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(INDIA)

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   (*f*) *Unpublished Work:* Rao, G., unpublished, Central Food Technological Research Institute, Mysore, India.

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Research Papers

Research Notes

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Studies on Ready-Mix for *Kheer* — Packaging and Storage in Flexible Pouches

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Sorption studies carried out at relative humidities (RH) ranging from 11 to 86% on *Kheer* ready-mixes based on 30% roasted wheat semolina (*Bansi* or white *soji*), 30% powdered sugar and 40% whole milk powder, indicated that an equilibrium moisture content (EMC) of 5.7-5.8% at 44% RH was critical, beyond which sogginess and lump formation were observed. The ready-mixes, when packed in polypropylene (200 gauge) and metallized polyester/poly pouches, kept well for (i) 120 and 150 days respectively at 65% RH and 27°C, and (ii) 46 days at 92% RH and 38°C.

Development of ready-mixes for several traditional snack foods offering convenience to housewife has become a fast growing trend among the processed food products[1]. Besides, the ease of preparation and consumer acceptability of such products, economic packaging and adequate shelf-life are of paramount importance for their successful marketing. *Kheer* or *Payasam* is a highly popular traditional food item among all cross-sections of the population of the Indian sub-continent, irrespective of the age and economic status. In an earlier publication, studies on the development of a ready-mix for *kheer* based on optimally processed wheat *soji* (semolina), milk powder and sugar have been reported[2]. Results of subsequent studies carried out on the *kheer* ready-mix with respect to design of a flexible package as well as its shelf-life are presented in this paper.

Materials and Methods

Ready-mix formulations: Two *kheer* ready-mixes based on 30 per cent roasted *Bansi* or white *soji* milled from durum or aestivum wheat respectively, 30 per cent powdered sugar, 40 per cent whole milk powder, 5 per cent each of pre-processed cashewnut and raisins, 0.7 per cent cardamom and 25 p.p.m. of edible 'sunset' yellow colour were used for packaging and storage studies.

Considering the physico-chemical attributes and the economics of the packaging materials as well as the product sensitivity to the vagaries of climate in different regions, 50 μm (200 gauge) polypropylene (PP), and 12 μm metallised polyester/40 μm polyethylene laminate (Met. PET/Poly) were tried for determining the suitability of these materials for packaging and storage.

Chemical analysis: The proximate composition, free fatty acids (FFA) and peroxide value (PV) of the ready-mix samples were determined in duplicate according to AACC procedures[3].

Sorption studies: The humidity-moisture relationship of the two ready-mix samples was studied at 27°C by exposing weighed quantities of the samples in petri dishes to RH ranging from 11 to 86 per cent, built in different desiccators by using appropriate saturated salt solutions[4]. The samples were periodically weighed till they attained constant weight or showed signs of fungal attack whichever was earlier. After equilibration, the samples were assessed for changes in free flow property, odour, colour, etc. The equilibrium moisture contents (EMC) of the ready-mixes were calculated from the changes in the moisture contents at different RH conditions and their respective initial moisture contents.

Packaging and storage studies: The water vapour transmission rate (WVTR) of the two packaging materials was determined according to the Indian Standards Institution method[5]. Two hundred grams each of the two *kheer* ready-mixes were filled in 127 × 152 mm pouches and the filled packs were heat sealed, weighed individually and exposed to accelerated storage conditions: 90 ± 2 per cent RH and 38 ± 1°C and overall average Indian conditions: 65 ± 2 per cent RH and 27 ± 1°C.

During the storage, the individual packs of ready-mixes were weighed periodically and the contents analysed for PV, FFA as well as overall acceptability by a panel of judges as described earlier[2].

Results and Discussion

Chemical analysis: The proximate composition (values in per cent) of *kheer* ready-mixes based on white and *Bansi* soji was: moisture 3.5, protein 13.2 - 13.7, ether extractives 12.1, total ash 2.8, carbohydrates (by diff.) 67.9 - 68.4. The small difference in the protein content was due to higher protein content of *Bansi* wheat *soji*, as compared to white wheat *soji*.

Sorption studies: The results of studies carried out at 27°C

TABLE 1. MOISTURE – HUMIDITY RELATIONSHIP OF *KHEER* READY-MIXES BASED ON WHITE AND *BANSI* WHEAT *SOJI*

RH (%)	White wheat *soji* EMC* (%)	White wheat *soji* Characteristics	*Bansi* wheat *soji* EMC* (%)	*Bansi* wheat *soji* Characteristics
11	3.6	Good, free flowing	3.7	Good, free flowing
22	4.4	—do—	4.5	—do—
32	5.0	—do—	5.1	—do—
44	5.7	—do—	5.8	—do—
56	7.2	Slightly soft, soggy	7.2	Slightly soft, soggy
64	8.0	Soft and soggy	7.8	Soft and soggy
75	10.0	Soft and mouldy	9.9	Soft and mouldy
86	17.8	Lumpy and mouldy	17.7	Lumpy and mouldy

*EMC = Equilibrium Moisture Content, on dry weight basis; initial moisture and critical moisture contents were 3.5 and 5.7% resp.

showed that both the ready-mixes with an initial moisture content of 3.5 per cent equilibrated to an RH of about 11 per cent. The sorption isotherms of the ready-mixes were of typical sigmoid type and exhibited considerable rise above 44 per cent RH. There was practically no difference in the sorption behaviour between the ready-mixes based on white wheat and *soji* from '*Bansi*' wheat. (Table 1). At 44 per cent RH, both the mixes with an EMC of 5.7-5.8 per cent were free flowing without any sogginess and lumpiness. However, the mixes equilibrated to 56 per cent RH were found to be slightly soggy with an EMC of 7.2 per cent. Both the mixes equilibrated to RH of 64 per cent and 75 per cent were very soft and soggy. At 86 per cent RH, the mixes became a lumpy mass. Onset of mould attack was observed in the mixes based on white wheat and from Bansi wheat *soji* equilibrated to 75 per cent and 86 per cent RH respectively. The moisture content under these RH conditions were 10.0 and 17.8 per cent for the mix based on white *soji* and 9.9 and 17.7 per cent for the mix based on *Bansi* wheat *soji* (Table 1).

From the sorption studies, it can be inferred that for both ready mixes, the moisture content of 5.7 per cent equilibrating to 44 per cent RH was critical, as above this level the ready-mixes were prone to rapid physical and chemical changes leading to deterioration in the quality. Both the ready-mixes were moisture sensitive and became soggy above 44 per cent RH and lost their free flow characteristics. The results also indicated that the ready-mix with an initial and critical moisture content of 3.6 and 5.7 per cent respectively, had a good tolerance for moisture with a permissible moisture pick up of 2.1 per cent. This suggested that a good moisture-proof packaging material is required for giving adequate protection to the mixes. However, as the ready-mix contains whole milk powder, it also needs a packaging material with satisfactory oxygen barrier property for protection against oxidation of fat.

Packaging and storage studies: The WVTR values observed for PP and Met.PET/Poly laminate were 9.0 and 1.5 g/m^2/day respectively under 90 per cent RH gradient at 38°C. The changes in moisture, free fatty acids (FFA) and overall acceptability of both the ready-mixes in two different pouches under two conditions of storage are presented in Table 2 The data indicate moisture pick-ups of 2.0 and 1.3 per cent in pouches of PP and Met.PET/Poly after 120 and 150 days respectively at 65 per cent RH and at 27°C. The moisture pick-ups were similar in both the mixes based on *Bansi* wheat and white wheat *soji*. The peroxide values of both the mixes packed in PP and Met.PET/Poly were nil throughout the storage period, while only slight increases in FFA were observed. Ready-mix based on *Bansi soji* with an initial FFA of 0.95, when packed in PP and Met.PET/Poly showed gradual increase to 1.35 and 1.20 per cent respectively at the end of 120 days. Similar trend in FFA values was observed in the ready-mix based on white wheat *soji*.

Eventhough, the moisture pick-up was within the permissible limits of 2.1 per cent, noticeable change in overall acceptability was observed in PP pouches at the end of 120 days. Both the ready-mixes were not acceptable at the end of 120 days storage, as *kheer* prepared from the mixes showed settling possibly due to denaturation of milk proteins during storage On the other hand, no change was noticed in the ready-mix packed in Met.PET/Poly and stored for 150 days. The overall acceptability of the mix was good.

The storage studies under accelerated conditions of 92 per cent RH, and at 38°C, showed moisture pick up of 2.08 and 1.58 per cent in pouches of PP and Met.PET/Poly respectively at the end of 46 days storage of ready-mix based on *Bansi* wheat *soji*. Eventhough, there was considerable difference in the WVTR of two packaging materials, there was higher moisture pick-up by the ready-mix packed in Met.PET/Poly. This was possibly due to slight delamination in a few pouches from sealed corners towards the centre observed under high humidity condition. Similar moisture changes were also observed in the mix based on white wheat *soji*. Further, the

TABLE 2. CHANGES IN MOISTURE*, FREE FATTY ACID** AND OVERALL ACCEPTABILITY OF *KHEER* READY-MIX IN FLEXIBLE POUCHES

Packaging material	Storage period (days)	*Bansi* wheat *soji* based mix			White wheat *soji* based mix		
		Moisture pick up (%)	FFA (%)	Overall accept-ability	Moisture pick up (%)	FFA (%)	Overall accept-ability
		Storage at 65% RH and 27°C					
Polypropylene	10	0.20	0.98	Good	0.20	0.99	Good
	25	0.50	1.00	Good	0.40	1.00	Good
	46	0.90	1.00	Good	0.90	1.30	Good
	90	1.50	1.20	Satisf.	1.60	1.30	Satisf.
	120	2.00	1.35	Poor	2.00	1.35	Poor
Met.PET/Poly	10	0.03	0.97	Good	0.06	0.98	Good
	25	0.10	1.05	Good	0.10	1.01	Good
	46	0.25	1.09	Good	0.27	1.20	Good
	90	0.61	1.20	Good	0.62	1.20	Good
	120	0.93	1.20	Good	0.81	1.30	Good
	150	—	—	Good	1.21	1.31	Good
		Storage at 92% RH and 38°C					
Polypropylene	10	0.60	1.00	Good	0.66	1.01	Good
	25	1.20	1.02	Good	1.36	1.08	Good
	46	2.08	1.14	Good	2.25	1.16	Good
	90	3.35	1.31	Poor	3.73	1.40	Poor
Met.PET/Poly	10	0.32	0.99	Good	0.30	1.00	Good
	25	0.76	1.01	Good	0.76	1.02	Good
	46	1.58	1.08	Good	1.66	1.10	Good
	90	2.78	1.20	Poor	2.63	1.25	Poor

*Initial moisture content was 3.5 per cent

**Initial free fatty acid as oleic acid was 0.95 per cent

development of peroxide value was nil in both the mixes throughout the storage period, while FFA increase was slight. At the end of 46 days of storage the ready-mix based on *Bansi* wheat *soji* and packed in PP and Met.PET/Poly had FFA values of 1.15 and 1.08 respectively. Similar trend was noticed in the ready-mix based on white *soji*.

It can be seen from Table 2 that the overall acceptability of the two ready-mixes packed in PP and Met.PET/Poly pouches was good for 46 days without any undesirable change. Subsequently, at the end of 90 days of storage, both the ready- mixes packed in two different flexible pouches underwent marked change in acceptability, as the *kheer* prepared therefrom showed settling due to curdling and was not acceptable.

Sorption studies indicated that for both the mixes with an equilibrium moisture content of 5.7-5.8 per cent equilibrating to 44 per cent RH was critical for avoiding adverse changes like sogginess and lumpiness.

The overall acceptability of two ready-mixes packed in polypropylene or metallised polyester/poly pouches and stored at 92 per cent RH and 38°C was good upto 46 days. Similarly, at 65 per cent RH and 27°C, the ready-mixes kept well upto 120 and 150 days in PP and metallised polyester/poly packs, respectively.

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Packaging Requirement and Stability of Fried Wheat Snacks (Trisnacks)

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Effect of ingredient composition and packaging on the storage stability of fried wheat snacks was studied. Frying medium and packaging material influenced the rate of peroxidation and changes in sensory scores of wheat snacks during storage. Sweet and salted snacks fried in vanaspati and packed in paper-aluminium foil-polyethylene laminate remained stable for one year. Snacks fried in groundnut oil and palm oil remained stable for 120 to 240 days respectively in various packaging films. Relatively sweet snacks were more stable to peroxidation than salted snacks. Crispness, aroma and taste were the major determinants of overall acceptability of fried wheat snacks. Both sweet and salted snacks were most stable around 0.33 water activity (a_w).

A large number of fried snacks varying in composition, method of preparation, shape, size, texture and flavour are prepared and consumed in our country. Despite their wide usage and good popularity, information on packaging requirement and storage stability of traditional snacks is lacking.

Both sweet and salted snacks are prepared by frying wheat flour dough after being shaped into suitable forms. As they are ready-to-eat items with high acceptance among troops, fried wheat snacks are ideally suited for operational and combat rations. Accordingly, studies were undertaken on packaging requirements and storage stability of these snacks.

Materials and Methods

Atta (whole wheat flour) was obtained by grinding 'Sharbati' wheat ('Bhojan Samrat') in a commercial *chakki* and whole wheat meal was sieved through a 30 mesh sieve. *Maida* (70 per cent extraction flour), salt, sugar, cumin seeds, *vanaspati* (*Dalda*) or hydrogenated fat and refined groundnut oil were purchased from the market. Refined palm oil was obtained from State Trading Corporation, Madras.

Preparation of sweet snacks: *Atta* (2 kg) and vegetable oil (200 g) were mixed in a dough kneader for 10 min. Sugar solution (1.2 kg sugar in 900 ml water) was then added and mixing continued for 30 min to obtain a sufficiently stiff dough to avoid puffing during frying. The dough was divided into 100 g pieces and rolled into circular discs of 20 cm diamter, which were then cut into 2.5 cm squares with the help of a stainless steel knife and fried in *vanaspati*, groundnut oil and palm oil at 170°C to a moderate light brown colour with moisture content of less than 5 per cent.

Preparation of salted snacks: *Maida* (1 kg), *atta* (1 kg) and cumin seeds (30 g) and vegetable oil (400 g) were mixed in a dough kneader for 10 min. One litre salt solution (3 per cent, w/v) was added and mixing continued for 30 min to obtain a smooth but sufficiently stiff dough. Dough pieces (100 g) were rolled into circular discs of 20 cm diameter and cut into 2.5 cm squares and fried in different vegetable oils at 170°C to amber brown colour and moisture content of less than 5 per cent.

Packaging and evaluation: Fried snacks (200 g) after cooling to room temperature were packed in polyethylene (75 μ), polypropylene (75 μ) and paper (45 GSM)-aluminium foil (20 μ)-polyethylene (37.5 μ) laminate pouches (10 × 12 cm) and heat sealed. The pouches were stored under ambient conditions (15-35°C) for 360 days. Initially and after every 60 days, two pouches of each type were removed and analysed for moisture, peroxide value (PV), free fatty acid (FFA) and thiobarbituric acid value (TBA) by the methods described earlier[1] and also for sensory quality. Initially the samples were analysed for protein, fat and soluble sugars.

For sensory acceptability, the stored products were evaluated by a trained panel of 10 members for taste, texture, colour, flavour and overall acceptability on a nine point Hedonic scale with 9 for excellent in all respects and 1 for highly disliked. The products receiving an overall acceptability score of 7 and above were considered acceptable and those receiving below 7 were considered unacceptable in estimating the shelf life.

Moisture equilibration: Powdered samples (15 g) of snacks were stored in petri dishes (20 cm diameter) in desiccators containing phosphorus pentoxide, saturated solutions of magnesium chloride, sodium bromide and sodium nitrate to obtain water activity (a_w) of 0.0, 0.33, 0.57 and 0.73 respectively. Initially and periodically stored samples were analysed for moisture content, peroxide value and free fatty acids to determine the rate of deterioration at each a_w level. Samples were also examined for any visible mold growth, ropiness and sliminess.

Results and Discussion

Crispness, taste and flavour were the major contributing

factors in determining the overall acceptability of sweet and salted snacks. These attributes were mainly governed by dough composition, frying temperature and final moisture level. Study of a large number of batches prepared with different dough composition and frying conditions revealed that the dough composition and frying conditions described here produced most acceptable sweet and salted snacks respectively. The sweet snacks prepared from the dough of above composition had (in per cent) moisture content 3.2, protein 6.3, fat 27.0 and total sugar 28.2 while salted snacks had moisture 3.5. protein 7.8 and fat 40.5. The absorption isotherms of the sweet and salted snacks are given in Fig.1. and 2 respectively. It may be seen that salted snacks equilibrated to higher moisture level than sweet snacks, the moisture contents at 0.0, 0.33, 0.57 and 0.73 a_w being 2.5, 3.3, 4.4 and 6.4 per cent respectively for sweet snacks and 4.2, 5.4, 7.4 and 9.9 per cent respectively for salted snacks. Higher equilibration moisture content for salted snacks may be attributed to the greater water absorption capacity of the wheat starch and proteins as compared to cane sugar. Salted snacks have relatively higher proportion of starch and protein than sweet snacks because of concentration dilution by sugar in sweet snacks. Neither sweet nor salted snacks supported bacterial, mold or yeast growth when stored upto 0.73 a_w for 90 days. The rate of peroxidation was lowest at 0.33 a_w and highest at 0.0 and 0.73 a_w in both sweet and salted snacks. This is in conformity with the published literature[2] as at

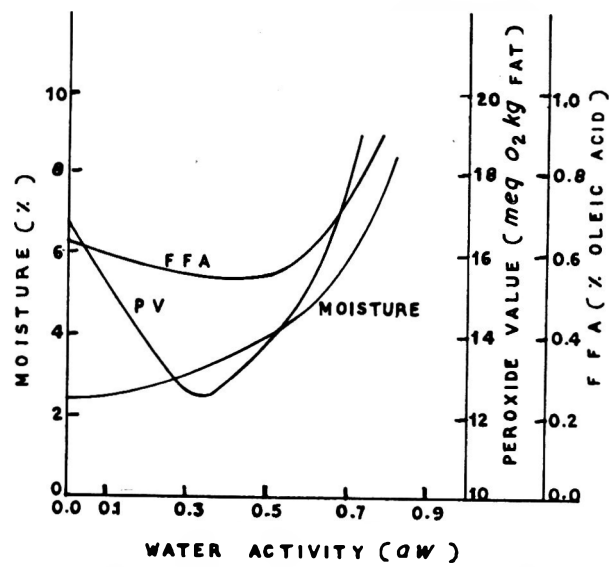

Fig. 1. Sorption isotherm, peroxide value and free fatty acid of sweet snack after 3 months storage

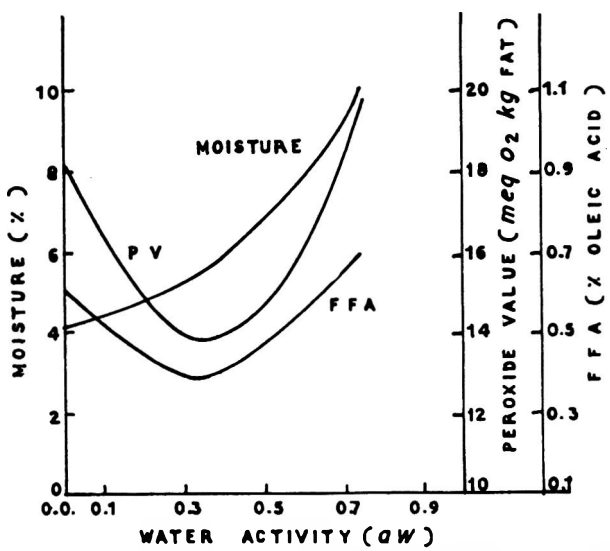

Fig. 2. Sorption isotherm, peroxide value and free fatty acid of salted snack after 3 months storage.

TABLE 1. CHANGES IN PEROXIDE VALUE, FREE FATTY ACIDS, (FFA) AND THIOBARBITURIC ACID VALUES OF SALTED SNACKS FRIED IN VANASPATI, PALM OIL, GROUNDNUT OIL AND PACKED IN POLYPROPYLENE

Storage period (days)	Frying medium	Peroxide value (meq O_2/ kg fat)	Free fatty acids (% oleic acid)	TBA (mg malon-aldehyde/ kg fat)
0	Vanaspati	5.7	0.21	0.09
	Palm oil	9.9	0.43	0.11
	Gr-oil	14.0	0.54	0.15
60	Vanaspati	8.2	0.29	0.15
	Palm oil	16.1	0.50	0.16
	Gr-oil	25.5	0.66	0.18
120	Vanaspati	12.2	0.35	0.17
	Palm oil	24.1	0.61	0.18
	Gr-oil	39.4	0.90	0.28
180	Vanaspati	14.8	0.38	0.22
	Palm oil	30.5	0.69	0.23
	Gr-oil	52.9	1.27	0.32
240	Vanaspati	16.9	0.57	0.33
	Palm oil	36.0	0.80	0.41
	Gr-oil	80.9	2.56	0.57
300	Vanaspati	20.6	0.71	0.40
	Palm oil	41.4	1.00	0.62
	Gr-oil	138.5	3.82	0.87
360	Vanaspati	22.7	0.79	0.44
	Palm oil	42.7	1.00	0.62
	Gr-oil	776.9	5.80	3.45

All results are mean of three replicates.

Maximum variation among replicates was < 3 % of the mean value.

TABLE 2. SENSORY SCORES OF SALTED SNACKS FRIED IN DIFFERENT OILS WHEN STORED IN POLYPROPYLENE POUCHES

Storage period (days)	Frying medium	Colour	Aroma	Taste	Texture	Overall acceptability
0	Vanaspati	8.7±0.3	8.1±0.2	8.6±0.1	8.0±0.1	8.7±0.2
	Palm oil	8.5±0.2	8.2±0.1	8.3±0.3	8.2±0.2	8.1±0.2
	Gr-oil	8.6±0.3	7.9±0.3	8.5±0.1	8.3±0.1	8.4±0.2
60	Vanaspati	8.4±0.2	7.9±0.1	8.2±0.2	7.5±1.0	8.4±0.1
	Palm oil	8.1±0.3	8.1±0.1	8.0±0.1	7.8±0.2	8.3±0.2
	Gr-oil	8.3±0.3	7.2±0.1	8.1±0.2	7.3±0.1	8.0±0.2
120	Vanaspati	7.5±0.2	7.2±1.0	7.8±0.2	7.2±0.2	7.9±0.6
	Palm oil	7.0±0.7	7.0±1.1	6.2±0.8	6.6±0.9	7.6±0.4
	Gr-oil	7.4±0.5	6.6±1.2	6.2±1.4	7.0±0.9	7.2±0.4
180	Vanaspati	6.8±0.5	7.2±0.7	7.4±0.5	7.2±0.5	7.5±0.5
	Palm oil	6.8±0.4	6.6±0.5	6.6±0.5	7.0±0.1	6.6±0.5*
	Gr-oil	6.1±1.0	6.0±0.9	6.4±0.9	6.8±0.4	6.5±0.6*
240	Vanaspati	7.0±0.7	6.8±0.9	7.2±0.5	7.2±0.7	7.2±0.9
	Palm oil	6.8±0.8	5.8±0.1	6.8±0.6	6.9±0.6	7.0±0.8
	Gr-oil	6.7±1.0	4.4±1.8	6.0±1.3	6.4±1.2	6.7±0.5
300	Vanaspati	7.6±0.4	6.9±0.4	6.7±0.5	7.3±0.9	6.8±0.6
	Palm oil	7.3±0.5	6.6±1.0	7.1±0.3	7.2±0.5	6.1±0.6
	Gr-oil	7.0±0.6	4.8±1.0	5.6±1.5	6.1±1.1	4.3±1.3**
360	Vanaspati	7.0±0.5	6.6±0.4	6.8±0.7	6.6±0.5	7.0±1.0
	Palm oil	7.5±0.5	5.6±0.8	6.1±1.1	6.3±1.5	6.0±1.4**
	Gr-oil	6.6±1.8	3.2±0.8	3.7±1.6	5.8±2.0	3.1±0.8***

All values are mean of six replicates.

