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Research Papers

Research Notes

Comparative Studies on the Packaging of Milk in Glass Bottles and Polyethylene Pouches

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Comparative studies carried out on the packaging of homogenised and unhomogenised cow and buffalo milks in polyethylene pouches or bottles showed that during storage, the fat losses were 3 to 4 times more in pouch packed milk. The organoleptic evaluation also indicated that milk in bottles scored a higher rating as compared to pouch packed milk. Shelf life of milk stored at 5-9°C in glass bottles and polyethylene pouches was 18 and 16 hr while that stored at 30±1°C was 10 and 8 hr respectively.

Layete[1] reviewed the packaging of milk in glass bottles, plastic bottles and in single service containers. Badings[2] investigated the organoleptic quality of pasteurised milk packaged in bottles and polyethylene satchets. Munroe[3] while discussing the future of milk bottle, emphasised that glass bottle has retained its position in United Kingdom and accounted for 83.5 per cent of all liquid milk packaged while plastic bottles and satchets accounted for only 0.8 per cent. Although milk distribution in India has been started by the organised sector in the conventional returnable glass milk bottles, it is being slowly replaced by the single service polyethylene pouch, popularly known as Pre-pac and Fil-pack systems. Though many advantages are claimed for the pouch, certain basic data such as the extent of fat losses due to adhering of fat, shelf life, etc., of milk packed in the pouch as compared to the glass bottle have not been reported. In order to provide information on these aspects which will be of interest both to the consumers and to the dairy plants, work was taken up to make comparative study of the quality of milk packed in these two containers. Unhomogenised and homogenised buffalo and cow milks packed in polyethylene pouches and in glass milk bottles and stored at two selected temperatures were taken up for investigation to broadly represent the large varieties of milk distributed in the country by the dairy plants.

Materials and Methods

Fresh raw buffalo and cow milks received at the Experimental Dairy of the NDRI, Karnal, were used for the studies to represent the high fat (5-6 per cent) milk and medium fat (3-4 per cent) milk. The raw milk for all the trials was pasteurised at 63°C with 30 min holding and cooled using the standard procedures. Homogenisation was done after pasteurisation, at 55-58°C under pressure of 175 kg/sq cm and 35 kg/sq cm for 1st and 2nd stages respectively in a Gaulin Model-2 homogeniser followed by final cooling. The pasteurised milk from each trial was filled manually in cleaned and sanitised glass milk bottles of 500 ml capacity[4] or in transparent polyethylene satchets of 500 ml filling capacity made from 95 micron film with±15 per cent tolerance on a Pre-pac equipment. The bottles were closed with aluminium foil caps and the satchets were heat sealed and tested for leakage. The filled containers from each batch were stored at the two selected temperatures, 5-9°C (refrigerator) and 30°±1°C. Milk samples stored at 5-9°C were analysed initially and after every six hours, while those stored at 30±1°C were tested initially and once every four hours till spoilage occurred. The contents of each container were emptied into a presanitised glass beaker, thoroughly mixed and samples analysed in duplicate. Organoleptic evaluation was carried out by a selected panel of five judges as detailed in ISI[5]. The fat was tested following ISI[6] method. As a screening test, fat was also determined by Rose Gottlieb method (Mojonnier modification) as given in Laboratory Manual[7].

Results and Discussions

Acidity: From Table 1, it can be seen that at the storage temperature of 5-9°C, irrespective of the source

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of milk (cow or buffalo), processing (homogenised or un-homogenised) and type of package (bottle or pouch) the acidity of milk increased with time and there was no appreciable difference between the milk packaged in the pouch and bottle. In general, different milk samples had a shelf life of 16-18 hr, with milk packed in bottle having a slightly longer shelf life than that packed in pouch.

TABLE 1. CHANGES IN TOTAL ACIDITY AND FAT LOSSES DUE TO CONTAINER STICKAGE DURING STORAGE (AVERAGE VALUES)

Period of storage (hr)	Unhomogenised milk				Homogenised milk			
	Bottle		Pouch		Bottle		Pouch	
	A	B	A	B	A	B	A	B
Buffalo milk 5-9°C								
0	0.14	—	0.14	—	0.14	—	0.14	—
6	0.16	0.05	0.16	0.22	0.16	0.06	0.16	0.28
12	0.17	0.06	0.17	0.24	0.17	0.07	0.17	0.29
18	0.18	0.06	0.18	0.25	0.19	0.08	0.19	0.31
24	0.19	0.06	0.19	0.26	0.20	0.07	0.20	0.32
Buffalo milk 30±1°C								
0	0.14	—	0.14	—	0.14	—	0.14	—
4	0.16	0.07	0.17	0.25	0.16	0.06	0.17	0.26
8	0.18	0.07	0.18	0.26	0.18	0.06	0.18	0.27
12	0.19	0.07	0.20	0.27	0.19	0.06	0.20	0.26
16	0.21	0.07	0.21	0.25	0.21	0.06	0.21	0.30
Cow milk 5-9°C								
0	0.14	—	0.14	—	0.14	—	0.14	—
6	0.16	0.05	0.16	0.32	0.16	0.07	0.16	0.22
12	0.17	0.05	0.17	0.32	0.17	0.07	0.17	0.23
18	0.18	0.06	0.19	0.33	0.18	0.08	0.18	0.22
24	0.19	0.06	0.22	0.33	0.21	0.08	0.21	0.23
Cow milk 30±1°C								
0	0.14	—	0.14	—	0.14	—	0.14	—
4	0.16	0.07	0.17	0.28	0.16	0.06	0.16	0.25
8	0.17	0.07	0.18	0.28	0.17	0.06	0.18	0.25
12	0.18	0.07	0.19	0.28	0.18	0.06	0.19	0.27
16	0.20	0.07	0.20	0.28	0.19	0.06	0.21	0.30

A: %Total acidity

B: % Fat losses due to container stickage

At 30±1°C (Table 1) storage, there was a tendency for higher acidity development in pouch packed milk than in bottled milk. At this temperature, the acidity developed at a faster rate in all the samples. Shelf life of the different samples at the storage temperature of 30±1°C can be taken as 7 to 12 hr with milk packed in bottles remaining acceptable for slightly longer periods than pouch packed milk.

Fat losses: At the storage temperature of 5-9°C the fat losses (Table 1) in all the samples of milk increased with time irrespective of the source of milk, processing and container used and were higher by 3 to 4 times in pouch packed milk than in bottled milk. The losses were slightly high in homogenised as compared to unhomogenised milk. The higher percentage loss in homogenised milk may be due to the uniform distribution of fat in milk, the residual milk sticking to the container must have taken away a higher amount of fat with it as compared to unhomogenised milk. The fat losses in different samples of milk packed in pouches and stored at 5-9°C for 24 hr varied from 0.22 to 0.33 per cent, whereas it was 0.02 to 0.06 per cent in bottles.

At the higher storage temperature of 30±1°C (Table 1) as in the case at 5-9°C, the fat losses in milk increased with time and were higher in pouch than in bottle. However, at this temperature, unhomogenised milk registered a greater percentage loss than the homogenised. The fat losses varied between 0.06 and 0.08 per cent in bottled milk, while they were from 0.26 to 0.28 per cent in pouch packed milk.

Organoleptic evaluation: The scores for organoleptic evaluation (Table 2) show that at 5-9°C, milk in bottle scored a higher rating as compared to the pouch except

TABLE 2. ORGANOLEPTIC EVALUATION OF COW AND BUFFALO MILK STORED AT 5-9°C OR 30±1°C

Type of Package	24 hr at 5-9°C				12 hr at 30±1°C			
	Unhomogenised		Homogenised		Unhomogenised		Homogenised	
	Score	Grade	Score	Grade	Score	Grade	Score	Grade
Buffalo milk								
Bottle	79.0	C	70.3	C	66.1	C	53.2	D
Pouch	67.8	C	66.0	C	55.5	D	48.2	D
Cow milk								
Bottle	80.4	B	79.8	C	62.9	C	52.7	D
Pouch	82.0	B	75.2	C	53.8	D	44.4	D

Fat churning was not observed in any of the samples.

the unhomogenised milk where the pouch packed milk scored marginally higher (by 1.6) points. In all other cases, the bottled milk scored higher by 4.3 to 11 points. No churning of fat was observed in any of the samples. All samples remained acceptable organoleptically at the end of 24 hr at 5-9°C storage temperature. Homogenised milk was rated lower than the unhomogenised milk although this lower score for homogenised milk can be attributed to the post contamination; however, the acidity values do not support this as acidity values of homogenised and unhomogenised milk were almost same at this temperature for the differently packed milks. Trout[8] reported that in a survey conducted, nearly 16 per cent of the respondents reported various off flavours in homogenised milk.

At the higher temperature of 30 ± 1°C storage, the trend was similar to that of 5-9°C except that the milk lost score more rapidly. Only unhomogenised buffalo or cow milk packed in bottles was given a score rated as acceptable at the end of 12 hr.

References

1. Layete, M. J., Packaging of liquid milk. *Via Lactea*, 1970, **2**, 23, (cited from *Dairy Sci. Abstr.*, 1971, **33**, 4971).
2. Badings, H.T., Package taint of pasteurised milk of varying fat content. *Off. Org. K. ned. Zuivelbond*, 1971, **63**, 342; (cited from *Dairy Sci. Abstr.*, 1971, **33**, 3851).
3. Munroe, A. F., The future of milk bottle. *Dairy Ind. Int.*, 1975, **40**, 251.
4. *Specification for Glass Milk Bottles*, IS:1392-1967, Indian Standards Institution, New Delhi.
5. *Methods for Sensory Evaluation of Milk*, IS:7768-1975, Indian Standards Institution, New Delhi.
6. *Detemrination of Fat by Gerber Method*, IS:1224-1977 Indian Standards Institution, New Delhi.
7. *Laboratory Manual, Methods of Analysis of Milk and Its Products.* Milk Industry Foundations, Washington, D. C., 1952, 3rd Edn.
8. Trout, G. M., Official acceptance of homogenised milk in the United States. *J. Dairy Sci.*, 1963, **46**, 342.

Heat Penetration Studies in Palm Wine Preservation

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Heat penetration characteristics of palm wine were examined with the intention of estimating heat loads on micro-organisms in the wine. Heat loads equivalent to 20, 3.1, 0.4 and 0.05 min of heating at 65.5, 70, 75 and 80°C respectively were found to be effective in ensuring a reasonable degree of safe keeping for a minimum period of two weeks under ordinary tropical conditions.

Palm wine, an alcoholic beverage obtained by natural fermentation of sap from the oil palm, (*Elaeis guinensis*) and the Raphia palm (*Raphia hookeri*) is extensively cherished and drunk in Nigeria. The unfermented sap contains 3-13 per cent sucrose, 0.95-3 per cent reducing sugar and about 0.36 per cent protein[1]. In addition, palm sap contains 10-19mg/100ml of vitamin C as well as about 160 μg/ml of vitamin B_{12}. Due to lack of aseptic precautions in the present mode of tapping, palm sap is easily contaminated as it drips from the incission on the palm tree to the collecting vessel. The contaminants, largely microorganisms from the air and the tapping equipment ferment the sap to produce palm wine containing varying levels of alcohol, acetic acid and other products.

Storage of palm wine under tropical ambient conditions results in souring of the product within 24 hr after collection from the palm tree. The acidity may rise to 0.68 per cent. At this level of acidity, palm wine is not acceptable to most consumers. The spoilage of palm wine is widely attributed to microbial activity. The dominant organisms responsible for souring include: *Saccharomyces cereviseae*, *Leuconostoc mesenteroides*, *Lactobacillus plantarum* and species from the genera *Acetobacter*, *Pediococcus*, *Corynebacterium*, and *Pichia*[1,2]. Generally, these organisms have low decimal

reduction values (D-values) under the conditions of pH and acidity prevalent in the wine[3].

Since the early studies on palm wine preservation by Levi and Oruche[4] and Chinnarasa[5], pasteurization has been found as an effective method. Apparently, not much has been mentioned on the temperature-holding time relationships for effective palm wine sterilisation. In this study, an attempt is made at examining the heat penetration characteristic of the palm wine and hence the lethality of heat loads on microorganisms in the wine.

Materials and Methods

Heat penetration studies: A 500 ml (working volume) cylindrical bottle was used for the determination of the slowest heating point according to the method described by Stumbo[6]. A thermometer (0-100°C) with a section of its bore firmly bound in an insulating cork was mounted through the bottle cork into the bottle. Five hundred millilitres of palm wine purchased from a local tapper (who previously had been instructed not to adulterate the sap with water or any additive) was poured into the bottle and the thermometer kept in place. The bottle was then gently lowered into a still water bath maintained at 75±1°C. The temperature of the palm wine was read off at intervals from the thermometer whose bulb was at a pre-set axial height inside the bottle. At the end of the heating period (when content of the bottle attained 70°C) the bottle was quickly transferred into a cold bath at 27±2°C and temperature monitoring continued until the content of the bottle attained the temperature of the cold bath (27°C). Several 500 ml aliquots of palm wine were treated as described above except that the axial height of the thermometer in the bottle was altered for each run.

Stability studies: In order to establish the effectiveness of different heat loads (F-values for the heating and cooling cycles) on the stability of palm wine, 500 ml of palm wine in the experimental bottles with their corks loosely fitted were heated without agitation in a water bath at 75°C for 0, 10, 15, 16, 17 and 18 min, respectively. The heating was followed by cooling of each bottle in a water bath at 28.5°C after the bottle had been tightly corked. The total heat load (F-values, at 65.6°C calculated for heating and cooling cycles) corresponding to 0, 10, 15, 16, 17 and 18 min heating period were 0, 0.44, 7.75, 12.64, 19.76 and 24.26, respectively.

Cooled samples given the above heat treatments were left in a dark cupboard at ambient temperature (26°C) for two weeks; the dark storage minimises changes in the drink[7]. Stored samples were then analyzed for biomass concentration, total sugar, pH and titratable acidity. For biomass concentration, the spectrophotometric method described by Pirt[8] was employed while the Lane and Eynon method[9] was used for total sugar determination on aliquots of stored palm wine after inversion with 6N HCl. Acidity of the samples were determined by titration with 0.1N NaOH while Fisher Accumet Model 230A pH meter was used for pH determination.

Nomenclature:

D = Time in min required to reduce the microbial count by a ten-fold at a particular temperature.

F = The equivalent, in terms of a holding time at a specified temperature, of the lethal effect of a heat load on organisms of specified z-value.

f = Time in min required for the temperature of the palm wine to increase or decrease by a ten-fold.

j = Lag factor for heating or cooling.

N = Cell count of organisms in the palm wine.

T = Temperature of the palm wine at time, t.

T^* = Temperature of heating or cooling bath.

t = time of heating and cooling.

z = increase in temperature required to effect a ten-fold decrease in D-value.

Subscripts: o = initial

r = referenced to 65.5°C.

Results and Discussion

The heat penetration parameters j and f expressed in the equation below were obtained from the temperature-time profiles of the palm wine when the thermometer bulb was placed in the different position in the experimental bottles.

$$\text{Log}\ \frac{j(T - T^*)}{(To - T^*)} = \frac{t}{f} \qquad (1)$$

From plots of log $(T - T^*)$ as a function of heating or cooling time in min typical of Fig 1, values of j and f for different thermometer probe locations were obtained as described by Lenninger and Beverloo[3]. Table 1 shows the values of j and f obtained from different probe positions along the central vertical axis during the heating and cooling phases.

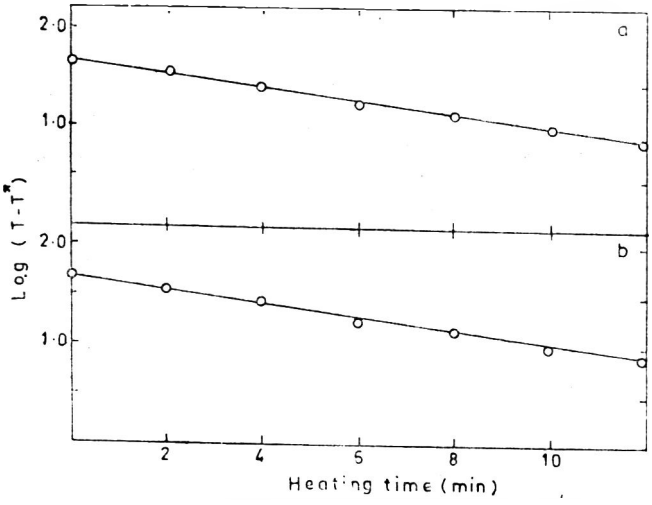

Fig 1. Semi log plots for determination of j and f values.

TABLE 1. HEAT PENETRATION PARAMETERS (J AND F VALUES) AT DIFFERENT PROBE POSITIONS

Probe position as fraction of axial height from bottle bottom	Parameter val. for heating phase		Parameter val. for cooling phase	
	j-value	f-value (min)	j-value	f-value (min)
0.6	1.0	14.5	1.0	21.7
0.5	1.0	15.1	1.0	15.4
0.4	1.0	18.0	1.0	15.3
0.3	1.0	18.4	1.0	15.4
0.2	1.0	15.4	1.0	11.5

Fig 2 plotted from these data suggests that the slowest heating point or the point with the largest f-value for the heating phase can be found between 0.3 and 0.4 of the axial height (measured from the bottom) in the liquid column. This point has an estimated f-value of 18.4 min for the heating and a corresponding value of 15.4 min for the cooling phase.

Lethality estimation: Palm wine which has a pH of less than 4.5 can be classified as an acid beverage. This pH value precludes the growth and toxin producing ability of *Cl. botulinum*[10]. Target organisms for estimating the heat load requirement in palm wine are generally non-sporulating mesophiles[1,2] characterized by short D-values (ranging from 0.5 to 1.0 min at 65.5°C) and a z-value of 4.4-4.6°C[3,5]. The choice of a heat load in terms of a temperature-time relationship was limited to temperatures less than 78°C, i.e. the lower boiling point of ethanol-water mixture at atmospheric pressure.

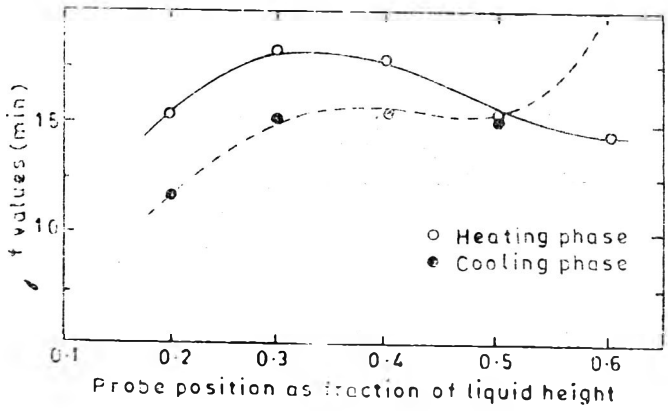

Fig 2. Variation of f-value with axial positions.

The estimation of lethality was based on the microbial death kinetic equation according to Lenninger and Beverloo[3]. The method of Steele and Board[11] was used to obtain F-values for different temperature-time heat loads given to the wine samples using the criteria given in Table 2. Table 3 shows the effect of heat loads on the shelf-life of palm wine samples. The results presented are average values obtained from six batches of palm wine processed in triplicate. The observations indicate that samples given heat loads less than 19.8 min of heating at 65.5°C showed considerable loss in sugar and appreciable increases in acidity and biomass. The samples given heat treatments in excess of about 19.8 min of heating at 65.5°C exhibited little or no changes in the variables measured. Data in Table 3 suggest that a holding time of about 20 min at 65.5°C should adequately increase or stabilize the shelf-life of bottled palm wine. For holding at higher temperatures, this heat load will approximate 3, 1, 0.4 and 0.05 min at 70, 75 and 80°C, respectively. In terms of reduc-

TABLE 2. COMPUTATIONAL CRITERIA FOR F-VALUE ESTIMATION

Temp. of heating bath (Th*)	75.0°C
Temp. of cooling bath (Tc*)	28.5°C
Reference Temp. (Tr)	65.5°C
Initial temp. of palm wine (To)	30.0°C
Heating lag factor (jh)	1.0
Cooling lag factor (jc)	1.0
f-value for heating phase (min)	18.4
f-value for cooling phase (min)	15.4
z-value of organisms	5.6°C
D-value of organisms (min)	1.0

TABLE 3. EFFECT OF HEAT LOADS ON SHELF LIFE OF PALM WINE

F-values at 65.5°C			Observation just after pasteurization				Observation two weeks after pasteurization			
Heating phase	Cooling phase	Entire cycle	Total sugar (dextrose g/100ml)	pH	Acidity acetic acid %	Biomass (g/100ml)	Total sugar (dextrose g/100ml)	pH	Acidity acetic acid %	Biomass (g/100ml)
0	0	0	6.37	3.6	0.23	1.86	0.23	3.2	1.46	3.0
10	0.32	0.44	5.76	3.6	0.21	2.3	0.78	3.5	0.33	2.8
15	6.46	7.75	6.00	3.6	0.23	3.05	1.10	3.4	0.27	3.68
16	10.53	12.64	6.21	3.7	0.23	2.03	3.54	3.4	0.38	2.57
17	17.02	19.76	6.00	3.6	0.25	2.07	5.80	3.7	0.24	2.13
18	21.32	24.26	6.36	3.6	0.23	1.89	6.15	3.7	0.22	1.89

tion ratio, the process implies a 20 logarithmic cycle reduction of the initial microbial load. This should guarantee a high safety probability for the processed bottles.

References

1. Okafor, N., Microbiology and biochemistry of oil-palm wine. *Adv. Appl. Microbiol.*, 1978, **24**, 237..
2. Basir, O., Some Nigerian wines. *African J. Biol. Appl. Chem.*, 1968, **10**, 41.
3. Lenninger, H. A. and Beverloo W. A., *Food Process Engineering*. D. Reidel Pub. Co., Dordrecht, 1975.
4. Levi, S. S. and Oruche C. B., The preservation and bottling of palm-wine. Inst. of Appl. Tech. Res., Lagos Nigeria Res. Rep. 1957, No. **1**.
5. Chinnarasa, E., The preservation and bottling of palm wine. Fed. Inst. of Ind. Res. (Lagos, Nigeria) Rep., 1968, No. **38**.
6. Stumbo, C. R., *Thermobacteriology in Food Processing*, Academic Press, New York, 1973.
7. Awan, J. A., Falaye O. A. and Okaka, J. C., Effect of bottle colour and storage conditions on the quality of soursop (*Annona muricata*) drink. *J. Fd Sci. Technol.*, 1980, **17**, 251.
8. Pirt, S. J., *Principles of Microbe and Cell Cultivation*. Blackwell Scientific Pub. Co., Oxford, 1975
9. Pearson, D., *The Chemical Analysis of Foods*. Churchill Livingstone, Edinburgh, 1976.
10. Roberts, T. A. and Gibson M., The relevance of *Cl. botulinum* in public health and food processing. *J. Fd Technol.*, 1979, **14** 211.
11. Steele, R. J. and Board P. W., Thermal process calculations using sterilizing ratios. *J. Fd Technol.*, 1979, **14**, 227.

Studies on Flour Particle Size and Endosperm Texture in Sorghum

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Flour particle size distribution of two sorghum cultivars was studied using three grinding and sieving methods. Sieve shaking machines provided a spurious picture of flour particle size distribution, due to agglomeration of fine particles on the sieves. Significant differences in flour particle size were observed between 15 cultivars, using hand sifting procedures. Endosperm texture was evaluated by three methods: estimation of breaking strength, microscopic observation of vitreousness and pearling grains with a seed scarifier. The parameters, % corneous endosperm, % pearling loss and % brokens were higly correlated between themselves and with % flour $<75\,\mu$m. The coefficient of variation was the lowest for the parameter % flour $<75\,\mu$m, which gave a reliable indication of grain hardness.

Sorghum (*Sorghum bicolor* (L.) Moench) is the staple food of millions of people in India and Africa. The ease of preparation and acceptance of sorghum food products is dependent on the texture of the grain[1]. Studies made on the milling quality of sorghum using a Strong Scott barley pearler showed that endosperm texture was related to milling quality and grain hardness[2]. Kirleis and Crosby[3] found that pearling and particle size indices offer sensitive and rapid measures of sorghum grain hardness. However, information on flour particle size in sorghum is limited and contradictory. Waniska[4] found significant differences in flour particle size between cultivars and noted that hard grains yielded flour with a fine particle size. Similar results were obtained by Murty *et al.*[5] using Waniska's methods of particle size analysis. However, Kirleis and Crosby[3] observed that hard grains produced a coarser flour than soft grains. Alicia de Francisco *et al.*[6] evaluated three sorghum cultivars and found that the flour particle size of Dwarf White was small, although it had a relatively hard endosperm. A critical study of the methods followed by these workers showed that the grinding and sieving techniques used were different. Therefore, a comparative study of flour particle size distribution in sorghum cultivars was undertaken by using three grinding and seiving methods. Attempts were also made to evaluate endosperm texture with a seed scarifier and to relate the texture to flour particle size.

Materials and Methods

Bulk samples of grain harvested during March 1982 from white pericarp sorghum cultivars, grown at the ICRISAT Center (Patancheru) in comparable field plots, were chosen for the present studies. All the samples were dried to a uniform moisture level (10±1 per cent) and stored at ambient temperature for further analyses. In one experiment, bulk samples of two cultivars, 'M 35-1' and 'SPV 386' were ground in three different mills: (*a*) a domestic carborundum grinder (Milcent D-2) with vertically placed stones; (*b*) a village flour mill or *chakki* equipped with horizontally placed stones; and (*c*) a Udy Cyclone mill with a 0.4 mm screen. The stone grinders were operated at a constant speed and setting. During each run the middle portion of the flour output was collected. The flour samples were stored at 8°C until the sieve analyses were carried out.

Five lots of flour were taken from each treatment and were sifted by five sieving methods: (*i*) by hand until no more flour passed through, (*ii*) sieving with a RoTap Sieve Shaker (Tyler) for 30 min. (*iii*) sieving with RoTap Sieve Shaker for 60 min, (*iv*) sieving with Portable Sieve Shaker (Tyler Rx-24) for 30 min, and (*v*) sieving with Portable Sieve Shaker for 60 min. Flour samples (25 g) taken for sieve analyses were kept in an oven at 70°C for two hours and then cooled in a desiccator. The samples were sieved using a series of US standard sieves. The sieve shakers were loaded with sieves of pore sizes

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250, 180, 150, 125, 106 and 75 μm in that order from top to bottom and the throughs of 75 μm were collected in a pan. Hand sifting was done using the same set of sieves. Flour was shaken and carefully rubbed with a fine hair brush on the sieve mesh. Flour samples of two cultivars, 'E 35-1' and '296B' were ground in the domestic grinder and were observed for their particle size distribution both by hand sifting and by using an Alpine Air-jet Sifter (Augsberg).

In another experiment, grain samples from 15 cultivars (Table 3) were ground in the domestic carborundum grinder, and particle size analysis of the resulting flour was carried out only by the hand sieving method. The experiment was repeated over three consecutive weeks and during each week three independent observations on particle size were made for each cultivar. Grain samples were evaluated for texture by using there parameters: breaking strength, per cent corneous endosperm and pearling losses. Breaking strength (kg) of the grain was observed for three individual grains in each week by using a Kiya rice hardness tester[5]. During each week longitudinal sections of three randomly chosen grains from each cultivar were observed under a light microscope. The vitreous and floury portions of the endosperm were traced on to graph paper using a Camera lucida and the proportion of vitreous area was expressed as per cent corneous endosperm.

Pearling quality of one sample from 13 cultivars was evaluated each week by using a Forsberg seed scarifier (Forsberg's Inc; Minnesota, USA) generally used to scarify legume seeds to hasten their germination. The scarifier consists of a drum (13 $\times$ 15 cm) in which four rotating blades (2.5 $\times$ 11.5 cm) are fixed at the bottom and are connected to a shaft powered by an electric motor (HP 1/3, RPM 1725). A cylindrical lid (12.5 $\times$ 15.4 cm) fits into the drum and is provided with a special sand paper on the walls. A 20 g sample was placed in the lid and scarification was carried out for 45 sec. The resulting sample was carefully recovered and sifted through an 850 μm screen to remove the bran. The throughs were expressed as pearling loss on per cent basis. The pearled product or overs were sifted on a 1700 μm screen and the throughs were expressed as brokens on per cent basis.

Results and Discussion

Flour particle size distribution data obtained using the five sieving procedures are presented in Table 1. When the shaking machines were used, the percentage of flour that passed through the 75 μm sieve was negligible while the corresponding amount for hand sieving was several times higher. For the convenience of tabular presentation, percentage of flour of $<$125 and $<$75 μm only are given for the sieve shakers. More than 80 per cent of the flour was held over the 180 μm screen when either of the sieve shakers were used. Agglomeration of fine particles on the sieve apparently blocked the passage of flour when the sieves were shaken. Agglomeration of flour may not pose serious problems if coarse meal or grits were to be studied by using sieve shakers. The finer the flour under study the more spurious are the values given by the shakers. When bouncers like rubber balls and plastic bangles were used on the sieves, improvement in the flour passage was small or negligible. Thus, flour particle size distribution

TABLE 1. FLOUR PARTICLE SIZE (μM) DISTRIBUTION (PER CENT) OF TWO SORGHUM CULTIVARS OBTAINED BY USING DIFFERENT GRINDING AND SIEVING METHODS*

	Hand sifting							RoTap sieve shaker				Portable sieve shaker	
								30 min		60 min		30 min	60 min
	>250	>180	>150	>125	>106	>75	<75	<125	<75	<125	<75	<125	<125
M_1C_1	0.5	2.4	1.8	4.2	5.7	12.5	73.5	2.0	0.1	4.5	0.4	0.0	0.0
M_1C_2	1.9	4.2	4.5	6.6	8.7	15.2	59.2	0.8	0.0	2.4	0.1	0.0	0.0
M_2C_1	2.9	5.9	5.7	8.9	8.8	15.7	52.2	1.7	0.1	1.8	0.1	0.0	0.0
M_2C_2	6.3	8.7	6.1	10.4	8.3	13.6	46.6	1.6	0.1	2.9	0.3	0.0	0.0
M_3C_1	9.6	9.1	5.1	5.9	6.1	11.9	52.2	0.9	0.0	5.1	0.1	0.0	0.0
M_3C_2	9.8	9.4	5.5	7.3	5.2	13.2	49.8	7.9	1.4	6.0	1.4	0.0	0.1
CD 5%	1.0	1.0	2.8	1.1	1.0	0.9	3.4	1.6	1.8	2.4	0.5	0.1	0.1
CV%	8.0	6.1	23.0	6.1	5.8	2.8	2.3	47.0	2.8	68.0	5.5	0.0	0.0

*Average of two observations.
M_1 = Domestic grinder, M_2 = Village flour mill, M_3 = Udy-Cyclotec Mill.
C_1 = Cultivar 'M 35-1', C_2 = Cultivar 'SPV 386'.

TABLE 2. FLOUR PARTICLE SIZE DISTRIBUTION OF TWO SORGHUM CULTIVARS ANALYSED BY TWO SIEVING METHODS

Cultivars	Sieving method	% flour accumulated through sieve of indicated size (μm)								
		250	180	150	125	106	100	75	71	63
E 35-1	Hand sieving	95.6	86.8	78.1	65.7	55.6	—	40.5	—	—
	Alpine air-jet sifter	97.0	84.5	75.0	62.0	—	49.5	—	33.5	26.0
296B	Hand sieving	98.0	93.9	90.1	83.0	75.8	—	61.0	—	—
%CV	Alpine air-jet sifter	98.0	94.5	90.5	81.0	—	71.0	—	54.0	41.0

obtained on sieve shakers needs to be cautiously interpreted particularly when the flour contains intermediate or fine particles. Data obtained by hand sieving showed that per cent flour of $<75\mu$m produced in the domestic grinder was higher compared to that obtained in the village flour mill and Udy mill (Table 1). Both hand sieving and the Alpine Laboratory Air-jet Sifter yielded comparable particle size values indicating that hand sifting with the help of a standard sieve and a fine hair brush could be used reliably in the absence of sophisticated sieving devices (Table 2).

Observations made in the second experiment on flour particle size, endosperm texture and pearling behaviour of the 15 cultivars are presented in Table 3. The flour particle size distribution curves are shown in Fig 1. On an average, 63 per cent of the flour produced in the domestic mill was composed of particles $<75\mu$m and 15 per cent of particles larger than 125 μm. The coefficient of variation for per cent flour <75 μm was only 2.8 per cent and was the most reliable parameter studied. The percentage of flour that passed through the 75μm screen ranged from 46 to 82 and was highly correlated with percentage of flour $>125\mu$m ($r=0.96$). Flour from the floury endosperm types such as 'IS 1401' and 'P-721' had the greatest proportion of particles $<75\mu$m. The vitreous grain types such as '2219B' and 'E 35-1' produced flour with the lowest proportion of particles $<75\mu$m size. The proportion of corneous endosperm

TABLE 3. ENDOSPERM TEXTURE AND MILLING PROPERTIES OF 15 SORGHUM CULTIVARS*

Cultivar	100 grain wt. (g)	% corneous endosperm	Breaking strength (kg)	% pearling loss	% brokens	% flour >125 μm	% flour <75 μm
M 35-1	3.92	32.5	5.7	28.0	9.8	9.13	74.4
2077B	2.30	49.2	4.1	28.1	21.6	8.87	72.4
IS 1401	3.00	4.0	4.3	36.0	37.8	7.48	80.9
IS 5604	2.31	48.1	5.0	17.4	3.5	24.75	49.2
CSH 6	2.82	50.1	6.1	13.9	2.0	20.64	48.0
E 35-1	3.50	68.4	11.0	15.6	0.9	19.50	48.8
SPV 351	2.50	61.6	8.1	12.9	0.8	22.17	46.2
SPV 422	3.27	57.8	7.9	27.3	3.3	11.04	67.2
CSH 8	4.10	49.3	5.8	25.3	25.4	11.47	65.0
296B	3.07	48.1	6.3	22.2	16.0	12.86	65.9
2219B	2.29	80.2	6.5	14.7	2.1	23.17	45.6
P721	2.15	5.8	5.2	—	—	10.43	78.4
S 29	2.43	75.1	7.2	19.6	4.4	17.47	55.8
IS 9985	5.46	45.1	6.1	—	—	6.26	81.5
SPV 393	2.72	57.2	6.8	15.5	6.3	14.47	61.7
Mean	3.05	48.8	6.4	21.4	10.8	14.62	62.7
SE	0.02	1.17	0.13	0.76	0.8	0.32	0.47
%CV	2.1	27.8	7.9	6.1	12.5	8.6	2.8

*Hundred grain weight, breaking strength, % corneous endosperm, % flour $>125\mu$m and % flour $<75\mu$m were averaged over 9 observations. Per cent pearling loss and % brokens were averaged over 3 observations.

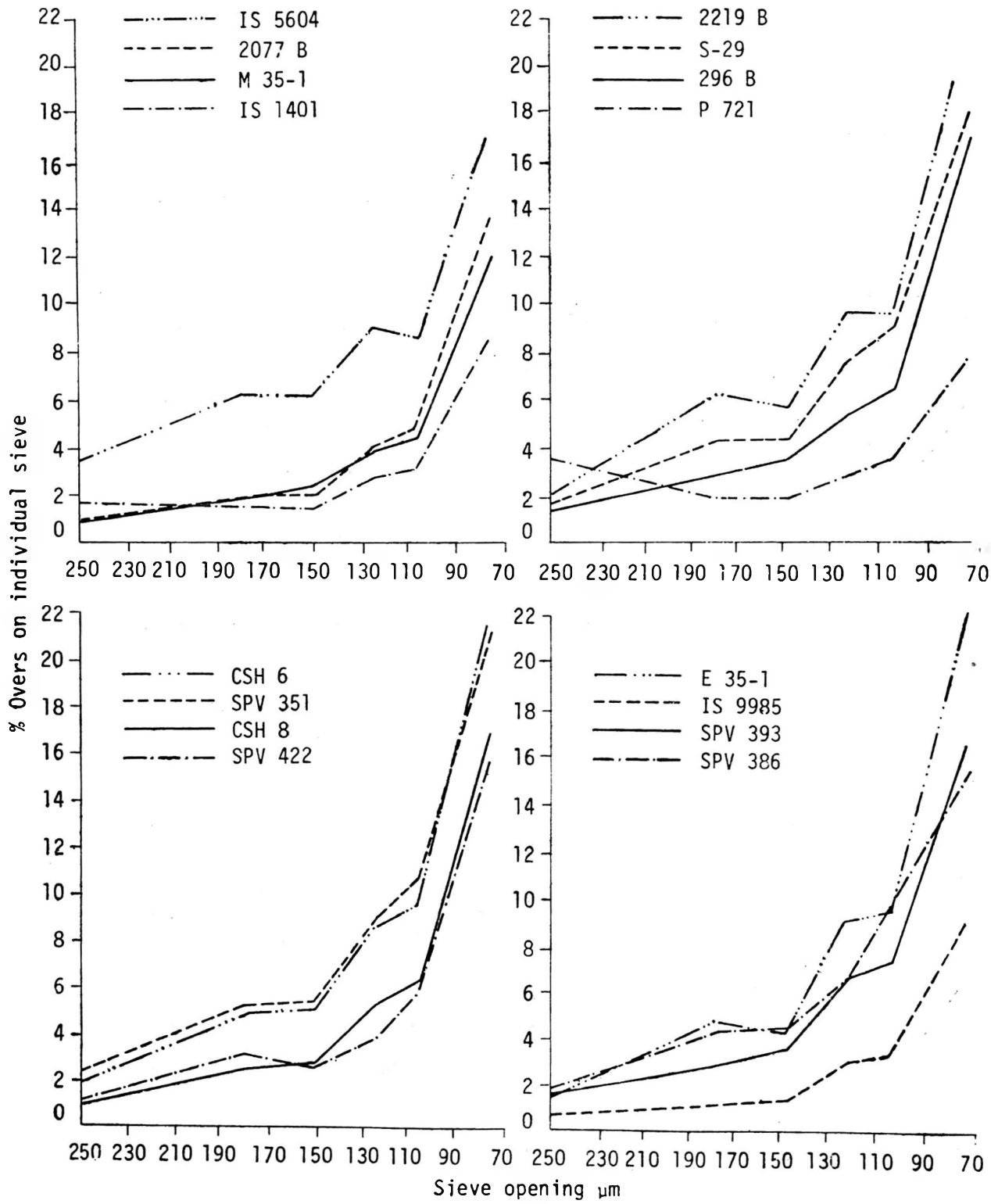

Fig. 1. Flour particle size distribution in sorghum.

varied from 49 to 80 per cent and was highly corrleated with percentage of flour $<75\mu m$ ($r = -0.73$, significant at 1 per cent probability). Kirleis and Crosby[3] also observed a strong correlation between endosperm vitreousness and particle size.

