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Variability in the Physico-chemical and Milling Characteristics of Indian Triticales

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Ten varieties of Indian triticales were evaluated along with Canadian and American varieties for their physico-chemical and milling characteristics. For milling of triticales in a Buhler laboratory mill, 12% moisture level in the grain was found to be optimum. The flour yields from different varieties ranged from 49.2 to 66.4%. The triticale flours had high Kent-Jones colour grade value of 8.6 to 13.5 and relatively low damaged starch content (4.7 to 9.4%). The protein content in the grain and the flours ranged from 11.0 to 15.9% and 9.6 to 13.9% respectively. Low values of wet gluten (17.0 to 31.0%) and sedimentation test (11.0 to 26.8 ml) indicated that the protein lacked both in quantity and quality. The low falling numbers (179 to 350) indicated high alpha-amylase activity, not so desirable for bread making, but suitable for blending with Indian wheat flours deficient in this enzyme.

Triticale—the first man-made cereal synthesised by crossing wheat (*Triticum vulgare/durum*) and rye (*Secale cereale* L.)-has been appreciated by breeders and technologists for its special qualities[1,2]. Although some trials have been carried out on developing triticales from the Canadian and American strains to suit the agro-climatic conditions of some rain-fed areas in the Indian sub-continent, comprehensive data regarding the technological quality characteristics of these Indian triticales and their utilisation in bakery products are lacking. Only a few studies on the quality of some Indian triticales have been reported[3,4]. The results of studies on the physical, chemical and milling characteristics of ten promising Indian triticales are presented in the paper.

Materials and Methods

Test material: Ten varieties of Indian triticales, namely, *Armadillo PM*-4, *Armadillo PPV*-13, *Bromco*-90, *PC*-202, *MSN*-372-1, *JNK*-6*T*001-*A*, *JNK* 6*T*090, *JNK* 6*T*200, *JNK* 6*T* 206-*B* and *Triticale No*. 4 grown at Pantnagar, Indore and Phaltan were used along with varieties *Rosner* (Canada) as well as 6*TA*-204 and 6-*TA* 206 (USA).

Methods: The hectolitre weight was determined according to AACC procedure[5]. The pearling index of the grains was determined according to the method described by McCluggage[6], using a Corcoran barley pearler.

The milling experiments were carried out in a Buhler Laboratory Mill (type MLU-202) according to AACC Procedure[5] and the yields of straight run flour were determined. The triticale samples were conditioned to 12 per cent moisture for a period of 18 hr. prior to milling. Five varieties of triticiales were milled at 11, 12, 13 and 14 percent moisture levels to arrive at the optimum moisture content of triticales for milling. The whiteness of the flour was determined using a Kent-Jones Flour Colour Grader.

Moisture, total ash, wet gluten, pigments (as β-carotene), diastatic activity and damaged starch in whole grain flours and/or Buhler milled flours, were determined by AACC methods[5]. The crude protein ($N \times 5.7$) was estimated by micro-kjeldahl method. Falling number was determined in whole grain flour, using a Hagberg's apparatus.

Results and Discussion

Physical characteristics: The hectolitre weights (Table 1) of Indian triticales (*i*) compared favourably with those of American and Canadian varieties, (*ii*) were higher than those reported for triticales by Hill *et al.*[7] and (*iii*) were lower than those reported for either Indian durum or aestivum wheats[8,9]. The ratio of length to breadth of Indian triticales were comparable to those of American and Canadian controls. All the varieties of triticales had shrivelled grains.

Milling characteristics: All the triticales, except *JNK* 6*T*200, had pearling index of more than 19 (Table 1) and were higher than those of durum[8] and aestivum[9] wheats. This indicated the soft nature of triticale.

Studies relating to conditioning of triticale for milling

TABLE 1. PHYSICAL CHARACTERISTICS OF TRITICALES

Variety	Place of cultivation	Hectolitre wt. (kg.)	1000 kernel wt. (g.)	Length (mm)	Breadth (mm)	Pearling index
Armadillo PM-4	Pantnagar	68.5	41.5	76	30	27.2
Armadillo PPV-13	,,	70.5	46.8	79	33	21.2
Bromco-90	,,	72.5	43.2	80	32	19.3
PC-202	,,	73.0	41.1	76	30	24.2
MSN-372-1	Indore	70.0	43.1	74	30	20.4
JNK 6T001-A	,,	75.0	38.6	78	29	19.9
JNK 6T090	,,	64.0	41.2	86	32	23.4
JNK 6T200	,,	63.0	32.3	78	30	17.5
JNK 6T206-B	,,	71.0	38.2	70	30	20.5
Triticale No. 4	Phaltan	63.5	28.7	81	28	22.8
Rosner	Canada	68.0	41.9	76	33	26.9
6-*TA*-204	USA	65.0	43.2	83	32	21.5
6-*TA*-206	USA	65.5	42.2	89	33	21.5
Mean		68.4	40.15	78.9	30.9	22.0
S.D.		±3.96	±4.84	±5.04	±1.06	±2.8

indicated that 12 per cent moisture level was the optimum, based on the flour yield and ease of sifting flour. This low level of moisture for conditioning corraborated with the high pearling index of triticales.

The yield of flour from varieties, except *Triticale No.* 4 and *JNK 6T090* ranged from 56.4 to 66.4 percent, (58.78±4.81) and were considerab y lower than the normal range of 70 to 72 per cent for aestivum wheats. (Table 2). Such lower yields have been attributed to the low hectolitre weights by Rooney *et al.*[10]. They observed that yields of flour varied from 50.5 to 63.1 per cent, when triticales were conditioned to 13 per cent moisture. Farrell *et al.*[11] have also reported flour yields ranging from 54.4 to 67.5 percent (mean 62.9 per cent) for several varieties of triticales grown in different parts of USA.

TABLE 2. MILLING CHARACTERISTICS OF TRITICALES

	Milled products			Damaged starch %	Colour grade value
	Flour %	Shorts %	Bran %		
Armadillo PM-4	66.4	4.2	29.4	5.1	9.7
Armadillo PPV-13	61.4	12.9	25.7	8.6	9.1
Bromco-90	63.3	12.9	23.8	9.4	8.9
PC-202	61.5	11.0	27.5	5.1	11.4
MSN-372-1	57.7	15.5	26.8	6.1	9.0
JNK 6T001-A	63.5	10.0	26.5	4.7	9.0
JNK 6T090	49.2	19.6	31.2	7.0	8.6
JNK 6T200	57.0	8.6	34.4	4.7	9.3
JNK 6T206-B	57.5	13.7	28.8	7.4	8.8
Triticale No. 4	51.7	16.3	32.0	6.2	13.5
Rosner	56.4	11.7	31.9	4.7	8.9
6-*TA*-204	61.4	11.9	26.7	5.2	6.2
6-*TA*-206	57.2	16.7	26.1	5.7	6.8
Mean	58.8	12.7	28.5	6.2	9.2
S.D.	±4.81	±3.94	±3.08	±1.54	±1.80

The damaged starch content of the flours from triticales ranged from 4.7 to 9.4 per cent (6.15±1.54), which was considerably lower than that of durum wheats (9.3 to 15.5 per cent)[8].

The Indian triticale flours were darker in colour and had Kent-Jones colour grade value of 8.8 to 13.5 as compared to 6.2 to 6.8 of American triticale samples and 5.1 to 7.9 of wheat flour.[9] Unrau and Jenkins[12] also found the triticale flours to be darker than the wheat flour.

Thus, based on the criteria of high pearling index, low optimum level of moisture for milling and low damaged starch contents of flour, it may be inferred that triticales behave as soft wheat with respect to their milling characteristics.

Chemical characteristics: The protein contents of triticales (12.96±1.48), were higher than that of aestivum wheats.[9] However, the respective Buhler milled flours of triticales had protein contents comparable to those of wheat flours[9]. The advantage of higher protein content in triticale grain is lost when it is milled into flour for use in bakery products.

TABLE 3 CHEMICAL CHARACTERISTICS[a] OF TRITICALES AND TRITICALE FLOURS

Variety	Protein (N×5.7)		Wet gluten	Total ash %		Ether extractives	Crude fibre	Sugars (A)			Falling No. (A)	Sedimentation value ml (M)	Diastatic activity[d] (M)	Pigments[e] ppm (M)
	(A)	(M)	(M)	(A)	(M)	% (A)	% (A)	Reducing[b]	Non-reducing[c]	Total[b]				
Armadillo PM-4	11.3	9.5	23.9	1.70	0.53	1.62	1.92	61	239	409	237	16.9	195	0.57
Armadillo PPV-13	11.7	9.8	24.9	1.79	0.51	1.58	1.82	77	402	542	210	16.5	151	0.44
Bromco-90	11.0	9.6	17.0	2.01	0.55	1.89	1.98	68	419	554	350	11.1	145	0.73
PC-202	12.9	10.0	26.6	1.77	0.54	1.42	1.97	56	252	366	219	18.0	207	0.29
MSN-372-1	11.4	10.9	24.6	1.63	0.51	1.48	2.52	53	314	445	179	26.8	170	0.29
*JNK 6T*001-*A*	14.1	11.3	29.2	1.60	0.51	1.64	2.41	57	239	350	206	20.2	183	0.57
*JNK 6T*090	13.5	11.9	26.3	1.54	0.62	2.00	2.14	63	304	445	247	23.9	120	0.57
*JNK 6T*200	12.7	10.2	22.2	1.89	0.63	2.15	1.92	40	309	418	303	19.1	172	0.85
*JNK 6T*206-*B*	13.9	11.4	30.4	1.77	0.51	1.58	2.49	69	359	477	237	20.1	135	1.16
Triticale No. 4	15.9	13.9	31.3	1.98	0.78	1.81	3.08	60	412	532	236	18.8	265	1.42
Rosner	11.8	9.6	25.2	1.75	0.45	1.69	2.29	56	286	412	90	17.5	316	1.43
6-*TA*-204	13.8	11.5	22.8	1.60	0.42	1.38	3.11	48	270	334	200	21.0	370	—
6-*TA*-206	14.5	11.9	24.3	1.63	0.41	1.34	3.58	48	288	357	76	20.3	266	—
Mean	13.0	10.9	25.3	1.74	0.54	1.66	2.40	58	315	434	214	19.3	207	0.76
S.D.	±1.48	±1.28	±3.74	±0.15	±0.10	±0.24	±0.55	±9.9	±63.9	±74.6	±73.5	±3.8	±75.5	±0.41

a: On 14% moisture basis; *b*: As mg maltose/10 g sample; *c*: As mg sucrose/10 g sample *d*: As mg maltose/10 g sample/hr at 30°C *e*: As β-carotene

A: Whole triticale flour M: Buhler milled flour.

The triticales from Phaltan and Indore were better with respect to the quantity and quality of gluten, but had lower flour yielding potential, as compared to those from Pantnagar. These differences may be attributed to the agro-climatic conditions. Ruckman *et al.*[1] and Welsh and Lorenz[2] also observed that similar to wheat, the agronomic and climatic conditions affect the protein content of triticales.

Except *Armadillo PM*-4, *Armadillo PPV*-13 and *Bromco* 90, the other Indian varieties had either comparable or higher wet gluten contents and sedimentation values than those of Canadian or American varieties. However, these were considerably lower than those of aestivum wheats[9]. The triticale flours lacked both in quantity and quality of protein, as compared to strong wheat flour used for bread making. Also, the observations of Venkateswara Rao *et al.*[4] that the triticale flours are better suited for biscuit rather than bread making, indicated that they are weak with respect to their baking quality.

The interesting observation was the significantly lower falling numbers ranging from 76 to 350 (214 ± 73.5) for triticale flours than those of aestivum wheats (480 to more than 1000)[9]. The Indian varieties had higher falling number than either the Canadian or the American varieties. Such low falling number was indicative of very high α-amylase activity, which is likely to be an additional drawback with respect to their suitability for bread making. However, the triticale flours can be used with advantage for blending with wheat flour to correct the deficiencies of α-amylase activity, commonly observed in Indian wheats.

Unlike the α-amylase activity, no appreciable differences were observed between the diastatic activity of Indian triticales and aestivum wheats[9]. A singificant negative correlation of -0.5543 was observed between the falling number and the diastatic activity ($P < 0.05$) of the different triticale flours.

The pigments in the flours milled from Indian triticales were, lower than the Canadian variety *Rosner* (Table 3). This value of all the triticales was, however, considerably lower than those of Indian durum as well as aestivum wheats[8,9]. This showed that the triticales have not inherited higher pigments from their durum parent. The total sugar contents of both the American varieties (334 and 357 mg maltose/10 g sample) were lower than those of Canadian or most of the Indian varieties (409 to 554 mg maltose/10 g sample). The non-reducing and total sugar contents were also higher than those of Indian wheats[13].

The physical, chemical and milling results indicated that the triticales resemble soft wheat which is generally found suitable for the preparation of biscuits and not bread. Development of triticales with lower α-amylase activity will go a long way in avoiding the problems of shrivelling of the grain and the resultant lower flour yields.

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Studies on Chemical Development of Dough of Indian Wheats for Bread Making

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Chemical development of dough of two medium-protein (8.7 to 8.8 per cent) Indian wheats, 'WG 357' and 'WL 711', to eliminate bulk fermentation using 20-40 ppm L-cysteine HCl and 25-100 ppm of oxidants for breadmaking was investigated. Handling properties of doughs were satisfactory with 20 ppm-L-cysteine HCl but at 40 ppm the dough was sticky. Sodium stearoyl-2-lactylate (0.5 g/100 g) was superior to hydrogenated fat (1.0 g) in the formula. Sugar (2 per cent) and amylase supplement were essential in the chemically developed doughs for breadmaking. A combination of L-cysteine HCl (20 ppm) and bromate (75-100 ppm) gave higher loaf volumes, softer texture, finer grain and an attractive and uniform crust. Reducing the level of L-cysteine HCl to 10 ppm was inadequate for chemical dough development with or without the oxidants.

Chemical development of dough without the necessity for bulk fermentation for breadmaking was reported by Henika and Rodgers[1]. The potential of chemical dough development for producing an acceptable loaf of bread was studied by Coppock[2], Pace and Stewart[3] and Chamberlain *et al.*[4] As reported by Maninder and Bains[5], the Indian wheats are characterized by poor mixing time, medium-protein content, higher water absorption and high damaged starch content and these affect their suitability for breadmaking by the conventional methods involving bulk fermentation. The possibility of using chemical dough development for Indian wheats has been studied.

Materials and Methods

Bulk samples of two commercially grown wheat varieties, 'WG 357' and 'WL 711' (1976-77 crop) were obtained from the Department of Plant Breeding, Punjab Agricultural University, Ludhiana. After thorough cleaning, the wheats were conditioned to 15.5 per cent moisture content and milled in the pneumatic Laboratory Buhler Mill (MLU-202).

Analytical methods: Moisture, protein, gluten, ash, diastatic activity and damaged starch contents were determined by the AACC methods[6]. Colour grade was measured in the Kent-Jones and Martin flour colour grader, series 3 (Henry Simon Limited, Stockport, England). The effect of reductants on physical properties of gluten was determined by hand stretching.

Amylograph curves: The procedure used by Maninder and Bains[7] was followed. The effect of L-cysteine HCl (0, 20, 40 and 80 ppm), sodium stearoyl-2-lactylate (0.25 and 0.50g/100g flour) and amylase supplement (0.50 g/100 g flour) on the paste viscosity was determined.

Baking tests: The baking formula included the following ingrieaents:

	g
Flour	100
Fresh compressed baker's yeast	2.5
Salt	1.5
Sugar	2.0
Malt syrup (60°L)	0.25
Fat/sodium stearoyl 2-lactylate (SSL)	1.0/0.5

Reducing agents:

L-cysteine HCl	0, 10, 20 and 40 ppm
Potassium metabisulphite (KMS)	0 and 20 ppm

Oxidants: Ascorbic acid/potassium bromate 0, 25 50, 75 and 100 ppm The dough was optimally mixed in the Swanson mixer with various levels of reducing and oxidizing agents, finished at 30°C, rounded and given a floor time of 15 min before sheeting and moulding. The proofing was for 65 min at 30°C and 90 per cent R. H. The loaves were baked for 25 min at 232°C. After cooling, the loaf volume was measured by the rapeseed displacement method of Binnington and Geddes[8]. The effect of barley malt flour providing 5.0 and 10.0 SKB units/100 g flour in the chemically developed dough on loaf quality was evaluated.

Results and Discussion

The yield of straight grade flour from 'WL 711' was 73.9 per cent as compared to 71.7 per cent from 'WG

TABLE 1. COMPOSITION OF STRAIGHT GRADE FLOURS OF 'WG 357' AND 'WL 711' WHEAT VARIETIES

Variety	Protein N×5.7 (%)	Ash (%)	Diastatic activity (mg maltose/10g)	Damaged starch (%)	Wet gluten (%)	Gluten hydration index (water/g)	Colour grade (Kent-Jones)
'WG 357'	8.7	0.50	235	10.1	26.9	1.98	2.5
'WL 711'	8.8	0.49	250	9.7	28.7	1.95	1.3

357'. The composition of the straight grade flours of both the varieties is given in Table 1. There was not much difference in the damaged starch content, protein contents and the hydration index of glutens between the two varieties.

Effect of reductants on gluten: There was practically no difference in the amount of gluten recovered from doughs containing 0 to 80 ppm of L-cysteine HCl and 0 to 20 ppm of potassium metabisulphite. The extensibility of 'WG 357' gluten increased from 20.3 to 71.1 cm and of 'WL 711' from 30.5 to 48.3 cm when L-cysteine HCl was increased from 0 to 80 ppm. The cysteine HCl dough gluten had smooth surface and yellowish hue compared to the rather uneven appearance and greyish colour of the gluten of control samples.

Amylograms: The peak viscosity of 'WG 357' was 645 A.U. as compared to 615 A.U. of 'WL 711' (Table 2) which tended to decrease and the gelatinization temperature increased as the amount of L-cysteine HCl was increased to 80 ppm, With SSL, there was a meagre increase in the paste viscosities. Addition of malt syrup (0.5 g/100 g) remarkably decreased the peak viscosity.

Effect of reductants, oxidants and SSL/fat on bread-making: At the higher levels of L-cysteine HCl (60 to 80 ppm), the reducing action in the doughs was strong which were difficult to handle even with 75 to 100 ppm of added oxidants. The doughs with 40 ppm of L-cysteine HCl and upto 100 ppm of oxidants were somewhat sticky, when sheeted. The doughs with fat were stickier than those having SSL. The latter showed better handling properties.

The loaf volumes of 'WG 357' were from 500 to 510 ml when SSL was used without oxidant, but with 20 and 40 ppm of L-cysteine HCl. With 20 ppm L-cysteine HCl and 50, 75 and 100 ppm bromate, the loaf volumes increased to 565, 580 and 585 ml in 'WG 357' and 565, 585 and 595 ml in 'WL 711', respectively. Where fat was used instead of SSL comparatively lower volumes were obtained.

