in our investigation could be the higher scalding temperature (74°C) used for spent hens which is higher than that normally used for broiler chickens (58–60°C). Higher scalding temperature was used for spent hens to facilitate feather plucking operation since the temperature normally used for broiler chickens was not sufficient for these old birds.

TABLE 2. MICROBIAL QUALITY OF FRESH SPENT HENS WHOLE CARCASSES

Organism	Log count/g
Total counts	5.46
Coliforms	3.43
Staphylococcus aureus	3.48
Faecal *Streptococcus*	2.00
Salmonella	Absent

TABLE 3. MICROBIAL QUALITY OF FRESH (O-DAY) MECHANICALLY DEBONED POULTRY MEAT

Sl. No.	Organism	Bacterial count (×log 10/g MDPM) in MDPM group			
		'a'	'b'	'c'	'd'
	Total counts	7.30	5.15	7.30	6.46
	Coliforms	4.30	4.40	4.27	4.45
	Salmonella	absent	absent	absent	absent
	Staphylococcus aureus	<2.00	<2.00	<2.00	<2.00
	Faecal *Streptococcus*	3.90	3.78	4.52	4.78
	Clostridium	4.11	4.04	<1.00	—
	Haemolytic count	3.38	2.85	3.85	<2.00

Microbial quality of fresh mechanically deboned poultry meat (MDPM): Microbial profile of various MDPM groups given in Table 3, revealed that total count was the lowest for 'b' group (5.15/g) as compared to other MDPM groups. The temperature difference during deboning, due to deboner setting between 'a' and 'b' groups, i. e., 7 and 4°C respectively, could be the possible reason for a lower count in the latter group. On the other hand, the higher total count for 'c' and 'd' groups, i. e., 7.30 and 6.46/g respectively, as compared to 'b' group, was presumably due to increased manual handling of raw material and chicken racks, during the cut-up process which could upset the level of hygiene expected to be maintained during the process. The higher total count in 'c' group (7.30/g) than that of 'd' group (6.46/g), may be the reflection of differences in hygienic practices between the two processing plants, quality of raw material and differences in deboning operation.

A similar trend was observed for faecal *Streptococci*, clostridial and haemolytic organisms. The contamination problem by coliforms as reflected by their counts ranging from 4.27 to 4.45/g was of similar magnitude in all the MDPM groups. Presence of coliforms and faecal *Streptococci* indicated direct or indirect contamination from faecal matter. Haemolytic count was the lowest in 'd' group and may also include certain pathogens. Hence, strict sanitary measures need to be observed to avoid contamination from these sources to render the product safe. Clostridial count was quite low (<1.00) for MDPM of chicken racks ('c' groups) than those of spent hens ('a' and 'b' groups). This suggest the effect of age of the birds and portion of the carcass used as raw material on MDPM quality. Clostridial group is mainly derived from sources like enteric matter and soil etc. *Staphylococcus aureus* was present but its count was less than 2.00 in all the MDPM groups, which is lower than the suggested limit of 2.00/g of raw minced meat and semi preserved meat[8]. Moreover, Staphylococcal enterotoxicosis occurs when *S. aureus* population reaches about 6.00 to 8.00/g. Human handlers who harbour this organisms in nasal passages, skin and boils etc are the main source of *S. aureus*. strict observance of personnel hygiene is necessary to minimise such contamination.

Microbial quality of different MDPM-groups during frozen storage: Microbial counts viz. total counts, coliforms and haemolytic counts of MDPM from chicken racks ('c' group) and spent hens ('a' group) during 0, 1, 2 and 4 months storage at -18°C, have been depicted in Fig 1. The results indicated that freezing reduced the microbial load in both the groups. This is in agreement with the findings of Ostover *et al.*[9] It was further observed that microbial population reduced with the storage time in both the groups of MDPM. However, chemical treatments with propyl gallate and sodium tripolyphosphate (Fig 2) showed little improvements in shelf-life of MDPM groups which is contradictory to the earlier findings[6].

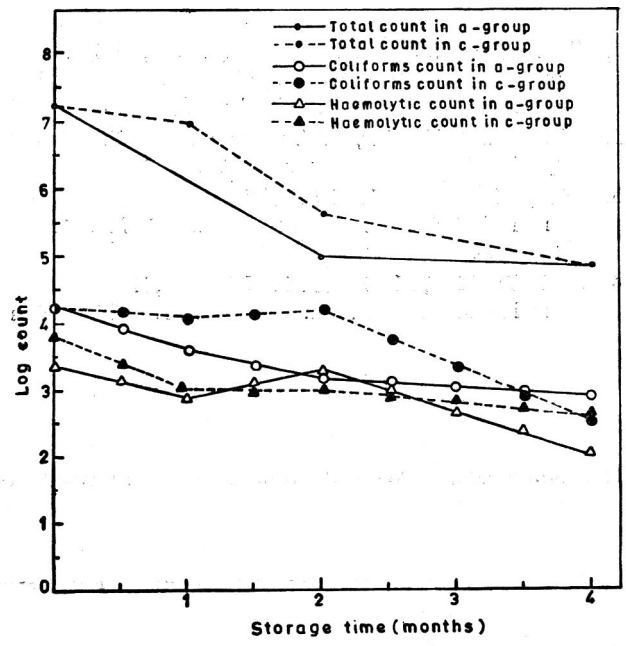

Fig 1. Microbial counts of MDPM from spent hens ('a'-group) and chicken racks ('c'-group) during frozen storage at -18°C.

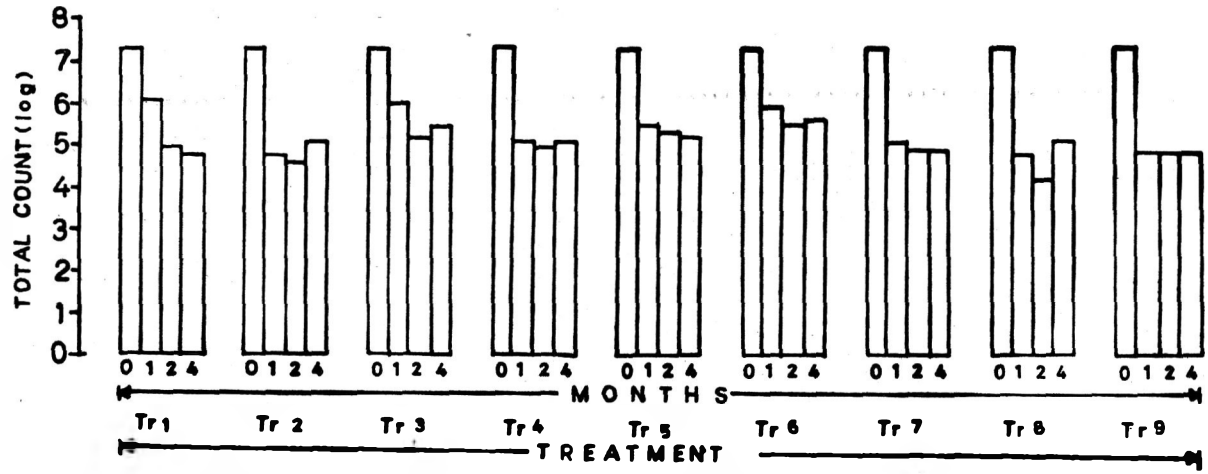

Fig 2. Effect of propyl gallate (PG) and sodium tripolyphosphate (TPP) on microbiological quality (total count) of MDPM from spent hen whole carcasses (SHI) during 4 month frozen storage at -18°C.

Tr. 1—Control
Tr. 2—50 ppm PG
Tr. 3—100 ppm PG
Tr. 4—0 ppm PG+0.25% TPP
Tr. 5—50 ppm PG+0.25% TPP
Tr. 6—100 ppm PG+0.25% TPP
Tr. 7—0 ppm PG+0.50% TPP
Tr. 8—50 ppm PG+0.50% TPP
Tr. 9—100 ppm PG+0.50% TPP

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Nutrition of *Cyprinus carpio* (L) Fingerlings in Relation to Their Essential Amino Acid Requirement

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Indispensable amino acids required for normal growth of *Cyprinus carpio* fingerlings were studied. Fingerlings of *C. carpio* were fed on experimental diets deficient in a single amino acid for 60 days in cisterns. Growth rates with these diets were compared to that obtained with the basal control ration. According to the results arginine, histidine, leucine, isoleucine, phenylalanine, threonine, valine, lysine, methtonine and tryptophan were found to be essential for normal growth. In contrast, tyrosine, glycine, alanine, aspartic acid and cystine were found to be non-essential. Thus, it was evident that *C. carpio* requires all the ten amino acids reported to be essential for other species.

In developing purified diets for optimum fish growth, it was found to be of great advantage to supply amino acid nitrogen as single nitrogen source for the production diets as the fishes are unable to synthesize certain amino acids[1]. As the quality of protein is determined by the presence of all essential amino acids it contains, their presence in production diet is of utmost importance for accelerating growth, because in the absence of any one of the essential amino acids, the rest of the essential amino acids fail to work. In addition, the availability of essential amino acids in production diets were found to be superior due to their lower conversion rate from essential to non-essential amino acids than any other source of nitrogen[2]. Therefore, to hasten the growth of fish, it is desirable to include essential amino acids in the diet in order to maintain proper amino acid pool.

Though the essential amino acids for different species of fishes have been reported[3,4], it has yet to be established whether similar amino acids are essential for all species or not. Carp culture has shown a promising future for commercial fish production. Knowledge of its nutritional requirement is essential for successful cultivation and development of amino acid enriched commercial feed for getting maximum production. Since very little is known regarding essential amino acids requirement in fish diets, the present study has been undertaken to determine their requirement for common carp and its deficiency symptoms.

Materials and Methods

Preparation of the experimental diet: The amino acids used were in L-form. Table 1 represents the composition of the basal control diet. Rice bran and mustard oil cake were finely sieved through sieve no. 60. Deficient amino acid diets were prepared by deleting a single amino acid from the basal control ration. All the ingredients were mixed according to Halver and Shanks[5] and dried in an oven at 60°C to a constant weight. These were ground thoroughly and stored in air tight glass containers till their use.

TABLE 1. COMPOSITION OF AMINO ACID BASAL DIET

Constituents	(g/100g diet)
Rice bran	30
Mustard oil cake	30
Amino acid mix*	40
Water	100

*Contains (g/100g diet): Arg HCl 3.5; Hist HCl; H_2O 1.5; Ileu 3.2; Leu 3.5; Lys HCl 3.2; Meth 1.5; Phenylalanine 2.5; Thr 2.2; Tryp 0.4; Val 3.6; Tyr 3.0; Gly 4.0; Ala 3.5; Asp 4.4; Cys 0.6

Experimental fish and feeding: The fingerlings of *Cyprinus carpio* were collected in two lots from the departmental nursery for two phases of the experiment and acclimatized in cisterns for two weeks, the first week without feed, while second week with experimental diets. For feeding trials, six measured fish were released in each cistern (86×46×50 cm) filled with

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settled and filtered well water. Feeding trial was carried out for sixty days. The fishes were fed with the experimental diets at the rate of 6 per cent of body weight in the form of paste twice every day at scheduled timings, 9:30 a.m. and 4:30 p.m.) except Sunday. Weights of the fishes were recorded fortnightly and thus their subsequent ration was adjusted. The water of the cistern was not changed during the experiment. Firstly, the growth rates of the fish fed on seven amino acid deficient diets were compared to those of the fish fed on a complete amino acid basal ration. After 30 days of feeding, the groups of fishes exhibiting growth rate similar to that of control were discarded. Each of the groups showing different growth rates from the control were divided into two equal sub-groups. One sub-group was continued to be fed with the same deficient diet while the other was given a complete basal ration. The experimental feeding was then extended for another thirty days.

In the second phase, the growth rates of the remaining eight amino acid deficient groups were compared with the control. Same feeding procedure as described for the first phase was followed.