* Significantly different from the corresponding PFP samples at 95% confidence.

** Significantly different from the corresponding PFP samples at 99.5% confidence.

*** Significantly different from the corresponding PFP samples at 99.95% confidence.

lower a_w, water forms hydrogen bonds with hydroperoxides. This essentially prevents further generation of free radicals from hydroperoxides and thereby lowers the overall oxidation rate. Water also hydrates trace metal ions which are known to catalyse autoxidation of fats. Hydration of metal ions decreases their catalytic activity. At very high a_w (>0.70) water enhances autoxidation due to increased mobility of the metal catalysts and swelling of the matrix which exposes new catalytic sites. The changes in FFA also followed the same pattern as those of peroxides suggesting increases in FFA as a result of secondary degradation products of hydroperoxides rather than due to hydrolysis of triglycerides.

The changes in FFA, PV and TBA values of salted snacks when fried in vanaspati, palm oil and groundnut oil are given in Table 1. As is evident, the rate of peroxidation was highest in snacks processed in groundnut oil followed by palm oil and vanaspati. After 360 days of storage, the peroxide value of snacks prepared in groundnut oil, palm oil and vanaspati were 776 9, 42.7 and 22.7 respectively establishing clearly the predominant role of frying media in determining the useful shelf life of the fried wheat snacks. The changes in TBA value and FFA followed similar pattern as observed for PV.

The mean of sensory scores in respect of colour, aroma, taste, texture and overall acceptability of salted snacks fried in different oils are given in Table 2. It may be observed that though the differences in the sensory scores of freshly prepared snacks when processed in these oils were not-significant, the differences became significant during storage especially after six months. The differences were larger for aroma, taste and overall acceptability than for colour scores.

TABLE 3. CHANGES IN PEROXIDE VALUE, FREE FATTY ACIDS AND THIOBARBITURIC ACID VALUES OF SALTED SNACKS FRIED IN VANASPATI AND PACKED IN DIFFERENT PACKAGING MATERIALS

Storage period (days)	Packaging material	Peroxide value (meq O_2/ kg fat)	Free fatty acids (% oleic acid)	TBA (mg malon-aldehyde/ kg fat)
0		6.50	0.34	0.061
60	PFP	10.2	0.48	0.070
	PP	11.0	0.48	0.072
	PE	12.0	0.47	0.075
120	PFP	11.6	0.47	0.070
	PP	12.2	0.48	0.072
	PE	13.7	0.48	0.074
180	PFP	12.3	0.47	0.069
	PP	14.3	0.48	0.071
	PE	15.7	0.50	0.075
240	PFP	13.1	0.47	0.071
	PP	14.7	0.49	0.079
	PE	16.1	0.50	0.079
300	PFP	14.3	0.49	0.081
	PP	15.9	0.51	0.087
	PE	16.6	0.52	0.084
360	PFP	19.0	0.55	0.130
	PP	20.9	0.59	0.140
	PE	21.1	0.62	0.150

All results are mean of three replicates.

Maximum variation among replicates was < 3 % of the mean value.

*PFP, Paper-Aluminium foil-polyethylene laminate; PP, Polypropylene; PE, Polyethylene.

It is also interesting to observe that differences in the rate of peroxidation in the snacks prepared in these oils became more predominant after six months storage further confirming the role of peroxidation in sensory acceptability. Since increase in FFA in fried snacks results mainly from secondary degradation products of hydroperoxides, changes in FFA also followed the same pattern as those of peroxidation rates.

The effect of packaging materials on the changes in PV, FFA, TBA values and sensory scores of salted snacks fried in vanaspati are shown in Tables 3 and 4 respectively. As expected, the rates of peroxidation as measured by changes in PV and TBA values were related to the oxygen permeability of the packaging materials. The rate of peroxidation was highest in snacks stored in polyethylene film and lowest in foil laminate pouches. Though mean sensory scores of the samples stored in laminate pouches were slightly larger than the one stored in polypropylene and polyethylene pouches, to the fact that differences in rates of peroxidation were not large enough to cause substantial differences in sensory scores. Though there were large differences in chemical and sensory scores of freshly prepared and 360 days stored samples, the differences due to packaging materials at any stage of storage were small. The level of peroxides at which the samples become unacceptable also varied with different oils. While samples fried in vanaspati developed perceptible off-odours at a peroxide value of 22 meq O_2/kg fat, the samples fried in palm oil and groundnut oil remained acceptable till their peroxide value crossed 40 meq O_2/kg fat. Based on changes in peroxide value and overall acceptability scores, the samples of salted snacks remained stable for 120, 240 and 360 days when processed in groundnut oil, palm oil and vanaspati respectively (Tables 1 and 2).

Since peroxidation of fats is the major cause of storage deterioration in fried snacks, the effect of incorporating antioxidant butyl hydroxy anisole (BHA) in the dough and its effect on the storage stability of salted snack was studied. The changes in PV, FFA and TBA values are given in Table 5. Incorporation of BHA did not significantly influence the rate of peroxidation in any of the packaging systems studied, nor it influenced the sensory acceptance of stored snacks.

The chemical and sensory changes which take place during storage of sweet snacks were very similar to the ones observed for salted snacks except that the rate of peroxidation was slightly slower (Table 6). After 360 days of storage, the PV of sweet snacks was 15.4 meq O_2/kg fat as compared to 21.2 meq O_2/kg fat in salted snacks when stored in polypropylene pouches. Similarly, the changes in FFA and TBA values were also slightly lower. Sweet snacks remained acceptable for more than 360 days when processed in vanaspati and packed in polypropylene or laminate pouches. When processed in groundnut oil and palm oil, sweet snacks remained acceptable for 120 and 300 days respectively when stored in laminate pouches.

Though the fat content in fried snacks was quite high (27 to 40 per cent) there was no seepage of oil/fat through the pouches irrespective of the nature of oil used for frying. Unlike instant mixes (*halwa, upma, pulav,* etc.) which cause excessive staining due to seepage of oil when prepared with groundnut oil and cottonseed oil, there was no seepage of oil and resulting staining or oiling-off of pouches when fried wheat snacks were processed in groundnut oil and stored in polypropylene or polyethylene pouches even after 12 months storage.

TABLE 4. SENSORY SCORES OF SALTED SNACKS WHEN PACKED IN DIFFERENT PACKAGING MATERIALS

Storage period (days)	Packaging material	Colour	Aroma	Taste	Texture	Over all acceptability
0		8.6±0.3	8.1±0.3	8.7±0.6	8.0±0.5	8.6±0.2
60	PFP	7.0±0.6	7.0±0.7	7.2±0.9	6.0±0.6	7.2±0.8
	PP	7.0±0.6	6.6±0.5	7.4±0.8	6.5±0.6	7.4±0.9
	PE	6.8±0.8	7.0±0.8	7.2±0.8	6.0±0.7	7.4±0.9
120	PFP	7.1±0.6	6.9±0.6	7.0±0.5	7.0±0.5	7.1±0.8
	PP	7.2±0.4	6.7±0.7	7.1±0.6	6.8±0.6	7.1±0.8
	PE	7.3±0.5	6.9±0.8	6.8±0.6	6.7±0.7	7.0±0.8
180	PFP	6.8±0.5	7.2±0.5	7.2±0.5	6.9±0.8	7.2±0.6
	PP	7.8±0.4	6.6±0.8	6.6±0.5	6.2±0.9	6.6±0.5
	PE	6.2±0.9	6.0±1.0	5.8±1.5	6.3±0.5	6.2±0.6*
240	PFP	7.5±0.5	7.6±0.5	7.2±1.0	7.5±0.5	7.4±0.7
	PP	7.6±0.5	7.0±0.7	7.3±0.7	7.2±0.7	7.3±0.5
	PE	7.6±0.5	7.2±0.7	7.2±0.7	7.2±0.5	7.3±0.4**
300	PFP	6.9±1.0	7.1±0.9	6.8±0.7	7.2±0.4	7.0±0.5
	PP	6.5±0.8	5.8±0.7	5.8±1.0	6.6±0.9	6.0±1.0
	PE	6.6±0.5	4.8±1.0	6.1±0.5	7.2±1.0	5.5±1.0*
360	PFP	7.6±0.5	7.2±0.9	6.1±0.5	6.8±0.5	7.0±0.3
	PP	7.6±0.5	6.6±1.0	6.1±1.0	7.0±0.8	6.3±0.7
	PE	7.6±0.5	6.9±1.2	6.4±1.1	7.0±0.8	5.6±0.8*

PFP, Paper-Aluminium foil-polyethylene laminate; PP, Polypropylene; PE, Polyethylene.

All values are mean of six replicates.

* Over all acceptability scores of all samples after 60 days of storage were significantly different from initial value.

Significantly different from the corresponding PFP samples at 97.5% confidence.

** Significantly different from the corresponding PFP samples at 99.5% confidence.

TABLE 5. CHANGES IN PEROXIDE VALUE, FREE FATTY ACIDS AND THIOBARBITURIC ACID VALUE OF SALTED SNACKS FRIED IN VANASPATI AND INCORPORATED WITH BHA (0.01 per cent fat basis) AND PACKED IN DIFFERENT PACKAGING MATERIALS

Storage period (days)	Packaging material	Peroxide value (meq O_2/ kg fat)	Free fatty acids (% oleic acid)	TBA (mg malon-aldehyde/ kg fat)
0		4.7	0.35	0.041
60	PFP	7.6	0.37	0.042
	PP	8.6	0.39	0.045
	PE	9.2	0.40	0.046
120	PFP	8.0	0.40	0.044
	PP	9.2	0.43	0.047
	PE	10.0	0.43	0.059
180	PFP	10.3	0.45	0.052
	PP	11.2	0.48	0.055
	PE	13.4	0.52	0.059
240	PFP	11.4	0.43	0.051
	PP	12.8	0.49	0.057
	PE	14.9	0.54	0.059
300	PFP	13.7	0.46	0.061
	PP	15.9	0.46	0.067
	PE	17.3	0.57	0.073
360	PFP	20.3	0.56	0.13
	PP	21.2	0.54	0.14
	PE	23.1	0.56	0.16

All results are mean of three replicates.

Maximum variation among replicates was < 3 % of the mean value.

*PFP, Paper-aluminium foil-polyethylene laminate; PP, Polypropylene; PE, Polyethylene.

TABLE 6. CHANGES IN PEROXIDE VALUE, FREE FATTY ACIDS AND THIOBARBITURIC ACID VALUE OF SWEET SNACKS FRIED IN VANASPATI DURING STORAGE IN POLYPROPYLENE POUCHES

Storage period (days)	Peroxide value (meq O_2/ kg fat)	Free fatty acids (% oleic acid)	TBA (mg malon-aldehyde/ kg fat)
0	4.2	0.28	0.10
60	6.2	0.31	0.10
120	7.5	0.36	0.11
180	10.6	0.39	0.12
240	12.2	0.45	0.12
300	14.3	0.47	0.13
360	15.4	0.56	0.13

All values are mean of three replicates.

Maximum variation among replicates was < 3 % of the mean value.

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Biochemical and Nutritional Changes Associated with Indian Punjabi *Warri* Fermentation

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Traditional Punjabi *warri* fermentation involving different substrates has been evaluated for biochemical and nutritional changes. A significant increase in the bacterial and yeast cell counts along with total acids, dough volume, soluble solids, non-protein nitrogen, soluble nitrogen, free amino acids, proteinases and water soluble vitamins including B_1, B_2 and B_{12} was observed during the fermentation of conventional black gram *warri* doughs thus accounting for increased digestibility and nutritional value. Total nitrogen and total proteins however did not show any significant change whereas pH, reducing sugars and soluble protein contents decreased appreciably following 5 days of simultaneous fermentation and drying in open. New *warri* doughs involving mung beans in place of black gram revealed the comparable changes as observed in the conventional type, but the soluble constituents and amylase contents were higher in the former.

Occurrence and role of several bacteria alone or with lesser proportion of yeasts in naturally fermented Punjabi *warri* based on black gram has been reported[1]. These organisms are contributed by the black grams (*Phaseolus mungo*) and the spice mixture used. The development and prevalence of microbial types is affected by seasons; summer being more favourable for bacteria and winter for yeast. *Leuconostoc mesenteroides, Lactobacillus fermentum* and *Streptococcus faecalis* are the principal bacteria involved in *warri* dough fermentation causing acidification and leavening[1,2]. Yeast flora generally comprise *Saccharomyces cerevisiae, Pichia membranaefaciens* and *Trichosporon beigelii* and add to the leavening during fermentation.

Although several reports have appeared on the changes indicating improved digestibility and nutritional value during the fermentation of various legume products[2-4], there is paucity of data indicating comprehensive changes during fermentations of Indian black gram products. In the present communication, different biochemical and nutritional changes occurring during fermentation of conventional *warri* doughs and some new dough types prepared by replacing black gram substrate with mung beans (*Phaseolus radiatus*) have been reported.

Materials and Methods

Raw ingredients and fermented samples of conventional *warri* doughs collected aseptically from different places of local market were analyzed for various biochemical and nutritional constituents to assess the changes produced as a result of fermentation.

Two sets of *warri* doughs were prepared and fermented in laboratory employing the traditional procedure[1] using dehulled black grams and the mung beans as the substrate. This involved the grinding of legume grains after overnight soaking and supplementing with several spices. The spiced paste/dough was then moulded into small balls and naturally fermented and dried in open air. The pattern of total microbial load and other biochemical and nutritional levels was studied in both the sets successively at 24 hr intervals for 5 days. Raw grains of mung beans used in the preparation of new dough types were also analyzed microbiologically and biochemically.

Total bacterial and yeast cell counts were determined in the samples after making the serial dilutions and spreading on agar plates containing appropriate media[1]. Dry matter[5] was calculated indirectly from the moisture content. Ten g samples were blended with 90 ml distilled water for few min. A 20 ml aliquot was centrifuged for 10 min (8500×**g** ; 4°C) and the supernatant analyzed for various soluble parameters. pH was noted directly using Beckman Zeromatic pH meter while total acids were calculated in terms of lactic acid by titrating with 0.1N NaOH[5]. Soluble solids[5], reducing sugars[6], soluble proteins[7], amylase activity[8] and proteinase activity[9] were assayed by known methods. Total nitrogen, non-protein nitrogen[5], free amino acids[10], vitamin B_1 (thiamine)[11], vitamin B_2 (riboflavin)[5], vitamin B_{12} (cyanocobalamin)[12] and vitamin C (ascorbic acid)[13] were also estimated in the samples. *Warries* prepared from both the doughs were also evaluated organoleptically by a panel of six judges. All the results indicating the changes during

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fermentations were statistically analyzed at 5 per cent level of significance.

Results and Discussion

The levels of microbial load consisting of bacteria and yeasts were appreciably higher in commercially fermented *warri* samples than in raw black grams and spices mixture (Table 1). The values of soluble solids, amylase, proteinase, non-protein nitrogen, soluble nitrogen, free amino acids, vitamin B_1 and B_2 were also higher while pH was significantly lower in the fermented samples than that in unfermented black grams. These differences in the levels of various constituents suggest that the traditional black gram *warri* fermentations are accompained by several changes in the ingredients.

Laboratory studies indicated that besides successive rise in bacterial and yeast cell counts (Table 2) during black gram *warri* fermentation, pH value declined from 5.65 to 3.20 while the total acid levels increased from 0.50 to 1.50 per cent following 5 days of incubation and drying in open air. Fermentation also brought about an increase in volume and soluble solids whereas the reducing sugars decreased

TABLE 1. MICROBIAL LOAD AND BIOCHEMICAL LEVELS OF THE RAW INGREDIENTS AND FERMENTED PUNJABI WARRI DOUGHS COLLECTED FROM THE LOCAL MARKET

Parameter	Raw black gram	Spices mixture	*Market fermented black gram *warri* doughs, range	Raw mung bean
Bacteria (CFU/g)	7.2×10^5	8.8×10^8	1.02×10^9 — 7.90×10^{12}	6.3×10^5
Yeasts (CFU/g)	Nil	Nil	0 — 4.7×10^7	Nil
pH	6.65	5.75	3.15 — 4.10	6.75
Soluble solids (%)	1.47	19.34	13.00 — 15.00	1.60
Reducing sugars (mg/g)	Nil	58.14	2.34 — 4.30	Nil
Soluble proteins (mg/g)	21.72	45.28	13.30 — 17.58	48.51
Amylases (IU/g)	1.40	10.82	3.07 — 4.70	2.22
Proteinases (IU/g)	1.44	6.75	5.07 — 6.00	1.17
Total nitrogen (%)	4.46	3.36	4.60 — 4.82	4.33
Non-protein N (%)	0.20	0.80	0.74 — 0.84	0.14
Soluble N (%)	0.45	0.40	1.42 — 1.55	0.37
Total proteins (%)	26.60	10.41	24.15 — 24.86	26.18
Free amino acids (mg/g)	6.41	29.20	37.41 — 42.15	6.83
Vitamin B_1 (mg/100g)	0.20	—	0.80 — 1.00	0.22
Vitamin B_2 (mg/100g)	0.16	—	1.25 — 1.44	0.10

All values have been expressed on dry matter basis., *Data give the range of 20 samples examined.

TABLE 2. CHANGES IN VARIOUS MICROBIOLOGICAL, BIOCHEMICAL AND NUTRITIONAL CONSTITUENTS DURING WARRI FERMENTATION

Parameter	Black gram dough		Mung bean dough	
	Value at start	Value at the end	Value at start	Value at the end
Bacteria (CFU/g)	$2\pm2\times10^{10}$	$6\pm5\times10^{12}$	$8\pm5\times10^9$	$2\pm1\times10^{12}$
Yeasts (CFU/g)	$9\pm5\times10^4$	$9\pm4\times10^6$	$7\pm5\times10^4$	$2\pm2\times10^6$
pH	5.65±0.52	3.20±0.27	6.70±0.20	3.71±0.22
Total acids (%)	0.50±0.20	1.50±0.10	0.40±0.10	0.90±0.15
Volume (ml)	200	420±20	200	410±20
Soluble solids (%)	8.0±2.00	15±2.50	4.00±2.00	19±1.60
Reducing sugars (mg/g)	13.8±0.80	5±0.50	25±2.20	20±4.10
Soluble proteins (%)	50±8.00	20±6.00	72±8.00	28±2.50
Total nitrogen (%)	4.5±0.30	4.9±0.50	4.3±0.15	4.5±0.18
Non-protein N (%)	0.20±0.07	0.68±0.21	0.35±0.08	0.80±0.05
Soluble nitrogen (%)	0.9±0.10	1.50±0.13	0.80±0.10	1.40±0.15
Total proteins (%)	27.0±1.00	27.0±2.00	24.7±0.40	23.8±2.00
Amylases (IU/g)	3.07±0.52	3.05±0.80	2.0±1.10	9.6±3.20
Proteinases (IU/g)	4.82±0.92	6.04±1.12	2.8±1.00	3.8±0.45
Free amino acids (mg/g)	9.79±4.39	45.15±9.30	8.2±2.60	41±5.00
Vitamin B_1 (mg/100g)	0.40±0.10	0.95±0.60	0.36±0.12	0.90±0.13
Vitamin B_2 (mg/g×100)	0.30±0.10	1.20±0.20	0.32±0.08	1.22±0.12
Vitamin B_{12} (mg/g×100)	0.20±0.10	0.80±0.30	0.12±0.03	0.58±0.05

Data represent average values of 15 replicates of black gram and 5 replicates of mungbean doughs.

significantly. Total nitrogen and total protein did not vary significantly, although non-protein nitrogen increased from 0.20 to 0.68 g per cent. Soluble nitrogen and free amino acids exhibited a greater rise (0.95 to 1.50 g per cent and 9.79 to 45.15 mg/g respectively), whereas the levels of soluble proteins fell significantly. Amylase activity showed an increase till the end of third day (from 3.07 to 4.21 IU/g) and declined thereafter, while the proteinase activity increased from 4.82 to 6.04 IU/g. Water soluble B-vitamins including thiamine, riboflavin and cyanocobalamin also increased significantly, while ascorbic acid (vitamin C) indicated a slight increase with the progress in conventional *warri* dough fermentation.

These changes are probably the result of microbial activities in the doughs involving the production of acid and gas from various carbohydrates[1] thus accounting for the rise in total acid levels and volume during the fermentation. The rise in the levels of soluble constituents including nitrogen, proteins and amino acids is presumably due to the production of proteolytic enzymes by the developing microorganisms and the hydrolysis of insoluble polymers under acidic conditions by these enzymes. The rise in various vitamin levels, especially B-vitamins, during fermentation appears to be due to the increase in microflora mainly yeasts most of which have the ability to produce vitamins from simple precursors. Most of the changes during *warri* fermentation cause improvements in digestibility, nutritional value and support the earlier observations on various legume based indigenous fermented foods of the world[2-4,14] Increase in total acidity during fermentation helps in enhancing the shelf-life of such foods. Soluble solids, soluble nitrogen, free amino acids and B-vitamins have also been observed to increase during the fermentations of *tempe*[17,19], *natto*[20,21] and *soysauce*[22], the other legume based foods.

Mung bean *warri* dough fermentation exhibited similar changes as observed in traditional black gram doughs except for amylases which revealed a gradual rise till the end. Data on the biochemical and nutritional constituents mentioned above revealed the levels of soluble solids, reducing sugars and amylases to be higher in the new product than achieved in the conventional product. The remaining biochemical characteristics revealed compatibility with the conventional preparations. The test doughs caused sufficient acidification and leavening and the texture of the mung bean *warri* was quite comparable with that of conventional types, which, however, exhibited better organoleptic characteristics than the former.

It is apparent that the traditional punjabi *warri* fermentation is brought about by the microflora coming from staples and the environment. Although this microflora brings about several changes leading to improved digestibility and nutritional value but the possibility of development of various undesirable microorganisms and the production of toxic substances by certain species is a point of serious concern to the food microbiologists. There is much to be learnt about the role of individual microorganisms, standardization of their inocula by artificially inoculating the doughs with desired microbes along with the optimization of various physico-chemical factors like temperature, dough pH and supplementation of some free sugars in the fermenting ingredients for controlled fermentation so that the nutritional and organoleptic constituents can be raised to maximum possible limits, as reported in case of *dosa*[23] and *idli*[24], the common cereal-legume based fermented foods of India.