The SSL treated loaves had whiter crumb, finer grain, smoother and more uniform texture than those containing fat. Bromate treatment gave loaves of softer texture, finer grain, attractive and uniform brown crust as compared with the ascorbic acid treated loaves with and without L-cysteine HCl.

Addition of oxidants alone increased the loaf volumes

TABLE 2. EFFECT OF L-CYSTEINE HCL, SSL AND AMYLASE SUPPLEMENT ON THE AMYLOGRAMS OF 'WG 357' AND 'WL 711' FLOURS

Treatment	'WG 357'		'WL 711'	
	Gelatinization temp. (°C)	Peak viscosity (A.U.)	Gelatinization temp. (°C)	Peak viscosity (A.U.)
Control	73.0	645	73.0	615
L-Cys. HCl (ppm)				
20	73.5	620	73.5	540
40	76.5	605	75.5	520
80	77.5	600	75.5	520
SSL (g/100g)				
0.25	79.0	670	77.5	570
0.50	79.8	680	79.8	590
Malt syrup (g/100g)				
0.50	68.5	255	67.8	210

TABLE 3. EFFECT OF L-CYSTEINE HCL, OXIDANTS WITH SSL/FAT ON THE LOAF VOLUMES OF 'WG 357' AND 'WL' 711

Oxidants (ppm)	Loaf volume (ml) at different levels of L-cysteine HCl (ppm)											
	'WG 357'						'WL 711'					
	0		20		40		0		20		40	
	SSL	FAT	SSL	Fat	SSL	Fat	SSL	Fat	SSL	Fat	SSL	Fat
0 (Control)	515	505	505	510	505	505	520	520	515	505	505	500
Ascorbic acid												
25	545	515	535	545	515	525	550	575	520	515	520	515
50	545	535	530	550	520	520	560	575	530	520	520	525
75	555	535	535	565	540	525	565	575	540	535	535	525
100	560	545	550	575	545	535	570	585	550	535	545	525
Potassium bromate												
25	545	535	535	525	525	520	555	585	545	530	520	525
50	555	530	565	535	535	540	560	585	565	535	540	540
75	560	540	580	545	545	530	575	595	585	540	565	550
100	565	550	585	585	585	550	585	600	595	560	585	555

(Table 3), but higher levels of oxidant did not increase the loaf volume particularly in 'WG 357' irrespective of the addition of SSL or fat. The loaf volume increase of 'WL 711' ascribed to ascorbic acid and bromate is evident from Table 3. With 25 ppm of the oxidants, the development of doughs was optimum but at the higher levels, they became extensible probably due to over oxidation. The grain of ascorbic acid and bromate loaves was medium fine to fine and the crusts were browner. Between 75 and 100 ppm of oxidants, the crumb texture was softer. The crusts of bromate loaves were even. Response to the oxidants was noted when 'No time' dough method was used for baking with the advantage of better dough handling properties at the lower levels of the oxidants. The response to the oxidants depended on the wheat variety which was noteworthy. Lower levels of L-cysteine HCl (10 ppm) did not show much effect with higher levels (75 ppm) of the oxidant However, 20 ppm L-cysteine HCl and 75 to 100 ppm of the oxidants proved their effectiveness (Table 4). The results clearly revealed that the Indian wheats are responsive to reducing agents in improving the dough system and baking quality. Much higher amounts (240 ppm) of crysteine, were found necessary for the Canadian high protein wheat flours for development of dough using chemicals[9].

Addition of potassium metabisulphite and SSL increased the loaf volumes of both the varieties (Table 5) which further increased with the inclusion of the oxidants. The response of 'WL 711' to bromate increased the loaf volume of 'WL 711' (570 ml) more than that of 'WG 357' (545 ml). However, much difference was

TABLE 4. EFFECT OF REDUCING AGENTS, OXIDANTS, SSL/FAT ON LOAF VOLUMES OF 'WG 357 AND 'WL 711' FLOURS

Reducing agent	Quantity (ppm)	Oxidizing agent	Quantity (ppm)	Loaf volumes (ml) 'WG 357' SSL	'WG 357' Fat	'WL 711' SSL	'WL 711' Fat
L-cysteine HCl	10	Control	0	490	500	510	505
L-cysteine HCl	10	Bromate	75	530	535	535	530
KMS	20	Control	0	495	495	510	510
KMS	20	Ascorbic acid	75	540	535	535	530
KMS	20	Bromate	75	545	540	570	565

TABLE 5. EFFECT OF L-CYSTEINE HCL (20 PPM), BROMATE (75) WITH AND WITHOUT AMYLASE SUPPLEMENTS, ON THE LOAF VOLUMES OF 'WG 357' AND 'WL 711' FLOURS

Amylase supplement	Loaf volume (ml) 'WG 357'	'ML 711'
Control	535	505
Malt syrup (0.25%)	555	545
Sugar (2%)	530	545
Malt flour (5.0 SKB)	520	515
Malt flour (10.0 SKB)	555	535

not found between SSL and fat with 'WL 711'. The KMS, SSL and bromate loaves had very fine grain, softer texture and whiter appearance.

Significance of sugar in the chemically developed dough for baking: The handling properties of dough from both the varieties were good with amylase supplement but without sugar. The loaf volumes were lower when there was no sugar and amylase supplement but contained 20 ppm of L-cysteine HCl and 75 ppm of bromate in the dough system. Higher loaf volume was observed with sugar and the enzymatic malt syrup. Sugar and amylase supplements, therefore, seemed essential along with 20 ppm L-cysteine HCl and 75 ppm bromate for obtaining a good loaf of bread. The crusts of 'WL 711' loaves appreared lightyelow (anaemic) to light brown with 0.25 per cent amylase malt syrup, but turned brown when sugar (2 per cent) was included in the formula. The amylase supplement alone (10.0 SKB/100 g flour) produced loaves with anaemic and light brown crust that was ascribed to the limited time factor for the enzyme action in the chemically developed dough. Henika and Rodgers[1] observed that bromate (upto 40 ppm) alone improved the breadmaking quality. A combination of L-cysteine HCl (80 ppm), whey solids (4 per cent) and bromate (50 to 60 ppm) gave excellent loaf volume. When weaker flours were used, 70 ppm of cysteine with oxidants was found effective by Chamberlain *et al.*[4]

These results show that the level of cysteine was critical in medium protein flours. Sodium stearoyl -2-lactylate was superior to fat in various dough systems tested. There was definite improvement in the loaf volume with 20 ppm L-cysteine HCl and 75 ppm bromate which had contributed to superior crumb characteristics compared to ascorbic acid. Combination of amylase supplement with sugar in the formula was desirable for producing bread of improved quality and crust colour. The baking formula failed to perform normally when sugar was omitted and instead the amylase supplement providing 5.0 to 10.0 SKB/100 g was used.

Acknowledgement

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The Quality of Wheat Flour: Intervarietal Quantitative Differences, Between Gluten Components

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Flours (whole meal) from eleven wheat varieties of varying strength were fractioned to give respective albumins, globulins, gliadins, glutenins and residue proteins. When wheat varieties are arranged in the order of decreasing strength as measured by dough stability and dough development time, the ratio of residue protein to gliadin + glutenin is found to decrease. It is suggested that this ratio can be used as an index of flour strength. Usefulness of the ratio in formulating flours of desired strength has been demonstrated.

It is generally accepted that the unique visco-elastic properties of wheat flour doughs are due to gluten proteins[1]. Recognition ot this fact has led to attempts to relate varietal differences in the quality of wheat flours to their gluten content and quality. As early as 1896, it was suggested by Fleurent[2] that the ratio of gliadin to glutenin correlated with baking strength of flours. The idea proved to be controvercial and was abandoned[3] In more recent times, intervarietal differences in solubility behaviour of wheat proteins have been observed. Thus, it has been shown by Pomeranz[4], that 3M urea solubilizes more of protein from weaker varieties of wheat. Weaker varieties have also more dilute acetic acid soluble glutenin[5]. Furthermore, Orth and Bushuk[6] on fractionation of wheat flours by modified Osborn procedure have found that the proportion of glutenin (fraction soluble in dilute acetic acid) was negatively correlated with loaf volume, whereas residue protein (fraction insoluble in dilute acetic acid) was positively correlated with loaf volume. They did not observe any trend in the quantities of gliadins. Essentially, similar results have been reported by Huebner and Wall[7]. These workers by extracting flours with AUC solvent (acetic acid, urea, hexadecyltrimethylammonium bromide) and fractionating the extracts on Sepharose-4B columns obtained gliadin, a low molecular weight protein (glutenin II) and a high molecular weight protein (glutenin I). The AUC insoluble material is residue protein. They found that strong wheat varieties contain more glutenin I and soft wheat varieties more of glutenin II.

We have fractionated proteins from eleven Indian wheat varieties and have found that their farinograph characteristics, dough stability and dough development time positively correlate with the ratio of residue protein to gliadin+glutenin.

Materials and Methods

The sources for wheat varieties were Dr. V. S. Mathur, Indian Agricultural Research Institute, New Delhi, 'HD 4530' and 'HD 1949'; Dr. T. B. Singh, G. B. Pant University of Agriculture and Technology, Pantnagar, U. P.; 'Sonalika'; Dr. A. N. Khanna, C. S. Azad University of Agriculture and Technology, Kanpur, U.P., 'K 65' and 'K 68'; Dr. S. R. Shurpalekar, Central Food Technological Research Institute, Mysore, 'Hyb. 65,' 'Kalyansona', 'C 306', 'UP-K1, 'HD 2189' and 'UP 283'.

Wheat was ground in Laboratory Kamas Mill (Swedish Model: SLAGY 200 A) to 60 mesh sieve. Whole meal (10 g., 14 per cent moisture basis) was extracted according to the procedure of Shorgen *et al.*[8] except that 0.5 M sodium chloride was used instead of water. The procedure gave a salt soluble fraction, gluten and starch. The salt soluble fraction was dialysed for 48 hr at 4°C with two changes of water. The precipitated globulin was recovered by centrifugation and freeze dried. The supernatant was freeze dried to give albumin. Gluten was washed free of salt and blended in a Sorval blendor at high speed for 1 min (blended twice for 30 sec each) with 50 ml of 0.1 M acetic acid. The suspension was centrifuged (10,000 g for 30 min) and the supernatant and residue freeze dried. The latter is residue protein. The freeze dried supernatant was fractionated into gliadin and glutenin according to the procedure of Nielson *et al.*[9].

Approved methods, AACC[10] were used for determining Kjeldahl nitrogen and for obtaining farinograph data.

Results and Discussion

The results are summarised in Table I, where wheat varieties are listed in the order of decreasing dough stability and dough development time. It is seen that all protein fractions show quantitative intervarietal differences.

Protein content of these varieties ranged from 11.3 to 16.5 per cent, but it does not show any correlation with dough stability or dough development time. Thus, the variety 'K68' and 'Sonalika' though show maximum difference in dough properties (Table 1) have similar protein content (12.3 and 12.5 per cent respectively).

Though the quantities of albumins and globulins vary from variety to variety, they show no definite trend in relation to dough stability and dough development time. This is consistent with the observation of Orth and Bushuk[6] and is not unexpected. Albumin and globulin are neither components of gluten nor do they possess visco-elastic properties. Their non involvement in bread making performance[11] and mixing requirement of flours[12] is known.

In contrast to albumin and globulin, gliadin, glutenin and residue protein are integral components of gluten, and all are found to show definite trends in relation to dough properties. The quantity of residue protein is found to decrease with decreasing dough stability and development time and the quantities of gliadin and glutenin are found to increase with decreasing dough stability and dough development time.

From the results it is clear that quantities of all these three proteins individually correlate with dough stability and dough development time. However, as gluten is one functional entity made up of gliadin, glutenin and residue protein, it is desirable to consider quantative variations in all three proteins for arriving at a relationship with dough properties. This is best done by using the ratio of residue protein which varies positively with dough properties to gliadin plus glutenin which vary negatively with dough properties. These ratios along with dough stability and dough development time are listed in Table 1. Table 2 lists correlation coefficients for gliadin, glutenin, residue protein and the ratio of residue protein to gliadin+glutenin *vs* dough stability and dough development time. It is seen that the correlations are better for the ratio than for individual protein fractions.

Fig. 1 and 2 are regressions of dough stability and dough development time on the ratio. The regression formula are shown under each Figure. The relationships are linear, and of the two farinograph characteristics, dough stability shows somewhat better correlation.

Fig. 3 gives farinographs of varieties 'K-65' (ratio 0.7), 'Sonalika' (ratio 0.073), 'C-306' (ratio 0.182) and a composite flour of varieties 'K-65' (3 parts) and 'Sonalika' (7 parts) having a calculated ratio of 0.207. Similarities

TABLE 2. CORRELATION COEFFICIENTS (r)

		r
1.	Dough stability *vs.* gliadin (C) ..	−0.886
2.	„ „ glutenin (D) ..	−0.921
3.	„ „ residue protein (E)	+0.932
4.	„ . E/C+D ..	+0.971
5.	Dough development time *vs* gliadin (C)	−0.843
6.	„ „ , glutenin (D)	−0.934
7.	„ „ „ residue protein (E)	+0.884
8.	„ „ „ E/C+D	+0.944

TABLE 1. COMPOSITION OF FLOUR PROTEIN AS PERCENTAGE OF TOTAL PROTEIN

Variety	Albumin A	Globulin B	Gliadin C	Glutenin D	Residue protein E	Dough development time (min)	Dough stability (min)	$\frac{E}{C+D}$
K68	10.5	17.1	21.1	18.4	32.9	9.0	11.5	0.833
K-65	12.5	16.6	22.3	19.4	29.2	8.0	9.0	0.700
Hyb-65	14.7	10.4	24.0	26.1	24.8	5.0	6.0	0.495
HD-4530	11.9	10.4	28.9	26.3	22.7	4.5	6.0	0.411
Kalyansona	17.9	7.5	26.6	28.1	19.8	4.5	4.5	0.362
HD-1949	14.0	9.6	31.9	30.0	14.5	4.0	4.0	0.234
C-306	16.0	9.8	35.4	27.3	11.4	4.0	3.0	0.182
UP-K1	14.5	10.5	28.7	26.1	20.1	3.0	3.0	0.367
HD-2189	16.0	11.1	31.9	32.0	9.1	2.5	2.3	0.142
UP-283	13.6	11.5	32.7	33.8	8.4	2.5	2.0	0.126
Sonalika	12.9	16.4	34.2	31.7	4.8	2.5	1.3	0.073

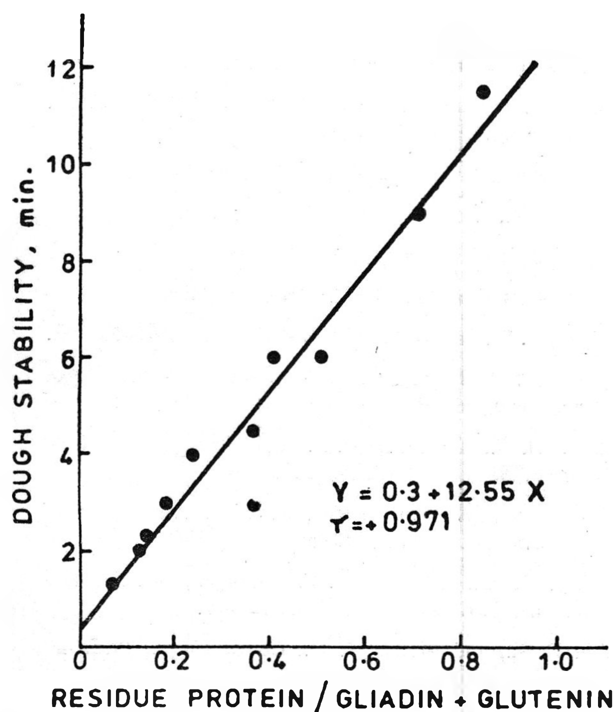

Fig. 1. Regression of dough stability on the ratio, residue protein/gliadin + glutenin.

in the farinographs of composite flour and variety 'C-306' are obvious. This not only supports the validity of the relationship between the ratio and the farinograph characteristics of doughs, but also provides a method

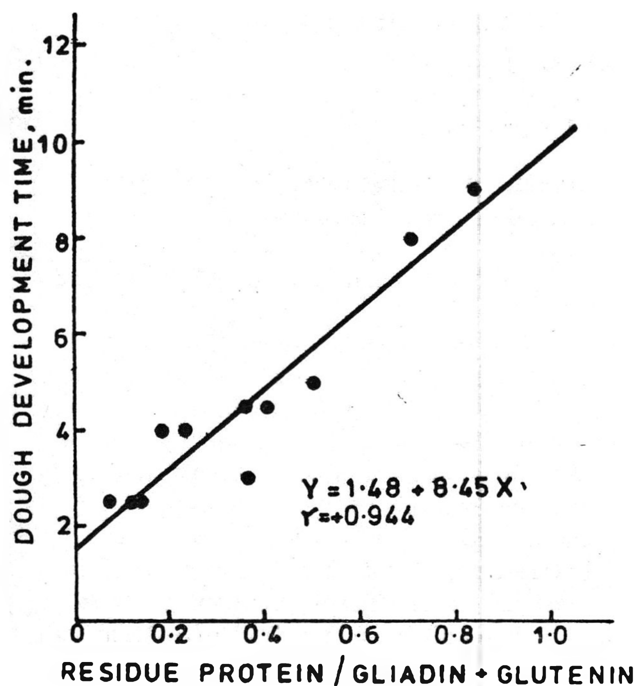

Fig. 2. Regression of dough development time on the ratio, residue protein/gliadin + glutenin.