Results and Discussion

The growth of *C. carpio* in response to complete amino acid basal control and amino acid deficient diets have been summarized in Tables 2 and 3. The control group in the first phase exhibited the highest growth (90.63 per cent), while arginine, leucine, histidine, isoleucine and methionine deficient groups showed lower growth rates. Similarly, in the second phase, highest growth rate was observed on the basal control diet (92.29 per cent) whereas in valine, phenylalanine, threonine, tryptophan and lysine deficient diets, lower growth rates were recorded. In all cases, the replacement of missing amino acids in the diet after 30 days in each sub-group showed an increase in their growth

TABLE 2. AVERAGE BODY WEIGHT (GRAMS) OF *CYPRINUS CARPIO* ON DIETS DEFICIENT IN AMINO ACIDS FED OVER A PERIOD OF 60 DAYS

Diets	0 day	15th day	30th day	45th day	60th day
Basal control	4.48	5.26	6.12 (36.60)	7.26	8.54 (90.63)
Arg. def.	4.48	4.86	5.52 (20.98)	5.92	6.68 (49.11)
Basal	—	—	5.52	6.32	7.64 (70.54)
Leu. def.	4.96	5.36	5.96 (20.16)	6.68	7.36 (48.39)
Basal	—	—	5.96	6.88	7.98 (60.89)
Hist. def.	5.00	5.45	6.02 (20.40)	6.76	7.48 (49.60)
Basal	—	—	6.02	7.12	8.46 (69.20)
Ileu. def.	4.96	5.25	5.66 (14.11)	6.26	7.36 (48.38)
Basal	—	—	5.66	6.82	7.99 (61.09)
Met. def.	5.04	5.45	5.96 (18.25)	6.58	7.52 (49.21)
Basal	—	—	5.96	6.95	8.64 (71.43)
Gly. def.	5.06	5.88	6.85 (35.38)	—	—
Cys. def.	4.86	5.64	6.58 (35.39)	—	—

Figures in parentheses indicate per cent growth.

TABLE 3. AVERAGE BODY WEIGHT (GRAMS) OF *CYPRINUS CARPIO* ON DIETS DEFICIENT IN AMINO ACIDS FED FOR 60 DAYS

Diets	0 day	15 day	30 day	45 day	60 day
Basal control	4.95	5.40	6.34 (36.34)	7.48	8.96 (92.29)
Val. def.	5.12	5.45	6.08 (18.175)	6.79	7.62 (48.83)
Basal	—	—	6.08	7.08	8.74 (70.70)
Pheny. def.	4.56	4.82	5.44 (19.30)	6.18	7.02 (53.95)
Basal	—	—	5.44	6.58	7.76 (70.18)
Try. def.	4.76	4.98	5.58 (17.23)	6.18	7.14 (50.00)
Basal	—	—	5.58	6.46	7.66 (60.92)
Lys. def.	5.36	5.62	6.08 (13.43)	6.95	7.98 (48.88)
Basal	—	—	6.08	7.42	8.84 (64.93)
Thr. def.	4.76	4.86	5.42 (13.87)	6.28	7.28 (52.94)
Basal	—	—	5.42	6.49	7.68 (61.34)
Ala. def.	4.76	5.45	6.48 (36.13)	—	—
Asp. def.	4.76	5.48	6.47 (35.90)	—	—
Tyr. def.	4.56	5.32	6.18 (35.53)	—	—

Figures in parentheses indicate per cent growth.

rate in contrast to the deficient diet fed group. Thus the sub-group fed with arginine deficient diet showed a growth rate of 49.11 per cent whereas the sub-group having been fed with basal control diet after 30 days exhibited a growth rate of 70.54 per cent. Similarly, all the sub-groups fed with the control diet replacing the missing amino acid after 30 days, showed higher growth rates than the deficient amino acid diets. Thus, fish fed with the diets deficient in arginine, leucine, histidine, isoleucine, methionine, valine, phenylalanine, threonine, tryptophan and lysine had lower growth rates whereas after replacing the missing amino acids in the diets the growth rate increased. Therefore, these amino acids were assumed to be indispensable for normal growth of *C. carpio*. Besides, the lower conversion rate of essential amino acid nitrogen to non-essential amino acid nitrogen than any other source of nitrogen is also responsible for enhanced growth rate of *C. carpio*[2].

Fish fed on the diets deficient in glycine, cystine, alanine, aspartic acid and tyrosine, however, exhibited a growth rate equivalent to the control having no significant differences ($F = -0.222$; $p > 0.05$). Although rice bran and mustard oil cake, used as protein source in the control diet contained amino acids like glycine, alanine, aspartic acid, cystine, tyrosine, etc. the growth of fish in control diet did not show any significant difference from those of such amino acid dificient diet fed group. On the other hand, diets formulated with some such amino acids also failed to show any significant increase in growth of fish. This positively indicated that the addition or deletion of amino acids like glycine, alanine, aspartic acid, etc. to a test diet could not exhibit any significant change in growth of fish and thus the above amino acids can be considered as dispensable for normal growth of *C. carpio*. Thus, the fish fed with above amino acid deficient diets showed the same growth response as observed in complete

amino acid control diet and the results are widely supported[3,5,6].

Throughout the experiment, neither any mortality nor any deficiency symptoms were observed which alone supports the suitability of the diets, whereas Halver and Shanks[6] reported scoliosis and Lordosis in sockeye salmon as symptoms resulting from essential amino acid deficient diet. Besides, a marginal or negative growth was also reported which was not true in the present study. The above variation in growth rate is mainly due to difference in fish species, water temperature and feed formulation. Further, rice bran and mustard oil cake were used as a secondary nitrogen source in the diet besides amino acid nitrogen which is also responsible for better fish growth. In view of the above, it can be concluded that *C. carpio* requires arginine, leucine, histidine, isoleucine, methionine, valine, phenylalanine, threonine, tryptophan and lysine for normal growth as do other fishes[7]; glycine, cystine alanine, aspartic acid and tyrosine are not required for normal growth.

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Studies on Protein Quality and Availability of Zinc from *Dosa*

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Wistar albino rats were fed various experimental diets comprising plain *dosa*, zinc supplemented *dosa*, raw *dosa* mixture and zinc supplemented raw *dosa* mixture. It was observed that body weight, protein efficiency ratio, liver weight and liver protein content were less in zinc unsupplemented *dosa* diet as compared to zinc supplemented *dosa* diet fed group. The animal absorbed more nitrogen and zinc from zinc supplemented plain *dosa* diet as compared to other experimental diets. The availability of zinc from plain *dosa* diet was more than that from the raw *dosa* mixture diet.

Zinc deficiency has been found to be associated with the retardation of growth and sexual maturation in humans[1,2]. Zinc deficiency in human nutrition is prevalent more in those countries where cereals and pulses form the primary items of diet, as both the cereals and pulses are rich in phytate which inhibit absorption of zinc. Fermentation of whole wheat[3,4] has been observed to reduce the phytate content and thus increas the availability of zinc. Fermented pulses and cereals are used for the preparation of different products like *dosa* and *idli*. *Dosa* is a fermented product prepared from a mixture of rice and dehusked black gram *dal* and is a good source of balanced protein. Not much information is available on the protein quality and the availability of zinc from *dosa*. Therefore, the present investigation was undertaken to study the availability of zinc from *dosa* and to determine the protein utilization of the fermented product with and without addition of zinc.

Materials and Methods

Rice and dehusked blackgram *dal* used in the present investigation were purchased from the local market. *Dosa* was prepared[5] from rice and *dal* mixture in the ratio of 2:1. The *dosas* were dried in a dehydrator at 60°C overnight, ground to a fine powder and analysed for moisture, ether extract, crude protein and crude fibre by the methods of AOAC[6] and phytic acid according to Oberleas[7]. The zinc contents of different samples were determined by atomic absorption spectrophotometry.

Animal experiment: Dosas were dehydrated at 50–60°C overnight and ground to fine powder. The diets were prepared at 10 per cent protein level and the percentage of fibre and ether extract in different diets were maintained constant; they were adequate with respect to vitamins[8] and minerals[9] except zinc in zinc-unsupplemented diet only.

Thirty wistar albino rats of the same age (about 24–28 days old) were randomly distributed into 5 groups each consisting of 6 rats (3 males and 3 females). Five experimental diets viz. skim milk powder diet (D_1), *dosa* diet (D_2), *dosa* with zinc supplemented diet (D_3), raw *dosa* mixture diet (D_4) and raw dosa mixture with zinc supplemented diet (D_5), were fed to the different groups for four weeks. The composition of experimental diets is given in Table 1.

TABLE 1. COMPOSITION OF EXPERIMENTAL DIETS (G/100G)

Ingredients	Skim milk powder (D_1)	*Dosa* diet (D_2)	Raw *dosa* mixture (D_4)
Vitamin mixture[8]	1.0	1.0	1.0
Salt mixture[9]	4.0	4.00	4.00
Cellulose	5.0	4.85	4.85
Groundnut oil	10.0	8.80	9.20
Corn starch	51.7	1.35	0.95
Skim milk powder	28.3	—	—
Dosa	—	80.00	—
Raw *dosa* mixture	—	—	80.00

D_1– Skim milk powder diet had 9.5 ppm zinc.
D_2– Plain *dosa* diet had 22.6 ppm zinc.
D_3– Plain *dosa* zinc supplemented diet; 50 ppm zinc as zinc sulphate was added to plain *dosa* diet.
D_4– Raw *dosa* mixture diet had 22.6 ppm zinc.
D_5– Raw *dosa* mixture zinc supplemented diet; 50 ppm zinc as zinc sulphate was added to raw *dosa* mixture in order to prepare zinc supplemented diet.

Skim milk powder diet contained 9.5 ppm zinc. The zinc unsupplemented diets (D_2 and D_4) contained 22.6 ppm zinc and the zinc supplemented diets (D_3 and D_5) were prepared by adding 50 ppm zinc as zinc sulphate to the zinc unsupplemented diets. The diets and deionised water were provided to rats *ad libium*. The animals were weighed at weekly intervals. The protein efficiency ratio of different diets was calculated according to the procedure of Chapman[8].

At the end of the experimental period, the rats were sacrificed after anaesthetising with chloroform; blood was drawn from the aorta. Liver was removed, cleaned of connective tissue, weighed and stored in polythene bags at–4°C. Right femur was removed and analysed for zinc content. Faeces were collected during last week of experimental period and analysed for nitrogen and zinc content.

Results and Discussion

Dosa and raw *dosa* mixture were found to contain same amount of crude protein and crude fibre (Table 2). However, the *dosa* had slightly more fat as compared to raw *dosa* mixture and this increase is due to oiling of *tava*.

The data on the effect of feeding different diets on the protein efficiency ratio, liver weight and liver protein are given in Table 3. The gain in body weight in *dosa* diet (D_2) fed group was more as compared to that in raw *dosa* mixture diet (D_4) fed group. The increase in the nutritive value of *dosa* diet (D_2) may be due to better protein utilization of fermented and baked product as compared to raw mixture and also to more Zn availability. The improvement in the body weight was further observed when Zn was supplemented to the diet. The small difference in body weight gain in groups fed Zn unsupplemented and supplemented diets may be due to the fact that the level of Zn available from the former diet was marginally sufficient to meet requirements for growth. The difference in protein intake, protein efficiency ratio (PER) values in D_2,

TABLE 2. CHEMICAL COMPOSITION OF *DOSA* AND RAW *DOSA* MIXTURE (G/100G)

Nutrients	*Dosa*	Raw *dosa* mixture
Crude protein (N×6.25)	12.60	12.50
Ether extract	1.50	1.00
Crude fibre	0.19	0.19
Phytate phosphorus	0.06	0.55

TABLE 3. GAIN IN BODY WEIGHT, PER, LIVER WEIGHT AND LIVER PROTEIN IN RATS FED DIFFERENT DIETS FOR 4 WEEKS

Diets	Protein intake (g)	Gain in body wt. (g)	PER	Total liver wt. (g)	Total liver protein (g)
SMP (D_1)	20.17±0.22	52.75±3.76	2.61±0.16	2.83±0.17	0.73±0.16
Plain *dosa* (D_2)	18.99±0.83	43.16±8.65	2.27±0.38	2.66±0.43	0.64±0.07
Dosa+Zn (D_3)	19.68±0.80	48.33±7.39	2.45±0.28	2.79±0.70	0.67±0.16
Raw *dosa* mixture (D_4)	17.88±1.01	36.33±12.35	2.01±0.59	2.62±0.25	0.64±0.10
Raw *dosa* mixture+Zn (D_5)	18.93±1.01	42.16±6.84	2.22±0.25	2.67±0.32	0.65±0.04

Values are Mean±S.D.

D_3 D_4, and D_5 diets fed groups were statistically not significant.