Breaking strength of the grains as determined by the

Kiya rice hardness tester varied from 4.1 to 8.1 kg with the exception of the cultivar, 'E 35-1' which has turtle shaped grains with a flat surface on one side. Kiya rice hardness tester observations on sorghum are affected by grain shape and could be misleading[1]. The correlation coefficients between breaking strength and corneousness, pearling losses and flour particle size were relatively low and statistically insignificant.

The amount of bran lost during scarification or per cent pearling loss for the 13 cultivars ranged from 13 to 36 and was positively correlated with per cent brokens ($r=0.82$) and per cent flour $<75\mu m$ ($r=0.94$). Per cent pearling loss was also negatively correlated with per cent corneous endosperm ($r=0.74$) showing that estimates of pearling losses could be used to evaluate the hardness of the grain. Shepherd[7] and Oomah *et al.*[8] described novel laboratory pearling devices that could be used to evaluate dehulling quality and hardness of sorghum grains. The scarification equipment used here provided adequate information on the hardness of the sorghum samples studied and the coefficient of variation (6 per cent) was much lower than that for the microscopic evaluation of corneousness. However, pearling behaviour is also affected by grain size and shape[3]. The mechanism of scarification involves whirling and abrasion of the grain against a sand-paper present on the inner surface of the scarifying drum. Further investigations are necessary to determine how accurately the pearling quality results obtained with the scarifier could predict the behaviour of sorghum samples in commercial pearlers where different techniques may be used[9,10].

These studies demonstrate that because of the agglomeration problems posed by fine flour particles, appropriate sifting techniques should be used to evaluate particle size. Endosperm texture, pearling quality and flour particle size measurements are highly associated and could be used to evaluate grain hardness in sorghum. Flour particle size analysis was the most reliable parameter to distinguish sorghum samples. The relative merit of the three different mills in the evaluation of grain texture and flour particle size could not be judged from the present data, as only two cultivars were compared. Apparently, the Udy mill is convenient because only small grain samples are required.

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References

1. Rooney, L. W. and Murty, D. S., Evaluation of sorghum food quality. *Sorghum in the Eighties: Proceedings of the International Symposium on Sorghum*, 2–7, Nov, 1981, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, A. P., India, 1982, 571.
2. Maxson, E. D., Fryar, W. D., Rooney, L. W. and Krishna Prasad, M. N., Milling properties of sorghum grain with different proportions of corneous to floury enodsperm. *Cereal Chem.*, 1971, **48**, 478.
3. Kirleis, A.W. and Crosby, K.D., Sorghum hardness: comparison of methods for its evaluation. *Proceedings of International Symposium on Sorghum Grain Quality*, 28-31 Oct., 1981, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, A. P., India, 1982, 231.
4. Waniska, R.D., *Methods to Assess Quality of Boiled Sorghum, Gruel and Chapaties from Sorghum with different kernel Characters.* 1976, M. S. Thesis, Texas A & M University, College Station, Texas, USA.
5. Murty, D. S., Patil, H. D. and House, L. R., Sorghum roti. II. Genotypic and environmental variation for roti quality parameters. *Proceedings of the International Symposium on Sorghum Grain Quality*, 28-31, Oct. 1981, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, A. P., India, 1982, 79.
6. De Franscisco, Alicia, Varriano-Marston, E. and Hoseney, R.C., Hardness of pearl millet and sorghum. *Cereal Chem.*, 1982, **59**, 2.
7. Shepherd, A. D., Laboratory abrasive decorating mill for small grains. *Cereal Chem.*, 1979, **56**, 517.
8. Oomah, B. D., Reichert, R. D. and Youngs, C. G., A novel multi-sample tangential abrasive dehulling device (TADD). *Cereal Chem.*, 1981, **58**, 392.
9. Desikachar, H.S.R., Pearling and milling studies on sorghum. *Proceedings of the International Symposium on Sorghum Grain Quality*, 28-31 Oct., 1981, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, A.P., India, 1982, 194.
10. Munck, L., Bach Knudsen, K. E. and Axtell, J. D., Industrial milling of sorghum for the 1980s. *Sorgum in the Eighties: Proceedings of the International Symposium on Sorghum* 2–7 Nov., 1981. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, A.P., India, 1982.

Studies on the Milling, Rheological and Baking Characteristics of Triticale and Wheat Blends

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Milling, rheological and baking characteristics of triticale and wheat blends were carried out with wheat varieties 'WL 1562' and 'WL 711' and triticale varieties 'TL 257' and 'TL 419'. Flour recovery of the blends decreased with the increase in the triticale component. The Mixographic and Farinographic studies revealed a decrease in mixing time and dough strength with the increase in triticale content. The baking studies revealed an improvement in absolute and specific loaf volumes upto 25% triticale content with wheat variety 'WL 711'. However, the blend of triticale with 'WL 1562' resulted in lower loaf volumes with the increase in triticale component. The studies on the cookie making characteristics of the blends revealed a progressive increase in the spread factor and other quality characteristics with the corresponding increase of triticale component.

Triticale does not compare favourably with bread wheat either for milling or baking characteristics[1-5]. Lorenz[6] and Lorenz *et al.*[7] reported that bread of acceptable quality can be produced from triticale flour with slight adjustments in the absorption and mixing times. Venkateswara Rao *et al.*[8] observed improvement in the baking quality of triticale flour with the addition of 20 ppm potassium bromate and 0.5 per cent sodium steroyl lactylate (SSL). Lorenz[6] also prepared good quality variety breads like white rye bread, hard rolls and noodles from the triticale flour.

Sekhon *et al.*[3,4] and Vankateswara Rao *et al.*[8] while studying the blends of wheat and triticale flours for bread, cookie and chapati making quality, observed no deleterious effect in blending triticale flour upto 50 per cent, on the loaf volume. Sekhon *et al.*[3,4] rather reported an improvement in the loaf volume with the replacement of 25 per cent of wheat flour with that of triticale. The present study was planned to confirm these findings and also to study the possibility of milling triticale and wheat together rather than mixing in the form of flour, along with its implications on the rheological and baking systems.

Materials and Methods

Representative samples of two commercial varieties of wheat viz; 'WL 1562' and 'WL 711' and those of two strains of triticale namely, 'TL 257' and 'TL 419' grown in Rabi 1980–81 were obtained from the wheat section of Punjab Agricultural University, Ludhiana. The cleaned samples of wheat were conditioned to a moisture level of 15.5 per cent and those of triticale to 12.0 per cent. After a rest period of 48 hr, 2 kg lots of different blends were prepared and milled in the Buhler Pneumatic Laboratory Mill (MLU 202). The flour yield was calculated on the basis of dry matter recovered in the form of bran and shorts. The composition of the samples is given in Table 1.

All analytical tests were conducted according to the AACC[9] approved methods. The mixograph was operated according to the method described by Kent Jones and Amos[10]. The constant flour weight and the straight dough methods of AACC[9] were used for Farinographic and baking studies respectively. The cookie test was conducted as is followed at the International Maize and Wheat Improvement Centre, Mexico.

Results and Discussion

The results in Table 2 show that a progressive increase of triticale proportion in the grist resulted in a progressive decrease in the yield of flour. However, the flour

Table 1. Physico chemical characteristics of triticale and wheat grains

Variety/ strain	Moisture (%)	1000 kernel wt. (g)	Hectolitre wt. (kg)	Protein (%)	Ash (%)
WL 1562	10.2	42.8	80.0	11.41	1.67
WL 711	10.4	44.4	81.5	9.45	1.65
TL 257	9.3	45.6	74.2	10.85	2.16
TL 419	9.6	43.6	74.0	12.05	2.12

TABLE 2. FLOUR YIELD AND CHEMICAL COMPOSITION OF TRITICALE AND WHEAT BLENDS

Blend	Yield		Protein	Ash	Damaged starch
	Observed (%)	Expected (%)	(%)	(%)	(%)
WL 1562:TL 257					
4:0	75.1	75.1	10.0	0.47	6.85
3:1	74.3	71.9	9.6	0.50	6.93
1:1	73.0	68.7	9.2	0.51	7.26
1:3	68.4	65.5	8.7	0.54	7.26
0:4	62.4	62.4	8.6	0.56	6.02
WL 1562:TL 419					
3:1	73.2	71.6	9.6	0.49	6.77
1:1	70.5	68.1	9.8	0.48	7.43
1:3	66.8	64.7	9.7	0.49	6.11
0:4	61.2	61.2	9.3	0.56	6.93
WL 711:TL 257					
4:0	75.4	75.4	8.4	0.46	10.23
3:1	73.1	72.1	8.8	0.43	8.58
1:1	70.4	68.9	8.6	0.45	8.25
1:3	66.9	65.6	8.9	0.46	7.59
WL 711:TL 419					
3:1	72.7	71.8	8.2	0.46	8.75
1:1	68.5	68.3	8.3	0.49	9.49
1:3	67.7	64.7	8.5	0.50	7.34
Mean	70.0	68.5	8.4	0.49	7.61

yield values for blends were higher than the expected values and the mean value was 70 per cent, against expected yield of 68.5 per cent. This improvement in flour recovery was found to be non-significant. The protein and ash contents of flours did not vary much with the changing proportions of wheat and triticale. The damaged starch content was invariably lowered as the proportion of triticale in the blend increased.

The mixing times ranged from 1.6 to 2.9 min. (Table 3). The maximum time was recorded for 'WL 1562' which decreased with the progressive increase in the proportion of triticale in the blends. On the other hand no noticeable change was observed in the mixing times of different blends of 'WL 711' with triticale. Actually, 'WL 711' was found to have a little lower mixing requirement than the triticale.

The values for the height of the curve as well as the area under the curve which are indicative of strength of dough and baking strength, respectively showed a progressive decline with the increase in triticale proportion in the blends. Farinographic studies (Table 3) corroborated these observations. Farinograph water absorption also showed a progressive decline with the increase in triticale proportion in the blends.

The results of baking tests (Table 4) revealed that

TABLE 3. MIXOGRAPHIC AND FARINOGRAPHIC CHARACTERISTICS OF TRITICALE AND WHEAT BLENDS

Blend	Mixographic characteristics			Farinographic characteristics			
	Mixing time (min)	Ht. of curve (cm)	Curve area (cm^2)	Absorption (%)	Dough dev. time (min)	Dough stability (min)	Degree of softening (BU)
WL 1562:TL 257							
4:0	2.9	7.3	87.3	62.6	2.0	13.0	10
3:1	2.6	7.1	77.6	62.8	1.3	12.8	30
1:1	2.4	6.8	72.5	60.6	1.5	5.5	75
1:3	2.3	5.8	62.0	61.0	1.5	4.2	175
0:4	2.3	5.2	51.7	53.2	1.0	3.0	195
WL 1562:TL 419							
3:1	2.4	6.8	71.8	57.4	2.0	11.7	40
1:1	2.4	6.2	67.6	57.0	1.5	6.5	110
1:3	2.2	5.3	54.8	56.4	1.8	5.0	110
0:4	1.9	4.8	50.0	56.2	1.6	2.1	155
WL 711:TL 257							
4:0	1.7	7.1	77.5	67.0	2.0	5.7	55
3:1	1.6	6.9	76.4	62.8	2.0	4.2	95
1:1	1.8	6.6	72.8	61.6	1.7	4.0	100
1:3	1.6	5.3	60.0	60.4	1.3	3.2	120
WL 711:TL 419							
3:1	1.7	6.7	74.5	63.8	1.8	3.8	95
1:1	1.8	6.2	65.7	61.6	1.5	3.6	115
1:3	1.9	5.5	57.4	57.4	1.5	3.3	125

TAELE 4. BAKING PERFORMANCE OF TRITICALE AND WHEAT BLENDS

Blend	Loaf characteristics					Cookie characteristics		
	Loaf vol. (cc)	Specific vol. (cc/g)	Crumb characters			Width(W)* (cm)	Spread factor (W/T)	Accepta-ability
			Colour	Grain	Texture			
WL 1562:TL 257								
4:0	645	4.96	CY	Fine	Soft	21.6	4.07	Good
3:1	625	4.69	CY	Fine	Soft	21.4	4.37	Good
1:1	595	4.37	CY	Fair	Soft	22.0	4.58	V. Good
1:3	500	3.87	CY	Fair	Semi-hard	22.7	4.93	V. Good
0:4	410	3.15	DC	Poor	Hard	22.9	5.09	Excellent
WL 1562:TL 419								
3:1	580	4.39	CY	Fine	Soft	21.6	4.24	Good
1:1	580	4.36	CY	Fair	Soft	21.9	4.66	V. Good
1:3	525	3.94	DC	Poor	Semi-hard	21.8	4.74	V. Good
0:4	385	3.00	DC	Poor	Hard	22.6	4.81	V. Good
WL 711: TL 257								
4:0	500	3.70	CY	Fine	Soft	20.8	4.16	Good
3:1	550	4.07	CY	Fine	Soft	21.2	4.33	V. Good
1:1	475	3.60	CY	Fair	Semi-hard	21.6	4.41	V. Good
1:3	450	3.37	DC	Poor	Hard	22.0	4.50	V. Good
WL 711:TL 419								
3:1	525	4.00	CY	Fine	Soft	21.4	4.12	Good
1:1	500	3.87	CY	Fair	Semi-hard	21.8	4.36	V. Good
1:3	460	3.56	DC	Fair	Semi-hard	22.7	4.93	V. Good

*Observation for four; CY—Creamish yellow; DC—Dull cream.

absolute and specific loaf volumes improved with the replacement of 25 per cent of 'WL 711' wheat with any of the two triticale strains. The loaf volume in case of stronger wheat, i.e. 'WL 1562' diminished progressively with the increased proportion of triticale strains.

The improvement in the loaf volume of 'WL 711' by the replacement of 25 per cent triticale flour has also been reported earlier[3,4]. The reduction in loaf volume of 'WL 1562' with the increasing porportion of triticale points to the fact that varietal interaction is also important. This fact is supported by the rheological data obtained with the mixograph and farinograph. The higher amylase content of the triticale flours as reported by Klassen *et al.*[11] and Pena[12] might have contributed to the increase in loaf volume at lower levels. The crumb and crust characteristics of bread remained unaffected with the triticale admixture upto 25 per cent. At higher levels, the crumb grain became coarser, the texture tended to be harder and crust darker.

The studies further showed that the cookie making qualities improved with the increased proportion of triticale in the grist (Table 4). The blends containing 50 per cent or more triticale produced very good cookies. The best cookies were produced by 'TL 257'. Similar findings have earlier been reported by Sekhon *et al.*[3,4]

References

1. Rooney, L. W., Gustafson, C. B., Perez, N. and Porter, K. B., Agronomic performance and quality characteristics of triticales grown in the Texas High Plains. *Progress Report, Texas Agric. Exp. Sta., Taxas A and M Univ.*, Sept., 1969.
2. Unrau, A. M. and Jenkins, B. C., Investigations on synthetic cereal species. Milling, baking and some compositional characteristics of some triticale and parental species. *Cereal Chem.*, 1964, **41**, 365.
3. Sekhon, K. S., Saxena, A. K., Randhawa, S. K. and Gill, K. S., Use of triticale for bread, cookie and chapati making. *J. Fd Sci. Technol.*, 1980, **17**, 253.
4. Sekhon, K. S., Gill K. S., Saxena, A. K. and Sandhu, G. S., Studies on the bread, cookie and chapati making properties of some high yielding varieties of triticale. *Proceeding of the Wheat and your Needs*, Seminar held at New Delhi, April 1980, 178.
5. Sehgal, K. L., Sekhon, K. S., Gupta, S. K., and Gill, K. S., Quality characteristics of some promising triticale strains of India. *J. Fd Sci. Technol.*, 1982, **19**, 133.

6. Lorenz, K., Food uses of triticale: hybrid of wheat and rye can be used in breads, rolls and noodles. *Fd Technol.*, 1972, **11**, 66.

7. Lorenz, K., Welsh, J., Normann, R. and Maga, J., Comparative mixing and baking properties of wheat and triticale flours. *Cereal Chem.*, 1972, **49**, 187.

8. Venkateswara Rao, G., Ranga Rao, G.C.P., Vatsala, C. N., Kumar, G. V. and Shurpalekar, S. R., Bread, biscuit and Chapati making quality of Indian triticale. *J. Fd Sci. Technol.*, 1978, **15**, 11.

9. *Approved Methods*, American Association of Cereal Chemists, Minnesota, 1969, 7th Edn.

10. Kent Jones, D. W. and Amos, A.J., *Modern Cereal Chemistry*, Food Trade Press, London, 1967.

11. Klassen, A. J., Hill, R. D. and Larter, E. N., Alpha-amylase activity and carbohydrate content as related to kernel development in triticale. *Crop. Sci.*, 1971, **11**, 265.

12. Pena, R. J., Grain, shrivelling in secondary hexaploid triticale. I. Alpha-amylase activity and carbohydrate content of mature and developing grains. *Cereal Chem.*, 1982, **59**, 454

Cooking Quality and Chemical Composition of Some Early, Medium and Late Maturing Cultivars of Pigeon Pea (*Cajanus cajan* (L.) Mill)

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Twenty pigeon pea (red gram) cultivars belonging to early, medium and late maturity groups grown during two seasons were studied for the cooking quality and chemical composition. Although no clearcut differences in cooking time, water absorption, solids dispersion, texture (extrusion force) and chemical constituents of cultivars of different maturity groups were observed, the cooking quality of early cultivars appeared to be better than those of the medium and late ones. Of the various physicochemical characteristics, water absorption, solids dispersion and texture were highly and significantly correlated with the cooking time. This shows that these characteristics can be conveniently used as objective tests to study the cooking quality of pigeon pea cultivars.

Traditional processing practices have been followed for many years to convert grain legumes into the consumable forms. Such processes not only improve the digestibility and palatability of food legumes but also help to remove deleterious effects of some antinutritional constituents. Pigeon pea is an important food legume of several countries in semi-arid tropical and semi-tropical regions of the world. In India, it is consumed in the form of dhal (decorticated dry spilt seeds) cooked with water until it becomes soft. Efforts have been made to study the association between the cooking quality and physicochemical properties of pigeon pea[1-3].

Baesd on the maturity period, pigeon pea cultivars can be broadly grouped into three groups: early, medium and late cultivars requiring 90-130, 130-170 and 170-280 days, respectively. Little information is available on the cookin quality and nutritional aspects of pigeon pea cultivars belonging to different maturity groups. Recently, it was reported that late cultivars were superior to early ones in seed yield, 100-seed weight, dhal yield and seed protein content[4]. We examined the cooking quality and chemical composition of early, medium and late maturing cultivars and the results are reported in this paper.

Materials and Methods

Pigeon pea cultivars belonging to different maturity groups grown in two successive years were evaluated. The pigeon pea was grown on black soils at ICRISAT Centre, Patancheru, near Hyderabad (17°N). India, during the rainy seasons of 1975–76 and 1976–77. The cultivars studied are given in Tables 1 and 2. Dhal (decorticated split cotyledons) were prepared by removing seed coat manually after soaking the whole seed in water overnight at 5°C. These were dried for 16 hr in an even at 65°C. For various chemical analyses dhal

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samples were ground in a Udy cyclone mill using a 0.4 mm screen and defatted in a Soxhlet apparatus using hexane.

Cooking time: Cooking time was determined by boiling the dhal in distilled water using a BD-20 heating block digestor (Tecator, Sweden). Suitable amount (10.0±0.5 g) of dhal was boiled in 75 ml of distilled water and the volume of water was maintained during cooking by adding boiling water. Boiled samples were removed at an interval of 1 min and examined for their softness by pressing between the forefinger and thumb, to determined its cooking time. Cooking time was the minimum time interval at which dhal was considered to be completely cooked by two persons out of a panel of three persons.

Water absorption: A suitable quantity (5.0 g±0.5 g) of dhal was taken in a digestion tube and boiled in excess distilled water (35 ml) for 25 min using the BD-20 block digestor. The excess water, after boiling, was decanted and the dhal was weighed. The amount of water taken up by the dhal was calculated and the results are expressed as per cent water absorption.

Solids dispersed: The percentage of solids dispersed into the cooking water was determined by boiling 5 g dhal for 25 min. The boiled material was passed through a 10 mesh sieve and the residue was thoroughly washed with distilled water. After washing, residue was dried at 110°C for 3 hr. The loss in weight of dhal after boiling was calculated and termed as per cent solids dispersion into cooking water.

Texture (extrusion force in kg): The texture was determined by using the back extrusion cell in the Instron

TABLE 1. COOKING TIME AND PHYSICO-CHEMICAL CHARACTERISTICS OF DHAL OF EARLY, MEDIUM AND LATE MATURING CULTIVARS GROWN DURING 1975–76

Cultivar	Cooking time (min)	Solids dispersed (%)	Water absorption (g/g dhal)	Texture (extrusion force, kg)	Phytic acid (mg/g)	Ca (mg/100g)	Mg (mg/100g)	Pectin (mg/100g)
				Early				
UPAS-120	26	50.6	1.8	150	14.5	68	120	31.0
Pant A-2	24	45.0	2.0	125	16.4	70	127	35.9
Prabhat	41	34.4	1.6	220	13.9	70	152	48.0
T-21	34	34.3	1.7	175	12.5	73	125	37.5
DL-74-1	28	38.1	1.9	135	14.6	76	127	31.9
				Medium				
C-11	32	31.7	1.7	180	15.1	72	133	35.4
No-148	35	46.2	1.6	200	14.5	90	160	37.0
Hy-3c	47	28.8	1.5	285	12.3	73	132	36.4
ICP-1	29	45.6	1.9	165	13.0	71	140	38.3
BDN-1	38	36.2	1.7	205	15.9	90	129	34.5
Mukta	48	30.8	1.5	278	12.2	87	168	35.8
Hy-2	47	34.6	1.5	270	11.9	89	163	34.2
PM-1	28	39.2	1.9	148	13.5	68	112	42.5
AS-71-37	40	36.6	1.6	215	12.9	90	133	34.8
ST-1	52	30.4	1.4	305	10.7	79	170	46.5
				Late				
NP(WR)-15	54	28.3	1.5	300	10.6	87	145	52.3
Gwalior-3	35	37.0	1.7	185	12.8	80	154	46.5
KWR-1	26	50.2	2.1	140	16.3	63	130	30.6
T-7	30	37.9	2.0	150	13.2	83	149	35.4
T-17	43	30.5	1.8	280	11.8	75	128	36.0
Mean	36.8	37.3	1.7	205.6	13.4	77.7	139.9	38.0
E[a]	9.2	6.9	0.2	60.4	1.7	8.7	16.8	5.9

a: Standard error of the mean.

TABLE 2. COOKING TIME AND PHYSICO-CHEMICAL CHARACTERISTICS OF DHAL OF EARLY, MEDIUM AND LATE MATURING CULTIVARS GROWN DURING 1976–77

Cultivar	Cooking time (min)	Solids dispersed (%)	Water absorption (g/g dhal)	Texture (extrusion force, kg)	Phytic acid (mg/g)	Ca (mg/100g)	Mg (mg/100g)	Pectin (mg/100g)
Early								
BR-172	28	39.6	2.0	145	15.3	74	125	40.6
T-21	32	33.5	1.9	160	13.6	80	120	30.6
Hy-1	40	31.0	1.5	205	12.5	87	165	50.4
Pusa-4-84	36	32.8	1.7	190	13.0	76	170	49.9
DL-74-1	35	36.0	1.7	210	13.5	75	128	41.2
HPA-1	38	39.6	1.5	225	13.4	72	135	51.0
BS-1	30	42.5	1.8	155	12.9	81	130	37.5
Medium								
C-11	36	33.4	1.6	195	14.2	83	142	37.2
No-148	42	28.5	1.6	230	13.0	74	158	48.7
ST-1	43	28.0	1.5	230	12.6	98	135	35.4
BDN-1	34	35.7	1.8	205	13.8	74	154	47.0
ICP-1	30	43.4	1.8	165	14.0	68	130	30.8
EB-38-70	52	26.7	1.4	245	10.5	82	165	59.0
PM-1	36	35.8	1.8	205	13.2	80	127	37.9
Late								
BDN-2	35	37.0	1.7	200	13.0	88	140	38.0
NP(WR)-15	41	29.5	1.7	240	12.3	81	153	47.5
Gwalior-3	42	30.5	1.5	240	12.0	80	150	38.9
KWR-1	32	40.8	1.8	165	13.6	76	142	50.3
T-7	38	34.7	1.7	185	12.8	83	148	52.0
ICP-7065	49	25.8	1.5	255	11.5	85	135	43.6
Mean	37.0	34.2	1.7	202.5	13.0	79.8	142.6	43.4
SE[a]	6.2	5.4	0.2	35.6	1.1	6.7	14.7	7.7

a: Standard error of the mean.

food testing instrument (Model 1140, High Wycombe, Berkshire, UK) according to the method described by Voisey and Nonnecke[5]. Each dhal sample (20 g) was put in a digestion tube and boiled in distilled water for 15 min; excess water was decanted and traces of water removed. The boiled material (30.0g±0.5 g) was transferred to a back extrusion cell and compressed by a loose fitting plunger until it was extruded through the gap between the plunger and container. The point where extrusion of compressed dhal started was measured from the peak recorded on the chart run on a 0-500 scale and termed as extrusion force[5].

Chemical constituents: Defatted and finely ground dhal was used for the estimation of chemical constituents. Fat, crude fiber and ash were estimated by AOAC procedures[6]. Nitrogen was determined by Technicon auto analyser procedure as described by Singh and Jambunathan[7], and the protein values were obtained by multiplying the nitrogen value with 6.25.

Soluble sugars were extracted from the defatted sample using 80 per cent ethanol in Soxhlet apparatus. Extracts were evaporated and the residue was taken in distilled water. Aliquots were used for estimation of soluble sugars by phenol sulphuric acid method[8]. The starch content in the residue was determined by enzymatic hydrolysis[9], with minor modifications[10]. Previously described procedures were followed for the determination of phytic acid[11], calcium and magnesium[12] and pectin[13].

Results and Discussion

Variation in cooking time and physicochemical characteristics: Cooking quality was measured as a function of cooking time, amount of water absorbed, solids dispersed and texture in early, medium and late cultivars of pigeon pea grown during 1975–76 (Table 1) and 1976–77 (Table 2). The cooking time of dhal showed a large variation between cultivars, but, early, medium and late maturity groups did not differ significantly with respect to cooking time and other characteristics for both the years. The mean cooking time was 30, 40 and 38 min for early, medium and late cultivars, respectively, during 1975–76 and was 34, 39 and 39 min during 1976–77. It appears that the cookability of early cultivars is better than the medium and late ones. The differences between the groups were larger in 1975–76 than in 1976–77. This observation was substantiated by the amount of solids dispersed into cooking water and the texture of boiled dhal as measured by Instron Food Tester. The mean extrusion force was 161, 225 and 211 kg for early, medium and late cultivars, respectively, during 1975–76 and this trend was also observed for 1976–77. The water absorbing capacity of early, medium and late cultivars did not show large differences.

The interaction between phytic acid, calcium and magnesium and pectin has been suggested to influence the cooking quality of grain legumes[14]. Noticeable differences were observed (Tables 1 and 2) in the phytic acid content of cultivars belonging to different maturity groups, whereas the variation, for calcium, magnesium and pectin were small. Comparison of cooking quality of 12 common cultivars grown during both seasons, showed noticeable differences. Ranking between years based on cooking time differed to a larger extent for quick cooking cultivars (26 to 34 min) than the slow cooking cultivars (36 to 52 min) indicating large differences in the latter ones. For some cultivars, the cooking time was longer in 1975–76, and for others in 1976–77, but the effect of year was more pronounced in case of 'ST-1' and 'NP (WR)-15'. Similar differences were observed for other constituents when results of two years were compared. It is difficult to point out the reasons for such variation. However, the effect of environmental factors such as soil, moisture, temperature and humidity at the time of seed development may play an important role.

Proximate composition of early, medium and late cultivars: The results on proximate composition of cultivars of different maturity groups are given in Tables 3 and 4. Protein and starch together constituted about 75 per cent of the total dhal weight. Only a small variation was observed between cultivars in the starch content. Protein content of cultivars ranged between 19.7 and 24.8 per cent during 1976–77 and between 20.6 and 24.9 per cent during 1975–76. The mean protein content of early, medium and late cultivars did not show any noticeable differences during 1975–76, whereas mean protein per cent was highest for late cultivars and lowest for early cultivars during 1976–77, and this observation agreed with earlier reported results[4]. There was a small variation in soluble sugars, fat, crude fibre and ash contents among early, medium and late cultivars. Variation in phytic acid, calcium, magnesium and pectin content of cultivars belonging to different maturity groups was larger than that in proximate compositions.

Relationship between cooking time and physicochemical factors: Highly significant and positive correlation was observed between cooking time on one hand and texture (extrusion force) and water absorption on the other hand (Table 5). The amount of solids dispersed into cooking

TABLE 3. PROXIMATE COMPOSITION (% DRY MATTER) OF EARLY, MEDIUM AND LATE MATURING CULTIVARS GROWN DURING 1975–76

Cultivar	Protein	Starch	Soluble sugars	Fat	Crude fiber	Ash
Early						
UPAS-120	21.4	54.5	4.8	2.2	1.5	3.5
Pant A-2	24.0	51.4	5.2	2.1	1.6	4.0
Prabhat	20.1	54.9	4.5	1.8	2.0	3.7
T-21	20.2	54.2	4.6	1.7	1.7	3.9
DL-74-1	23.4	54.2	3.9	1.8	1.4	4.6
Medium						
C-11	23.7	57.6	4.2	2.0	1.6	3.5
No-148	22.7	54.2	4.3	1.7	1.8	3.2
Hy-3c	20.3	58.2	5.0	1.8	1.9	3.5
ICP-1	21.6	54.8	5.5	1.5	2.0	4.0
BDN-1	23.2	52.9	5.1	1.6	1.5	2.8
PM-1	19.7	58.2	4.9	2.1	1.6	3.1
AS-71-37	20.9	56.9	5.0	2.0	1.3	3.5
ST-1	21.8	55.7	5.2	1.9	1.7	3.7
Late						
NP (WR)-15	23.7	54.7	4.8	2.2	1.9	3.0
Gwalior-3	24.8	51.5	5.5	2.0	1.8	4.1
KWR-1	22.6	55.0	4.3	1.8	1.4	3.6
T-7	22.2	53.7	4.5	1.6	1.5	3.9
T-17	22.0	54.5	5.0	1.9	1.3	3.8
Mean	21.1	54.8	4.8	1.9	1.6	3.6
SE[a]	1.46	1.90	0.4	0.2	0.2	0.4

a: Standard error of the mean.

TABLE 4. PROXIMATE COMPOSITION (% DRY MATTER) OF EARLY, MEDIUM AND LATE MATURING CULTIVARS GROWN DURING 1976-77

Cultivar	Protein	Starch	Solube sugars	Fat	Crude fiber	Ash
Early						
BR-172	21.8	55.4	5.5	2.0	2.1	3.4
T-21	22.0	54.3	5.0	1.9	2.0	2.8
Hy-1	21.5	55.8	5.4	1.5	1.8	3.6
Pusa-484	21.7	55.6	4.8	1.7	2.2	4.0
DL-74-1	20.6	53.4	4.9	1.3	1.9	2.9
HPA-1	21.6	55.0	5.0	1.9	1.8	2.9
BS-1	21.2	54.5	5.1	1.8	2.0	3.1
Medium						
C-11	21.2	55.7	5.4	1.7	1.9	3.4
No-148	21.8	56.8	5.3	2.0	1.8	3.5
ST-1	21.6	55.3	5.0	1.6	1.7	2.9
BDN-1	22.3	54.5	5.1	1.5	2.0	3.4
ICP-1	21.0	54.7	5.3	1.7	2.1	4.0
EB-38-70	22.5	55.4	5.7	1.9	1.8	4.2
PM-1	21.5	56.8	4.9	1.4	1.6	4.1
Late						
BDN-2	21.0	57.4	4.9	1.7	1.9	3.9
NP (WR)-15	23.2	56.8	4.8	1.8	2.0	4.0
Gwalior-3	24.9	50.6	5.0	2.1	1.8	3.7
KWR-1	22.4	53.4	5.1	1.9	2.2	3.5
T-7	22.6	54.1	5.2	1.4	2.1	4.1
Mean	22.0	55.0	5.1	1.0	1.9	3.5
SE[a]	0.4	1.5	0.2	0.2	0.2	0.5

a: Standard error of the mean.

water was negatively correlated with the cooking time, and was in agreement with the results obtained by earlier work[2]. Of the chemical constituents, phytic acid was negatively correlated with the cooking time in both the years. Calcium, magnesium and pectin showed low positive correlations with the cooking time. However, earlier workers had reported that these constituents were not correlated with the cookability of pigeon pea dhal[1]. Protein, starch, soluble sugars, fat, crude fiber and ash contents did not show any correlations with the cooking time.

A stepwise multiple regression analysis was carried out to relate physico-chemical factors to cooking time. Texture alone accounted for nearly 90 per cent of the variation in cooking time. But there was no noticeable improvement in the R^2 value when water absorption and solids dispersed were further used in the multiple regression of cooking time on above variables, indicating that texture alone explains most of the variability. A significant improvement in R^2 value was noticed when the combination of calcium, magnesium and pectin was tested against cooking time, whereas the addition of phytic acid as another variable did not help much. None of the combinations from protein, starch, soluble sugars, ash, fat and crude fibre resulted in significant improvement in R^2 values.

Based on these results, it appears that cooking time is highly correlated with water absorption, solids dispersed and texture (extrusion force). Further, no clear cut distinction could be made between early, medium and late maturing cultivars on the basis of these characteristics. Early cultivars required shorter cooking time

TABLE 5. CORRELATION COEFFICIENTS AMONG VARIOUS COOKING QUALITY PARAMETERS

Parameter	Solids dispersed	Water absorption	Texture	Phytic acid	Calcium	Magnesium	Pectin	Season
Cooking time	-.79**	-.38**	.98**	-.77**	.55**	.69**	.50*	1975-76
	-.87**	-.86**	.90**	-.87**	.45*	.60**	.50*	1976-77
Solids dispersed		.67**	-.75**	.67**	-.37	-.30	-.45*	1975-76
		.66**	-.78**	.69**	-.53*	-.49*	-.30	1976-77
Water absorption			-.84**	.64**	-.56**	-.59**	-.44*	1975-76
			-.82**	.75**	-.43	-.51*	-.42	1976-77
Texture				-.76**	.48*	.55**	.42*	1975-76
				-.73**	.33	.42	.37	1976-77
Phytic acid					-.35	-.46*	-.54*	1975-76
					-.46*	-.49*	-.44*	1976-77
Calcium						.55**	.10	1975-76
						.08	-.09	1976-77
Magnesium							.36	1975-76
							.73**	1976-77

* and ** significant at 5 and 1 per cent respectively.

in comparison with medium and late cultivars and this could possibly be due to differences in environment.

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References

1. Sharma, Y. K., Tiwari, A. S., Rao, K. C. and Misra, A., Studies on chemical constituents and their influence on cookability in pigeon pea. *J. Fd Sci. Technol.*, 1977, **14**, 38.
2. Narasimha, H. V. and Desikachar. H.S.R., Objective methods for studying cookability of *tur* pulse (*Cajanus cajan*) and factors affecting varietal differences in cooking. *J. Fd Sci. Technol.*, 1978, **15**, 47.
3. Manimekalai, G., Neelakantan, S. and Annapan, R. S., Chemical composition and cooking quality of some improved varieties of red gram dhal. *Madras agric. J.*, 1979. **66**, 812.
4. Tripathi, R. D., Srivastava, G. P., Misra, M. C. and Sinha, S. T., Comparative studies on the quality characteristics of early and late cultivars of red gram (*Cajanus cajan* L.). *Indian J. agric. Chem.*, 1975, **8**, 57.
5. Voisey, P. W. and Nonnecke, I. L., Measurement of pea tenderness. III. Field comparison of several methods of measurement. *J. Texture Studies*, 1972, **3**, 329.
6. *Official Methods of Analysis*, Association of Official Analytical Chemists, Washington, 12th Edn., 1975.
7. Singh, U. and Jambunathan, R., Evaluation of rapid methods for the estimation of protein in chick pea (*Cicer arietinum* L.). *J. Sci. Fd Agric.*, 1980, **31**, 247.
8. Dubois, M., Gilles, K. A., Hamilton, J. J., Rebers, P. A. and Smith, F., Colorimetric method for determination of sugars and related substances. *Analyt. Chem.*, 1956, **28**, 350.
9. Thivend, P., Mercier, C. and Guilhot, A., Determination of starch with glucoamylase, in *Methods in Carbohydrate Chemistry*, by R. L. Whistler, and J. N. BeMiller, (Ed). Academic Press, New York, 1972, Vol. **VI**, 100.
10. Singh, U., Jambunathan, R. and Narayanan, A., Biochemical changes in developing seeds of pigeon pea (*Cajanus cajan* L.). *Phytochem.*, 1980, **19**, 1291.
11. Makower, R. U., Extraction and determination of phytic acid in beans (*Phaseolus vulgaris*). *Cereal Chem.*, 1970, **47**, 288.
12. Piper, C. S., Wet digestion with sulphuric acid, nitric acid, and perchloric acid, in *Soil and Plant Analysis*, Hans Publisher, Bombay, 1966, 272.
13. Dekker, R.F.H. and Richards, G. N., Determination of pectic substances in plant material. *J. Sci. Fd Agric.*, 1972, **23**, 475.
14. Crean, D.E.C. and Haisman, D. R., The interaction between phytic acid and divalent cations during the cooking of dried peas. *J. Sci. Fd Agric.*, 1963, **14**, 824.

Drying of Tomatoes

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'Pusa Ruby' variety of tomato was blanched for 10 sec in 2.5% brine, cooled, sliced into pieces and dried in sun and tray drier (70 and 80°C) to 8-10% moisture. Slices of 2 and 3 cm thickness required 28 and 35 hr drying as compared to 22 hr for 1 cm slices. Blanching whole tomatoes, slicing into 1 cm pieces and sun drying gave as good dried product as those dried in the tray drier. Sun-dried samples had higher moisture levels. Products like soup and slurry made from dried samples were rated as good as those from fresh tomatoes.