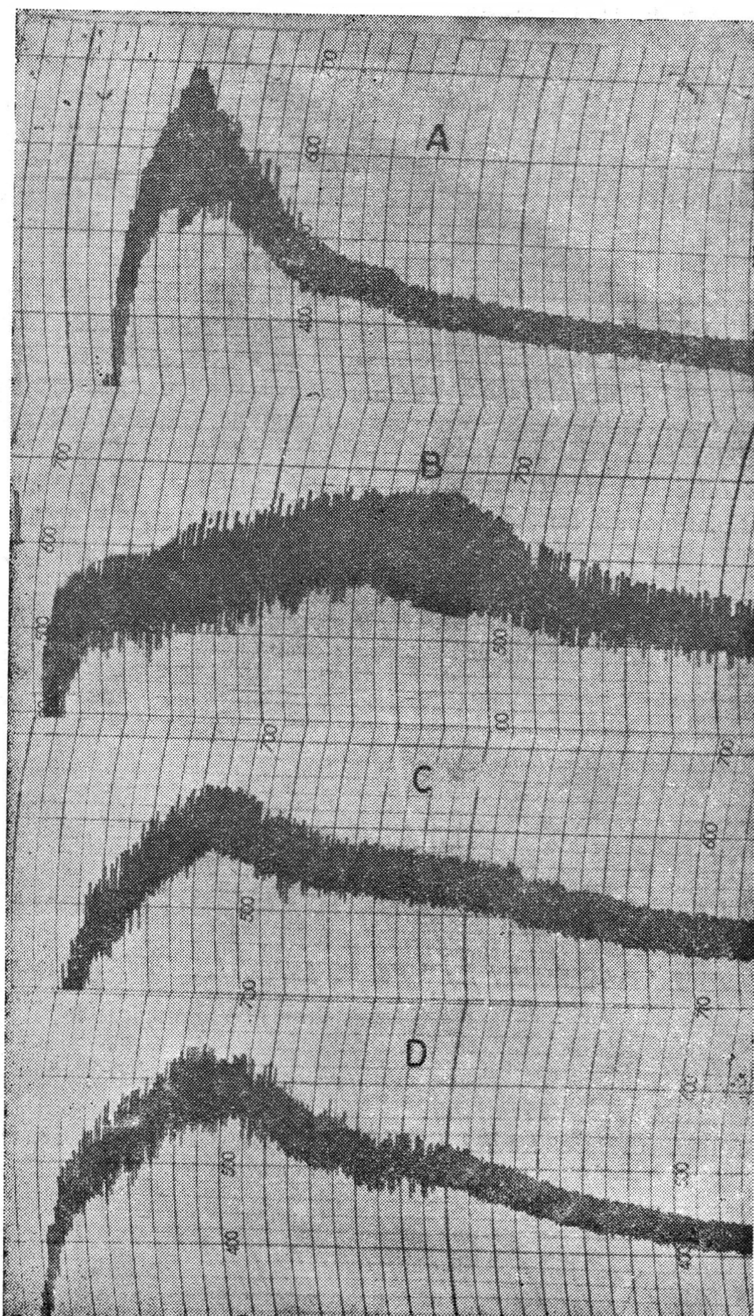

Fig. 3. Farinographs of single varieties and one composite flour. A = Sonalika (0.073), B = K-65 (0.70), C = C-306 (0.182), D = Composite of A and B (0.207). The number in paranthesis are the ratios of residue protein/gliadin + glutenin.

for formulating flours of desired dough characteristics from two or more flours with differing dough characteristics.

For calculating the ratio we have put gliadin and glutenin together as both these show similar quantitative variation to dough stability and dough development time. However, functionally gliadin is viscous, whereas

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glutenin is elastic. Thus, the latter is more like residue protein which is also elastic. It is surprising that functionally similar proteins, eg., glutenin and residue protein, have dissimilar quantitative relationship with dough characteristics and functionally dissimilar proteins, e.g. glutenin and gliadin, have similar quantitative relationship. With respect to the quantitative relationships of glutenin and residue protein with loaf volume, the results of Orth and Bushuk are similar[6]. At present, the roles and contributions of gluten components to its overall functional characteristics are poorly understood. In the absence of this understanding, we can do little more than emphasize the emprical nature of the relationship proposed between the ratio and the farinograph characteristics of dough.

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Studies on Bland Groundnut (Peanut) Flour

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"Bland" groundnut flour free from nutty odour has been prepared by extracting the defatted flaked groundnut kernels with 90% isopropyl alcohol. The nitrogen solubility profile and emulsion capacity of the bland flour are discussed.

Considerable amount of work has been done on the processing of groundnut (*Arachis hypogea*) flour into edible grade flour[1-4] and protein isolate[5] for use in protein enriched foods and imitation dairy products like Miltone[6]. The main factors limiting the increased use of groundnut in food formulations are its nutty flavour and sometimes bitter taste. These drawbacks can be overcome to some extent by suitable processing of the flour with added ingredients and flavours, but are not eliminated completely. Investigations on groundnut have shown that some of the minor constituents present in the meal are bitter tasting and that many of the precursors to flavour factors are concentrated in the alcohol soluble fraction of defatted flour[7,8]. Studies on soybean have indicated that extraction procedures using aqueous alcoholic solvents offer promise of producing bland protein products and isolates[7,9,10].

Several flavour components present in raw[11] and roasted[12] groundnuts have been isolated[13] and characterised[14]. Nagaraj and Subramanian[15] have studied the extraction of expeller pressed edible defatted groundnut flour with solvents such as ethanol, isopropanol and hydrochloric acid with a view to obtaining bland protein concentrates. Use of azeotropic mixtures of hexane-ethanol, hexane-methanol or hexane: 2 propoanol for removing residual oil and flavour components in soybean have been reported in literature[16,17]. Many of these treatments have only helped in reducing the flavour to a certain extent, but have not yielded a completely bland product. The present paper deals with the preparation of 'bland' groundnut flour with desired functional

properties, by extracting with solvents. The effect of these extractions on protein solubility and emulsion capacity of the flour has been discussed.

Materials and Methods

'Batani' variety of groundnut seeds available in the local market was used for these studies. To facilitate removal of the testa, hand picked groundnut seeds were subjected to mild roasting (50-60°C) for 10 min in a laboratory coffee roaster and then rubbing by hand. Moisture content of the seeds was adjusted to 12 percent and the kernels were passed through flaking rollers (Kranmaskiner, Malmo, Type J. No. 6725) to obtain flakes of 2mm thickness. Flakes were dried in a through-flow drier at 45°C to bring the final moisture content to 4-5 percent and were extracted with hexane. The defatted flakes were subjected to extraction by solvents, 90% isopropanol, 90 percent ethanol, 70 percent ethanol at 50°C, and azeotropic mixtures of hexane—methanol (75:25) and hexane: isopropanol (80:20). Three successive extractions were carried out for 1 hr in each case, with a meal to solvent ratio of 1:2, 1:1 and 1:1 respectively. After each extraction, the dispersion was centrifuged at 4000 rpm (Janetzki, T_3 Model) for 15 min. The extracted residues were collected and spread in trays and dried in a current of hot air (45-50°C) and desolventized in a vacuum shelf-drier. The material was ground to pass through 80 mesh (BSS) sieve.

Extraction of groundnut flour with HCl and NaCl: 100 g lots of defatted groundnut flour were used for extraction with 0.1N HCl and 0.2M NaCl solution separately. Three successive extractions were done with a meal to solvent ratio of 1:10, 1:5 and 1:5 respectively. The dispersion was stirred for 30 min, each time. After each extraction, the dispersion was centrifuged (Janetzki T_3 Model) at 4000 rpm for 15 min and the extracted residues were collected, spread in trays and dried in warm air (45-50°C). The material was cooled, and ground to pass through 80 mesh (BSS) sieve. The sieved material was used to study the following functional properties.

(*a*) *Nitrogen solubility:* This was carried out in the pH range of 1.5 to 10.5 by dispersing 1 g of the sample in 40 ml of water and adjusting to the desired pH using acid or alkali.

The dispersions were stored for 20 min and centrifuged at 3000 rpm for 15 min and aliquots of the supernatant were analysed for nitrogen content. The percentage of soluble nitrogen was calculated.

The nitrogen solubility of these samples in 10 per cent NaCl solution was similarly determined.

Nitrogen Solubility Index (NSI) which determines the dispersible nitrogen in the flour was calculated according to the formula:

$$\text{NSI} = \frac{\text{Nitrogen in the extract}}{\text{Total Nitrogen}} \times 100$$

The results are presented in Fig. 1.

(*b*) *Emulsion capacity:* Emulsion capacity of the samples was determined by the procedure of Inklaar and Fortuin[18]. In a jar[2] g. sample and 23 ml of distilled water were mixed and blended for 30 sec at low speed in a Waring blender. Refined groundnut oil was added from a burette to the blending sample at a rate of 0.4 ml/sec until the emulsion breakpoint was reached. The break-point was defined subjectively as the point at which the emulsion broke and when there was phase separation. The data are presented in Table 1.

Results and Discussion

(*i*) *Flavour of the flour:* The physico-chemical studies on groundnut flour extracted with various solvents and the flavour/odour/colour of the product obtained therefrom are reported in Table 1. While there was no

TABLE 1. PHYSICO-CHEMICAL STUDIES ON GROUNDNUT FLOUR EXTRACTED WITH VARIOUS SOLVENTS

Treatment No.	Solvent	Protein % (N×6.25)	Solubility in 10% NaCl solution (%)	Emulsifying capacity*	Flavour/Odour/Colour
1.	Hexane	52.0	86.4	13.4	Considerable nutty flavour
2.	Hexane:Methanol (75:25 v/v BP 51°C)	52.2	84.5	19.1	Solvent odour
3.	Hexane:Isopropanol (80:20 v/v BP 63°C)	53.0	81.5	19.1	–do–
4.	90% ethanol	55.3	72.7	18.9	Solvent odour; no nutty flavour
5.	90% ispropanol	56.5	79.5	20.9	White
6.	70% ethanol at 50°C	55.5	14.9	5.4	Light brown.
7.	Acid extraction at pH 4.0	56.0	17.2	9.2	Nutty flavour; slightly yellowish.
8.	0.2M NaCl	50.4	—	10.9	Grey; salty taste

(*ml of oil consumed per 100 mg protein to reach the breaking point).

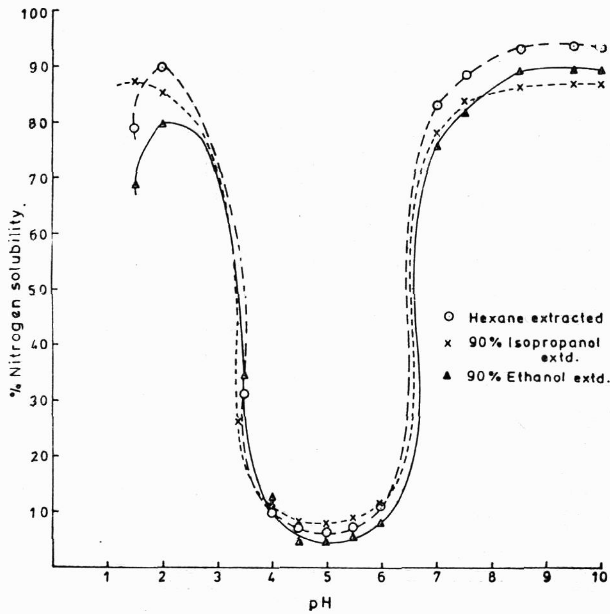

Fig. 1: Nitrogen Solubility (%) of treated groundnut flour at different pH

significant difference in the protein content of the flour subjected to various treatments, in all the cases except in treatments 6 and 7. the solubility was about 72.7-86.4 percent. The material treated with 90 percent isopropyl alcohol was, however, white free from any odour and of bland taste.

(ii) Nitrogen solubility: Nitrogen solubility profiles of groundnut flour at pH ranges of 1.5 to 10.5 are shown in Fig. 1. It is evident that in all the three cases, the iso-electric pH is between 4.5 and 5.0 This is in agreement with reported values[19]. At neutral pH, the solubility ranged between 76 and 83 percent although at the alkaline pH, it was 90 percent in all the three cases. At acidic pH (1.5 to 2.5), although the solubility is between 70 and 90 percent, the colour of the resulting solution was brown. This could, evidently, not be used for beverage preparation. It was only the flour extracted by 90 percent isopropanol that renderd itself well for the preparation of a milk-like beverage, because it was white in colour, free from nutty odour and completely bland to taste as evaluated organoleptically by a panel of judges. Results of large scale trials to prepare larger batches of the bland material for use in beverages will be reported later.

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Control of Spoilage During Sun-Drying of Coconut

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It was found that spoilage of coconut during sundrying can be arrested by the application of a thin coat of glacial acetic acid on the kernel surface. Even a single application was found to be effective when the relative humidity (RH) does not exceed 85%. At higher humidities the treatment may have to be repeated once or twice. Copra made from treated coconuts was found to contain less than 0.1% residual acetic acid. Cost of application is found to be only 2 to 3 paise per coconut, Commercial level studies have also been made.

In India coconut is broken transversely into two cups and is then sun-dried. About seven days are needed to reduce the moisture content to 5-6 per cent. In rainy weather it is difficult to dry the coconut. Microbial infection is common resulting in discoloured copra which yield rancid oil with high free fatty acid. Subrahmanyan[1] has found that destruction of dry matter including oil may occur to the extent of 30 per cent by microbial attack and estimated that a loss in weight of 15 per cent or more may occur even in ordinary commercial practice of copra making.

A large number of investigators have suggested various methods for preventing spoilage of copra. Most important of these have been in designing and developing improved types of driers which can be economically used for the rapid conversion of coconut to copra[2]. Chemical treatments were tried by Surridge[3] and Blackie[4] as early as 1931. They suggested SO_2 which, though effective in copra storage, has little effect on drying coconut. Subrahmanyan and coworkers[5] evolved an inexpensive dilute acetic acid—mineral acid treatment in the Philippines. They also found that a coat of slaked lime mixed with sodium hydroxide and sulphur was effective[1]. These were, however, not found to work satisfactorily under the conditions in Kerala.

Materials and Methods

Fully mature coconuts (11-12 months) harvested from the laboratory campus or locally purchased were used in these experiments. Samples for moisture determination were taken by cutting out a piece of 1 cm width from the edge of the cup up to its centre.

A comparative study of the oven method[6], distillation method[7] and the infra red balance method for determination of moisture was made and the infra red method which was found to be most suitable was adopted. (Table 1). All moisture determinations were carried out by this method after cutting the sample into pieces of 2 mm thickness and 4 to 5 mm width. The moisture balance was adjusted to a temperature of 85°C and generally it took about 20 min for one determination.

Sun-drying of coconut cups were carried out in the terrace of the laboratory. Shade-drying was done in a corridor with good cross-ventilation. Mechanical drying was done in a cross-flow drier at 75°C.

For determining material loss, on extreme conditions of infection, the kernel was separated from the shell immediately after breaking open and sliced to a thickness of 3 mm. Slices were well mixed to ensure uniformity of sample and duplicate samples of 400 g were used for each test. Sun-drying in bright sun-shine and mechanical drying provided the controls. Similar samples were kept in beakers covered with perforated plates to allow growth of bacteria and fungi. Duplicate lots were removed after three, five and seven days and mechanically dried. Yield on dry basis was calculated and free fatty acid content of the extracted oil was determined[6].

Table 1. Comparison of different methods of moisture determination of coconut kernel

Infra red moisture balance	Toluene distillation	Oven drying at 75°C
47.5	47.7	47.1
45.2	44.7	44.6
18.2	17.9	17.7
6.2	6.0	6.3

For determining material loss due to slight fungus growth, four uniform samples were prepared by cutting each cup into four equal pieces and adding one piece from each cup to a sample. Control samples were sun-dried in fair weather and experimental samples were shade dried to produce infection, and finally sun-dried. Subsequently, moisture content was determined and yields on moisture free basis were calculated.

Chemical treatments were done, after completely draining the water, by keeping the freshly broken coconut inverted for about 15 min. Usually, the surface remained wet at the time of treatment. Two coats of solutions were uniformly applied with a brush and the excess was allowed to drain away by keeping the cups inverted, again for 15 min. Solids were applied uniformly with a small hand duster.

Results and Discussion

It was generally observed during these studies that the actual moisture content of the kernel is not the deciding criterion, for microbial infection. In dry weather, the kernel surface remains dry and even cups of high moisture content do not develop infection. But in wet weather, the surface does not dry up and infection develops even at medium moisture levels of 15 to 20 percent. This is in conformity with the findings of earlier workers, that it is essential to keep the surface dry for obtaining good quality copra[1,2]. With relative humidites above 75 per cent, it becomes difficult to keep the surface dry and either artificial drying or chemical treatments become necessary.

On a comparative study of infected and uninfected samples of identical quality prepared from the same nut, it was found that slight fungus infection does not cause appreciable loss of dry matter as seen in Table 2. Dry matter loss varied from 2 to 5 percent only in normal infections. However, under extreme conditions of spoilage dry matter loss amounts to more than 16 per cent (Table 3). A slight infection affected the quality of oil considerably, and the oil became rancid with a free fatty content of more than 0.75 per cent. Often the free fatty acid also exceeds 3 percent which is the maximum permissible limit according to Prevention of Food Adulteration Act. Profuse infection by bacteria and fungus, makes the oil highly rancid and totally inedible with a free fatty acid content of more than 25 percent (Table 3).

TABLE 3. CHANGES DUE TO BACTERIAL AND FUNGUS INFECTION IN COCONUT KERNELS*

Sample	Yield of dry matter (%)	Oil content (%)	FFA of oil (%)
Sun-dried (control)	58.1	69.4	0.5
Mechanically dehydrated (control)	57.8	69.7	0.2
Infected sample after 3 days	52.5	70.8	14.5
Infected sample after 5 days	49.9	74.0	18.6
Infected sample after 7 days	48.4	70.2	26.1

*Extreme conditions of spoilage were allowed to develop.

A variety of chemicals, both permitted and nonpermitted, were tried during drying of coconuts to find out a suitable treatment that will give complete protection even under very rainy conditions. These included calcium hydroxide, chloroxylenol, paraform, pentachlorophenol, potassium metabisulphite, sodium benzoate, sodium carbonate, sodium chloride, sodium hydroxide, sorbic acid, dilute sulphuric acid and acetic acid. Solutions of these chemicals, at various concentrations and their mixtures were tried. Though some of these chemicals could delay the onset of infection by one to three days, none of them except acetic acid was really effective in preventing infection. Acetic acid of 5 to 50 per cent strength was able to prevent fungus growth only by 36 to 48 hr. Seventy five per cent acetic acid was effective in dry weather (R. H. below 75 per cent) but could only delay infection by 3 to 4 days under rainy conditions. It was found that only glacial acetic acid could prevent infection during shade drying in wet weather. In intermittent rains, when the R. H. is below 85 per cent during

TABLE 2. LOSS OF YIELD OF COPRA DUE TO BACTERIAL AND FUNGUS GROWTH

Treatment	Sample size (g)	Condition of fungus infection	Yield of copra (%)	Difference in yield from control (%)	Yield loss (%)
Glacial acetic acid treated	500	No fungus	60.8	—	—
No treatment	500	Covered with powdery growth	59.0	1.8	3.0
Glacial acetic acid treated	720	No fungus	58.8	—	—
No treatment	720	Covered with powdery growth	57.0	1.8	3.1
Glacial acetic acid treated	1175	No fungus	57.5	—	—
No treatment	1080	Covered with powdery growth	54.4	3.1	5.4

TABLE 4. ACETIC ACID CONTENT OF ACID-TREATED COPRA DURING DRYING AND STORAGE

Period (days)	Control		Acid-treated and sun-dried			Acid-treated and shade-dried		
	Moisture (%)	Acidity (mg of acetic acid/g of dry sample)	Moisture (%)	Total acidity (mg of acetic acid/g.)	Acetic acid (mg/g)	Moisture (%)	Total acidity (mg of acetic acid/g. sample)	Acetic acid (mg/g.
0	30.2	1.82	35.2	10.72	8.9	34.2	6.11	4.29
4	7.6	1.07	8.2	2.68	1.61	16.2	2.25	1.18
15	4.6	0.96	5.0	1.93	0.97	5.0	2.14	1.18

the major part of the day, one treatment was found to be sufficient. In extremely wet weather, when there was incessant rain throughout the day, and the R.H. was above 90 per cent the treatment had to be repeated every fifth day to obtain completely fungus free copra.