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Effect of Hydro-Thermal Treatment on Mechanical Oil Expression from Soybean

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Effect of various hydrothermal treatments on the oil recovery from soybean is described. Analysis of data revealed that boiling of soybean splits and whole soybean with water for 30 min followed by sun-drying to about 7% moisture content (wb) gave the maximum oil recovery of 82.40 and 84.72% in three pass pressing with specific energy consumption of 0.370 and 0.503 kWh/kg of feed respectively when compared to other treatments. Though it appears to be a bit tedious from practical point of view, considering the importance of protein as well as edible oils in Indian diets boiling of splits with water (free of hulls) followed by drying to 7% moisture may be practised for expression.

India produces about one million tonnes of soybean (1985-86) from about 1.3 million hectares of land with an average productivity of about 755 kg/ha[1]. With about 40 per Cent protein and 20 per cent oil, it is an advantageous crop of the country. For narrowing down the national demand and supply gap of about one million tonnes of edible oils, soybean is recognised to be one of the most potential crops in India. Though solvent extraction methods have been efficient and leave only about 1 per cent oil in cake, they being capital and volume intensive and requiring special skills, do not suit the small scale rural or urban processors. Moreover, about 90 per cent of the total oilseeds are presently being crushed in mechanical screw expellers available in different parts of the country. Research information relating to oil expelling from soybean has been rather meagre. Smith and Kraybill[2] reported that better yields of soy oil were obtained at higher temperatures of 97°C and above, although satisfactory yields were also obtained at about 65°C. Clark and Wamble[3] reported that a cone clearance of 2 to 2.5 mm gave maximum oil recovery from hard seeds.

Singh *et al*[4] reported that soy splits treated with water sprinkling and conditioned to about 17.2 per cent moisture content (wb) yielded about 62 per cent oil with minimum specific energy consumption in 4 to 5 passes by mechanical screw pressing. This appears to be quite low yield. Therefore, in the present investigation, efforts were made to improve upon the per cent oil recovery giving soybeans various hydro-thermal treatments prior to mechanical screw expression. This paper describes the effect of these treatments on the soy oil recovery.

Materials and Methods

Soybean '(JS-7244)' cleaned of its impurities was taken for the study. Whole soybean was converted into splits free of hulls by a dehuller (make CIAE, capacity = 100 kg/hr, hp = 1). These splits were then given different treatments prior to expression e.g. tap water soaking for 1 hr at room temperature, boiling in water for 30 min. The process flow chart is shown in Fig.1. In one case, whole soybean was also water boiled for 30 min. All these samples were sun-dried

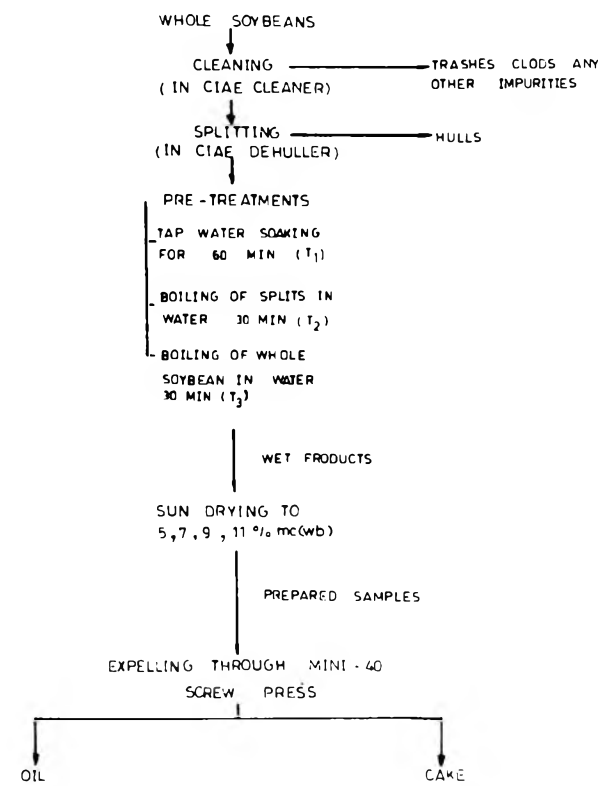

Fig.1. Process flow chart for mechanical oil expression of soybean.

to about 5, 7, 9 and 11 per cent moisture content (wb) (the average values of final moisture content have been rounded-off to the nearest digits) and stored in the air tight containers for equilibration. The moisture contents of samples were determined by standard hot air oven method[5]. Thus prepared samples, each weighing about 3 kg, were fed into operating mini 40 screw press oil expeller (make-Rosedown, reported capacity = 40 kg/hr, motor hp = 3, and screw shaft r.p.m. = 120) for expression. Prior to feeding, the expeller was run for about half an hour with raw soybean in order to raise the initial temperature of the screw and barrel assembly (as per manufacturer's recommendations) from ambient to about 45°C. The cake obtained after each pass was the feed for the subsequent passes. During the operation temperature of the barrel, energy and processing time were recorded in each pass by probe thermometer, energy meter (30 amp, 50 cps and 60 rev/kWh) and the stop watch respectively. The oil was collected from the barrel's slots in the measuring cylinders and the cake at the discharge end. Overall in three passes, the oil obtained has been used for determining per cent oil recovery except for tap water-soaked samples. Beyond third pass, the expression was not feasible as quality of cake and oil used to be adversely affected e.g. charring and browning of cake and burning smell and discolouration of oil and also the quantity of oil obtained was negligible. As recommended, a clearance of 2.0 mm was maintained for first pass. In the remaining two passes, the clearance was reduced to 0.4 mm. The oil was allowed to settle for particles in suspension for about 24 hr. The clear oil was filtered and stored for further refining and processing. Each treatment was replicated thrice.

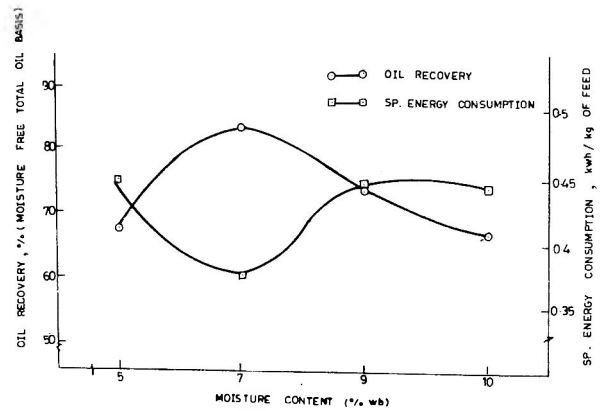

Fig.3. Variations in oil recovery and specific energy consumption with moisture content corresponding to water boiling treatment of soy splits.

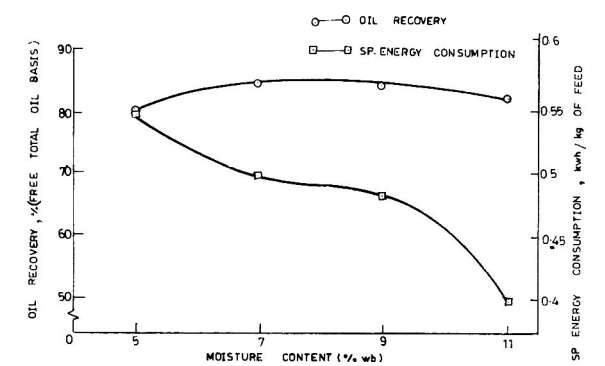

Fig.4. Variations in oil recovery and specific energy consumption with moisture content corresponding to boiling treatment of whole soybean.

Results and Discussion

Analysis of data revealed that in most of the cases, oil recovery had an increasing trend with increase in moisture content from 5 to 7 per cent and beyond 7 per cent it had a declining trend except in one case (Fig. 2 through 4) the reason for which is explained later in the text. The increase

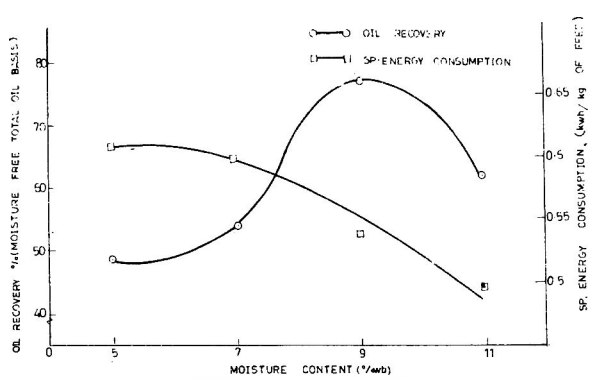

Fig.2. Variations in oil recovery and specific energy consumption with moisture content corresponding to tap water-soaking treatment of soy splits.

was faster in case of soy splits boiled in water for 30 min followed by sun-drying. But in case of water-soaked samples at room temperature, this increase was slow and continued upto 9 per cent moisture level. The specific energy consumption decreased with increase in moisture content except for one case i.e. 30 min boiling of splits and then drying wherein beyond 7 per cent moisture, it increased and the curve flattened after 9 per cent. As per available literature[6], this could happen due to the fact that wet heat penetrated faster and coagulated proteins making cell walls more permeable and enabled early release of oil from within the splits. However, with increase in moisture content beyond certain limit probably the rupture force decreased through deformity could have increased causing pliability of particles. It could also be found that maximum expressible oil could be recovered upto third pass pressing (Fig. 5) in the screw expeller in case of wet neat treatment while it required minimum of four passes with tap water-soaked samples. The oil yield decreased after third pass pressing. This could happen probably due to formation of progressively rigid cake matrix which resisted the applied pressure as well as flow

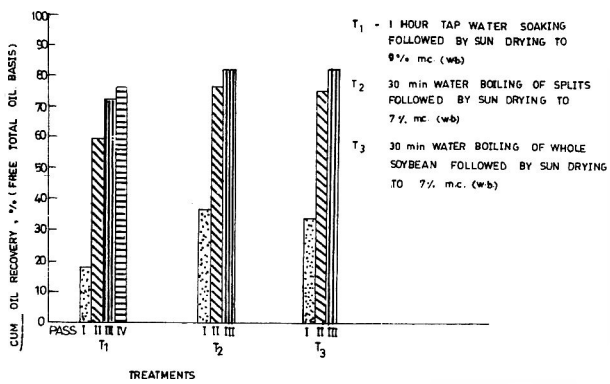

Fig.5. Passwise cumulative oil recovery corresponding to different hydrothermal treatments and optimised moisture contents of soybean/splits.

of oil. Also beyond third pass, the rise in barrel temperature (123-136°C) adversely affected the quality of oil and cake, as mentioned earlier. The oil recovery in case of whole soybean was also identical but rate of change in increase was almost negligible. This could happen due to the presence of soy-hulls which increased the frictional forces inside the screw and barrel making the crushing (pressing) more effective for the wider range. Also in this case, energy consumption decreased with increase in moisture content. Corresponding to 11 percent moisture content the problem of choking was more frequent which required cleaning of the screw barrel assembly. Though, the actual energy consumed in pressing was very low, the fact remains that energy consumed in clearing the choking is not included, otherwise it would have been upto 0.517 kWh/kg of feed. The data were also analysed statistically. The mean deviations were found to be 1.778, 3.337, 2.670 and 2.887 corresponding to 1 hr tap water-soaked and sun-dried samples to 5, 7, 9 and 11 per cent moisture contents respectively. Also these values were 7.611, 2.222, 3.689 and 3.333 with respect to 30 min boiling of soy splits in water followed by sun-drying to 5, 7, 9 and 11 per cent respectively. Similarly, for 30 min boiling of whole soybean sun-dried to 5, 7, 9 and 11 per cent moisture contents, the respective values of mean deviation were 3.111, 0.556, 1.333 and 1.111.

Further the statistical analysis revealed that hydrothermal treatments influenced the per cent oil recovery quite significantly. From among these, the boiling of soy splits (free of hulls) in water for 30 min followed by sun-drying to about 7 per cent moisture content (wb) gave significantly higher (cv = 1.45 per cent) oil recovery of about 82.40 per cent with 0.370 kWh/kg of feed of energy consumption. The cake produced was also of good edible quality because its enzymes such as lipoxygenase and antinutritional factors like trypsin inhibitors are inactivated and is good in appearance and flavour. Therefore, though the treated whole soybean gave slightly better oil recovery with higher significance (cv = 0.422 per cent) with relatively higher energy consumption, the presence of hulls in cake adversely affected the edible quality of cake. Thus, the later one may not be appreciated considering the importance of proteins in foods.

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Comparative Suitability of Resultant *Atta* and Whole Wheat Flour for Brown Bread

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Studies on blends of commercial wheat flour i.e., *maida* (WF) and resultant *atta* (RA) from roller flour mill or whole wheat flour (WWF) from disc mill (*chakki*) showed gradual increase in ash (0.57 to 1.61%), protein (8.78 to 9.26%), colour grade value (4.1 to > 18), damaged starch (12.1 to 18.6%), diastatic activity (149 to 304 mg maltose/10 g of flour), farinograph water absorption (55.2 to 71.4%), dough development time (4.5 to 7.0 min.) and decrease in sedimentation value (19 to 6.5 ml), dough stability (8.0 to 5.5 min), extensograph area (>113 to 66 cm^2) and amylograph peak viscosity (2420 to 1310 AU), as the RA/WWF content increased. Bread making characteristics of blends showed increase in loaf weight (132.8 to 147.0 g) decrease in loaf volume (475 to 354 ml), crumb score (7.5 to 2.3) and crumb softness, as the RA/WWF content increased. The results indicated the possibility of preparing good quality brown bread using 60% RA or 40% WWF in the blend.

Bread consumption in India is steadily increasing, as it offers convenience and relief from the drudgery in food preparation. The present production of bread in India is 9.58 lakh tonnes and the estimated growth rate is 9.7 per cent per annum[1]. However, in order to sustain the growth, the industry needs to diversify its products. Brown bread is one of the popular bakery products based on whole meal and wheat flour in the advanced countries. In India, the roller flour milling industry produces resultant *atta* along with wheat flour and semolina. The whole wheat flour is produced mostly in disc mills, hammer mills and stone mills. Resultant *atta* was found to be superior to whole wheat flour nutritionally and contains about twice as much thiamine and one and half times as much riboflavin and lysine, as compared to whole wheat flour[2]. Comparative suitability of whole wheat flour and resultant *atta* for making chapati was studied by Haridas Rao *et al.*[3], while changes in quality of whole wheat flour and resultant *atta* during storage were reported by Leelavathi *et al.*[4] Utilization of resultant *atta* and whole wheat flour for brown bread preparation would increase the nutritional quality of bread and bring in diversity in the manufacture of bakery products. In this paper, the results of utilising whole wheat flour or resultant *atta* in the preparation of brown bread are discussed.

Materials and Methods

Whole wheat flour (WWF) milled in a disc mill and wheat flour (WF) locally known as *maida*, and resultant *atta* (RA) milled in a 20 tonne roller flour mill from the same commercial aestivum wheat sample were used for the studies.

Total ash, dry gluten, sedimentation value, diastatic activity and damaged starch were determined according to AACC procedures[5]. Crude protein (N × 5.7) was estimated by micro-Kjeldahl method. The flour colour was determined using a Kent-Jones Flour Colour Grader (Series III).

WF and RA/WWF blends were prepared in the ratio of 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100.

Dough properties of flours and their blends were studied using the Brabender farinograph and extensograph according to AACC procedures[5].

Breads were prepared according to remix procedure of Irvine and McMullan[6] with a reduced fermentation period of 90 min. for the dough instead of 165 min. Compressibility of bread crumb was measured in a General Foods Texturometer (Model GTX). Evaluation of bread was carried out after 24 hr by a panel of six judges.

Duncan's new multiple range test at 5 per cent level was used for finding out the results of test of significance.

Results and Discussion

Chemical characteristics: The data on chemical characteristics of flour and blends are presented in Fig.1, 2 and 3. WF had 0.57 per cent ash content, 4.1 colour grade value, 12.0 per cent damaged starch, diastatic activity of 149.4 mg of maltose/10 g of flour, 8.8 per cent protein, 19.0 ml sedimentation value and 8.3 per cent dry gluten. It is evident from Fig.1 and 2 that these values increased with increase in WWF or RA content in the blend. The ash content, colour grade value, diastatic activity and damaged starch in blends of WF and WWF were higher than those in the corresponding blends of WF and RA, due to higher values for the above parameters in WWF as compared to RA.

In contrast, WF and WWF blends had lower protein, sedimentation value and dry gluten than those corresponding

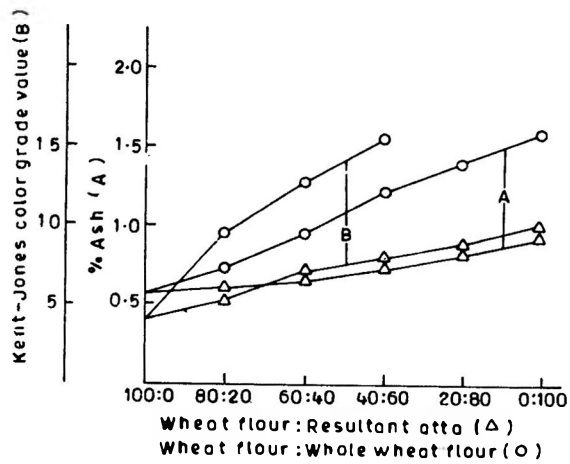

Fig.1. Ash and Kent-Jones colour grade values of flour blends.

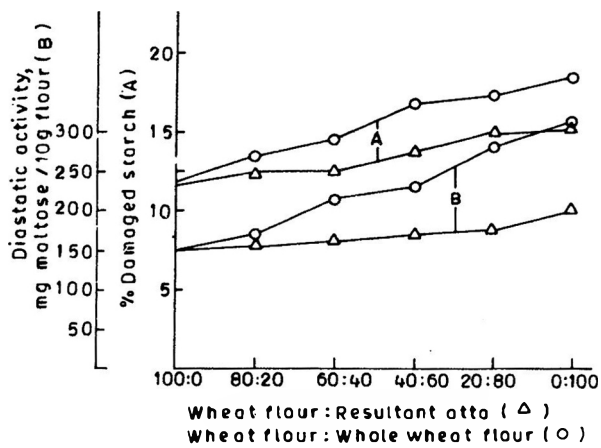

Fig.2. Damaged starch and diastatic activity values of flour blends.

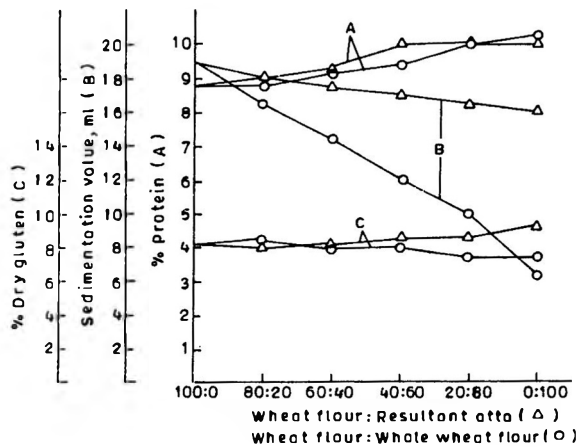

Fig.3. Protein, sedimentation value and dry gluten contents of flour blends.

blends from WF and RA (Fig.3). Although there was not marked variation of protein or dry gluten contents of respective WF and WWF/RA blends, quality was adversely affected in case of WF and WWF blends, as is evident from lower sedimentation values. This can be attributed to the low sedimentation value of 6.5 ml for WWF, as compared to 16.0 and 19.0 ml recorded for RA and WF respectively.

TABLE 1. PARTICLE SIZE DISTRIBUTION OF WHEAT FLOUR AND RESULTANT *ATTA*/WHOLE WHEAT FLOUR BLENDS

Flour blend*	Overtailings (%)			
WF : RA	10 XX	12 XX	25 P	Pan
100 : 0	—	75.3	17.3	7.4
80 : 20	6.8	53.1	27.3	12.8
60 : 40	13.8	46.5	26.8	12.9
40 : 60	19.9	42.5	25.5	12.1
20 : 80	26.3	40.8	23.9	9.0
0 : 100	32.5	46.2	12.6	8.7
WF : WWF				
80 : 20	12.0	58.9	26.1	3.0
60 : 40	16.0	56.9	18.8	8.3
40 : 60	23.1	51.5	15.3	10.1
20 : 80	30.4	43.0	13.9	12.7
0 : 100	35.9	39.2	13.4	11.5

*WF — Wheat flour; RA — Resultant *atta*; WWF — Whole wheat flour

Particle size distribution: The data presented in Table 1 indicate that in different blends overtails of 10 XX increased, while overtails of 12 XX and 25 P decreased with the increase in RA or WWF content. The increase in the coarseness of

TABLE 2. FARINOGRAPH CHARACTERISTICS OF WHEAT FLOUR AND RESULTANT *ATTA*/WHOLE WHEAT FLOUR BLENDS

Flour blend	Water absorption (%)	Dough develop. time (min)	Dough stability (min)	Mixing tolerance index (BU)
WF : RA				
100 : 0	55.2	4.5	7.5	80
80 : 20	58.0	4.5	7.5	70
60 : 40	58.8	4.5	7.5	70
40 : 60	60.7	6.0	7.5	45
20 : 80	62.2	6.0	7.5	50
0 : 100	65.1	6.5	7.5	40
WF : WWF				
80 : 20	58.5	5.0	8.0	70
60 : 40	61.4	5.0	7.0	70
40 : 60	65.0	5.0	6.0	50
20 : 80	69.8	6.0	6.0	40
0 : 100	71.4	7.0	5.5	35

blends reflected in the adverse change in dough properties and baking characteristics.

Farinograph characteristics: The data on farinograph characteristics of doughs are presented in Table 2. Farinograph water absorption of WF was 55.2 per cent, which increased gradually to 65.1 and 71.4 per cent respectively, as the RA and WWF content in blends increased. The higher water absorption in case of WF and WWF blends may be attributed to higher damaged starch in WWF. There was gradual increase in dough development time from 2.0 to 2.5 min. It may be attributed to slower hydration due to increase in the coarseness of flours, as RA or WWF content increased. Interestingly, the stability of WF and RA blends (7.5 min.) was not affected while it decreased from 8.0 to 5.5. min in case of WF and WWF blends. This may be due to the coarse bran particles of WWF affecting the protein films and hence the stability. Decrease in mixing tolerance index indicated marginal improvement in dough mixing properties, as RA or WWF content increased.

Extensograph characteristics: It can be observed from Table 3, that with increase in RA/WWF content in the blend, resistance to extension and ratio figure of the doughs and also the strength, as indicated by area decreased. However, only in case of WF and RA blends, the extensibility increased, while it remained unaffected for the blends of WF and WWF. The data indicated that the blends of WF and RA showed comparatively better dough properties than those of WF and WWF.