Tomatoes can be dried by foam-mat drying[1], spray drying[2], freeze drying[3] and vacuum drying[4]. Mechanical drying is costly because of high moisture content of the fruits. Sun-drying of tomatoes has been in practice in many Mediterranean countries like Italy[5] and to a limited extent in Indian also. However, sun-dried product is dark in colour and the reconstituted product is thin. In Northern India, main harvesting season is from November to June. During February to June generally the days are bright with sunshine and relative humidity

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is also low. Sun drying of tomatoes was taken up during this period and the results are presented here.

Materials and Methods

Ripe tomatoes of variety 'Pusa-Ruby' obtained from Horticultural Research Centre of the University, were used in this study.

Preparation of material: Healthy tomatoes were washed thoroughly with water and peeled manually after dipping in boiling 2.5 per cent brine for 20 sec. Another lot of tomatoes were blanched either by dipping in boiling water for 15 sec or in boiling brine for 10 sec, and cooling in water. They were cut into slices of 1, 2 and 3 cm thicknesses with stainless steel knives. Slices were kept on a sieve for a few minutes for draining and spread on wire-mesh trays at the rate of 6.28 kg/m^2.

Sun-drying: Trays were covered with polyethylene sheets (having about 100 holes per sq.m.) and kept in the sun between 9.00 a.m. and 5.00 p.m. till the product dried. The temperature during drying ranged between 37.8 and 45.5°C and the average relative humidity was 58 per cent.

Tomato slices were also dried in a tray drier at 80°C for 3 hr initially and then at 60°C. Air velocity was 135 m/min.

Dried products were packed in polyethylene bags soon after drying and sealed.

Chemical analysis: Moisture, acidity, pH and ash content were determined in fresh tomatoes and dried slices according to the methods given in the Manual of Analysis of Fruits and Vegetables[6]. Total sugars were determined by volumetric method[6], ascorbic acid titrimetrically[7] and lycopene and pectin by the methods suggested by Ranganna[6]. Total soluble solids (TSS) were read in a hand refractometer.

Pectin methyl esterase (PME) activity in samples were measured by the method of Lineweaver and Jansen[8].

Drying rate: Moisture content of the tomato slices during drying was estimated at hourly intervals in the case of tray drying and every 2 hr in the case of sun-drying.

Quality of the dried tomato slices: Dehydration ratio (DR) and rehydration ratio (RR) were determined according to the procedure given by Ranganna[6].

Sensory evaluation of dried products were carried out with the samples as such and also after they were processed into soup and slurry of 4.5° Brix. For preparing soup, dried products were soaked in water for 30 min, and onion, spices, etc., were added. The boiling time required for soup preparation was 60 min. With fresh tomatoes cooking time was 20 min.

For preparing slurry, dried slices were soaked in water and blended in a mixer.

The products were assessed by a panel of judges, following the Hedonic scale, for colour, mouthfeel, aroma and absence of defects. They were given 20/20, 40 and 20 per cent weightage respectively. Sensory evaluation data were analysed statistically using Randomised Block design for significant difference at 5 per cent level[9].

Results and Discussion

Chemical composition of tomatoes variety 'Pusa Ruby' used in this study is given in Table 1. T.S.S. and total sugars were lower than the values reported by Narkviroj and Ranganna[10] but slightly higher than those found by Hobson[11]. Total acidity as citric acid, was 0.62-0.65 per cent, and the sugars to acid ratio was found to be on an average 4.56. Its pectin content was 0.328-0.355 per cent (Table 1), which was higher than the values reported by Gould[12]. The lycopene content of this variety of tomato was in the range of 3.75-5.11 mg per 100 g. The tomatoes were found to have high PME activity also.

Preliminary studies conducted to standardize the pretreatments for drying showed that peeling tomatoes with boiling water or 2.5 per cent brine resulted in a loss of 9.5 and 9.8 per cent juice respectively. This loss increased further during the process of seed removal.

In unblanched tomatoes, cutting into slices of 1, 2 and 3 cm resulted in a loss of 12.5, 10 and 9 per cent juice respectively. These losses were higher by 0.2 to 3.5 per cent in the blanched samples. Loss of juice was minimum in the samples blanched in brine.

Drying studies conducted with 1 cm slices of tomatoes given different treatments indicated that the drying time is not much affected by the presence of peel and seeds; rather their removal lowered the yield by 21.7 per cent (Table 2). Removal of seeds alone from unpeeled tomatoes resulted in loss of 16.7 and 21 per cent of yield of tray dried tomatoes. The corresponding losses in sun-drying were 10 and 16 per cent, respectively. Presence of peel did not affect the dehydration ratio

TABLE 1. CHEMICAL COMPOSITION OF FRESH TOMATOES VAR. PUSA RUBY

Moisture (%)	93–96
Total soluble solids (°Brix)	4.0–5.5
Total acids (% anhydrous citric)	0.61–0.65
Sugars (%)	3.71–3.85
Ascorbic acid (mg/100 g)	20.6–23.17
Ash (%)	0.612–0.671
Pectin (%)	0.328–0.355
Lycopene (mg/100 g)	3.75–5.11
pH	4.1–4.3
PE activity (PE u/100 g)	4.961–4.991

TABLE 2. EFFECT OF VARIOUS PRETREATMENTS ON DRYING CHARACTERISTICS AND YIELD OF DRIED PRODUCT FROM 1 CM THICK TOMATO SLICES

Pretreatment	Drying time (hr)	Yield (%)	Drying ratio	Rehydration ratio
Tray dried[1]				
Peeled by hot water dip, seeds not removed	8.50	72.0	18.75	3 45
Peeled by hot brine dip, seeds not removed	8.50	70.0	18.90	3.49
Unpeeled, blanched, seeds not removed,	8.25	93.7	16.10	4.50
Unpeeled, blanched, seeds removed	10.00	77.0	20.00	4.80
Unpeeled, unblanched, seeds not removed	8.50	98.0	14.80	4.00
Sun dried[2]				
Unpeeled, blanched, seeds not removed	22.00*	91.0	17.00	4.19
Unpeeled, blanched, seeds removed	21.00*	75.0	20.50	5.18
Unpeeled, unblanched, seeds not removed	26.00*	85.0	18.40	4.06

[1]Drier temperature 70°C.

[2]Temperature 37-48°C, R. H. 52-62%.

*Period for which product was kept in sun for drying.

TABLE 3. DRYING CHARACTERISTICS AND REHYDRATION RATIO OF TOMATO SLICES (1 CM THICK) DRIED UNDER DIFFERENT CONDITIONS

	Sun-drying		Tray drying			
	Unblanched	Blanched[1]	Unblanched		Blanched[1]	
Temperature (°C)	36-48	36-48	70	80[a]	70	80[a]
Drying time (hr)	26	22	8.5	5.5	8.25	5.25
Moisture in dried samples (%)	10	10	8.1	8.5	6.1	6.0
Dehydration ratio	18.4	17.0	14.8	15.8	16.1	16.2
Rehydration ratio	4.06	4.19	4.00	4.40	4.50	4.85
Yield[2] (%)	85	91	98	92	94	90

[1]Blanched in boiling 2.5% brine for 10 sec.

[a]Drier temperature was 80°C for first 3 hr and then 60°C.

[2]Yiled calculated on the basis of total solids present in the fresh material and total solids recovered in dried product.

(DR) or rehydration ratio (RR) (Table 2). Since loss of juice during slicing was 10.8 per cent in samples blanched for 10 sec in brine as compared to 12.8 per cent during water blanching (15 sec), and peeling and/or seed removal did not affect the drying time, DR and RR, in subsequent studies tomatoes were blanched in hot brine and sliced into 1, 2 and 3 cm thick pieces without peeling or deseeding.

Sun-drying of 1 cm unblanched slices took 26 hr (Table 3). Blanching reduced this time by 4 hr. Loss of moisture was much faster in these slices as compared to those of 2 and 3 cm (Fig. 1). Unblanched slices of 2 and 3 cm took 31 and 38 hr for sun-drying. The corresponding times for blanched slices were 28 and 35 hr, respectively. The drying curves started levelling-off after the moisture content in the slices was reduced to about 10 per cent. Further moisture removal was very slow. Hence, drying was stopped at this point. The product temperature was found to be 1-4°C higher than the atmospheric temperature during sun-drying. The raise in product temperature was more in the afternoon.

In tray drier, time required for the reduction of moisture from 93-96 per cent to 5-8 per cent, took 8.25-8.50 hr at 70°C and 5.25-5.5 hr at 80°C (Table 3). Drying time of blanched samples was much less than that of unblanched samples (Table 3 and Fig. 2). Drying time at 70°C was more than that at 80°C. Sun-drying took maximum time.

Drying ratio of sun-dried samples was 17 and 18.4 for unblanched and blanched samples, respectively, which is higher than that of tray dried samples (Table 3). The moisture content of the sun-dried samples was higher but apparently there were more losses during sun-drying, which is obvious from lower yield of sun-dried product.

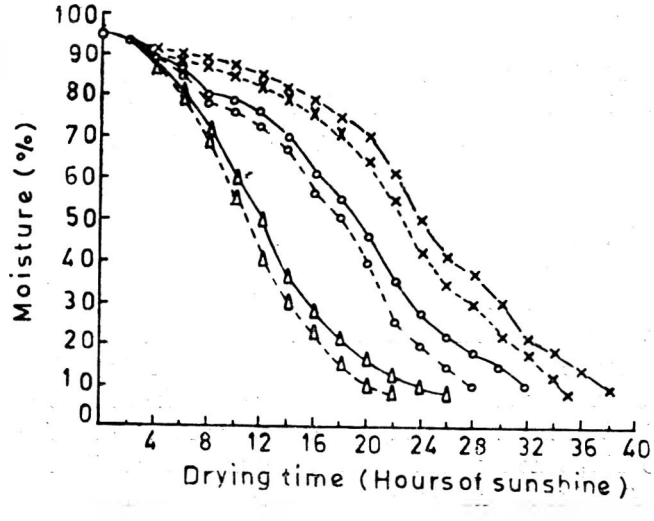

Fig. 1. Loss of moisture during sun drying of tomato slices (Atmosph. temp. 36-48°C, R. H. 52%).

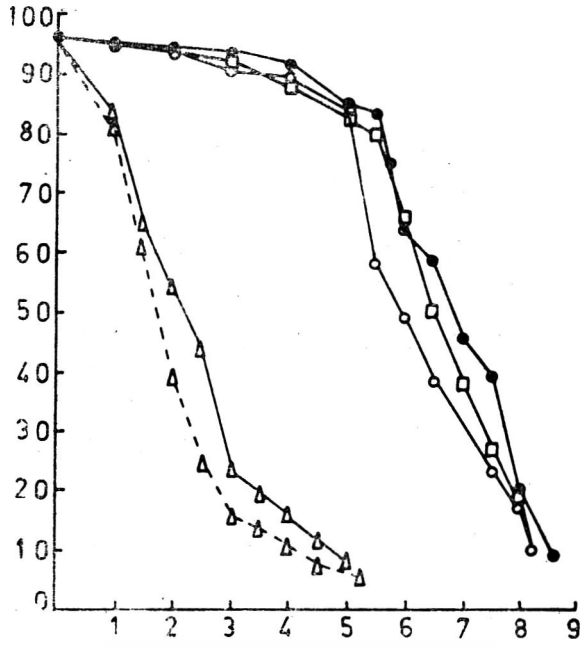

Fig. 2. Loss of moisture during tray drying of tomato slices of 1 cm thickness, at 70 and 80°C.

Raw tomatoes contained 75.5-76.84 per cent (dry weight basis) sugars. This was reduced to 59.58 per cent of total solids in unblanched, 1 cm thick sun-dried slices and to 57.51 per cent in blanched and dried samples (Table 4). The differences in loss of sugar by the two methods of drying are small.

Fresh tomatoes were rich in ascorbic acid (Table 1). However, during drying about 38.8 per cent of ascorbic acid was lost (Table 4). The loss was higher in unblanched sun-dried samples. Blaching before slicing reduced the losses. Greater retention of ascorbic acid in blanched samples may be due to inactivation of ascorbic acid oxidase.

Pectin methyl esterase (PME) activity in unblanched samples was about 99 PEu per 100 g of solids (Table 1). Blanching reduced it by 78 per cent. Pectin content of unblanched dried samples was lower than that of dried blanched samples (Table 4).

Raw tomatoes contained 3.75-5.11 mg lycopene per 100 g, which is equivalent to 75.06-102.26 mg per 100 g of solids (Tables 1 and 4). It was reduced during blanching and drying processes. These losses are less than 17 per cent as reported[13] in tomato juice during heating at 130°C for 8 min.

For dried tomato to be acceptable, it should have good rehydration characteristics. Rehydration ratio of sun-dried samples were found to vary from 4.06 to 4.19 which are close to the corresponding values for tray dried samples (Table 3).

Blanched samples rehydrated better than unblanched samples. All the samples, whether dried in sun or tray drier, were found to darken during drying operation as seen visually. The sun-dried samples were of lighter colour than the those dried in cabinet drier. The loss of colour was more in those samples where greater loss in total sugar was noted (Table 4).

Sensory evaluation of dried samples was carried out after 20 to 30 days of drying. Upon rehydration the structure of dried tomato slices collapsed. The slices did not regain their original shape. Hence, dried samples as such, and in the forms of slurry and soup were

TABLE 4. CHEMICAL CHARACTERISTICS (ON DRY WEIGHT BASIS) OF DRIED TOMATO (1 CM THICK) SLICES

Pre-treatment	Temp. (°C)	Component per 100 g total solids					
		Total sugars (g)	Acidity (%)	Pectin (g)	Ascorbic acid (mg)	Lycopene (mg)	PE activity (PEu)
		Mechanically dried					
Blanched[1]	70	52.24	11.78	3.67	313.31	91.19	6.73
Unblanched	70	54.29	13.91	0.47	194.72	71.31	7.44
Blanched[1]	80[a]	51.11	12.00	3.87	283.31	93.93	9.78
Unblanched	80[a]	52.11	12.30	0.62	127.75	70.89	15.11
		Sun-dried					
Blanched[1]	37–48	57.51	13.10	3.00	245.70	66.12	7.39
Unblanched	37–48	59.58	12.31	1.85	180.76	72.02	10.87

[1]Blanched for 10 sec in boiling 2.5% brine.

[a]Drying temp. was 80°C for first 3 hr; reduced to 60°C for rest of the drying period.

TABLE 5. CENTRAL ANALYSIS OF VARIANCE FOR DRIED TOMATO SLICES, SLURRY AND SOUP

Source of variance	d.f.	Mean square for dried slices[1]	d.f.	Mean square for slurry[2]	d.f.	Mean square for soup[3]
Sample	4	263.35	4	62.882	1	0.18
Error	28	109.46	20	826.434	10	0.96
Fc		7.40		1.44		0.91
F at 5% level		2.71		2.87		4.96

[1]Sensory evaluation of dried tomato slices was done by the composite scoring-test.

[2]Sensory evaluation of slurry (4% T.S.S.) was done by composite scoring-test.

[3]Sensory evaluation of soup was done on the 'Hedonic scale'.

subjected to sensory evaluation. Statistical analyses of these data are presented in Table 5. This analysis indicates that there was no significant difference at 5 per cent level in the acceptability of the dried slices either as such or as slurry. However, there was a preference for the blanched tomato slices dried at 80°C. Soup was prepared from this sample and fresh tomato keeping the level of tomato solids same. The panel members could not find any significant difference between the two samples.

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References

1. Ginnette, L. F., Graham, R. P., Miers, J. C. and Morgan, A. I. Jr., Tomato powder by foam-mat drying. *Fd Technol.*, 1963, **17**, 811.
2. Lazar, M. E., Brown, A. M., Smith, G. S., Wong, S. F. and Lindquist, F. E., Experimental production of tomato powder by spray drying. *Fd Technol.*, 1956, **10**, 129.
3. Hamed, M.G.E. and Foda, Y. H., Uberdie herstellung, veroachung und lagerung gefriergetrocknetem to motern pulver. *Z. Labensmittel Unters. Forsch.*, 1966, **130**, 388.
4. Kaufman, V. F., Wong, F., Taylor, D. H. and Talburt, W., Problems in the production of tomato juice powder. *Fd Technol.*, 1955, **9**, 120.
5. Goose, P. G. and Binsted, R., *Tomato Paste, Puree, Juice and Powder*. Food Trade Press Ltd., London, 1964.
6. Ranganna, S., *Manual of Analysis of Fruit and Vegetable Products*. Tata Mc-Graw Hill Publishing Co. Ltd., New Delhi, 1979.
7. *Official Methods of Analysis*. Association of Official Analytical Chemist's, Washington, 1965.
8. Lineweaver, H. and Jansen, E. F., *Adv. Enzymol.*, 1955, Vol. II, 267.
9. Amerine, M. A., Pangborn, R. M. and Rosseler, E. B., *Principles of Sensory Evaluation of Foods*. Academic Press, New York, 1965.
10. Narkviroj, P. and Ranganna, S., Manufacture and quality control of tomato products. *Indian Fd Pckr.*, 1976, **30**, 44.
11. Hobson, C. E., Pectinesterase in normal and abnormal tomato fruit. *Biochem., J.*, 1963, **86**, 358.
12. Gould, W. A., *Tomato Production, Processing and Quality Evaluation*. AVI, New York, 1974.
13. Noble, A. G., Investigations of the colour changes in heat concentrated tomato pulp. *J. agric. Fd Chem.*, 1975, **23**, 48.

Heat Induced Changes in the Proteins of Milk During Preparation of Khoa from Lactose Unhydrolysed and Lactose Hydrolysed Buffalo Milk

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Significant ($P<0.05$) reduction in total-N, non-casein-N, total-albumin-N and β-lactoglobulin-N with concomitant increase in casein-N and non-protein-N fractions was observed when khoa was made either from lactose unhydrolysed (LUM) or lactose hydrolysed (LHM) buffalo milk. Casein isolated from LUM-khoa or LHM-khoa contained significantly higher ($P<0.05$) nitrogen and hexosamine but lower hexose and phosphorus than the casein isolated from the corresponding raw milk.

Decrease in FDNB-reactive lysine of casein from LUM-khoa and LHM-khoa was about 19 and 30 per cent, respectively but from the trichloroacetic acid precipitable proteins of these two types of khoa the loss of lysine was 12 and 20 per cent, respectively over the corresponding samples from raw milk. The TNBS-reactive lysine also showed a similar trend but the values were generally higher. The *in vitro* proteolysis of caseins by trypsin was in the order casein from milk > casein from LUM-khoa > casein from LHM-khoa.

Heat processing brings about noticeable changes in the major and the minor proteins of milk. Temperatures employed during pasteurization do not alter the casein much but at elevated temperatures peptide bond cleavage and release of glycopeptides especially from the K-casein[1], dephosphorylation of casein fractions[2] and increase in the casein particle diameter[3] have been reported. Denaturation of whey protein[4], their aggregation[5], formation of casein-whey protein complex[5] and interaction of proteins with lactose through Maillard reaction[6] are the other major changes. The extent of such changes depend upon the time-temperature combinations followed during processing. Conditions of heat processing employed during manufacture of khoa are different from those employed for the manufacture of other milk products. Therefore, in this investigation an attempt has been made to study the comparative changes in the distribution of nitrogen, composition of casein, status of available lysine and *in vitro* digestioility of proteins isolated from raw milk and khoa made from lactose unhydrolysed and lactose hydrolysed milk.

Materials and Methods

Lactose hydrolysed buffalo milk was prepared by using Lactozyme (1500 lactase units/ml), at the rate of 1 ml/l milk. The raw milk samples with the enzyme were incubated in water bath maintained at 40°C and the residual lactose was estimated by the method of Nickerson *et al*[7]. Under these conditions, about 72 per cent lactose was hydrolysed in the milk. Khoa was prepared from both lactose unhydrolysed (LUM) and the corresponding lactose hydrolysed buffalo amilk (LHM) by open pan desiccation[8] in batches of 3 l each. Total thermal exposure time required for attaining proper body and texture varied between 40 and 45 min.

Nitrogenous constituents of milk and reconstituted (20 g/100 ml) LUM-khoa and LHM-khoa were fractionated as reported by Aschaffenburg and Drewry[9] and the nitrogen content was estimated by Kjeldahl method[10].

Casein was prepared by the acid precipitation method[11]. The casein isolated from milk, LUM-khoa and LHM-khoa were analysed after defatting with petroleum ether (boiling range 40 to 60°C) by Soxhlet extraction for 8 hr, for moisture[10], nitrogen[12], phosphorus[13], hexose[14] hexosamine[15] and sialic acid[11]. The available lysine was estimated by methods using 1-fluoro-2,4-dinitrobenzene[16] and 2,4,6-trinitrobenzenesulphonic acid[17]. The rate of proteolysis of caseins isolated from raw milk, LUM-khoa and LHM-khoa was assessed by trypsin (E. Merk) under the conditions specified by Roy[18] and the tyrosine released was estimated by the method of Lowry *et al*[19].

Trichloroacetic acid precipitable protein (TCA-P)

was obtained by precipitating the proteins from the raw milk and the two types of khoa with 24 per cent (w/v) trichloroacetic acid. The precipitates were dialysed repeatedly against distilled water at 10°C until acid free and were then defatted with petroleum ether. The TCA-P was also analysed for available lysine as described above for casein.

The significance of the changes in the two types of khoa as compared to milk was analysed by 't' test[20].

Results and Discussion

It is evident from Table 1 that on conversion of either type of milk to khoa, total-N content decreased. This may be due to the decomposition of some nitrogenous compounds during heating and agitation process[21]. A significant ($P<0.05$) increase is observed in the casein-N when milk is converted to khoa, because the whey proteins, particularly the β-lactoglobulin form a complex with casein, specifically with k-casein fraction in heated milk and get co-precipitated[22] with casein when the milk is brought to pH 4.6. The increase in the casein-N fraction while making khoa is also supported by a corresponding significant decrease in non-casein-N, total albumin-N and β-lactoglobulin-N. The results show that when the two types of khoa are compared for their total albumin-N and β-lactoglobulin-N, the LHM-khoa contained significantly ($P<0.05$) higher level of β-lactoglobulin-N fraction suggesting that hydrolysis of lactose in milk presumably offers to some extent a protective action against complete denaturation of this protein during heating. With respect to proteose-peptone-N fraction, the decrease is non-significant in both the types of khoa. The significant ($P<0.05$) increase in non-protein-N fraction in both types of khoa could be due to thermolytic cleavage of peptide bond and release of peptides especially from casein[1,23]. The differences in the values of total-N, as in the non-casein-N contents of milk, LUM and LHM-khoa in comparison to the actual estimates (Table 1) and those computed through the values of their different constituent fractions obtained by independent estimations could be partly due to lack of absolute specificity of the fractionation methods and partly due to the possible experimental errors.

The analysis of casein samples isolated from raw whole milk, LUM-khoa and LHM-khoa (Table 2) reveal that nitrogen content varied from 14.65 to 15.13 per cent in different casein samples which is slightly lower than those reported in literature[24]. This could be due to incomplete removal of fat and also partly due to fat globule membrane proteins which on an average contain lower nitrogen than the rest of the milk proteins[25].

The phosphorus content of casein isolated from both types of khoa is lower than that of casein from milk. The lower values of phosphorus could be due to the thermal dephosphorylation of casein[2] and the interaction of whey proteins with casein which are devoid of phosphorus and get co-precipitated with casein during isolation.

The hexose content of casein samples isolated from the two types of khoa was significantly ($P<0.05$) lower than that of casein from raw milk which could be due to the release of glycopeptides from casein, especially the

TABLE 1. DISTRIBUTION OF NITROGEN (G/100 G SOLIDS) FRACTIONS IN MILK AND KHOA FROM LACTOSE UNHYDROLYSED AND LACTOSE HYDROLYSED BUFFALO MILK

N fraction	Milk	LUM-khoa	LHM-khoa
Total N	3.53	3.41	3.41
Casein N	2.92 (82.71)	3.23* (94.72)	3.22* (94.42)
Non-casein N	0.61 (17.28)	0.18* (5.27)	0.19* (5.57)
Total albumin N	0.38 (10.76)	0.04* (1.17)	0.05* (1.46)
β-lactoglobulin N	0.14 (3.96)	0.01* (0.29)	0.02* (0.58)
proteose-peptone N	0.15 (4.24)	0.02 (0.58)	0.05 (1.46)
Non-protein N	0.04 (1.13)	0.09* (2.63)	0.09* (2.53)

Values are the averages of six samples.
*Significant at 5% level.
Figures in the parentheses indicate per cent of total N.

TABLE 2. COMPOSITION OF CASEIN ISOLATED FROM RAW MILK AND KHOA FROM LACTOSE UNHYDROLYSED AND LACTOSE HYDROLYSED BUFFALO MILK

Source of casein	N (%)	P (%)	Hexose (mg/g)	Hexosamine (mg/g)	Sialic acid (mg/g)
Milk	14.65	1.20	2.17	1.22	2.08
LUM-khoa	15.13	1.08	1.70*	1.86*	2.18
LHM-khoa	15.07	0.83*	1.85*	2.37*	2.16

Values are on dry wt basis and each value is the average of 6 samples.
*Significant at 5% level.

k-casein, on heat treatment[23]. The hexosamine content of khoa caseins is significantly ($P<0.05$) higher than that of casein from milk, possibly due to fat globule membrane protein interactions which are also the glycoproteins in milk[25]. No significant difference is observed in the sialic acid content of casein isolated from khoa and raw milk. The carbohydrate composition of the glycopeptides released due to thermolysis of casein have shown significantly higher concentrations of neutral sugar than the basic and the acidic sugars[23]. This may also explain the differential status of various sugars in caseins isolated from raw milk and the two type of khoa.

Available lysine was estimated in casein and the total milk proteins (TCA-P) by the FDNB and the TNBS methods. The results (Table 3) show that the FDNB-reactive lysine is significantly ($P<0.05$) higher in the casein and the TCA-P of raw milk as compared to those isolated from LUM-khoa and LHM-khoa. On conversion of lactose unhydrolysed milk into khoa, about 19 and 12 per cent FDNB reactive lysine is lost from casein and TCA-P, respectively. These results further reveal that when lactose hydrolysed milk is used for khoa making, the loss of FDNB reactive lysine is enhanced to about 30 and 20 per cent from casein and TCA-P, respectively. The TNBS reactive lysine also gives a similar trend except that this reagent irrespective of the type of protein and its source of isolation gives higher values for lysine than the FDNB-method. Also it has been observed[26] that TNBS can react with the ϵ-nitrogen portion of the Maillard compounds and on acid hydrolysis there is a high yield of TNP-lysine. The loss of available lysine is mainly due to lactose-protein interaction (Maillard reaction) as have been observed in case of heat processed milk and milk products[27]. Greater loss of available lysine in khoa samples made from lactose hydrolysed milk is due to extensive reaction of lysine with both glucose and galactose which are formed on hydrolysis[28].

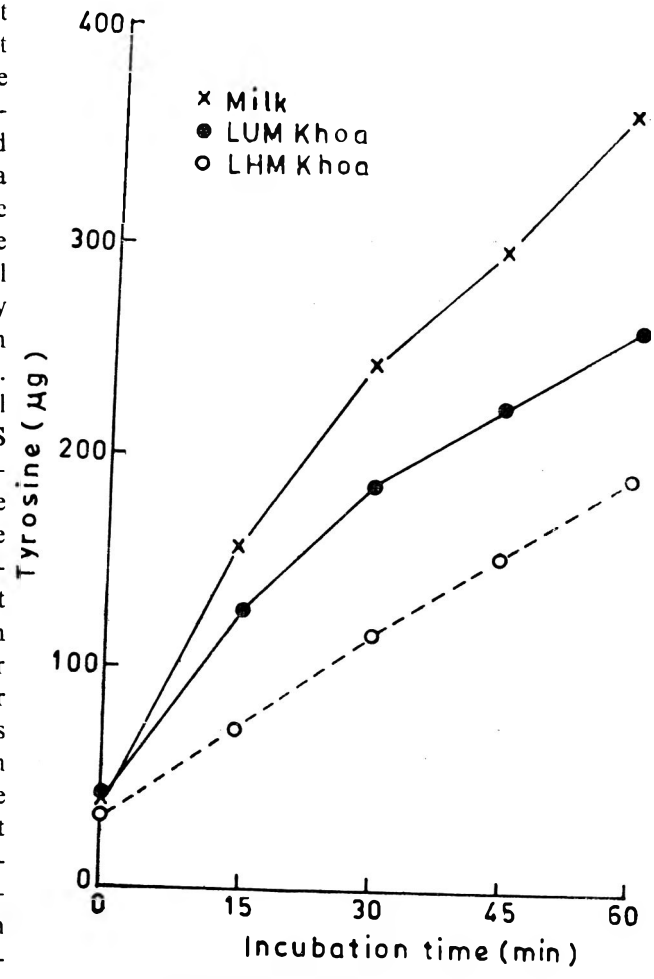

Fig. 1. Action of trypsin on caseins from milk and two types of khoa.

The action of trypsin on the caseins isolated from LUM-khoa and LHM-khoa is slower than the casein isolated from raw milk (Fig. 1) indicating that the *in vitro* digestibility of protein is lowered when milk is turned to khoa and such reduction in digestibility of casein is still higher in khoa made from lactose-hydrolysed milk. This is due to extensive Maillard reaction in the khoa made from lactose hydrolysed milk, which is supported by the higher loss of available lysine in such khoa (Table 3). It is known that trypsin, an endopeptidase, can split only those peptide linkages which contain the α-carboxyl group of arginine and lysine[29]. Due to lactose-protein reaction, the site of trypsin action is therefore may not be accessible.

TABLE 3. AVAILABLE LYSINE (G/100 G PROTEIN) IN CASEIN AND TCA-P OF RAW MILK AND KHOA FROM LACTOSE UNHYDROLYSED AND LACTOSE HYDROLYSED BUFFALO MILK

Source	Casein		TCA-P	
	FDNB reactive	TNBS reactive	FDNB reactive	TNBS reactive
Milk	7.94	9.36	7.52	10.27
LUM-khoa	6.42 (19.14)	7.25 (25.45)	6.60 (12.23)	7.80 (24.05)
LHM-khoa	5.51 (30.60)	7.17 (27.28)	5.95 (20.87)	7.54 (26.38)

Values are average of six samples.
Values in parentheses indicate per cent reduction from milk.

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References

1. Hindle, E. J. and Wheelock, J. V., The release of peptides and glycopeptides by action of heat on cows' milk. *J. Dairy Res.*, 1970, **37**, 397.
2. Belec, J. and Jenness, R., Dephosphorization of casein in solution and in milk by heat treatment. *J. Dairy Sci.*, 1961, **44**, 1163.
3. Youssef, A. M., Salama, F. A. and El-Deeb, S. A., Effect of preheating and sterilization on the physico-chemical properties of cows' and buffalos' milk. *Egyption J. Dairy Sci.*, 1977, **5**, 17.
4. Rawland, S. J., The heat denaturation of albumin and globulin in milk. II. Denaturation and degradation of protein at temperatures of 75-120°C. *J. Dairy Res.*, 1937, **8**, 1.
5. Sawyer, W. H., Heat denaturation of bovine β-lactoglobulins and relevance of disulphide aggregation. *J. Dairy Sci.*, 1968, **51**, 323.
6. Finot, P. A., Non-enzymatic browning, in *Proteins in Human Nutrition*, by J.W.G. Porter and B. A. Rolls, (Ed), Academic Press, London, 1973, 501.
7. Nickerson, T. A., Vujicic, I. F. and Lin, A. Y., Colorimetric estimation of lactose and its hydrolytic products. *J. Dairy Sci.*, 1976, **59**, 386.
8. Srinivasan, M. R. and Anantakrishnan, C. P., *Milk Products of India*, Indian Council of Agricultural Research, New Delhi, 1964, 3.
9. Aschaffenburg, R. and Drewry, J. D., New procedure for the routine determination of the various non-casein proteins of milk. *Proc. Int. Dairy Cong.*, 1959, **3**, 1631.
10. *Methods of Test for Dairy Industry. Part II. Chemical analysis of milk.*, IS-1479: 1961, Indian Standards Institution, New Delhi.
11. Gupta, S. K. and Ganguli, N. C., Sialic acid content of casein preparations from cow and buffalo milks. *Milchwissenschaft*, 1965, **20**, 10.
12. *Official Methods of Analysis*, Association of Official Analytical Chemists, Washington, 11 Edn., 1970.
13. King, E. J., The colorimetric determination of phosphorus. *Biochem. J.*, 1932, **26**, 292.
14. Dubois, M., Gillis, K. A., Hamilton, J. K., Rebere, P. A. and Smith, F., Colorimetric method for determination of sugars and related substances. *Anal. Chem.*, 1956, **28**, 350.
15. Morgan, W.T.J. and Elson, L. A., A colorimetric method for the determination of N-acetylglucosamine and N-acetylchondrosamine. *Biochem. J.*, 1934, **28**, 988.
16. Carpenter, K. J., The estimation of the available lysine in animal protein foods. *Biochem. J.*, 1960, **77**, 604.
17. Tella, A. F. and Ashton, W. M., Studies on 2,4,6-trinitrobenzensulphonic acid reactive lysine using cowpeas (*Vigna unguiculata* (L) Walp), maize (*Zea mays*) and DL-lysine. *J. Sci. Fd Agric.*, 1978, **29**, 447.
18. Roy, D. D., Proteolysis of goat milk by trypsin *in vitro*. *Indian J. Dairy Sci.*, 1980, **33**, 510.
19. Lowry, O. H., Rosebrough, N. J., Farr, A. L. and Randall, R. L., Protein measurement with the folin-phenol reagent. *J. biol. Chem.*, 1951, **193**, 265.
20. Snedecor, G. W. and Cochran, W. G., *Statistical Methods*, Oxford and IBH Publ. Co., New Delhi, 1968, 59.
21. Menefee, S. G., Overman, O. R. and Tracy, P. H., The effect of processing on nitrogen distribution in milk. *J. Dairy Sci.*, 1941, **24**, 953.
22. Muller, L. L., Manufacture and uses of casein and coprecipitates. *Dairy Sci. Abstr.*, 1971, **33**, 659.
23. Lahav, E., Edelsten, D., Sode-Mogensen, M. T., and Sofer, E., Properties of basic glycopeptides released from cow milk proteins by heat. *Milchwissenschaft*, 1971, **26**, 489.
24. Gardon, W. G., Semmett, W. F., Cable, R. S. and Morris, M., Amino acid composition of ∝-casein and β-casein. *J. Am. chem. Soc.*, 1949, **71**, 3293.
25. Brunner, J. R. and Thompson, M. P., Characteristics of several minor-protein fractions isolated from bovine milk. *J. Dairy Sci.*, 1961, **44**, 1224.
26. Finot, P. A. and Mauron, J., Blockage of lysine by the Maillard reaction. II. Chemical properties of the N-(deoxy-1-D-fructosyl-1) and N-(deoxy -1-D-lactulosyl-1) derivatives of lysine. *Helvetica Chimi. Acta*, 1972, **55**, 1153.
27. Mauron, J. and Mottu, F., Relationship between *in vitro* lysine availability and *in vivo* protein evaluation in milk powders. *Arch. Biochem. Biophys.*, 1958, **77**, 312.
28. Reynolds, T. M., Non-enzymatic browning. *Adv. Fd Res.*, 1965, **14**, 219.
29. Neurath, H. and Schwet, G. W., The mode of action of the crystalline pancreatic proteolytic enzymes. *Chem. Rev.*, 1950, **46**, 69.

Flow Characteristics of Khoa at Different Stages of Processing

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Flow characteristics of three types of khoa, *Pindi*, *Dhap* and *Danedar*, have been investigated in terms of flow behaviour index (n) and consistency coefficient (m) using constant temperature capillary tube viscometer. Khoa has been prepared at temperatures of 116.2, 126.64 and 134.2°C to determine the effect of processing temperature on flow behaviour. Khoa at all stages of concentration has been found to be pseudoplastic non-Newtonian food product.

Khoa is the heat coagulated milk product prepared by partial dehydration of cow or buffalo milk or their admixture, without adding any foreign ingradient. Generally, traditional methods are followed and three main types, namely *Pindi*, *Dhap* and *Danedar* are recognised. Each type differs in quality, texture and composition[1]. Each variety is used in the preparation of specific types of sweets.

Instruments used for determining the viscosity of fluids can be classified into two types, namely, the rotational and the capillary flow viscometers. When the rotational viscometer is used for determining the viscosities of fluid foods containing suspended solids erroneous readings would be obtained because of the separation of the solids. The pressure losses and rheological properties of flowing butter through stainless steel tubing have been investigated by Hank *et al*[2]. However, no published information is available on flow characteristics of khoa at different stages of processing, and therefore, efforts to mechanize the process of khoa making has become difficult. A systematic study was undertaken to find out the flow characteristics of different types of khoa at various stages of processing and the results are presented here. A constant temperature capillary tube viscometer was developed and used in the study.

Materials and Methods

The tube viscometer used in the study is shown in Fig 1. It consisted basically of a sample container, horizontal straight tube, constant temperature water bath and a regulated air pressure system. The sample container having a diameter of 4.5 cm and a height of 12.5 cm was made out of stainless steel tubing. One of its ends was connected to air pressure system and the other to a glass capillary tube through one way stainless steel plug cocks. A constant temperature water bath and side tube were used to provide the isothermal conditions. Glass capillary tubes of 3 mm diameter and 36 cm length were employed where the total solid content of the product was below 40 per cent, capillary tubes of 4 mm diameter and 45 cm length for total solids between 40 to 50 per cent and capillaries of 5 mm diameter and 52 cm length when the solids were more than 50 per cent.

Different types of khoa used in the experiment were prepared in the improved khoa-pan developed by Sawhney *et al*[3]. The milk used for making khoa contained 6.5 per cent fat and total solids of 16.2 per cent on an average. The pan was operated at three different steam pressures, viz. 0.7, 1.4 and 2.1 kg/cm^2, thereby maintaining the corresponding temperature of heating medium at 116.2, 126.64 and 134.2°C, during processing of khoa. Higher temperatures were not used as it led to rapid browning of the product. Two hundred ml of samples were drawn in sampling vials at different stages of khoa preparation (5-6 per batch) and the product was allowed to flow in the capillary for a precise time interval by applying air pressure.