Acetic acid content of the treated coconut during and after drying were determined and are given in Table 4. It was found that only about 1.18 mg of acetic acid per gram of copra was retained at the end of 15 days even in shade drying. Acetic acid content of the twice and thrice treated copra was not very different. Being a permissible food additive, these concentrations of acetic acid may not be objectionable. Though there was a slight difference in flavour between the treated and untreated copra, in oil and cake it was not noticed by the common consumer and only experienced persons in the trade could detect the difference. The odour of acetic acid, could not be detected in food products where oil extracted from treated copra was used.

Semicommercial scale trials using 500 cocnuts were tried in the laboratory and two other places during the monsoon season. The places tried were Kayamkulam in Southern Kerala and Irinjalakuda in Central Kerala (India). Cost of treatment workes out to between 2 and 3 paise per coconut in these trials. These confirmed the result of the laboratory study. As shown in Table 5 only less than 0.5 mg of acetic acid was present per gram of oil from the treated copra and the cake had less than 0.1 mg of acetic acid per gram. The oil was practically free of any acetic acid flavour and only-one third of the judges could detect it even when specifically asked to look for it. Others were unable to detect any difference and also no difficulty was experienced in selling the oil and cake through normal commercial channels.

TABLE 5. ACID LEVELS IN CAKE AND OIL FROM COMMERCIAL LEVEL ACETIC ACID TREATMENTS

Samples	Oil	Cake
	Total acidity as mg of Acetric acid g of sample	Acetic acid as mg g of dry sample
Untreated, sundried copra	0.50	0.03
Acid-treated and sun-dried	0.96	0.07
Acid-treated and shade-dried	1.15	0.11

Applying a thin coat of glacial acetic acid on the exposed surface of the coconut kernel is thus found to be a satisfactory method for preventing microbial growth during sun-drying.

Acknowledgement

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In-Pack Processing of Ready-to-Eat Foods in Indigenous Flexible Packaging Materials, Part III. Studies on Newer Packaging Materials Capable of Withstanding the Processing Temperature*

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Polypropylene film which is stable at the processing temperatures of 115° to 130°C and which is being indigenously produced now, has offered a promising starting material for, the development of retortable pouch. The film, as produced at present, has however been observed to possess certain undesirable characteristics which detract from its full satisfactory utilisation in the production of retort foods. Even then, pending further developments, the film has been utilised, with certain precautionery measures, to produce a few types of ready-to-eat foods with a shelf life of 4 months.

Previous work carried out in this laboratory[1-4] related to the use of low density polyethylene based packaging materials. It was observed[4] that even under milder heat processing conditions and other precautions in handling and protective outer packaging system a failure rate upto 2 per cent could not be avoided in large scale production which was principally due to the thermal damage caused to the polyethylene layer. This was clearly far from being a satisfactory position. Hope was revived, however, after a foil laminate with high density polyethylene film as its heat sealable layer was developed in collaboration with trade and later polypropylene film became indigenously available. The present paper relates to further work carried out with these packaging materials.

Materials and Methods

Basic pouch making materials: Two types of materials were investigated: (*a*) a foil laminate having the construction, 60g maplitho paper/.009 mm aluminium foil/75 micron high density polyethylene and (*b*) a food grade polypropylene film of thickness varying from 50 to 60 micron made by the usual extrusion method in an unoriented form.

Food materials: The following ready-to-eat foods were used for in-pack processing and storage studies:—

(*a*) Sweet stuffed parotta made out of wheat flour dough and a mixture of cooked arhar dal, jaggery, grated copra and cardamom flavour as the stuffing. The parottas were fried with hydrogenated fat.

(*b*) *Kachodi:* made as normally done with wheat flour dough and spiced and pasted black gram dal stuffing. This was shallow fried with hydrogenated fat.

(*c*) Suji halwa

(*d*) Baked beans in tomato sauce (pH approx. 5.0)

(*e*) Alu choley

(*f*) Mutton biriyani

(*g*) Mutton kofta curry.

In all the above cases, except in (*a*), (*b*) and (*c*), cooking prior to packaging was partial so that it was completed during the processing stage.

Pouch carrier and handling device: A rectangular aluminium mould made of hinged and grooved pair of plates with clipping arrangement on the other three sides holds the food pack with its central bulge enclosed securely within the grooved hollow of the former. This device not only prevents displacement of the pack contents inside the pouch but also secures the latter against damage while it is subjected to processing in the autoclave. The carriers with enclosed pouches are arranged in wiremesh baskets in upright position (Fig. 1 and 2).

Packaging system: Each item was first enclosed in a MST cellophane pouch and then repacked in a polypropylene pouch after removing air to the extent possible. The quantity and the shape in which an item was

*Part of this work was reported in a paper presented at the Indian Convention of Food Scientists and Technologists 1978

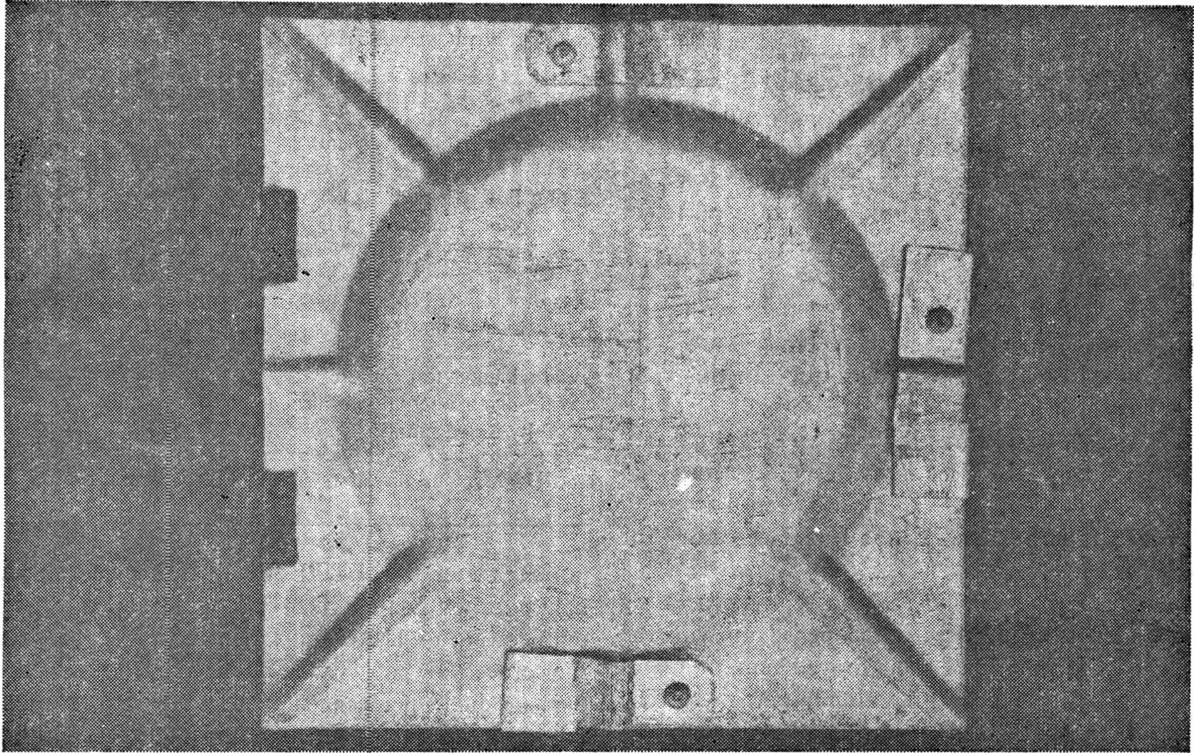

Fig. 1. Pouch carrier

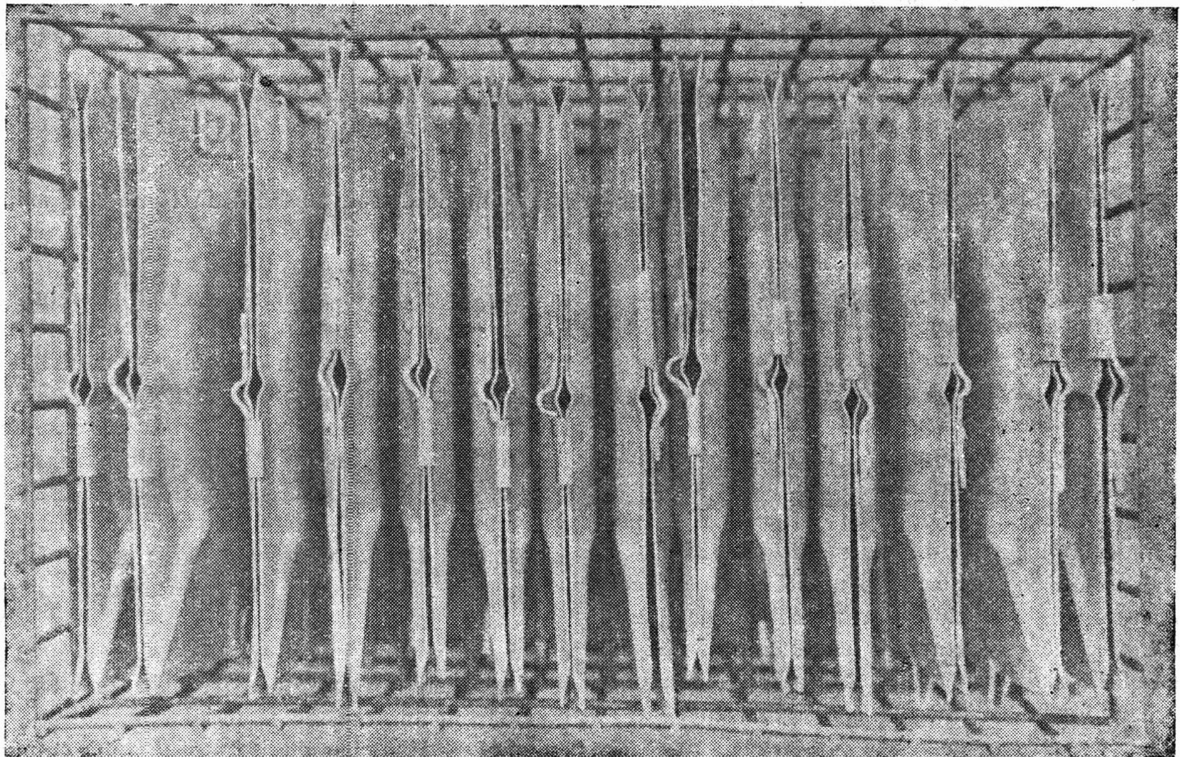

Fig. 2. Wiremesh basket fitted with pouch carriers

packed in the pouch were such as to allow snug fitting of the pack into a pouch carrier. After retort processing was over and subsequently the packs were dried in a cross flow air drier, each pack was enclosed in a rectangular cardboard cover which completely immobilised the pouch inside it. Five such protected pouch packs were repacked in a three-ply corrugated fibre board carton for storage. When required to be transported, a suitable number of these cartons were repacked in a wooden case.

Experiments on the use of foil laminate with high density polyethylene as its heat sealable layer were restricted to sweet stuffed parottas only. In this case, other packaging details remained the same.

Processing details: Processing with air-steam mixture was carried out at 115°C as previously described[5] so as to have a process value varying between 4.5 and 6. A processing time of 32 min. was found necessary for this purpose.

Post processing precautions: Soon after the processing was over, the pouch carriers were opened up with the pouch still lying in one of the grooved pair of plates and spread side by side on long aluminium trays. The trays with their contents were in turn placed in a cross-flow air drier at a temperature of 80-85°C. The pouches were not touched by hand till completely dry. After drying, further protective packaging was carried out as described above.

(*a*) *Effect of heat processing on the physical properties of the pouch materials:* the effect of heat processing on tensile strength, elongation, tear resistance, and internal burst test of pouches were determined both before and after processing. The first three tests were carried out as per standard methods[6,7]. For internal burst test, a sealed pouch of 10 cm×5 cm with enclosed air was compressed between parallel plates of a compression tester[8] watching the load recorded till it reached a maximum of 60 kg at which the pouch was held for 30 sec., If leakage or burst occurred at a lower load that was recorded. The load divided by surface area on one side of the pouch gave the pressure (kg/cm^2) withstood by the seams of the pouch.

(*b*) *Storage and transportation:* The cartonised packages of different food items were subjected to rail/road transportation (Mysore to Jodhpur and back) and then stored under ambient conditions of Mysore (25-30°C), the total period covered being 4 months. At the end random sampling was done for microbiological tests and organoleptic evaluation by a panel of 5 judges. The rest of the packs were subjected to a hundred percent visual check for microbiological spoilage, if any.

Results and Discussions

Pouch materials and their limitations: Of the two pouch materials, HDPE-foil laminate developed in collaboration with a firm did withstand a processing temperature of 115°C but failed in practical tests when the processed packs were subjected to transporation trial (about 5 per cent showing crack in the pouch at the seam and consequent mould attack). The failure was found to be due to poor seam quality after processing.

Table 1. Effect of heat processing at 115°C on the physical properties of polypropylene film

	Before processing	After processing
Tensile strength (Kg/sq cm)	176 (MD) 125 (TD)	227 (MD) 237 (TD)
Elongation at break (%) (av. of fig. taken in MD & TD)	900	200 (Approx.)
Tear resistance (g) (60 micron film)	228 (MD) 224 (TD)	115 (MD) 136 (TD)
Internal burst test (failure rate at an internal pressure of 1.2 kg/sq cm)	Nil	60%

MD = Machine direction TD = Transverse direction

The second pouch material, polypropylene film, easily meets the requirements of temperature stability and is known to have been used for retort processing of foods though the exact quality of the polymer used is not known. The film obtained from local converters through Indian Petro chemical Corporation Ltd., does not appear to possess all the desirable qualities for making processable pouches. It undergoes changes in properties on processing as shown in Table 1. The increase in tensile strength and considerable loss in elongation at break and also tear resistance are clear evidences that the polymer molecules have undergone reorientation into a higher degree of crystallinity. These changes together with a clear feel of stiffiness compared to the original film suggested a loss in flexibility of the film. Internal burst test of the pouches was carried out in order to determine the quality of the seam as has recently been done[9]. Data in Table 1 indicate that there has been a definite weakening of the seam due to the effect of processing. Determination of seal strength of the seam is another method used for ascertaining the effect of processing in the seam quality. This test however, could not be done in the present case as even at a very low load there was enormous stretch in the test specimens taken from unprocessed material.

In view of the characteristics of the film noted above no attempt was made to develop its laminate with aluminium foil. Instead, the possibility of utilising the

TABLE 2. EFFECT OF POUCH CARRIER ON THE HEAT PROCESSING OF STUFFED PAROTTA

Autoclaving conditions of pouch	Period of initial steaming (min)	Processing conditions	F°value attained
Unsupported pouch	30	115°c, 20 lb for 32 min.*	Min. 1.3 Max. 2.6
Pouch supported by aluminium mould carrier	30	-do-	Min. 4.2 Max. 6.0

*During processing a mixture of air-steam at a total pressure of 20 lb was used. During cooling cycle air pressure at 20 lbs was maintained.

film itself as such was investigated. It was evident that besides permeability problems, which would preclude long shelf life to the food processed, extra care would have to be taken in protecting the pouch and specially its seams from the hazards of handling and transportation and the possibilities of microbiological contamination resulting from any physical damage thereby. Precautions such as use of moulded aluminium frame as pouch carrier, immediate drying of the processed pouches and avoiding manual handling of the wet pouches and lastly the protective outer packaging system were all aimed at protecting the pouches from damage and contamination. The need for avoiding manual handling of processed pouches till they are dry has been emphasized by several workers[10,11,12]. The use of the aluminium frame as pouch carrier has an additional advantage. Since it holds tightly the food contents of the pouch, it squeezes out any air to the peripheral area of the pouch and thus facilitates quicker heat penetration inside the pack. The results of process value (F° value) studies of the pouches with and without these frames as shown in Table 2 clearly confirm this contention.

A polypropylene film of 75 microns will be preferable to 50 to 60 micron film. However, due to certain difficulties, this was not readily available from the trade. The development of a suitable foil laminated pouch material will also await further R & D efforts. The present investigation was therefore, carried out to provide a stop gap solution to the problem of producing retort processed pouch food.

Choice of food material and its processing conditions: For the success of retort food, besides the pouch material the following factors are also important: (*i*) Choice of the food items. A suitable food item is one in which the components do not undergo adverse change in processing. (*ii*) Method of processing prior to subsequent retort processing. It is to be remembered that retort processing also results in cooking and so over cooking should not occur making the food unpalatable. (*iii*) Retort processing conditions. These three factors were given due consideration and for each item the best processing conditions were worked out by trial.

Transportation, storage studies and shelf-life: The cartonised packages repacked in wooden cases were sent by rail/road transportation to Jodhpur, and back from Jodhpur to Mysore which involved quite a good number of transhipments. When received back, the pouches inside cardboard cover were found to be in good condition without any sign of wrinkles or transit damage. After 4 months' storage period the food materials were found microbiologically sterile and were rated "like very much" to "like" in organoleptic evaluation. 100 per cent check also showed that none of the packs had been spoiled and in no case the polypropylene pouch indicated any visible damage. In separate experiments it was observed that though the foods remained sterile for much longer periods undesirable changes in the appearance and flavour became apparaent from the fifth month onwards. A shelf life of only 4 months could therefore, be safely assigned to the food packages. A longer shelf life of 6 months to 1 year, to meet the practical needs of either military use or certain commercial use will await, as pointed out earlier the development of a suitable laminated pouch material.

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Relationship Between Uncooked Pulses and Intestinal *Clostridia* in Flatulence

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The propensity of uncooked pulses to promote formation of intestinal gas by indigenous Clostridia was studied *in vitro*. On cultural examination of five affected human faecal samples, three different species of Clostridia viz. *Clostridium perfringens*, *C. sporogenes* and *C. butyricum* were isolated under strict anaerobic conditions. The gas production properties of various pulses tested *in vitro* showed high rate from uncooked pulses containing oligosaccharides like verbascose, raffinose and stachyose. *C. perfringens* produced maximum gas and chick pea (*Cicer arietinum*) induced maximum gas production by all the 3 species of Clostridia.