Amylograph characteristics: It is evident from Table 4, that there is not marked variation in the gelatinization temperature of the WF and RA/WWF blends. The peak viscosity decreased by 520 AU and 1110 AU, when RA and

TABLE 3. EXTENSOGRAPH CHARACTERISTICS OF WHEAT FLOUR AND RESULTANT *ATTA*/WHOLE WHEAT FLOUR BLENDS

Flour blend	Resistance to extension (R) (BU)	Extensibility (E) (mm)	Ratio R/E	Area (cm^2)
WF : RA				
100 : 0	> 1000	106	> 9.5	> 113
80 : 20	> 1000	103	> 9.4	> 111
60 : 40	> 1000	120	> 8.3	> 111
40 : 60	785	125	6.3	112
20 : 80	785	121	6.5	114
0 : 100	770	124	6.2	113
WF : WWF				
80 : 20	> 1000	84	> 11.9	> 96
60 : 40	> 1000	84	> 11.9	> 97
40 : 60	> 1000	33	> 12.0	> 89
20 : 80	790	82	9.6	71
0 : 100	765	83	9.3	66

TABLE 4. AMYLOGRAPH CHARACTERISTICS OF WHEAT FLOUR AND RESULTANT *ATTA*/WHOLE WHEAT FLOUR BLENDS

Flour blend	Gelatinization temp (a) °C	Peak height AU	15 min. height (b) AU	Cold paste viscosity at 50°C (c) AU	Set back (c-b) AU
WF : RA					
100 : 0	61	2420	1480	3360	1880
80 : 20	59	2390	1430	3170	1740
60 : 40	59	2360	1420	3050	1630
40 : 60	59	2300	1300	2800	1500
20 : 80	59	2040	1260	2550	1290
0 : 100	60	1900	1140	2260	1120
WF : WWF					
80 : 20	60	2170	1380	2620	1240
60 : 40	60	2060	1210	2400	1190
40 : 60	60	1740	1080	2260	1180
20 : 80	60	1350	870	1650	780
0 : 100	60	1310	880	1660	780

TABLE 5. BREAD MAKING QUALITY OF WHEAT FLOUR AND RESULTANT *ATTA*/WHOLE WHEAT FLOUR BLENDS

Flour blend	Loaf wt (g)	Loaf vol (ml)	Crumb score*	Crumb texture (kg/v)
WF : RA				
100 : 0	132.8^{a}	475^{a}	7.5^{a}	2.80^{ab}
80 : 20	135.6^{b}	455^{ab}	6.9^{ab}	2.83^{ab}
60 : 40	137.0^{bc}	464^{a}	6.6^{b}	2.84^{ab}
40 : 60	138.3^{c}	443^{abc}	6.3^{bc}	3.50^{abc}
20 : 80	140.7^{d}	419^{bcd}	5.6^{cd}	3.80^{bc}
0 : 100	143.0^{f}	381^{def}	5.0^{de}	4.45^{cd}
WF : WWF				
80 : 20	136.9^{bc}	479^{a}	6.9^{ab}	3.00^{ab}
60 : 40	140.4^{d}	450^{ab}	5.5^{d}	3.04^{ab}
40 : 60	142.0^{df}	410^{cde}	4.6^{e}	4.10^{c}
20 : 80	146.5^{g}	374^{ef}	2.8^{f}	4.50^{cd}
0 : 100	147.0^{g}	354^{f}	2.3^{f}	5.10^{d}
SE_m	±0.599	± 12.38	±0.26	±0.68

* Maximum — 8

Each observation is a mean of four replicates

Means of same column followed by different letters differ significantly at 5% level according to Duncan's New Multiple Range Test.

WWF contents respectively increased in the blend indicating increase in the α-amylase activity. The decrease in set back value by 760 and 1100 AU due to increase in RA and WWF contents in the blends, respectively, indicated possibly the slowing of retrogradation of starch.

Bread making quality: The results of bread making trials are presented in Table 5. There was gradual increase in loaf weight, as RA/WWF content increased in the blend. This can be attributed to the increase in the water absorption (Table 2). Statistical analysis of data indicated that loaf volume and crumb texture were significantly affected, when RA and WWF contents in the blends exceeded 60 and 40 per cent respectively. Crust colour increased gradually from light brown to dark brown. The wholesome wheatish taste was observed, when RA or WWF content in the blends was 40 per cent or more. The decrease in crumb score due to RA was 2.5, as against 5.2 in WWF. The crumb texture of blends recorded as compressibility showed gradual increase. The crumb softness of breads from WF and RA blends was comparatively better than that of corresponding WF and WWF blends.

It may be concluded in terms of chemical, rheological and bread baking quality, the blends of WF and RA are comparatively better than those of WF and WWF and good quality brown bread can be prepared from 40:60 WF and RA or 60:40 WF and WWF blends.

Acknowledgement

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Effect of Atmospheric and Vacuum Roller Drying Systems on the Physical and Chemical Characteristics of Buffalo Skim Milk Powder

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The skim milk powder prepared by atmospheric roller drying system showed higher sinkability, more wettability time, lower solubility, bulk density (both loose and packed) and dispersibility. The particle size of vacuum roller dried powder was smaller and more uniform and the colour of atmospheric roller dried powder was more brownish than that of vacuum roller dried milk powder. The moisture content was observed to be comparatively more in vacuum roller dried samples. 5-hydroxymethyl furfural (HMF) values were found to be almost 7 times higher for atmospheric roller dried samples than vacuum roller dried powders.

Most of the dry milk in India is made exclusively from buffalo milk. The beverage quality of skim milk powder (SMP) of easy dispersibility and adequate shelf life can be produced by vacuum drying process. In milk powders, casein particles play an important role and affect the various attributes. This paper deals with the effect of vacuum roller drying in comparison with atmospheric roller drying on the physico-chemical characteristics of SMP made from buffalo milk.

Materials and Methods

The fresh buffalo milk was obtained from the institute herd comprising of Murrah buffaloes. The raw milk was separated, and the skim milk was preheated to 90°C and condensed to 20 and 25 per cent total solids (TS) in a Volma double effect falling-film evaporator. The condensed milk samples of both concentrations (20 and 25 per cent TS) were divided into two portions. One portion was dried by using atmospheric roller drier, while the other portion was dried on vacuum roller drier.

Atmospheric roller drying: Simon's 18 × 54 in. twin cylinder drier was used for atmospheric roller drying. Two steam pressures of 50 psig and 60 psig were selected for the study. The drying of milk was achieved in customary manner. The powder was received on conveyor and collected in buckets.

Vacuum roller drying: A laboratory model, twin cylinder vacuum drier made of stainless steel was used. The length and diameter of each roller was 15.2 cm, and the capacity of drier was 800-1000 g/hr of dry product containing about 4.5-5.0 per cent moisture. The rollers were mounted inside a chamber which was closed during operation under vacuum. All the operating conditions were kept the same as in the case of atmospheric roller drying. The vacuum inside the chamber was maintained at 27 in. of Hg. The feed rate was adjusted to 3.5 and 4.0 kg/hr corresponding to 20 and 25 per cent TS, respectively in concentrate. The vapours condensed inside the coils were removed after every 30 min. At this stage, the machine was stopped and vacuum released. The powder collected in trays inside the chamber was taken in triplicate for studies.

Physico-chemical analysis: The colour of SMP samples was estimated by slightly modifying the method suggested by Ingle[1]. Animal charcoal was used in the present investigation in place of Norrit. The particle size of the sample was determined by a modification of microscopic procedure described by Janzen *et al.*[2] and adopted by Beckett *et al.*[3]. The bulk density was determined according to the procedure detailed by Sjollema[4]. The solubility index and dispersibility were tested following the standard methods[5]. Wettability time was examined as suggested by Muers and House[6], and sinkability as prescribed by Bullock and Winder[7]. The samples were analysed for fat, moisture, TS content[8], and titratable acidity (TA)[9]. The content of 5-hydroxymethyl furfural in SMP was estimated by following the method-A of Keeney and Bassette[10].

Results and Discussion

The results pertaining to physical characteristics of the SMP samples are presented in Table 1.

As expected, the solubility of vacuum roller dried powders was greater than that of the atmospheric roller dried samples. Higher steam pressure of 60 psig employed in the atmospheric roller drying and use of feed concentrate with higher TS of 25 per cent resulted in lower solubility of the powders; whereas the effect was not so much on solubility due to increased steam pressure in case of vacuum roller dried samples. However, the increase in TS in feed concentrate resulted in decreased solubility for vacuum roller dried samples. The packed bulk density was found to be greater

TABLE 1. EFFECT OF DIFFERENT ROLLER DRYING SYSTEMS AT 50 PSIG AND 60 PSIG ON THE PHYSICAL CHARACTERISTICS OF BUFFALO SKIM MILK POWDER*

Characteristics	Atmospheric at 50 psig		Vacuum at 50 psig		Atmospheric at 60 psig		Vacuum at 60 psig	
	Level of total solids in conc milk				Level of total solids in conc. milk			
	20%	25%	20%	25%	20%	25%	20%	25%
Solubility index (ml)	7.90	8.63	2.10	2.43	9.40	10.04	2.14	2.43
Bulk density (g/ml)								
Loose	0.302	0.310	0.363	0.367	0.321	0.331	0.364	0.361
Packed	0.389	0.400	0.468	0.475	0.412	0.421	0.469	0.476
Dispersibility (g)	17.252	17.620	21.156	21.574	16.156	16.320	21.155	21.240
Wettability (s)	254.3	203.6	39.6	38.2	297.8	218.2	39.6	38.2
Particle size (μ)								
Range	18.53— 80.34	20.39— 85.60	16.44— 31.06	18.87— 38.54	20.58— 91.29	20.92— 101.80	18.08— 101.80	19.46— 35.63
Average	48.42	51.83	20.79	21.36	55.65	57.97	20.67	22.03
Colour index+	2	2+	1	1	2+	3	1	1
Sinkability (% transmittance)								
2 min	90.3	87.8	83.3	80.0	92.7	90.1	83.3	80.0
4 min	86.8	84.3	79.5	76.9	88.6	87.4	79.5	76.9
6 min	83.8	81.7	74.3	72.0	86.2	83.8	74.2	72.1

*Average of three replicates

+ Compared with colour standards

than loose bulk density in case of all the samples prepared by employing two drying techniques. The bulk density, loose as well as packed, of vacuum roller dried samples was observed to be more than that of atmospheric roller dried powders. The higher values for bulk density of vacuum roller dried samples may be due to a more uniform size of milk powder particles (Fig.1) obtained as a result of vacuum drying process, and non-uniform sized particles of powder (Fig.2) obtained in atmospheric roller drying. Use of higher TS in feed concentrate and increase in steam pressure were found to enhance the bulk density of the samples.

The extent of dispersibility was more for the samples made by vacuum roller drying process. This may perhaps be due to lesser degree of heat induced changes in the samples during vacuum drying. A higher steam pressure of 60 psig used in the atmospheric roller drying process produced milk powder with lower dispersibility, but no effect in case of vacuum roller dried samples. A higher TS of 25 per cent in the feed concentrate gave a slightly more dispersible product as compared to 20 per cent TS for both the roller drying systems. The vacuum roller dried samples showed a much lower wettability than the atmospheric roller dried samples. A higher steam pressure of 60 psig resulted in a higher wettability time in case of atmospheric roller dried samples only. In both drying systems, the wettability time for samples was found to be lower when a higher TS of 25 per cent were used in the feed concentrate.

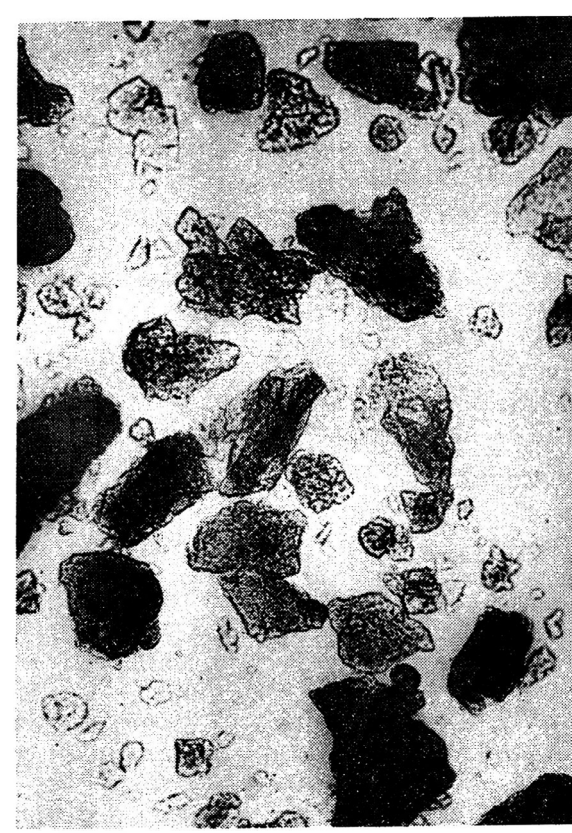

Fig.1. Micro-photograph of vacuum roller dried buffalo skim milk powder.

The average particle size of vacuum roller dried sample was much smaller than that of atmospheric roller dried sample. A higher percentage of TS in feed concentrate (25 per cent) resulted in a slightly larger sized powder particles. Also, higher steam pressure of 60 psig produced comparatively bigger sized particles. The vacuum roller drying system produced powder particles of more uniform size as compared to atmospheric roller drying system (Fig. 1 and 2). The use of atmospheric roller drying process and higher steam pressure produced slightly brownish coloured powder as compared to vacuum roller drying process, obviously due to higher heat treatment. The variation in TS of feed concentrate did not affect the colour of the samples obtained by vacuum roller drying process.

The results for sinkability indicate that the values were lower for the vacuum roller dried samples. The increase in steam pressure was observed to slightly increase the sinkability only in case of samples made by atmospheric roller drying process. The increase in TS content from 20 to 25 per cent slightly decreased the sinkability in both the drying systems.

The results for chemical characteristics are given in Table 2. The fat content in samples varied between 0.97 and 1.03 per cent, suggesting that the method of drying, variation in steam pressure, and change in TS content of feed concentrate did not significantly affect the fat content of the milk powder. The moisture content of atmospheric roller dried samples was observed to be comparatively lower than the vacuum roller dried samples. This was mainly due to higher degree of heat treatment received by the milk during atmospheric roller drying. For the same reason, the samples made by applying higher steam pressure of 60 psig resulted in the product with lesser moisture content in atmospheric roller drying only, because the drying temperature mainly depends upon the extent of vacuum, and not the steam pressure. A higher TS content of 25 per cent in the feed concentrate gave the samples

Fig.2. Micro-photograph of atmospheric roller dried buffalo skim milk powder.

with higher moisture content in both the drying systems. This was perhaps due to a thicker milk film when the TS in the feed concentrate were more, and probably the drying was not efficient. Further, higher the values for moisture content, lower were the TS content and *vice-versa*.

The TA (per cent lactic) of the samples prepared by atmospheric roller drying process was slightly lesser compared to vacuum roller dried samples. However, higher

TABLE 2. EFFECT OF DIFFERENT ROLLER DRYING SYSTEMS AT 50 PSIG AND 60 PSIG ON THE PHYSICAL CHARACTERISTICS OF BUFFALO SKIM MILK POWDER*

Characteristics	Atmospheric at 50 psig		Vacuum at 50 psig		Atmospheric at 60 psig		Vacuum at 60 psig	
	Level of total solids in conc milk				Level of total solids in conc. milk			
	20%	25%	20%	25%	20%	25%	20%	25%
Fat (%)	0.97	1.03	1.00	1.00	0.99	1.02	0.99	0.98
Moisture (%)	3.75	3.99	4.64	4.71	3.50	3.69	4.64	4.70
Total solids (%)	96.25	96.01	95.36	95.29	96.50	96.31	95.36	95.30
Titratable acidity (% lactic)	0.128	0.129	0.133	0.133	0.127	0.127	0.128	0.130
5-hydroxy methyl furfural (μ mol/l of milk)	6.365	7.699	0.894	1.93	8.116	9.395	0.893	1.195

*Average of three replicates

concentration of TS in feed did not markedly influence the TA of the samples, while increased steam pressure used for the manufacture of SMP resulted in the product with slightly higher TA.

The observations on 5-hydroxymethyl furfural (HMF) of the SMP samples in Table 2 show that higher steam pressure of 60 psig in atmospheric roller drying of milk resulted in samples with higher HMF, probably due to greater incidence of heat exposure, whereas in vacuum roller drying, the increased steam pressure caused no effect on HMF values of the SMP samples. Similarly, higher TS content in feed concentrate gave a product with more HMF. The amount of HMF formed during processing measures the heat exposure of milk, provided the TS content of the milk are kept constant[11]. Further, the total HMF colour is an indicator of the solids content in milk, with higher solids yielding more colour. In general, the results on HMF reported in this communication are in harmony with those of Della Monica *et al.*[11].

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Occurrence of Enterococci in Milk and Milk Products. III. Enterocin Typing of Deoxyribonuclease Positive Enterococci and Epidemiological Significance

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Among the 224 DNase positive enterococci recovered from 208 samples of milk and milk products and 24 sources other than dairy products, 83.9% were enterocin typable. Of these, 28 belonged to *Streptococcus faecalis* var. *faecalis*, 16 to *S. faecalis* var. *zymogenes*, 87 to *S. faecalis* var. *liquefaciens*, 51 to *S. faecium* and 6 to *S. durans*. Sixteen enterocin patterns were noticed among *S. faecalis* and its varieties. The most predominant type was 65-603 followed by 10541 and X-9. Similarly, nine enterocin patterns were observed among *S. faecium* and *S. durans*. Among these, enterocin type X-9 was the most predominant. Enterocin patterns found among enterococci isolated from milk and milk products were also observed among the enterococci recovered from other non-dairy sources. Enterocin type X-9 recovered from both dairy and non-dairy sources was the most prevalent (29.2%) either singly or in combination with the other types followed by types 10541 (15.4%) and 65-603 (14%). The epidemiological significance of enterocin typing of enterococci has been discussed.

Among the different types of microorganisms that can easily gain access to milk products, entercocci constitute an important group. The presence of these organisms in dairy products is considered significant because of their possible role in food spoilage[1,2] and food poisoning under certain conditions[3,4]. Enterococci may also be used as indicators of unhygienic conditions during the production of dairy products[5,6]. The significance of these organisms in dairy products has been highlighted in our previous communications[7,8]. These organisms are also implicated in diferent diseases like urinary tract infections[9] and septicemia[9,10] in man and mastitis in animals[11]. Production of thermostable deoxyribonuclease by enterococci has also been suggested as an index of their enterotoxigenicity[12]. In view of the considerable public health significance of enterococci in dairy products, identification of the possible sources of contamination by enterocin typing could be useful. In this investigation, this method of epidemiological typing has been carried out on DNase positive enterococci isolated from dairy products as well as from their possible sources of contamination.

Materials and Methods

Screening of enterococci for DNase and TNase: A total of 810 enterococcal isolates characterized as 'true enterococci', recovered from 208 samples of milk and milk products and 24 other sources (faecal matter, urine, dairy water and hand washings of milk handlers) were subjected to deoxyribonuclease (DNase) as well as thermonuclease (TNase) tests[7]. The enterococcal isolates exhibiting DNase activity were identified[13]. All the cultures were maintained on blood agar[14] with subculturing every fifteen days.

Enterocin typing procedure: All the DNase positive enterococci were subjected to enterocin typing following the modified plate assay technique[15] and a total of 18 indicator strains were used in our study. Each indicator strain was grown in 10 ml glucose broth at 37°C for 8 hr. Samples of 0.1 ml aliquots (containing approximately 50 to 100 $\times$ 10^6 cfu/ml) were spread on the surface of serum agar plates and the inoculated plates were surface dried at 37°C for 30 min. Each petri plate was divided into eight equal parts and each part was spot inoculated with brain heart infusion (BHI) culture of the test organism. Sterile BHI broth was similarly spot inoculated in the centre of the agar plate to serve as a control. The inoculated plates were incubated at 37°C for 18 hr and the zones of inhibition were measured. An average zonal diameter of 2.0 mm or more (excluding spot inoculum) was taken as a positive indication of enterocin production after replicate trials.

Indicator strains: The following 18 indicator strains for enterocin typing were obtained through the courtesy of Takako Ito, Department of Microbiology, Tokyo Women's Medical College, Tokyo, Japan:

Liq A	:	Group A *Streptococcus faecalis* var. *liquefaciens* strain A
Liq B	:	Group D *S. faecalis* var. *liquefaciens* strain B
2025	:	Group D *S. faecalis* var. *liquefaciens* 2025
10541	:	Group D *S. faecalis* ATCC 10541
9790	:	Group D *S. faecalis* NCTC 9790

7073
X-9
65-609
815-2
1151
1081
927
244
697
739

Group D strains isolated from patients

T_3 : Group A, type 3 strain RI-T_3
T_{12} : Group A, type 12 strain RI-T_{12}
PcT_{12} : Group A, type 12 strain Pc-T_{12}

Hemolytic activity: All the DNase positive enterococci were tested for their hemolytic activity on blood agar following the method of Cruickshank[14].

Results and Discussion

The ability of enterococci to produce enterocins has been used in the classification and epidemiological typing of these organisms. In the present study, 224 enterococcal isolates were selected for enterocin typing out of 810 on the basis of their ability to produce DNase. From the data presented in Table 1, it is quite evident that a sizeable number of enterococci (83.9 per cent) were typable with eighteen indicator strains. The number of typable strains was 182 (84.2 per cent) out of the 216 isolates recovered from milk and milk products compared to (75.0 per cent) of the 8 isolates from sources other than dairy products. Further, the majority of the enterocin typable isolates belonged to *S. faecalis* var. *liquefaciens* (46.3 per cent) followed by *S. faecium* (27.1 per cent). Similarly, among all the *S. faecalis* var. *liquefaciens* strains of dairy origin, 92.0 per cent were typable. The number of typable isolates (36) were recovered from infant foods followed by Cheddar cheese (34), ice cream and non-fat dry cow's milk (21 each). The most predominant types from these products were *S. faecalis* var. *liquefaciens*, *S. faecium* and *S. faecalis* var. *faecalis*. The results of the present findings are consistent with those of our previous findings[16] where 76.0 per cent of the isolates were enterocin typable. In terms of recovery of the isolates, our results are in agreement with those of Maleszewski and Stec[17] who had also observed that *S. faecalis* constituted the highest proportion (88-89 per cent) of strains producing bacteriocins antagonistic to other bacteria. These workers suggested that bacteriocins may be an important factor in regard to the dominance of enterococci in foods.