The volume of the sample collected was measured. Flow rate of each sample was measured at 0.6, 0.5, 0.4 and 0.3 kg/cm^2 pressures starting with the highest pressure. The time varied from 5 to 30 sec and the volume collected varied from 15 to 140 ml. All measurements were made at a temperature of 95±2°C. Solids content of the sample was determined by the standard Majonnier method.

1. Air compressor
2. Air Pressure regulator
3. Pressure gauge
4. Shut off valve
5. Bye-pass valve
6. Hot water bath
7. Sample container
8. Sample inlet valve
9. Sealing cork
10. Side tube
11. Capillary tube
12. Stirrer
13. Stirrer speed regulator
14. Stirrer motor
15. Sample collector

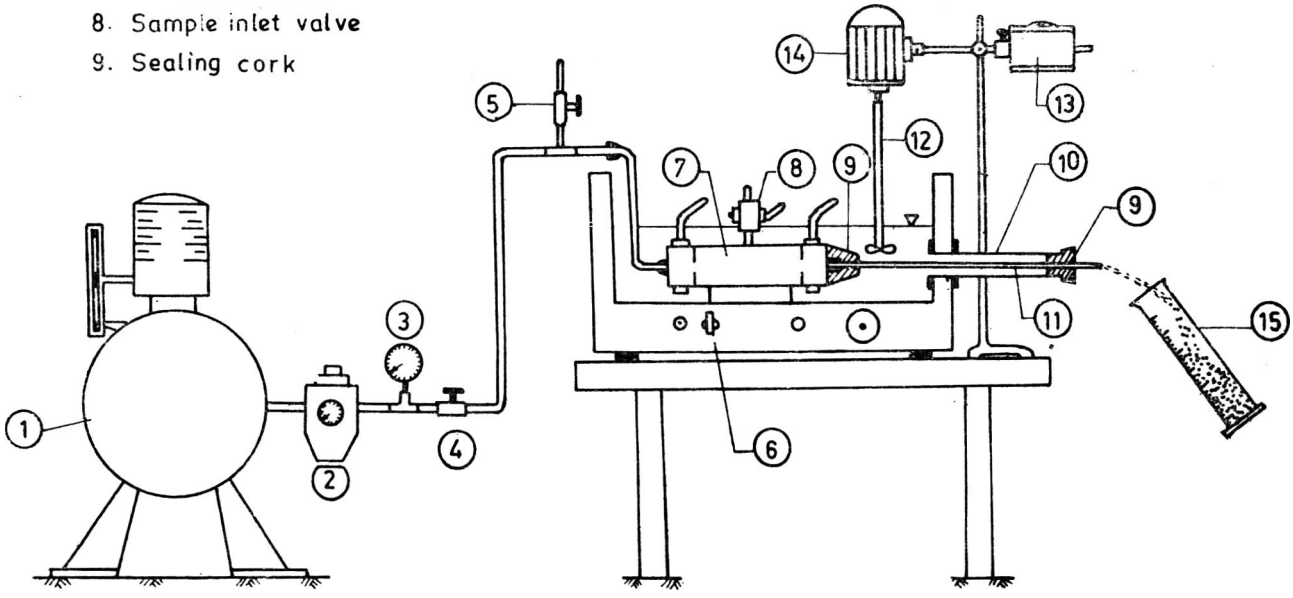

Fig. 1. Experimental set-up with constant temperature capillary tube viscometer.

For each measurement, the flow characteristics were determined in terms of two rheological paremeters viz., flow behaviour index (n) and consistency coefficient (m). For a tube-viscometer, the volumetric flow rate (Q) for the non-Newtonian fluids obeying power-low equation, could be develpoed by the integration of the velocity distribution[4].

$$Q = \int_0^R u(r)\,2\pi r dr = \pi \left(\frac{\Delta P}{2mL}\right)^{1/n} \left(\frac{n}{3n+1}\right) R^{\frac{3n+1}{n}}$$

Where 'r' is the variable radius of the tube, 'L' is the length and 'u' is the velocity of flow. The equation is only applicable when the following conditions are met, (*a*) a laminar flow has developed a steady state, (*b*) the measurement is conducted under isothermal conditions, and (*c*) the entrance and the exit effects are negligible. The last condition is approximated when the diameter is small and length to diameter ratio is more than hundred[5].

The determination of m and n was accomplished by plotting the logarithm of the volumetric flow rate (Q) versus the logarithm of $\left(\frac{\Delta P}{2L}\right)$. The flow behaviour index was measured as the slope of the straight line obtained from log—log plot while the consistency coefficient was evaluated from the above equation.

Results and Discussion

Pressure drop versus capillary flow data for three varieties of khoa at different stages of processing is summarized in Table 1. The variations of consistency coefficient (m) with different concentrations of the product are shown in Fig. 2, 3 and 4 for the three varieties of khoa. As may be seen from these figures the consistency coefficient of all varieties of khoa remained constant $\left(0.5 \times \frac{10^{-2}\text{kgf–sec}^n}{m^2}\right)$ up to a concentration of 30-35 per cent. The consistency coefficient increased with the increase in concentrations beyond 35 per cent. It increased at a faster rate for higher concentration range of 40 to 60 per cent. The highest value of consistency coefficient was for *pindi* $\left(73.019 \times \frac{10^{-2}\text{kgf–sec}^n}{m^2}\right)$.

It is evident from the Fig. 5, 6 and 7 that the flow behaviour index (n) also remained constant (0.86) for all varieties of khoa up to a concentration of 30-35 per

TABLE 1. PRESSURE DROP VERSUS CAPILLARY FLOW DATA OF THREE VARIETIES OF KHOA AT DIFFERENT TEMPERATURES OF PROCESSING

Pressure drop [(△P) kg/cm²]	134.2°C		126.24°C		116.27°C	
	Total solids (%)	Flow (Q) (10^{-6}m³/sec)	Total solids (%)	Flow (Q) (10^{-6}m³/sec)	Total solids (%)	Flow (Q) (10^{-6}m³/sec)
			Pindi			
0.6	18.75	21.05	17.60	21.00	18.60	—
0.5	18.75	17.62	17.60	17.30	18.60	18.20
0.4	18.75	13.50	17.60	13.30	18.60	13.80
0.3	18.75	10.00	17.60	9.50	18.60	9.90
0.6	31.50	22.05	33.50	21.00	22.71	19.67
0.5	31.50	18.00	33.50	17.25	22.71	17.60
0.4	31.50	15.50	33.50	13.25	22.71	13.50
0.3	31.50	8.65	33.50	9.50	22.71	9.50
0.6	46.01	5.10	44.01	12.60	40.65	—
0.5	46.01	3.45	44.01	8.90	40.65	40.10
0.4	46.01	2.50	44.01	6.65	40.65	34.50
0.3	46.01	1.65	44.01	4.50	40.65	23.50
0.6	54.20	9.30	49.76	5.45	51.10	3.90
0.5	54.20	6.30	49.76	3.70	51.10	3.00
0.4	54.20	3.20	49.76	2.70	51.10	2.20
0.3	54.20	2.20	49.76	1.76	51.10	1.45
0.6	59.50	8.10	54.02	7.30	57.70	—
0.5	59.50	5.65	54.02	5.45	57.70	5.33
0.4	59.50	3.90	54.02	3.85	57.70	3.85
0.3	59.50	2.00	54.02	2.43	57.70	2.40
0.6	64.80	7.15	65.11	5.45	64.60	—
0.5	64.80	4.65	65.11	3.53	64.60	5.30
0.4	64.80	2.95	65.11	1.98	64.60	3.65
0.3	64.80	1.53	65.11	—	64.60	2.10
			Danedar			
0.6	18.60	—	19.70	—	18.50	—
0.5	18.60	17.62	19.70	17.60	18.50	17.60
0.4	18.60	13.50	19.70	13.50	18.50	13.50
0.3	18.60	10.00	19.70	10.00	18.50	10.00
0.6	31.10	—	22.85	—	38.65	—
0.5	31.10	16.50	22.85	17.50	38.65	7.67
0.4	31.10	12.10	22.85	13.50	38.65	5.85
0.3	31.10	9.05	22.85	10.00	38.65	4.10
0.6	39.40	4.25	40.10	9.90	46.40	9.50
0.5	39.40	3.33	40.10	7.75	46.40	7.25
0.4	39.40	2.50	40.10	5.90	46.40	5.50
0.3	39.40	1.74	40.10	4.05	46.40	3.75
0.6	51.55	7.60	53.98	7.60	55.10	7.58
0.5	51.55	5.45	53.98	5.10	55.10	5.80
0.4	51.55	3.70	53.98	3.10	55.10	3.75
0.3	51.55	2.24	53.98	2.32	55.10	2.55
0.6	59.95	—	60.60	8.10	60.15	—
0.5	59.95	6.30	60.60	5.75	60.15	5.75
0.4	59.95	3.80	60.60	3.95	60.15	3.95
0.3	59.95	2.03	60.60	1.65	60.15	2.15
			Dhap			
0.6	19.70	—	18.23	21.00	18.50	—
0.5	19.70	17.63	18.23	17.30	18.50	17.60
0.4	19.70	13.50	18.23	14.10	18.50	13.50
0.3	19.70	10.10	18.23	9.50	18.50	10.00
0.6	34.05	22.37	31.05	17.87	24.30	21.05
0.5	34.05	17.50	31.05	15.30	24.30	17.63
0.4	34.05	13.60	31.05	11.75	24.30	13.50
0.3	34.05	9.50	31.05	8.20	24.30	10.00
0.6	41.50	10.70	39.20	14.70	32.10	18.50
0.5	41.50	8.30	39.20	11.80	32.10	15.10
0.4	41.50	6.33	39.20	8.90	32.10	11.50
0.3	41.50	4.45	39.20	6.10	32.10	8.25
0.6	45.02	4.45	43.05	11.10	40.70	—
0.5	45.02	3.40	43.05	8.75	40.70	49.98
0.4	45.02	2.45	43.05	6.50	40.70	39.00
0.3	45.02	1.63	43.05	4.50	40.70	27.16
0.6	51.80	7.85	51.70	5.75	46.50	11.10
0.5	51.80	5.55	51.70	4.44	46.50	8.70
0.4	51.80	3.75	51.70	3.15	46.50	6.60
0.3	51.80	2.25	51.70	2.07	46.50	3.47
0.6	55.81	7.77	56.05	6.40	54.00	6.67
0.5	55.81	5.17	56.05	4.65	54.00	5.10
0.4	55.81	3.32	56.05	3.15	54.00	3.66
0.3	55.81	1.75	56.05	1.99	54.00	2.35

All values are averages of 5 replicates at each concentration.

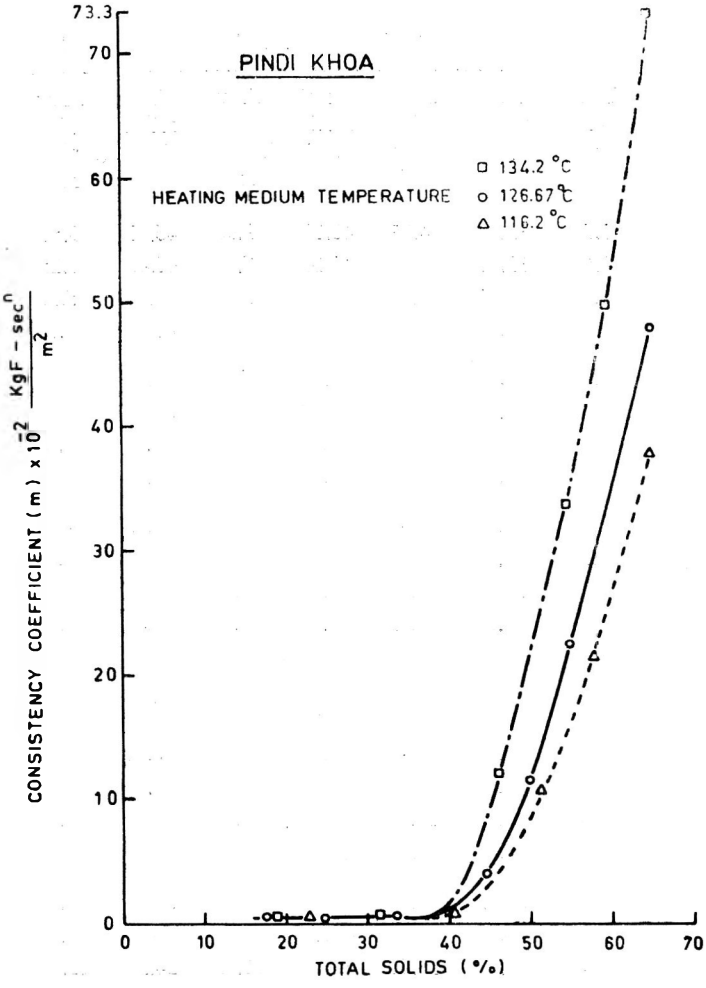

Fig. 2. Variation of consistency coefficient (m) of *pindi* khoa at different stages of processing.

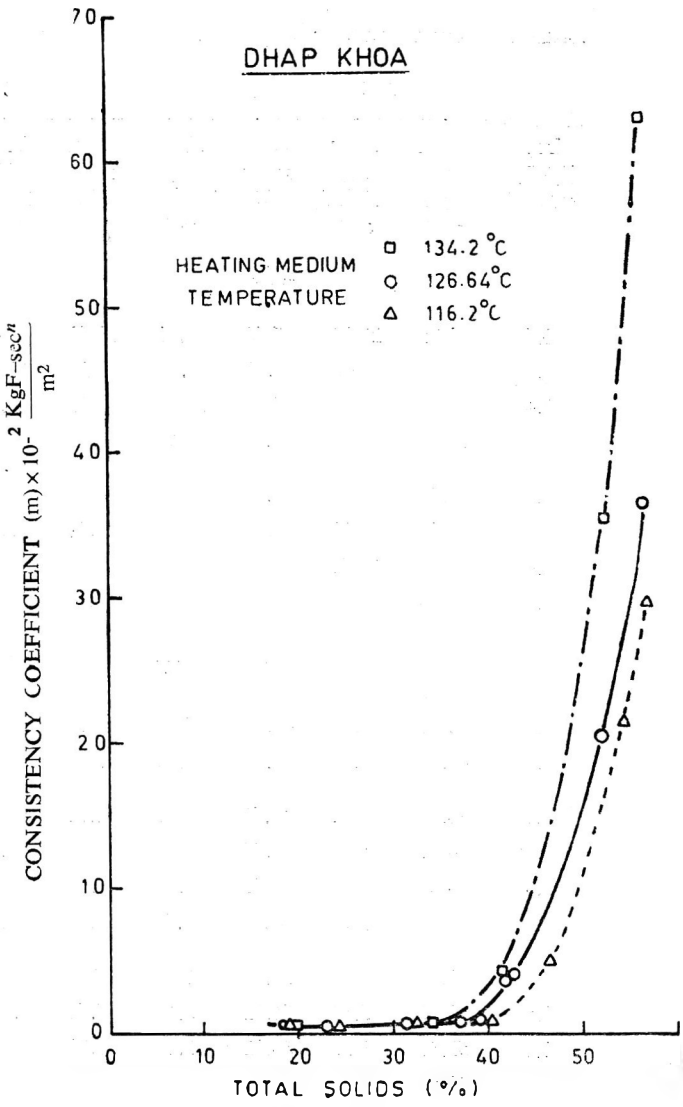

Fig. 3. Variation of consistency coefficient (m) of *Dhap* khoa at different stages of processing.

cent and decreased rapidly beyond this concentration. Amongst the three types of khoa, it decreased most rapidly in *Danedar* as compared to *Pindi* and *Dhap*. As the values of 'n' for all varieties of khoa remained less than unity it indicated the pseudoplastic behaviour of the product at all the concentrations.

The maximum value of consistency coefficient for *Pindi* is due to its lower moisture content. Very little difference was found in the consistencies of *Pindi* and *Danedar* khoa though the latter contains fairly large amount of moisture as compared to the former. The higher value of consistency coefficient of *Danedar* khoa was due to larger suspended particles in the product. Also the fat globules in *Pindi* khoa get ruptured because of working on the product by a wooden block, during later stages of preparation. This leads to the free fat formation in the product and hence imparts higher flowability to it at the elevated temperatures.

The temperature of heating medium for khoa preparation had no effect on the consistency coefficient and flow behaviour index of different varieties in the initial stages of their preparation. But both 'm' and 'n' varied considerably after a concentration of 38 per cent. The consistency coefficient was higher for the product prepared at the higher temperature irrespective of the type of khoa. Contrary to this, the value of flow behaviour index was higher for all varieties of khoa prepared at lower temperature (116.27°C). This might be due to more denaturation of milk proteins at higher temperatures, imparting a more pseudoplastic characteristic to the product. The

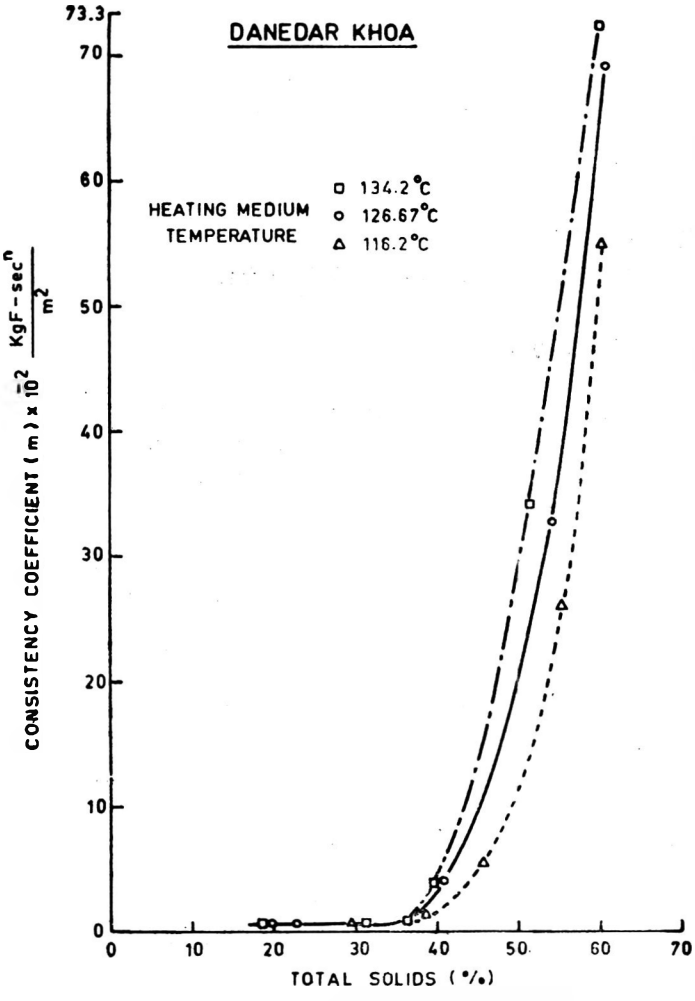

Fig. 4. Variation in consistency coefficient (m) of *Danedar* khoa at different stages of processing.

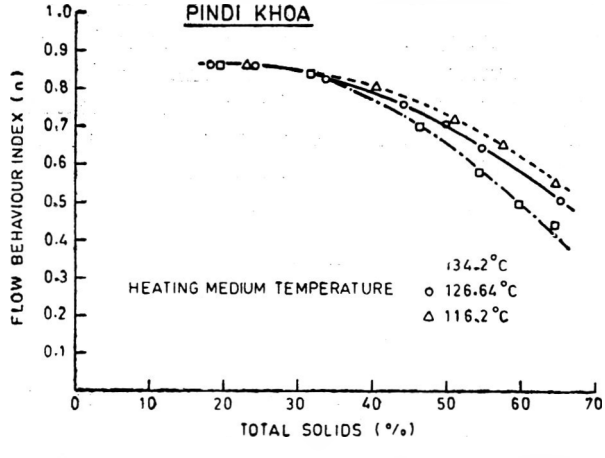

Fig. 5. Variation in flow behaviour index (n) of *Pindi* khoa at different stages of processing.

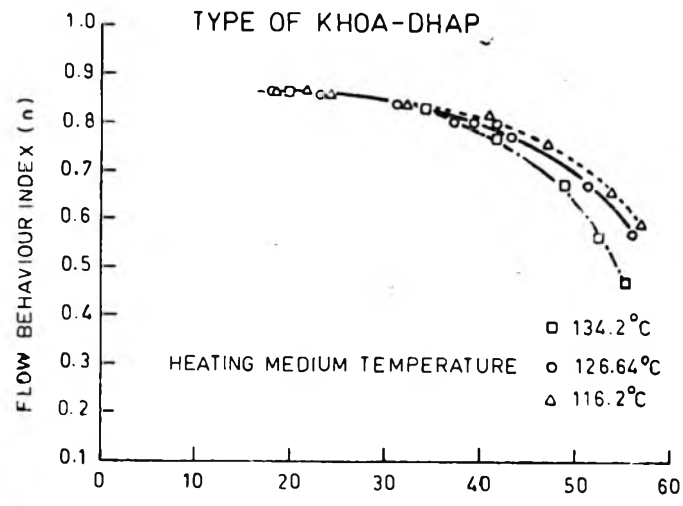

Fig. 6. Variation of flow behaviour index (n) of *Dhap* khoa at different stages of processing.

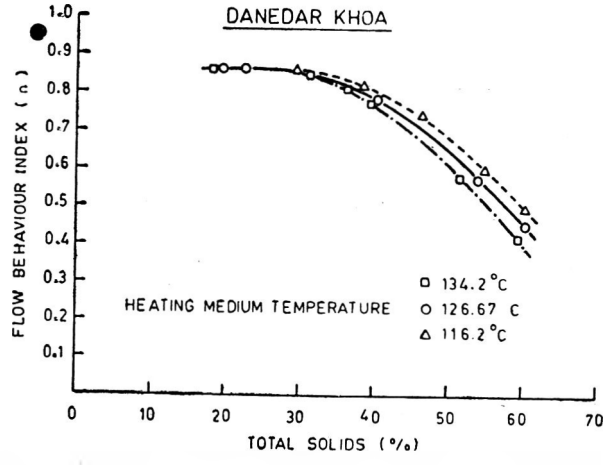

Fig. 7. Variation in flow behaviour index (n) of *Danedar* khoa at different stages of processing.

effect of temperature of processing was found to be more pronounced in *Pindi* khoa because of its higher concentration.

References

1. *Specifications for Khoa*, IS:4883–1980, Indian Standards Institution, New Delhi,
2. Hank, R. C., Hall, C. W. and Hedrick, T. I., Pressure losses and rheological properties of flowing butter. *J. Fd Sci.*, 1966, **31**, 534.
3. Sawhney, I. K., Sarma, S. C., Bikram Kumar and Rajorhia, G. S., Development of village level khoa-pan. *J. Inst. Engrs. India*, 1980, **61**, 13.
4. Heldman, D. R., *Food Process Engineering*, AVI Publishing Co., Connecticut, 1975.
5. Rao, M. A. and Otoyapalomino, L. N., Flow properties of tropical fruit purees. *J. Fd. Sci.*, 1974, **39**, 160.

Rheological Characteristics of Spreadable Butter from Buffalo Cream

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The rheological characteristics of butter at different temperatures were studied to arrive at a range of objective characteristics of a good spreadable butter. It was concluded that a penetration value range of 80-170, extruder thrust range of 0.5-1.2 kg and a minimum oiling off of 0.7% could be assigned for a good spreadable butter. However, no definite range could be assigned for extruder friction, viscostiy and yield stress.

The rheological characteristics of butter are important since about 40 per cent of the sensory score is assigned to body and texture of butter[1]. Due to improved procurement of milk in dairies in the country, the production of butter has increased considerably. Buffalo milk is the major source of butter. There is not much information available on the rheological characteristics of buffalo cream butter. In this study an attempt has been made to fix ranges of objective characteristics within which butter will be graded as suitable for spreading by subjective analysis.

Materials and Methods

Butter: Butter from buffalo fresh cream was prepared in the experimental dairy of National Dairy Research Institute, Karnal, in a Vane power churn (U.S.A.). The butter was stored at 0°C before analysis. The mean composition of butter was fat 80-82 per cent, moisture 16-17 per cent, salt 2 per cent and curd 1-1.5 per cent.

Tempering: Butter exposed to temperatures of 15±1°C, 18±1°C, and 21±1°C, in incubators for 48 hr were analysed for rheological characterstics by objective and subjective methods as mentioned below.

Penetration value: The penetration value (PV) of butter was measured by Universal cone penetrometer made to AOCS[2] specifications.

Spreadability and stickiness: These were measured by using FIRANIRD extruder[3] which recorded the extruder thrust(ET) and extruder friction (EF) respectively. The ET is inversely correlated to the spreadability and EF directly with stickiness of butter (FIRANIRD extruder manual).

Viscosity and yield stress: The viscosity and yield stress (YS) of butter were measured by a modified Stormer's viscometer[4] as follows:

About 50 g of butter was fixed into the sample cup of viscometer at the temperature of analysis. The cup was fixed in position by raising the stand until the apex of the inner cone gets into the hole at the bottom of the outer cylinder. Weights were placed in the weight pan and the time taken for the larger disc to complete one rotation was noted. The weight was gradually increased by units of 10 or 20 g and the angular velocity was determined atleast with 3 such increments. Then the weights were gradually reduced and corresponding angular velocities determined. Then a graph was drawn by plotting weight against angular velocity. From the curve obtained, the YS was calculated.

Oiling Off(OO)*:* Oiling off(OO) of butter was measured by the method of De Man and Wood[5].

Sensory evaluation of butter: The hardness, sprdeadability and stickiness of butter were assessed by a panel of judges from Dairy Technology Section of National Dairy Research Institute, Karnal, who were selected by preliminary screening tests. Each panel member did this by spreading a part of butter on bread with a table knife at a uniform experimental temperature. The panelists were instructed to rate each sample on a seven point scale[6] with descriptive tests at 2 points interval as follows.

Hardness: 1. Very soft, 3. moderately soft, 5. moderately hard, and 7. very hard.

Spreadability: 1. Very easy to spread, 3. suitable to spread, 5. rather difficult to spread, and 7. difficult to spread.

Stickiness: 1. Not sticky, 3. slightly sticky, 5. moderately sticky and 7. very sticky.

Analysis of data: The data obtained were analysed by 1 and 2 factor ANOVA for objective and subjective methods respectively as described by Snedecor and Cochran[7].

Results and Discussion

The mean rheological characteristics of butter measured by objective and subjective methods of analysis are given in Table 1 and Table 2 respectively.

It is observed from Table 1 that the PV of butter increased or the hardness decreased with the increase in temperature. When the same samples were tested for hardness by subjective method of analysis at 15°C, they were graded as moderately hard while the samples at 18°C were graded in between moderately hard and moderately soft. At 21°C the samples were graded between moderately soft and very soft. For butter to be suitable for spreading, it should be neither hard nor sloppy, but should be moderately soft and this grading corresponds to a score of 3 on the sensory scale. In the sensory evaluation at a mean score of 3.5 (Table 2) which approximately corresponds to moderately soft, the PV was 79. At a PV of 224 the butter was judged in between very soft and moderately soft. Therefore, for butter to have desired spreadable character a PV in the range of 80-170 can be assigned. The values of PV reported for butter of good spreadability fall within the range mentioned above[8,9]. In the statistical analysis it was observed that the objective and subjective hardness differed significantly with the temperature of analysis (Table 3 and 4).

The mean ET of butter ranged from 0.34-1.36 kg between 15 and 21°C (Table 1). The mean subjective score corresponded to grades between 'rather difficult to spread' and 'suitable to spread' and 'very easy to spread' or slightly sloppy at 21°C (mean score 2.5). For butter of desired spreadability it should have a score of 3 on the sensory scale which corresponds to 'suitable to spread'. Here, at a sensory score of 2.9 at 18°C the mean ET was 0.43 kg which is very near to 'suitable to spread'. Butter at a sensory score of 2.5 observed at 21°C is slightly sloppy and the corresponding ET is 0.34 kg (Table 1 and 2). At a ET value of 1.36 kg at 15°C the butter was graded nearer to 'rather difficult to spread'. Hence the range of ET for butter of good spreadable characteristics lies between 0.5 and 1.2 kg approximately, which is almost the same as reported by

TABLE 1. MEAN RHEOLOGICAL CHARACTERISTICS OF BUTTER MEASURED BY OBJECTIVE TESTS

Characteristics	15°C	18°C	21°C
Penetration value ($MM \times 10^1$)	52.75	79.00	224.20
Extruder thrust (kg)	1.36	0.43	0.34
Extruder friction (kg/cm)	0.31	0.38	0.53
Oiling off (%)	0.70	1.60	6.00
Viscosity (Poise)	331.00	141.50	29.60
Yield stress (dynes/cm^2)	646.70	373.50	243.40

TABLE 2. MEAN SENSORY SCORE OF BUTTER MEASURED BY SUBJECTIVE TESTS

Characteristics	15°C	18°C	21°C
Hardness	5.0	3.5	2.5
Spreadability	4.1	2.9	2.5
Stickiness	3.1	2.9	3.9

TABLE 3. ANALYSIS OF VARIANCE OF RHEOLOGICAL CHARACTERISTICS OF BUTTER MEASURED BY OBJECTIVE TESTS (F-VALUE)

Treatment	df	PV		ET		EF		OO	
		SS	F-Value	SS	F-Value	SS	F-Value	SS	F-Value
Temperature	2	61106.0	945.0*	2.5	749.8*	0.10	12.70*	63.74	40.2*
Error	6	194.0	—	0.01	—	0.02	—	4.75	—

*Statistically significant

TABLE 4. ANALYSIS OF VARIANCE OF RHEOLOGICAL CHARACTERISTICS OF BUTTER MEASURED BY SUBJECTIVE TESTS (F-VALUE)

Treatment	df	Hardness		Spreadability		Stickiness	
		SS	F-Value	SS	F-Value	SS	F-Value
Temperature	2	38.3	58.8*	23.8	19.9*	9.26	2.9
Error	39	12.7	—	23.5	—	62.13	—

*Statistically significant.

Burki and Fluckiger[10] for butter from cow cream. The statistical analysis indicated that (Table 3 and 4) the objective and subjective spreadability differed significantly among different temperatures of analysis.

The EF of butter increased gradually with increase in temperature. No definite relation was observed at different temperatures between objective and subjective analysis. Statistical analysis showed that the temperature had a significant effect on the objective stickiness (EF) but its effect on subjective stickiness was not significant.

The mean oiling off of butter increased significantly with increase in temperature (Table 1 and 3). Butter samples which were found suitable to spread were having values of oiling off ranging from 1.27 to 1.93 per cent. On earlier occasions, the oiling off of butter suitable for spreading ranged from 0.7 to 39 per cent and hence no definite range could be assigned for oiling off of good spreadable butter. However, based on our present and earlier observations all butter samples with good spreadability had a minimum of oiling off of 0.7 per cent. No value could be assigned for upper limit.

The viscosity was also found to vary significantly with temperature (Table 1). Based on the viscosity values and the mean subjective score, no definite range of viscosity could be assigned for butter of good spreadability.

The mean YS of butter was also affected significantly by temperature (Table 1). In the present study all the butter samples which have been judged as suitable to spread showed YS values which ranged from 344 to 392 dynes/cm^2. In an earlier study[3], a set of butter samples having good spreadability showed a different range of YS (247-292 dynes/cms). The range of values reported by Parekh and Srinivasan[11] was 250-500 dynes/cm^2. Hence from the above data it has not been possible to fix a definite range of YS value for good spreadable butter. The reasons for such variations is not known.

Thus in this study, an attempt has been made to fix a range of values of various objective tests so that the rheological characteristics of butter suitable for spreading could be defined.

References

1. Davies, J. G., *Cheese*, Vol. I, Churchill Ltd., London, 1963.
2. *Consistancy Penetration Method*, CC 16-60, American Oil Chemists society, Washington, 1964, 2nd Edn.
3. De Man, J. M., Voisey, P. W., Rasper, V. F. and Stanley, D. W., *Rheology and Texture in Food Quality*, AVI Publishing Co. Inc., Connecticut, 1976.
4. Chari, S. S. and Awasthy, E. R., Instrument for determining rheological properties of butter at tropical temperatures. *J. Anim. Sci.*, 1970, **41**, 369.
5. De Man, J. M. and Wood, E. W., Oiling off of butter. *J. Dairy Sci.*, 1958, **41**, 369.
6. Dixon B. D., Spreadability of butter. Pilot re-working studies. *Aust. J. Dairy Technol.*, 1967, **22**, 202.
7. Snedecor, G. W. and Cochran, W. G., *Statistical Methods*, Allied Pacific Pvt. Ltd., Bombay, 1956.
8. Dixon, E. D., Spreadability of butter, determination, description and comparison of five methods of testing. *Aust. J. Dairy Technol.*, 1974, **29**, 15.
9. Satish Kulkarni, and Rama Murthy, M. K., Incorporation of safflower oil improve rheological characteristics of whipped buffalo cream butter. *XVIII Dairy Industtry Conference*, 1982.
10. Burki, C. and Fluckiger, E., A Study of spreadability of butter samples at different temperatures. *Proc. XIX Dairy Congr.*, 1974, **1E**, 681.
11. Parekh J. V. and Srinivasan, M. R., Studies on spreadability of table butter from buffalo milk including methods for improvement of same. NDRI Annual Report, 1976, 242.

Lipid and Fatty Acid Composition of Fish and Shell Fish*

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Lipid and fatty acid compositions of five species of lean fish (*Johnius argentatus*, *Chanos chanos*, *Etroplus suratensis*, *Pseudarius jella*, *Tachysurus* sp) and three species of shell fish (*Perna viridis*, *Neptunus pelagicus*, *Macrobrachium rosenbergii*) are reported. Phospholipid content of these samples varied from 0.87 to 0.96% of the tissue, on wet weight basis. Phosphatidyl choline was the major phospholipid in all the species studied. It was found that phospholipids were richer in polyunsaturated acids, compared with neutral lipids. Proportion of monounsaturated acids was less in phospholipids than in neutral lipids.

Fish lipids have been receiving great attention as a source of unsaturated fat in human diet. Data on lipid and fatty acid composition of many Indian fish and shell fish are available[1-5]. However, there are many species whose lipid and fatty acid composition have not been studied. Lipid and fatty acid composition of five species of lean fish and three species of shell fish are reported in this paper.

Materials and Methods

Five species of lean fish, silver jew fish (*Johnius argentatus*, milk fish (*Chanos chanos*), pearl spot (*Etroplus suratensis*, cat fish (*Pseudarius jella* and *Tachysurus* sp.) and three species of shell fish, mussel (*Perna viridis*), crab (*Neptunus pelagicus*), and fresh water prawn (*Macrobrachium rosenbergii*) were used in the study. Fresh fish packed in ice was brought to the laboratory within 2 to 3 hr of catching. Edible portions of fish or shell fish were minced and used for lipid extraction, by the method of Bligh and Dyer[6]. The chloroform extract was washed to remove non-lipid impurities[7], evaporated under vacuum and the lipid samples were stored at–20°C under nitrogen for further analysis. Separation into neutral lipids and phospholipids was done by silicic acid column chromatography[8]. Neutral lipids were eluted with chloroform and phospholipids with chloroform-methanol mixture. All the phospholipid fractions were pooled together, concentrated and analysed by thin layer chromatography on silica gel G plates[9]. Identification of the separated components was done by comparing their R_f values with those of standards and by spraying with specific reagents for phosphate, choline and amino group. Quantitative determination of the components was carried out by determination of phosphorus in the separated spots[9] and by scanning the charred spots with TLC scanner (Hitachi Model 556). Methyl esters of the fatty acids of neutral and phospholipids were prepared according to the AOAC procedure[10] and analysed on a column of Silar 5 CP (10 per cent) on Gaschrom Q, 80/100. Identification and estimation of the components were done as described earlier[3].

Results and Discussion

Lipid content and phospholipid composition of the fishes are given in Table 1. Phospholipid content of the lean fish varied from 0.7 to 0.89 per cent and that of shell fish from 0.86 to 0.97 per cent of the tissue. Phospholipid composition of fish (and shell fish) tissues do not show much variation from species to species[11]. Gopakumar and Rajendranathan Nair[2,5] reported that phospholipid content of fish and shell fish of this region fall within a narrow range. Results of the present investigations are in agreement with these observations.

Phosphatidyl choline was the major phospholipid in all the samples studied. In lean fish, its proportion varied from 55.9 to 63.8 per cent and in shell fish, from 44.0 to 68.9 per cent of total phospholipids. Phosphatidyl ethanolamine content was the second highest component (except in fresh water prawn). Its proportion in lean fish varied from 14.9 to 21.7 per cent of total phospholipids. Fresh water prawn was notable for its very low content of phosphatidyl ethanolamine (8.6 per cent). Phosphatidyl serine, phosphatidyl inositol, sphingomyelin and small quantities of lyso-derivatives of phosphatidyl choline and phosphatidyl ethanolamine were also present in these samples.

Fatty acid composition of neutral and phospholipids

*Forms part of Ph.D. Thesis, of the first author submitted to University of Kerala, 1981.