Flatulence is one of the most common complaints of persons with indigestion or other intestinal disorders. One of the main causes of intestinal gas production is fermentation of various substrates by the indigenous microflora. Most investigators[1-3] ascribe flatulence to the action of intestinal anaerobic microflora on the oligosaccharides present in mature pulses which can be degraded by specific enzymes present in bacteria. These enzymes are absent in human digestive secretions and the oligosaccharides remain unhydrolysed and unabsorbed. Among the indigenous microflora, Clostridia play an important role in gas production. In the present study attempt has been made to establish relationship between uncooked pulses and intestinal Clostridia in flatulence.

Four varieties of pulses selected for the study included chick pea (*Cicer arietinum*), dried pea (*Pisum sativum*), lentil (*Lens esculentum*) and soybean (*Glycine max*).

Isolation of Clostridia: The specific black colony method of Mossel *et al.*[4] was adopted for the isolation of Clostridia from human faeces. The fresh faecal samples were inoculated in sterilized sodium thioglycollate broth in screw capped tubes.

Isolates were identified according to Schemata contained in Bergey's Manual of Determinative Bacteriology'[5] The following characteristics and methods of testing were utilized: catalase test, gram stain[6], H_2S production, indole production, motility[7], nitrate reduction, Oxygen requirement, shape and size, spores and sugar fermentation.

The method of Richards *et al.*[8] for *in vitro* gas production was followed with the help of sterilized injection syringes.

Morphological and biochemical characteristics of five isolates from human faecal samples are summarized in Table 1. All isolates were gram positive, strictly anaerobic spore forming rods with no catalese activity. The cultures were designated as A,B,C,D and E. Culture C did not reduce nitrate. H_2S was produced by isolates A and C while the other three were negative. Indole was not produced by any of the cultures (Table 1).

Sugar fermentation characteristics of all isolates were confirmed from the Key given by Buchnan and Gibben[5]. Twelve sugars were selected for the study which included fructose, galactose, glucose, inositol, lactose, maltose, mannose, melibiose, raffinose, stachyose, sucrose and xylose. The cultures A and B were positive for all sugars except B which was negative for xylose. Culture C was positive for glucose, fructose, maltose, sucrose and stachyose while other sugars were not fermented. Cul tures D and E were very similar in their sugar fermentation characteristics. Both strains were negative for xylose and melibiose. The isolates were identified as species of the genus *Clostridium*. Three isolates belonged

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TABLE 1. MORPHOLOGICAL AND BIOCHEMICAL CHARACTERISTICS OF ISOLATES

Isolate number	Shape of cells	Shape of spores	Size of cells (microns)	Motility	Nitrate reduction	H_2S production
A	Rod	Oval	3.5–6.0×0.9–1.5	+	+	+
B	Rod	Oval	4.0–8.0×0.5–1.0	—	+	—
C	Rod	Round	2.0–5.0×0.5–1.0	+	—	+
D	Rod	Oval	4.0–7.0×0.5–1.5	—	+	—
E	Rod	Oval	3.0–8.5×1.0–1.5	—	+	—

to *Clostridium perfringens* (B, D and E) while two (A and C) were *C. butyricum* and *C. sporogenes* respectively.

Gas production: Gas production property of uncooked substrates such as chick pea, dried pea, soybean and lentil was measured (Table 2). Chick pea (*Cicer arietinum*) induced maximum gas production by all species of clostridia. *In vitro* gas production was measured by taking various substrates in injection syringes and inoculating with test organisms. It was evident that chick pea induced maximum gas production followed by dried pea, soybean and lentil. The higher contents of galactooligosaccharides (raffinose, stachyose and verbascose) in check pea, dried pea and soybean and lower contents of the same in lentil is thought to be the reason attributed to the varied amount of gas produced as reported by Rackis *et al.*[2]

Several investigators have attempted to characterise the flatulence factor (FF) in pulses and legumes. Rackis *et al.*[2] by a series of steps involving successive extraction with diethyl ether and hot 60 per cent ethanol reported that the active fraction contained raffinose, stachyose, verbascose and sucrose. Cristofaro *et al.*[9] repotred that the enzyme responsible for the hydrolysis of these tri-tetra-and penta galacto oligosaccharides (which are abundant in pulses) are absent in the human intestine and hence they remain unabsorbed. These galactooligosaccharides are acted upon by specific enzymes α-galactosidases and β-D-fructosidases of Clostridia[9]. As a result of hydrolysis, monosaccharides are formed. The microorganisms ferment the simple sugars and produce gas. *C. perfringens* produced highest amount of gas (14.08 ml to 23.06 ml) with all substrates. The gas production property of three *C. perfringens* cultures were different. This is attributed to strain variation. *C. sporogenes* induced lowest gas production by all substrates tested.

TABLE 2. GAS PRODUCED (ML/24 HR) WITH UNCOOKED PULSES (PER 10 G DRY WT.)

Substrate	A *C. butyricum*	B *C. perfringens*	C *C. sporogenes*	D *C. perfringens*	E *C. perfringens*
Chick pea	12.62	16.26	7.52	14.08	23.06
Dried pea	10.61	15.27	5.69	11.64	20.70
Soybean	6.40	9.99	4.61	7.68	11.52
Lentil	4.49	5.99	3.24	4.99	9.23

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The use of Ragi *(Eleusine Coracana)* in Brewing

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Studies revealed that ragi could be used along with barley malt in equal proportions as an adjunct in brewing. Microbial enzymes like amylases and proteases had to be used to get a wort and beer with desirable characters. When mashed without microbial enzymes, ∝-amino nitrogen level in wort was found to be 120 mg/l. and the degree of fermentation of wort was also less compared to that of control. With the use of microbial enzymes ∝-amino nitrogen level was increased to 175 mg/l. and marked improvement in the degree of fermentation was also observed. With all the desirable characters, the wort could be fermented smoothly and the foaming character of beer appeared to be better.

Barely malt derived from barley grain is still the choice raw material used in brewing with option to use unmalted cereals like barley grain, maize, sorghum, wheat, rice, etc. as adjuncts. Adjunct beers are economical and have better attenuation, characteristic flavours, biological and colloidal stability as it dilutes the level of proteins and polyphenols.[1] In recent years, search for newer adjuncts is being made. It is imperative that any adjunct used in brewing should not in any way affect the quality of either wort or beer.

Ragi (*Eleusine coracana*) is an important millet extensively grown in the areas of Karnataka, Tamil Nadu and Maharashtra. Ragi[2] has about 6-7 per cent protein and 55-60 per cent starch which is almost equal to that of barley and could be used in brewing as it contains only 1-1.5 per cent fat. In addition ragi possesses remarkable keeping quality and the high calcium content (253-661 mg per cent) has an added advantage during mashing. With these advantages studies were undertaken to use it as an adjunct in brewing and the findings are reported here.

Materials and Methods

Raw materials: "Poorna" variety of ragi procured from Karnataka Agro-Industries Seed Corporation, Mysore, was used in the study. Commercially available barley malt and enzymes reported earlier[3] were used. Bohemian hops were used. A strain of brewer's yeast (*Saccharomyces carlsbergensis*) from CFTRI Culture Collection was used for fermentation.

Moisture and protein were determined according to the standard A.O.A.C. methods.[4] Starch was estimated according to the method described by Woodman[5]. Total carbohydrates were determined by the method of Yadav *et al.*[6] and ∝-amino nitrogen by EBC ninhydrin method[7]. Specific gravity and alcohol were determined by ASBC method[8]. Fermentable sugars were determined according to the method of Buckee[9]. Apparaent, real extracts and degree of attenuation were calculated according to the procedure of ASBC[8].

Mashing: (*i*) Single infusion method of Enevoldsen[10] was employed to mash powdered ragi and barley malt in the ratios of 30/70, 40/60 and 50/50 respectively with and without the addition of microbial enzymes. (*ii*) Prior to mashing, powdered ragi was cooked separately for 10 min at 75-80°C with five times its weight of water. Cooked ragi was cooled to room temperature (28-30°C) and protease was added at 100 mg per cent to it. At the end of 30 min, powdered barley malt with five times water and 200 mg per cent amylase was mixed with the above cooked and cooled ragi and mashed as follows:

Temp. (°C)	Time (Min)
40-52	30
52-63	20
63	30
63-78	30
78	10

At the end of 120 min, wort was filtered and boiled with hops (700 mg/1) for 1 hr adding hops at intervals of every 15 min in equal quantity. Hopped wort was strained through a strainer and cooled to 10°C before pitching with a strain of brewer's yeast. Fermentation was carried out at 10°C for 12 days. Fermented brew was filtered, carbonated and bottled.

Results and Discussion

'Poorna' variety ragi had moisture, 14.1; protein, 6.6;

TABLE 1. ANALYSIS OF WORT DERIVED FROM RAGI AND BARLEY MALT COMBINATIONS

Barely malt:Ragi	Enzymes	Sp. gr.	pH	α-amino N (mg/l)	Total carbohydrates g(%)
70:30	With enzyme	1.047	6.0	107	11.1
	No enzyme	1.047	6.0	88	11.1
60:40	With enzyme	1.047	6.2	92	11.1
	No enzyme	1.048	6.2	77	11.1
50:50	With enzyme	1.047	6.2	77	11.1
	No enzyme	1.048	6.2	62	11.1

and starch, 60.0 per cent while barley malt had moisture, 6.0; protein, 8.0; and starch, 52.0 per cent.

The physical and chemical characters of the worts prepared from three different combinations of ragi and barley malt are given in Table 1. Complete hydrolysis of starch could not be achieved in any of the combinations in spite of prolonged mashing and even with the addition of microbial enzymes, though malts with high enzyme activity are known to convert mashes made even with very high unmalted cereals[10]. Since the malt employed was not a special malt with high diastatic power, it was felt that gelatinisation of ragi starch could facilitate complete hydrolysis. Ragi powder, was therefore, separately cooked for 10 min at 75-80°C, cooled and powdered barley malt was mixed along with it and mashed. It was noticed that complete hydrolysis of starch was achieved even in the combination of ragi and barley malt in equal proportion without the addition of external α-amylases. Gelatinisation of ragi starch was thus a prerequisite prior to mashing. However, worts obtained in any of the combination had only 120 mg/l of α-amino nitrogen though they had the other desirable characters. This limitation was overcome by the addition of microbial proteases when the α-amino nitrogen content increased to 175 mg/l, a desirable level for smooth fermentation of wort (Table 2).

The levels of total carbohydrates and of fermentable sugars were same in both the enzyme and non-enzyme treated worts. It was, however, observed that saccharification time of amylases treated wort was less by about 10 min than in the untreated wort. The yield of the extract was less by about 2 per cent as compared to all-malt wort (control). The other characters of wort such as colour and flavour were same in both the enzyme and nonenzyme treated worts. Compared to the control wort, the experimental worts had more of total carbohydrates and fermentable sugars except the level of α-amino nitrogen which was more in all-malt wort. pH of the experimental worts were slightly more than that of control wort perhaps to the high calcium content in ragi. The time taken for mashing (160 min) was less than that required for all-malt wort (180 min) by single infusion process. The filteration was normal and the clarity of the experimental worts compared favourably with that of control wort.

Fermentation of enzyme treated wort derived from ragi and barley malt combination (50:50) was carried out at 10°C as the α-amino nitrogen content was adequate for fermentation. The analysis of fermented brew is shown in Table 3. The colour of the experimental beer compared favourably with that of all-malt beer but the flavour was not as malty as that of all-malt

TABLE 2. ANALYSIS OF WORT DERIVED FROM COOKED RAGI AND BARLEY MALT (50:50)

Wort	Sp. gr.	pH	α-Amino N (mg/l)	Carbohydrates Total (g%)	Carbohydrates Fermentable (g%)	Carbohydrates Non-fermentable (g%) (by diff)
With enzymes	1.0566	6.6	175	13.9	12.0	1.9
No enzymes	1.0573	6.6	120	13.9	12.0	1.9
All-malt (control)	1.0570	5.8	226	12.3	10.0	2.3

TABLE 3. ANALYSIS OF BEER

Physico-chemical characters	Exp. brew; Ragi+ Barley malt (50:50) enzyme treated	All malt brew (control)
Sp. gr.	1.0100	1.0059
pH	6.3	5.7
Alcohol (W/W)	5.5	5.0
Real extract, (%)	5.38	3.58
Apparent extract, (%)	2.56	1.52
Degree of attenuation, (%)	81.80	87.50
Colour	Normal	Normal
Flavour	Less malty	Malty

beer. The degree of attenuation was over 81 per cent. The foaming character of beer appeared to be better than that of all-malt beer.

Conclusion

In the search for newer adjuncts in brewing, ragi has been found to be quite suitable as an adjunct and can replace barley malt by fifty per cent. However, precooking ragi powder or gelatinisation of ragi starch is necessary prior to the addition of barley malt in the preparation of wort. The addition of external source of proteases and amylases is necessary to increase the level of α-amino nitrogen and the degree of attenuation. The resulting beer had the colour akin to all-malt beer and acceptable flavour.

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Comparative Studies on Dehydration of peas in Fluidized Bed and Conventional Tray Drier

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Drying of pea in conventional tray drier and fluidized bed drier was studied. The drying rate was faster in fluidized bed drying of pricked pea, about one fourth of the time required in conventional through flow tray drier for same textural hardness. The optimum drying temperature was found to be 70-75°C with an air velocity of 240-280 m/min in fluidized bed drier. At lower temperature (60-65°C) of drying in fluidized bed, the dried product showed considerable shrinkage. However at the optimum temperature of drying, pricked dried peas were found better in colour, texture, flavour and reconstitutive property.

Peas (*Pisum sativum*) are grown abundantly in India. The problems of moisture migration due to resistance in outerskins, especially at later stages of drying, rehydration characteristics and shrinkage etc. were the major cause of shortfall in the production of quality dehydrated peas. The defect in moisture migration in tray drier has been improved appreciabiy in fluidized bed drier[1]. The overall quality of the dried product produced in the later was found to be better with particular reference to colour, texture, taste and reconstitution characteristics than in the former.

Materials and Methods

Shells were removed from peas by hand, graded

according to their sizes, blanched in hot water (90°C) for 2 min and pricked by some suitable pricking device. 500 g of materials were then fed into laboratory fluidized bed drier. Materials were dried at three different ranges of temperatures (60-65°C), (70-75°C) and (80-85°C) and the air velocity was maintained between 240 and 280 m/min in all the cases without air recirculation. RH of entering air was 65 to 70 per cent while RH of exit air was 10 to 25 per cent. Towards the beginning the RH of air was 25 per cent while towadrs the end it was only 10.0 per cent. Moisture was estimated according to A.O.A.C.[2]. Texture was determined in Asha Tester for determination of hardness as per DIN 53505 (German) and ASTM D 1706-61, ASTM D 676-59 (American Standard). Air velocity was determined by Anamometer No 39503 chome Nalimune Suginami-Ku-, ota Keiki Seisakusho (Japan). Rehydration characteristics were studied as per ISI Specification[3]. Relative humidity was measured by dry and wet bulb thermometer.

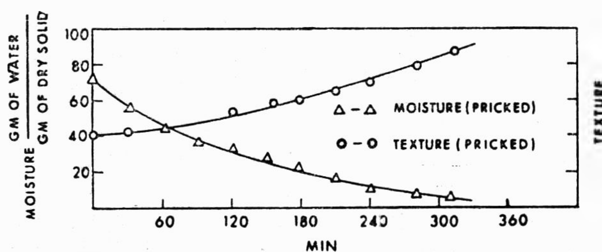

FIG. 1 CHANGES IN MOISTURE & TEXTURE DURING DRYING OF PRICKED PEA IN THROUGH FLOW TRAY DRIYING (70-75°C) & AIR RATE 100 METERS/MIN

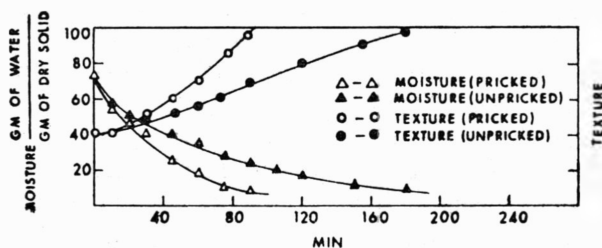

FIG. 2 CHANGES IN MOISTURE & TEXTURE DURING DRYING OF PEA IN FLUIDIZED BED DRIER AT (70-75°C) & AIR RATE 240-280 METERS/MIN

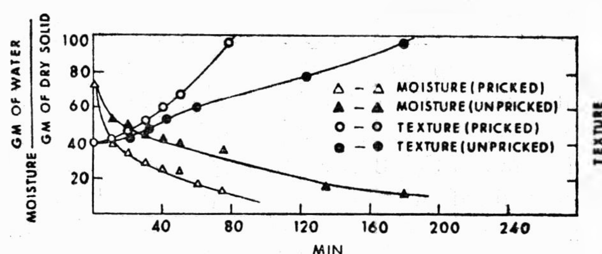

FIG 3 CHANGES IN MOISTURE & TEXTURE DURING DRYING OF PEA IN FLUIDIZED BED DRIER AT (60-65°C) & AIR RATE 240-280 METERS/MIN

TABLE 1. RECONSTITUTIVE PROPERTY OF DRIED PEAS

Drier	Temp. (°C)	Rehydration ratio	
		Pricked	Unpricked
Tray	70–75	2.2:1	—
Fluidized bed	70–75	3.3:1	2.1:1
Fluidized bed	60–65	2.8:1	2:1

Results and Discussion

The rate of drying of pricked pea at 70-75°C in fluidized bed drier is faster than in conventional tray drier (Fig. 1). The tray dried and the fluidized bed dried pea attain the textural hardness (86) in 315 and 80 min respectively. The total time required to bring the moisture level of pricked pea below 10 per cent level in fluidized bed drier is only 90 min (Fig. 2) which is about one fourth the time required in conventional tray drier (Fig. 1). Unpricked pea even in fluidized bed drier took about twice the time than that of pricked peas under identical condition of drying.

Attempts were made to optimize the temperature by subjecting the peas to drying above and below 70-75°C. Though the drying time was not significantly extended (100 min) at 60-65°C it affected the textural quality, particularly the overall shrinkage of the dried pea. The dried product has the same textural hardness (86) in 70 min. The unpricked pea took comparatively long time (Fig. 3). However drying rate at 80-85°C was enhanced (not shown) but it affected the colour and reconstitution property significantly. In all the cases the drying rate was found to be ineffective above the specified air velocity range and it also did not reduce the drying time significantly.

Pricked pea at lower temperature of drying did not show significantly higher reconstitutional property (Table 1) due to high shrinkage. Apart from reconstitution, characteristics organoleptic test was also carried out with particular reference to colour, flavour and texture. In general, it was observed that pea, dried at 70-75°C in pricked form at an air velocity of 240-280 m/min showed comparatively better colour, flavour, texture and reconstitution property.