The data regarding the enterocin patterns exhibited by different enterococcal types isolated from different sources have been recorded in Table 2. From the data, it is fairly evident that sixteen different enterocin patterns were associated with *S. faecalis* and its varieties from dairy origin. The most prevalent pattern among these isolates was 65-603 followed by 10541 and X-9. The enterocin pattern 65-603 alone was exhibited by 26 isolates belonging to *S. faecalis* var. *liquefaciens* and 2 isolates belonging to *S. faecalis* var. *faecalis*. However, the pattern X-9 was shown by 14 isolates of *S. faecalis* var. *faecalis* and 6 of *S. faecalis* var. *zymogenes*. Among the *S. faecium* and *S. durans* isolates recovered from milk and milk products, the most prevalent type was X-9 as 34 isolates belonging to *S. faecium* alone exhibited this pattern. However, pattern 65-603 was shared by three isolates each of *S. faecium* and *S. durans*. Apart from these, seven other patterns namely 244; X-9, 244; X-9, 1151; 65-603;

TABLE 1. NUMBER OF ENTEROCIN TYPABLE DNase POSITIVE ENTEROCOCCI RECOVERED FROM DIFFERENT SOURCES*

Source	*S. faecalis* var. *faecalis*	*S. faecalis* var. *zymogenes*	*S. faecalis* var. *liquefaciens*	*S. faecium*	*S. durans*	Total
Raw cow's milk	3	1	1	5	1	11
Pasteurized cow's milk	0	0	0	0	0	0
Sweet cheese	7	0	4	0	0	11
Cheddar cheese	6	2	25	1	0	34
Butter	4	0	3	0	1	8
Kulfi	3	2	6	7	0	18
Kulfi mix	1	3	6	1	0	11
Ice cream	1	1	11	7	1	21
Sweetened condensed milk	0	2	0	8	1	11
Non-fat dry cow's milk	1	1	9	9	1	21
Infant food	1	4	18	12	1	36
Total (milk products) (A)	27	16	83	50	6	182
	(87.1)	(69.6)	(92.0)	(78.1)	(75.0)	(84.2)
Non-milk product sources (B)	1	0	4	1	0	6
	(100)		(100)	(33.3)		(75.0)
Total of (A) + (B)	28	16	87	51	6	188
	(14.9)	(8.5)	(46.3)	(27.1)	(3.2)	(83.9)

Figures in parentheses indicate per cent values.

TABLE 2. ENTEROCIN PATTERNS OF DNase POSITIVE TYPES OF ENTEROCOCCI ISOLATED FROM MILK AND MILK PRODUCTS AND OTHER SOURCES*

Enterocin pattern (single/combination)	Number of typable strains				
	S. faecalis var. *faecalis*	*S. faecalis* var. *zymogenes*	*S. faecalis* var. *liquefaciens*	*S. faecium*	*S. durans*
X-9*	14(1)	6	0	34	0
244	0	2	9	2	0
X-9, 244	0	1	0	2	0
9790	0	2	6	0	0
X-9, 9790	0	1	0	0	0
X-9, 1151	2	0	3	2	0
1081	1	0	6	0	0
X-9, 1081	1	0	6	0	0
10541*	2	2	21(1)	2	1
65-603*	1	0	26(2)	3	3
10541, 65-603*	1	0	9(1)	2	1
X-9, 7073	0	0	0	0	0
X-9, 2025	0	0	0	0	0
244, 7073	0	0	0	0	0
2025, 7073	0	0	0	0	0
815-2	0	1	3	0	1
T_3	0	0	0	0	0
Liq A*	1	1	0	3(1)	0
Liq B	1	0	0	0	0
244, Liq A, X-9, 65-603 815-2, 739, Pc-T_{12}	0	0	0	0	0
Liq A, Liq B, 244, X-9	1	0	0	0	0
L-9, 697, 244, 815-2	0	0	0	0	0
X-9, 244, 1082, Liq A, Liq B, 10541, 9790 7083, 1151, 697, T_3	1	0	0	0	0
Untypable	4	7	7	14(2)	2
Total	31(1)	23	90(4)	64(3)	8

Figures in parentheses indicate types recovered from sources other than milk and milk products. *Prevalent types in sources other than milk and milk products.

10541; 01541, 65-603; Liq A were also recorded in the sixteen other isolates of *S. faecium* and *S. durans*. Among the isolates from sources other than milk and milk products only five enterocin patterns, namely X-9; 10541; 10541, 65-603; 65-603 and Liq A were observed.

The prevalence of enterocin patterns 65-603 and X-9 in majority of the isolates belonging to *S. faecalis* and its varieties recovered from dairy products especially infant foods and non-fat dried cow's milk is consistent with our earlier observations[15] where similar patterns were recorded in enterococci recovered from infant foods. However, Sharma *et al*[18]., demonstrated the predominance of enterocin types X-9 and 1081 among group D streptoccci isolated from clinical sources. In case of *S. faecium* and *S. durans*, the predominance of pattern X-9 and 65-603 respectively is again in agreement with the findings of Sharma *et al*[18]., who also recorded the prevalence of types X-9 and 244 among the isolates of these two types from clinical sources. Since nine enterocin patterns were recorded among *S. faecium* and *S. durans* recovered from dairy products in the present study as compared to sixteen from *S. faecalis* and its varieties, the heterogeneity of the former types in milk and milk products appears to be considerably lower. Nevertheless, the occurrence of enterocin patterns X-9, 1081 and 244 prevalent both in the clinical isolates[18] and in milk and milk products (present study) do highlight the possible role of these types in causing human infections. A comparison between the five enterocin types recovered from sources other than milk and milk products with those obtained from milk and milk products indicates that many of the patterns were common in both, thereby, suggesting that human faecal matter, dairy water and milk handlers might be the possible sources of enterococci in dairy products. However, the sources of other enterocin types could not be ascertained.

The data pertaining to distribution of prevalent enterocin types in different milk and milk products and other sources have been recorded in Table 3. From the Table, it is quite evident that infant foods accounted for the maximum number of typable isolates. X-9 was the most prevalent type in infant foods as 19 out of 36 typable isolates exhibited this pattern.

TABLE 3. DISTRIBUTION OF ENTEROCIN PATTERNS SHOWN BY DNase POSITIVE ENTEROCOCCI IN DIFFERENT SAMPLES OF MILK AND MILK PRODUCTS AND OTHER SOURCES

Enterocin pattern (single/ combination	No. of typable isolates													
	RCM	PCM	SC	CC	B	K	KM	IC	SCM	NFDCM	IF	FM	W	HWM
X-9*	6	0	0	8	1	5	3	2	0	10	19	1	0	0
224	1	0	1	0	6	2	1	2	0	0	0	0	0	0
X-9, 224	1	0	1	1	0	0	0	0	0	0	0	0	0	0
9790	1	0	0	0	0	3	2	2	0	0	0	0	0	0
X-9, 9790	0	0	0	0	0	1	0	0	0	0	0	0	0	0
X-9, 1151	0	0	0	0	0	1	0	3	2	1	0	0	0	0
1081	1	0	0	0	0	1	0	4	0	0	0	0	0	0
X-9, 1081	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19541*	0	0	8	4	0	1	0	0	0	0	0	0	0	0
65-603*	1	0	0	10	1	2	5	1	1	5	8	0	0	2
10541, 65-603*	0	0	1	11	0	1	0	0	0	0	0	1	0	0
815-2	0	0	0	0	0	0	0	0	0	2	3	0	0	0
Liq A*	0	0	0	0	0	0	0	0	0	0	5	0	1	0
Liq B	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Liq A, Liq B, 244, X-9		0	0	0	0	0	0	0	0	1	1	0	0	0
X-9, 244, 1081, Liq A,	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Liq B, 1081, 9790, 7073, 1151, 697, T_3														
Total	11	0	11	34	8	18	11	21	11	21	36	2	2	2

RCM — Raw cow's milk; PCM — Pasteurized cow's milk; SC — Sweet cheese; CC — Cheddar cheese; B — Butter; K — Kulfi; KM — Kulfi mix; IC — Ice cream; SCM — Sweetened condensed milk; NFDCM — Non-fat dry cow's milk; IF — Infant food; FM — Faecal matter (human); W — Water (Dairy); HWM — Hand washings of milkers *Prevalent types in sources other than milk and milk products.

The same pattern was also observed in isolates recovered from non-fat dried cow's milk, cheddar cheese, raw cow's milk, *kulfi* and ice cream. Infant foods also contributed another enterocin pattern Liq A. In addition to these, several other enterocin patterns were also observed in enterococci isolated from other types of dairy products, although their incidence was considerably lower. The chief source of enterocin pattern 65-603 incriminating milk and milk products appears to be the hands of the milkers since the same pattern was also prevalent in the milker's hand washings. The prevalence of enterocin types X-9 and 65-603 in infant foods and other products corroborates our earlier findings[16].

The data pertaining to the enterocin typability of hemolytic enterococci have been presented in Table 4. As is clear from the Table, a sizeable number (33.9 per cent) of enterococci exhibited either alpha or beta hemolysis. Out of these, 84.2 per cent were enterocin typable. All the hemolytic isolates recovered from Cheddar cheese, ice cream and *Kulfi* mix as well as in infant foods exhibited enterocin typability. Similarly, majority of the hemolytic isolates (> 85 per cent) recovered from *Kulfi*, sweetened condensed milk, non-fat dried milk and sources other than milk and milk products were also enterocin typable. Our results in this regard are in agreement with those of Appelbaum and Zimmerman[19] who also reported that hemolytic strains of *S. faecalis* var. *zymogenes* were capable of enterocin production. However, our findings indicate that

TABLE 4. ENTEROCIN TYPABILITY OF HEMOLYTIC ENTEROCOCCI RECOVERED FROM DIFFERENT SOURCES

Sample/type	No. of isolates	No. of hemolytic isolates	No. of hemolytic entercocci exhibiting enterocin typability	% typability of hemolytic enterococci
Raw cow's milk	23	18	11	61.1
Sweet cheese	15	0	0	0.0
Cheddar cheese	35	5	5	100.0
Butter	8	0	0	0.0
Kulfi	21	9	8	88.9
Kulfi mix	15	7	7	100.0
Ice cream	25	4	4	100.0
Sweetened condensed milk	12	7	6	85.7
Non-fat dried milk	25	15	13	86.7
Infant food	40	4	4	100.0
Other products*	8	7	6	85.7
Total	224	76 (33.9%)	64	84.2

*Sources other than milk and milk products

all the enterocin producing isolates need not be hemolytic as is evidenced by high typability of several non-hemolytic enterococci also.

Hence, from this study, it can be concluded that the enterococci appear to be quite heterogenous as several enterocin patterns were recorded. Nevertheless, enterocin typing could be a useful epidemiological tool for locating the possible sources of contamination in dairy products.

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Development of Meat Preserve

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A new meat product, 'Meat Preserve' with optimum salt concentration, low pH and low moisture level, which can be stored at ambient temperature (25-30°C) was developed. The desired moisture level in meat (38-40%) could be obtained by frying pork slices of one inch cube, in oil hydro between 150°-160°C, for about 30 min. Salt content of 6-8% and pH of 3.8-4.0, were obtained by equilibrating the fried pork cubes with acidulated brine solutions containing 25% salt in 5% acetic acid. 'Meat Preserve' obtained by mixing the treated pork cubes with a gravy containing spices, was found microbially safe, and had acceptable taste and flavour upto six months of storage, at ambient temperature.

Preservation of meats either in the fresh form, or conventional processed form, demands considerable amount of energy input. Alternate methods of preservation, preferably at ambient temperature, would not only save energy but also bring better economic returns. Meat preserves can be prepared at optimum salt concentration and low pH and moisture levels in meats with or without added preservatives along with a gravy of spices.

In the present investigation, attempts were made to develop a new meat preserve which can be stored at ambient temperature, with optimum salt concentration, low pH and moisture level. Systematic studies on the treatment of fried meats with acidulated brines of various strengths and the effects of treatments on salt penetration, pH and textural changes were conducted in order to develop a 'Meat Preserve'. Microbial quality and storage stability of the product were also studied and the results are presented in this paper.

Materials and Methods

Pork from hind legs of Yorkshire pigs of about 12-15 months old was obtained from local market of Mysore city. The skin, bone and fat layers were removed and lean meat of 2.5 cm cubes were made and used for frying experiments. Frying the meat cubes was carried out in an electrically heated pan at temperature between 150 and 160°C for about 30 min. The fried meat cubes were then equilibrated in acidulated brine solutions of various concentrations like 10, 15, 20 and 25 per cent salt in 2 and 5 per cent acetic acid solutions. The ratio of fried meat cubes to acidulated brine solutions was taken as 1:2 in all the cases to ensure complete immersion of the meat cubes in the liquid. Moisture, pH, and salt content in the meat cubes were determined after equilibrium was attained. The pH of meat was determined by the method given by Ockerman[1]. Moisture and salt content in meat were determined by A.O.A.C. methods[2]. For the development of 'Meat Preserve', meat cubes equilibrated with 5 per cent acetic acid containing 25 per cent salt were used. A gravy of spices was prepared and mixed in 1:1 ratio.

Gravy preparation: The composition of gravy is given in Table 1. The oil was heated in an electrically heated pan to about 150°C. The sliced onions, ginger and garlic were fried to light brown colour. Chilli powder was added with stirring, followed by powdered coriander seeds, cumin, cloves and cardamom. Turmeric powder and salt were added while mixing. Lime juice, red chillies, mustard powder, vinegar and sugar were added at the end and heating was continued till the resulting mass became thick and viscous.

The fried and equilibrated pork cubes were then added to the spice gravy in the ratio of 1:1 and mixed. After cooling, the meat preserve was filled in glass bottles (450 g).

TABLE 1. COMPOSITION OF GRAVY FOR MEAT PRESERVE

Onion (g)	150
Red chilli (powder) (g)	20
Turmeric (g)	10
Vinegar (ml)	150
Sugar (g)	60
Salt (g)	15
Lime juice	30 ml
Red chillies, quartered (g)	3
Mustard powder (g)	2
Coriander seeds (powder) (g)	50
Cumin. (powder) (g)	25
Ginger (slices) (g)	5
Garlic (g)	5
Cloves (g)	5
Cinnamon (g)	5
Cardamom (g)	5
pH of gravy	3.8

Fifty ml of mustard oil was heated to 60°C and added to each bottle of the preserve to cover the surface. The bottles were closed with bakelite screw caps and stored in a cool place at ambient temperature of 25-30°C. Sensory evaluation, and microbiological analyses[3] were conducted at regular intervals till six months of storage period.

Results and Discussion

The pH of gravy was found to be 3.8 (Table 1) which is ideal for the development of meat preserve. When raw pork cubes of 2.5 cm size, were fried in oil hydro between 150 and 160°C, the moisture content reduced from 72 to 38 per cent in a period of about 30 min. One kg of pork cubes (2.5 cm size) on frying became 350 g at the end. The minimum time required to reach equilibrium between the fried pork and acidulated brine (25 per cent salt in 5 per cent acetic acid) was 5 hr at ambient temperature (25-30°C). The moisture content in the fried meats was in the range of 36 to 42 per cent after equilibrium was attained, with the acidulated brines of different concentrations. But the pH and salt contents in the treated fried meats varied from 3.7 to 4.3 and 3.6 to 7.3 per cent respectively (Table 2). Moisture and salt contents in the fried meats treated with the acidulated brines of 25 per cent salt in 5 per cent acetic acid (w/v) were found to be 36.4 and 7.3 per cent respectively, which is ideal for the development of 'Meat Preserve'.

TABLE 2. MOISTURE, pH, Nacl AND W.B. SHEAR VALUES IN FRIED PORKS AFTER TREATMENT WITH ACIDULATED BRINES OF VARIOUS STRENGTHS

Salt (%)	Acetic acid (%)	Moisture (%)	pH	NaCl (%)	W.B. shear values (lb/in^2)
10	2	42.7	4.0	3.6	10.5
10	5	43.3	3.9	4.4	13.1
15	2	41.3	4.0	4.7	10.6
15	5	40.4	3.8	5.4	13.4
20	2	38.6	4.0	6.2	11.8
20	5	38.1	4.3	6.9	13.6
25	2	35.8	3.8	6.3	11.6
25	5	36.4	3.7	7.3	13.8

The fried pork had 38.40% moisture and 12.0 lb/in^2 W.B shear values.

TABLE 3. PROXIMATE COMPOSITION OF MEAT PRESERVE

Constituents	Per cent
Moisture	38.2
Protein	30.1
Fat	25.2
Ash	6.8
Salt (NaCl)	6.1
pH	4.0

It was also observed that with decrease in moisture content in the meat, increased were the W.B. Shear values (Table 2). The 'Meat Preserve' obtained after mixing with the spice gravy had pH in the range of 3.8-4.0 and moisture content between 38 and 40 per cent and salt content between 6 and 8 per cent. The proximate composition of meat preserve is given in Table 3. The preconditioning of meat by equilibration has helped to overcome the high buffer capacity of meat and this has resulted in maintaining the pH of the finished product (Table 3) very close to the pH of the gravy (Table 1).

Microbiological studies on meat preserve, revealed that the product was free from pathogens. Total plate counts, were within the permissible limits and did not increase during the six months storage period. The preserve had acceptable taste and flavour and did not show any change in quality during the storage period.

Hence, a safe meat preserve could be prepared, with salt acidulation combination and the product is suitable for use in our dietary system.

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The Influence of Oxygen Accessibility on the Growth of Yeast in Fish/Rice Fermentation

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Fish/Rice mixture (1:3.6) was prepared and fermented between 12 and 21 days using 1 and 5% inoculum levels under three methods of air exclusion viz. layering with paraffin oil (PO), paraffin wax (PW) and fermentation lock alone (control). Yeast growths were recorded under all experimental conditions. No growth was recorded by the 12th day in the control. There was no significant difference in yeast counts between PO, PW and control. Yeasty flavour developed in bottles exposed to air while the characteristic acid aroma was exhibited by other systems.

Fermented fish products — pastes and sauces are important food supplements in South-East Asia and parts of Senegal (West Africa). These products come under several names in South-East Asia. Amano[1], Mackie *et al.*[2] and Van Veen[3,4] had reviewed fermented fish products found in these areas, but Towry *et al.*[5] reporting its preparation in Senegal referred to it as noucmam. In addition to preserving the fish, fermentation results in development of novel food products. Fish is low in fermentable carbohydrates and for good lactic acid fermentation, an adequate amount of fermentable sugar is added. Several carbohydrate sources such as malt, oat meal[6], tapioca[7] and rice have been used[8-10]. Salt is added to enhance the growth of lactic acid bacteria. Solidum[9] and Mendoza[10] have studied the lactic acid bacteria involved in the fermentation.

Several authors[9-11] have isolated yeasts from the fermenting mixture, which in some cases developed yeasty flavour. This yeasty flavour is not typical of these products and may suggest defective fermentation. This work was aimed at studying the influence of air accessibility on the growth of yeasts in fish/rice mixture with a view to establishing its role in the fermentation and contribution to product quality.

Materials and Methods

Fresh mackerel (*Scomber scombrus*) and polished rice (*Oryza sativa* L.) were obtained from local shops in Reading. Mackerel was used because of availability and low unit cost. The initial inoculum used for the study was a 2-week old fermented fish/rice mixture obtained from L.S. Mendoza (Food Microbiology Laboratory, NCFT, Reading). Other materials used were obtained from Food Microbiology Unit, NCFT, Reading.

Preparation of mixture: The method of Solidum[9] as modified by Mendoza[10] was used for the study, except that the inoculum level was increased from 0.1 to 1 per cent. This level was later increased to 5 per cent in subsequent preparations when it was found that the yeast count became nil after 12 days of fermentation.

The mixture was tightly packed into fermentation bottles (180 ml) after thorough mixing. Some bottles were layered with sterile paraffin oil (PO) and other with paraffin wax (PW) before being stoppered with fermentation lock filled with water. The control set had no layer of paraffin oil or wax before being stoppered with the lock. The last set had no water placed in the lock so as not to impede the flow of air. They were then incubated at 30°C for fermentation.

Yeast and bacterial count and pH measurement: Counts were made on day 0, 4, 6, 9 and 12 in Batch 1 and day 0, 2, 6, 12 and 21 in Batch 2 (Batch 1 had 1 per cent inoculum level, while Batch 2 had 5 per cent inoculum level) by homogenizing 10 g of thoroughly mixed fermented mixture in 90 ml of sterile 0.1 per cent peptone water using a Stomacher (Colworth Stomacher 400) from which serial dilutions were made. Yeast counts were made on Rose Bengal Chloramphenicol (RBC) agar (Labm, London), while bacterial counts were made on de-Man-Rogosa-Sharpe (MRS) Agar (Oxoid). All plates were incubated at 30°C for 24 to 48 hr. pH of fermenting mixture was measured using pH meter (Vibret laboratory).

Anaerobiosis in fermenting mixture: Oxoid anaerobic indicator BR 55 was placed on top of the mixture after exposing part of the paper to air, before the bottles were stoppered with the locks. They were examined daily for colour change.

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Anaerobic cultivation of isolated yeast: Yeast isolated from the fermenting mixture was grown on RBC and Malt Extract Agar (MEA), and incubated anaerobically with *Penicillium frequentans* and *Saccharomyces cerevisiae* (NCFT culture collection), for comparison using a Gaspak system (Baltimore Biological Laboratory). The plates were examined for growth at the end of one week. The plates were subsequently incubated aerobically for 48 hr at 30°C.

Results and Discussion

Fermentation was vigorous within the first 3 days and by day 12, it had reduced considerably as indicated by gas bubbling through the fermentation lock. The headspace became anaerobic within 2 to 3 days as indicated by colour change in the Oxoid indicator paper.

pH dropped from 6.40 at day 0 to 3.7 at day 2 in the second batch as against a drop from 6.45 to 4.0 in the first batch with the same period. There was, however, no noticeable change afterwards in pH but fluctuated between 3.9 and 4.0 in all the samples except in open bottles which indicated a pH of 4.2 by the 14th day.

Organoleptic changes: The colour of the fermenting mixture became creamy brown and fluidy from its white/ brown coloration and solid mass as fermentation period prolonged. This fluidy consistency could be due to the hydrolysis of starch. The aroma of the mixture which was fishy at the start became acidic after 3 to 6 days of fermentation in anaerobically fermented mixtures. Acid aroma is associated with successful lactic acid fermentation of fish[12]. A yellow mass of yeast growth appeared on the surface of open fermenting mixtures by the 6th day. The yellow coloration could be due to lipid oxidation, although yeasty odour overshadowed any rancid odour. The yeasty odour is however not typical of these products. Burkholder *et al.*[13] experimentally produced fermented fish paste using yeasts. The yeasty odour they obtained differed markedly from the acid odour of fish pastes of South-East Asia.

Yeast and lactic acid bacteria growth: The growth of lactic acid bacteria fluctuated between 10^8/g and 10^9/g during the period (Fig. 1) and this pattern has been observed in fish fermentation[9-11] and sauerkraut[14]. This could be due to the inhibitory effect of lactic acid at high levels on lactic acid bacteria.