TABLE 1. PHOSPHOLIPID COMPOSITION OF THE LIPIDS OF FISH AND SHELL FISH

Fish/Shell fish	Sample size (Nos)	Lipids*			Phosphatidyl**				Sphingo-myelin	Phos-phat-idic acid	Lysophosphatidyl		Uniden-tified
		Total	Neutral	Phos-pholi-pid	choline	ethano-lamine	serine	inositol			choline	ethano-lamine	
J. argentatus	9	1.1	0.31	0.77	55.9	19.2	7.5	6.5	2.6	3.0	0.9	1.1	3.3
C. chanos	12	3.5	2.61	0.89	63.8	18.2	3.7	2.7	4.0	2.2	0.5	0.2	4.7
E. suratensis	10	1.9	1.16	0.70	57.9	14.9	7.8	2.8	3.1	Nil	2.5	1.3	10.4
P. jella	15	2.6	1.88	0.74	61.0	17.8	7.3	1.8	3.6	4.1	1.4	1.2	1.8
Tachysurus sp.	15	2.0	1.24	0.73	59.6	21.7	5.6	3.9	3.5	2.6	0.8	0.7	1.5
P. viridis	450	1.3	0.33	0.97	44.0	30.0	7.3	2.0	6.0	0.5	1.2	Nil	8.6
N. pelagicus	60	1.9	0.90	0.96	48.3	23.9	9.7	3.4	5.9	2.9	2.4	1.4	2.0
M. rosenbergii	1.5 kg	1.2	0.34	0.87	68.9	8.6	11.1	1.9	Nil	1.0	1.8	0.8	6.0

*% of tissue on wet weight basis
**% of phospholipid

TABLE 2. FATTY ACID COMPOSITION (% BY WEIGHT) OF NEUTRAL LIPIDS OF FISH AND SHELL FISH

Fatty acids	*C. chanos*	*E. suratensis*	*Pseudarius* sp	*Tachysurus*	*J. argentatus*	*M. rosenbergii*	*P. viridis*
12:0	0.1	0.6	0.2	0.2	0.6	2.7	0.2
13:0	0.1	Nil	0.1	Nil	0.2	0.8	0.1
14:0	1.2	1.9	3.4	1.2	3.0	4.0	6.7
15:0	2.9	0.7	1.1	0.7	2.1	2.7	2.3
16:0	23.8	21.8	21.4	27.9	20.3	18.4	20.2
18:0	11.7	12.2	10.7	10.2	11.3	7.6	6.0
Total	39.8	37.2	36.9	40.2	39.2*	36.2	35.5
16:1	7.7	9.0	9.8	10.6	13.5	7.5	11.6
18:1	22.0	24.8	16.3	18.7	12.0	18.2	4.6
20:1	Nil	Nil	Nil	0.4	Nil	Nil	5.3
22:1	1.5	Nil	Nil	Nil	Nil	Nil	5.2
Total	31.2	33.8	26.1	30.1[a]	25.5	25.7	26.7
18:2	3.3	4.3	3.1	1.5	3.7	12.8	1.6
18:3	4.1	5.8	3.2	2.1	3.7	3.6	Nil
20:2	3.9	3.1	1.6	0.9	2.1	3.5	3.0
20:3	1.5	2.0	0.8	Nil	1.6	Nil	Nil
20:4	6.2	5.0	5.0	3.4	6.6	3.3	2.9
20:5	3.1	1.3	6.4	3.6	5.3	2.4	13.0
22:3	Nil	0.9	1.8	1.0	1.2	0.9	Nil
22:4	Nil	1.4	1.4	1.4	1.7	1.4	2.0
22:5	2.3	3.1	3.3	3.3	2.3	2.7	1.7
22:6	2.8	2.4	10.1	12.4	7.2	8.6	13.4
Total	27.2	29.0	37.0[b]	29.6	35.4	38.2	37.6

*1.7% of 19:0 was also present *a* 0.4% of 14:1 was present *b* 0.3% of 18:4 was present.

TABLE 3. FATTY ACID COMPOSITION (% BY WEIGHT) OF PHOSPHOLIPIDS OF FISH AND SHELL FISH

Fatty acids	*C. chanos*	*E. suratensis*	*Pseudarius* sp	*Tachysurus* sp	*J. argentatus*	*M. rosenbergii*	*P. viridis*
12:0	2.7	1.3	3.2	2.0	0.5	0.5	Nil
13:0	2.8	1.3	0.3	2.0	0.5	1.4	Nil
14:0	4.0	1.3	3.6	1.3	0.9	2.3	2.2
15:0	Nil	1.5	2.1	3.5	1.0	1.5	3.6
16:0	16.7	16.3	11.9	14.8	15.9	15.7	10.0
18:0	12.8	10.9	13.7	11.4	12.0	12.6	3.3
Total	39.0	32.6	34.8	35.0	30.8	34.0	19.1
13:1	1.7	Nil	Nil	0.5	0.3	Nil	Nil
14:1	Nil	Nil	1.3	Nil	Nil	1.3	5.8
15:1	Nil	Nil	Nil	Nil	Nil	1.8	8.2
16:1	4.5	4.6	4.1	4.9	5.5	7.1	7.7
18:1	18.0	15.3	14.8	13.4	10.2	21.9	2.5
20:1	Nil	Nil	Nil	Nil	1.8	Nil	5.3
22:1	3.5	Nil	Nil	Nil	Nil	Nil	5.0
Total	27.7	19.9	20.2	18.8	17.8	32.1	34.5
18:2	2.8	3.3	1.6	1.4	1.0	7.7	2.7
18:3	2.9	3.4	0.7	1.6	1.7	2.7	5.0
20:2	2.6	2.1	Nil	2.7	1.0	1.4	2.1
20:3	0.6	2.9	0.7	Nil	0.9	Nil	1.3
20:4	7.6	10.1	9.5	8.2	12.9	8.4	5.1
20:5	4.8	3.8	7.1	4.9	6.8	7.4	8.3
22:3	Nil	1.1	0.8	1.9	2.5	1.0	3.4
22:4	Nil	1.6	2.0	2.8	5.1	1.1	3.9
22:5	2.7	5.3	2.5	2.9	2.4	0.6	3.2
22:6	9.2	14.1	19.3	19.8	17.9	3.7	11.6
Total	33.2	47.7	44.9*	46.2	51.3	34.0	46.5

*18:4, 0.7%

of the fish and shell fish studied are given in Tables 2 and 3. In general, it was found that phospholipids were richer in polyunsaturated acids compared to neutral lipids. However, the neutral lipids of fresh water prawn was found to have higher levels of polyunsaturated acids than the phospholipids. This species had an unusually high level of $C_{18:2}$ acid (12.8 per cent in neutral lipids). Proportion of $C_{22:6}$ acid was significantly high in the phospholipid fraction, except in the two shell fish. Proportion of monounsaturated acids was low in all the samples studied. Similar low levels of monounsaturated acids had been reported for several other species[12,13]. In the present case it was found that neutral lipids were richer in monounsaturated acids compared with phospholipids.

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References

1. Gopakumar, K. and Rajendranathan Nair, M., Fatty acid composition of eight species of Indian marine fish. *J. Sci. Fd Agric.*, 1972, **23**, 493.
2. Gopakumar, K. and Rajendranathan Nair, M., Lipid composition of five species of Indian prawns. *J. Sci. Fd Agric.*, 1975, **26**, 319.
3. Viswanathan Nair P. G. and Gopakumar, K., Fatty acid compositions of 15 species of fish from tropical waters. *J. Fd Sci.*, 1978, **43**, 1162.
4. Ramachandran Nair, K. G. and Gopakumar, K., Fatty acid composition of marine fish body fat. *J. Fd Sci. Technol.*, 1977, **14**, 268.
5. Gopakumar, K. and Rajendranathan Nair, M., Phospholipids of five species of Indian food fishes. *Fish. Technol.*, 1971, **8**, 171.

6. Bligh, E. G. and Dyer, W. J., A rapid method of total lipid extraction and purification. *Can. J. Biochem. Physiol.*, 1959, 37, 911.

7. Radin, N.S., Preparation of lipid extracts, in *Methods in Enzymology*, by M. Lowenstein (Ed.), Academic Press, New York, Vol. **14**, 1969, 245.

8. Sweeley, C. C., Chromatography on columns of silicic acid, *Methods in Enzymology* by M. Lowenstein (Ed.), Academic Press, New York, Vo. **14**, 1969, 254.

9. Parker, F. and Peterson, N. F., Quantitative analysis of phospholipids and phospholipid fatty acids from silica gel thin-layer chromatograms. *J. Lipids Res.*, 1965, 6, 455.

10. *Official Methods of Analysis*, Association of Official Analytical Chemists, Washington D. C., 12th Edn., 1975.

11. Lovern, J. A., The lipids of fish and changes occurring in them during processing and storage, in *Fish in Nutrition*, by E. Heen, and R. Kreuzer, (Eds.), Fishing News Books, London, 1962, 86.

12. Silk, M. H. and De Koning, A. J., Phospholipids of the South African pilchard (*Sardina ocellata Jenyns*). *J. Am. Oil Chem. Soc.*, 1964, **41**, 619.

13. Ackman R. G. and Burgher, R. D., Cod flesh: Component fatty acids as determined by gas-liquid chromatography. *J. Fish. Res. Bd Can.*, 1964, **21**, 367.

Effect of Phosphorus on Fatty Acids of Tea Leaves and on the Quality of Teas

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In Assam type tea leaf, fatty acids present are decanoic, lauric, myristic, stearic, palmitic, palmitoleic, oleic, linoleic and linolenic acids, of which, oleic, linoleic, palmitic and linolenic acids form a major part. Phosphorus added through fertilizer (at 45 or 180 kg per hectare as P_2O_5) appears to have no effect on the composition of fatty acids, but oleic acid and linolenic acid appear to decrease with increased doses of phosphorus. Teas with less oleic and linolenic acids are preferred by tea tasters.

In black teas[1-2], linoleic and linolenic acids are shown to be the precursors of hexanal and *trans*-2-hexanal respectively. During fermentation, in the preparation of black tea, linoleic and linolenic acids decrease and hexanal and *trans*-2-hexanal increase[3]. Hatanaka *et al*[4]. have shown that *cis*-3-hexenal, *trans*-2-hexanal and *n*-hexanal were generated by an enzyme bound to lamellae of chloroplasts in tea leaves, when the leaves were cut or mechanically ruptured in the presence of oxygen. Wright and Fishwich[5] reported that lipid breakdown in tea leaves is complete after 2 hours of fermentation. However, there is no report available on the role of fatty acids in tea quality. In the present study an attempt is made to quantify some of the fatty acids in tea leaves, their changes by phosphorus fertilizers and to correlate the fatty acid in leaves with tea quality.

Materials and Methods

Tea leaves from clone 'TV 2' (Assam variety) from the bushes receiving 0, 45 and 180 kg P_2O_5 with a basal dose of 135 kg N and 45 kg of K_2O per hectare during March were collected from the experimental plot of Tocklai Experimental Station at fortnightly intervals from May to November. Leaves were steamed for one minute and dried using hot air flow at 60°C.

Fatty acids were extracted from tea leaves following the method used by Saijo and Takeo[1]. Five gram of dried leaves were ground to powder and extracted with 100 ml of chloroform and methanol mixture (2:1) for 5 hr with continuous stirring in cold room at 10°C. Extracts were concentrated under reduced pressure to give crude lipid fractions. Fatty acids were converted to methyl esters with diazo-methane after which they were analysed by gas chromatography as reported by Sukhija and Bhatia[6].

Theaflavins (TF) and thearubigins (TR) were estimated by the method of Roberts and Smith[7]. Teas were tasted by Tocklai and London tasting panels.

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TABLE 1. FATTY ACID COMPOSITION OF TEA LEAF (CLONE 'TV2')

Fatty acid components	12/5	26/5	23/6	7/7	21/7	Average
Decanoic	7.8	10.6	5.3	7.5	3.6	6.96
Lauric	7.8	10.6	5.3	7.5	3.8	7.00
Myristic	13.6	8.2	6.3	7.5	3.6	7.84
Palmitic	30.1	20.8	36.0	37.9	32.9	31.54
Palmitoleic	1.2	2.0	1.0	3.7	1.5	1.88
Stearic	2.4	2.3	1.8	3.7	2.0	2.64
Oleic	6.0	14.0	10.2	9.5	13.5	10.64
Linoleic	14.0	16.0	15.2	9.8	14.1	13.82
Linotenic	15.5	15.5	18.9	12.3	24.0	17.24
Total	93.4	100.0	100.0	99.4	100.0	99.56

TABLE 2. EFFECT OF PHOSPHORUS ON THE FATTY ACID COMPOSITION IN ASSAM TYPE TEA LEAF

Fatty acid components	P_0	P_{45}	P_{180}
Decanoic	4.97	5.00	6.96
Lauric	5.04	5.00	7.00
Myristic	5.04	5.78	7.84
Palmitic	30.30	30.90	31.54
Palmitoleic	2.83	2.04	1.88
Stearic	2.87	2.24	2.64
Oleic	14.03	12.68	10.64
Linoleic	15.42	15.88	13.82
Linolenic	19.80	18.88	17.24
Total	100.30	98.40	99.56

Results and Discussion

The fatty acid composition in tea leaves of Assam variety, namely clone 'TV 2' are presented in Table 1. Results show that major fatty acids are palmitic, oleic, linoleic and linolenic and minor ones are decanoic, lauric, stearic, myristic and palmitoleic acids. However, in Japanese tea, lauric, myristic, stearic, oleic, linoleic and linolenic acids are noteworthy, of which, linoleic and linolenic acids are quite high in the phospholipid fractions. Hatanaka *et al*[4]. recorded only traces of free fatty acids in tea leaf but non-ionic lipids and phospholipids fractions contained palmitic acid 53.2 mg, linoleic acid 32.3 mg and linolenic acid 172.4 mg per 100 g of fresh leaf. They have also shown that linolenic acid and linoleic acid do not show marked variation except a big peak in October. Our results from early May to late July show that oleic acid and linolenic acid increased during late July while there was no change in the total fatty acids (Table 1). Since *trans*-2-hexenal is derived from linolenic acid and it increases from April reaching a maximum in July as reported by Hatanaka *et al*[4]. lends support to our observation. However *trans*-2-hexenal content in Japanese tea declines in autumn and reaches a minimum value in December.

The fatty acid composition in tea leaves from bushes which received 0, 45 and 180 kg P_2O_5/ha are presented in Table 2. Phosphorus application did not seem to have any significant impact on the total quantity of fatty acids. However, a gradual fall in the concentrations of oleic acid and linolenic acid and increase in the palmitic acid was noticed with the increased dose of phosphorus.

Tea quality showed a marginal improvement with the increased dose of phosphorus. Theaflavins and thearubigins which are considered to be responsible for quality of tea, were of almost similar concentration in the teas, but their ratio showed a marginal increase in the teas from leaves with higher dose of phosphorus (Table 3). Interestingly, tasters valuations were higher in teas with higher dose of phosphorus. Scores given by London tasting panel clearly show preference for teas from leaves with increased dose of phosphorus. Improvement of tea quality by phosphorus application was also reported by Salukvadze[8] and Rahman *et al*[9].

Total fatty acid in leaves appeared to have no correlation with tasters valuation. However, oleic and linolenic acids showed a gradual decline with the increased dose of phosphorus (Table 4). Incidentally, tasters marks also increased with the decreased levels of oleic acid and linolenic acid.

TABLE 3. EFFECT OF FERTILIZER PHOSPHORUS ON TEA QUALITY

P_2O_5 (kg/ha)	Chemical assessment			Tasters valuation	
	Theaflavins (%)	Thearubigins (%)	TF/TR	Tocklai scores/kg	London scores/kg
0	2.04	15.56	0.131	7.30	7.53
45	2.03	15.15	0.133	7.32	7.80
180	2.08	15.51	0.134	7.65	7.93

Each value is the average of 15 replication.

TABLE 4. CORRELATION OF TASTERS SCORE ON TEAS WITH SOME FATTY ACID COMPONENTS OF TEA LEAF

Fatty acid	P_0	P_{45}	P_{180}
Total fatty acids	100.30	98.40	99.56
Oleic acid	14.03	12.68	10.64
Linoleic acid	15.42	15.88	13.82
Linolenic acid	19.30	18.88	17.24
London taster's score	7.53	7.80	7.93

It has been shown by Saijo[3] that linoleic acid and linolenic acid undergo change to hexanoic acid and *trans*-2-hexenoic acid through hexanal and *trans*-2-hexenal respectively. The oxidation was initiated by lipoxygenase. It is not known whether hexanal, *trans*-2-hexenal and their acids are detrimental to tea quality. This aspect needs a closer study in view of the fact that Takeo and Tsushida[10] claimed that lipoxygenase activity is higher in the good fermenting clones than in the corresponding poor fementing clones. If hexanoic acid or *trans*-2-hexenoic acids are the end products of linoleic acid and linolenic acid respectively during fermentation which show a progressive increase with the increase in the lipoxygenase activity of leaf, excessive accumulation of these acids may cause variations in tea quality. Therefore, a coordinated study of the linoleic acid, linolenic acid, lipoxygenase activity, degradation products of linoleic acid and linolenic acid and tea quality is necessary. This may help in selecting quality clones for planting in new areas.

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References

1. Saijo, R. and Takeo, T., The importance of linoleic acid and linolenic acid as precursor of hexanal and *trans*-2-hexenal in black tea. *Plant Cell Physiol.*, 1972, **13**, 991.
2. Saijo, R., Study of black tea aroma in special reference to formation of volatile carbonyl compounds. *Japan Agric. Res. Quart.*, 1973, **7**, 202.
3. Saijo, R., Biochemical studies on the formation of volatile compounds in black tea. *Bull. Natl. Res. Inst. Tea.*, 1973, **48**, 171.
4. Hatanaka, A., Kajiwara, T. and Sekiya, J., Seasonal variations in *trans*-2-hexenal and linolenic acid in homogenates of *Thea sinensis* leaves. *Phytochem.*, 1976, **15**, 1889.
5. Wright, A. J. and Fishwich, M. J., Lipid degradation during manufacture of black tea. *Phytochem.*, 1978, **18**, 1511.
6. Sukhija, P. S. and Bhatia, I. S., Lipids of taramira (*Eruca sativa*) and linseed (*Linum usitatissimum*). Tentative identification of various components and their fatty acids make up. *Indian, J. Biochem.*, 1970, **7**, 271.
7. Roberts, E.A.H. and Smith, R. F., Spectrophotometric measurements of theaflavins and thearubigins in black tea liquor in assessment of quality in teas. *Analyst, Lond.*, 1961, **86**, 94.
8. Salukvadze, M. M., Effect of doses of phosphorus fertilizer on qualitative indices of the tea leaf. *Sub. Trop. Kult.*, 1980, **5**, 28.
9. Rahman, F, Bhagawaty, H., Basu, R., Choudury, R., Das, A.K., Dutta, S. K., Gilchrist, R. C., Sharma K. N. and Trinick, J. M., Effect of different field management practice on cup characters and valuation of teas. *Two Bud*, 1978, **25**, 86.
10. Takeo, T. and Tsushida, T., Changes in lipoxygenase activity in relation to lipid degradation in plucked tea shoots. *Phytochem.*, 1980, **19**, 2521.

Evaluation of Some Chemical Methods for the Measurement of the Progress of Oxidative Deterioration in Edible Oils

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Peroxide value (PV), anisidine value (AV), Kreis value (KV), diene value (DV) were compared for their suitability to monitor oxidative deterioration in edible oils. Groundnut, mustard, sesame, safflower and coconut oils were stored at 20-27 (ambient), 30 and 37°C for 20 weeks. Oil samples were analysed periodically for the above parameters and were found to be reliable indices of autoxidation in groundnut oil; AV being more accurate and consistent. Very low values for the methods were obtained for sesame and mustard oils. For safflower oil a negative correlation was observed between the chemical indices and storage temperature besides values being very high. Coconut oil failed to respond to any of these parameters.

Autoxidation is the major cause of deterioration of fats and oils and fatty foods. The unsaturated fatty acids of food lipids are the primary target of oxidation accompanied by various secondary reactions leading to off-flavour and rancidity. The rate of oxidation increases geometrically with the number of double bonds. Temperature, light and heavy metals like iron and copper accelerate the reaction. Because of the complexity of the end products and the factors influencing the reaction kinetics, attempts to quantify the rancidity of food products have met with limited success. Labuza[1] has reviewed the kinetics of lipid oxidation in foods. Gray[2] has discussed various chemical and physical methods for the measurement of rancidity and their correlation with organoleptic evaluation.

There are quality standards for rancidity of fats and oils prescribed by various national and international agencies based on peroxide value (PV). The validity of PV to monitor rancidity has been questioned on many grounds. The peroxides *per se* are odourless and the off-flavour or rancidity is caused by the secondary degradation products and hence PV is not a direct measurement of odouriferous compounds. Furthermore, the rate of oxidation depends on the degree of unsaturation and storage conditions of the fats and oils. It is therefore, argued that PV as a standard for rancidity of all fats and oils with a single limit value is without sufficient scientific basis. Several workers have compared various chemical parameters for their suitability to quantify rancidity of fats and oils with varying degree of success. In India, number of oils with widely differing unsaturation and storage histories are consumed. A study was, therefore, undertaken to find suitable chemical parameters that can monitor the extent of oxidative deterioration of the popular edible oils of this country.

Materials and Methods

Coconut, groundnut, sesame, mustard and safflower oils of unrefined quality were stored in clean tin containers. Surface to volume ratio and head space were identical for all the samples. Oils were stored at ambient (20-27°C), 30 and 37°C. Samples withdrawn periodically were analysed for PV[3], anisidine value (AV)[4], kreis value (KV)[5], diene value (DV)[6], thiobarbituric acid value (TBAV)[7] and refractive index (RI)[8].

For the determination of AV, two methods (IUPAC[9] and a modified method of Jirousova[4]) were compared and the modified method was found more reliable and reproducible and hence it was followed. A known quantity of the fat sample (10-50 mg) was taken in chloroform (2 ml) and 4 ml of 1.5 per cent TCA in alcohol followed by 4 ml of 0.25 per cent p-anisidine (recrystallised) in alcohol were added. The tubes were stoppered and mixed well and incubated at 60°C in a water bath for 60 min. The colour was measured at 400 nm. The result was expressed following the formula.

$$A.V. = \frac{(E - E_0 - E_1).10}{n}$$

where

E=extinction of sample; E_0=extinction of blank; E_1=extinction of fat solution and n=weight of fat in grams.

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TABLE 1. PEROXIDE VALUES (MEQ O_2/KG FAT) OF OILS ON STORAGE

Oil	Storage temp. (°C)	Period of storage in weeks							
		0	3	6	9	12	15	18	20
Groundnut	20–27	1.5	1.5	2.5	4.8	6.9	11.0	11.2	14.0
	30	1.5	2.0	4.5	8.2	15.2	22.0	20.3	29.7
	37	1.5	1.7	6.8	13.2	20.0	33.1	27.0	42.2
Mustard	20–27	1.5	4.5	10.0	9.7	9.8	9.7	10.0	9.5
	30	1.5	5.2	12.0	13.0	11.5	10.5	11.0	10.5
	37	1.5	5.4	11.0	13.5	12.9	11.0	10.0	10.0
Sesame	20–27	2.0	2.8	2.4	4.8	6.6	3.5	4.1	4.7
	30	2.0	2.9	3.2	5.4	6.4	4.8	4.7	5.3
	37	2.0	3.9	3.7	6.2	6.8	8.3	6.8	7.9
Safflower	20–27	3.0	18.4	26.5	58.0	58.0	65.0	73.0	83.0
	30	3.0	36.0	45.0	54.4	55.0	63.0	72.0	73.0
	37	3.0	27.5	37.1	40.6	41.0	45.0	48.0	44.0

Values for coconut oil were <0.5 for all the temperatures studied.

By this method very high numerical values were obtained compared to the corresponding values, obtained by IUPAC.

Results

Peroxide value: PV are presented in Table 1. PV for groundnut oil registered a progressive increase with the period of storage at all temperatures. A significant difference in the PV due to the temperature of storage was observed, i.e., the rate of peroxide development was higher at higher temperature. Mustard and sesame oils showed somewhat similar pattern of PV, though the values for sesame oil were very low. After a slight increase in the initial stages, PV for mustard oil did not

TABLE 2. ANISIDINE VALUES OF OILS ON STORAGE

Oil	Storage temp. (°C)	Period of storage in weeks							
		0	3	6	9	12	15	18	20
Groundnut	20–27	20	20	20	20	29	49	58	72
	30	20	20	30	44	67	106	185	232
	37	20	20	60	72	87	186	215	272
Mustard	20–27	30	77	100	119	191	195	205	340
	30	30	91	127	127	167	185	191	364
	37	30	95	125	129	135	190	211	370
Sesame	20–27	20	22	57	62	53	61	64	55
	30	20	29	65	41	52	68	69	56
	37	20	49	65	61	53	54	65	77
Safflower	20–27	50	138	197	437	450	495	504	603
	30	50	191	311	508	520	540	541	613
	37	50	198	254	451	470	450	409	435
Coconut	20–27	—	—	—	5	5	10	15	20
	30	—	—	—	5	5	10	15	27
	37	—	—	—	5	5	10	20	35

increase till the end of the storage period. The increase of PV for sesame oil was very slow and small compared to other oils. Both mustard and sesame oil did not show any significant difference in their PV due to temperature of storage. Safflower oil followed an interesting pattern of peroxide development different from other oils. Very sharp increase in PV was recorded at the initial stages of storage for all temperatures. The measurable PV was highest for the sample stored at ambient followed by 30 and 37°C in that order. PV was very high for safflower oil. Coconut oil did not record PV more than 0.5 throughout the storage period.

Anisidine value: Table 2 shows AV of the oils on storage. Groundnut oil recorded a steady increase in AV after an initial lag period. There was a marked difference in AV of the groundnut oil stored at different temperatures; at 37°C the rate of increase was highest followed by 30°C and ambient. Though mustard oil also registered a progressive increase of AV, the effect of storage temperature was not very significant. Nevertheless AV was a better index than PV for mustard oil. There was no substantial increase in AV for sesame oil due to storage or temperature. Safflower oil at ambient and at 30°C recorded a steady increase in AV; the rate of increase being higher at 30°C. As observed for PV, safflower oil stored at 37°C showed a lower rate of increase for AV. Coconut oil did not give any measurable AV though towards the end of storage it gave very low values.

Kreis value: Kreis values are recorded in Table 3. KV for groundnut oil were consistent with the pattern of PV and AV with respect to temperature and period of storage. Mustard oil also showed an increase in KV but the rate of increase was fairly uniform for all the temperatures. Sesame oil exhibited a similar trend but at a slower rate of increase. Safflower oil at ambient temperature recorded the maximum rate of increase, but at 30 and 37°C the rate of increase was reduced significantly as observed for other parameters of this oil. Coconut oil failed to respond to KV during the storage period.

Diene value: Table 4 indicates the DV of the oils. DV of groundnut oil followed a similar pattern as observed for other parameters suggesting consistency among these parameters. Influence of storage temperature was also reflected in DV as higher rate of increase was noticed at 30 and 37°C. Mustard and sesame oil did not show any specific trend with respect to storage period or temperature. The values were erratic and did not increase significantly. Safflower oil registered a progressive increase in DV with the time of storage. However, the rate of increase was decreased at 37°C as observed in PV, AV and KV. There was no measurable DV for coconut oil.

Thiobarbituric acid value and refractive index: No measurable colour could be developed to obtain TBA value for any of the oil samples by this method. The increase in RI was too low to be of any practical significance. Hence, values for TBA and RI are not recorded.

Discussion

The oils selected for this experiment are popular

TABLE 3. KREIS VALUES (O.D./G FAT) OF OILS ON STORAGE

Oil	Storage temp. (°C)	Period of storage in weeks							
		0	3	6	9	12	15	18	20
Groundnut	20–27	0.25	0.25	0.25	0.34	0.38	0.40	0.73	0.70
	30	0.25	0.25	0.30	0.41	0.76	0.60	1.00	1.30
	37	0.25	0.26	0.39	0.63	1.00	1.00	1.30	1.90
Mustard	20–27	0.30	0.28	0.60	0.54	0.75	0.80	0.89	0.75
	30	0.30	0.43	0.77	0.49	0.77	0.80	0.77	0.82
	37	0.30	0.43	0.74	0.57	0.96	0.90	1.00	0.84
Sesame	20–27	0.20	0.20	0.23	0.23	0.17	0.22	0.18	0.33
	30	0.20	0.20	0.31	0.29	0.29	0.24	0.16	0.32
	37	0.20	0.25	0.32	0.25	0.30	0.28	0.30	0.47
Safflower	20–27	0.50	1.84	2.81	2.50	3.30	3.20	3.90	3.10
	30	0.50	1.16	1.65	2.70	3.30	3.10	3.80	3.30
	37	0.50	1.10	1.85	2.30	3.25	2.90	3.10	2.70

Values for coconut oil were not significant.

TABLE 4. DIENE VALUES (%) OF OILS ON STORAGE

Oils	Storage temp. (°C)	Storage period in weeks 0	4	8	12	16	20
Groundnut	20–27	0.153	0.221	0.231	0.243	0.278	0.395
	30	0.153	0.221	0.240	0.256	0.279	0.603
	37	0.153	0.227	0.263	0.255	0.443	0.739
Mustard	20–27	0.200	0.200	0.235	0.250	0.270	0.276
	30	0.200	0.258	0.268	0.270	0.273	0.283
	37	0.200	0.258	0.268	0.275	0.286	0.307
Sesame	20–27	0.210	0.210	0.210	0.255	0.277	0.320
	30	0.210	0.210	0.250	0.268	0.311	0.355
	37	0.210	0.210	0.262	0.296	0.353	0.359
Safflower	20–27	0.350	0.550	0.764	0.850	1.070	1.450
	30	0.350	0.580	0.790	1.210	1.450	1.490
	37	0.350	0.458	0.588	0.855	0.949	1.230

Values for coconut oil were very low.

edible oils, used in different regions of the country. These oils have widely varying unsaturation which is useful to test the reliability of any particular chemical method to monitor rancidity in the range of temperature prevailing in our country. Groundnut oil seems to respond to PV, AV, KV and DV over the period of storage and in the temperatures tested. There was a progressive increase for all these values with the time of storage. The influence of temperature of storage was also reflected in the values suggesting that any of these chemical parameters could be used to indicate rancidity of groundnut oil; AV being more reliable for its sensitivity and reproducibility. However, the rancidity of any oil indicated by chemical methods must be corroborated by organoleptic evaluation before it is adopted for practical purposes.

The results indicate that sesame oil is very resistant to oxidation as there was very little change in PV, AV, KV and DV over the time and temperatures of storage. It is difficult, therefore, to state the stage of rancidity of sesame oil based on these values. Mustard oil also showed more or less similar trend except that the rate of increase was higher. Among the parameters, only AV showed linear increase with the period of storage with minimum of influence by temperature in mustard oil. Therefore, this appears to be of practical significance to indicate rancidity in mustard oil. Though the values in safflower oil recorded a progressive increase with time of storage, the rate of increase was highest at ambient followed by at 30 and 37°C in that order indicating a negative correlation with the temperature of storage. Therefore, the rancidity of safflower oil cannot be established because of the interaction of the temperature. The fact that coconut oil did not respond to the methods used here shows the limitations of chemical parameters to indicate rancidity of oils with widely varying chemical characteristics.

Chemical characteristics of the oils used for this investigation are presented in Table 5. The incompatible behaviour of the chemical parameters in different oils could be explained by the chemical composition of the oils. The analytical methods used here are based on certain chemical changes brought about during primary and secondary stages of the oxidation. PV indicates the amount of peroxides, formed by the reaction between atmospheric oxygen and unsaturated fatty acid during

TABLE 5. FATTY ACIDS (F.A.) CONTENT OF OILS

Oil	Total saturated f.a. (%)	Total unsaturated f.a. (%)	Monoene f.a. (%)	Diene f.a. (%)	Polyene f.a. (%)
Groundnut	20.0	80.0	53.0	27.0	—
Mustard	5.0	95.0	73.0	15.0	7.0
Sesame	14.0	86.0	45.0	41.0	—
Safflower	10.0	90.0	14.0	75.0	1.0
Coconut	91.0	9.0	7.0	2.0	—

the primary stage of oxidation. DV is the amount of conjugated fatty acids formed by the isomerization of unsaturated peroxides. AV and KV measure secondary breakdown products like unsaturated carbonyl compounds derived from fatty acids containing two or more double bonds. It can, therefore, be said that the rate of oxidation is the function of unsaturation, particularly the diene and polyene fatty acids. Failure of coconut oil to respond to the chemical methods can be attributed to very little unsaturation of the oil. On the contrary, safflower oil contains very high amount of diene acids (75 per cent) and hence highly vulnerable to oxidation especially in the absence of natural inhibitors. Very high values for PV, AV, KV and DV for safflower oil could, therefore, be correlated with the high diene content. At higher temperature, the peroxides and unsaturated carbonyls further breakdown to other end products. This would explain the lower values for safflower oil stored at 37°C compared to ambient and 30°C.

Sesame and mustard oils, though very unsaturated with 41 and 15 per cent diene fatty acids (18:2) respectively, in addition to 7 per cent triene fatty acid (18:3) in the latter, are resistant to oxidation; sesame oil being more resistant. Resistance to oxidation is reflected in the low values for PV, AV, KV and DV. Sesame oil contains sesamine and sesamol, that are well known natural antioxidants. Similarly, mustard oil contains appreciable amount of sulphur compounds that inhibit oxidation markedly. Lower values for the chemical parameters for sesame and mustard oils, therefore, could be attributed to the presence of natural inhibitors of oxidation, Groundnut oil is a medium unsaturated oil with very little natural inhibitors. The fact that only groundnut oil responded favourably to the chemical methods suggests that the widely varying chemical composition coupled with the storage conditions are major limiting factors of the methods. It further emphasises the inadequacy of a single limit value based on a particular method as the index of rancidity for all edible oils. This is more relevant in India where several oils with varied chemical characteristics and with extreme storage histories are used as cooking medium. Further research supported by organoleptic evaluation data are necessary to substantiate these findings.

References

1. Labuza, T. P., Kinetics of lipid oxidation in foods. *CRC Critical Rev. Fd Technol.*, 1971, **2**, 355.
2. Gray, J. I., Measurement of lipid oxidation. *J. Am. Oil Chem. Soc.*, 1978, **55**, 539.
3. *Official and Tentative Methods*, American Oil Chemists' Society, 1973, Cd- 8-53.
4. Jirousova, J., Modified anisidine value determination of oxidised fats and oils. *Nahrung*, 1975, **19**, 319.
5. Poole, M. F. and Prater, A. N., A modified Kreis test suitable for photocolorimetry. *Oil Soap*, 1945, **22**, 215.
6. *Official and Tentative Methods*, American Oil Chemists' Society, 1973, Cd: 7-58.
7. Sidwell, C. G., Salwin, H., Benca, M. and Mitchell, J. H., The use of thiobarbituric acid as a measure of fat oxidation. *J. Am. Oil Chem. Soc.*, 1954, **31**, 603.
8. *Official and Tentative Methods*, American Oil Cehmists' Society, 1973, Cc: 7-25.
9. *Standard Methods for the Analysis of Oils and Fats, and Derivatives*, IUPAC, 6th Edn., 1979, 143.

Effect of Intermittent Frying on the Physico-chemical Constants of Ghee and Refined Groundnut Oil

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During intermittent *puree* frying, butyrorefractometer reading (BR) of buffalo ghee increased, while iodine value (IV) decreased, and Reichert Meissl and Polenske values remained unaffected. The changes in BR and IV were more in refined groundnut oil than in buffalo ghee, and these changes were more when the frying was done in iron than in aluminium or stainless steel containers. Absorption of fat by '*puree*' was more when fried in ghee than in refined groundnut oil; the absorption increased with progressive frying.

The effects of frying of foods on some of the physico-chemical constants of fats and oils have been studied extensively[1-8]. Similar informations on ghee (butter oil) are limited[9-10]. In the present investigation, a systematic study of intermittent *puree* frying without replenishing the fat was carried out in different metallic containers using ghee and a standard vegetable oil to have comparative data on the changes taking place in their physico chemical constants and also to provide standards for heated ghee.

Materials and Methods

Ghee was prepared by creamery butter method from buffalo milk. A commercial brand of refined groundnut oil was used.

The fryings were done as follows: About 2 kg of ghee was taken separately in circular stainless steel, aluminium and iron *karahis* (diameter 35.5 cm and depth 10.2 cm) and brought to the frying temperature of about 200°C by continuous heating on a heater. Dough made from 300 g wheat flour with 195 ml of water was divided into 24 balls of approximately the same size. These balls were flattened in a *puree* making machine to get the shape of *puree* and fried one by one at regular intervals. After every 7 min one *puree* was dropped in the ghee maintained at about 200°C and fried for 30-40 sec. After the completion of frying (3 hr), the ghee was left overnight undisturbed in the respective containers. The frying was repeated on 2nd, 3rd and 4th day with overnight storage after each frying without replenishing the fat. Similar trials of frying *puree* in refined groundnut oil were carried out in aluminium and iron containers under identical conditions.

The samples of fats drawn at different intervals of time from different containers and trials, and the fat samples extracted from the *purees* with ethyl ether-petroleum ether (1 : 1) mixture were analysed for iodine value, saponification value, Reichert-Meissl value, Polenske value and BR readings at 40°C by the methods mentioned in ISI[11].

Results and Discussion

Samples of fats drawn from three different trials in different metallic pans were analysed and the average values are presented in Tables 1 and 2. From Table 1 it is seen that buffalo ghee used for intermittent *puree* frying for 12 hr had no significant change in RM and Polenske values irrespective of the metallic containers used for frying. This indicates that intermittent frying of *purees* for 12 hr did not bring any appreciable change in the amount of lower chain fatty acids of buffalo ghee. These results agree with those of Mitra[9], and Bector and Narayanan[12]. Singh and Verma[13] have reported slight increase in RM and Polenske values during heating of ghee at various temperatures.

From Table 2 it is seen that there was an increase in BR readings and decrease in iodine values of buffalo ghee and refined groundnut oil throughout the period of intermittent frying in all the metallic pans. The total increase in BR reading of buffalo ghee at the end of 12 hr of frying in stainless steel, aluminium and iron pans were 4.5, 5.0 and 6.0 units respectively. The correponding increases in BR readings

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TABLE 1. EFFECT OF INTERMITTENT *PUREE* FRYING IN DIFFERENT METALLIC FRYING PANS ON REICHERT MEISSL AND POLENSKE VALUES OF BUFFALO GHEE

Day of frying	Frying period (hr)	Stainless steel pan		Aluminium pan		Iron pan	
		RM value	Polenske value	RM value	Polenske value	RM value	Polenske value
First	Control	33.5	1.5	33.5	1.5	33.5	1.5
	½	33.6	1.6	33.4	1.4	32.9	1.6
	1	34.0	1.5	33.0	1.4	33.0	1.6
	3	34.0	1.5	33.4	1.4	32.9	1.5
Second	0	33.7	1.6	33.0	1.4	33.0	1.5
	3	33.5	1.5	33.0	1.5	32.8	1.6
Third	0	33.7	1.5	33.2	1.6	33.1	1.6
	3	33.4	1.6	33.2	1.4	32.7	1.6
Fourth	0	33.8	1.6	33.6	1.5	33.0	1.5
	3	33.6	1.5	33.7	1.5	32.7	1.6

The values are averages of 3 trials.

of refined groundnut oil under identical conditions of frying in aluminium and iron pans were 5.5 and 8.0 units respectively.