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Studies on deep Fat Frying—Changes During Heating of Oil

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In order to find out the deteriorative changes during heating of groundnut oil, vanaspati (partially hydrogenated vegetable oils) and safflower oil, model experiments were conducted. Results indicated considerable damage of test oils through the formation of oxirane-oxygen, conjugated double bonds, oxidised and non-urea adduct forming fatty acids during heating. Associated with these, there were continuous deteriorative physical and chemical changes as reflected in increase in Lovibond colour units. viscosity, foaming property, free fatty acids, refractive index and decrease in smoke point and iodine value. In presence of added dimethyl polysiloxane (silicone), the above changes were substantially retarded.

In India, oils and fats are extensively used for the preparation of deep fat fried products. Substantial part of dietary fat is derived from such products.

During deep fat frying when the period of heating is short as encountered in household practice, the changes are considered favourable as this improves the organoleptic quality of the product through removal of raw odour of oil and providing desirable aroma and flavour to the products. During such short period, character and concentration of undesirable compounds originating as a result of heating do not pose any problem. But when fats and oils are heated for a considerable time as encountered in commercial practice, there is an excessive accumulation of oxidised, polymerised and cyclic compounds as a result of hydrolytic and oxidative reations and these are considered harmful to human health. The chemical and biological aspects of heated and oxidised fats have been well documented by Artman[1] and Lee[1a].

Assessment of quality of frying oil used for considerable period is a necessity to provide a limit for judging its suitability from the stand point of health and nutrition. However, specific information on the deterioration of different kinds of edible oils and fats is lacking particularly with reference to Indian practices.

The present investigation was undertaken to find out (1) the progressive changes in physical and chemical characteristics of certain edible oils and fats (commonly used in India) that take place during heating and (2) possibilities of minimizing deteriorative changes observed during heating of oil through the use of silicone. In order to obtain precise information on the changes or the effect of silicone, model experiments were conducted.

Materials and Methods

Materials: (*i*) Refined groundnut oil, refined safflower oil and vanaspati (partially hydrogenated vegetable oil containing 10 per cent edible oils including 5 per cent sesame oil, also known as Indian magarine) of standard commercial brands purchased locally in sealed containers and (*ii*) dimethyl polysiloxane (silicone) (Dow corning 200 fluid food grade, 350 CS viscosity, 100 per cent silicone fluid) received through the courtesy of Dow Corning Coproation, Midland, USA, were used in the present investigation.

Heating: Groundnut oil was heated at 180°C for 48 hr. The oil was agitated for 5 min at half hourly interval. Safflower oil and vanaspati were similarly heated with or without the addition of silicone (10 ppm on the weight of the oil).

Methods: Colour of oil samples was assessed in a Lovibond tintometer using 1 cm cell. Refractive index, free fatty acids, iodine value, viscosity, smoke point and peroxide value were determined by the methods described in A.O.C.S.[2]. In addition, oxirane—oxygen[3], non-urea adduct forming fatty acids[4], oxidised fatty acids[5], conjugated fatty acids[6], thiobarbutyric acid (TBA) value[7] and foaming height[8] were determined. Fatty acids obtained by saponification and acidification were made free from oxidised fatty acids; methyl esters of fatty acids thus obtained were prepared by using diazomethane[9]. G.L.C. apparatus (Chromatography and Instrument Co., Baroda, India) with flame ionisation detector fitted with a column (7 ft × 1/8 inch) of diethylene glycol succinate on chromosorb W, with a column temperature 175°C, injection temperature 180°C,

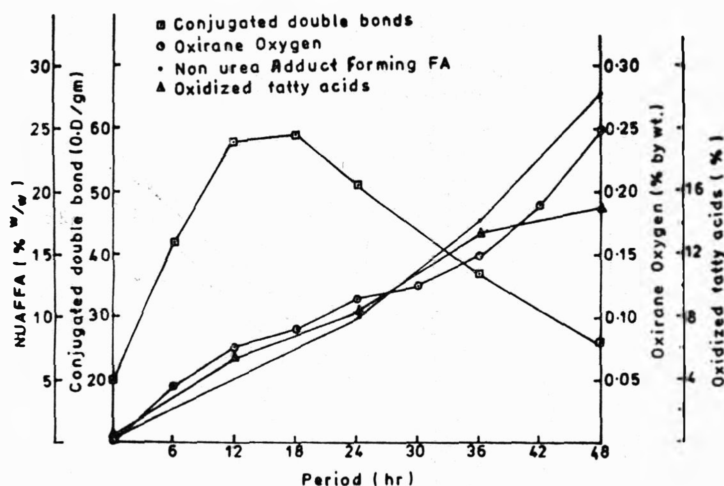

Fig. 1. Change in conjugated double bond, non-urea-adduct-forming fatty acids, oxirane—oxygen and oxidized fatty acids of refined groundnut oil during heating (180°C).

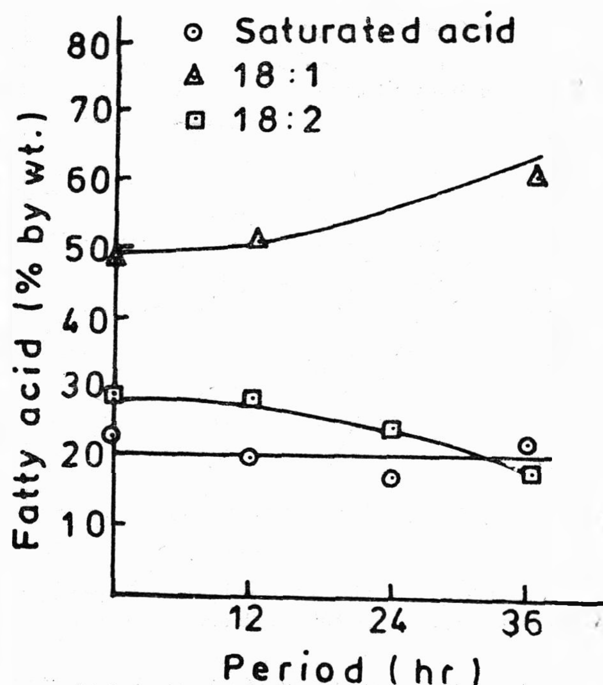

Fig. 2. Change in fatty acid composition of refined groundnut oil during heating (180°C).

attenuation ×8, charts, speed 1 cm/min was used. Peaks were identified by comparison of retention time obtained with standard fatty acid mixtures (Applied Science Laboratories Inc., USA) fed to the instrument at the beginning and at the end each day whenever test samples were analysed. The percentage composition was determined by the method of triangulation.

Results and Discussion

Groundnut oil and vanaspati were selected because of their wide use in India for the preparation of deep fat fried products.

Safflower oil was selected because it is quite often recommended for use by patients having heart disease and high serum cholesterol. The oil is only used in household practices for preparation of deep fat fried products.

Changes during heating of refined groundnut oil: There was considerable increase in conjugated double bond during the first 18 hr followed by a decrease possibly due to polymerisation. Polymerisation of refined groundnut oil when heated at 180°C for 3-6 hr has been reported by Vidyasagar *et al.*[10] There was gradual increase in oxirane-oxygen content, non-urea adduct forming and oxidised fatty acids. In 48 hr of heating oxirane-oxygen content increased to 0.25 per cent (or about 4.7 per cent epoxy acid), corresponding values for non-urea-adduct forming and oxidised fatty acids weer 28 and 15 per cent respectively (Fig. 1).

TABLE 1. CHANGES IN CHARACTERISTICS OF REFINED GROUNDNUT OIL DURING HEATING AT 180°C

	Period of heating (hr)								
	0	6	12	18	24	30	36	42	48
Colour (Lovibond unit, 1 cm cell)	R = 0.1 Y = 0.5	R = 0.1 Y = 0.5	R = 0.1 Y = 0.7	R = 0.5 Y = 2.6	R = 0.2 Y = 5.1	R = 0.7 Y = 7.9	R = 1.2 Y = 2.0	R = 3.3 Y = 13.0	R = 4.3 Y = 20.0
FFA (as oleic acid %)	0.1	0.3	0.2	0.3	0.4	0.5	0.7	0.7	0.8
P. V. (meq O_2/kg of oil)	0.7	5.2	8.0	6.1	4.2	4.0	3.0	1.4	2.2
TBA (μg/ml)	0.6	—	2.8	4.1	4.1	4.1	4.6	—	6.9
Iodine value (Wijs)	92.5	88.2	84.6	82.4	79.3	78.4	70.1	68.9	55.4
Refractive index (40°C)	1.4628	1.4632	1.4638	1.4651	1.4658	1.4663	1.4674	1.4685	1.4693
Viscosity (CPS)	63	79	97	125	157	211	270	460	575
Smoke point (°C)	242	236	231	228	219	215	183	180	180
Foaming height (cm)	1.5	1.5	1.5	1.5	2.0	2.0	2.5	2.5	3.0

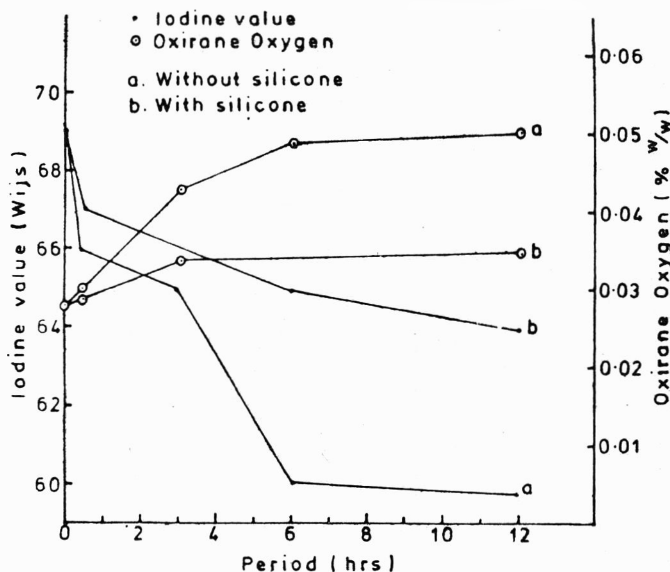

Fig. 3. Change in iodine value and oxirane-oxygen content of vanaspati during heating (180°C) with and without silicone.

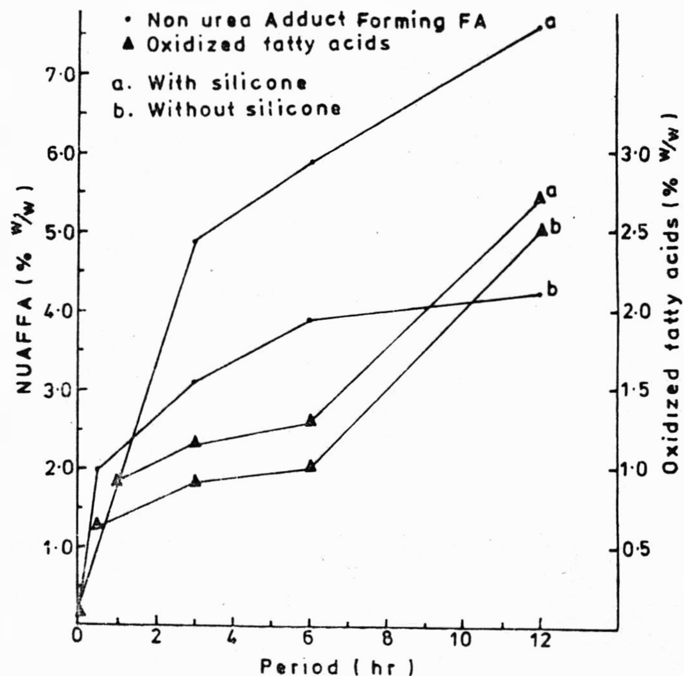

Fig. 4. Change in non-urea-adduct and oxidized fatty acid content of vanaspati during heating (180°C) with or without silicone.

(NUAFFA – non urea adduct forming fatty acids).

In addition, there was gradual increase in FFA (0.1 to 0.8%), refractive index (1.4628 to 1.4693 at 40°C), decrease in iodine value (92.5 to 55.4), increase in viscosity (63 to 575) and decrease in smoke point (242°C to 180°C). There was gradual browing of oil and increase in TBA value. Peroxide value showed a steady rise up to 12 hr of heating followed by subsequent steady decline due to decomposition of hydroperoxides (Table 1). Decrease in iodine value, increase in FFA and oxirane-oxygen content during heating of groundnut oil has been earlier reported by Arya *et al*[11].

In non-oxidised fatty acid fraction (Fig. 2) there was a gradual decrease in linoleic acid content with an increase in the amount of oleic acids. Total saturated fatty acids content remained more or less constant. The decrease in linoleic acid content during heating of refined groundnut oil has also been reported earlier by Vidyasagar *et al*[10]. Thus, during heating, lineolic acid only was damaged while oleic acid remained uneffected.

Changes during heating of vanaspati: With vanaspati there was considerable increase in epoxy (oxirane-oxygen), non-urea-adduct forming and oxidised fatty acids during 12 hr of heating (Fig. 3 and 4). There was

TABLE 2. CHANGES IN CHARACTERISTICS OF VANASPATI DURING HEATING (180°C) WITH OR WITHOUT SILICONE

	Period of heating								
	0 hr	½ hr		3 hr		6 hr		12 hr	
		I	II	I	II	I	II	I	II
Colour (Lovibond units, 1 cm cell)	R – — Y – 2.1	R – 0.1 Y – 2.1	R – 0.1 Y = 1.4	R – 0.5 Y – 2.1	R – 0.1 Y – 1.7	R – 0.6 Y – 2.8	R – 0.5 Y – 2.7	R – 0.8 Y – 4.7	R – 0.3 Y – 4.3
FFA (oleic acid, %)	0.06	0.12	0.09	0.33	0.12	0.39	0.11	0.46	0.39
P. V. (meq O_2/kg of oil)	1.0	1.4	0.9	1.0	1.4	5.1	1.4	6.1	5.2
Refractive index (40°C)	1.4610	1.4615	1.4611	1.4612	1.4613	1.4619	1.4614	1.4627	1.4623
Smoke point (°C)	252	240	252	232	249	230	246	222	244
Foaming height (cm)	1.0	1.6	1.4	2.5	1.5	2.5	1.8	3.0	2.0

I = without silicone II = with silicone

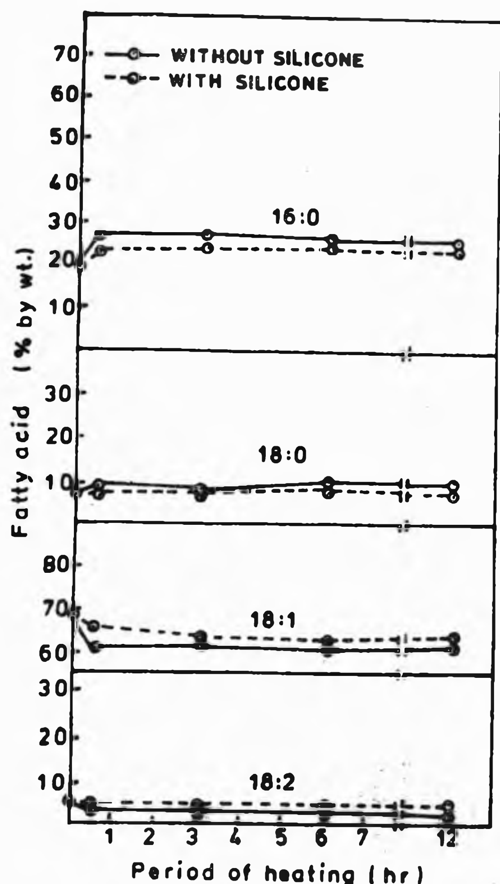

Fig. 5. Change in fatty acid composition of vanaspati during heating (180°C) with or without silicone.

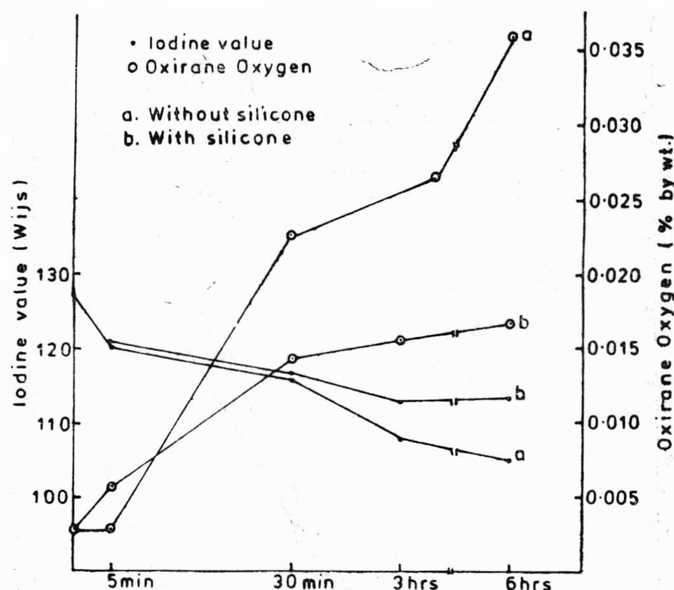

Fig. 6. Change in iodine value and oxirane-oxygen content of safflower oil during heating (180°C) with and without silicone.

gradual decrease in iodine value (Fig. 3) and smoke point, increase in FFA, refractive index and foaming height (Table 2). Change in fatty acid composition of fraction free from oxidised fatty acids is given in Fig. 5.