The maximum liver weight and liver protein content were observed in the control group (D_1) and the minimum was in the raw *dosa* mixture diet (D_4) fed group. The difference in the total liver weight and liver protein of various groups were however statistically not significant. Similar results were reported by various workers[10,11] by feeding zinc dificient and supplemented pulse diets to rats.

Faecal nitrogen excretion/day (Table 4) was more in Zn unsupplemented diet fed groups (D_2 and D_4) as compared to that in Zn supplemented diet fed groups (D_3 and D_5) and the difference was significant. More faecal nitrogen excretion was found in Zn unsupplemented raw *dosa* mixture diet (D_4) fed group as compared to plain *dosa* diet (D_2) and Zn supplemented *dosa* diet (D_3) fed groups and the difference was statistically significant. In Zn supplemented diet fed groups (D_3 and D_5) the nitrogen absorption was maximum.

TABLE 4. NITROGEN INTAKE AND FAECAL NITROGEN EXCRETION IN RATS FED DIFFERENT DIETS

Diets	N intake/day (mg)	Faecal N excretion/day (mg)	N absorbed/day (mg)
D_1	115.14±1.25	17.55±0.31	98
D_2	107.93±3.71	24.65±3.39	83
D_3	112.80±4.56	20.16±0.83	93
D_4	101.14±5.68	28.04±1.35	73
D_5	108.09±6.44	23.61±2.66	85
C.D. at 5% level		2.77	8.9

Values are Mean±S.D.

There was a significant difference in the faecal zinc excretion in D_3 and D_5 diet fed groups (Table 5). The high faecal zinc excretion may be due to impairment of both the absorption of dietary zinc and reabsorption

TABLE 5. EFFECT OF FEEDING DIFFERENT DIETS ON FEMUR WEIGHT, FEMUR ZINC, PLASMA ZINC, AND FAECAL ZINC EXCRETION IN DIFFERENT GROUPS OF RATS

Diets	Dietary Zn intake (μg/day)	Faecal Zn excretion (μg/day)	Dietary Zn absorbed (μg/day)	Total femur wt (mg)	Total femur Zn (μg)	Plasma Zn (μg/100 ml)
SMP (D_1)	76.03±0.95	62.53±3.92	13.50	140.33±12.42	32.00±2.25	117.00±1.41
Plain *dosa* (D_2)	169.53±5.76	160.20±2.38	9.33	100.35± 8.78	30.35±3.80	85.00±2.47
Dosa+Zn (D_3)	566.76±22.80	497.33±3.20	69.43	114.36±10.80	37.27±5.93	128.00±6.36
Raw *dosa* mixture (D_4)	160.23±9.17	156.80±8.39	3.43	83.65±15.86	21.00±3.89	69.00±6.01
Raw *dosa* mixture+Zn (D_5)	539.05±18.71	514.00±9.07	25.05	96.28±13.72	32.22±4.66	106.00±2.82
C.D. at 5%	17.95	7.91		16.62	7.44	

Values are the Mean±S.D.

of indigenously secreted zinc. The amount of dietary zinc absorbed per day in Zn unsupplemented *dosa* diet fed group (D_2) was more as compared to zinc-unsupplemented raw dosa mixture diet group (D_4). Zinc supplemented *dosa* (D_3) group absorbed more zinc per day as compared to the zinc supplemented raw *dosa* group (D_5). *Dosa* is a fermented product and during fermentation the phytate content is reduced (Table 2). The increased availability of Zn in plain *dosa* diet (D_2) as compared to the raw *dosa* diet (D_4) fed group may be due to decrease in the phytate content in the *dosa*.

There was significant difference in femur weight between plain *dosa* (D_2) and raw *dosa* mixture diet (D_4) fed groups. The femur Zn content was the highest in Zn supplemented *dosa* diet group (D_3) and was lowest in the raw *dosa* mixture diet (D_4) fed group; the difference was significant. The increase in femur zinc content in D_2 and D_3 diet fed groups may be due to more availability of Zn from the diets.

The Zn unsupplemented plain *dosa* fed group (D_2) had higher plasma zinc content as compared to Zn unsupplemented raw dosa mixture diet fed group (D_4) and this may be due to decrease in phytic acid content and better Zn availability from the diet.

On the basis of the present investigation, it may be concluded that the zinc unsupplemented raw *dosa* mixture diet produced lower gain in body weight, PER, liver weight, liver protein, femur zinc, plasma zinc and lower zinc absorption as compared to zinc unsupplemented plain *dosa* diet, when fed to albino rats. The difference in the various parameters may be due to more availability of zinc and better protein quality of *dosa* diet as compared to raw *dosa* mixture diet.

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The Effect of Polishing Jowar *(Sorghum vulgare)* on the Nutritive Value of Protein

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A common jowar variety was investigated in rat experiments for protein quality by PER and NPU methods. Unpolished jowar showed higher PER and NPU values than jowar, polished at a higher degree. Lysine supplementation of jowar, increased its PER. The livers of jowar-fed rats had a higher fat content which could be reversed by lysine supplementation. Polishing between 5 and 8% was found optimal. Neither polishing nor storage for 11 months affect the protein quality of jowar. Jowar bran added to a control casein diet reduced its PER, as also did pure cellulose at 20 and 15% level, but not at 8%. Faecal bulk of rats fed jowar or control diets supplemented with cellulose was higher than controls. The faeces of rats fed jowar and a cellulose containing control diet had a higher nitrogen content.

Jowar (*Sorghum vulgare*) is one of the staple millets of poorer rural populations in India[1]. Certain components, such as tannins and phytin, mainly present in the bran layer, cause antinutritional effects at higher concentrations[2,3]. Polishing improves the appearance of the grain and to some extent its nutritional quality[4,5]. On the other hand, polishing also removes some of the important nutrients and thus reduces the overall nutritional value of the grain[6-8]. Dietary fibre present in the bran of cereals can have beneficial and also adverse effects[9]. Higher concentrations of fibre may reduce the absorption of nutrients, specially when the protein level in the diets is marginal. With lysine as the first limiting amino acid in jowar, animals fed this cereal as exclusive protein source showed a reduced weight gain and the protein and fat contents of the rat liver were affected[10-12]. Since lysine is found in higher concentrations in bran and germ, the lysine content of jowar is further reduced through polishing. The proper degree of polishing may therefore be crucial for the exclusive jowar eater. Factors influencing the protein utilization of a widely consumed jowar variety have been studied in relation to the effect of polishing and supplementation with lysine. The optimal degree of polishing was determined on the basis of the protein utilization.

Materials and Methods

A commonly marketed variety of jowar, yellowish-white and of medium size, was used. Polishing was done in a laboratory McGill mill after previous moistening of the jowar grains. The bran was dried after milling and passed through a 18 mesh sieve and weighed. On the basis of the bran weight the percentage of polishing was determined. The jowar grains were ground into flour for the experimental diets. Protein content was determined by the micro-Kjeldahl method, fat by Soxhlet extraction and lysine by microbiological assay[13]. The tannin content of jowar samples and bran was estimated by modified Vanillin-HCl (MV-HCl) method[14,15]. The values were expressed as catechin equivalents (CE).

The utilization of jowar protein was tested by the protein efficiency ratio (PER) and net protein utilization (NPU) method. For the PER studies, 21-day old male weanling rats of Wistar strain, randomized for weight, were fed for 28 days with 10 animals per group. The experimental diets were compared with a casein-corn starch control diet of equal protein, calorie and fat content. A vitamin mixture at 1 per cent level and a mineral mixture at 4 per cent level were added, according to the ISI specifications[16]. The rats were pair-fed and weighed weekly. To avoid spillage of the diets these were mixed with hot water and made into a paste. At the end of the PER study the rats were sacrificed.

NPU was determined for unpolished and polished jowar (>10 per cent level), according to the method reviewed by Venkat Rao *et al.*[17] and compared with a control diet as described above.

During most of the PER studies the faeces of the rats were collected groupwise, their dry weight deter-

mined and also their protein content. At the end of the PER experiment, the livers of the rats were collected, dried and their fat content estimated.

In a series of PER experiments the effect of various aspects of polishing was studied: (*a*) initially the difference in PER values between unpolished and polished (10—12 per cent) jowar, (*b*) the effect of lysine supplementation of polished and unpolished jowar on PER values and the fat content of the rat liver. Lysine as L-lysine HCl was supplemented to equal the lysine level of casein, (*c*) the effect of tannic acid added to a control diet at the tannin level of the bran of the studied jowar variety, (*d*) the effect of addition of bran to polished jowar to find out whether the process of polishing could affect the protein quality, (*e*) bran added to a control diet at 20 per cent level was also tested in PER studies. (*f*) The possibility of protein changes during storage was considered and jowar, stored for 11 months, was tested against new jowar. PER of both, stored and fresh, was tested with unpolished and polished jowar. PER was also done with lysine supplemented new jowar, polished and unpolished. (*g*) To find out the optimal degree of polishing jowar was polished from 0—19.3 per cent, as described above (*see also* Table 3). (*h*) Since addition of bran to a control diet had reduced the PER values, it was attempted to find out the effect of cellulose as single bulk constituent. A commercially available purified cellulose was therefore added to a control diet at 20, 15 and 8 per cent level, compared with a control diet and jowar at 0, 5 and 12 per cent polishing representative of low, high and zero level of polishing.

Results and Discussion

The protein content of the jowar samples ranged from 7.0–11.7 g per cent and the moisture between 6.2 and 12.5 per cent depending on the season. Values for fat, tannin and lysine contents are given in Table 1. PER studies showed that:

(*a*) Jowar polished for more than 10 per cent level showed lower PER values than unpolished jowar (Table 2–4).

TABLE 1. FAT, TANNIN AND LYSINE CONTENT OF JOWAR

	Fat (%)	Tannin (CE)	Lysine (mg/g N)
Unpolished jowar	2.9	0.16	0.22–0.26
Polished jowar	2.0	0.12	0.15–0.21
Bran	7.9	0.20	0.36

TABLE 2. PER AND FAT CONTENT OF LIVERS OF RATS FED STORED AND FRESH JOWAR

Group	PER*	Fat content+ of liver(%)
Control (casein)	2.83^{a}	12.9
Polished jowar (stored)	0.61^{b}	20.4^{b}
Unpolished jowar (stored)	0.87^{d}	20.3^{b}
Polished jowar (new)	0.63^{b}	20.2^{b}
Unpolished jowar (new)	0.98^{d}	21.4^{b}
Unpolished jowar (new)+lysine	2.21^{e}	12.3^{a}
Polished jowar (new)+lysine	2.26^{e}	13.7^{a}

*Means of the same column followed by different superscript differ significantly at 5% level, according to Duncan's New Multiple Range test ($P<0.05$)

+Based on dry wt of the liver.

TABLE 3. PER AND LIVER FAT CONTENT OF RATS FED JOWAR AT DIFFERENT LEVELS OF POLISHING

% Polish	PER*	Fat content+ of liver (%)
Control (casein)	2.66^{a}	14.7^{a}
4.8	0.52^{bed}	23.2^{b}
4.8	0.66^{b}	19.6^{b}
7.5	0.63^{bc}	21.7^{b}
11.8	0.40^{d}	20.6^{b}
16.1	0.45^{cd}	18.8^{b}
19.3	0.45^{cd}	20.5^{b}

*Means of the same column followed by different superscripts differ significantly at 5% level according to Duncan's New Multiple Range test ($P<0.05$).

+Based on dry weight.

TABLE 4. PER AND FAT CONTENT OF LIVER OF RATS FED JOWAR AND CELLULOSE CONTAINING DIETS

Group	PER*	Fat content+ of liver (%)
Control (casein)	3.05^{a}	12.5^{ab}
Unpolished jowar	0.89^{b}	18.2^{c}
Control+20% cellulose	2.59^{c}	13.6^{a}
Jowar polished at 5.2%	0.86^{bd}	24.4^{d}
Control+15% cellulose	2.85^{e}	9.2^{b}
Jowar polished at 11.9%	0.73^{d}	22.9^{d}
Control+8% cellulose	3.03^{a}	10.6^{ab}

*Means of the same column followed by different superscripts differ significantly at 5% level.

+Based on dry wt of liver.

(*b*) Lysine supplementation at the level of casein increased the PER values. The livers of the jowar fed rats, independent of the degree of polishing, had a statistically significant higher fat content than the control (Tables 2–4). The fat content of the liver of the lysine supplemented groups of rats did not differ from the values of the control group.