At the end of 12 hr of intermittent frying, the decreases in iodine value of frying ghee from stainless steel, aluminium and iron pans observed were 4.0, 4.0 and 6.2 units respectively. The decreases in the corresponding samples of refined groundnut oil from aluminium and iron pans were 12.6 and 14.6 units respectively. It was further observed that the flavour of both the frying fats deteriorated, colour became darker and the foaming tendencies increased as the period of frying progressed.

TABLE 2. EFFECT OF INTERMITTENT *PUREE* FRYING IN DIFFERENT METALLIC FRYING PANS ON BR, IV AND SV OF BUFFALO GHEE AND REFINED GROUNDNUT OIL

Day of frying	Frying period (hr)	Buffalo ghee									Refined groundnut oil					
		Stainless steel pan			Aluminium pan			Iron pan			Aluminium pan			Iron pan		
		BR	IV	SV	BR	IV	SV	BR	IV	SV	BR	IV	SV	BR	IV	SV
		Buffalo ghee														
1st	Control	41.0	30.4	232.1	41.0	30.4	235.2	41.0	30.4	235.2	56.0	90.1	187.6	56.0	90.1	187.6
	½	41.5	30.2	230.8	41.5	30.1	237.8	41.5	29.4	238.6	56.5	88.3	190.6	56.5	87.9	185.4
	1	42.0	30.1	227.8	42.0	30.0	234.6	42.5	28.4	238.3	57.5	87.7	188.8	57.5	87.1	185.2
	3	42.5	29.8	232.8	43.0	29.4	240.5	43.5	27.5	240.3	58.0	86.4	190.9	58.0	86.2	188.6
2nd	0	43.0	29.3	230.1	43.0	29.1	239.8	44.0	27.1	240.2	58.5	85.6	195.0	59.0	85.0	187.1
	3	43.5	28.7	232.5	43.5	28.7	239.2	44.5	26.3	240.2	59.0	83.0	194.9	59.5	82.0	188.7
3rd	0	44.0	27.7	234.5	44.0	28.2	241.0	45.5	25.9	238.8	59.0	81.4	194.6	60.0	80.8	191.2
	3	44.0	27.1	233.3	44.5	27.4	241.1	46.0	25.3	240.6	59.5	79.8	195.4	61.5	78.2	186.7
4th	0	44.5	27.0	232.6	45.5	27.0	242.9	46.5	25.0	241.0	60.5	78.9	186.8	62.5	77.2	191.7
	3	45.5	26.5	233.7	46.0	26.4	242.3	47.0	24.2	241.3	61.5	77.5	194.0	64.0	75.5	190.5

The values are averages of three trials

BR=Butyro refractometer reading; IV=Iodine value; SV=Saponification value

At the end of frying, these changes were observed to be more in groundnut oil than in ghee, and also more in iron than aluminium or stainless steel pans.

Decrease in iodine values and increase in BR readings were also reported by other workers during heating of ghee[12-13] and vegetable oils[5,8,14-16].

From Table 2 it is evident that there was no definite trend in the changes in saponification values of both the frying fats in any of the metallic pans.

From the above studies, it is evident that stainless steel or aluminium frying pans would be more desirable than iron frying pan.

There was not much difference in the amount of fat absorbed during frying of *purees*, in stainless steel, aluminium and iron pans (Table 3). Irrespective of the metallic containers used, it was observed that on the first day of 3 hr of frying the average amount of absorbed ghee and refined groundnut oil were 14.4-14.8 and 13.4-13.5 per cent, respectively. The corresponding amounts on the fourth day of intermittent frying were 17.9-18.2 and 15.8-16.0 per cent respectively. From this it appears that the absorption of fat is more during frying of *purees* in ghee than in refined groundnut oil. These results further indicate that there was an increase in the fat absorption as the frying progressed. Sen *et al*[17]. have reported that oil absorption was more or less the same (14-16 per cent), irrespective of the component fatty acids of different oils.

The physico-chemical constants of the absorbed/extracted fat are presented in Table 4, which show that there was no appreciable difference in the physico-chemical constants, between the extracted fat and the corresponding frying fat (Tables 1 and 2).

TABLE 3. EFFECT OF INTERMITTENT *PUREE* FRYING IN GHEE AND REFINED GROUNDNUT OIL ON FAT ABSORPTION

Day of frying	Buffalo ghee absorbed (%)			Refined groundnut oil absorbed (%)	
	Stainless steel pan	Aluminium pan	Iron pan	Aluminium pan	Iron pan
First	14.5	14.8	14.4	13.4	13.5
Fourth	18.1	17.9	18.2	16.0	15.8

The values are the average of three trials.

TABLE 4. EFFECT OF INTERMITTENT *PUREE* FRYING IN DIFFERENT METALLIC FRYING PANS ON THE PHYSICO-CHEMICAL CONSTANTS OF ABSORBED FAT

Physico-chemical constants	Stainless steel pan		Aluminium pan		Iron pan	
	1st day	4th day	1st day	4th day	1st day	4th day
Buffalo ghee						
Reichert Meissl value	33.7	33.3	32.7	33.4	33.0	33.0
Polenske value	1.5	1.6	1.5	1.5	1.5	1.5
BR readings	42.5	45.0	43.0	45.5	43.5	47.0
Iodine value	30.1	26.6	29.9	26.6	28.6	24.2
Sapon. value	234.0	234.2	237.8	242.3	241.2	239.3
Refined groundnut oil						
BR readings	—	—	57.5	61.5	57.5	63.5
Iodine value	—	—	86.2	78.6	87.1	75.5
Sapon. value	—	—	186.9	194.4	187.0	190.3

The values are the average of 3 trails.

References

1. Porter, F. R., Michaelis, H. and Shay, F. G., Changes in fats during frying. *Indian Engng Chem.*, 1932, **24**, 811.
2. Lantz, C. W. and Carlin, G. T., Stability of fats used for deep fat frying. *Oil Soap*, 1938, **15**, 38.
3. Krishnamurthy, R. G., Kawada, T. and Chang, S. S., Chemical reactions involved in the deep fat frying of foods. *J. Am. Oil Chem. Soc.*, 1965, **42**, 878.
4. Perkin, E. G. and Van Akkeren, L. A., Chemical changes in fats subjected to deep fat frying-cotton seed oil. *J. Am. Oil Chem. Soc.*, 1965, **42**, 782.
5. Vidyasagar, K., Arya, S. S., Premavalli, K. S., Parihar, D. B. and Nath, H., Chemical and nutritive changes in refined groundnut oil during deep fat frying. *J. Fd Sci. Technol.*, 1974, **11**, 73.
6. Alexander, J. C., Biological effects due to changes in fats during heating. *J. Am. Oil. Chem. Soc.*, 1978 **55**, 711.
7. Chang, S. S., Peterson, R. J. and CHI-Tang Ho, Chemical reactions involved in the deep fat frying of foods. *J. Am. Oil Chem. Soc.*, 1978, **55**, 718.
8. Sulthana, S. N. and Sen, D. P., Studies on deep fat frying: Changes during heating of oil. *J. Fd Sci. Technol.*, 1979, **16**, 708.
9. Mitra, S. N., The effect of frying Indian cereal foods on the constants of butter fat (ghee). *J. Proc. Inst. Chem., (India)* 1954, **26**, 99.
10. Mitra, S. N., Mathew, T. V., Guha, K. C., Bose, P. K. and Basak, A., Effect of frying *dalmot* on the constants of butter fat (ghee). *Sci. Cult.*, 1964, **30**, 44.
11. *Methods of Sampling and Tests for Ghee (Butter fat)*, IS-3508: 1966 Indian Standards Institution, New Delhi.
12. Bector, B. S. and Narayanan, K. M., Effect of thermal oxidation on the physico-chemical constants of ghee. *Indian J. Dairy Sci.*, 1974, **27**, 90.
13. Singh, M. and Verma, N. S., Studies on the effect of heating on the chemical nature of buffalo ghee. *Indian J. anim. Res.*, 1971, **5**, 45.
14. Custot, F., Toxicity of heated fats-problem of frying oils. *Ann. Nutr. Aliment*, 1959, **13**, A417.
15. Becker, E. and Rost, H. E., Frying fats. *Fette Seifen Anstri. Mittel.*, 1964, **66**, 123.
16. Montefredine, A., Chemical modifications in frying oils. *Riv. ital. Sostanze Grass*, 1965, **66**, 482.
17. Sen, P., Rao, C.V.N. and Mehta, T. N., Behaviour of certain edible oils in the frying pan. *Indian Soap. J.*, 1951, **17**, 107.

Effect of Fortification of Triticale with Pulses on the Preparation of Some Common Indian Recipes

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Triticale flour can be blended with Bengal gram (*Cicer arietinum* L.,) green gram (*Phaseolus radiatus* L.,) and soybean (*Glycine max* (L) Mer.) flours (10 to 30% levels) for improving its products. Blends with all the three pulses were acceptable for preparing *paratha*, porridge, *phulka* and *dosai*. Blending improved the nutritional quality of protein without significant changes in colour, flavour, texture or aroma.

Protein quality of the cereal products is enhanced when pulses rich in sulphur amino acids are used for blending[1]. Eventhough triticale is rich in lysine, sulphur containing amino acids are limiting as in wheat and other cereals[2,3]. It has been reported that acceptability of triticale is enhanced when it is blended with wheat between 25 and 50 per cent level, in baked and unbaked goods[4]. In this study, triticale was blended with pulses like Bengal gram, green gram and soybean or with wheat and their effect on sensory characters and acceptability of some Indian dishes were evaluated. Blending with pulses improves the nutritional quality and quantity of protein in the dishes.

Materials and Methods

Wheat was used as control (T-1). Treatments consisted of triticale and wheat in the ratio of 1:1 (T-2), triticale blended with Bengal gram flour at 10 per cent (T-3a), 20 per cent (T-3b) and 30 per cent (T-3c), triticale blended with green gram flour at 10 per cent (T-4a), 20 per cent (T-4b), and 30 per cent (T-4c), and triticale blended with soyflour at 10 per cent (T-5a), 20 per cent (T-5b) and 30 per cent (T-5c). These composite flours or grits were used in the preparation of different dishes-*paratha*, porridge, *dosai* or *phulka*.

Paratha: A soft dough was made out of flour (100 g), salt (1 g) and water (67 ml). The dough was divided into four parts, each part rolled to 0.3 cm thickness, folded twice to a triangle form with 1 g of fat smeared between the folds of each *paratha*. The *parathas* were rolled and toasted with a little fat.

Porridge: Grits (50 g) was roasted in 10 g of ghee (butter fat) for 2 min. This mixture was added to boiling milk (50 ml) and water (150 ml). It was cooked for 8

TABLE 1. ANALYSIS OF VARIANCE FOR THE SCORES OF SENSORY EVALUATION OF TRITICALE AND PULSE COMBINATION PRODUCTS

Source	df	Mean sum of squares (MSS)				
		Appearance	Texture	Aroma	Flavour	Overall quality
		Paratha				
Judges	7	1.3	2.2	2.0	3.2	1.35
Treat	4	3.3*	1.4*	2.0*	2.4*	3.3*
Concn	2	2.3*	0.3*	0.03	0.2*	0.3*
Treat × concn	8	1.0*	0.8	0.9*	0.7	1.0*
Error	98	0.4	0.5	0.3	0.4	0.43
Total	119	—	—	—	—	—
		Porridge				
Judges	7	1.5	2.3	3.0	1.4	1.1
Treat	4	4.5	0.8	3.7*	4.1*	3.0*
Concn	2	0.9	3.3*	2.8*	0.9	1.0
Treat × concn	8	0.3*	0.5	0.3*	0.6	0.5
Error	98	0.5	0.5	0.3	0.4	0.3
Total	119	—	—	—	—	—
		Dosai				
Judges	7	3.4	5.0	2.7	3.4	3.8
Treat	4	1.6*	0.9*	1.5*	1.0	1.8*
Concn	2	3.0*	0.8	0.3	0.1	0.1
Treat × concn	8	0.6	0.3	0.4*	1.0	0.7
Error	98	0.4	0.3	0.5	0.7	0.4
Total	119	—	—	—	—	—
		Phulka				
Judges	7	4.7	2.1	3.7	3.0	3.1
Treat	4	5.9*	2.6*	2.8*	3.7*	3.2*
Concn	2	2.1*	1.1*	1.8	1.9*	1.8*
Treat × concn	8	0.9*	0.7*	1.0*	1.5*	1.2*
Error	98	0.4	0.3	0.4	0.5	0.5
Total	119	—	—	—	—	—

*Significant at 5%

min, then sugar (25 g) and cardamom powder (1 g) were added and mixed.

Dosai: A free flowing batter was made with flour (100 g), salt (1 g) and water. One laddle of the batter was poured on a preheated oil smeared griddle. The *dosai* was toasted on pan till both sides turned brown. Oil (10 ml) was used while preparing *dosai*.

Phulka: A soft dough was made using flour (100 g) and salt (1 g) with 65 ml of water. The dough was divided into four parts and each part rolled into circular discs, roasted for 3 min, exposed to open flame till puffing, then ghee (1.25 g) was smeared on each *phulka*.

Sensory evaluation: The panel of judges consisted of eight trained personnel. Each person was served with five samples having two control and three experimental samples. The process was repeated and the average values were statistically analysed. A 7-point hedonic rating was used to evaluate the product for appearance, aroma, flavour, texture/consistency and overall acceptability[5]. Analysis of variance was done on the scores of the judges for each of the characters[6,7].

Results and Discussion

Results of analysis of variance are given in Table 1. Characteristics of each dish are discussed here.

TABLE 2. MEAN SCORES OF SENSORY EVALUATION FOR *PARATHA*

Treatments	Appearance	Texture	Aroma	Flavour	Overall quality	Remarks
			Wheat			
Wheat 100%	5.5	4.5	5.1	5.1	5.1	C for b
T-1	5.9	4.9	5.2	5.1	5.3	C for b
T-1	5.4	4.3	4.4	4.3	4.5	C for c
T-1	5.6	4.7	4.9	4.8	5.0	PMS
			Triticale 50%+Wheat 40%			
T-2	4.7	4.5	4.7	4.8	4.6	C for a
T-2	5.4	4.8	4.5	4.4	4.6	C for b
T-2	5.0	4.0	4.1	4.3	4.3	C for c
T-2	5.0	4.4	4.4	4.6	4.5	PMS
			Triticale + Bengal gram			
T-3a	4.6	4.8	4.1	4.0	4.1	
T-3b	4.9	4.6	4.2	4.3	4.2	
T-3c	4.5	4.7	4.3	4.1	4.3	
T-3a, b, c	4.6	4.7	4.2	4.1	4.2	PMS
			Triticale + Green gram			
T-4a	4.4	3.9	3.8	3.8	3.8	
T-4b	4.8	4.3	4.1	4.1	4.1	
T-4c	5.4	4.2	4.5	4.3	4.4	
T-4a, b, c	5.0	4.1	4.1	4.1	4.1	PMS
			Triticale + Soybean			
T-5a	4.4	4.6	4.2	4.1	4.1	
T-5b	4.6	4.4	4.1	4.0	4.1	
T-5c	5.4	5.1	4.6	4.2	4.7	PMS
T-5a, b, c	4.8	4.7	4.3	4.1	4.3	PMS
T-3,4,5 a*	4.7	4.4	4.4	4.4	4.4	PMS
T-3,4,5b*	5.1	4.6	4.4	4.4	4.5	PMS
T-3,4,5c*	5.1	4.5	4.4	4.2	4.5	PMS
			Significance			
CD/LSD (Tr)+	0.36	0.39	0.29	0.32	0.35	
CD/LSD (C)+	0.28	0.30	0.23	0.29	0.26	
CD/LSD (Tr Vs C)+	0.61	0.67	0.51	0.65	0.57	

a, b and c represent 10, 20 and 30% of pulse in the recipe respectively

Score system: 1. Dislike extremely, 2. Dislike moderately, 3. Dislike slightly, 4. Acceptable, 5. Like slightly, 6. Like moderately, 7. Like extremely

*all pulses; C for a, C for b and C for c represent control for a, b and c respectively. PMS: Pooled mean score. + at 5% level of significance.

Parathas from all the treatments were either acceptable or only liked slightly (Table 2). Triticale blended with 30 per cent soy flour gave the best texture. All the control *Parathas* had higher aroma and flavour scores. T-1a, T-1b, T-1c, T-5c and T-2a, T-2b, T-2c were good in that order for overall acceptance. Triticale blended with pulse combinations were better and almost like wheat *parathas*. Bengal gram with triticale showed uniformly good scores at all levels of blending but with green gram, scores were higher with the increase in the pulse content. Soy bean at 30 per cent level (T-5c) also scored higher than 10 and 20 per cent levels. Thus, for appearance T-1 was highly acceptable (5.6) followed by T-2 and T-4; for texture T-3 and T-5 scored similar to T-1; for aroma T-1 scored highest followed by others which were almost similar.

Data with regard to porridge are presented in Table 3. Controls were the best for aroma, flavour and overall eating quality. Among the treatments, T-1 received the highest score followed by T-2. Among the

TABLE 3. MEAN SCORES OF SENSORY EVALUATION FOR PORRIDGE

Treatments	Appearance	Texture	Aroma	Flavour	Overall quality	Remarks
			Wheat			
Wheat 100%	5.8	5.3	5.5	5.6	5.6	C for a
T-1	5.4	4.6	5.1	5.1	5.1	C for b
T-1	5.6	4.9	5.2	5.0	5.0	C for c
T-1	5.6	4.0	5.3	5.2	5.3	PMS
			Triticale 50%+Wheat 50%			
T-2	4.8	4.9	4.8	5.1	5.1	C for a
T-2	4.7	4.1	4.1	4.3	4.4	C for b
T-2	4.7	4.9	4.9	4.9	4.9	C for c
T-2	4.7	4.6	4.6	4.8	4.8	PMS
			Triticale+Bengal gram			
T-3a	4.6	4.4	4.6	4.3	4.4	
T-3b	4.6	4.3	4.1	4.1	4.4	
T-3c	4.7	5.0	4.8	4.6	4.8	
T-3a, b, c	4.6	4.6	4.5	4.4	4.5	PMS
			Triticale + Green gram			
T-4a	4.7	4.9	4.3	4.1	4.3	
T-4b	4.3	4.3	4.1	4.3	4.2	
T-4c	4.9	4.8	4.4	4.3	4.4	
T-4a, b, c	4.6	4.5	4.3	4.2	4.3	PMS
			Triticale+Soybean			
T-5a	4.4	4.6	4.2	4.3	4.5	
T-5b	4.3	4.4	4.1	4.3	4.3	
T-5c	4.8	4.9	4.7	4.7	4.8	
T-5a, b, c	4.5	4.6	4.3	4.4	4.5	PMS
T-3, 4, 5a	4.9	4.7	4.7	4.7	4.8	PMS
T-3, 4, 5b	4.7	4.3	4.3	4.4	4.5	PMS
T-3, 4, 5c	5.0	4.9	4.8	4.8	4.8	PMS
			Significance			
CD/LSD (Tr)	0.42	0.39	0.33	0.38	0.34	
CD/LSD (C)	0.33	0.30	0.26	0.29	0.26	
CD/LSD (Tr×C)	0.73	0.67	0.57	0.68	0.59	

Legend same as under Table 2

three pulses, Bengal gram plus triticale (T-3) porridge scored slightly higher than other two pulses.

Dosai obtained with triticale with 30 per cent soy meal had the best appearance (Table 4) followed by T-2c. For texture, T-1 was the best. Controls T-1 and T-2 scored higher for aroma and flavour. For overall eating quality T-2c, T-5c and T-1c were found acceptable.

Phulka: As seen from Table 5, flour from T-1 andT-2 gave good *phulkas* followed by T-3b and T4b in the order of preference for the appearance. The same order held for texture, and T-2 control had better aroma and flavour scores for *phulkas*. T-5c scored higher (4.7) than its control T-1c (4.6). All the triticale combinations at 20 per cent pulse addition and T-2, scored higher for overall eating quality.

It has been reported that chapaties made from triticale and wheat flour (2:3 ratio) and chapaties prepared with wheat, triticale and Bengal gram flour (2:2:1 ratio) gave a protein efficiency ratio of 1.72 and 2.12 compared with 1.85 for wheat flour and 1.91 for

TABLE 4. MEAN SCCRES OF SENSORY EVALUATION FOR *DOSAI*

Treatments	Appearance	Texture	Aroma	Flavour	Overall quality	Remarks
			Wheat			
Wheat 100%	5.0	4.5	4.6	4.6	4.7	C for a
T-1	4.9	4.3	4.1	3.7	4.3	C for b
T-1	5.2	4.8	4.8	4.4	4.8	C for c
T-1	5.0	4.5	4.5	4.2	4.6	PMS
			Triticale 50%+Wheat 50%			
T-2	4.5	4.4	4.3	4.4	4.2	C for a
T-2	4.6	4.4	4.4	4.3	4.4	C for b
T-2	4.9	4.3	4.2	4.1	4.3	C for c
T-2	4.6	4.2	4.3	4.2	4.3	PMS
			Triticale+Bengal gram			
T-3a	3.9	3.8	3.8	3.8	3.6	
T-3b	4.8	4.2	3.9	4.0	4.1	
T-3c	4.8	4.1	3.9	3.7	3.9	
T-3a, b, c	4.5	4.0	3.9	3.8	3.9	PMS
			Triticale+Green gram			
T-4a	4.5	4.2	4.2	4.1	4.4	
T-4b	4.1	4.0	4.0	4.0	4.0	
T-4c	4.7	4.1	3.8	3.4	3.7	
T-4a, b, c	4.4	4.1	4.0	3.9	4.0	PMS
			Triticale+Soybean			
T-5a	3.9	3.9	4.1	3.5	3.9	
T-5b	4.4	4.4	3.7	4.0	3.9	
T-5c	5.0	4.5	4.1	4.2	4.6	
T-5a, b, c	4.4	4.3	4.0	3.9	4.1	PMS
T-3,4,5a	4.4	4.1	4.2	4.1	4.2	PMS
T-3,4,5b	4.6	4.3	4.0	4.0	4.2	PMS
T-3,4,5c	4.9	4.4	4.2	4.0	4.2	PMS
			Significance			
CD/LSD (Tr)	0.37	0.34	0.31	0.48	0.37	
CD/LSD (C)	0.29	0.26	0.30	0.37	0.29	
CD/LSD (Tr Vs C)	0.65	0.59	0.67	0.83	0.64	

Legend as in Table 2

TABLE 5. MEAN SCORES OF SENSORY EVALUATION FOR *PHULKA*

Treatments	Appearance	Texture	Aroma	Flavour	Overall quality	Remarks
			Wheat			
Wheat 100%	5.6	4.6	4.4	4.5	4.8	C for a
T-1	5.4	4.9	4.4	4.5	4.7	C for b
T-1	5.5	4.8	4.8	4.6	4.8	C for c
T-1	5.5	4.8	4.5	4.5	4.8	PMS
			Triticale 50%+Wheat 50%			
T-2	5.1	4.5	4.2	4.3	4.3	C for a
T-2	5.1	4.6	4.2	4.1	4.4	C for b
T-2	5.6	4.9	4.7	4.9	5.0	C for c
T-2	5.2	4.7	4.4	4.4	4.6	PMS
			Triticale + Bengal gram			
T-3a	4.1	4.4	3.6	3.5	4.1	
T-3b	5.1	4.4	4.3	4.3	4.5	
T-3c	4.2	3.6	3.3	3.4	3.4	
T-3a, b, c	4.5	4.1	3.8	3.7	4.0	PMS
			Triticale+Green gram			
T-4a	4.3	4.4	3.5	3.4	3.9	
T-4b	5.0	4.6	4.3	4.5	4.5	
T-4c	4.8	3.9	3.5	3.2	3.4	
T-4a, b, c	4.7	4.3	3.8	3.7	3.9	PMS
			Triticale+Soybean			
T-5a	3.9	4.1	4.1	3.9	4.1	
T-5b	4.7	4.1	4.1	4.2	4.4	
T-5c	4.4	3.8	3.8	4.7	3.8	
T-5a, b, c	4.3	4.0	4.0	3.9	4.1	PMS
T-3, 4, 5a	4.6	4.4	4.0	3.9	4.1	
T-3, 4, 5b	5.1	4.5	4.2	4.3	4.5	PMS
T-3, 4, 5c	4.9	4.2	4.0	4.0	4.1	PMS
			Significance			
CD/LSD (Tr)	0.36	0.33	0.38	0.39	0.40	
CS/LSD (c)	0.28	0.25	0.29	0.30	0.30	
CD/LSD (Tr Vs C)	0.62	0.57	0.65	0.68	0.69	

Legend as in Table 2

triticale. Chapaties prepared from wheat and triticale at 1:1 ratio also showed higher protein efficiency ratio and better acceptability than triticale alone[1,2]. In this study too, control and T-2 treatment gave similar results. The protein content of bread has been increased by 65 to 78 per cent by the addition of winged bean flour to wheat or triticale upto 20 per cent[8]. Sekhon *et al.* have used wheat and winged bean flours in the ratio of 3:1, 1:1, and 1:3 for bread, cookies and chpaties, and found that bread obtained with 1:1 flour ratio gave good crumb texture and loaf volume which improved with increased wheat flour[9]. Our results also indicate that the texture of the product of wheat was better.

It is evident from the results that certain pulses can be used to fortify triticale at 20-30 per cent level. For *parathas* and *dosai*, triticale with soy and Bengal gram flour can be used while for *phulkas* and porridge, green gram and soybean can be utilized.

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References

1. Juneja, P. K., Kawatra, B. L. and Bajaj, S., Nutritive value of triticale and effects of its supplementation to wheat and Bengal gram. *J. Fd Sci.*, 1980, **45**, 328.
2. Vaidehi, M.P., *Acceptability Levels of Two Triticales in Chapaties and Their Nutritional Evaluation of Protein Quality*, 1974, Ph.D. Thesis, Kansas State University, Kansas.
3. Gopalan, C., Balasubramanian, S. C., Ramasastry, B. V. and Vishweshawara Rao, K., *Nutritive value of Indian foods*, National Institute of Nutrition, (ICMR), Hyderabad, India, 1975.
4. Sekhon, K. S., Sexena, A. K., Randhawa, S. K. and Gill, K.S., Use of triticale for bread, cookies and chapathi making. *J. Fd Sci. Technol.*, 1980, **17**, 233.
5. Amerine, M. A., Pangborn, R. M. and Roessler, E. B., *Principles of Sensory Evaluation of Food*, Academic Press, New York. 1965.
6. Sundararaj, N., Nagaraju, S., Venkat Ramu, M. N. and Jagannath, M. K., *Design and Analysis of Field Experiments*. University of Agricultural Sciences, Bangalore, 1972, 152.
7. Anon, Sensory evaluation guide for testing food and beverage products. *Fd Technol.*, 1981, **35**(11), 54.
8. Blaise, D. S. and Okezie, B. O., Baking and organoleptic quality of composition flour bread with winged bean, triticale and wheat. *Baker's Dig.*, 1980, **54**, 22.
9. Sekhon, K. S., Gill, K. S., Sexena, A. K. and Sandha, G. S. Studies on the bread, cookies and chapathi making properties of some high yielding varieties of triticale. *Indian Miller*, 1980, **11**, 29.

RESEARCH NOTES

COMPARATIVE PERFORMANCE OF PACKING APPLES IN TRAYS AND CONVENTIONAL PACK DURING TRANSIT

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Bruising in apples was reduced from 36% in conventional pack in wooden boxes to 5% in tray packs in wooden or corrugated fibre board carton. Tray packed apples fetched higher over the conventional packed fruits. Tray packing is better as it avoids wrapping of individual fruits, provides cushioning material, prevents sufffocation of fruits due to proper circulation of air among the fruits and dispenses with the services of trained packers to repack these boxes for marketing. These trays can be recycled.

In India, apple is mostly grown in the hilly areas of Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh and production of this commodity is steadily increasing touching 7.6 lakh tonnes in 1979[1] This additional production has created a problem of packing, transport and storage

Selection of appropriate packaging is crucial for safe transit and subsequent storage of apples. At present wooden boxes made of spruce or fir wood are used for this purpose. In Simla packs, individual fruits are wrapped in paper and arranged inside the box tightly

In the present study, the effect of packing apples in moulded paper trays having cavities to hold the fruit were tried to find out the extent of bruising losses during transit and quality during storage.

Trials were conducted in standard size (30 × 30 × 45 cm) wooden boxes of 18 kg capacity using large size 'Royal Delicious' variety of apples packing 96 apples in four layers. Conventional wooden boxes, known as Simla pack were used as control. Before packing, individual fruits were wrapped in paper. In Simla pack, paper trays were also tried beside the paper wrap. Corrugated fibre board box with trays were also tried. The trays were supplied by M/s. G. Claridge & Co. Ltd., of Bombay and are prepared from paper pulp. Five trays are required for a box to pack large size apples and cost of each tray is one Rupee. The boxes were packed at Government Progeny Orchards, Khadrala (H.P.), brought to road by mules and further transported by road in trucks to Delhi covering a total distance of about 500 km. The boxes were stored at a temperature of 12-24°C and relative humidity of 40-70 per cent. Damages were like bruising recorded by checking thirty fruits at random from each box. Data are reported as the average of five boxes. Observations on physiological loss of weight (PLW), firmness of the fruit (in lbs), specific gravity and °Brix of apple juice were estimated after a storage period of 21 days.

Data on the extent of fruit damage by bruising during packaging and transportation is presented in Table 1. A maximum bruising damage of 36 per cent was observed when the fruits were packed in Simla pack with paper wraps. Bruising damage was reduced to 8.0 per cent when trays were substituted for paper wraps in Simla pack and to 5 per cent when corrugated fibre board box with trays were used. It clearly indicates the superiority of packing apples with trays to reduce bruising losses.

TABLE 1. BRUISING DAMAGE IN APPLES DURING PACKING AND TRANSIT

Type of box/packing	Bruising (%) Mean ± S.E.
Simla pack with paper wrap	36.0 ± 5.42
Simla pack with trays	8.0 ± 2.17
Corrugated fibre board box with trays	5.0 ± 1.87

Each value is the average of 5 replicates

TABLE 2. CHANGES IN QUALITY PARAMETERS DURING STORAGE OF APPLES UNDER AMBIENT CONDITIONS

Quality parameters	Simla pack Mean ± S.E.	Corrugated box tray pack Mean ± S.E.
Physiological loss of wt. (%)	8.0 ± 0.03	7.0 ± 0.02
Total soluble solids (°Brix)	11.0 ± 0.07	12.5 ± 0.09
Fruit pressure (lb)	9.5 ± 1.03	12.5 ± 0.08
Specific gravity	0.80 ± 0.01	0.82 ± 0.01

Each value is the mean of 5 replicates
Storage condition: 12-24°C, 40-70 per cent R.H., period 21 days.

TABLE 3. ECONOMICS OF PACKING IN WOODEN AND CORRUGATED FIBRE BOARD (CFB) CARTON

	Wooden pack Rs.	CFB pack Rs.
Cost of packing case	8	15
Cost of paper wrapping and nails	3	6
Total	11	21
Cost realised (18 kg pack)	60	80
Extra amount realised	—	10

A comparison of the quality constituents of apples in the two types of boxes with two types of packing when stored at ambient condition (12-24°C 40-70 per cent R.H.) for 21 days are given (Table 2). It can be seen that all quality parameters were retained much better in tray packed corrugated fibre board box as compared with conventional Simla pack. The reason for better performance may be ascribed to better aeration which removes the heat produced by respiration, thus keeping the fruits at a lower temperature as compared with tightly packed conventional packing.

Data presented in Table 3 indicate that packing of apples in corrugated fibre board box with trays is better than packing in wooden box with conventional packing and the cost is reduced by ten rupees in the former packing.

Tray packing has other advantages like less time taken to pack the box, sufficient resilance and cushioning effect of trays to minimize bruising damage, better presentation of fruit during sale; less ester formation due to proper aeration among the fruit. There is no need for trained packers to arrange the fruits as needed in conventional packs.

From the above discussion, it is quite clear that tray packing of apples is superior to conventional packing in reducing bruising losses, retention of better quality during storage and a simple and easy method of packing.

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References

1. *Production Year Book*, F.A.O. of the United Nations, Rome, 1979, **33**, 142.

USE OF HIGH MOLECULAR WEIGHT HIGH DENSITY (HMHD) FILM POUCHES FOR PROCESSING AND STORAGE OF MANGO AND TOMATO PULPS

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Both mango and tomato pulps were heated to 80°C, packed in high molecular weight high density (HMHD) pouches (200g) and processed at 100°C for 20 minutes. Losses of carotene in mango and lycopene in tomato were measured during storage at 0 and 40°C. These losses and nonenzymatic browning (NEB) were higher at 40°C. Addition of SO_2 to mango pulp upto 150 ppm helped to retain its quality during storage. Light adversely affected the quality. The pulps in this film can be stored upto two months at ambient condition (24-28°C).

Fruit juices and pulps are generally preserved in cans and bottles after heat processing or by addition of chemical preservatives. In recent years many food grade flexible package films have been developed which can withstand a temperature of 100°C and have been tried for packing food materials[1]. These films are cheaper as compared to cans and bottles. In the present studies, mango and tomato pulps were packed in HMHD (High Molecular weight High Density) film and the storage behaviours evaluated.

HMHD film was purchased from Bitto Plastics Works, New Delhi. This film has advantages like high melting point, freedom from cracking and bursting, low permeability to water vapour and gases etc. Before packing fruit pulps, permeability of the film to water vapour and SO_2 was tested using pouches with surface area of $2 \times 9.5 \times 13.5$ cm and filled with 100 ml solution containing 2 per cent salt, 0.5 per cent citric acid and 1728 ppm SO_2. The filled pouches were processed in boiling water for 90 minutes to find out escape of SO_2 during heating. These pouches were stored at ambient (24-28°C) and at a higher temperature (40°C).

Mango and tomato pulps were obtained from NAFED food processing factory, New Delhi. Mango pulp was preserved with (100 ppm) and without KMS. Tomato pulp was preserved as such.

Pulps were heated to 80°C and 200g portions of each pulp were transferred into 200 gauge HMHD bags which were then heat sealed after squeezing out as much air as possible and taking care that the surface was not soiled with the pulp at the point of sealing. Pouches were

processed in boiling water for 20 min which was found sufficient for the pouch centre to attain a temperature of 85°C. Thereafter pouches were cooled immediately in water.

The heat treated pouches were stored at 0, 24-28 and 40°C. At ambient temperature (24-28°C), samples were kept both in light and dark. Dark conditions were obtained by keeping the pouches in kraft paper bags. The stored samples were analysed upto 3 months at one month interval.

The total soluble solids (°Brix) was estimated with a hand refractometer. Residual SO_2 content was determined by modified Monier-William method[2]. Carotene in mango pulp was estimated according to the method described by Roy[3] and lycopene in tomato pulp by the method described by Beerh and Siddappa[4]. Non-enzymatic browning (NEB) was recorded at 400 nm of an alcoholic extract[5] of mango (10 ml pulp+20 ml alcohol) and tomato (2ml pulp+10 ml alcohol). Organoleptic evaluation was made on the basis of colour, flavour and overall acceptability by a panel of five judges.

From the data presented in Table 1 and 2, it can be seen that the film is permeable both to water and gas vapours and the losses were greater at higher temperatures. There was a continuous loss of SO_2 from the film during its exposure to heating (Table 3). Loss of water from the pouch could be reduced by putting it in another pouch of slightly larger size (Table 4). From the above discussion it is quite clear that to minimise these losses, the pouches need to be stored at low temperature.

TABLE 1. LOSS OF WATER FROM THE HMHD FILM AT DIFFERENT TEMPERATURES OF STORAGE

Storage temp. (°C)	Water loss (mg) at diff days of storage		
	15	30	45
40	300	800	1600
24-28	200	600	1300

TABLE 2. LOSS OF SO_2 (PPM) FROM THE HMHD FILM (200G) AT DIFFERENT TEMPERATURES OF STORAGE

Storage period (days)	SO_2 loss at diff. temp	
	24-28°C	40°C
0	1728	1728
30	1216	1088
40	1088	768
45	1024	448
50	960	320
55	864	256

TABLE 3. LOSS OF SO_2 FROM THE HMHD FILM DURING PROCESSING IN BOILING WATER

Period (min)	SO_2 (ppm)
0	1728
5	1344
10	1294
20	1216
30	1152
60	1067
90	960

TABLE 4. LOSS OF WATER FROM THE HMHD FILM IN SINGLE AND DOUBLE POUCH

Storage period (days)	Water (mg) loss in	
	Single pouch	Double pouch
5	100	nil
10	170	60
20	220	100

When mango pulp is stored in HMHD film for 3 months at different temperatures, the changes in quality parameters viz. carotene, °Brix, non-enzymatic browning (NEB) and SO_2 revealed that these changes were faster at 40°C than at 0°C (Table 5 and 6). Changes in carotene and NEB were much less in dark than in light. Addition

TABLE 5. CHANGES IN °BRIX AND SO_2 CONTENT DURING STORAGE OF MANGO PULP IN HMHD FILM AT DIFFERENT TEMPERATURES

Storage temp. (°C)	KMS added (ppm)	°Brix at indicated period (months)			SO_2 (ppm) at indicated period (months)		
		1	2	3	1	2	3
24-28	—	12.5	12.5	12.5	—	—	—
	100	11.0	11.0	11.0	69	42	30
24-28*	—	12.5	12.5	12.0	—	—	—
	100	11.0	11.0	11.0	72	50	33
0	—	12.0	12.0	12.0	—	—	—
	100	11.0	11.0	11.5	80	72	68
40	—	12.5	12.5	13.0	—	—	—
	100	11.5	11.5	11.5	32	18	12

*Stored in dark

TABLE 6. CHANGES IN CAROTENE AND NON-ENZYMATIC BROWNING (NEB) DURING STORAGE OF MANGO PULP IN (HMHD) AT DIFFFRENT TEMPERATURES

Storage temp. (°C)	KMS added (ppm)	Carotene (mg/100g) at indicated period			NEB (O.D. at 400 nm) at indicated period (months)		
		1	2	3	1	2	3
24-28	—	0.494	0.439	0.274	0.22	0.23	0.25
	100	0.823	0.768	0.439	0.15	0.18	0.20
24-28*	—	0.549	0.494	0.439	0.18	0.22	0.23
	100	0.823	0.823	0.713	0.16	0.18	0.20
0	—	0.823	0.768	0.768	0.17	0.17	0.18
	100	0.823	0.823	0.768	0.17	0.17	0.17
40	—	0.384	0.329	0.165	0.26	0.28	0.30
	100	0.658	0.384	0.219	0.17	0.21	0.23

*Stored in dark

of SO_2 proved beneficial during storage. Storing the pulp with KMS in the dark was as good as keeping it at 0°C. Slight rise in °Brix during storage at high temperature could be attributed to the concentration of pulp due to moisture loss through the film.