During the first 30 min of heating there was certain amount of decrease in C18:1 and C18:2 acids with corresponding increase in saturated fatty acid (C16:0 and C18:0). Subsequently, there was no appreciable change in these fatty acids. Apparently during first 50 min, triglycerides containing C18:1 and C18:2 were involved. Vanaspati is a mixture of partially hydrogenated vegetable oils containing 5 per cent sesame oil and 5 per cent other liquid oil as permitted by VOP control order[12]. The linoleic acid content of vanaspati was estimated as 5.2 per cent and this agreed with the calculated value on the assumption that it was entirely derived from 10 per cent added liquid oils of vanaspati. Thus linoleic

TABLE 3. CHARACTERISTICS OF SAFFLOWER OIL DURING HEATING WITH OR WITHOUT SILICONE

	Period of heating								
	0 min	5 min		30 min		3 hr		6 hr	
		I	II	I	II	I	II	I	II
Colour (Lovibond units, 1 cm cell)	Y=0.5	Y=0.4	Y=0.5	Y=0.5	Y=0.5	Y=0.9 R=0.1	Y=0.5	Y=6.0 R=0.6	Y=0.7
FFA (oleic acid, %)	0.09	0.13	0.08	0.14	0.07	0.26	0.10	0.28	0.15
P. V. (meg O_2/1000 g of oil)	5.2	6.1	1.0	14.0	4.2	8.1	2.8	3.0	3.1
Refractive index (40°C)	1.4690	1.4696	1.4690	1.4699	1.4691	1.4702	1.4692	1.4722	1.4699
Viscosity (CPS)	52	56	61	60	60	75	72	124	73
Smoke point (°C)	250	246	250	240	244	240	242	230	242
Foaming height (cm)	1.1	2.0	1.5	2.0	1.5	2.0	1.5	2.8	1.7

I = without silicone II = with silicone

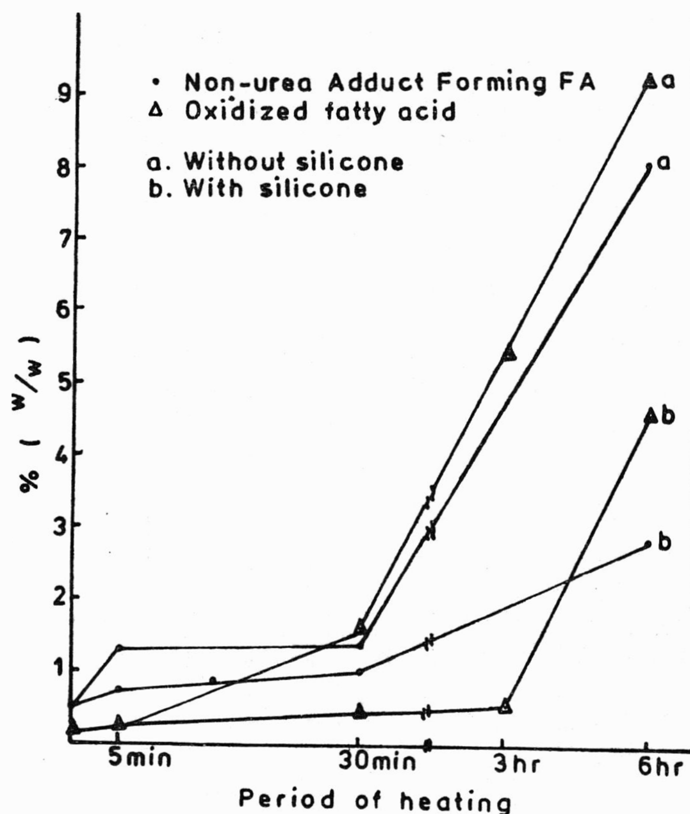

Fig. 7. Change in non-urea and oxidized fatty acid of safflower oil during heating with or without silicone.

acid which was damaged during the first 30 min may be from triglycerides containing 18:1 and 18:2 from these liquid oils.

Changes during heating of safflower oil: Safflower oil is used in household practices only for the preparation of deep fat fried products. In household practices period of heating is expected to be short. For this reason, samples were subjected to shorter periods of heating. In addition to 5 min and 30 min, 3 hr and 6 hr heated samples were taken for analysis. As observed with groundnut oil and vanaspati, there was increase in oxirane-oxygen (epoxy acids), non-urea-adduct forming and oxidised fatty acids (Figs. 6 and 7), free fatty acid, viscosity, foaming height, refractive index and decrease in smoke point (Table 3) and iodine value (Fig. 6). In addition, there was gradual discolouration of oil. There was increase in peroxide value during the the first 30 min. Afterwards, it indicated a decrease (Table 3).

Even 30 min of heating seemed to damage the oil (lowering of iodine value and smoke point, increase in oxirane-oxygen). However, during this period, formation of oxidised fatty acid and non-urea-adduct forming fatty acids and increase in viscosity was marginal.

The study indicates considerable heat damage to refined groudnut oil, safflower oil and vanaspati through the formation of damaged fatty acids and bringing about change in physical characteristics. There is a need to carry out further study to fix the limits of these parameters from nutritional consideration and from the stand point of product quality.

Effect of silicone: Silicone was tried with vanaspati and safflower oil. It retarded discolouration, increased the FFA, refractive index, viscosity, foaming height, oxidized fatty acid, non-urea-adduct forming acids and oxirane-oxygen content and also decreased smoke point and iodine value.

With saflower oil which is considered as unsaturated oil with about 75 per cent linoleic acid, the effect was substantial. After six hours of heating, safflower oil had 8 per cent non-urea-adduct forming fatty acids, corresponding value for sample heated with silicone was about 3 per cent. Similarly oxidised fatty acid content was only about 4.5 per cent for sample with silicone as against 9.0 per cent for the sample heated without silicone.

Study on the fatty acid composition indicated that vanaspati treated with silicone had higher proportion of linoleic acid during the entire period of heating than that observed in sample without silicone.

The results with vanaspati and safflower oil clearly indicate high beneficial effect of silicone in the prevention of severe deterioration.

According to Freeman *et al.*[13] the beneficial effect of silicone could be due to the formation of a monolayer of silicone on the oil to air surface or alternatively it acted as a true anti oxidant. Beneficial effect of silicone added to butter oil by raising the smoking point and by lowering the degree of foaming has been reported by Chang *et al.*[14]

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VARIETAL DIFFERENCE IN EQUILIBRIUM MOISTURE CONTENT OF RICE AND EFFECT OF KERNEL CHALKINESS

Rice varieties differ in the equilibrium moisture content attained by them when soaked in water at room temperature (EMC-S) depending primarily on their amylose contents. In five out of seven varieties tested, chalky rice kernels absorbed more water upon soaking than translucent kernels. However, inter-varietal difference in EMC-S was maintained even among fully translucent or fully chalky kernels.

We have repeatedly observed in a large number of varieties[1-3], confirmed recently in an extensive study of 180 varieties[4], that there was a clear varietal difference in the equilibrium moisture content attained by rice grains when soaked in water at room temperature (EMC-S). Researchers at the International Rice Research Institute[5-6] also observed this phenomenon in a limited number of varieties.

This difference can be attributed to three possible factors. First, the EMC-S has been clearly observed to be inversely related to the amylose content[2-6] (Table 1).

TABLE 1. EQUILIBRIUM MOISTURE CONTENT ATTAINED BY MILLED RICE WHEN SOAKED IN WATER AT ROOM TEMPERATURE (EMC-S)[1-4]

Rice type	Amylose (% dry basis)	EMC-S (% wet basis)
High-amylose: general	>26	27–29
High-amylose: selected dwarf *indica*[a]	>26	28.5–30.0
Intermediate-amylose[b]	22–26	30–32
Low-amylose	15–22	30.5–33
waxy	0–5	34–37

[a]This anomalous high-amylose class comprises of the recent high-yielding dwarf *indica* introductions from Taiwan (such as Taichung Native 1) and some of their progenies (such as IR 8, Jaya). These varieties have other distinctive characteristics as well (e.g., they have a very high water-insoluble amylose content, B-type alkali reaction and very low viscographic breakdown, and they cook very hard and flaky)[2-4, 7,8] and they belong to the rice quality type I as per the classification recently proposed by us[7,8].

[b]There are exceptions to this group also. Scented and bulu varieties, though intermediate-amylose, give EMC-S nearly like high-amylose rice[3,4,8]. But these are not further discussed here.

A second possible relation is with the gelatinization temperature (GT). The waxy, low-amylose and intermediate-amylose rices which give a high EMC-S (Table 1) also most often possess a low GT[2-4]. Indeed even the anomalous high-amylose class of certain dwarf *indicas* which show a relatively high EMC-S despite their high amylose contents (Table 1), usually have a very low GT[2-4]. However, it is not clear whether this association between EMC-S and GT is real or coincidental. We came across several low-amylose and waxy rices which possessed an intermediate or high GT but still showed a high EMC-S as characteristic of their amylose class[2-4]. Similarly Kongseree and Juliano[5], after a study of two parents and nine progenies having different combinations of amylose content and GT, concluded that the EMC-S was inversely related to the amylose but was not related to the GT. This relation is therefore still uncertain.

A third possible factor is kernel chalkiness. Antonio and Juliano[6], while confirming the anomalous slightly high EMC-S of certain dwarf *indicas* like IR 8 as reported by us[2], suggested that this was an artefact caused by chalky kernels usually found in these varieties. Comparison of the kernel chalkiness score and EMC-S data in several varieties in a recent study[3] seemed to discount this latter hypothesis. However, a more direct study of the effect of kernel chalkiness on EMC-S was thought desirable.

Seven varieties of milled rice containing a good number of chalky grains was selected from laboratory stock. Fully translucent as well as highly and slightly chalky kernels were manually separated in each sample. EMC-S was determined[1] in each subsample as well as in the aggregate sample. The aggregate samples were also tested for their total[9] and water-insoluble[2] amylose contents, alkali reaction type and score[10]. Chalkiness score was determined as per the following modification of the IRRI score card[11]:

Score	% Kernel area chalky
0	Nil
1	< 10
5	10-20
7	20-50
9	> 50

The amylose contents and alkali test data (Table 2) show that the first two samples belonged to the high-amylose dwarf *indica* type I rice described above, the last sample was a low-amylose rice, and the rest general high-amylose type. Their aggregate EMC-S results

TABLE 2. EFFECT OF KERNEL CHALKINESS AND OTHER QUALITY TRAITS ON EMC-S OF RICE

Variety	Class[a]	Amylose (% d.b.)[b]		Alkali test		Mean chalkiness score	EMC-S (% w. b.)[b]			
		Total	Insoluble	Type	Score		Aggregate sample	In kernels with chalkiness score		
								0	1	9
Sabarmati	di	29.0	19.0	A.B	8.0[c]	2.2	29.0	28.3	—	29.4
T (N) 1	di	28.8	18.5	B	8.0[c]	1.5	28.7	28.4	29.0	29.8
Ratna	di	29.0	13.7	$A(B_1)$	4.5	1.4	26.5	26.2	—	27.8
Jenugudu	ti	29.2	11.8	A	3.0	1.2	26.6	26.5	27.1	27.9
B 1399	ti	30.3	12.5	A(C)	3.5	3.0	27.3	27.0	27.0	26.6
S 705	ti	28.7	12.2	A	3.8	2.3	26.3	26.0	26.4	26.0
Moirangphou	ti	21.4	8.3	C	7.0[c]	2.9	30.5	29.5	—	31.3

[a]di, ti = dwarf and tall *indica*, respectively.

[b]d.b., w.b. = dry and wet basis, respectively.

[c]The high alkali score indicates a low gelatinization temperature.

were generally as discussed above (slightly lower, because the samples were very old).

EMC-S results in separated kernels showed that chalky kernels indeed absorbed more water than the translucent kernels in most of the varieties. It has been suggested that chalky areas in rice kernel represent loosely packed cells with air spaces[12]; this might account for their greater water absorption. However, B 1399 and S 705 varieties were exceptions to the above results, where chalkiness had no effect on water absorption (Table 2). Clearly there might be differences in the nature of rice chalkiness.

Irrespective of the effect of chalkiness, however, varietal differences in aggregate EMC-S were maintained among the respective translucent as well as chalky kernels (Table 2). This shows that the slightly high EMC-S of certain high-amylose dwarf *indica* rice[1-3] is not an artefact caused by their chalky kernels but is something intrinsic. The reason for this rather high water absorption capacity is not known at this time, but it may have some implication in terms of the rather exceptional quality characteristics of these varieties.

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SIMPLIFIED EXTRACTION PROCEDURE IN THE RAPID SPECTROPHOTOMETRIC METHOD FOR LYCOPENE ESTIMATION IN TOMATO

Lycopene may be extracted from tomatoes completely by shaking with acetone for 15 min.

Tomato breeders all over India are actively engaged in breeding new tomato varieties with deep red colour to meet the requirements of the processing industry. The red colour of ripe tomato is due to the pigment lycopene ($C_{40}H_{56}$) although other carotenoid pigments besides lycopene are also present. Beer and Siddappa[1] standardised a rapid spectrophotometric method for the lycopene estimation. The method involves extraction of lycopene using acetone by grinding in a pestle and mortar or in an electric blender till the residue becomes colourless, transfer of pigment from acetone to petroleum ether phase and measurement of the optical density of the extract at 503 nm (since β-carotene has negligible absorbance at this wave length). Extraction procedure followed by them are laborious, time consuming and needs more solvent. Investigations carried out for rapid extraction of the pigments from tomato juice are presented in this paper.

In the preliminary investigations, various solvents were tried repeatedly for four times to verify reproducibility of results. The procedure consisted of shaking 1g of tomato juice (taken in duplicate in 100 ml stoppered conical flask) with 20ml of solvent for 30 min. on an electric shaker having a speed of 120 strokes per min. Optical density of colour was measured either directly in the extract or after transferring the pigments to petroleum ether phase and removal of moisture from the solvent using anhydrous sodium sulphate (Table 1).

Table 1 shows that extraction of lycopene was maximum in acetone. The pigments could then be transferred to 20 ml petroleum ether for measuring the colour intensity.

TABLE 1. OPTICAL DENSITY OF COLOUR EXTRACTED USING DIFFERENT SOLVENTS

Solvent system used	Optical density at 503 nm
Hexane (20 ml)	0.1938
Acetone+hexane (10 ml each)	0.1675
Petroleum ether (20 ml)	0.1549
Acetone+petroleum ether (10 ml each)	0.1549
Acetone (20 ml)[a]	0.4685
Acetone (20 ml)[b]	0.4089

[a]Pigments transferred to 20 ml petroleum ether and then the OD measured.

[b]Pigments transferred to 20 ml hexane and then the OD measured

TABLE 2. COMPARISON OF SIMPLIED METHOD WITH THE ORIGINAL METHOD OF BEER AND SIDDAPPA[1]

Method used	Optical density at 503 nm
1. *Beer and Siddappa's method*	
(*a*) Tomato juice (1g) ground with acetone using pestle and mortar till the residue was colourless, transferred to petroleum ether (20ml) and the colour measured at 503 nm using a spectophotometer.	0.4949
(*b*) Similar to 'a' but blending in an electric blender instead of grinding in pestle and mortar.	0.3979
2. *Proposed method*	
Tomato juice (1g) shaken with acetone (20 ml) for 15 min on an electric shaker Pigments transferred to petroleum ether (20 ml) and the optical density measured.	0.5086

The minimum time required for the complete extraction of pigment was standardised by using acetone as solvent. Time of shaking varied from 0 to 60 min. and the experiment was repeated thrice to check the reproducibility of the results. The results revealed that shaking for 15 min was sufficient to extract lycopene completely.

The standardised method was compared with the method of Beer and Siddappa.[1] Table 2 shows that blending as compared to grinding resulted in loss of pigments. perhaps during transferring of the samples, which is difficult to overcome. However, there was no difference between the values obtained by grinding (method 1*a*) and shaking on an electric shaker (method 2). The latter method appeared to be equally efficient to the method of grinding and extraction followed by Beer and Siddappa[1]. The method is simple, less laborious, equally precise, requires less solvent and enables handling of more number of samples.

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LACTOSE CONTENT AND PARTICLE SIZE DISTRIBUTION IN GHEE RESIDUE OBTAINED FROM DIRECT CONTACT HEAT EXCHANGE PROCESS

Lactose content of ghee residue obtained by direct contact heat exchange (DCHE) method, was approximately three times higher than in the conventional pan (CP) method. The residue particle size for DCHE and CP was 138 and 106 microns respectively.

The process feasibility of ghee making by direct content heat exchange was explored and reported[1]. This process appeared quite promising in respect of acceptability of the product, foaming and scale formation, energy requirements and fat recovery. Further investigations were carried out to determine the lactose content and particle size distribution in the ghee residue obtained from direct contact heat exchange process. The values were compared with those obtained for the residue from conventional process.

Lactose: Lactose was estimated according to Lane and Eyenon[2] with a slight modification in regard to the precipitation of proteins from the sample.

The lactose in ghee residue was estimated on fat free basis as the fat content in conventional process residue was found to differ from that of the direct contact heat exchange process.

Five samples of residue obtained from both the processes were analysed. In the samples from conventional method the lactose content varied from 7.76 weight percent to 7.94 weight per cent on fat free basis with an average value of 7.88. However the weight percent of lactose in the samples obtained from direct contact heating varied from 23.88 to 24.89 with 24.52 as the average value. From these results it is evident that the lactose content in the ghee residue obtained from direct contact heat exchange process is approximately three times higher than the sample obtained from conventional process. In the latter process most of the lactose is lost because of its reaction with proteins (*Maillard* reaction) and by high temperature denaturation (caramalization).

Particle size distribution: Wet screening method with certain modifications was employed in the particle size analysis[3]. The arithmatic average particle size in the case of conventional method sample was found to vary

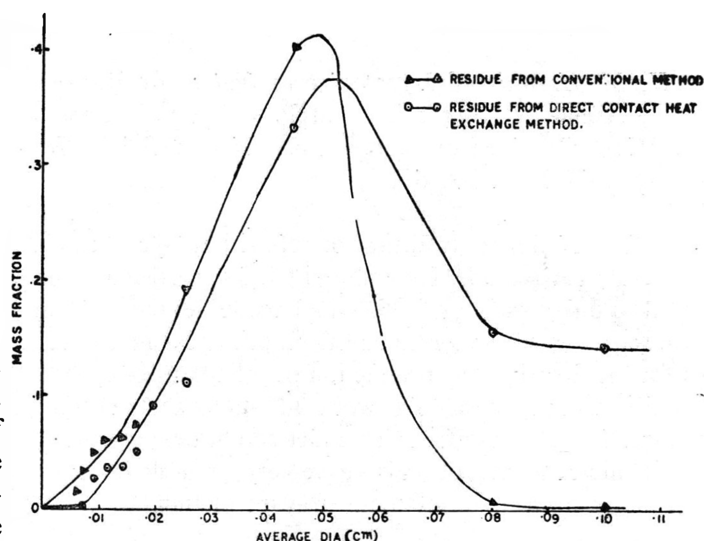

FIG. 1 PARTICLE SIZE DISTRIBUTION FOR GHEE RESIDUE FROM CONVENTIONAL AND THE NEW METHOD

from 97.0 to 121.0 microns with the mean value as 106.8 microns. The range of the particle size obtained from direct contact heat exchange method was 131 to 145 microns with the average value as 138 microns. Hence there was not much difference in the average values of particle size. However a plot in mass fraction versus average diameter for both the type of samples as shown in Fig. 1 reveals that the sample obtained from direct contact heat exchange method contains lesser number of fines compared to the other sample. Reduction in the number of fines will result in their easy removal and will also reduce the fat losses because large number of fines trap more fat on the surface.

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BOOK REVIEWS

Health Hazards of Mycotoxins in India: by Ramesh V. Bhat, V. Nagarajan and P. G. Tulpule, Indian Council of Medical Research, New Delhi, 1978; pp. 60, Price Rs. 5/-.

The National Institute of Nutrition spearheaded research work on Mycotoxins in India particularly on aflatoxins during the 1960's and made very significant discoveries of its morbid effects on primates and showed for the first time the production by aflatoxins of cancers of liver in monkeys. The work on rats by acute/chronic administration of aflatoxins under conditions of protein/ vitamin A deprivation also gave very valuable information on hazards of aflatoxin relevant to India.