(*c*) Addition of tannic acid to a control diet did not affect its PER value.

(*d*) Readdition of bran to flour of polished jowar gave a PER value of 1.03 against 1.20 for unpolished jowar. These values were statistically not significant.

(*e*) However, addition of jowar husk at 20 per cent level to a control casein diet decreased the PER values significantly in two repeated experimental series by 0.5 (3.3 to 2.8 and 2.6 to 2.1 respectively).

(*f*) The PER value of jowar protein was not affected by 11 months storage (Table 2).

(*g*) PER studies with jowar, polished from 0–19.3 per cent level showed a statistically significant difference between the samples polished below 10 and above 10 per cent. Polishing at a low level seemed to improve the protein utilization compared with unpolished jowar though the values were not significant statistically (Table 3).

(*h*) Addition of cellulose at 20 and 15 per cent level to a control diet reduced the PER values significantly. However, 8 per cent cellulose level did not affect the protein utilization (Table 4).

The NPU values were 82.6 per cent for control, 50.9 per cent for unpolished jowar and 43.9 per cent for polished jowar. These values differ significantly at 5 per cent level.

The NPU values also showed a lower protein utilization for polished jowar. The high bulk diets produced a larger volume of faeces, though not directly proportionate to the dietary bulk, where at higher levels a difference in the weight of the faeces was not found (Table 5). The higher protein content of the faeces of jowar and high bulk diet may not be indicative of unutilized dietary protein but of a higher bacterial load and/or a higher cellular turnover of the intestinal mucosa, though increased peristalsis may reduce protein absorption. Goussault *et al.*[18] tried to connect nitrogen digestion with the pentosans of the grain bran. In this study both jowar bran and cellulose added to the control reduced the PER values.

PER and NPU values of unpolished and polished jowar above 10 per cent compare well with those of Eggum *et al.*[19] Lysine, the first limiting amino acid of jowar, seems to be the main cause for low PER values and high fat content of the rat liver. A loss of 19 to 32 per cent of lysine was reported by Balasubramanian *et al.*[20] when ground jowar samples of one variety were stored. Storage of jowar grains, as done in this study, did not affect the protein quality.

TABLE 5. TOTAL FOOD AND PROTEIN INTAKE OF RATS AND WEIGHT AND PROTEIN CONTENT OF FAECES*

Group	Total food intake (g)	Protein intake (g)	Faeces dry wt. (g)	Faeces proteins content (g) (N × 6.25)
Control	1676	155	99	29
Unpolished jowar	1148	88	151	27
Polished at 5%	1136	86	120	33
Polished at 12%	1180	78	127	43
Control + 20% cellulose	1957	181	437	92
Control + 15% cellulose	1939	175	456	76
Control + 8% cellulose	1682	138	135	27

*Weight of groupwise collected faeces.

The process of polishing did not seem to lead to any nutrition-specific changes of the protein, since PER values of unpolished and polished jowar with readdition of the removed bran were comparable. Ten per cent polishing of jowar was considered optimal by Raghavendra Rao and Desikachar[4] judged by the chemical composition and grain appearance. Considering, however, the PER results of this investigation polishing between 5–8 per cent seems to be a reasonable range.

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RESEARCH NOTES

EFFECT OF SOME MINERALS ON THE PRODUCTION OF *MORCHELLA ESCULENTA* MYCELIUM

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Studies on the effect of minerals on the production of *Morchella esculenta* mycelia indicate that optimum levels of KH_2PO_4 and $MgSO_4.7H_2O$ are 0.1 and 0.05% respectively and those of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$ are 0.0023 and 0.0015%, respectively. Calcium ion when added as $CaCl_2.2H_2O$ has got a stimulatory effect on the growth of the mushroom mycelia.

Mushrooms are known to be good sources of proteins, vitamins and minerals[1-5] and their large scale production would be desirable. For submerged cultivation of mushroom, it is important to select a proper strain which will give a high yield, has good nutritional value and pleasant flavour. The morel mushroom or *Morchella* variety is ideal for this purpose as the mycelia retain the flavour of the fresh mushroom.

Mushrooms require suitable carbon and nitrogen sources as also minerals for their growth. Role of particular mineral element required by a fungus to complete its life cycle is described by Arnon[6] and Nichloas[7]. Other workers[8-10] have studied the effect of minerals on mushroom mycelia production. Litchfield *et al.*[9] studied the effect of phosphate on the growth of *Morchella* species on organic waste minerals. However, there is no report on the requirements of minerals for production of *Morchella esculenta* mycelia and this paper presents the results of such work.

Morchella esculenta was obtained from Solan, India. The culture was maintained on potato-dextrose-agar slants and transferred weekly. Inoculum was prepared by transferring the mycelial mass of two PDA slants to 50 ml water taken in a 250 ml Erlenmeyer flask together with 30 glass beads and left on a rotary shaker (120 rpm) for 48 hr at 22±2°C. Five ml of this suspension was used as standard inoculum for 45 ml medium. The effect of the following minerals (in per cent) was studied in the synthetic medium: sucrose 4.5; $NaNO_3$ 0.75; KH_2PO_4 0.1; $MgSO_4.7H_2O$ 0.05; $FeSO_4.7H_2O$ 0.0005; $ZnSO_4.7H_2O$ 0.0005 and pH 6.5. Triple glass-distilled water was used throughout the experiment. Chemicals used were of analytical grade. The solutions of sugar, nitrate and phosphate were purified by the adsorption method as the use of the chelation method for removal of trace element contaminants results in very low production of mycelia. The solutions of sugar, nitrogen and phosphate were each heated in an autoclave for 15 min at 15 lb pressure in the presence of excess precipitated $CaCO_3$ (15 g/l) and filtered while hot through Whatman No 1 filter paper. Removal of trace element impurities was caused by trace element alkalinity, which causes a precipitation of the alkaline earth metal (Ca) simultaneously with the undesired trace elements as phosphates, hydroxides, carbonates or basic carbonates. The calcium precipitate itself serves as an adsorbent. The filtered solutions of sugar, nitrate, phosphates and the mineral solutions were sterilized separately and mixed in required amounts, just prior to inoculation. For every experiment, 45 ml of medium was taken in 250 ml Erlenmeyer flasks and the pH adjusted. Inoculated flasks were incubated at 22±2°C on a rotary shaker (120 rpm) for 10 days after which the mycelial pellets were washed, dried at 60°C overnight and dry weight determined.

In a typical experiment, the mineral under observation was first omitted from and then added in graded doses to the basal medium in separate flasks to determine optimal concentration. A minimum of four sets was taken for each experiment.

The results of the experiments are shown in Tables 1 and 2. The optimum concentrations of KH_2PO_4 and $MgSO_4.7H_2O$ for production of mycelia of *Morchella esculenta* were 0.1 and 0.05 per cent respectively while those of $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$ were 0.0023 and 0.0015 per cent respectively. It is interesting to note that there was production of mycelia, though poor, in the absence of iron salt. This may have been due to either the medium not being absolutely free from iron, or that some other elements present have the sparing effect. Growth was also prominent in the absence of zinc. It was, however, seen that for maximal growth of mycelia trace amount is necessary. Calcium has a profound effect on the biomass production by *Morchella esculenta*[9]. In order to find the effect of calcium ion on production, $CaCl_2.2H_2O$ was selected as it is soluble in the medium and it has got stimulatory effect on growth of *Morchella esculenta* mycelium.

The present study on the mineral requirements of the organism for growth has helped in the selection of a suitable synthetic medium of the following com-

TABLE 1. EFFECT OF MINERALS ON THE PRODUCTION OF *M. ESCULENTA* MYCELIUM

Concn. KH_2PO_4 (%)	Mycelial wt (g/l)
0.00	1.9
0.05	5.2
0.10	10.2
0.12	7.7
0.15	6.8
0.17	6.6
Concn. $MgSO_4.7H_2O$	
0.00	2.5
0.02	4.9
0.03	8.4
0.05	10.9
0.08	10.2
0.10	6.9
0.20	4.7
Concn. $CaCl_2.2H_2O$	
0.00	12.2
0.10	12.7
0.30	15.1
0.50	16.8
0.80	16.3
1.00	15.3
2.00	13.4

TABLE 2. EFFECT OF IRON AND ZINC ON PRODUCTION OF *M. ESCULENTA* MYCELIUM

Concn. of $FeSo_4.7H_2O$ (mg/100 ml)	Mycelial wt (g/l)
0.0	0.8
1.5	9.6
1.8	9.7
2.0	10.8
2.3	11.2
2.5	10.1
2.8	9.6
Concn. of $ZnSO_4.7H_2O$ (mg/100 m)	
0.0	9.3
0.5	11.5
0.8	12.2
1.0	12.3
1.5	12.9
2.0	11.8
3.0	11.2

position: sucrose, 4.5; $NaNO_3$, 0.7; KH_2PO_4, 0.1; $MgSO_4.7H_2O$, 0.05; $FeSO_4.7H_2O$, 0.0023; $ZnSO_4.7H_2O$, 0.0015; and $CaCl_2.2H_2O$, 0.5; and pH 6.5±0.1. The mycelial yield of *Morchella esculenta* in this medium was 16.8 g/l.

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EFFECT OF ROASTING ON PROTEIN QUALITY OF CEREALS

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Protein quality of roasted wheat, maize and rice was studied by feeding to albino rats. Protein efficiency ratio, true digestibility, biological value and net protein utilisation decreased significantly on roasting. Relative nitrogen utilisation also decreased on roasting but the effect was more with rice and maize compared to wheat.

Cereals constitute a major part of Indian diets and in addition to baking and boiling, a number of products are made after roasting. Though roasted grains are not part of regular meals, they contribute significantly

in the form of snacks to the daily intake of cereals. Roasting makes the grains crunchy so that they are easily masticated and improves their acceptability. However it might adversely affect protein quality due to high temperature. In the present study an attempt was made to study the effect of roasting on protein quality of wheat, maize and rice

Samples of wheat, maize and paddy were procured from the local market and processed as follows. Maize grains were soaked in water for 2 hr, sun-dried and then roasted; paddy and wheat were directly roasted. Roasting was done along with sand at a temperature of 220–280°C for 2–2½ min. The samples were cleaned and finely ground and analysed for proximate principles. Methionine was estimated according to Horn *et al.*[1] after hydrolysis of fat free samples with 6N HCl. Available lysine was estimated using the method of Carpenter[2] as modified by Booth[3].

Wheat and maize diets were prepared at 10 per cent protein level but rice diets at 5 per cent protein level because of the low protein content of rice. Crude fibre and fat were adjusted to 5 and 10 per cent, respectively, by the addition of non-nutritive cellulose and refined groundnut oil. Vitaminised starch and salt mixture were prepared as described by Chapman *et al.*[4] and Hawk and Oser[5] and were added to diets at 1 and 4 per cent levels, respectively. Casein and skim milk powder were used as reference proteins for 10 and 5 per cent level of dietary protein. The diets were fed to 24-day old male albino rats and protein efficiency ratio (PER) and nitrogen utilisation were calculated as described by Evans and Witty[6]. Relative nitrogen utilisation (RNU) was calculated using skim milk as standard. True digestibility (TD), biological value (BV) and net protein utilisation (NPU) were estimated using adult rats (average weight of 350 g) carcass method as described by Evans and Witty[6].

As shown in Table 1, the methionine content of raw grains was within the normal range. The slight increase in methionine content of roasted grains might be the result of loss of moisture. Kapoor and Gupta[7] showed that roasting did not affect the methionine content of soy protein. Available lysine for wheat was 1.84g/16g N. Lysine availability of 70 per cent has been reported by Gupta *et al.*[8] using weanling mice for wheat. Roasting of wheat decreased available lysine by about 40 per cent. Losses between 10 and 30 per cent have been reported during baking of bread and were higher when bread was toasted[9]. Roasting of maize and rice decreased the available lysine to the extent of 54 and 68 per cent, respectively, in the present study.

As reported earlier by others[10-12] the protein efficiency ratio of all the three cereals decreased on roasting and it was probably the result of binding the already limiting amino acid lysine. Diets prepared from roasted maize and rice did not support growth. In rice, in addition to loss of lysine, low protein content of the diet might have aggravated the decrease in the PER value. The PER value of casein at 10 per cent level (1.85) was, however, lower than the standard value and this might be the result of processing conditions; similar low PER values (1.63±0.08) for casein were also reported by Shao Wenlin *et al*[13]. due to unexplainable reasons.