The yeast growth in open mixtures was high rising to about 10^8/g and did not fall below 10^7/g at the end of 21st day. The yeast counts in other systems were below 10^6/g and declined faster as fermentation period prolonged. The decline was faster in the control which recorded no growth by 12th day and 21st day in both batches, than in paraffin layered mixtures which exhibited yeast growth (Fig. 2). However, there was no significant difference in yeast count between PO, PW and the control. The yeasts (unidentified) grew slowly on MEA and RBC forming pseudomycelial structure with detached cells looking oblong under anaerobic condition. This indicates

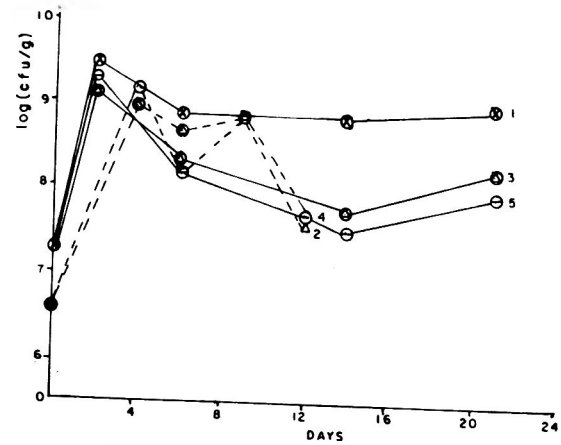

Fig.1. Lactic acid bacteria growth dynamics in the fermenting mixture
1 = Open fermentation
2 = Paraffin oil sealed (1% inoculum)
3 = Paraffin oil sealed (5% inoculum)
4 = Control (1% inoculum)
5 = Control (5% inoculum)

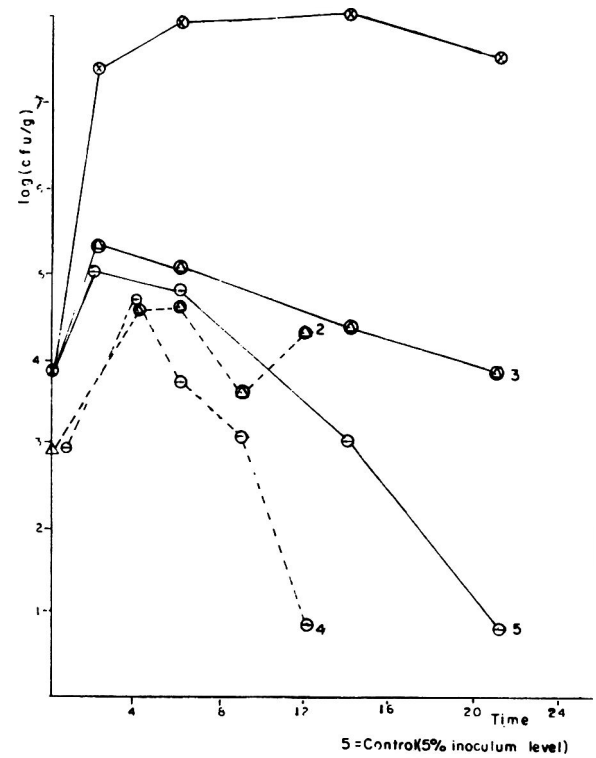

Fig.2. Yeast growth dynamics in the fermenting mixture.
1 = Open fermentation
2 = Paraffin sealed (1% inoculum level)
3 = Paraffin sealed (5% inoculum level)
4 = Control (1% inoculum level)
5 = Control (5% inoculum level)

that anaerobiosis is not ideal for the growth of the yeast. A similar observation was made by Vaughn *et al.*[15] with vegetable fermentation. The death of the yeasts in anaerobically fermenting mixtures supports this observation and

further suggests that their presence was not vital in the process. Although, a pure lactic acid bacterial fermentation was not carried out, it will be necessary to explore this area, so as to ascertain product quality. The present study shows that a simple method of completely excluding air can give a good flavoured fermented fish paste.

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EFFECT OF DRYING AND STORAGE ON THE FATTY ACID COMPOSITION OF RICE

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The effect of drying and storage of three varieties of paddy ('IR-8', 'PR-108' and 'Basmati-370') on fatty acid composition was investigated. Drying of paddy before storage did not produce a notable effect on the fatty acid composition except that palmitic acid increased and linoleic acid decreased to some extent. Lower fatty acids, like palmitic, palmitoleic, stearic and linolenic acids increased with increase in storage period. Oleic and linoleic acids consistently decreased with increase in storage period.

It is a common practice to store the harvested paddy for sometimes before milling. Apart from other chemical and biochemical changes occurring in stored paddy, changes in fatty acid composition and fat also occur. The rice lipids are prone to oxidation and hydrolysis during storage and are liable to alter the flavour characteristics of the stored rice. In the present study, an attempt was made to investigate the changes in fatty acid composition of lipids of some of the Indian rice varieties grown extensively in Punjab and adjoining areas.

Samples of 'IR-8', 'PR-108' and 'Basmati-370' varieties of paddy were obtained from the Department of Plant Breeding, Punjab Agricultural University, Ludhiana. The moisture contents at the time of harvest for 'IR-8', 'PR-108' and 'Basmati-370' were 19.6, 18.8 and 17.5 per cent, respectively. One lot of samples from each variety was stored immediately after harvest at original moisture content for one year in gunny bags under ambient conditions. The other lot was dried to 12 per cent moisture content using forced air circulation drier prior to storage under similar conditions. The mean temperature and relative humidity during storage were 24.5°C and 57 per cent respectively. The paddy samples were milled to 6 per cent degree of polish after 1, 6 and 12 months of storage.

Fatty acids were analysed as their methyl esters with gas liquid chromatography (GLC) equipped with a flame ionization detector, fitted with 10 ft × ⅛ in. stainless steel column, packed with 20 per cent diethyl glycol succinate (DEGS). The lipids were converted into methyl esters of fatty acids by the method of Luddy *et al.*[1].

The samples were cooked and evaluated by a panel of judges for taste, appearance, stickiness, colour, tenderness and aroma on a 4-point scale and overall mean values were computed. Drying of paddy before storage did not produce a notable effect on the fatty acid composition except that palmitic acid increased and linoleic acid decreased to some extent. Significant changes in fatty acid composition were observed in milled rice on storage of paddy (Table 1). Lower fatty acids, palmitic, palmitoleic, stearic and linolenic acids showed a consistent increase but oleic and linoleic acids decreased with the increase in the storage period. Higher fatty acids showed a decrease at 6 months and an increase was observed after 12 months of storage. Conflicting results were earlier reported by Tsuzuki *et al.*[2] and Ramarathnam and Kulkarni[3] about the effect of storage on fatty acid composition. Our results for linoleic acid are in agreement with those reported by Tsuzuki *et al.*[2] but are at variance for oleic acid. The differences could be due to the differences in storage conditions.

Varieties differed significantly with respect to fatty acid composition. Oleic acid and linoleic acid were the major fatty acids in all the varieties. 'Basmati-370' and 'PR-108' had higher oleic and linoleic acids respectively. Juliano[4] reported that the fat present in the rice contained 40 per cent oleic acid, 35 per cent linoleic acid and 1-2 per cent linolenic acid. Upto 6 months of storage, the organoleptic quality of cooked rice improved from a mean score of 2.63 to 2.93 but thereafter the quality deterioration started and mean score value after a year was 2.46 (Table 2). The improvement in the cooking quality after 6 months was due to ageing effect. The decrease in the oleic and linoleic unsaturated fatty acids during this time also supported the improvement in the cooking quality. The increase in the higher fatty acids after one year storage deteriorated the cooking quality of rice. Drying of paddy, however, improved the organoleptic quality of rice as inferred from the Table values.

The changes occurring in fatty acid composition of stored rice affected the flavour of cooked rice due to increase in lower fatty acids (C_{14} and less) during storage.

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TABLE 1. FATTY ACID COMPOSITION OF MILLED RICE AS AFFECTED BY DRYING AND TIME OF STORAGE OF PADDY*

Variety	Storage period (months)	Lower fatty acids (%)	Palmitic (%)	Palmit-oleic	Stearic (%)	Oleic (%)	Linoleic (%)	Lino-lenic (%)	Higher fatty acids (%)
				Storage without drying[a]					
IR-8	1	0.76	19.19	0.08	1.20	41.29	32.07	1.17	4.24
	6	3.29	20.39	0.93	1.81	39.73	31.11	2.30	0.44
	12	4.85	18.24	1.11	1.60	39.58	30.04	2.05	2.53
	Mean	2.97	19.27	0.71	1.54	40.20	31.07	1.84	2.40
PR-108	1	0.71	18.25	0.06	1.20	42.20	33.72	1.19	2.67
	6	3.95	18.51	0.84	1.58	40.33	31.92	1.87	1.00
	12	4.75	18.82	1.87	1.52	36.79	29.25	2.22	4.48
	Mean	3.14	18.53	0.92	1.53	39.77	31.63	1.76	2.72
Basmati 370	1	0.48	18.09	0.05	1.69	48.05	29.03	1.01	1.60
	6	2.63	19.28	0.26	2.18	46.03	27.01	1.75	0.86
	12	4.97	19.58	0.62	2.21	44.51	24.71	1.52	1.88
	Mean	2.69	18.98	0.31	2.03	46.20	26.92	1.43	1.45
				Storage after drying[b]					
IR-8	1	0.98	21.23	0.07	1.76	40.76	31.45	1.14	2.61
	6	3.55	21.21	0.43	1.58	38.94	31.48	1.39	1.42
	12	4.60	18.53	0.72	1.17	40.13	30.47	1.82	2.56
	Mean	3.04	20.32	0.41	1.50	39.94	31.13	1.45	2.20
PR-108	1	0.62	19.66	0.05	1.28	42.58	32.55	1.13	2.13
	6	2.71	18.63	0.37	1.58	41.45	32.78	1.45	1.03
	12	4.98	18.86	0.57	1.36	36.65	29.37	2.32	5.89
	Mean	3.77	19.05	0.33	1.41	40.23	31.57	1.63	3.02
Basmati-370	1	0.41	17.35	0.06	1.75	48.24	29.45	1.13	1.61
	6	1.82	19.32	0.32	2.32	47.27	26.91	1.15	0.89
	12	5.20	20.24	0.43	2.56	42.96	25.50	1.63	1.48
	Mean	2.48	18.97	0.27	2.21	46.16	27.29	1.30	1.33

[a], Stored immediately after harvest; [b]Stored after drying to 12% moisture. *The total fat content of 'IR-8', 'PR-108' and 'Basmati-370' when stored as such and after drying was 0.99, 1.02, 1.19 and 1.04, 1.07 & 1.14% respectively.

TABLE 2. OVERALL MEAN SCORE* OF COOKED RICE FROM THE STORED PADDY

Variety	Storage				
	1 month	6 months	12 months	Without drying	With drying
IR-8	2.42	2.66	2.28	2.27	2.58
PR-108	2.67	2.82	2.59	2.54	2.85
Basmati-370	2.80	2.30	2.52	2.77	3.05
Mean	2.63	2.93	2.46	2.53	2.83

*Out of a max. of 4.

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ASSESSMENT OF PROTEIN QUALITY OF DEPIGMENTED PEARL MILLET

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The protein quality of pearl millet soaked in 0.2 N HCl for 15 hr and scarified upto 8.10, 11.56 and 15.84% and soaked in 0.2 N HCl for 40, 25 and 20 min, respectively, was assessed by using rats. The PER was found significantly increased from 2.14 to 2.32 in 15 hr soaked and to 2.44 in 15.84% scarified and 20 min soaked pearl millet. The TD, BV, NPU and UP were also found significantly increased in both soaked and scarified and soaked pearl millet. Soaking followed by scarification showed maximum improvement in protein quality.

In pearl millet, the large amount of polyphenols and phytate present in the pericarp (aleurone layer) of grain could be removed partially by dehulling[1]. Reichert[2] identified that the objectionable grey colour of roti of pearl millet was due to polyphenolic pigments present in the peripheral area of the grains. Reichert and Youngs[3] further observed that soaking pearl millet grains in dilute hydrochloric acid or citric acid was the most efficient method to bleach the grains.

The data on functional[4] and rheological[5] properties of depigmented pearl millet flour and sensory quality of roti show that depigmentation was most beneficial to improve some of these properties of flour and roti. Unfortunately, time required to depigment the grains was observed to be 15 to 25 hr.[3,6,7] If grains are scarified and then soaked in acid, the time required to depigment was drastically reduced to a great extent.[3,8] Moreover, phytate was also reduced to a considerable extent and there was an improvement in *in vitro* protein digestibility[8]. It was of great interest at this juncture, to assess the protein quality of such pearl millet and therefore this work was undertaken.

Pearl millet grains were purchased from the local market and cleaned. A sample (25 g) was soaked in 75 ml of 0.2 N HCl for 15 hr. For scarification, 500 g sample was used, (Osaw make) for 1 min (8.10 per cent) and then soaked in 0.2 N HCl (1:3, w/v) for 45 min. Similarly, another such two sets of samples were scarified for 2 (11.56 per cent) and 3 (15.84 per cent) min and then soaked for 25 and 20 min, respectively. Soaking was carried out at room temperature (~ 28°C). After soaking the grains were filtered and optical density of the filtrate was measured at 400 nm. The grains were washed with water for 3 to 4 times to remove the residual HCl. For comparable bleaching of grains, the optimum soaking time observed was for unscarified; 15 hr and for 8.10, 11.56 and 15.84 per cent scarified; 45, 25 and 20 min, respectively[8]. The scarified and soaked grains (200 g) were dried, ground to pass through 0.25 mm screen and protein content (N×6.25) was determined by micro-Kjeldahl method[9]. The protein quality was assessed by determining the protein efficiency ratio (PER) as specified in IS[10] and experimental values were corrected. For nitrogen balance study, adult rats (8 weeks old, 90-100 g each) were used. They were housed in individual cages and fed the experimental diets. After three days adaptation, urine and fecal samples were collected for three days. The true protein digestibility (TD), biological value (BV) and net protein utilization (NPU) were calculated as per the procedure of Mitchell[11]. The utilizable protein (UP) was determined as protein × NPU/100.

The data on PER values (Table 1) show a significant improvement in rats fed scarified and soaked pearl millet over

TABLE 1. PER AND BIOLOGICAL EVALUATION OF DEPIGMENTED PEARL MILLET

Treatment		Protein	PER		TD	BV	NPU	UP
Scarified (%)	Soaking period (hr/min)	(%)	Observed	Corrected	(%)	(%)	(%)	(%)
Untreated	—	12.8	2.17	2.14	90.91 ± 2.8	55.32 ± 3.4	50.18	6.42
—	15 hr	12.8	2.35	2.32	95.16 ± 3.1	66.45 ± 2.9	63.23	8.03
8.10	40 min	12.7	2.34	2.31	91.56 ± 3.4	59.71 ± 3.8	54.67	6.94
11.56	25 min	12.4	2.46	2.43	96.10 ± 2.7	68.18 ± 4.1	65.52	8.12
15.84	20 min	12.1	2.47	2.44	96.84 ± 3.9	68.85 ± 2.8	66.67	8.73
Control (SMP)		38.0	3.04	3.00	98.11 ± 3.4	91.68 ± 3.6	89.94	34.17
	SE ±	—	0.140	0.009	0.7239	0.6036	1.7293	0.1387
	LSD (P=0.05)	—	0.432	0.029	2.2308	1.8603	5.3290	0.4274

Results are expressed as mean ± SD of three independent experiments.
Soaked in 0.2 N HCl.
Protein = N×6.25 (dry weight basis). SMP = Skimmed milk powder.

rats fed untreated and even 15 hr soaked pearl millet. The PER values of soaked and scarified and soaked pearl millet were also significantly higher than the PER of the untreated one. The corrected PER of the sample soaked for 15 hr and scarified for 1 min and soaked for 40 min was more or less same but it was increased in the remaining diets. The corrected PER values of scarified and soaked sample ranged from 2.31 to 2.44 compared with 3.00 for skimmed milk powder (a reference protein diet). The significant improvement in PER values of sample soaked for 15 hr and of samples scarified upto 11.56 and 15.84 per cent and soaked for 25 or 20 min, respectively, may be due to removal of polyphenols and phytate which could have probably made more protein available for utilization. Reichert *et al*[12], however, did not find significant difference in feed intake, weight gain and feed/gain ratio in the feeding experiments of dehulled and whole pearl millet. The significant differences in PER values in the present investigation may be due to combined effects of scarification and soaking. The polyphenols and phytate being soluble in dilute HCl might have been also leached out and decreased.

The data on biological evaluation of pearl millet (Table 1) coincide with the results of Singh *et al.*[13] who observed 94.4 to 97.3, 54.9 to 66.6, 51.8 to 64.8 and 5.61 to 11.77 per cent TD, BV, NPU and UP, respectively. in high and low protein peral millet varieties. However, the data show the significant improvement in TD, BV and NPU of depigmented pearl millet. This improvement was observed in scarified and soaked pearl millet for varying periods and even in unscarified but only soaked pearl millet. But soaking followed by scarification was more advantageous than only soaking in all the parameters of protein quality. There was significant improvement in UP also during these treatments. Reichert *et al.*[12] had observed significant improvement in dry matter digestibility but not in protein digestibility of dehulled and whole pearl millet. The improvement in protein quality of scarified and soaked samples may be due to combined effects of these two treatments during which a large part of antinutritional factors might have been either removed and/or leached out.

Finally it can be concluded that soaking followed by scarification of pearl millet not only reduces the soaking time for removal of polyphenols but also reduces phytate appreciably and results in improved protein quality.

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STUDIES ON FUNGAL AND MYCOTOXIN CONTAMINATION OF STORED MILLETS KODON (*PASPALUM SCROBICULATUM*) AND KUTKI (*PANICUM MILIARE*)

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Screening of Kodon (*Paspalum scrobiculatum*) and Kutki (*Panicum miliare*) stored in traditional storage structures revealed that these millets were infected with aflatoxin producing fungi. Most of the stored millets contained more than detectable quantity of aflatoxin. Proper storage can avoid danger of mycotoxins.

Mycotoxin contamination of food, a resultant of the infection of stored foodgrains by certain species of fungi has now been recognised as one of the health hazards. Aflatoxicosis was identified as the cause of the death of several persons in tribal parts of Banswara and Panchmahal districts of Rajasthan and Gujarat states respectively[1]. Unhygienic post-harvest practices as well as humid climate during storage increase toxin production in foodgrains.

Lesser millets form major part of daily meals of tribal people. Large parts of Madhya Pradesh (M.P.) State are also known to be inhabited by a number of tribal communities and they grow lesser millets and use the same as staple food. The production of Kodon (*Paspalum scrobiculatum* L.) and Kutki (*Panicum miliare* L.) together in M.P. during the years 1980-81, 81-82 and 82-83 was 236.9, 253.3 and 212.1 thousand tonnes respectively[2]. Therefore, present studies were undertaken to know the extent and type of fungi associated with and toxins present in Kodon and Kutki stored in the intensely tribal populated three districts of Madhya Pradesh.

Tribal districts of M.P. viz. Bastar, Mandla and Shahdol were selected for studies where the production of these millets is maximum in comparison to other districts. Three villages from each of the districts were chosen at random and samples of Kodon and Kutki each weighing approximtely 500 g were collected for the study. The samples collected in polythene bags were sealed and screened in the laboratory for the presence of fungal contamination on the surface of the seeds, if any. Blotter method was applied for the isolation of the fungi. Isolated species were grown on Czapek's agar media for the identification of the species.

The samples which were found to be infected by the toxin producing fungi like *Aspergillus flavus* were further analysed for the presence of aflatoxin B_1. The extraction of the aflatoxin present in the samples was done by Pons method[3]

The extract of the samples was further dried by passing it through a bed of anhydrous sodium sulphate and immediately thereafter solvents were completely evaporated on water bath. The residue thus obtained was dissolved in chloroform and this solution was spotted on T.L.C. plate with a reference standard aflatoxin B_1. The plate was developed in an unequilibrated tank containing mixture of acetone and chloroform in the ratio 1:9. When the solvent front reached 12-14 cm, the plate was withdrawn, the solvent was evaporated and the plate was exposed to long wave U.V. lamp (363 nm) in a chromate viewer. Aflatoxin B_1 was identified by its typical Rf value and further confirmed by treating the spots with 1 μ l trifluoroacetic acid[4]. The quantity of toxin was estimated by dilution to extinction procedure[5].

The fungi identified are given in Tables 1 and 2.

A total of 29 species of fungi were found to infect Kodon grains. Among the aspergilli isolated, *Aspergillus flavus* was

TABLE 1. FUNGI ISOLATED FROM KODON (*PASPALUM SCROBICULATUM*) SEEDS COLLECTED FROM THREE DISTRICTS ALONGWITH THE FREQUENCY OF OCCURRENCE IN PER CENT

Fungal spp.	Bastar (21)	Mandla (27)	Shahdol (60)
Aspergillus candidus	4.7	—	—
A. flavus	19.0	40.7	35.0
A. fumigatus	9.5	7.4	5.6
A. niger	4.7	18.5	15.0
A. nidulans	4.7	—	—
A. ochraceus	—	—	1.6
A. sydowi	7.4	—	—
A. terreus	—	3.7	—
A. versicolor	—	—	1.3
Penicillium citrinum	—	—	3.3
P. frequentans	—	—	3.3
P. oxalicum	19.0	—	3.3
P. rubrum	—	—	3.3
Penicillium (mono)	—	—	13.3
Penicillium spp.	—	11.1	6.6
Penicillium monoverticiilata spp.	—	7.4	—
Alternaria alternata	—	7.4	—
Curvularia lunata	14.2	55.5	33.3
C. pallescens	—	7.4	3.3
Cladosporium cladosporioides	28.5	25.9	13.3
Cephalosporium certipes	9.5	7.4	5.0
Drechslera hawaiiensis	—	7.4	1.6
Drechslera spp.	4.7	—	—
Chaetomium globosum	—	7.4	—
Fusarium oxysporium	—	7.4	—
Phoma spp.	4.7	7.4	—
Trichoderma viridae	—	—	1.6
Rhizopus arrhizus	—	7.4	10.0
Mucor pusillus	4.7	—	—

Figures given in paranthesis indicate the total number of samples screened.

the most abundant. The frequency of occurrence of this species was 19.0, 40.7 and 35.0 per cent in the samples collected from Bastar, Mandla and Shahdol districts respectively (Table 1).

Among the fungi imperfecti isolated, the most abundant species were, *Cladosporium cladosporioides* (28.5 per cent) isolated from foodgrains collected from Bastar district and *Curvularia lunata* recorded from Mandla and Shahdol districts the frequency being 56.5 and 33.3 per cent respectively (Table 1).

Out of 20 species of fungi isolated from Kutki grains *Curvularia lunata* was most abundant followed by *Aspergillus flavus, Drechslera* spp., *Cladosporium cladosporioides* and *Phoma* spp. (Table 2).

Thirty samples which were contaminated with toxigenic fungi (*A. flavus*) were analysed for the presence of aflatoxin B_1. Among the 30 samples, 17 samples were found to be contaminated with the detectable amount of aflatoxin B_1. Remaining 13 samples infected with *A. flavus*, were found to be free from aflatoxin. Detection of aflatoxin in foodgrain stored in 17 storage premises could have been possible due to host of favourable factors like temperature and humidity in the storage premises including high moisture content of the grains, which allowed complete development of *A. flavus* while remaining 13 storage containers contained millets with lesser moisture content and other unfavourable factors. Therefore, the toxin producing fungus might not have produced toxin under the changed environmental conditions.

The quantity of aflatoxin B_1 present in 17 samples ranged from 12 to 44 p.p.b. Out of 17 contaminated samples, only two samples contained aflatoxin B_1 beyond the permissible limit of 30 p.p.b.

It was interesting to note that Kutki grains, were either free from contamination or few grains were infected by moulds. It may perhaps be due to the small size and smooth surface of the Kutki grains which provide lesser chances for establishment of the spores of the fungi in comparison to Kodon grains which have larger size and rough surface.

Studies thus revealed that Kodon and Kutki which are the staple constituents of daily meals of tribal people remain prone to be infected by a host of fungal species during storage. Presence of aflatoxin, in some of the samples of traditionally stored Kodon brings home the importance of storing food commodities in improved storage bins.