Therefore, the Country Status Report for the FAO from the National Institute of Nutrition could scarcely have been prepared by anyone else in the country, who could claim the same degree of interest, involvement and expertise. Despite their own expertise it is to the credit of the Scientists concerned that they made a compilation dispassionately and without comment. Systematising on the basis of all available local data has been indeed a commendable effort. This country report should serve as a useful reference book and guide for scientists interested in the problem of Mycotoxicoses in India.

The first and fifth chapters should be of particular interest to Agriculturists and Food Corporations as they highlight the problems of storage of food grains in India and the approaches to be adopted to overcome these in the prevention and control of fungal infestation. These should serve as guidelines for greater attention and emphasis from agricultural Scientists who could specify methods to be prescribed and implemented by authorities in charge of storage and distribution of food grains.

The second chapter on occurrence, merely catalogues data from reports on various samples of oilseeds, cereals and pulses etc. examined by different people at different times and the range of mycotoxin levels found or the fungal strain isolated and their toxigenicity. These data for want of epidemiological correlation are uninteresting but underscore the absolute need of such studies in epidemiological work on Mycotoxicoses. What is interesting is the statement that sunflower, safflower, niger, sesame, mustard have been found to be poor substrates for *A. flavus*, while groundnut and cottonseed were sensitive equally, this is food for thought and work for Mycologists.

Chapters 3 and 4 enumerate the episodes of mycotoxicoses in animals and human beings reported from different parts of the country. These refer to reports of mortality and morbidity in dairy cattle (24 buffaloes in Andhra Pradesh 1965; 58 deaths in Karnataka 1968); Fowsl (2219 chicks died in Karnataka 1969), Ducklings (Heavy mortality in Hosur cattle farm Tamil Nadu 1962), Rabbits (4000 deaths in a Kulu farm), Pigs (Kerala) and Dogs (Western India). The essential feature common to all being damage to liver and a preponderant evidence suggestive of *A. flavus* infested or aflatoxin containing groundnut meal in feed as a aetiology. Much of the awareness and reporting seems to be from the southern part of the country and in the wake of reports on the aetiology of 'Turkey X' disease in the U.K. It is surprising that such episodes either did not occur or were not reported from other parts of the country.

The "Degnala" disease from Punjab much before this time and its recurrence in late sixties calls for an in depth study in this subject.

Despite the high humidity, high temperature conditions prevalent in India, surprisingly, there is a paucity of epidemics of ergotism (which occurred in Russia in 1926, Ireland in 1929 and in France in 1953). Moreover, it is intriguing that in India the symptoms and signs are of gastrointestinal upset rather than of the cerebral or vascular types and due to ergot in 'Bajra' rather than any other cereal.

The discovery of *Heterosporium* as cause of mouldy 'Ragi' poisoning as early as 1929 and kodo millet poisoning of Elephants and Tigers make interesting reading.

Aflatoxicoses as a cause of liver injury, cirrhotic ascites or hepatocellular carcinoma should receive greater attention from medical practitioners where a casual approach would tend to blame it on alcohol consumption or virus.

The book makes very cogent recommendations in chapter 8 and leaves little doubt in the mind of the reader that it would be very useful to toxicologists, medical men, veterinarians, post-harvest technologists, food technologists and mycologists in India and elsewhere as stated by Dr. Gopalan in the Foreward.

M. J. MULKY
HINDUSTAN LEVER LIMITED,
BOMBAY.

Basics of Food Allergy: by Dr. J. C. Breneman, M. D. Charles C. Thomas, Springfield, Illinois, U.S.A., 1978; Pp. 278, Price $ 29.50.

This is an ambitious work by Dr. J. C. Breneman, an expert allergist. The author emphasises the need for the physicians to appreciate the importance of food allergy, as he strongly believes that 60 per cent of human illness involves food intolerance and allergy. With the help of 19 comprehensive chapters, he leads us to believe that when conventional therapy fails with many disorders, "the elimination diet" therapy could be tried successfully.

The text includes chapters on the importance, occurrence and factors inducing food allergy, the diagnosis of food allergy and on the method of Elimination Diet by which the patient and the physician can identify and eliminate the food allergens from the diet. In another group of chapters, the author describes the type of diseases and symptom caused by particular food and goes on to explain scientifically how diverse aspects like Bedwetting, Gall bladder disease, Hives, Allergic Arthritis, Gastrointestinal allergy, Mental Disorders, etc., could be treated by application of allergic concepts and the Elimination Diet Method. In another chapter, the author recommends certain treatments for a sudden and severe allergic reactions and also suggests future methods for the prevention of food allergies. Another excellent chapter is on the current theories of food allergy. The author explains lucidly with the help of nice illustrations and diagrams how the well known four types of Gell-Coombs classification of allergic reactions could be used to explain the food allergy. In addition, a fifth type (Systemic Mediator Reaction—SMR) has also been suggested by the author. Yet another chapter lists the various allergens hidden in commercial food products.

In addition to the above chapters dealing with basic knowledge and new developments in food allergy which form the core of the book, numerous appendices are included to present information on common sources of yeast, soybean and cottonseed, single and combination milk–, wheat–, corn–, and egg-free diets, food families, etc. A glossary of terms is a thoughtful addition.

Though the book is written for general physicians and medical students, Dr. Breneman should be congratulated for presenting a scientific account of food allergy in a simple way so that even biologists and non-allergist specialists could understand and appreciate the subject.

K. SANTHANAM
DFRL, MYSORE.

Proceedings of a Workshop on Food Legume Improvement and Development: held at the University of Aleppo, Syria, 2-7 May 1978. Edited by Geoffrey C. Hawtin and George J. Chancellor and Published by International Centre for Agricultural Research in the Dry Areas and the International Development Research Center., Canada.

The contents of the volume are divided into 7 sections: the first two sections give a review of the production situation of legumes in West Asian and North African countries. Reference is made on the influence of Agro-climatic and Agroeconological factors as well as socio-economic conditions of the farmers on the legume production in these areas. The importance of legumes on the nutritional quality of the food consumed by the people of Middle Eastern countries has also been discussed in one paper. Major constraints to legume production in these countries are highlighted. Diseases and pest problems and problems associated with marketing are also discussed to some extent. The general awareness of the people of these countries for enhancing legume production has been indicated.

The third and fourth sections deal with diseases, pests and weeds of legume crop. These problems are more or less common in different countries and obviously there is ample repetition in the subject matter presented here.

Section Five contains useful and latest information on genetic resources of grain legumes in the Middle Eastern countries with special reference to breeding methodology, germ plasm collection and improvement in plant ideotype. Two papers in this section deal with agronomic and physiological aspects of the legume food crops in West Asia and role of symbiotic nitrogen fixation in food legume production.

The four papers presented in the VI section give an excellent summary of the "Training and Communication Programme of ICARDA, FAO Food Legume Programmes in the Middle East and North Africa, Food Legume Improvement and Development programme of the Field Crops Section at ACSAD and the role of IDRC in Food Legume Improvement Research.

Several Useful recommendations for futurue priorities are presented in the VII Section.

T. SRINIVAS
CFTRI, MYSORE.

The Processing of Banana Products for Food Use: by Crowther P. C. Tropical Products Institute, 56/62, Gray's Inn Road, London, WC 1X 8LU, 1979; Pp. 18, Price £ 0.85.

This short brochure gives a brief account of preparation and processing of major food products from

banana viz. banana puree, canned banana slices, banana figs, banana powder, flour from raw banana, banana chips, banana jam, banana flakes and banana beverages. The information from selected references has been condensed and presented without omitting essential details. Additional references have been included to cover other products and by-products of banana to complete the picture.

Thus this brochure includes requisite information on banana products for those interested in the field, and is complementary to the report of the Tropical Products Institute (G 103) "The International Market for Banana Products" for Food Use" by R. J. Wilson (1975).

S. RANGANNA
CFTRI, MYSORE.

The Small-Scale Manufacture of Soap: An Economic Study: by Penelope A. Mars, Tropcial Products Institute, London, 1978, Price £ 1.00.

This report is designed with the purpose of serving local entrepreneurs and economic planning organisations in developing countries as a basis for making decisions. It comprises of four sections: (*i*) purpose and scope, (*ii*) raw materials for soap manufacture, (*iii*) outline of the manufacturing processes, and (*iv*) cost models and their implications.

The cost models including the working capital needed, profit obtainable, raw materials and the three processes–the cold process, the semi-boiled process, and the fully boiled process are described. A fully useful report for the small-scale manufacturers of soaps.

This report is written in simple language and well documented. Using the data given in the report, production can be carried out, on varying scales, in different countries having different supply patterns of raw materials. As such the report has fully accomplished the purpose for which it was prepared, viz., guiding the local entrepreneurs and in economic planning/production of laundry and toilet soaps in the small scale sector.

B. C. SUBBA RAO
HINDUSTAN LEVER LIMITED, BOMBAY.

ASSOCIATION NEWS

Head Quarters

A symposium on "By-products from food industries: Utilisation and disposal" is being planned in collaboration with CFTRI, Mysore during May 1980. The venue of the 2-day symposium will be CFTRI, Mysore. Authoritative papers will be requested from persons or institutions in the areas listed below. In addition, contributed papers are also invited well ahead for submission to a screening committee.

The delegate registration fee for AFST members will be Rs. 15 per head and for others Rs. 50 per head. Further details may be had from Mr. J. D. Patel, Hony Secretary, Association of Food Scientists and Technologists (India), CFTRI, Mysore-570 013.

The areas to be covered include the following:

A. By-Products and their Utilisation from the

1. Sugar, starch and fermentation industries
2. Fruit, vegetable, plantation products and oleoresin industries
3. Cereals, pulses and oilseed processing industries
4. Animal product industries including dairying, meat, fish and poultry.

B. Effluents and Discharges and Equipment for their Disposal from the

1. Yeast, starch, sugar/molasses industries
2. Fruit and vegetable industries
3. Dairy industries
4. Slaughter houses, prawn processing and pultry industry

C. Legal and other Regulations Regarding water and the environment as Prevalent in

1. India
2. USA
3. USSR
4. Japan
5. Other countries

ANNOUNCEMENT

Dear Member,

You may be aware that the new Bye-laws of AFST(I) comes into effect from Ist January 1980. As per this Bye-laws, the membership fee and the subscription rates should be paid on or before 31st March of each calendar year. I request all the members/subscribers to pay their membership fee/subscriptions as early as possible so that you may not miss any issue of our Journal.

The revised membership fee is as follows:

Mode of membership	Fee	Admission Fee
Life Member	Rs. 300-00	Rs. 2-00
Corporate Member	Rs. 300-00	Rs. 5-00
Members (Ordinary)	Rs. 20-00	Rs. 2-00
Affiliate Member	Rs. 30-00	Rs. 2-00
Student Member	Rs. 10-00	Re. 1-00

There is no changes in the existing subscription rates.

It is also requested that the arrears, if any, may also be cleared.

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OF

THE ASSOCIATION OF FOOD SCIENTISTS & TECHNOLOGISTS (I)

(Central Food Technological Research Institute Campus, Mysore)

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1. **REVIEWS IN FOOD SCIENCE AND TECHNOLOGY — VOL. IV**

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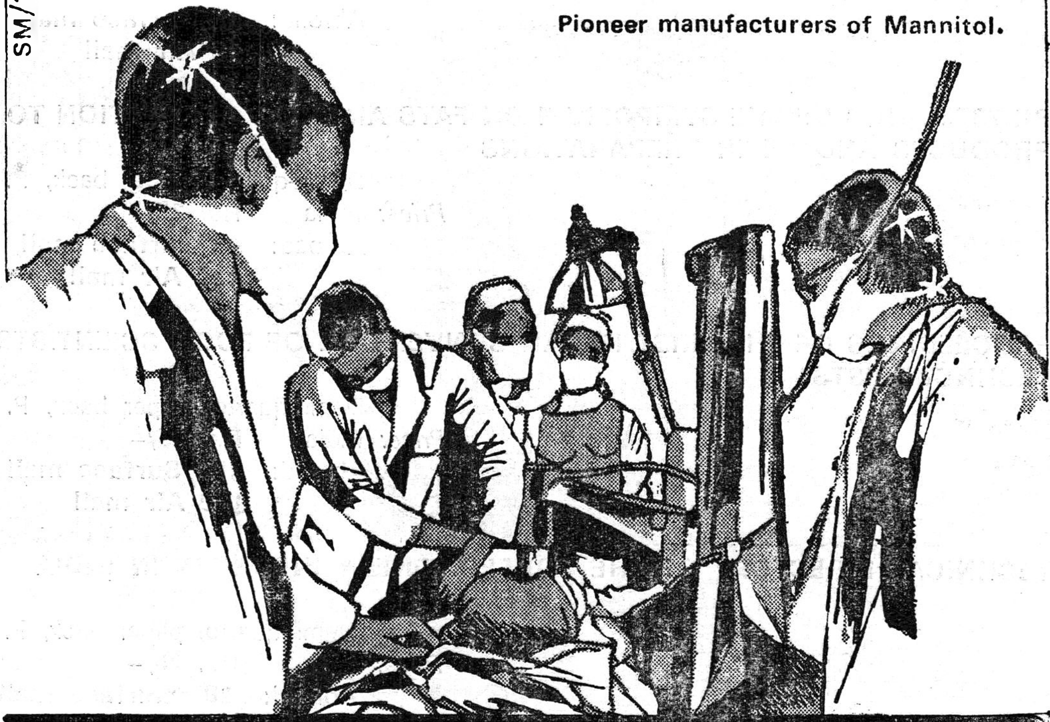

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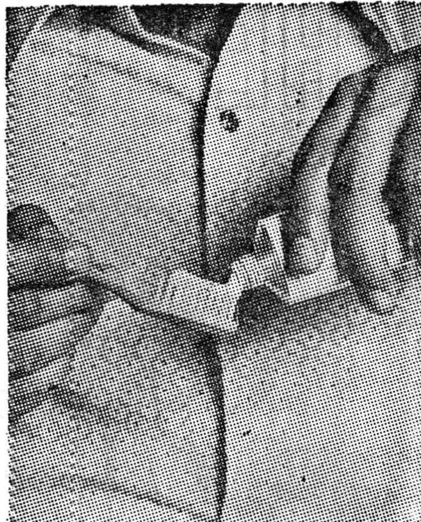

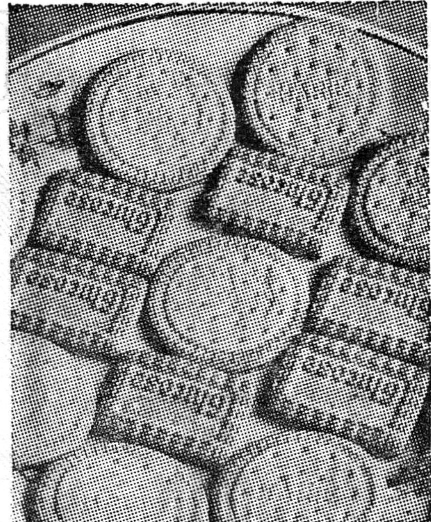

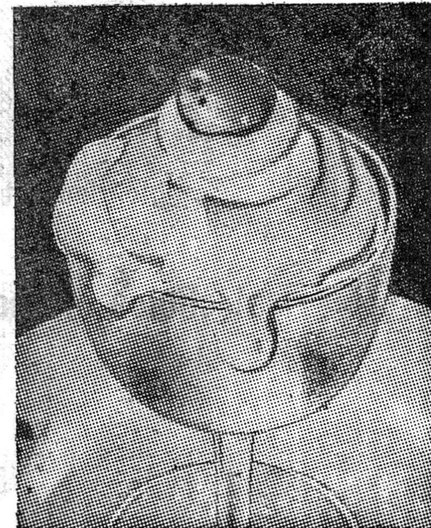

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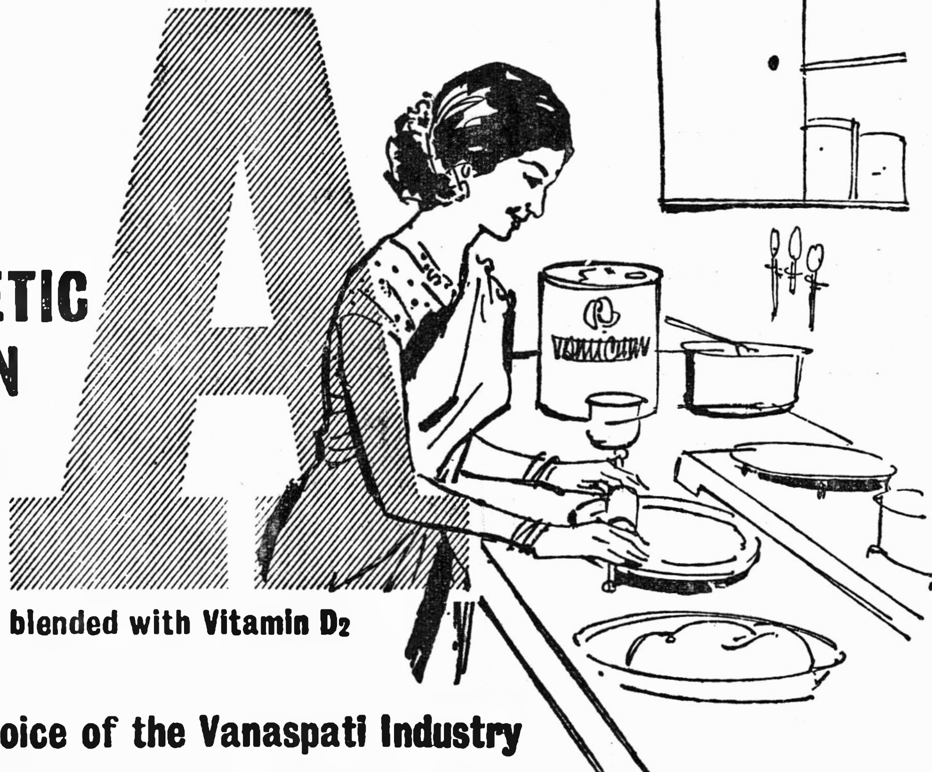

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2. Short communications in the nature of Research Notes should clearly indicate the scope of the investigation and the salient features of the results.

3. Names of chemical compounds and not their formulae should be used in the text. Superscript and subscripts should be legibly and carefully placed. Foot notes should be avoided as far as possible.

4. **Abstract:** The abstract should indicate the scope of the work and the principal findings of the paper. It should not normally exceed 200 words. It should be in such a form that abstracting periodicals can readily use it.

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

   (*a*) *Research Paper:* Menon, G. and Das, R. P., J. sci. industr. Res., 1958, **18,** 561.

   (*b*) *Book:* Venkataraman, 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:* As in (*c*).

   (*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.

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