The relative nitrogen utilisation (RNU) also decreased on roasting and the effect was maximum in

TABLE 1. EFFECT OF ROASTING OF CEREAL ON PROTEIN QUALITY

Cereal grain	Methionine (g/16g N)		Lysine (g/16g N)		PER		Relative N utilization		True digestibility		BV		NPU	
	Raw	Roasted	Raw	Roasted	Raw	Roasted	Raw	Roasted	Raw	Roasted	Raw	Roasted	Raw	Roasted
Wheat	1.34	1.34	1.84	1.12	1.61 ±0.21	1.05 ±0.44	63.72 ±16.20	57.73 ±17.18	80.37 ±4.50	76.38 ±5.00	58.78 ± 8.81	50.91 ±9.26	46.99 ±5.26	38.79 ±8.12
Maize	2.37	2.46	1.79	0.82	1.21 ±0.32	1.38 ±0.70	6.77 ± 1.08	4.27 ± 1.62	71.00 ±2.83	66.37 ±4.22	74.53 ± 9.74	52.76 ±8.32	52.63 ±6.56	37.01 ±8.07
Rice	2.38	2.43	3.09	0.96	1.67 ±0.27	1.54 ±0.59	80.60 ±12.00	30.63 ±14.06	91.89 ±6.52	68.93 ±1.14	71.12 ±10.27	37.80 ±7.04	67.33 ±8.91	26.14 ±4.80
Casein	—	—	—	—	1.85 ±0.23		78.20 ± 5.40		87.46 ±1.40		62.49 ±4.98		52.62 ±3.78	
Skim milk	—	—	—	—	1.66 ±0.05		100		90.50 ±2.09		76.64 ± 6.51		69.30 ±5.09	

Mean±S.D. values are average of 8 rats in each group.

rice followed by maize and wheat. The RNU was low for raw maize compared to raw rice and wheat diets. Roasting decreased relative nitrogen utilisation also. The true digestibility coefficient (TD) was highest for rice and lowest for maize. Roasting decreased the digestibility of the proteins of all the three cereals, the damage being greater in case of rice. The BV of raw wheat (58.78) and raw rice (72.38) corresponded to the literature values[14] but BV of raw maize was higher and this was probably due to low digestibility (66.37) of maize in the present study compared to digestibility value of 90 reported by Mitchell *et al.*[10] The BV of all the cereals decreased on roasting probably due to decrease in lysine availability.

The net protein utilisation (NPU) of raw grains corresponded to values reported in literature[14] but a significant decrease was found in the NPU values of all the grains on roasting and this was possibly the effect of loss of lysine availability during roasting.

The results of the present study confirm the fact that roasting adversely affects the protein quality of cereals due to decrease in available lysine. Hence supplementation of roasted cereals with lysine rich grains such as legumes becomes all the more important.

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MALTING QUALITY OF RAGI VARIETIES: NUTRIENT AND MINERAL COMPOSITION OF THEIR MALTS

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Malts were prepared from eight newly introduced brown and white varieties of ragi (*Eleusine coracana* Gaertn.) viz., 'JNR 852' 'JNR 981', 'JNR 1008', 'PR 202', 'WR 13', 'CO 9', 'WR 5', and 'WR 4'. They differed significantly in crude protein (4.6 to 5.7%), NPN (0.148 to 0.346%), true protein (2.6 to 4.8%), carbohydrate (73.7 to 83.1%), soluble sugar (2.9 to 9.9 mg/100g), fat (1.2 to 2.3%) and phytic acid (160 to 190 mg/100g) contents. Amylase activity of malt flour from brown seeded varieties was higher than white seeded varieties. Mineral composition of malt also showed significant differences in calcium, magnesium, sodium, potassium, sulphur, phosphorus, copper, manganese, zinc and iron content. The malting process reduces the phytic acid content thereby improving the nutritional quality of the product.

Malting of ragi is done in many parts of India and tropical Africa. Recently many high yielding varieties of ragi have been released; it is therefore necessary to evaluate their relative malting qualities. With these objectives the present investigation was undertaken to study the malts prepared from these new varieties of ragi.

Grains of eight improved varieties ('JNR 852', 'JNR 981', 'JNR 1008', 'PR 202', 'WR 13', 'CO 9', 'WR 5', and 'WR 4') of ragi (*Eleusine coracana*) were obtained from the breeder seeds production unit of J.N. Krishi Vishwa Vidyalaya, Jabalpur. Ragi malt was prepared as described by Malleshi and Desikachar[1]. The proximate principles of malt were assayed according to the

methods of A.O.A.C.[2] Non protein nitrogen (NPN) content was determined by the method of Bhatty *et al.*[3] NPN was subtracted from the total nitrogen content and multiplied by 6.25 to calculate the true protein (TP). Soluble sugars and phytic acid were estimated according to Dubois *et al.*[4] and Rosenbaum *et al.*[5] Amylase activity of malt flour was determined by the method of Bernfield[6]. Germination percentage was determined by keeping 100 seeds in a petri dish, having filter paper soaked with distilled water, this being kept at 25°C for 72 hr in a germinator, and then counting the germinated seeds.

The mineral content of ragi malt flour was determined in diacid digest (5:2) of nitric and perchloric acid: Calcium and magnesium by versenate titration[7], phosphorus and sulphur according to Koening and Johnson[8], and Bardsley and Lancaster[9] respectively, copper, iron, zinc and manganese by atomic absorption spectroscopy[7] and sodium and potassium by flame photometery[7]. The experiment was conducted in complete randomized design with three replications and the data were analysed statistically.

Biochemical characteristics of ragi malt: A significant variation among the varieties was observed for protein, carbohydrate, fat and soluble sugar content of the whole meal flour of ragi malt. As shown in Table 1 the malt from 'JNR 852' had the highest protein whereas that from 'JNR 1008' had the lowest protein content. The NPN and TP content varied from 0.15 to 0.35 per cent and 2.6 to 4.8 per cent respectively; these findings corroborate the study of Malleshi and Desikachar[1,10]. The carbohydrate and soluble sugar content varied from 73.7 to 83.1 per cent and 2.9 to 9.9 mg/100 g respectively; 'WR 4' and 'PR 202' contained the highest amounts of these constituents respectively. The germination percentage varied from 77.7 to 93.0 per cent. The brown seeded varieties proved better in their malting quality due to higher percentage of germination and high α-amylase activity of their malt as compared with the white seed coat varieties. These observations are in agreement with the earlier report[1] that brown seeded varieties are superior for malting.

Mineral content of ragi malt: From Table 2 it is seen that the whole meal malt flour of different cultivars of ragi showed significant differences in the minerals content. Ragi malt is rich in calcium and phosphorus; it contained lower levels of calcium than the control seed (331.80 to 542.4 mg/100 g). This could be due to the removal of bran or husk from the malt seed while preparing malt flour[11]. The sulphur and magnesium content of ragi malt ranged from 88.5 to 137.0 mg/100 g and 170.6 to 233.4 mg/100 g, respectively. The variety 'JNR 1008' had the highest amount of potassium and sodium. Among the micro nutrients iron and copper ranged from 6.7 to 10.2 mg/100 g and 0.75 to 1.10 mg/100 g respectively, whereas zinc and manganese contents were highest in 'PR 202'. 'CO 9', (3.5 mg/100 g) and 'CO 9' (44.40 mg/100 g), respectively. Phytic acid, an antinutritional factor, was found to be highest in white ragi whereas brown cultivars had the lowest.

TABLE 1. COMPOSITION OF RAGI MALT

Sl. no.	Varieties	Germination (%)	Protein (%) N X 6.25	Amylase activity*	Ether extractive (%)	Total carbohydrate (%)	Soluble sugars (mg/100g)	Non-protein N (%)	True protein (%)
1.	'WR 13'	93.0	5.5	300.1	1.2	78.5	2.9	0.185	4.4
2.	'JNR 852'	85.3	5.7	222.4	1.3	80.5	6.7	0.160	4.8
3.	'PR 202'	89.7	4.8	217.6	1.1	73.7	9.9	0.259	3.5
4.	'JNR 1008'	86.7	4.6	208.8	2.2	76.8	6.8	0.148	3.6
5.	'CO 9'	84.7	5.5	190.4	1.7	77.1	9.2	0.305	3.0
6.	'WR 4'	83.0	4.8	166.4	2.0	82.1	9.5	0.346	2.6
7.	'WR 5'	82.3	5.5	156.8	1.3	83.1	8.6	0.185	4.3
8.	'JNR 981'	77.7	5.0	156.8	1.1	76.8	3.8	0.185	3.9
SEM		±2.5	±0.2	±8.8	±0.1	±1.8	±0.5	±0.015	0.2
C.D. at 5%		7.7	0.5	26.4	0.3	5.6	1.7	0.046	0.6

Sl. no. 1, 5, 6 and 7 are white cultivars of ragi and remaining are brown seeded.

*mg maltose released by 1g of malt flour when acted on 1 ml of 1% starch at 37°C for 30 min.

TABLE 2. MINERAL CONTENT (MG/100G) OF RAGI MALT

Variety	Calcium	Phosphorus	Sulphur	Magnesium	Sodium	Potassium	Iron	Zinc	Copper	Manganete	Phytic acid
'WR 13'	379.2	339.6	99.4	180.1	8.0	98.6	9.8	2.5	0.75	41.8	128.0
'JNR 852'	447.6	311.6	131.6	176.9	8.3	101.3	7.4	3.2	0.75	41.4	173.0
'PR 202'	453.1	311.6	108.9	233.4	7.8	88.0	7.0	3.5	0.87	62.1	160.0
'JNR 1008'	458.3	314.3	137.0	195.3	9.5	104.0	7.7	3.1	0.86	24.0	182.0
'CO 9'	325.0	349.6	88.5	176.9	9.2	88.0	10.2	3.5	0.90	44.4	167.3
'WR 4'	337.1	349.6	117.5	195.9	8.5	96.0	7.3	2.6	1.10	49.9	190.0
'WR 5'	410.8	284.4	90.0	199.0	8.0	101.3	7.0	3.0	0.82	36.6	187.0
'JNR 981'	474.1	304.0	121.3	170.6	9.1	93.3	6.7	3.0	0.90	39.6	186.3
SEM	±26.6	±03.3	±2.6	±12.0	±0.43	±1.88	±0.66	±0.15	±0.076	±0.69	±8.8
C.D. at 5%	80.3	10.1	7.9	36.4	1.31	5.68	2.01	0.47	N.S.	2.08	26.4

As regards the quality of ragi for preparation of malt, varieties 'JNR 1008' and 'JNR 981' seem to be most suited while other varieties are intermediate. These varieties are also superior in other constituents. Since preparation of ragi malt is very easy both at the household and at the village level, these improved varieties can be used for preparing ragi malt of higher nutrient composition, which may find use in weaning food or other special food preparation[12].

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QUALITY CHARACTERISTICS OF PROMISING HIMACHAL OLIVE VARIETIES (*OLEA EUROPAEA* L.)

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The mesocarp of four varieties of olives were examined for crude fat, protein, total ash and sodium, potassium, calcium and phosphorus. The variety 'Coratina' gave maximum oil content of 43.4 per cent. The major fatty acids in the oil observed were oleic, linoleic and linolenic. Traces of lauric, myristic, arachidic, eicosenoic were also found. The storage stability of olive varieties on the basis of their unsaturated and saturated fatty acids ratio is in the order: 'Coratina', 'Laccino', 'Balanquata' and 'Pendolino.'

Italian and Spanish varieties of olives have, recently been introduced in Himachal Pradesh. Elaborate plan

for extension of olive cultivation in the State, is in the process of execution and the annual production is expected to reach 100 tonnes by 1984–85. The cultivation at present is confined to Panarsa, in Mandi District and is also introduced in Solan area. This study was conducted for appraising the suitability of four varieties viz. 'Balanquata', 'Pendolino', 'Coratina', and 'Laccino' of olives from Panarsa, 1983–84 crop, for processing on the basis of chemical parameters and fatty acids composition.