TABLE 2. FUNGI ISOLATED FROM KUTKI (*PANICUM MILIARE*) SEEDS COLLECTED FROM TWO DISTRICTS ALONGWITH THE FREQUENCY OF OCCURRENCE IN PER CENT

Fungal spp.	Bastar (46)	Mandla (16)
Aspergillus flavus	17.3	18.70
A. niger	4.3	6.26
A. oryzae	—	6.25
Penicillium (mono)	—	6.25
Penicillium (*biverticillate* spp.)	2.1	6.25
Alternaria alternata	2.1	—
Curvularia lunata	30.0	18.75
Cladosporium cladosporioides	13.0	—
Cephalosporium curtipes	4.3	—
Drechslera hawaiiensis	—	6.25
Drechslera spp.	15.2	—
Fusarium semitectum	2.1	—
F. oxysporium spp.	—	6.25
Nigrospora oryzae	—	6.25
Chaetomium globosum	—	6.25
Phoma spp.	8.6	12.50
Rhizopus arrhizus	2.1	6.25
R. chinesis	2.1	—
Mucor pusillus	2.1	—
Absidia remosa	2.1	—
Mycelia sterilia	—	6.25

Figures given in parentheses indicate the total number of samples screened.

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BLANCHING REQUIREMENTS FOR DEHYDRATION OF GREEN COWPEA (*VIGNA UNGUICULATA* WALP) PODS

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The presence of peroxidase was found to have no significant effect on sensory qualities of dehydrated pods. Water activity of the dehydrated pods (16 min blanch, 5.9% moisture) was 0.28. Green cowpea pods should be dehydrated to about 4.7% moisture which was found to be their critical moisture level and it should not be allowed to rise above 8.2% during storage in order to ensure retention of its qualities.

Green cowpea (*Vigna unguiculata* Walp) pods contain catalase, lipoxygenase and peroxidase[1]. They are not destroyed completely at drying temperatures and remain active even at low water activity[2]. Therefore, they are destroyed by blanching. Kozlowski[3] surveyed the theoretical basis of blanching and concluded that vegetables like broad beans (*Vicia faba*), French beans (*Phaseolus vulgaris* L.) and peas (*Pisum sativum*) which have high metabolic activity at harvest should be adequately blanched to get good quality frozen product. But overblanching lowers the quality of the product. Therefore, blanching process is optimized[4] using the most heat resistant enzyme, generally peroxidase in vegetables as an index[5]. But many workers[6-9] did not note any undesirable change in vegetables with only residual peroxidase activity. Use of lipoxygenase[8] or catalase[9] as a blanching index has been suggested because their residual activity was found to be more closely related to the quality changes during storage than peroxidase. The present authors[1] have found that thermal resistance of catalase in green cowpeas was lower than peroxidase but higher than lipoxygenase which makes selection of a proper blanching index necessary. In this study, the effect of residual catalase or peroxidase activity on quality of dehydrated green cowpea pods was examined.

Green cowpea pods cv 'Pusa Komal' obtained from the Horticultural Research Centre of this University were sorted, pods of proper maturity were washed well and trimmed to remove stalk, flower ends and string. Pods (about 500 g) were tied loosely in muslin cloth and blanched in hot water (95°C). Blanching time was equivalent to 2 D^1 process for catalase and peroxidase, respectively. One lot of catalase-free pods were dipped for 1.5 hr in 1 l catalase solution at room temperature. Similarly, another lot of peroxidase-free sample was treated with peroxidase solution. Soaking time was enough to allow sufficient absorption of enzyme by the blanched pods. They were spread uniformly in a monolayer on trays (0.2 kg/m^2) and dehydrated for 5 hr to about 5 per cent moisture at 69 ± 1°C in a tray drier. Dehydrated samples were packed in polyethylene bags, sealed airtight and stored at room temperature for 3 months.

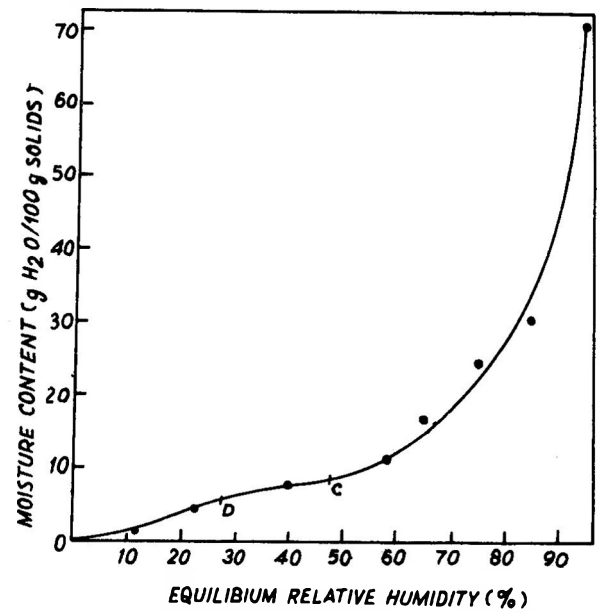

Fig.1. Sorption isotherm for cowpeas blanched for 16 min at 95°C, dried at 69 ± 1°C and stored at 37°C.

Dehydrated samples were analyzed for extent of browning (EB), dehydration ratio (DR) and rehydration ratio (RR) by the methods described by Ranganna[10]. Water activity (a_w) of the dehydrated product was determined by Wink's weight equilibrium method using saturated salt solutions[10] and bone-dried (70°C, vacuum oven) dehydrated pods. Two sets of relative humidity dessicators were used. Monolayer water content and heat of sorption were calculated using BET equations[11]. Equilibrium moisture contents corresponding to first (D) and second (C) points of inflection on sorption isotherm (Fig.1) were determined. During storage for a_w estimation, their external appearance was recorded regularly.

Proximate composition and alcohol insoluble solids (AIS) in fresh pods were determined according to the methods described by Ranganna[10]. Total chlorophylls were estimated by extracting samples with 85 per cent acetone, transferring the pigments to ethyl ether and measuring OD at 660 nm[10]. Catalase was assayed by the iodimetric method and peroxidase by indophenol dye-titration method[12].

For sensory evaluation, dehydrated pods were boiled in 2 per cent NaCl for 5 min, and subjected to evaluation on a 9 point Hedonic scale. The samples were evaluated for colour,

TABLE 1. QUALITY CHARACTERISTICS OF GREEN COWPEA PODS DRIED TO 5.0–5.8 PER CENT MOISTURE IN TRAY DRIER AT 69 ± 1°C

Blanching		Enzyme					Mean sensory score	
Temp. (°C)	Time (min)	Added	Residual activity K_f/g	EB (O.D.)	Dehydration ratio	Rehydration ratio	Texture	Overall
—	—	—	—	0.91	5.5	1:3.4	3.15	5.43
95	16	Nil	Nil	1.19	5.5	1:2.7	4.80*	5.96
95	16	Cat	0.007	1.20	5.5	1:2.9	4.06	5.67
95	30	Nil	Nil	1.19	5.5	1:2.7	3.81	5.88
95	30	Per	0.063	1.19	5.5	1:2.7	3.75	5.65

[1]Initial catalase activity 0.058 K_f/g and peroxidase activity 0.326 K_f/g.
*Significantly different at 5% level; Cat = Catalase; Per = Peroxidase.

texture and overall acceptability and analyzed statistically[12].

Green cow pea pods of 'Pusa Komal' variety contained 85.8 per cent moisture and 4.0 per cent AIS. Percentages (moisture-free basis) of protein, fat, ash and crude fibre were 21.6, 3.1, 5.0 and 12.1, respectively. Total chlorophyll content (mg/100 g solids) of fresh cowpeas was 397.9 which reduced to 148.9 in unblanched dehydrated sample. Blanching followed by drying reduced its chlorophyll content to 25.9 mg/100 g solids, irrespective of the blanching period. This shows that the chlorophyll loss has taken place during both these steps as reported by Foda *et al.*[14] Colour of the dehydrated product, as indicated by EB was found to be related to its chlorophyll content. Unblanched dried cowpeas containing more chlorophyll showed less browning (EB 0.91) as compared to blanched and dried cowpeas (Table 1). Blanching did not affect DR (5.5). However, it reduced RR. Rehydration ratios of samples blanched for 16 or 30 min were almost the same (1.27-1.29).

Mean sensory scores for overall quality or flavour did not differ significantly (Table 1). This shows that added or residual catalase or peroxidase activity did not influence the sensory qualities of the products. The 16 min blanched sample showed the highest score of 5.96 eventhough only catalase was inactivated and peroxidase was present in them. The main difference was noted in their texture. The 16 min blanched sample (catalase-free) got the highest score of 4.80 for texture which was significantly superior (Table 1). The blanched dehydrated samples got higher score because their brown colour leached during rehydration giving them light green colour, enhancing their acceptability.

Changes in the appearance of dehydrated cowpeas (16 min blanch) during storage for a_w estimations were recorded (Table 2). At 11 per cent RH, slight bleaching was observed.

TABLE 2. CHANGES IN QUALITY OF DRIED GREEN COWPEA PODS DURING 18 DAYS STORAGE AT 37°C UNDER DIFFERENT RELATIVE HUMIDITIES

RH (%)	Moisture (g/100 g solids) On the day of colour change	After 18 days	Quality characteristics on 18th day
11	1.20	1.6	Slight colour loss
22	NCC	4.3	Retained initial colour and crispness
40	6.1	7.4	Slightly brownish, crisp
58	8.5	11.0	Moderately brown, not very crisp
65	15.7	16.4	Brownish, crispness lost
75	23.7	24.4	Brown, moderately moist
85	22.4	31.7	Dark brown, very moist, mould growth on 9th day
95	43.6	71.1	Dark brown, very moist, mould growth on 9th day

NCC: No colour change

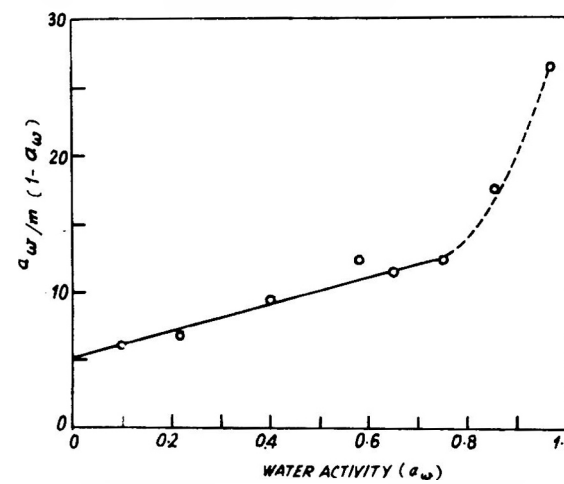

Fig.2. BET plot for cowpeas blanched for 16 min at 95°C, dried at 69 ± 1°C and stored at 37°C (a_w : water activity, m : g H_2/100 g solids).

TABLE 3. WATER ACTIVITY OF DEHYDRATED GREEN COWPEA PODS

	Values
Moisture (g/100 g solids)	5.90
Water activity (a_w)	0.28
BET monolayer value (g H_2O/100 g solids)	0.65
Critical moisture content (g/100 g solids)	8.20
Heat of absorbance (kcal/mole)	11.07
ERH at critical moisture content (%)	45.00

The corresponding equilibrium moisture content (EMC) (on moisture-free basis) was 1.2 per cent. Under higher RH ($\geq$ 40 per cent) slight browning and softening was noticed in the product. The product retained its colour and texture during 18 days of storage at 22 per cent RH. EMC of the product at this RH was 4.3 per cent.

The sorption isotherm of the dehydrated cowpeas is shown in Fig.1. Water activity of the product was 0.28 (Table 3). From BET plot of the product (Fig.2), monolayer water content (g/g solids) was found to be 0.065 and heat of absorbance 11.07 kcal/mole (Table 3). Moisture content corresponding to critical point C is the upper limit for safe storage of the dehydrated product[10]. It was found to be 8.2 g/100 g solids which corresponded to an ERH of 45 per cent (Fig.1). This is close to the observed value (Table 2). Since the danger point (D) was at 4.7 H_2O/100 g solids, cowpeas should be dehydrated to this moisture level. Monolayer value was very low (0.65 g H_2O/100 g solids) and drying cowpeas to that level would result in loss of colour (Table 2). Packaging should ensure that product moisture does not rise above 8.2 g/100 g solids during storage.

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STUDIES ON OPEN SUN-DRYING OF BLANCHED SOYBEAN

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Open sun-drying of blanched soybean and soy split is an important step in production of full fat soy flour at rural level. The experiments were conducted on black polyethylene sheet as drying flour at spreading densities of 3.25 kg/m^2, 6.5 kg/m^2 and 9.8 kg/m^2.The whole clean soybean and soy splits were subjected to blanching in boiling water for 40 min to remove antinutritional factors. The variation in moisture content was monitored by weighing samples at every one hour interval during drying. The EMC was determined as per the equation of Chung and drying constants were computed. The net drying time for soy splits was 7.5 hr (< 1 day), 12 hr (< 2 days), and 13 hr (3 days) and 12 hr (< 2 days), 12.5 hr (< 2 days) and 15.5 hr (3 days) for whole soybean at spreading densities of 3.25, 6.5 and 9.8 kg/m^2 respectively.

Soybean contains 40 per cent protein and 20 per cent oil and can solve the protein calorie malnutrition of ever expanding population in our country. However, to make it popular as food, it is essential that the antinutritional factors present in soybean are eliminated and simple food products developed to suit the liking and taste of rural masses.

The production of full fat soy flour is a feasible way of processing soybean at rural level. The process developed at CIAE[1] is very simple requiring blanching of soy splits in boiling water for 40 min and drying to 10 per cent moisture content (wb) for making flour (Fig.1).

The drying at rural or domestic level cannot be done artificially and hence open sun-drying is followed. Although this practice is susceptible to damage due to inclement weather, given favourable sunny weather it may be the most energy efficient process[2]. Studies on open sun-drying of paddy[2], chillies[3] copra[4] have been conducted to know the effect of spreading density, type of surface and season on drying time and quality of the product.

Similarly, the studies have been conducted on open sun-drying of blanched whole soybean and soy splits and results are presented here.

The soybean of 'JS-7244' variety was used for experiments. The open sun-drying was performed on black polyethylene sheets to get advantage of heat energy absorbed by black surface. The sheets were 37.5 cm × 37.5 cm to maintain the grain layer only on 30 cm × 30 cm area. The whole soybean as well as hull free soy splits in a lot of 2 kg were blanched

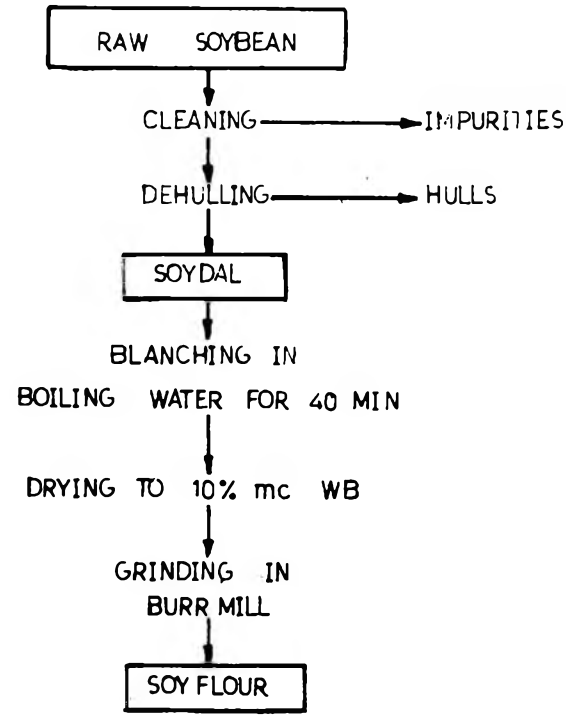

Fig.1. Process chart to prepare full fat soy flour at rural level.

in boiling water for 40 min. The drying trials were conducted at spreading densities of 3.25 kg/m^2, 6.5 kg/m^2 and 9.8 kg/m^2. The experimental samples were weighed on a platform scale balance having least count of 2.5 g before starting and intermittantly while drying. The initial moisture content was determined by standard air oven method of drying at 105°C for 16 hr. The moisture content variation while drying was monitored by formula of material balance.

$$Q_1 (100 - M_1) = Q_2 (100 - M_2) \qquad \text{——— (1)}$$

Where Q_1 and Q_2 are initial and final weights in gram and M_1 and M_2 are moisture contents on wet basis at Q_1 and Q_2.

To find out rate of drying, the value of equilibrium moisture content Me was as per following equation.

$$Me = B - C \ln (- (T+A) \ln RH) \qquad \text{——— (2)}$$

The values of the coefficients A, B and C for soybean were taken as A = 100.288, B = 0.41631 and C = 0.071853.

The relationship as given in equation 3 was used to express the moisture loss.

$$\frac{M - Me}{Mo - Me} = e^{-kt} \qquad \text{———(3)}$$

The temperature of drying air just near the drying surface was measured with mercury thermometer and the average ambient conditions over the period of experiments were obtained from local observatory. It included ambient

temperature, relative humidity and solar energy incident on horizontal surface.

The material was spread for drying at 9 a.m. and collected at 5 p.m. The same material was spread again on next day at 9 a.m. till the drying was completed. Collecting and storing the material in the laboratory during nights also allowed the tempering of grain for moisture equilibriation.

Though drying was conducted from 9 a.m. to 5 p.m. it was observed that from 9 to 10 a.m. the material was getting warmed up and in the evening from 4 to 5 p.m. the material was getting cooled as experiments were conducted in the months of Jan-Feb. Hence effective drying time per day was 6 hr. i.e. from 10 a.m. to 4 p.m. The initial moisture content of blanched soy dhal and whole soybean was about 60 and 53 per cent (wet basis) respectively. The average temperature developed just near the drying surface and ambient weather condition during the experiment is given in Tables 1 and 2. The average temperature and relative humidity during drying time i.e. 10 a.m. to 4 p.m. were 40°C and 38 per cent respectively. The variation of temperature and RH during a day is quite evident. However, average value was assumed as corrected value of the drying air condition. The variation of moisture content with drying time at various spreading densities was recorded and the drying was faster for first few hours in all the cases. The drying rate was higher at lower densities than at higher spreading densities. The drying took place in two distinct falling rate periods, first upto 4 hr and the second from 4 to 12 hr. The average values of the rates have been indicated in Table 3. The data were fitted in equation number 3 and constants were computed for various spreading densities for whole soybean as well as soy dhal. The drying was faster in case of soy dhal than in whole soybean which may be due to the fact that the hull was removed in dhal which helped in faster transfer of moisture from centre to surface. The larger surface area obtained by dhal making might have also helped in faster drying. A spreading density of more than 9.80 kg/m^2 was apparantly looked dense and hence the maximum level of spreading density was kept at 9.8 kg/m^2.

TABLE 1. DRYING TEMPERATURE AT DIFFERENT HOURS OF THE DAY

Time of the day	Av. temp. near surface (°C)
10 a.m.	30.5
11 a.m.	36.0
12 noon	38.0
1 p.m.	48.0
2 p.m.	48.0
3 p.m.	40.0
4 p.m.	40.0
5 p.m.	38.0

TABLE 2. WEATHER CONDITION DURING OPEN SUN-DRYING STUDIES

Parameter	First half	Second half
Ambient temp (°C)	24.26 (23—27.83)	26.99 (25—29.5)
Relative humidity (%)	51.00 (33—63.16)	42.99 (32.25—51)
Solar radiation, (lux on horizontal surface)	915.66 (734—1125)	421.66 (340—605)

TABLE 3. DRYING TEST RESULTS

Spreading density (kg/m^2)	Net drying time (hr)	Equation developed	Y Value	Ist falling rate Kg.H_2O/Kg/m/hr	II falling rate Kg.H_2O/Kg/m/hr	Drying performance index Kg/m^2/hr)
		Blanched Soy dhal				
9.80	13.0 (3)	$MR = 1.10e^{-0.2406T}$	0.9930	0.2013	0.06005	0.75
6.50	12.0 (>2)	$MR = 0.7976e^{-0.236T}$	0.9832	0.2508	0.04177	0.54
3.25	7.5 (>1)	$MR = 0.3986e^{-0.196T}$	0.9180	0.3311	0.05350	0.43
		Blanched Soybean				
9.80	15.5 (3)	$MR = 0.9317e^{-0.192T}$	0.9920	0.1732	0.03805	0.63
6.50	12.5 (>2)	$MR = 0.6906e^{-0.194T}$	0.9794	0.1792	0.02762	0.52
3.25	12.0 (>2)	$MR = 0.6848e^{-0.190T}$	0.9652	0.1869	0.03161	0.27

Values in parantheses are time(days) taken for drying

The drying time required at 3.25 kg/m^2 for soy dhal and whole soybean was 7.5 hr and 12 hr respectively spread over two days.

In all the cases, drying took place in falling rate with two distinct periods. The higher first falling rate period was observed at lower spreading densities of 3.25 kg/m^2, in both the cases. However, at higher spreading densities second falling rate was faster, as the overall drying is slow resulting in higher gradient of moisture during second falling rate period.

The drying performance index expressed as kg/m^2/hr were 0.75, 0.54 and 0.43 for soy dhal and 0.63, 0.52 and 0.27 for soybean at various spreading densities.

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SODIUM AND POTASSIUM CONTENTS OF SELECTED PROCESSED FRUITS AND VEGETABLES

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The sodium and potassium contents were determined in processed fruits, vegetables and their products. It was observed that processing has affected both sodium and potassium contents and their ratio in fruits and vegetables. However, the change was more significant for canned vegetables than frozen vegetables or their products.

A number of studies have been conducted in India on the processed fruits and vegetables. They have focussed the losses of water soluble vitamins during processing. There is limited information on the effect of processing on their mineral content. Therefore, the present study was undertaken to determine the effect of processing on the sodium and potassium contents of processed fruits and vegetables.

Different types of processed fruits, vegetables and/or their products as listed in Tables 1 and 2 were purchased from the local markets in Bombay. For each sample, the different lots of same brand were pooled together and mixed thoroughly in a blender. An aliquot of the mixed sample was then taken for analysis. All analyses were performed in triplicate.

The sample was ashed in a muffle furnace at 525°C and the solution was prepared by dissolving 30-100 mg of ash in deionized water and making up the solution to 100 ml in a volumetric flask. The sodium and potassium contents in the ash solutions were then determined by using AIMIL flame photometer[1]. The sodium/potassium concentration in the sample was calculated from the calibration curves of standard sodium and potassium.