There was a slight increase in °Brix in tomato pulp when stored in HMHD (200g) film at different temperatures. Maximum loss of lycopene occurred in the sample stored at 40°C followed by those at room temperature (24-28°C) when kept in light. Storing the samples in dark, even at room temperature as at 0°C encountered little loss in lycopene (Table 7). For retaining quality of tomato pulp in these pouches, they should be stored at low temperature and in the dark.

Although the colour of mango and tomato pulps was acceptable even upto three months of storage, the flavour was slightly affected after two months of storage. Hence this film may be more useful for mass distribution which does not require very long shelf life e.g. ready-to-serve juices, etc.

The performance of the flexible pouches may not match that of can or a glass bottle with respect to shelf life of the product as it has certain drawbacks like permeability to moisture and gases and transparency. However, in recent years developments have been made in the production of co-extension film in which the outer film was made opaque or a coloured to reduce the effect of light and also to give benefit of double layer to take care of the permeability effects.

As these pouches are cheap (Rs. 30-40/kg) and processing is easy, it may go a long way in the distribution of quick sale items like beverages, with the added advantages like light weight, non fragility and easy handling.

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References

1. Ghosh. K. G., Krishnappa, K. G., Srivastava, A. N., Eapen, K. C. and Vijayaraghavan, P. K., In pack processing of ready to eat foods in indigenous flexible packaging material. Part III. Studies on newer packing material capable of withstanding the processing temperatures. *J. Fd Sci. Technol.*, 1979, **19**, 198.
2. Pearson, D., *Laboratory Techniques in Food Analysis*. Butterworth, London, 1973, 79.
3. Roy, S. K., A simple and rapid method for estimation of total carotenoid pigments in mango. *J. Fd Sci. Technol.*, 1973, **10**, 45.
4. Beerh, O. P. and Siddappa, G. S., A rapid spectrophotometric method for the detection and estimation of adultrants in tomato ketchup. *Fd Technol. Chicago.*, 1959, **13**, 414.
5. Ranganna, S., *Manual of Analysis of Fruit and Vegetable Products*. Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 1977, 634.

TABLE 7. CHANGES IN °BRIX, NONENZYMATIC BROWNING (NEB) AND LYCOPENE CONTENT DURING STORAGE OF TOMATO PULP IN HMHD FILM (200g) AT DIFFERENT TEMPERATURES

Storage temp. (°C)	°Brix at indicated periods (months)			NEB (OD at 400nm) months at indicated periods			Lycopene (mg/100g) at indicated period (months)		
	1	2	3	1	2	3	1	2	3
-10	8.0	8.0	8.0	0.46	0.46	0.46	3.74	3.74	3.74
24-28	8.0	9.0	9.0	0.52	0.68	0.72	2.65	2.03	1.25
24-28*	8.0	9.0	9.0	0.50	0.58	0.62	2.96	2.34	1.56
0	8.0	8.0	8.5	0.50	0.52	0.54	3.12	2.50	1.87
40	8.5	9.0	9.5	0.56	0.70	0.78	2.34	1.72	1.25

*Stored in dark

ENERGY REQUIREMENTS DURING PROCESSING AND COOKING OF RICE

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The energy requirement for parboiling, pressure parboiling, milling and flaking of paddy has been computed. The drying of parboiled paddy with hot air is a highly energy consuming step in parboiling. Drying with hot sand as in the *poha* process consumes less energy. Besides the energy needed for boiling water prior to cooking, the cooking time largely determines the energy requirements. Flaking of rice considerably reduces time and energy needed for cooking.

Paddy is milled either raw or parboiled. Although parboiled rice has many nutritional and technological advantages, the dense texture it acquires during parboiling and drying impairs water permeability during cooking[1,2] causing increase in cooking time and thus energy required. It has been observed[3] that flaking of legumes results in reducing cooking time. Flaking of precooked rice or paddy is practised in the customary method of making rice flakes.

The present study is an assessment of energy spent during parboiling, milling, flaking, cooking and other allied aspects of rice processing and consumption.

'Gowrisanna' variety of paddy was milled and the rice freed from brokens. The same variety of paddy was parboiled in the laboratory by the hot soaking method[4]. In some experiments, parboiled paddy (18-19 per cent w.b.) was shelled, while hot, using a centrifugal sheller[5] to retain its thermoplastic nature.

Paddy was converted into rice flakes by the continuous method developed at this Institute using a mechanised sand roaster. Shelling was done in a centrifugal sheller and polishing in a cone mill followed by flaking between two iron rolls[5]. Samples with different flake thickness, varying from 0.5 to 1.2 mm were prepared.

Energy required for each operation was measured by an electrical energy meter attached to the main drive in the respective processes. Energy requirements for milling of raw and parboiled paddy were measured in a local mill of 1 t/hr capacity for 30 min by the energy meter attached to the main motor.

TABLE 1. ENERGY (WATT-HR) REQUIRED IN PROCESSING AND COOKING OF ONE KILOGRAM OF MILLED RICE

Sl. No.	Sample description	Processing			Cooking*	Total
		Wet-heat treatment	Milling	Flattening/ flaking		
1.	Raw rice	0	21	0	650 (25)	671
2.	Parboiled rice (sun-dried)	186	32	0	873 (45)	1091
3.	Parboiled rice (mechanically dried in oil fired LSU drier)	1042	32	0	873 (45)	1947
4.	Pressure parboiled rice (mechanically dried in oil fired LSU drier)	463	32	0	1090 (60)	1595
5.	Soaked paddy roasted in sand at 180°C for 40 sec in oil-fired gram-roaster and milled	273	28	0	803 (37)	1104
6.	As in (2) and flattened to 1.1 mm	186	32	16	574 (21)	808
7.	As in (3) and flattened to 1.1 mm	1042	32	16	574 (21)	1664
8.	As in (4) and flattened to 1.1 mm	463	32	16	664 (27)	1175
9.	As in (5) and flattened to 1.1 mm	273	28	16	556 (20)	873
10.	As in (5) and flaked to 0.5 mm	273	28	33	418 (3)	752

*Energy values include energy needed for heating water and to completion of cooking. 400 watt-hr are required to raise water from room temp. to boiling point in 13 min. Figures in parenthesis indicate cooking time in min.

All rice samples were polished to about 4% and cooked to same degree of softness. The requirement of manual energy for Sl. No. 2, 3, 4 and 5 are 7, 15, 5 and 15 watt-hr/kg respectively (Ref. 7, 13). Capacity of production for Sl. No. 2, 3, 4 and 5 are 1, 2 ½, 1 and ¼ tonne per hour respectively.

Energy required for parboiling as well as for pressure parboiling of paddy was computed from the data provided by Shivanna[7,8]. One kilogram samples of rice were cooked in 2.5 kg of water and the energy and time needed for soft cooking of rice were measured for the raw, parboiled and flattened rice samples on an electrical hot plate of 2 KW capacity coupled with an energy meter.

Parboiled rice, pressure parboiled rice[6] or milled rice obtained from the cone polisher in the rice flaking studies[5] was flaked to different thickness by passing the rice grain between two rollers by suitably adjusting the clearance between the rolls. The moisture content of the rice for flaking was adjusted to about 18 per cent (w.b.) at the time of flaking. All flaked samples were air dried to 14 per cent moisture.

The data on energy consumption for parboiling and drying of rice by various methods and for milling of the samples are given in Table 1. Parboiled paddy required about 65 per cent higher energy for milling than raw rice. The major energy requirements for parboiling are for soaking, steaming and drying. Parboiling (hot soaking and steaming) followed by sun-drying required minimum energy (186 watt-hr/kg). If mechanically dried, energy consumption is 1042 watt-hr/kg. Maximum energy was required for mechnical drying with hot air (856 watt-hr/kg). Pressure parboiled rice wherein the moisture content of the paddy to be dried is low (about 25 per cent w.b.) required 463 watt-hr/kg indicating its potential for large energy saving during the production of the parboiled rice. When cooking and drying of soaked paddy were carried out in a hot sand medium instead of drying with hot air. the energy required was only 273 watt-hr/kg indicating a considerable saving. This process is similar to the traditional process of making rice flakes. Rice obtained by this method is similar to rice made by conventional parboiling[9,10].

Flattened parboiled rice samples having thickness of 0.5, 0.85, 1.1 and 1.2 mm were found to cook in 3, 18, 21 and 22 min respectively, while control sample with thickness of 1.4 mm took 45 min. Cooked parboiled rice flakes of 0.85 mm thickness appeared somewhat flat after cooking. Optimum thickness was found to be 1.1 mm. This type of flattening did not affect the visual appearance of the cooked rice and also reduced the cooking time and energy requirement considerably[11]. This perhaps is not only due to decrease in thickness but also prevention of retrogradation[12]. Flattening required considerably less energy than parboiling or cooking (16 to 33 watt-hr/kg depending upon thickness).

Energy requirement for cooking different types of rice was also worked out (Table 1). About 400 watt-hr/kg were needed to make the water boil. Between raw and parboiled rice, the latter required more energy because of longer cooking time. This was even more with pressure parboiled rice which needed nearly 60 min for cooking. Flattening of the rice reduce the time and energy needed for cooking. Thinner the flake, shorter was the cooking time and hence lower the energy consumption for cooking.

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References

1. Kurien, P. P., Radhakrishna Murthy, R., Desikachar, H.S.R. and Subrahmanyan, V., Effect of parboiling on swelling quality of rice. *Cereal Chem.*, 1964, **41**, 16.
2. Bhattacharya, K. R. and Subba Rao, P. V., Effect of processing conditions on quality of parboiled rice. *J. agric. Fd Chem.*, 1966, **14**, 476.
3. Desikachar, H.S.R. and Subrahmanyan, V., The effect of flaking on the culinary quality of pulses. *J. scient. ind. Res.*, 1961, **20D**, 413.
4. Ghose, R.C.M., Ghatge, M.S. and Subrahmanyan, V., *Rice in India*, Indian Council of Agriculture Research, ICAR, New Delhi, 1960. Revised Ed.
5. Narasimha, H. V., Ananthachar, T. K., Shankara, R., Gopal, M. S. and Desikachar, H.S.R., Development of a continuous process for making rice flakes. *J. Fd Sci. Technol.*, 1982, **19**, 233.
6. Ali, S. Z. and Bhattacharya, K. R., Studies on pressure parboiling of rice. *J. Fd Sci. Technol.*, 1982, **19**, 236.
7. Shivanna, C. S., Traditional and modern methods of parboiling and drying of paddy. *Fd. Ind. J.*, 1971, **4**, 1.
8. Shivanna, C. S., Economics of pressure parboiling of paddy. *J. Fd Sci. Technol.*, 1974, **6**, 285.
9. Ali, S. Z. and Bhattacharya, K. R., High temperature drying-cum-parboiling of paddy. *J. Fd Process Engng*, 1980, **4**, 123.
10. Srinivas, T., Bhashyam, M. K., Shankara, R., Vasudeva Singh and Desikachar, H.S.R., Drying-cum-curing of freshly harvested high moisture paddy by roasting with hot sand. *J. Fd Sci. Technol.*, 1981, **18**, 184.
11. Mahadevappa, M. and Desikachar, H.S.R., Expansion and swelling of raw and parboiled rice during cooking. *J. Fd Sci. Technol.*, 1968, **5**, 72.
12. Ali, S. Z. and Bhattacharya, K. R., Comparative properties of beaten rice and parboiled rice. *Lebensmittel-wiss-Technol.*, 1976, **9**, 11.
13. Araullo, E. V., De Padua, D. B. and Graham, M., *Rice: Postharvest Technology*, International Development Research Centre, Ottawa, 1976, 187.

STUDIES ON BACTERIOLOGICAL QUALITY OF DRIED WHOLE MILK IN RELATION TO THE INITIAL QUALITY OF RAW MILK

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Thirty samples each of raw whole and dried whole milk made from same raw milk samples were assessed for standard plate counts (SPC), thermoduric counts, coliform counts, spore counts and titratable acidity. The study revealed that (*i*) the poor quality raw milk will yield a powder with high bacterial count, (*ii*) there is a positive correlation (r = 0.97) between thermoduric count of raw milk and SPC of dried whole milk, (*iii*) there is no correlation between coliform counts of raw milk and dried whole milk (*iv*) the spore count of raw milk has some influence on the spore counts of dried milk, (*v*) titratable acidity of raw milk can be taken as a good index of titratable acidity of resultant dried milk.

The ability of some bacteria and spores to resist the lethal action of high temperatures of drying milk, presents a serious problem to Dairy and Food Processing industries. Crossley[1] reported that the powder from good quality milk contained fewer bacteria than that from the poor quality milk. However, contrary to the earlier statement of Crossley, Crossley and Johnson[2] stated that there was no direct relation between the bacterial quality of raw milk and bacterial quality of milk powder produced from it. Burdet[3] obtained a positive correlation between direct microscopic clump count of raw milk and direct microscopic clump count of dried milk made from it. Wallgren[4] obtained a reasonably good relationship between the thermoduric count in raw milk and bacterial count in resulting dried milk.

The information available on bacteriological quality of dried milk in relation to the raw milk quality is inadequate in India. In this study, an attempt has been made to investigate the bacteriological quality of dried milk in relation to total plate count, thermoduric count, spore count and coliform count in the raw milk supply. The study was undertaken under field conditions at Milk Products Factory, Andhra Pradesh Dairy Development Corporation (Pvt.) Limited, Vijayawada.

Receipt and standardization of milk: The factory receives mixed milk from Vijayawada milk shed villages. The milk received was stored in raw milk storage tanks at 5 to 7°C. The raw milk intended for whole milk powder was standardized to contain 3.2 to 3.3 per cent fat and 9 per cent SNF; pasteurised and stored for 4 to 20 hr at 5 to 7°C.

Preheating: Chilled pasteurized milk was preheated in vertical tubular heat exchanger to 90 to 95°C.

Preconcentration: The preheated milk was evaporated under vacuum to contain 45 to 48 per cent total solids. A vacuum of 27 to 28 in Hg was maintained during evaporation.

Spray drying: The preconcentrated milk was dried in a drying chamber whose inlet air temperature was maintained at 170 to 175°C and the outlet air temperature at 95 to 100°C.

Thirty samples each of raw whole milk and dried whole milk made from the same raw milk samples were collected in sterile containers taking all possible precautions. The following tests were conducted to assess the quality.

Standard plate count agar[5] was used for estimating standard plate counts (SPC). Violet red bile agar[5] was used for estimation of coliforms. Aliquots of laboratory pasteurised (63±0.2 C for 30 min) samples of raw milk and reconstituted dried whole milk[6] were plated with standard plate count agar for estimation of thermoduric bacterial counts (Td BC). Indian Standards Institution procedure[7] for estimation of spores was used. Total titratable acidity of raw and dried whole milk was estimated and expressed as per-cent titratable acidity[6] in terms of lactic acid. ISI procedure[6] was used for reconstituting the dried whole milk for estimation of bacterial numbers.

The standard plate count in raw milk ranged from 0.77 to 29.40 million/ml and in the resulting dried whole milk from 0.004 to 0.2 million/g. It is observed that the higher standard plate counts in raw milk contribute to higher standard plate counts in dried whole milk (Table 1). The correlation between these counts in raw milk and dried whole milk was 0.74 indicating the necessity for good quality raw milk to obtain a powder of high quality. The high correlation obtained in this study compared to the coefficient correlation of 0.53 to 0.66 between DMC of raw milk and DMC of skim milk powder obtained by Burdet[3] may be due to the difference in counting methods.

The results presented in Table 2 reveal that thermoduric bacterial counts in raw milk and SPC in dried whole milk bear a close relationship as reported earlier by Wallgren[4]. The average thermoduric bacterial count of raw milk samples was 33,600/ml and SPC of dried whole milk was 30,300/g. It is evident that most

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TABLE 1. RELATIONSHIP BETWEEN STANDARD PLATE COUNTS IN RAW MILK AND DRIED WHOLE MILK

Raw Milk				Dried whole milk mean
Range of SPC/ml ($\times 10^3$)		Distribution (%)	Mean* SPC/ml $\times 10^3$	SPC/g ($\times 10^3$)**
$< 1 \times 10^3$		3.33	770	4.30
1×10^3	2×10^3	3.33	1440	4.00
2×10^3	3×10^3	20.00	2700	12.00
3×10^3	4×10^3	13.33	3650	13.66
4×10^3	5×10^3	16.66	4460	22.75
5×10^3	6×10^3	6.66	5500	29.00
6×10^3	7×10^3	6.66	6900	65.00
7×10^3	8×10^3	3.33	7760	15.00
8×10^3	9×10^3	3.33	8900	16.00
9×10^3	10×10^3	3.33	9200	56.00
10×10^3	11×10^3	3.33	10000	22.00
11×10^3	12×10^3	3.33	11000	7.60
$> 12 \times 10^3$		13.33	21500	89.00
Mean+		—	7099	30.30

*Average counts of No. of samples in each distribution range.

**Mean of counts of dried whole milk samples made from same raw milk samples from each distribution range.

+Mean of counts of 30 samples (each sample was plated in duplicate).

Coefficient of correlation between SPC of raw whole milk and of dried whole milk=0.740.

TABLE 2. RELATIONSHIP BETWEEN THERMODURIC BACTERIAL (TDBC) COUNTS IN RAW MILK AND SPC, TDBC AND SPORE COUNT IN DRIED WHOLE MILK

Raw Milk			Dried Whole Milk		
Range of TdBC/ml ($\times 10^3$)	Distribution (%)	TdBC/ml* ($\times 10^3$)	Mean SPC/g+ ($\times 10^3$)	Mean TdBC/g	Spore** count/g
< 10	16.66	7.84	7.20	772	340
10–20	33.33	15.86	13.85	2576	315
20–30	20.00	26.66	26.50	2125	270
30–40	13.33	34.00	33.25	2450	365
40–50	3.33	48.00	46.00	2800	440
50–60	3.33	54.0	48.00	2000	320
60–70	3.33	65.00	88.00	1800	340
> 70	6.66	175.00	147.00	31500	405
Mean‡	—	33.60	30.30	5030	314.10

*Average thermoduric bacterial count in each distribution range.

+Average standard plate count of dried whole milk made from same raw whole milk sample from each distribution range.

**Average spore count of dried whole milk made from same raw milk samples from each distribution range.

‡Average counts of 30 samples, (each sample was plated in duplicate).

Coefficient of correlation between

(*a*) TdBC of raw whole milk and SPC of dried whole milk =0.970

(*b*) TdBC of raw whole milk and of dried whole milk =0.656

(*c*) TdBC of raw whole milk and spore count of dried milk =0.520

of the thermoduric bacteria survived the drying temperatures and the correlation between thermoduric counts in raw milk and SPC in dried whole milk is 0.97. The thermoduric bacterial counts in raw milk and spore counts in dried milk are independent of each other with a correlation of 0.52 (not significant at 0.01 level). However, thermoduric counts in raw milk and dried whole milk have a correlation of 0.656 and is highly significant.

The coliform counts (data not presented) in raw milk ranged from 4280 to 132000/ml with an average of 28660/ml. In dried milk the counts ranged from 0 to 5/g. The per cent samples of dried whole milk containing coliforms is 16.66 and they may be of thermoduric type as reported by Crossley[1] and Hall[8]. It was observed that coliform counts in raw and dried whole milk are independent of each other (coefficient of correlation is -0.111).

The data in Table 3 show that the spore count in raw milk ranged from 76 to 365 with an average of 193/ml and in powder 35 to 500 with an average of 314/g. It is also observed that as the spore counts in raw milk increased, the spore count in dried whole milk also correspondingly increased. The correlation between spore counts in raw milk and in dried whole milk (0.8135) indicate that raw milk with high spore counts results in a powder with a high spore count. The relationship between spore counts in raw milk and dried whole milk appears to depend on the type of spores rather than on the number of spores present in raw milk.

All the samples of dried whole milk prepared from the raw milk used in this study showed less than 1.2 per cent titratable acidity (data not presented) which is an acceptable level[6], the titratable acidity of raw milk was

TABLE 3. RELATIONSHIP BETWEEN SPORE COUNTS IN RAW MILK AND DRIED WHOLE MILK

Raw Milk			Dried whole milk spore count/g**
Range of spore count/ml	Distribution (%)	Spore count/ml*	
<100	10.00	76.00	191.66
100–120	13.33	107.33	297.50
120–140	16.66	131.00	252.00
140–160	6.66	155.00	172.00
160–180	3.33	165.00	300.00
180–200	10.00	196.00	403.00
200–220	6.66	216.00	340.00
220–240	3.33	240.00	415.00
240–260	13.33	252.00	340.00
260–280	3.33	275.00	420.00
>280	13.33	365.00	440.00
Mean+	—	193.00	314.00

*Average spore count of raw whole milk sample in each distribution range

**Average spore count of dried whole milk made from same raw whole milk samples from each distribution range.

+Average count of 30 samples.

Coefficient of correlation between spore count of raw whole milk and dried whole milk=0.813.

positively related to the titratable acidity of dried whole milk. The average titratable acidity of raw milk and dried whole milk was 0.137 and 0.87 per cent, respectively. The titratable acidity of raw milk can be taken as a good index of the titratable acidity of resultant dried milk.

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References

1. Crossley, E. L., The bacteriology of spray dried milk powder. *J. Dairy Sci.*, 1938. **21**, 303.

2. Crossley, E. L. and Johnson, W. A., Bacteriological aspects of manufacture of spray dried milk and whey powders including some observations concerning moisture content and solubility. *J. Dairy Res.*, 1942, **13**, 5.

3. Burdet, H., Factors affecting direct microscopic clump count of non-fat dry milk. *J. Dairy Sci.*, 1960, **43**, 317.

4. Wallgren, K., Some bacteriological problems in connection with the manufacture of dried milk. *Meddn. Svenska Mejeriern. Riksforen*, 1965, **81**, 19, (cited in *Dairy Sci. Abstr.* 1965, **27**, 2551).

5. *Methods of Test for Dairy Industry*. IS:1479—1962 (Part-III), *Bacteriological Analysis of Milk*. Indian Standards Institution, New Delhi.

6. *Specifications for Milk Powder (whole and skim)*. IS:1165-1967 Indian Standards Institution, New Delhi.

7. *Specifications for Sterilized Milk*. IS:4238-1967, Indian Standards Institution, New Delhi.

8. Hali, H. E., Brown, D. F., Robinson, H. M., Donnelly, C. B. and Reyes, A. L., Bacteriological examination of grade 'A' dry milk powder. *J. Milk Fd Technol.*, 1967, **30**, 219.

STORAGE BEHAVIOUR AND DRYING CHARACTERISTICS OF COMMERCIAL CULTIVARS OF ONION

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Studies on the varietal characteristics, storage and drying behaviour of four commercial varieties of onion viz. 'Mahua', 'Ropali', 'Nasik' and 'Rangda' revealed that var. 'Ropali' is better suited both for storage and dehydration. Its dry matter, alcohol insoluble solids and pyruvic acid contents could perhaps explain better performance of this variety over others.

India is the largest producer of onion in the world after China, with a total production of 24.5 lakh tonnes[1]. Onion is grown throughout the country. Price of onion varies considerably depending on the production and demand. Harvested crop is generally stored under ambient conditions on improvised racks under a thatched roof with a free flow of air. The losses due to desiccation and rotting is around 40–60 per cent. To stabilize the price of onion, it is necessary to reduce these losses and develop proper storage facilities. We have to select varieties having longer shelf life and better suited for dehydration.

Variability of storage life of different cultivars has been reported by several workers[2-4]. Poor keeping cultivars have a low dry matter content[5], a low refractive index[6,7] high rate of water loss[5] and are generally less pungent[8]. Similarly, the desirable traits needed in onion for dehydration include: (*a*) white coloured flesh; (*b*)

solid content around 15 per cent but preferably as high as 20 per cent; (*c*) high degree of pungency; (*d*) storage life of 2-3 months; and (*e*) free from joints[9-10].

Keeping these points in view, four commercial cultivars of rabi onion available in Delhi were studied for varietal characteristics, storage properties and drying behaviour.

Four commercial varieties of onion popularly known as 'Mahua', 'Ropali', 'Nasik and 'Rangda' were obtained from New Azadpur Market, Delhi in the month of April (cropping season Oct-Nov. to April-May). 'Nasik and 'Rangda varieties are grown in Maharashtra and have a red or purple colour skin. 'Mahua' and 'Ropali' varieties are grown in Gujarat and have a light pink colour skin.

For studies on optimum keeping quality, 5 kg material from each variety was kept in triplicate in plastic trays under ambient condition (28-33°C, 40-60 per cent RH) and the physiological loss of weight was recorded at monthly intervals.

For dehydration, 5 mm thick slices were spread on an aluminium tray at 4 kg/sq m. and three trays were kept for each cultivar. Tray load was fixed on the basis of trial runs for optimum load carried out earlier on the solar dryer.

The solar dryer used in this study was a "Forced indirect solar air dryer" developed by National Physical Laboratory, New Delhi. It had a solar energy catchment area of 6 sq. m. painted with an ordinary black paint. Drying chamber measuring 2 m×1.5 m×1.5 m could accommodate 45 trays. About 40 kg material could thus be dried in one batch. The blower used could blow 2000 cu ft of hot air/min.

Specific gravity, °Brix, dry matter, alcohol insoluble solids, reducing and total sugars were estimated according to A.O.A.C.[11] in three samples from each cultivar. Pungency in onion was measured as pyruvic acid by the method of Schwimmer and Guadagin[12]. Colour estimate in the dehydrated onion was made by drenching the aliquots in 10 per cent NaCl solution and measuring O.D. at 420 nm in a Klett-Summerson colorimeter.[13]

From the results on physical properties of four varieties of onion (Table 1) it is seen that 'Nasik' and 'Ropali' possessed higher percentage of TSS and dry matter.

High degree of pungency is considered essential to retain better flavour and keeping quality in the dehydrated product. Among the present varieties, 'Nasik' was found to possess the least amount of pungent principles as against 'Ropali' which contained twice as much of pungency as the former variety.

Lower ratios between reducing and non-reducing sugars is essential to minimize browning of dehydrated material. In this regard 'Mahua' variety was found to be superior while the other three varieties were found to be at par with each other.

TABLE 1. PHYSICO-CHEMICAL CHARACTERISTICS OF FOUR COMMERCIAL VARIETIES OF ONION

Estimates	Mahua	Ropali	Nasik	Rangda
Colour	Violet red	Light pink	Violet red	Light pink
Sp. gr.	0.92	1.08	1.24	0.93
°Brix	10.3	12.0	14.0	12.0
Dry wt. (%)	13.4	15.8	14.1	12.9
Alcohol insoluble solids (%)	2.30	3.58	2.56	2.63
Pyruvic acid/ (μmoles/100g)	495	510	260	325
Reducing sugars (%)	2.07	2.35	2.44	2.40
Total sugars (%)	7.00	6.90	6.30	7.20

High insoluble solid content (about 1 per cent) is considered desirable to impart good consistency and rehydration properties to the dehydrated product. Variety 'Ropali, was found to possess the highest alcohol insoluble solids of 3.58 per cent. It varied from 2.30 to 2.63 per cent in the other three varieties.

On the basis of light colour, higher contents of dry matter, alcohol insoluble solids and pyruvic acid, the most desirable traits for dehydration, was found in variety 'Ropali.

From the data presented in Table 2, it can be seen that 'Ropali' has a better storage capability as compared to other varieties. It showed least physiological loss of weight during the entire period of storage. Next in order of storage were 'Rangda' and 'Mahua'. Sprouting was not observed in any of the varieties during storage. PLW varied from 28 to 40 per cent from 5 kg onions in

TABLE 2. STORAGE BEHAVIOUR OF FOUR COMMERCIAL VARIETIES OF ONION

Variety	Physiological loss of wt (%) after indicated months			
	1	2	3	4
Mahua	7.5	13.0	26.3	32.0
Ropali	7.00	12.5	19.2	28.0
Nasik	11.2	18.2	34.7	40.0
Rangda	8.0	14.0	24.5	30.0

TABLE 3. DEHYDRATION DETAILS OF FOUR COMMERCIAL VARIETIES OF ONION

Variety	Wt. of slices(g)		Drying ratio	Reconstitution ratio	Pyruvic acid (μm/100g)			Colour (O.D. at 420 nm)
	Fresh	Dry			Initial	Final	Loss %	
Mahua	1000	150	6.7:1	1:4.8	495	683	79.4	105
Ropali	1000	170	5.9:1	1:4.8	510	653	78.2	97
Nasik	1000	150	6.7:1	1:4.7	260	510	70.2	110
Rangda	1000	155	6.4:1	1:4.8	325	397	80.9	93

a four month storage period at 28-33°C. Loss of 6 to 20 per cent in pyruvic acid was observed in different varieties with the least loss in 'Ropali' and the maximum in 'Mahua' after a period of three months storage. Higher dry matter and pyruvic acid content are considered valuable traits for better storage life and these were found at a higher level in 'Ropali' cultivar.

Data on the dehydration of four commercial varieties along with pyruvic acid and final colour of the material is presented in Table 3. It can be seen that in a solar dryer, variety 'Ropali' has given the highest final yield with a dehydration ratio of 5.9:1. Reconstitution ratio (1:4.8) was found to be the highest in 'Ropali'. Loss of pyruvic acid was the least in 'Ropali' and the highest in 'Mahua' after dehydration. Loss of pyruvic acid in different varieties varied from 70 to 81 per cent.

Colour of the final product after dehydration was found to be the best in 'Rangda' and 'Ropali'. These two varieties have also got light, pink colour as compared to violet red of 'Mahua' and 'Nasik'.

From the above findings, it is quite clear that the variety 'Ropali' had better quality characteristics and storage life as compared to the other varieties. It is more suited for drying also, as can be seen from its dehydration characteristics.

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References

1. *Fruit and Vegetable Processing Industry in India, Commodity Notes*, Indian Institute of Foreign Trade, New Delhi, 132.
2. Magruder, R., Webster, R. E., Jones, H. A., Randall, T.E., Snyder, G. B., Brown, H. D. and Hawthorne, L. R., *Storage Qualities of Principal Varieties of American onions*, U.S. Dept. Agric. Circ. 618, 1941, 48.
3. Marlatt, R. B. and Mckittrick, R. T., Pink rot resistant onions for Arizona. *PL. Dis. Reptr.*, 1958, **42**, 1310.
4. Whuler, G.F.C. and Finch, C. G., Variety trials with main crop onions. *Expt. Hort.*, 1962, **7**, 33.
5. Woodman, R. M. and Barnell, H. R., The connection between the keeping quality of commercial varieties of onion and the rate of water loss during storage. *Ann. appl. Biol.*, 1937, **24**, 219.
6. Foskeh, R. L. and Peterson, C. E., Relation of dry matter content to storage quality in some onion varieties and hybrids. *Proc. Am. Soc. hort. Sci.*, 1950, **55**, 314.
7. Hanoaka, T. and Ito, K., Studies on the keeping quality of onions. 1. Relation between characters of bulbs and their sprouting during storage. *J. hort. Ass. Japan.*, 1957, **26**, 129.
8. Kampeng J. Van., The improvement of available onion varieties. *Zaadbelangen*, 1970, **24**, 135.
9. Jones, H.A. and Mann, L.K. *Onions and Their Allies*, Leonard Hill Book Ltd., London, 1963.
10. Fairbrother, J. G., Onion varieties suitable for dehydration. *Tasm. J. Agric.*, 1968, **39**, 149.
11. *Official Methods of Analysis*, Association of the Official Analytical Chemists, Washington D. C., 11th Edn., 1970.
12. Schwimmer, S. and Guadagin, D. G., Relation between olfactory threshold concentration and pyruvic acid content of onion juice. *J. Fd Sci.*, 1962, **27**, 94.
13. Hart, F. L. and Fisher, H.J., *Modern Food Analysis*, Sprmger-Verlag, Berlin, 1971.

STUDIES ON QUALITY AND NUTRITIONAL ASPECTS OF TOMATO

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Components responsible for the taste and flavour of tomato fruits were estimated in seven tomato cultivars. 'Pant T-3' was found to have relatively high amounts of ascorbic acid and β-carotene. 'Karnataka Hybrid' had very high lycopene content. It also has desirable characteristics like high titratable acidity, low sugar/acid ratio and high ascorbic acid. 'Punjab Chhuhara' was found to contain more dry matter than other cultivars.

Tomato is one of the important fruits which is consumed as such or canned or processed into products like ketchup, sauce, chutney, paste. Quality and flavour of the processed products depend on chemical components like reducing sugar, acidity, lycopene, β-carotene, dry matter, total soluble solids, etc. The composition of tomato has been reported to vary greatly with variety, soil condition and environment[1-3]. Breeding for specific components suitable for processing is common in deve-

loped countries[4,5]. In India, a number of varieties giving higher yields have been evolved and little attention has been paid to their quality, especially carotenoid content. Lycopene is the predominant carotenoid of tomato responsible for its colour[5]. Besides this, β-carotene is also present in tomato to a certain extent. Distribution of carotenoid compounds is also one of the factors contributing to the flavour of tomato[6]. Therefore, a study was undertaken to determine the variability in chemical composition including the carotenoids of some promising cultivats grown in Tamil Nadu Agricultural University, Coimbatore, and the results are presented in this paper.

Tomato fruits of seven cultivars as given in Table 1 were collected from the Faculty of Horticulture, Tamil Nadu Agricultural University, Coimbatore. Firm, uniform and ripe fruits from third pickings were washed with water and wiped with a muslin cloth. Three to five fruits in each variety were cut into small pieces and pooled together. Duplicate samples were weighed and blended with a mixture of metaphosphoric acid and acetic acid for ascorbic acid estimation[7]. Remaining pooled sample was pulped into a smooth consistency and was used for analysis. Lycopene and total carotenoids were extracted in acetone[8] and taken up in light petroleum for spectrophotometric analysis. Fruit pulp was extracted with ethanol-hexane mixture for estimation of β-carotene[7]. Dry matter was determined by drying about 100 g of fresh tomato fruit tissue in an oven at 80° for 2-3 days[9]. Reducing sugar and total free amino acids were estimated in 80 per cent alcohol extracts as per Somogyi[10] and Lee and Takahashi[11] respectively. Estimation of titratable acidity was carried out as per A.O.A.C. method[12].

TABLE 1. CAROTENOID CONTENTS IN TOMATO CULTIVARS

Cultivars	Lycopene (mg/100g)	β-carotene (mg/100g)
Karnataka Hybrid	7.8 (88.0)	0.28 (3.2)
Mangala	3.6 (87.0)	0.27 (6.5)
Punjab Chhuhara	3.3 (83.2)	0.27 (6.9)
AC 238	2.6 (79.0)	0.22 (6.8)
Pant T-3	2.3 (75.2)	0.36 (11.6)
Sweet 72	3.3 (85.8)	0.30 (7.8)
Siaux	4.1 (87.2)	0.25 (5.3)

Figures in paranthesis indicate the percentage with respect to total carotenoids.

Carotenoid contents of tomato cultivars are given in Table 1. Amount of lycopene varied from 75 to 88 per cent of the total carotenoids; maximum amount being present in 'Karnataka Hybrid' (7.75 mg/100g). This may be used for crossing with high carotene containing varieties like 'Pusa Ruby', red fruited variety, was utilized by Premchandra *et al.*,[13] for producing red coloured, higher β-carotene containing cultivars. Amount of β-carotene, varied from 0.22 mg per 100 g in 'AC 238' to 0.36 mg per 100 g in 'Pant T-3', which corresponds to 3.2 to 11.6 per cent of total carotenoids. Changes in carotenoid contents of tomato results in changes in the concentration of certain volatile compounds responsible for the tomato-like flavour and the proportion of lycopene and β-carotene is important for the flavour of fresh tomato[6].

Table 2 presents data on ascorbic acid, sugar/acid ratio, titratable acidity, reducing sugar and dry matter contents in the seven cultivars analysed. Variability in ascorbic acid concentration was observed among these cultivars; the range being 25.7-16.27 mg per 100 g with coefficient of variation of 19.4. 'Pant T-3', 'Mangala' and 'Karnataka Hybrid' had ascorbic acid content of 25.7, 24.4 and 21.6 mg per 100 g, respectively. Generally, higher ascorbic acid containing cultivars were found to have high titratable acidity also. This may be due to the fact that presence of acids by virtue of their chelating power reduces catalytic activity of metals like copper and iron thereby increasing the stability of ascorbic acid[5].

The reducing sugar content of the cultivars ranged from 2.78 to 1.54 per cent; 'Siaux' having the highest amount and 'Sweet-72' having the lowest. The soluble carbohydrate of tomato fruit is made up almost entirely of reducing sugars and are an important constituent of flavour[5].