The moisture, ash, ether extractives (crude fat) were assayed by AOAC[1] method. Nitrogen was estimated by Kjeldahl method using Kjeltec assembly. Sodium, potassium and calcium were estimated flame photometrically, while phosphorus and iron were determined colorimetrically[2,3]. For fatty acid determination the oil was extracted from the mesocarp with petroleum ether (60–80°C) and purified by Folch *et al.* method[4]. Methyl esters obtained by saponification, removal of unsaponifiable matter and esterification with 4 per cent HCl in methanol at 70–90°C for 12–14 hr[5] were studied by gas liquid chromatography. The operating conditions of GLC were: Pye Unicam-GLC instrument 204 series, Reoplex glass column, 2 m length, $\frac{1}{4}$ in diameter, nitrogen as the carrier gas, 35 ml/min flow rate, detector FID, column temperature 190°C, injection port and detector temperature 270 and 300°C respectively. The retention times of methyl esters were compared with authentic samples and the amounts were calculated as the average of triplicate analysis values of integrated area percentages.

The olive varieties were examined for crude fat, protein and total ash contents of mesocarp and the results on dry weight basis varied from 40.0–43.4, 3.5–5.1 and 2.5–3.6, respectively (Table 1). The range of Na, K, Ca and P contents were 42–59, 1360–1700, 127–199 and 72–115 mg/100 g, respectively. The oil from 'Balanquata', 'Coratina' and 'Laccino' varieties had linoleic content of 59.0, 49.2, 49.6 per cent, respectively which is lower compared to the corresponding high oleic acid content of 35.5, 39.3, 36.4 per cent, respectively (Table 2). The oil of 'Pendolino' variety was characterized by a relatively high linoleic (85.1 per cent) and lower oleic acid (10.1 per cent) content. The difference in composition is not reflected in the iodine value that varied between 63.6 and 67.1. Seven fatty acids were identified in the oily fraction of different varieties. The major fatty acids in olive oil were, oleic (10.1–39.4 per cent) linoleic (49.2–85.1 per cent) and linolenic (2.8–8.3 per cent). In addition, traces of lauric, myristic, arachidic and eicosenoic were also found in olive oil. The total saturated and un-saturated fatty acids varied from 0.3 to 8.6 and 91.4 to 99.7 per cent, respectively. On the basis of the ratios of total unsaturated to saturated fatty acids, the stability efficiency of the oil among the varieties could be arranged in the order of 'Coratina', 'Laccino', 'Balanquata' and 'Pendolino'. The physical and chemical characteristics of Himachal olives are in variance with the information available in literature. This may be due to the different agroclimatic conditions.

TABLE 1. CHEMICAL COMPOSITION OF OLIVE VARIETIES GROWN IN HIMACHAL PRADESH

Constituents	'Balan-quata'	'Pendo-lino'	'Coratina'	'Laccino'
Fat (g/100g)	40.00	40.60	43.40	41.00
Protein (g/100g)	5.13	3.88	3.50	3.75
Total ash (g/100g)	3.64	2.55	2.55	2.78
Na (mg/100g)	59	45	59	42
K (mg/100g)	1640	1700	1430	1360
Ca (mg/100g)	136	163	199	127
P (mg/100g)	111	72	115	94

TABLE 2. CHARACTERISTICS OF THE OLIVE OILS FROM VARIETIES GROWN IN HIMACHAL PRADESH

Fatty acids	'Balan-quata'	'Pendo-lino'	'Coratina'	'Laccino'
12:0	—	1.80	1.12	0.83
14:0	—	—	2.01	0.60
18:1	35.53	10.19	39.30	36.48
18:2	59.00	85.13	49.20	49.60
18:3	5.20	2.88	2.90	8.33
20:0	0.27	—	1.00	0.83
22:0	—	—	4.47	3.33
*UFA/SFA	36.90	54.50	10.62	16.88
Iodine value	67.10	63.60	66.90	66.10
Refractive index	1.484	1.482	1.481	1.482

*UFA-Unsaturated fatty acids; SFA-Saturated fatty acids

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EVALUATION OF OIL FROM OLIVES GROWN IN HIMACHAL PRADESH

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Oil of seven cultivars of olive (*Olea europaea*) growing in Solan (H.P.) was extracted and evaluated. The cultivar 'Leccino' gave highest oil yield (40%) as compared to other cultivars. The Himachal olive oil showed low iodine value ranging from 63 to 77 and a very low free fatty acid percentage indicating better storage quality and commercial acceptability of the oil. The cultivars 'Ascoiterana', 'Cornicobra Attica', 'Frantoio' and 'Pendulino' showed higher saponification value as compared to other cultivars. Unsaponifiable matter varied from 0.6 to 1.2. Hehner number of olive oil, from all the cultivars, ranged from 92.8 to 98.2. Oil from Himachal Pradesh olives showed characteristics similar to that of oil obtained from Italy or other olive producing countries and can find a good market acceptability.

Olive (*Olea europaea*) plays a dominant role in the economy of Mediterranean countries of Europe (Spain, France, Italy and Greece). Other major olive producing countries are Australia and Argentina[1]. In India exotic cultivars of olive are under trial in Jummu & Kashmir, Himachal Pradesh and Uttar Pradesh and commercial cultivation is at infancy stage. The oil is used for edible purpose and for application on human skin as it is known to have some medicinal properties[2,3]. Some cultivars have been introduced in Himachal Pradesh during 1976. Information on characters of olive oil with respect to cultivars grown under Indian conditions is not available. Attempts have therefore, been made to study some of the properties of olive oil extracted from cultivars grown under the agro-climatic conditions prevailing in Himachal Pradesh and results are reported in this paper.

Seven cultivars of olive (*Olea europaea* cvs. 'Ascoiterana', 'Leccino', 'Pendulino', 'Groseena', 'Cornicobra Attica', 'Cornicobra' and 'Frantoio'), growing in the orchards of the Department of Pomology and Fruit Technology, Solan (H. P.) were selected and the fruits were harvested at fully ripe stage during 1983.

One hundred gram fruit in each case was kept in an oven at 70°C till constant weight was obtained. From the moisture-free fruits the oil was extracted using Soxhlet apparatus. Excess of the solvent was removed under reduced pressure in rotary-evaporator. The oil extracted was analysed for various parameters in triplicate. Specific gravity was determined with specific gravity bottle and refractive index with an Abbe Hand Refractrometer at 16.5°C. Saponification value, unsaponifiable matter, iodine value (Wij's) and Hehner number were determined following the method of AOAC[4]. Free fatty acid (FFA) as oleic acid percentage was estimated by Pearson's method[5].

The results presented in Table 1 show that the moisture content of the fruits was highest in 'Cornicobra Attica' followed by 'Cornicobra'. The cultivar 'Cornicobra' had the lowest whereas 'Leccino' had the highest percentage of oil. Wide range of oil yield in the olive fruits indicates that choice of cultivar can go a long way in bringing olive cultivation at commercial scale. The cultivar 'Leccino' with high oil content is found to grow well even in the low altitude of Bilaspur[6]. The values of specific gravity of olive oil (Table 1) growing in the agro-climatic conditions of Himachal Pradesh are higher than those reported in literature[1]. 'Cornicobra Attica' showing highest and 'Ascoiterana' lowest refractive index and the values are quite comparable to that reported by Ockerman[7] and BP[8]. Iodine value which indicates the degree of unsaturation was lowest in 'Ascoiterana'. Raina *et al.*[9] also reported iodine value ranging from 63.6 to 67.1 for olive oil from Kulu in Himachal Pradesh. The iodine value of oil obtained from Italy, Argentina, Tunisia and Morocco varies from 78.0 to 88.3, 84.1 to 87.6, 80 to 92 and 84 to 93, respectively. Thus, iodine values of olive oil from Himachal Pradesh are lower than the values reported by others[5,10-12]. Non-drying nature of olive oil is considered to be an important character for its use and non-drying oils mostly have low iodine value. Woodman[1] reported that lower the iodine

TABLE 1. MOISTURE CONTENT OF FRUITS, OIL YIELD AND CHEMICAL CHARACTERS OF OIL FROM DIFFERENT CULTIVARS OF OLIVE GROWN IN HIMACHAL PRADESH

Cultivar	Oil yield* (%)	Sp. gr. (I6.5°C)	Refractive index (I6.5°C)	Iodine value (Wij's)	Sapon. value	Unsapon. matter (%)	Hehner number (%)	FFA (as oleic acid) (%)	Moisture (%)
'Ascoiterana'	26.3	0.921	1.468	63.5	211.8	0.9	96.0	1.04	65.0
'Leccino'	40.5	0.960	1.470	70.6	191.5	0.6	96.3	1.42	68.2
'Pendulino'	20.9	0.901	1.469	73.2	200.4	1.2	92.8	1.49	63.5
'Groseena'	20.2	0.935	1.472	70.0	195.3	0.7	94.4	0.58	66.4
'Cornicobra Attica'	14.9	0.951	1.474	71.7	211.8	0.8	98.0	0.86	70.0
'Cornicobra'	11.7	0.922	1.469	65.6	188.5	0.7	98.2	0.90	69.0
'Frantoio'	25.0	0.904	1.472	77.0	201.1	1.0	98.2	0.90	67.3

Values are means of triplicate determinations.

*On moisture free basis.

value, more is the acceptability of oil. Saponification value was relatively higher in 'Ascoiterana', 'Cornicobra Attica', 'Frantoio' and 'Pendulino' as compared to the values reported from foreign sources[2,10]. Relatively higher saponification value indicates that fatty acids in olive oil of Himachal Pradesh have shorter carbon chain length. Unsaponifiable matter was present upto 1.2 per cent in 'Pendulino' and 0.6 per cent in 'Leccino'. The range of unsaponifiable matter is within the acceptable limits and close to the values reported in literature[12]. However, the values are higher as compared to those reported from Tunisia[12]. Hehner number, determining the insoluble fatty acid percentage varies from 92.8 to 98.2 which is relatively close to the values reported by Pearson[5] and is within the range of acceptable limits[8]. High fatty acid percentage is considered undesirable for storage. According to PFA[13] free fatty acid should not exceed 3 per cent. Olive oil extracted from different cultivars of olives of Himachal Pradesh shows free fatty acid percentage well below the acceptable limits.

From the data presented above it can be concluded that oil extracted from olives grown in Himachal Pradesh shows characteristics similar to that of oil obtained from Italy or other olive producing countries. However, olive oil from Himachal Pradesh olives has lower iodine value and free fatty acid percentage than oil from other regions and, therefore, can find a better market acceptability. The cultivar 'Leccino' grows well even in lower hill areas and is promising with respect to oil yield.

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SEMI-PILOT PRODUCTION OF SUCROSE FROM DATES AND SWEET SORGHUM USING ETHANOLIC EXTRACTION TECHNIQUE

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A semi-pilot plant was designed to extract sucrose from dates (*Phoenix dactylifera*) and other sources using ethanolic extraction technique. Dates harvested early in September gave a maximum of 19.0% sucrose compared with 11.4% for dates harvested in late September. The presence of starch, aconitic acid and reducing sugars did not impose a limitation on the use of this method for extraction of sugar from sweet sorghum (*Sorghum bicolor*) stalks.

The increasing domestic consumption of sugar in Iraq brought our attention to the possibility of producing sugar from dates (*Phoenix dactylifera* L., var. Zahdi) and sweet sorghum (*Sorghum bicolor* L. Moench). Becuase of the high content of reducing sugars, ash and colouring material, extraction of sucrose from dates using the methods in vogue for the production of sugar from sugar cane or beet would not be possible[1].

There is a surplus of low priced Zahdi dates available during September in Iraq. Also ethanol is available locally at reasonable price from the fermentation of low grade Zahdi dates and other agricultural sources. As for sweet sorghum, it is a short duration crop of 100 to 130 days and it can be grown twice yearly (Autumn and Spring) in Iraq which makes the process running all year through.

Many methods were used for the crystallization of sugar from sweet sorghum[2,3] using the sugar cane and sugar beet processing techniques. The modifications made on such methods were mainly concerned with the elimination of starch and precipitation of aconitic acid for satisfactory sugar recovery.

In our laboratory, a solvent extraction technique on semi-pilot scale was developed for the recovery of sucrose from Zahdi dates[4,5]. The applicability of this method for Zahdi dates and sweet sorghum stalk as a starting material for sugar production was tried.