The sodium and potassium contents of different processed fruits given in Table 1. For apple juice are the Goldcoin brand had significantly higher potassium content of 65.8 mg/100 g compared to 16.3 mg/100 g in Appy. These losses could have taken at any of the stages like washing with dilute acid, peeling, grating or straining during processing. However, our

TABLE 1. SODIUM AND POTASSIUM CONTENTS OF PROCESSED FRUITS AND THEIR PRODUCTS

Fruit/Products	Manufacturer	Sodium (mg/100g)	Potassium (mg/100g)	Na:K
Apple juice	Appy	12.0	16.3	1:1.4
	Goldcoin	14.0	65.8	1:4.7
Banana-Green/raw				
Wafers (thin)	Janta	408.0	563.0	1:1.4
(thick)	Janta	668.0	470.0	1.4:1
Cherries				
Glazed	—	94.6	15.5	6.5:1
Canned	Jayees	1.8	127.0	1:70
Guava pulp frozen	Mafco	8.4	113.0	1:12.5
Mix fruit cocktail	Sil	14.7	39.2	1:3
	Northland	15.3	43.9	1:3
Orange juice	Kissan	21.4	65.7	1:3.1
	Sil	37.7	40.3	1:1
Pineapple juice	Kissan	1.3	115.0	1:89
	Sil	5.9	39.9	1:7
Pineaaple slice	Frozen-Mafco	6.5	55.4	1:8
	Canned-Sil	5.7	39.8	1:4
Peaches canned	HPMC	36.1	129.0	1:4
Mango juice	Dippy's	5.4	35.1	1:6
	Sil	8.8	38.9	1:4
	Frooti	17.9	23.2	1:1.3
Mango pulp (Alphanso)	Mafco	7.0	128.0	1.18

values were higher for sodium and lower for potassium than those reported by Lapedes for apple juice[2]. These differences may be attributed to the different varieties of apple.

In Banana Wafers, salt was added as sodium chloride to enhance the flavour and taste.

The sodium and potassium contents of glazed and canned cherries showed an interesting trend. The sodium in glazed cherries was 52 times higher than in canned cherries. While

TABLE 2. SODIUM AND POTASSIUM CONTENTS OF PROCESSED VEGETABLES AND THEIR PRODUCTS

Vegetable/product	Manufacturer	Sodium (mg/100g)	Potassium (mg/100g)	Na:K
Bambo shoots	Sil	314.0	121.0	2.6:1
Chilli sauce	Dalal	1105.0	177.0	6.2:1
Carrots frozen	Mafco	33.7	77.1	1:2.3
Corn flakes	Champion	888.0	197.0	4.5:1
	Life	506.0	176.0	3.0:1
Corn shelled frozen	Mafco	1.7	125.0	1:7.4
Corn sweet	Dippy's	316.0	35.4	9:1
	Sil	270.0	67.4	4:1
French beans frozen	Mafco	7.1	152.0	1:21
Green Peas				
Frozen	Mafco	2.6	99.8	1:38
Inbrine	Sil	505.0	210.0	2:1
Lilva frozen	Mafco	2.7	188.0	1:69
Fenugreek leaves dehydrated	---	474.0	1263.0	1:3
Mushroom Button				
	Hyacinth	544.0	194.0	3:1
Mix. vegetables frozen	Mafco	9.8	117.0	1:12
Papad frozen	Mafco	24.0	182.0	1:7
Potato salt	Janta	390.0	800.0	1:2
Potato wafers dehydrated	Home made	1356.0	542.0	2.5:1
	Janta	513.0	702.0	1:1.4
Potato chips	Niknak	304.0	842.0	1:3
	Simba	215.0	912.0	1:4
Spinach frozen	Mafco	138.0	107.0	1.3:1
Tomato juice	Kissan	276.0	261.0	1.1:1
	Dippy's	353.0	230.0	1.5:1
Tomato ketchup	Kissan	1342.0	291.0	4.6:1
	Dippy's	967.0	339.0	3:1
Tomato puree	Dippy's	273.0	564.0	1:2
Tomato sauce	Kissan	1256.0	272.0	4.6:1
	Dippy's	756.0	317.0	2.4:1
	Maggi (Hot & sweet)	1519.0	213.0	7:1

potassium content of canned cherries was 9 times higher than glazed cherries. Our results for canned cherries were very close to those reported by Tver and Russel[3], who reported 1 mg sodium and 124 mg potassium in 100 g cherries.

The sodium and potassium contents of guava pulp were 1.5 and 1.2 times higher than the fresh fruit[4] respectively.

The sodium and potassium contents of different brands of mix fruit cocktail were not significantly different. However, the sodium content was higher while potassium content was lower than the values reported for fruit cocktail[5]. This may be because of differences in the fruits which make up the fruit cocktail.

Sil brand orange juice had higher sodium content than Kissan brand juice. This increase in sodium content may be due to the preservatives added to the juice to prevent deterioration of the orange juice. Similar observation was made for pineapple juice of same brand. However, reverse trend was observed for canned pineapple slices.

Our results are very close to those reported by Guthrie[6] for unsweetened pineapple juice (canned). The sodium and potassium contents of pineapple juice (Kissan) were 1.3 mg/100 g and 115 mg/100 g for sodium and potassium respectively and those reported by Guthrie[6] were 1.2 mg and 134 mg/100 g.

As a result of canning, the sodium content of peaches increased (18 times higher than the values reported for the fresh fruit) and potassium decreased to one third of the amount in fresh fruit[4]. This may be probably due to peeling or slicing.

Mangoes are usually processed into juice (canned/pulp). In different brands of mango juice, sodium and potassium contents were 3-6 times higher than the values reported for fresh fruit[4]. The sodium content in Frooti was higher than in other brands.

The sodium and potassium contents of different processed vegetables are given in Table 2.

It was observed that the sodium content of canned bamboo shoots were nearly 3 times higher than the values reported for fresh shoots[4]. This could be due to sodium chloride added during processing as flavour enhancer and preservative.

The sodium content of frozen carrots was similar to the fresh[4] while the potassium was nearly 30 per cent lower. This was also reported by Wyatt and Ronan[7] who observed significant loss of potassium in blanched carrots.

The processing of dry corn flakes had increased its sodium content (31-56 times) while potassium was largely unaffected. In canned sweet corn, sodium content was 5-6 times higher than in the fresh corn[4], whereas potassium was 2-4 times lower. In frozen corn, the sodium content significantly decreased (from 51.7 to 1.7 mg/100 g) while potassium content of frozen corn was only 26 mg/100 g.

Frozen French beans was high in sodium and potassium compared to fresh beans[4]. It was interesting to note that retention of potassium was more than 100 per cent. Nearly 3 mg/100 g increase in sodium could be due to water used for freezing or during blanching as reported by Marsh *et al.*[8]

TABLE 3. RETENTION OF SODIUM AND POTASSIUM IN CANNED AND FROZEN GREEN PEAS ON THE BASIS OF ELEMENT CONCENTRATION IN FRESH PEAS BEING 100%

Type	Canned		Frozen	
	Sodium (mg/100 g)	Potassium (mg/100 g)	Sodium (mg/100 g)	Potassium (mg/100 g)
Fresh	7.8	79.0	7.8	79.0
Finished product	505.0	210.0	2.6	99.8
Retention (%)	6474.0	265.0	33.0	125.0

In frozen green peas sodium content was significantly lower than in canned green peas. The higher sodium content in canned peas may be due to the brine used in processing or due to blanching. The retentions of sodium and potassium are shown in Table 3. Lee[9] had observed that blanching can alter potassium content.

Frozen Lilva had nearly 21 times lower sodium content than fresh[4] whereas potassium had increased by 2-3 times. The sodium might have been leached out in water during processing. Frozen Lilva can add variety in low sodium diet.

Dehydrated fenugreek leaves showed significantly higher sodium (6 times) and potassium (40 times) contents compared to fresh methi leaves[4]. This was not unexpected as dehydration increases mineral concentration.

For mushrooms, sodium values were higher than those reported by Marsh *et al.*[8] They reported 430 mg of sodium and 196 mg potassium for 100 g of mushrooms.

In frozen papadi sodium content was lower and potassium content was higher than the fresh papadi[4] (Faba vulgaris).

Potato products were available in chip, wafer and sali forms. Potato sali had increased its sodium content by factor of 35-36 and potassium content by 3 times. Dehydrated potato wafers had 123 times higher sodium content as compared to fresh whereas potassium content was higher by 2 times. In home-made preparation, sodium chloride was used as a preservative. Secondly, potato wafers may be kept in brine solution or bath to prevent browning of potatoes[10]. Potassium might have leached out in drained liquid. Commercially prepared wafers had nearly two and a half times lower sodium content as compared to home made wafers. Even potassium content was slightly higher.

Frozen spinach had nearly 2 times higher sodium content compared to fresh spinach while the potassium content in frozen spinach was nearly half of that found in fresh[4].

In tomato juice (canned) Kissan brand had lower sodium and higher potassium content than Dippy's, whereas in case of tomato ketchup, Dippy's brand had lower sodium and higher potassium content than Kissan. In tomato sauce, Maggi brand (hot and sweet) had highest sodium content followed

by Kissan and Dippy's brand. In tomato puree also sodium was 21 times higher, whereas potassium was 3-4 times higher compared to fresh. This could be due to addition of sodium based chemical additives, which act, as a leavening agent or to adjust acidity[8,10].

Chilli sauce had 156 times higher sodium content compared to fresh chilli, whereas potassium lower by 40 mg/100 g. The increase in sodium could be due to salt and spices added during processing[11].

Raw vegetables are generally low in sodium and high in potassium[12]. This trend has been maintained in frozen carrots, frozen corn, frozen green beans, lilva (frozen), papadi-frozen, potato products like wafers, chips and tomato puree. However, in canned foods such as bamboo shoots, sweet corn, peas, mushrooms, potato wafers — dehydrated, tomato juice, tomato ketchup and sauce, the sodium potassium ratio was drastically altered. The sodium levels in these foods were significantly higher than potassium levels. This may be attributed to processing practices, addition of sodium based additives.

In frozen foods, however, processing does not appear to upset the sodium and potassium ratio as in canned vegetables. The frozen vegetables can add variety in the diet of sodium restricted patients.

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BOOK REVIEWS

Research and Development Funding Schemes of Central Government Departments and Agencies: by Ministry of Science and Technology, Dept of Science and Technology, New-Delhi-16, NMIS publication, 1989, Series G. No.7/89, Price: not mentioned.

The booklet details the general information about the funding schemes of the Central Government, which pictures a study increase in the budget for Research & Development (R&D) activities. The expenditure on R&D and related S&T activities increased from 0.23% of GNP in 1958-59 to 1.1% in 1986-87. The estimated expenditure as said in it, for S&T was of the order of Rs.3,300 crores in 1987-88. Major Scientific Departments and Agencies of Central Government are spending about 6% of their total resources on time bound R&D Projects. The booklet lists 18 Government Departments which support various R&D activities. They are Department of Atomic Energy (DAE); Department of Bio-technology (DBT); Department of Coal (DOC); Department of Education (DOEd); Department of Electronics (DOE); Department of Environment (DOEn); Department of non-Conventional Energy (DNCE); Department of Ocean, Development (DOC); Department of Science and Technology (DST); India Meteorological Department (IMD); Department of Space (DOS); Aeronautics Research and Development Board (ARDB); Central Board of Irrigation and Power (CBIP); Council of Scientific and Industrial Research (CSIR); Defence Research and Development Organisation (DRDO); Indian Council of Agricultural Research (ICAR); Indian Council of Medical Research (ICMR) and University Grants Commission (UGC).

The booklet describes the nature of various R&D projects to which the above cited Departments provide funds. It has also provided the specific addresses in various Departments as contact points for submission of projects for funds.

To a limited extent R&D is also supported by the State Councils and State Departments of S&T on problems relevant to their local needs. The addresses of the contact points are given in Annexture II. For the convenience of the users, Government Orders relating to the revision of emoluments of Research Personnel and import of scientific equipment are included in Annexure III and IV respectively. Contact addresses of Regional Sophisticated Instrumentation Centres and National instrument facilities set up by DST for analytical and testing purposes in R&D are given in Annexure V.

The booklet is the fifth edition which is revised and enlarged. I sincerely wish that the hope expressed in the preface regarding this booklet would be of some help to the scientific community in selecting the funding schemes and will be amply fulfilled.

The booklet is worth possessing by all R&D persons intending to submit project proposals for funding. The booklet can be got free of cost from the Director, Information Management Division, New Mehrauli road, New Delhi-110 016.

J.R. RANGASWAMY
C.F.T.R.I., MYSORE.

Crystallization and Polymorphism of Fats and Fatty Acids: Vol.31, Ed. by Nissim Garti and Kiyotaka Sato; Marcel Dekker Inc, 270, Madison Avenue, New York, N.Y. 10016., 1988, pp:450; Price: not mentioned.

The book is the 31st volume in surfactant science series. The contents of the book have been divided into two parts; part I being devoted to fundamentals and part II dealing with applied aspects. Part I has six sections dealing with crystallisation and polymorphic transformation; Thermal behaviour and polymorphism of acylglycerides., Crystal structures of facts and fatty acids., Vibrational spectroscopic aspects of polymorphism and phase transition of fats and fatty acids., Fundamentals of nucleation and crystal growth, and crystallisation of fats and fatty acids. Part II has five sections dealing with effects of surfactants on crystallisation and polymorphic transformation of fats and fatty acids., Fat crystal structure in cream and butter., Solidification and polymorphism in Coca butter and blooming problems., Material design for hard butter and vegetable fats and solidification problems in preparation of fats.

It will be a good and handy reference book on the basic concepts and techniques concerning the physical behaviours related to the crystallisation and phase transformations of polymorphic fats and fatty acids. The readers by going through this book will learn how different polymorphs can be obtained with and characterised by modern techniques and how polymorhic behaviours can be sensitively influenced by varying internal and external factors. The crystallisation processes have been discussed from the view points of thermodynamics and kinetics of nucleation and crystal growth.

The book is worth possessing by all those concerned with Fats and Fatty acids. It also serves as a good reference book in any library.

J.R. RANGASWAMY
C.F.T.R.I., MYSORE.

Industrialization of Indigenous Fermented Foods: (Food Science and Technology Series/33): Edited by Keith H. Steinkraus, Marcel Dekker Inc, 270, Madison Avenue, New York, 10016., 1989, pp:456; Price: $99.75 (U.S. and Canada), $119.50 (All other countries).

The book comprises of nine sections. The first eight sections deal with eight different fermented foods. The book is concentrating on Japanese and African fermented foods. An exception is a section on Tapai processing in Malaysia.

The author of first section on Soy Sauce is Danji Fukushima of Japan. The section deals in great detail about the origin and history of the product. It appears to be a little over elaborate. A lengthy description of the present status of the product in Japan and the situation in China, Southeast Asia and the United States is given by the author. The section has excellently brought out the metamorphosis from traditional preparation of Soy Sauce to the modern way of production with improved enzyme activities and yield. Microorganisms and the enzymes involved in the production are well explained and the author has given an account of safety of the product since the fermentation process is natural type. Attempts to improve the process by whole cell immobilization and strain improvement have also been discussed with a forecast on the future of the product.

The second section is on Miso, a semisolid fermented food made from soybeans, rice or barley, written by Hideo Ebine. The section deals with processing of raw materials and fermentation process, microbial succession during fermentation, spoilage problems, chemical and biochemical changes, problems faced in industrializing the product and future prospects of the product.

The third section is on industrialization of Sake manufacture written by K. Yoshizawa and T. Ishikawa. The section starts with brief introduction and history of the product describing its origin and the organisms involved. Production of Sake, the way it is consumed in the diet, the raw materials used and their quality requirements, step-wise processing, an account of traditional and industrial preparations, and treatment of effluent are the other aspects dealt in this chapter. Although a little repetition of some information is observed, the section is very informative.

Fourth section deals with Tapai processing in Malaysia written by Z. Merican and Y. Quee-Lan. The section starts with the description of this Malaysian delicacy. Earlier works on Tapai, substrates and microflora in Tapai are briefly described. Starter cultures, spoilage microorganisms, traditional and small scale industrial preparations, problems in industrializing the product, chemical/biochemical changes and nutritive value during production and processing are the other aspects dealt in brief in this section.

From fifth to eighth section the book deals with African fermented foods. Fifth section describes in detail about the African beer made of sorghum, some times of millet or maize. This section is written by S. Haggblade and W.H. Holzapfel. The section describes the product characteristics, history, a comparison of ancient and modern home brewing. Industrial production and, biochemistry and microbiology of the product are dealt in great detail. The section is very informative and ends with the future prospects of the product.

Mageu, a traditional sour maize beverage more popular in southern Africa is dealt in the sixth section by W.H. Holzapfel. The section starts with an introduction followed by a brief account of the contribution of the product to the diet, annual production, history, substrates used and Mageu production in olden days. Industrial production is explained in detail. The section ends with chemical and biochemical changes and nutritive value of the product.

The seventh section is on Ogi — another African traditional fermented food made of maize, sorghum and millets. The authors are O.O. Onyekwere, I.A. Akinrele and O.A. Koleoso. The authors have explained in brief, the place of Ogi in the African diet, background of the product, substrates used, home preparations, a comparison of indigenous and modern processing, problems in industrializing the product, fermentation and spoilage microorganisms, chemical/biochemical/nutritive changes, improvement in the nutritive value by soy supplementation and future prospects of the product.

Eighth section is written by O.O. Onyekwere, I.A. Akinrele, O.A. Koleoso and G. Heys on Gari, a cassava root fermented product which is a staple food in southern Nigeria. A brief description of the way of Gari consumption, description of the substrate, ancient way of production, production in cottage/village level, description of the process of Gari manufacturing and the grading of the product are some of the important aspects explained in this section. Based on the practical experience of a private industry, the major problems in the industrialization of the product are explained. Optimum environmental conditions for fermentation, microorganisms of fermentation and spoilage, chemical/biochemical changes and nutritive value and a forecast on the future prospects of Gari in tropical countries are also explained.

Application of biotechnology to industrialize the indigenous fermented foods is explained in the ninth section written by D.R. Glenn and P.L. Rogers. Standardising the product/process, improving the process control systems, strain improvement, scaling up of indigenous fermented foods are discussed in brief in this section. Each section has a comprehensive bibliography of the respective product. The book contains more than 150 photographs/diagrams depicting the ancient/village or cottage level/industrial production of various products and the microorganisms involved in the fermentation. The book can help to visualise the problems in industrializing the indigenous fermented foods and can be a good addition to the libraries.

T.N. BHAVANISHANKAR
GEMINI DISTILLERIES LTD., NANJANGUD

Principles and Practice of Chromatography: by B. Ravindranath, John Wiley & Sons Ltd., Baffins Lane, Chichester, West Sussex P.O.19, 1UD, England; 1989, pp:502; Price: St. 58.50.

Today chromatography is such a vast subject that an attempt to write a single volume book of reasonable size covering the entire range of the subject is certainly a difficult task. The author of this book has done so with success.

The book is in four parts, Part I begins with the introductory chapter. This chapter in addition to the usual historical account, nomenclature and a sweeping overview of chromatography, also gives a very brief account of distillation (helpful in understanding the concept of theoretical plates) and counter current distribution (a non-chromatographic partition separation process). These are welcome additions. Chapter 2 gives the characteristics of the chromatogram and the basics of separation. The treatment though not thorough is adequate.

Part II (gas chromatography) and Part III (liquid chromatography) give comprehensive accounts of these techniques in clear cut presentation. However, a few topics whose inclusion though, can be justified from the point of view of comprehensive coverage could have been left out because of their limited applications. These are: steam as a mobile phase and the sub-techniques (thermal, sedimentation, electrical, flow field and steric) of field flow fractionations.

Part IV (applications) appears to be not as well put together as the first three parts. At 83 pages, it is short for a book of 502 pages, and at places the relative allotment of space is not satisfactory. Thus, element analysis by gas chromatography is given in one page, though this is not one of the established applications of gas chromatography. In contrast to this, amino acids, peptides and proteins an area in which several chromatographic techniques are extensively used is assigned only two pages.

Over all, it is a good book and can be read with profit by beginners as well as by practising chromatographers.

S.N. NIGAM
C.F.T.R.I., MYSORE

Chemical Senses, Vol.1, Receptor Events and Transduction in Taste and Olifaction: Ed by Joseph G. Brand, John H. Teeter, Robert H Cagan and Morley R. Kare, Marcel Dekker Inc, 270, Madison Avenue, New York, N.Y. 10016, 1989, pp:560; Price: US$ 135 (US and Canada), $162 (All other countries).

This volume of chemical senses is based on the international symposium on Receptor Events and Transduction in Taste and Olifaction held at Monell Chemical Senses Centre, 1988. The contents of the book have been presented in 5 parts. Part I — Biochemical events in taste reception and transduction, Part II — Ionic mechanisms of taste cell activities. Part III - Biochemical events in olfactory reception and transduction. Part IVA — Ionic mechanisms of olfactory transduction. Part IVB — Ionic mechanisms of olfactory transduction and Part V — Conclusion.

The papers presented under the above five headings present information on receptor events and transduction in taste and olfaction by the investigators whose laboratories are currently active in the field. The role of phospholipase A_2 in signal transduction., Biochemical events in taste transduction., The receptor events and second-messenger cyclic "AMP production., The ionic processes underlying taste cell activation. Single channel and whole cell recordings; Stimulus mediated process., The initial receptor and second messenger events in olfaction, an olfactory binding protein such as G protein., Stimulus metabolism, transport in an olfactory model and generation of second messengers., The ionic processes involved in primarily olfactory signal transduction are discussed with emphasis on cyclic nucleotide and stimulus-gated channels including activation of dissociated olfactory cells by electrical and chemical stimuli.

The book contains exhaustive cross references in the field, in addition to pictorially represented course of events both in olfaction and taste transduction. The get up and printing irresistibly arrest the attention of the reader. The book provides valuable information for those involved in the field and a good addition to library.

J.R. RANGASWAMY
C.F.T.R.I., MYSORE

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I, Dr. P. Haridas Rao, hereby declare that the particulars given are true to the best of my knowledge and belief.

P. Haridas Rao
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Food Irradiation Symposium,

Bombay

A National Symposium on "Food Irradiation: Perspectives and prospects" was organised by Food & Agriculture Committee, Board of Research in Nuclear Science, Department of Atomic Energy, at Bombay University Department of Chemical Technology Matunga, Bombay from January 3 to 5, 1990. This Symposium was co-sponsored by Bombay University Department of Chemical Technology, Association of Food Scientists & Technologists (India) Bombay Chapter, and Protein Foods & Nutritional Development Association of India. More than 250 delegates including Food Scientists, representatives from industries, consumer organisations and the press, and students were actively participated in the discussions.

The Symposium recommended that:

1. *It is high time that the Government recognises the need to expeditiously grant unconditional clearance for food irradiation technology in conserving various food commodities both for internal consumption and export and import purposes.*

2. *Government Departments concerned must take concerted action to expedite the implementation of irradiation technology for the benefit of consumers.*

3. *BARC has, on the basis of the extensive work carried out so far, now to concentrate on upgrading the process into technology, building up the infrastructure needed and adopting strategies for implementation. With this in view it is necessary to formulate regulations for the control of the process and trade in irradiated foods.*

4. *Government should consider establishing experimental pilot units for onions/potatoes, fish, spices, grains and dry food products for field trials and transfer the technology from laboratory to the market place and industry.*

5. *Government should encourage free and frank flow of information on the peaceful uses of Atomic Energy in general and on food irradiation technology in particular in order to dispel any doubts in the minds of consumers.*

INSTRUCTIONS TO AUTHORS

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2. The typescript should be arranged in the following order: Title (to be typed in capital and small letters for Research Papers and all capitals for Research Notes), Authors' names (all capitals) and Affiliation (capitals and small letters). Also give a short running title not exceeding 10 words as a footnote.

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

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8. Consult the latest issue of the *Journal* for guidance. For "Additional Instructions for Reporting Results of Sensory Analysis" see **issue No. 1** of the Journal.

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