The titratable acidity of the varieties also varied markedly from 8.1 m-equiv. per 100 g in 'Punjab, Chhuhara' to 13.4 m.equiv. per 100 g in 'Karnataka Hybrid'. Higher the titratable acidity of the fruits higher the flavour[2] and lower its pH. Since varieties having low pH are desirable for canning purposes, 'Karnataka Hybrid', 'Sweet 72' and 'Pant T3' may be chosen for canning. Overall flavour intensity was largely determined by an interaction between sugar and acids[6,7]. Sugar to acid ratio should be narrow for better flavour of the fruits. The cultivar 'Sweet 72' besides having high acidity, has low reducing sugar/acid ratio of 0.120. Among the cultivars having high reducing sugars, 'Karnataka Hybrid' has low sugar/acid ratio and hence will be superior in flavour than the other cultivars. Another component contributing to the flavour of tomato is total free amino acids and variability among cultivars in its concentration is also observed. Dry matter content of the fruits was found to vary from 7.1

TABLE 2. CHEMICAL COMPONENTS OF TOMATO CULTIVARS

Cultivars	Dry matter (%)	Reducing sugar (%)	Titratable acidity (m.eq/100g)	Ascorbic acid (mg/100g)	Total free amino acids (mg/g)	Reducing sugar/ acid
Karnataka Hybrid	4.40	2.50	13.38	16.8	7.41	0.19
Mangala	6.69	1.90	10.02	16.3	6.84	0.19
Punjab Chhuhara	7.08	2.70	8.10	24.4	7.11	0.33
AC 238	6.28	2.60	10.87	21.1	13.00	0.24
Pant T-3	5.74	1.70	11.70	25.7	7.41	0.14
Sweet 72	4.80	1.50	12.84	21.6	8.66	0.12
Siaux	6.72	2.80	9.42	16.4	7.79	0.30
Mean	5.96	2.23	10.90	20.3	8.32	0.22
S.E.	0.39	0.20	0.71	1.5	0.81	0.06
C.V.	17.18	23.54	17.34	19.4	25.78	71.10

to 4.4 per cent. Varieties having high amounts of dry matter are preferred for tomato paste production[8]. Hence 'Punjab Chhuhara' and 'Mangala' by having comparatively higher dry matter are suitable for tomato paste manufacture. 'Punjab Chhuhara' may also be utilized for manufacture of ketchup and puree. Cultivars having high dry matter were found to contain low titratable acidity with a highly significant correlation coefficient of –0.9666**. This may be due to the presence of less dry matter in high locule containing varieties and locules were found to have higher acidity than the fruit walls and placenta[6].

Nutritionally, 'Pant T-3' is superior to other cultivars because of its high ascorbic acid and β-carotene contents. 'Karnataka Hybrid' has high titratable acidity, low sugar/acid ratio, high ascorbic acid and lycopene contents.

References

1. Jeyadeviah, M. S., Tondon, G. L. and Giradhari Lal, Composition of tomatoes. *Bull. Cent. Fd Technol. Res. Inst.*, Mysore, 1965, **5**, 180.
2. Winsor, G. W., Some factors affecting the quality and composition of tomatoes. *Acta Hort.* 1979, **93**, 335.
3. Davies, J. N. and Hobson, G. E., The constitutents of tomato fruit—the influence of environment, nutrition and genotype. *CRC Critical Rev. Fd Sci. Nutr.*, 1981, **15**, 205.
4. Stevens, M. A. and Rudich, J., Genetic potential for overcoming physiological limitations on adaptability, yield and quality in the tomato. *Hort. Sci.*, 1978, **13**, 673.
5. Hobson, G. E. and Davies, J.N., The tomato, in *Biochemistry of Fruits and Their Products*, A. C. Hulmes, (Ed.), Academic Press, London, 1971, Vol. II, 437.
6. Stevens, M. A., Tomato quality: Potential for developing cultivars with improved flavour. *Acta Hort.*, 1979, **93**, 317.
7. Ranganna, S., *Manual of Analysis of Fruit and Vegetable Products*. Tata-McGraw-Hill, New Delhi, 1977, 634.
8. Adsule, P. G. and Amba Dan, Simplified extraction procedure in the rapid spectrophotometric method for lycopene estimation in tomato. *J. Fd Sci. Technol.*, 1979, **16**, 216.
9. Hobson, G. E., Pectin esterase in normal and abnormal tomato fruit. *Biochem. J.*, 1963, **86**, 358.
10. Somogyi, M., Notes on sugar determination. *J. biol. Chem.*, 1952, **200**, 145.
11. Lee, Y. P. and Takahashi, T., An improved colorimetric determination of amino acids with the use of ninhydrin. *Anal. Biochem.*, 1966, **14**, 71.
12. *Official Methods of Analysis*, Association of Official Analytical Chemists, Washington, 1970, 11th Edn.
13. Premchandra, B. R., Vasantharajan, B. N. and Gama, H. R., Improvement of the nutritive value of tomatoes. *Curr. Sci.*, 1976, **45**, 56.

CHANGES IN THE CHEMICAL COMPOSITION AND ORGANOLEPTIC QUALITY OF CITRUS PEEL CANDY DURING PREPARATION AND STORAGE

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There was total loss of ascorbic acid during curing of candied peel prepared from all the three kinds of citrus fruits. Losses in sugars, acids, carotenoids, flavonoids and phenols were higher during curing than during preparation and storage. 'Kinnow' peel candy was the best organoleptically soon after preparation as well as after storage when compared with 'Bood-red' and 'Villafranca'.

Citrus peel, which is generally considered a waste is more nutritious than juice and pulp and can be processed into candies. Although preparation of candy, has been reported by many workers[3,6,7,8] no systematic work has been done on its chemical and organoleptic quality. The present investigation was carried out to evaluate the utility of peels for the preparation of candy.

Three citrus varieties, namely the loose jacketted mandarin (*Citrus reticulata*) variety 'Kinnow', the sweet orange (*Citrus sinensis*) variety 'Blood-red' and the lemon (*Citrus limon*) variety 'Villafranca' were supplied by the Department of Horticulture, Punjab Agricultural University, Ludhiana. After extraction of juices, the residue was utilized for the preparation of candy.

Preparation of candied peel: After separation of rags and seeds, the peels were placed in 2.0 per cent common salt solution, the strength of which was increased by 2.0 per cent every 24 hr till 8.0 per cent. On the fifth day, the peels were washed and placed in a freshly prepared 8.0 per cent common salt solution containing 0.2 per cent potassium meta-bisulphite and 1.0 per cent calcium chloride and stored for one month.

TABLE 1. EFFECT OF PREPARATION AND STORAGE ON CHEMICAL CONSTITUENTS OF PEEL CANDY

	Colour		Ascorbic acid (mg/100g)	Acidity* (g)	Sugars			Carotenoids (β-car) (mg/100g)	Flavonoids (as rutin) (mg/100g)	Phenols Total
					Reducing	Non-reducing	Total			
Kinnow										
Fresh	Orange	26A	92.30	0.38	9.80	2.71	12.66	7 60	3.37	225.00
Cured	Orange	26D	0.00	0.02	2.02	Traces	4.53	4.54	1.22	192.00
Candied peel	Gray orange	168B	0.00	0.11	25.00	28.98	55.00	4.13	0.56	135.00
Stored** Candied peel	Gray orange	166B	0.00	0.108	26.82	28.52	56.85	3.70	0.25	92.50
Blood-red										
Fresh	Yellow orange	22B	82.45	0.45	10.99	1.91	13.00	6.05	59.50	362.50
Cured	,,	22D	0.00	0.02	2.41	Traces	5.12	4.06	29.60	190.20
Candied peel	Gray orange	168B	0.00	0.09	21.70	40.28	64.10	2.50	14.48	96.00
Stored** Candied peel	,,	164A	0.00	0.08	23.72	40.28	66.20	1.90	5.00	70.00
Villafranca										
Fresh	Gray yellow	162A	36.35	0.80	6.25	1.06	7.37	0.30	11.70	451.00
Cured	,,	162D	0.00	0.20	1.02	Traces	3.19	0.22	5.10	223.00
Candied peel	,,	163B	0.00	0.29	20.00	40.00	62.10	0.12	2.00	102.50
Stored** Candied peel	Gray orange	165B	0.00	0.27	22.21	39.65	63.95	Traces	0.50	45.00

*as anhydrous citric acid; **after 8 months of storage

TABLE 2. EFFECT OF STORAGE ON ORGANOLEPTIC CHARACTERISTICS OF CITRUS PEEL CANDY

Citrus variety	Flavour		Colour		Bitterness		Texture		Overall acceptability	
	Initial	Stored	Initial	Stored	Initial	Stored	Initial	Stored	Initial	Stored
Kinnow	16*	15*	15	14	16*	13	17*	16*	16*	15*
	(3.2)	(3.0)	(3.0)	(2.8)	(3.2)	(2.6)	(3.4)	(3.2)	(3.2)	(3.0)
Blood-red	11	8	11	8	13	11	11	8	12	9
	(2.2)	(1.6)	(2.2)	(1.6)	(2.6)	(2.2)	(2.2)	(1.6)	(2.4)	(1.8)
Villafranca	11	10	10	8	13	8	12	10	12	9
	(2.2)	(2.0)	(2.0)	(1.6)	(2.6)	(1.6)	(2.4)	(2.0)	(2.4)	(1.8)

Rank sums by 5 judges, maximum 4 marks each for flavour, colour, bitterness, texture and overall acceptability.
Figures in parentheses indicate mean scores given by 5 judges; *significant at 5 per cent level.

These peels were washed several times in water, and boiled for softening. The peels were then covered with a cold sugar syrup of 30° Brix in a vessel and left for 48 hr. On the third day, the °Brix was raised by 10° and the peels were boiled with the syrup for about 5 min. The process was repeated until 60 °Brix was reached. At this stage citric acid (0.15 per cent of the weight of the peel) was added. The strength of the syrup was then raised to 75 °Brix (5° on each day). The peels were left in the syrup for three weeks. Finally, they were drained and dried on trays at room temperature for eight days and then dried at 50°C for 2 hr in a through flow drier till stickiness was lost. The prepared candied peels were put in polythene bags and stored in glass jars for eight months.

Chemical analysis: Peel was analysed for colour[5], ascorbic acid[4], sugars[4], total carotenoids[4], total flavonoids[2], and total phenols[7] at four stages, i.e., fresh, after curing, after preparation and after storage for eight months.

Organoleptic evaluation: Organoleptic evaluation of the prepared candy was carried out soon after preparation and after eight months of storage. A panel of 6-8 judges was selected for the evaluation of the candy.

Effect of processing on chemical composition: There was change in colour during curing, preparation and storage of the candied peel (Table 1). Ascorbic acid was totally destroyed during curing. Acidity was also negligible after curing. The prepared candy, regained acidity because of addition of citric acid. Later, slight loss in acidity was observed during storage. A loss of 60-65 per cent of total sugars and 78-90 per cent of reducing sugars occurred in the peel during curing. Dried candy showed an increase in total as well as reducing sugars. Losses of carotenoids, flavonoids and phenols were maximum during curing of peels and preparation and storage of candied peels.

Organoleptic quality: 'Kinnow' peel candy ranked superior to that of 'Blood-red' and 'Villafranca' candided peels (Table 2). A slight change in colour and taste of 'Kinnow' peel candy was noticed after storage but was acceptable eventhough it was little sticky. There was significant change in flavour, colour, taste, texture and overall quality of candied peels of 'Blood-red' and 'Villafranca' varieties during storage. 'Blood-red' peel candy was not accepted after storage because it deteriorated as seen by its sensory characters (Table 2). 'Kinnow' and 'Villafranca' peel candies were found acceptable even after storage.

The candied citrus peel can be used in the baking industry in the preparation of cakes, cookies, steamed puddings and sweet breads and can be marketed as mixed candied fruits. These can also be used as marmalade bases.

References

1. *Official Methods of Analysis*, Association of Official Analytical Chemists, Washington, 1975, 12 Edn.

2. Balbaa, S. I., Zaki, A. Y. and Elshamy, A. M., Total flavonoid and rutin content of the different organs of *Sophora japonica* L. *J. Ass. Off. anal. Chem.*, 1974, **57**, 752.

3. Hendrickson, R. and Kesterson, J. W., By-products of Florida citrus. Composition, technology and utilization. *Univer. Florida, Agric. Expt Stn. Bull.*, 1965, 698.

4. Ranganna, S., *Manual of Analysis of Fruit and Vegetable Products*, Tata McGraw-Hill Publishing Co Ltd., New Delhi, 1977, 9.

5. *RHS Colour Chart*, The Royal Horticultural Society, Lond, 1966.

6. Sinclair, W.B., *The Grape Fruit. Its Composition, Physiology and Products*, University of California, Division of Agricultural Science, Berkeley, California, 1972.

7. Swain, T. and Hills, W. E., The phenolic constituents of *Prunus domestica*. The quantitative analysis of phenolic constituents. *J. Sci. Fd Agric.*, 1959, **10**, 63.

8. Swisher, H. E., Guards citrus-peel flavourings. *Fd Engng.*, 1962 **34**,(2), 92.

STUDY ON THE EFFECT OF FORMALIN AS A PRESERVATIVE ON DIFFERENT CONSTITUENTS OF RAW MILK SAMPLES DURING STORAGE

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Effect of formalin at 0.4 and 0.6% levels during storage on milk constituents like fat, solids not fat, lactose and titrable acidity was studied for one year. Study has shown that formalin at a concentration of 0.4% is suitable for the effective preservation of milk samples and there is no significant change in the fat content of milk when stored in glass bottles for one year.

Formalin is used as a preservative for milk, *chhanna*, cream, *dahi*, jaggery, *gur* and ice-cream, under the Prevention of Food Adulteration Act 1954 and Rules thereof, of India. It inhibits enzyme activity and prevents growth of microorganisms. It is reported that addition of formalin to milk gives lower values for fat content in milk samples due to hardening of casein[1,2]. Bakalor[3] suggests use of a higher concentration of sulphuric acid to overcome this. In view of these reports, a study was undertaken for assessing the suitability of formalin as a preservative on different constituents of milk during storage, within the frame work of sampling procedure laid down under the Provisions of PFA Act.

Fresh cow milk procured from a local dairy was divided into 30 units of 225 g each and stored in narrow mouth glass bottles after adding formalin. Bottles were closed with cork, tops were sealed with wax and stored in dark at 37°C for one year.

Formalin (BDH 40 per cent aqueous solution of formaldehyde) was used at two levels to give a final concentration of 0.4 and 0.6 per cent in milk.

Fat content was estimated by Gerber Method[4] and Rose Gottleib Method[5], solids-not-fat (SNF) content of milk was estimated by deducting fat content from total solids. Titrable acidity and lactose contents were determined as per the ISI methods[5].

During the storage of samples at 37°C in dark, cream plug appeared within 24 hr. A white sedimentation probably due to casein, globulin and albumin appeared at the bottom after one month. It continued to increase in volume with passage of time. At the end of one year there were three distinct layers in the samples. They were (*i*) top layer of cream plug, (*ii*) middle layer of liquid, and (*iii*) bottom layer of semi-solid material.

On blending, these layers mixed readily and the resultant sample was stable. In this study, samples were blended using "Braun" blender. The blended samples were warmed to 40°C on a water bath, and cooled to ambient temperature before analysis.

There was no significant change in the constituents of milk immediately after adding formalin except for increase in titrable acidity. Milk solids dissolved readily in 91 per cent sulphuric acid after addition of formalin on first day and upto one month, thereafter the protein did not dissolve completely. However, it was possible to dissolve milk proteins by heating the butyrometers at 60°C for sometime or by using 94 per cent sulphuric acid[3].

From the data given in Table 1 it is clear that there is no perceptible change in the average fat value of milk when treated with 0.4 per cent formalin, even upto a storage period of 12 months when tested either by Gerber method or by Rose Gottleib method. In the latter case, a small increase of 0.04 per cent was observed; however, at 0.6 per cent level of formalin, a slight decrease in average fat value of milk in samples stored for 2, 4, 6 and 9 months was observed in both the methods.

No change occurred in the SNF value of milk samples treated with 0.4 and 0.6 per cent formalin. No significant change occurred in the lactose value of the samples treated with 0.4 and 0.6 per cent formalin. On addition of formalin there was immediate increase in titrable acidity of milk, which continued to increase with passage of time. It may be due to the liberation of carboxyl groups from proteins and not due to lactic fermentation because lactose content of the sample did not change significantly.

The study has shown that formalin at a concentration of 0.4 per cent as recommended in the Prevention of Food Adulteration Act 1954[6] is suitable for the effective preservation of milk samples and there is no significant change in the fat and solids-not-fat content of milk when stored in glass bottles for 12 months at ambient temperature.

TABLE 1. VALUES OF DIFFERENT CONSTITUENTS OF MILK PRESERVED WITH FORMALIN FOR DIFFERENT PERIODS OF STORAGE

Period (month)	Formalin (%)	S.N.F. (%)	Fat (%) Gerber method	Fat (%) Rose Gottelib method	acidity (lactic acid) (%)	Lactose by wt. (%)
0	0.4	8.21	4.0	4.05	0.17	2.98
	0.6	—	—	—	—	—
0*	0.4	8.21	4.0	4.08	0.22	3.01
	0.6	8.20	4.0	4.05	0.23	2.96
½	0.4	8.15	4.05	4.07	0.25	3.01
	0.6	8.16	4.00	4.10	0.26	2.98
1	0.4	8.18	4.05	4.09	0.26	2.96
	0.6	8.29	4.00	4.02	0.26	3.02
2	0.4	8.22	3.9	4.04	0.27	2.96
	0.6	8.23	3.9	4.04	0.27	3.01
4	0.4	8.23	4.0	4.01	0.28	2.92
	0.6	8.23	3.9	4.02	0.28	2.99
6	0.4	8.24	3.9	4.00	0.28	2.99
	0.6	8.28	3.9	4.02	0.28	2.94
9	0.4	8.24	4.0	4.06	0.32	2.98
	0.6	8.30	3.9	4.00	0.30	2.95
12	0.4	8.19	4.1	4.09	0.32	3.00
	0.6	8.16	4.0	4.05	0.32	3.09

*Determined immediately after adding preservative.

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References

1. Pien, J., Desirant, J. and Avril, P., Estimation of fat in formaldehyde treated milks by Gerber's Method. *Annls. Falsif. Expert. Chim.*, 1972, **65**, 468.
2. Communication from the Dairy Sub-Committee of Central Committee for Food Standards, New Delhi.
3. Bakalor, S., Rapid methods for the estimation of fat content II. *Dairy Sci. Abstr.*, 1955, **17**, 980.
4. *Determination of Fat by Gerber Method*, IS:1224 (Part I) 1977, Indian Standards Institution, New Delhi.
5. *Methods of test for Dairy Industry*, Part II, *Chemical Analysis, of Milk*, IS:1479 (Part II), 1961, Indian Standards Institution, New Delhi.
6. *Prevention of Food Adulteration Act* 1954 *and Rules thereof*, Government of India, New Delhi.

PREPARATION OF LOW-FAT, HIGH-PROTEIN SESAME SEED

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The principle of the method is to press sesame for partial recovery of oil, then reshape the pressed seed by immersion in boiling water, and finally dry the reconstituted wet seed in the sun. The oil content in the reconstituted seed was 26-33% and protein content was 31-36%.

In an earlier paper[1], the preparation of a low-fat, high-protein groundnut was described. Subsequently, Bongirwar, Padawl-Desai and Srinivasan described preparation of low-fat, high-protein groundnut and soybean. Sesame seed is not only rich in oil but also it contain essential amino acids like lysine and methionine. If the fat content is reduced without altering its shape, the high-protein seed could be used in protein foods, snacks and other preparations, and can be an article of popular demand.

Studies were carried out on the preparation of a low-fat, high-protein sesame seed and the results are presented. Both brown and white varieties, as well as decuticled seeds of brown variety were utilized in the experiments.

The principle of the method is to press sesame seed for partial recovery of oil, then reshape the pressed seed by immersion in boiling water, and finally dry the reconstituted wet seed in the sun.

A Carver laboratory model hydraulic press was used for partial recovery of sesame oil from cleaned sesame seed (100 g) under the experimental conditions given in Table 1. The pressed seed was removed and subjected to a process of reconstitution which involved dipping the pressed seed held in a perforated cylinder in boiling water for a few minutes. The wet seed was dried in the sun or in a hot air oven. A bench-scale hand screw press was used for partial recovery of sesame

TABLE 1. COMPOSITION OF LOW-FAT, HIGH-PROTEIN (RECONSTITUTED) SESAME SEED

Seed variety	Seed pressing yield (%)		Oil (%)		Protein (%)	
	Oil	Reconst. seed	Original seed	Reconst. seed	Original seed	Reconst. seed
Laboratory Carver hydraulic press						
Brown I	30	60	48	25	22	33
Brown II	34	54	50	27	22	34
-do- decuticled	43	49	60	33	24	36
White	35	55	50	29	22	35
Bench-scale hand screw press						
Brown II	25	65	50	33	22	31

Conditions in Carver pressing: Pressure 1000 kg/cm^2, temp. 75°C, time 30 min.

Conditions in hand screw pressing: Manual pressure, temp. 75°C, time 60 min.

oil where the batch size was 3.5 kg seeds. Results are given in Table 1.

The oil yield was 30 to 43 per cent in hydraulic press and 25 per cent in hand screw press (Table 1). The oil contents in the reconstituted seed varied between 26 and 33 per cent as against 48-60 per cent in the original seed. A loss of about 10 per cent was recorded in the reconstitution process. The protein contents, increased from 22-24 per cent in the original seed to 31-36 per cent in the reconstituted seed.

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References

1. Ramachar, D., Thirumala Rao, S. D. and Reddy B. R., Laboratory prepared high protein, low oil groundnuts. *Indian Fd Packr.*, 1974, **28**,(1), 79.

2. Bongirwar, B. R., Padwal-Desai, S. R. and Srinivasan, A., Studies on defatting of peanuts and soybeans for develo'ing ready-to-eat snack items. *Indian Fd Packr.*, 1977, **31**,(3), 61.

EFFECT OF SUB LETHAL CONCENTRATION OF *BACILLUS THURINGIENSIS* ON THE DEVELOPMENT OF RICE MOTH, *CORCYRA CEPHALONICA* (STAINT)

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Sub lethal concentrations of *Bacillus thuringiensis* in the diet of *Corcyra cephalonica* larvae at 20 mg/kg level retarded the pupation and prolonged the larval period beyond 95 days. In addition, the larval weight was reduced by more than 40% after an exposure of 15 days in the treated diet.

Corcyra cephalonica (Staint) is a serious pest of stored grains and grain products in India. This insect can attack stored rice, wheat, groundnut, cocoa, nutmeg, linseed, Bengal gram, red gram, green gram as well as animal feeds like wheat bran, rice bran and cotton seed[1]. The repeated applications of insecticides to control storage insects have caused development of insect resistance to malathion and synergised pyrethrin in moth population[2]. Hence, biological control measures using *Bacillus thuringinesis* Berliner is being adapted for the control of lepidopterous insects in storage[3].

When the *B. thuringiensis* formulations are applied to the crop in the field it is observed that sometimes, due to feeding habits of the insects, adequate dose of toxin is not consumed by the pest to cause death. The effect of sub lethal concentrations of the δ-endotoxin of *B. thuringinesis* on the larval development and mortality of tobacco budworm, *Heliothis virescens* has been studied by Dulmage and Martinez[4]. Yamvarias[5] has reported reduction in oviposition of *Anagasta kuhniella* after exposure to *B. thuringiensis* formulation. There is no information on the effect of sub lethal dose of *B. thuringiensis* formulation on the breeding of lepidopterous storage pests. Hence, the present work was carried out to study the effect of *B. thuringiensis* formulation on the rice moth, *Corcyra cephalonica*.

A culture of *Bacillus thuringiensis* var. *thuringiensis* originally isolated by Majumder *et al*[6]. from diseased *Heliothes obsoleta* larvae and cultured in the laboratory fermentor on a medium containing silkworm pupa meal +sugarcane molasses was used in this study[7]. The freeze dried product had a spore count of 35×10^9/g.

Eggs of *Corcyra cephalonica* were collected from the stock culture maintained in this laboratory. The stock diet consisted of whole wheat flour having 12 per cent moisture. For mass culture, 1000 eggs were released in a

TABLE 1. EFFECT OF SUB LETHAL CONCENTRATION OF *B. THURINGIENSIS* (SPORE+TOXIN) ON THE DEVELOPMENT OF *C. CEPHALONICA* LARVAE

Diet			After 15 days exposure*		B.t.spores in the gut of larva after 22 days	Av. wt. of adult moth (mg)	Days for 1st moth emergence	% moth emerged upto 75 days exposure	After 95 days exposure		Av. wt of moth, 16 days after transfer to control diet (mg)
B.t. (mg/kg)	B.t. spores (10^2/g)	Other bacteria (10^2/g)	Wt. of larva (mg)	Wt. gained (mg)					Av. wt of surviving larva (mg)	% larva surviving	
20	5300	0	8.09	5.42	152	25 (18)	63	16	29.41 (25)	21.0	16.29 (10)
10	3120	0	8.05	5.80	75	23 (7)	58	9	30.50 (20)	12.5	23.88 (7)
5	630	13	9.96	7.51	6	30 (11)	58	24	31.45 (2)	2.5	—
2.5	875	170	9.49	7.36	14	25 (7)	58	16	21.0 (1)	2.5	11.6 (1)
1.25	270	30	9.76	7.47	16	30 (7)	60	16	—	—	—
0	0	170	14.59	12.29	0	23 (3)	56	9†	—	—	—

*Average of 4 replicated experiments, each replicate consisting of 40 larvae.

†Moth emergence in control was low due to visible fungal growth (*Aspergillus glaucus*) in the diet.

Figures in parentheses indicate the number of larva/moth from which the average weight was derived.

glass trough of 22 cm diameter filled with 250 g of stock diet and maintained in a humid chamber at 75 per cent RH in the laboratory (26±1°C).

Known quantity of *B. thuringiensis* spore formulation was suspended in 2 ml of sterile distilled water and mixed with 2 g of stock diet. From this a series of experimental diets were prepared by diluting with stock diet so as to yield a final *B. thuringiensis* spore+toxin concentrations of 20, 10, 5, 2.5 and 1.25 mg/kg of diet.

To find out the viable spore count in the experimental diet and also to check the uniform mixing of *B. thuringiensis* spores, one gram of the diet from each concentration was plated on nutrient agar medium. Bacterial counts were also made from the control samples.

From the mass culture, 40 preweighed, 15 day old larvae were released into each replicate having 12 g of the experimental diet. Each treatment including control had four replicates. All the petri dishes were incubated in the room (26±1°C) in a dessicator at 77 per cent RH for 95 days.

The spore count of *B. thuringiensis* at various dilutions in the feed and insect gut, presence of other bacterial colonies in the diet, weight of larvae after 15 and 95 days of exposure to the treated diet, first adult emergence and per cent emergence are recorded in Table 1.

It is observed that *Corcyra* larvae after feeding for 15 days on the *B. thuringiensis* incorporated flour at 20 mg/kg level gained only 44 per cent weight as compared to control and took 7 days more for the first adult emergence. In this treatment, upto 75 days of exposure only 16 per cent of the moths emerged whereas after 95 days of incubation still 21 per cent of the larvae were alive. These larvae were small in size, each weighing 30 mg, whereas fully grown larva in the control group weighed around 60 mg. After a continuous exposure of 95 days in the *B. thuringiensis* treated flour the larvae were transferred to untreated flour for further observation. These larvae pupated and adult emergence occurred after an incubation of 16 days. However, the moths emerged were small in size, each weighing only 16.29 mg as compared to 23 mg in the control group.

The first batch of moths which emerged in all the treatments including control upto 75 days of exposure, revealed no difference in the weight of emerged adult moths. The reason for some of the larvae emerging as adults during the first phase of 75 days and some remaining in a retarded condition beyond 95 days could be that either the toxin was not uniformly got mixed up due to the micro level incorporation or due to the non-migratory nature and feeding habits of the larvae. There was no difference in the various parameters observed, when the incorporated *B. thuringiensis* level in the diet was lower than 10 mg/kg.

Dulmage and Martinez[4] in their study on the sub

lethal effect of *B. thuringiensis* on tobacco bud worm larvae (*Heliothis virescens*) had used 80 IU of *B. thuringiensis* toxin per ml as the highest concentration in the diet. The LC_{50} dose reported for *H. virescens* is 313 IU/ml of diet. At 80 IU/ml level they observed mortality of larvae before pupation. They also correlated the increase in development time and reduction in pupal weight to the toxin content in the diet.

In this experiment, the highest level of *B. thuringiensis* formulation incorporated in the diet is 20 mg/kg which consisted of 5.3×10^5 spores/g. The LC_{50} of this *B. thuringiensis* formulation to *C. cephalonica* larvae (fourth instar having an average weight of 26 mg/larva) was reported to be 5.1×10^9 spores/g of diet[8]. The retardation of growth without causing the mortality of the *Corcyra* larvae observed in the present study could be attributed to the very low level of toxin incorporation as compared to the LC_{50} dose to this pest.

Another interesting observation is that other bacterial flora and fungi were not detected in flour treated with *B. thuringiensis* at 10 and 20 mg/kg level, whereas control group had visible infection by *Aspergillus glaucus*. This fungal infection has also affected the normal adult emergence in the control group. Kreig[9] has reported the presence of antagonistic substance thuricin against gram positive bacteria by *B. thuringiensis*. This could be one of the reasons for the absence of other bacteria in the *B. thuringiensis* treated flour.

This study has revealed that *B. thuringiensis* formulations, as a biological control agent, can also prevent the completion of life cycle of *C. cephalonica* larvae, when present in sub lethal concentrations in the diet.

The authors are thankful to Mr. S. K. Majumder, and Dr. B. L. Amla, of the Institute, for providing necessary facilities to carry out this investigation. They are also thankful to Dr. N. G. K. Karanth for critical evaluation of the manuscript.

References

1. Sheshagiri Rao, D., Notes on rice moth, *Corcyra cephalonica*. *Indian J. Entomol.*, 1954, **16**, 95.
2. Zettler, J. L., McDonald, L. L., Redlinger, L. M. and Jones, R. D., *Plodia interpunctella* and *Cadra cautella* resistance in strains to malathion and synergized pyrethrins. *J. econ. Entomol.*, 1973, **66**, 1049.
3. McGaughey, W. M., Repsones of *Plodia interpunctella* and *Ephestia cautella* larvae to spores and parasporal crystals of *Bacillus thuringiensis*. *J. econ. Entomol.*, 1978, **71**, 687.
4. Dulmage, H. T. and Martinez, E., The effects of continuous exposure to low concentrations of the δ-endotoxin of *Bacillus thuringiensis* on the development of tobacco budworm, *Heliothis virescens*. *J. Invert. Pathol.*, 1973, **22**, 14.
5. Yamvrias, C., Contribution to the study of the mode of action of *Bacillus thuringiensis* as regards the flour moth *Anagasta* (*Ephestia*) *kuebniella*. *Entomophaga*, 1962, **7**, 101 (cited from *Rev. Appl. Entomol.*, 1963, **51**, 481).
6. Majunder, S. K., Muthu, M. and Pingale, S. V., A bacterial disease of *Heliothis obosleta*. *Curr. Sci.*, 1955, **24**, 122.
7. Hegde, R. V., Central Food Technological Research Institute, Mysore, Unpublished data. 1980.
8. Chatterjee, B., Studies on Multiplication of *Bacillus thuringiensis* in Some Lepidopterous Larvae. 1982, M.Sc., (Food Tech.) thesis, University of Mysore.
9. Kreig, A., Thuricin, a bacteriocin produced by *Bacillus thuringiensis*. *J. Invert. Pathol.*, 1970, **15**, 291.

BOOK REVIEWS

Leaf Protein Concentrates: by Lehel Telek and Horace D. Graham, AVI Technical Books, Inc, West Port, Connecticut, U.S.A., 1983; pp 844; Price $ 93.50.

The book has been dedicated to Dr. N. W. Pirie, the pioneer of leaf protein. It is a timely publication putting together the different aspects of leaf protein research.

The work on leaf protein concentrate (LPC) has come a long way and has got over its initial teething troubles. With the world population growing unabated, we shall have to look to leaf proteins as the renewable source to meet the prime nutrient demand of the underfed of world population.

The authors have divided the material into 4 parts. Part I is a compilation of leaf protein extraction from grasslands, plant sources of temperate and tropical climate and tobacco leaf with reference to their production potential and chemical and nutritional characteristics.

Part II deals with the proximate composition and the proteins and amino acid content of LPC and nutrition studies on the availability of amino acids. The gas liquid chromatographic and gel chromatcgraphic techniques have also been detailed. There are chapters on carbohydrates in LPC, the pigments and phenolic compounds in leaf and their interaction with LPC. Information on lipids of LPC has also been presented.

Part III enumerates the different techniques of LPC production and economics of their production.

Part IV is quite an exhaustive compilation of LPC research all over the world including those from Brazil, Egypt, India, Newzealand, Japan, Nigeria, Pakistan, Poland and USSR.

LPC has a great potential if production costs could be reduced. Though the product is of a deep green colour, this should not be a serious handicap in its utilization as civilization have been consuming leafy material in their food.

All in all, the authors have done a very creditable job of compiling the leaf protein research all over the world. Thus the book perforce is a book of reference on fundamental and applied aspects of leaf protein research. It will be worthwhile for the libraries and the leaf protein workers to possess this bock.

D. S. WAGLE
HARYANA AGRICULTURAL UNIVERSITY, HISSAR

Hydrogenation of fats and oils: by H.B.W. Patterson, Applied Science Publishers, Barking, Essex, England; 1983; pp. xv+310; Price: £ 38.00.

This compact book discusses important aspects of hydrogenation from a practical stand point and is a valuable source of reference to research scientists, engineers and technologists in the field. The text covers various aspects of hydrogenation technology of oils and fats in nine chapters: The Hydrogenation Reaction, Hydrogenation Process Techniques, Hydrogenation Plant, Hydrogen, Catalysts, Hydrogenation Methods, Safety, Quality and Control, and Glossary of Hydrogenation and Related Technical Terms. Written in a lucid style, each chapter covers the essentials that are necessary for running a hydrogenation plant, in an unique manner that is not found in other books. The clear definition of the meaning of selectivity in hydrogenation in theory and practice (Ch. 1), unusual coverage of the purchase of hydrogen (Ch. 4), hydrogen receipt by road/rail and general precautions covering static charges and electrical equipment (Ch. 7) are just a few examples which show that the author has given enough thought to blend the theoretical and practical aspects judiciously. The book has a major section on the hydrogenation methods for various oils and fats that include oils of groundnut, coconut, rapeseed, safflower, sesame, cottonseed, soyabean, sunflower, castor and rice bran which are of interest to our country and in vanaspati manufacture. The section also covers the problems that restrict the use of palm oil in vanaspati manufacture.

In a book of this type, one does expect information on newer and related aspects like biohydrogenation, nutritional aspects of hydrogenated fats and so on, but the author has made it clear in the preface to the book—"It (the book) is addressed in the first place to production staff who expect quick access to advice on specific problems and then to development personnel who if they do not find a ready-made answer to their problem, may at least obtain useful directions.... and for the beginner, an attempt is made to describe the 'why' and 'how' of hydrogenation.... the information has been arranged as a direct practical advice and as explanations as to why changes occur as they do....."

The book has 296 useful references. It is an welcome addition to any library and an useful reference for the vanaspati manufacturers.

J. V. PRABHAKAR
C.F.T.R.I., MYSORE

ASSOCIATION NEWS

Bangalore Chapter

The Chapter arranged following lectures: (1) Primary health care in food technology by Dr. V. Ramakrishna and Dr. C. Achuthan, on 4th Setember 1984; (*ii*) Application of enzymes in the food and beverage industries by Mr. Kiran Majumdar on 1st October 1984 and (*iii*) Food flavour by Dr. K. W. Gopinath on 6th November 1984.

Bombay Chapter

The Annual General Body Meeting was held on 28th April 1984 at the Department of Chemical Technology, University of Bombay, Matunga. Dr. A. S. Aiyar, President of the Chapter welcomed the members to the meeting. An account of the activities during 1983 was presented by Dr. C. P. S. Menon, Hon. Secretary. The Treasurer's report was read by Dr. V. K. Joshi. The students' awards were then presented by the President to Miss. Kalpana Bhavsar, P. V. Polytechnic (Rs. 250/-) for standing first in Diploma in Food Technology in 1982–83 and to Miss Dazy Sagar, S. V. T. College of Home Science (Rs. 400/-) for standing first in M.Sc. (Food and Nutrition) in 1982–83.

The Secretary announced the names of the office bearers and the members of the executive committee for 1984. They are; *President:*—Dr (Mrs) S. R. Modambi, *Vice-Presidents:*—Dr. S. G. Bhat, and Mr. V. C. Sane, *Hon-Secretary:*—Dr. C. P. S. Menon, *Hon. Jt. Secretary:* Ms. Lalitha Iyer Bhattacharya, *Hon. Treasurer:*—Dr. V. K. Joshi, *Members:*—Dr. D. R. Bongirwar, Dr. A. S. Gholap, Dr. R. R. Mallya, Dr. D. P. Nerkar, Dr. S. V. Padgaonkar, Dr. S. R. Padwal-Desai, Mr. M. Venkataraman and Dr. G.M. Tewari, *Co-opted members:* Prof. K. M. Agashe, and Dr. M. R. Vora. After a vote of thanks, the AGM was adjourned.

There was also a talk by Mr. N. S. Pochkhanawala, food consultant of Bombay.

Bombay Chapter has started publishing a News Letter for effective communication among the members. Members are requested to contribute their views and news items.

OBITUARY

The sudden and unfortunate demise of Prof. D. V. Tamhane, on Monday the 10th September 1984, has been a great shock to food scientists and technologists. Dr. Dattatraya V. Tamhane had a brilliant academic record, taking his B.Sc. (Tech.) with honours in 1950 and Ph.D. in 1955 at the Department of Chemical Technology, Bombay.

After serving for a short period as Research Chemist in D & P Products (Now Dipy), he joined as lecturer in Food Technology at UDCT in 1957. He was the Professor of Fermentation Technology since January 1984, and was heading the Food and Fermentation Technology Section. He had guided more than 25 students for Ph.D. degree. Most of his students hold reputed positions in industries. He had professional connection with several national laboratories and universities in the country. As a consultant to food industry, Prof. Tamhane was well-known for his innovative and humane approach.

Prof. Tamhane nurtured and took keen interest in the activities of professional bodies like AFST, Indian Institute of Chemical Engineering, Association of Microbiologists of India, and Oil Technologists Association of India. He was one the architects of Bombay Chapter of AFST(I) and the present developmental activities of the Chapter is due to the untiring efforts of Prof. Tamhane. He was the President of AFST(I), Bombay Chapter for two years.

It is indeed a great loss to Food Science community which will be felt for a very long time. We all share the sorrow of his bereaved family.

SUBJECT INDEX

Vol. 21, 1984

AUTHOR INDEX

Vol. 21. 1984

INSTRUCTIONS TO AUTHORS

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

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

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

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

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

6. **Illustrations:** Graphs and other line drawings should be drawn in *Indian ink* on tracing paper or white drawing paper preferably art paper. The lettering should be in double the size of printed letters. For satisfactory reproduction, graphs and line drawings should be at least twice the printed size 16 cm (ox axis) × 20cms (oy axis); photographs must be on glossy paper and must have good contrast; *three copies* should be sent.

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

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

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

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

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

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

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

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

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

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

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

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Research Papers

Research Notes

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