The Zahdi dates used in this study were harvested

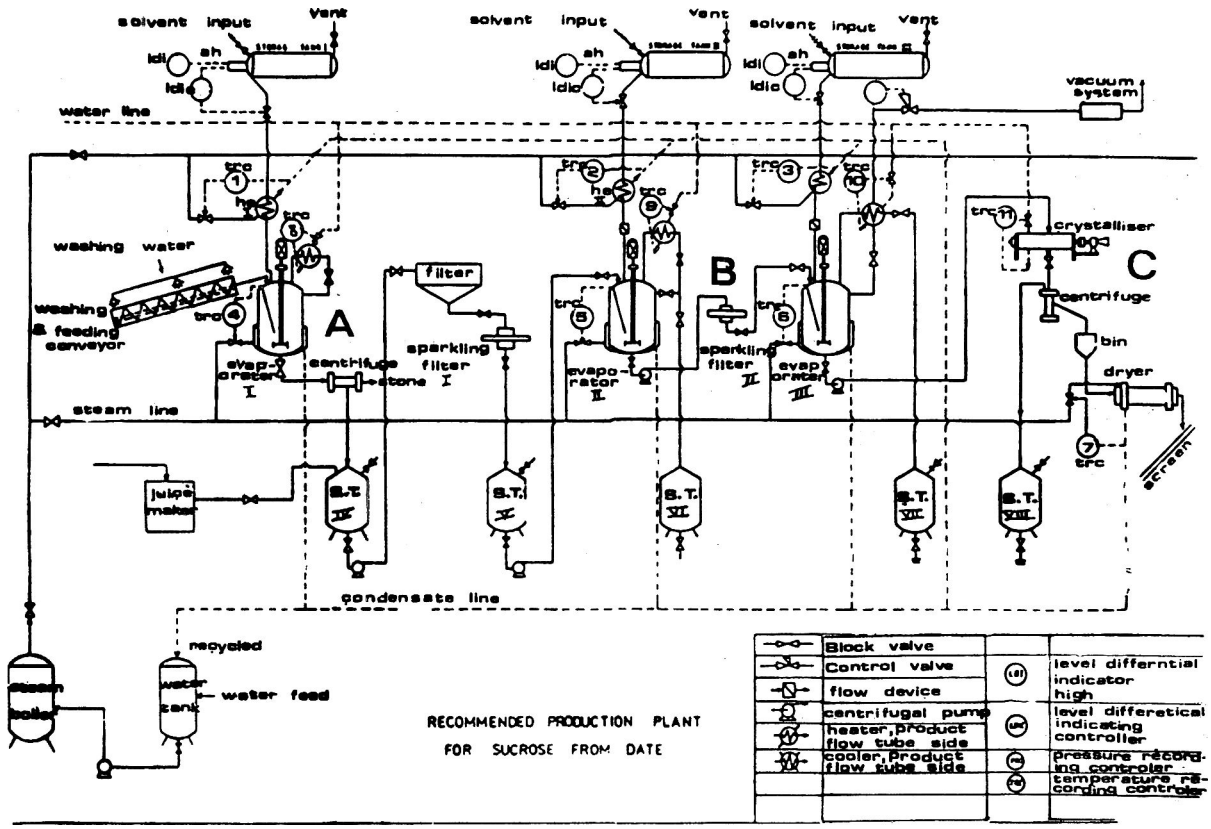

Fig 1. Pilot plant recommended for the production of sucrose from dates and sweet sorghum using ethanolic extraction technique

from Za' afarania Experimental Station and the sweet sorghum varieties 'Mn-1500', 'Sart', 'Rio', 'Killer', 'Wray', 'Roma' and 'Rex' were obtained from our experimental field station.

Colorimetric determination of sugars was carried out according to the method of Bernfield[6]. Starch was determined as described by Smith and Reeves[7], and Dubois *et al*[8]. Aconitic acid in sorghum was estimated as described by Poe and Barrentine[9].

The process used for the production of sucrose from dates is outlined in Fig 1, which is as follows:

Date juice preparation: Dates were cooked in water (1:5w/v) in jacketed vessel at 100°C for 1–1.5 hr. Raw juice was pumped to a rotary vacuum filter and then a sparkling filter and collected in a storage tank.

Evaporation: Concentrated juice was separated from water in jacketed evaporators. Ethyl alcohol (95 per cent), 1:8 (w/v) was added to the concentrated syrup. Distillation was carried out at 50°C under reduced vacuum for 30 min and the juice was pumped to the next evaporator through sparkling filter. Ethyl alcohol (97 per cent), 1:12 (w/v) was added to this concentrated juice. Evaporation at total reflux was carried out for 1 hr at 50°C. The solution was then pumped to the crystallization stage after cooling.

Crystallization: A Swenson-Walker crystallizer was used with a long pitch spiral agitator at slow rotational speed. After the separation of sucrose, mother liquor was evaporated to separate alcohol from glucose-fructose syrup.

Preparation of sorghum extract: Sweet sorghum stalks were autoclaved at 121°C for 15 min followed by hydraulic pressing at 400 bar. The extracted juice was evaporated and aqueous ethanol was added as described for dates.

Table 1 shows the quantities of sucrose and other components recovered from dates. Stored Zahdi dates harvested in 1981 season gave a recovery of 10.1 per cent sucrose. Higher recoveries were obtained when fresh dates harvested in 1982 season were used. Dates harvested in early September gave a maximum of 19.1 per cent sucrose compared with 11.4 per cent for dates harvested in late September.

Complete utilization of date could be achieved. Glucose-fructose syrup recovered maintained a golden colour and acceptable taste after 4 months of storage, with no perceptible turbidity. Fibre and seeds obtained while crushing could be used as animal feed. The fibre was found to contain 1.7 per cent protein[10]. After sugar extraction, the ash content was 5.7 per cent on dry weight basis[11].

Juice extracted from fully mature sweet sorghum stalks by hydraulic filter press after autoclaving represent 60 per cent of the total weight calculated on wet basis. Sucrose recovery from the stalk depended on the variety. 'Rex' had the highest sucrose content of 24 per cent, but only 42 per cent was recovered. Whereas 'Sart' and 'Mn-1500' with lower sucrose content of 19.0 and 15.0 per cent respectively gave much higher recoveries of 82 and 80 per cent respectively. Other varieties were as good as these varieties for sucrose recovery. We used one step extraction but higher recovery could be obtained with more than one step extraction.

Aconitic acid content of the juices extracted from 'Sart', 'Rio', 'Killer' and 'Mn-1500' varieties was 0.07, 0.32, 0.43 and 0.30 g/100 ml respectively and the starch content amounted to 0.09, 0.08, 0.09 and 0.12 g/100 ml respectively. The aconitic acid contents of raw juices of the 'Rio' and 'Sart' varieties grown in our experi-

TABLE 1. SUCROSE RECOVERY FROM ZAHDI DATES USING ETHANOLIC EXTRACTION TECHNIQUE

Harvesting date	Sucrose^{+} (%)	Stones (g)	Fibre (g)	Glucose-fructose syrup (g)	Sucrose recovered (g)	Sucrose recovered (%)
19–9–1981*	10.5	120.3	362.4	411.1	101.1	10.1**
11–9–1982	19.6	122.8	342.1	333.3	190.4	19.0^{++}
18–9–1982	12.7	125.4	366.5	375.2	121.6	12.2^{++}
25–8–1982	11.8	120.1	360.8	376.8	113.7	11.4^{++}

*Deep-frozen for 1 year before processing.

$^{+}$Calculated by GLC,

**Mean of 10 experiments, each of 1 kg batch.

$^{++}$Mean of 4 experiments, each of 1 kg batch.

mental fields are considerably lower than values reported in juices from the same varieties grown elsewhere[9]. This observation is similar to that reported by Smith *et al.*[12]

Thanks are due to Mr. Kelly Freeman, Research Leader, U. S. Sugar Crops Field Station, Meridian, Missisippi, 39301 for providing sweet sorghum seeds and agronomic information which made this work possible and to Dr. I. Ibrahim from our faculty for growing the sweet sorghum.

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THE EFFECT OF DESALTING SUDANESE CHEESE ON GROWTH OF AND TOXIN PRODUCTION BY *STAPHYLOCOCCUS AUREUS* 196E

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Sudanese white cheese prepared from salted milk (8% W/V) inoculated with *Staphylococcus aureus* 196 E (toxins A and D producer) plus rennet tablets was packed in whey and stored for a week at 37°C. *Staph. aureus* count, general viable counts, pH, % NaCl and a_w, were determined before and after storage. After storage, it was submerged in *Staph. aureus* free tap water for 7 days and the above parameters were determined. Before steeping all parameters investigated were reduced except % NaCl increased while the contrary was observed after steeping. No toxin was detected after steeping.

Sudanese white cheese is traditionally prepared from raw brined cows or goats milks and packed in whey. It is usually stored at room temperature (28–37°C). It was observed that the consumers steep the cheese in tap water before eating to (*a*) lower the salinity, if it is intially high and (*b*) maintain the softness of the cheese. Storage at ambient temperature was found to result in undesirable sensory qualities like yellowish colour and hard texture.

In the present study cheese was prepared according to the Sudanese traditional method[1,2] from pasteurized milk inoculated with *Staph. aureus* 196E; toxin A and D producer, supplied by Prof. M. S. Bergdoll, Food Research Institute Wisconsin. The milk was pasteurized to destroy any *Staphylococci* that may be present in it. The product was stored in whey for one week in the traditional method. Duplicate samples of the cheese were taken before and after storage for determination of *Staphylococcus aureus* count, on Baird-Parkers medium recommended by TCMSF[3]; total viable count using Miles and Misra technique[4]; pH with pH meter 7020 (Electronic Instruments, England); percentage sodium chloride (NaCl) by Volhard titration procedure B[5] and the water activity (a_w) using Sina Nova equihygroscope Model SMA/T (Novasina A.C. CH 8050 Zurich). The average of the readings were tabulated.

The cheese was also screened for the presence of thermostable deoxyribonuclease (index of toxin pro-

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TABLE 1. *STAPH. AUREUS*, GENERAL VIABLE COUNT, PH, %NaCl, A_w AND ENTEROTOXIN CONTENT OF THE CHEESE

Type of cheese	*Staph. aureus* count/g	General viable count/g	pH	NaCl (%)	a_w	Enterotoxins A	Enterotoxins D
Before storage	5.9×10^5	4.2×10^6	6.4	7.4	0.935	-ve	-ve
After 7 days storage in whey	3.7×10^3	9.6×10^5	5.9	8.1	0.930	-ve	-ve
After storage in tap water for 1 day	4.0×10^3	1.5×10^5	5.9	7.7	0.937	-ve	-ve
2 days	9.3×10^4	1.6×10^7	6.2	7.4	0.940	-ve	-ve
3 days	2.1×10^6	2.8×10^8	6.2	6.9	0.945	-ve	-ve
7 days	8.3×10^7	7.1×10^{10}	6.2	5.3	0.969	+ve	-ve

duction) by Lachica *et al.*[6] method recommended by ICMSF[3] and a sample was kept in the deep freeze (-50°C); it was extracted to detect toxin production at the end of the investigation.

The rest of the cheese was transferred into a clean container, submerged under cool sterilized tap water, stored at 37°C for 7 days and samples were taken after 1, 2, 3 and 7 days for the determination of the parameters mentioned earlier.

The storage period was terminated since *Staph. aureus* numbers were observed to increase to about 10^8/ g at the end of the storage period while the salt content was reduced to 5.3 per cent. Also the cheese was inedible from an organoleptic stand point.

All the cheese samples were extracted by the acid extraction method of Reiser *et al.*[7] and the extracts examined for presence of enterotoxin by the double diffusion microslide technique of Casman *et al.*[8]

Table 1 shows that *Staph. aureus* counts of the unsteeped cheese were greatly reduced after one week of storage when compared to fresh cheese. While the decrease in the general viable count (GVC) was less than one log cycle. Since the *Staph. aureus* population contributes to the GVC the comparative small reduction in the latter could be due to the appearance of some salt tolerent organisms. The pH and a_w were also reduced while the per cent NaCl increased. After steeping, the surviving *Staph. aureus* increased after a lag-phase (Fig 1) which may be in response to change of environment. The *Staph. aureus* population and a_w continued to increase while per cent NaCl dropped.

The pH increased from 5.9 to 6.2 and then after wards remained constant. The experiment was terminated when the *Staph. aureus* count reached a level expected to produce enterotoxin. Enterotoxins were not produced except in the desalted cheese and after a week of storage, only enterotoxin A was detectable.

Staph. aureus population in the fresh cheese was less than 10^7 (5.9×10^5), the expected number to secrete detectable level of enterotoxin under normal growth conditions[9]. This number decreased to 3.7×10^3 during storage in whey for a week. This may perhaps be due to the increase in the actual indigenous salt concentration of the cheese and decrease of its a_w together with comparatively high temperature of food storage (37°C). It was also observed that the cheese texture had become progressively harder with increase of storage period. This agrees with Hojvat and Jackson[10] who found that high incubation temperature negatively

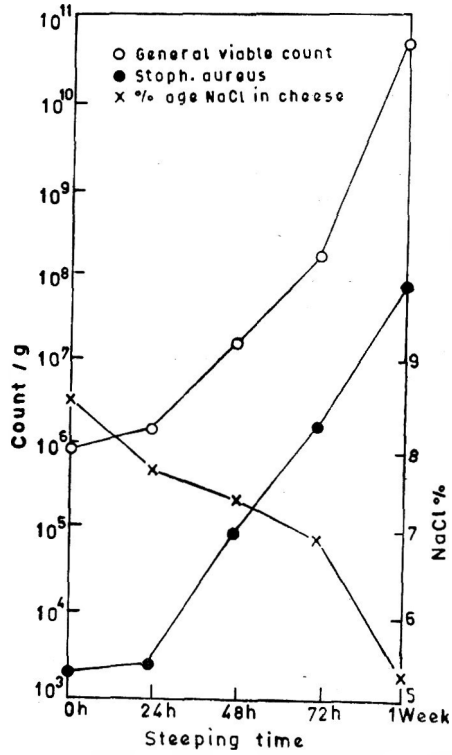

Fig 1. The effect of steeping on general viable count, *Staphylococcus aureus* count and percentage NaCl in cheese

affected growth of *Staph. aureus* in media containing salt, due to metabolic injury and drop of a_w. The effect of the declining a_w was in agreement with Troller[11] who reported that lowering a_w from 0.99 progressively unfavoured growth of *Staph. aureus* and enterotoxin A production.

Steeping cheese had resulted in (*a*) reducing the salinity, and (*b*) raising the a_w, allowing the surviving *Staph. aureus* to multiply after 7 days to a number capable of producing detectable level of enterotoxin A. (Table 1). In this sense desalting introduces more hazards to the consumer if the cheese to start with was free from enterotoxin.

The pH change may not be a key factor in this type of cheese, since the change is within the pH tolerance of the organism[12]. Nevertheless, very slight increase or drop may have played a role in retarding or enhancing the effect of salt and a_w through modification of the micro-environment[10,13].

Enterotoxin A was detected in the 7 days desalted sample, while enterotoxin D was not detectable. It may, perhaps, mean that production of enterotoxin D needs higher *Staph. aureus* count and a_w levels and lower storage temperature[13].

From this investigation it seems, even if cheese reached the consumer free of enterotoxins due to either check of growth of *Staph. aureus* or limitation of toxin production by one or more factors the consumer unwittingly encourages the growth of *Staph. aureus* and toxin production by favouring the conditions through steeping the cheese to decrease the salinity and retain the texture.

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BOOK REVIEWS

Progress in the Design and Operation of Refrigerating Equipment and in the Processing of Fruit and Vegetable by Refrigeration: International Institute of Refrigeration, 177, Boulevard Malesherbes—F 75017, Paris, France, 1982–4, pp. 436; Price: 170 FF.

The book contains the proceedings of commission B2, C2 and D1 of the International Institute of Refrigeration held in Sofia, Bulgaria to study the progress in the design and operation of refrigeration equipment and in the processing of fruit and vegetable by refrigeration. More than 200 experts from 21 countries presented 67 papers and they were thoroughly discussed. The Seminar was conducted according to the sections/commissions. The first section is on refrigeration machinery, and has 19 papers dealing specially on computer simulations and computer application of the energy concept. The second section deals with food science and technology where various parameters like efficiency of post-harvest chemical treatment of fruits and vegetable and other factors which influence ripening, on the mechanical properties and quality of fresh and frozen cereals and other related matters were considered. Another chapter was commission C_2/D1 on food science and technology and refrigerated storage. This chapter specially focusses attention on the changes in fruits when refrigerated in natural and conditioned atmosphere, thermal properties of package layers of fruit, a study on the effect of factors during static diffusion concentration of fruit juices and other related topics. The last section of the report discusses refrigerated storage where techno economic parameters and aspects in the design and construction of new fruit and vegetable stores in the European context and other construction details were dealt with. The proceedings were well presented and discussions and conclusions were summarised. The book is recommended for libraries dealing in post harvest technology specially in refrigeration and cold storage.

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Developments in Dairy Chemistry. 3. *Lactose and Minor Constituents*, Edited by P. F. Fox, Elsevier Applied Science Publishers, London and New York, 1985: pp:405, Price: Sw. Fr. 253.

This book is the third in the series on the chemistry and physical chemistry of milk constituents. It consists of eleven chapters, five with the milk sugar lactose and six with minor constituents like salts, vitamins and enzymes.

Lactose, the main carbohydrate of milk of most species, is a non-sweet, poorly soluble reducing disaccharide. It has many applications in food, pharmaceutical and chemical industries. Although estimated annual world wide availability of lactose is several million tons, not more than 10 per cent of this is actually utilized. However, with the advent of recent developments in technologies, its use particularly in food industries, has greatly increased. In Chapters 1–5, different aspects of lactose have been adequately covered, with more emphasis on industrial applications. Lactose has certain unique properties among sugars such as low sweetness, poor solubility, low osmolality and low digestibility. These may be advantageous or disadvantageous depending upon the application. All these physicochemical properties of lactose are discussed in the context of its applicability in Chapter 1. Like other sugars, lactose may be modified to yeild analogues. However, their current applicability is limited. With the advantage of improved methods of recovering lactose from whey, lactose might become a cheap and competetive chemical feed stock. Therefore, potential use of lactose analogues should increase in future. Various methods of chemical modification and potential use of lactose analogues are dealt in Chapter 2.

There is a widespread interest both from the nutritional and commercial view points, in reducing the lactose content of milk. The enzyme β-galactosidase of microbial origin is used to hydrolyse lactose. Recent advances in enzyme engineering, particularly enzyme immobilization methods, have yielded such a stable enzyme preparation, that enzymatic removal of lactose has nowadays become an economically viable and industrially applicable process. Therefore, a significant portion of Chapter 3 is devoted to a review of technology of applying the immobilized lactase for processing of milk and whey. Milk is considered a practically complete food, especially in the diets of developing countries. However, a majority of the world's population cannot digest milk (lactose intolerants) due to deficiency of β-galactosidase. Current views on this nutritionally important problem are discussed in Chapter 4. Under normal conditions, galactose formed from lactose by the action of intestinal β-galactosidase, is absorbed and metabolized in liver by the Leloir pathway. Deficiency of either galactose-1P, uridyltransferase or galactokinase results

in a relatively rare congenital disease known as galactosemia. Lactose being the principal source of galactose, galactose metabolism and galactosemia are aptly discussed as a part of lactose, which many reviews and books on lactose neglect. Instead of treating this in a separate chapter (Chapter 5), it could have been merged with Chapter 4.

Quantitatively, the salts of milk are minor constituents, but they play a disproportionately important role in many of the technologically important properties of milk. Recent literature on the rather complex chemistry of milk salts *per se*, is reviewed in Chapter 6. Since a variety of major as well as trace minerals are required for proper growth and development and milk is the sole source of these at a critical stage of infant growth, the significance of milk as a source of dietary minerals is discussed in Chapter 7. The flavour/off-flavour of milk and dairy products is undoubtedly technologically important and extremely complex and a comprehensive summary on this subject is presented in Chapter 8. Chapters 9, 10 and 11 review the recent literature on the indigenous enzymes in milk, indigenous antibacterial systems and vitamins, respectively.

There is some overlapping of the subjects, particularly with respect to chapters dealing with lactose. This is inevitable in such a multi-authored book. The book is well-written and includes adequate figures and tables. As a collection of authoritative and revelatory reviews written by authors who are well-known in their fields, this book puts the subject in a proper perspective and provides both opinion and forecast. This book should be of immense value to research workers, particularly in the food and dairy technological fields.

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AFST(I) News

Pantnagar Chapter

The Annual General Body Meeting of the above Chapter was held and the following office bearers were elected for the year 1986.

President:	Dr. N. S. Verma
Hony. Secretary:	Dr. Maharaj Narain,
Hony. Treasurer:	Dr. G. S. Chauhan.

Jabalpur Chapter

The Annual General Body Meeting of the above Chapter was held on 5th May 1986. The following executives were elected for 1986.

President:	Prof. Y. K. Sharma
Vice-President:	Dr. G. P. Keshervani
Hony. Secretary:	Sri L. P. Rajput
Hony. Jt. Secretary:	Ms. P. Sharma
Hony. Treasurer:	Sri A. Tomar

Trivandrum Chapter

The Annual General Body Meeting of the above Chapter was held on 8th July 1986 and the following office bearers were elected.

President:	Sri A. Govindan.
Vice President:	Sri S. K. Nanda
Hony. Secretary:	Dr. N. Gopalakrishnan
Hony. Jt. Secretary:	Sri V. B. Manilal
Hony. Treasurer:	Sri V. Sashidharan Nair

INSTRUCTIONS TO AUTHORS

1. Manuscripts of papers (in triplicate) should be typewritten in double space on one side of bond paper. They should be complete and in final form, since only minor corrections are allowed at the proof stage. The submitted paper should not have been published or data communicated for publication anywhere else. Only invited review papers will be published.

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

3. Names of chemical compounds and not their formulae should be used in the text. Methods of sampling, number of replications and relevant statistical analyses should be indicated. Super-scripts and subscripts should be legibly and carefully placed. Foot notes especially for text should be avoided as far as possible.

4. **Abstract:** The abstract should indicate the principal findings of the paper. It should be about 200 words and in such a form that abstracting periodicals can readily use it.

5. **Tables:** Tables as well as graphs, both representing the same set of data, should be avoided. Tables and figures should be numbered consecutively in Arabic numerals and should have brief titles. They should be typed on separate sheets. Nil results should be indicated and distinguished clearly from absence of data, which is indicated by '—' sign. Tables should not have more than nine columns.

6. **Illustrations:** Graphs and other line drawings should be drawn in *Indian ink* on tracing paper or white drawing paper preferably art paper not bigger than 20 cm (oy axis) $\times$16 cm (ox axis). The lettering should be such that they are legible after reduction to column width. Photographs must be on glossy paper and must have good contrast; *three copies* should be sent.

7. Abbreviations of the titles of all scientific periodicals should strictly conform to those cited in the World List of Scientific Periodicals, Butterworths Scientific Publication, London, 1962.

8. **References:** Names of all the authors along with title of the paper should be cited completely in each reference. Abbreviations such as *et al.*, *ibid*, *idem* should be avoided.

   The list of references should be included at the end of the article in serial order and the respective serial number should be indicated in the text as superscript.

   Citation of references in the list should be in the following manner:

   (*a*) *Research Paper:* Jadhav, S. S. and Kulkarni, P. R., Presser amines in foods. *J. Fd Sci Technol.*, 1981, **18,** 156.

   (*b*) *Book:* Venkataramar., K., *The Chemistry of Synthetic Dyes*, Academic Press, Inc., New York, 1952, Vol. II, 966.

   (*c*) *References to article in a book:* Joshi, S. V., in *The Chemistry of Synthetic Dyes*, by Venkataraman, K., Academic Press, Inc., New York, 1952, Vol. II, 966.

   (*d*) *Proceedings, Conferences and Symposia Papers:* Nambudiri, E. S. and Lewis, Y. S., Cocoa in confectionery, *Proceedings of the Symposium on the Status and Prospects of the Confectionery Industry in India*, Mysore, May 1979, 27.

   (*e*) *Thesis:* Sathyanarayan, Y., *Phytosociological Studies on the Calcicolous Plants of Bombay*, 1953, Ph.D. Thesis, Bombay University.

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

9. Consult the latest issue of the *Journal* for guidance.

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Research Papers

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