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Interaction of Plastic Films with Foods . I. Effect of Polypropylene and Polyethylene Films on Fruit Squash Quality

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Effect of polyethylene (PE) and polypropylene (PP) film contact on the quality of fruit squash (orange and lemon) and beverages (mango, orange and blue grape) was studied by storing them in glass bottles at room temperature (18-35°C) both with and without pieces of plastic films immersed in them. Both PE and PP significantly increased the rate of non-enzymic browning and depletion of d-limonene and anthocyanin concentrations. PE and PP contact did not significantly influence ascorbic acid (AA) degradation in squashes/beverages. But in isolated system, AA degradation increased in the presence of films. The changes in total carotenoids, sulphur dioxide and titratable acidity were not affected by films. PE and PP contact did not cause perceptible changes in sensory quality of squashes/beverages.

Plastic films and their laminates are finding extensive use in food packaging. The quality and shelf life of packaged foods are known to be governed by the physico-chemical properties of the films and the interactions taking place between food and packaging films during processing and storage. Though the role of physico-chemical and barrier properties of plastic materials on loss of flavours and ingress of oxygen and water vapour and their influence on keeping quality and acceptability of foods is well investigated, the role of plastic film-food interactions on the sensory quality and stability of foods is less understood. Without the involvement of barrier properties, packaging film-food interaction may take place by the migration of the plastic film constituents in the food, by absorption of food constituents by the film and by the reactions of food constituents with the reactive site on the film surface.

Among the various food materials, fruit juices are highly susceptible to quality deterioration during processing and storage and a number of workers have studied the storage stability of aseptically packed fruit juices in plastic film laminated carton packs. It was found that the rate of quality deterioration in fruit juices during storage was faster in carton packs than in glass packages[1,2]. A distinct reduction in flavour intensity and increased rate of browning and ascorbic acid degradation was reported as a result of polyethylene film contact with fruit juice in laminated carton packs[3,4]. Since increased browning and ascorbic acid degradation can also result from increased oxygen permeability of plastic film laminated cartons[1,2] as compared to glass bottles, it is not clear whether the above reactions occur as a result of plastic film-juice contact *per se* or merely as a result of increased oxygen availability. The present study was, therefore, planned to investigate the effect of polyethylene and polypropylene films contact *per se* when immersed in fruit squash/beverage on the quality changes taking place during storage.

Materials and Methods

Polyethylene (75 μ m) and polypropylene (75 μ m) films were obtained from leading manufacturers. Good quality mangoes ('Alphanso' and 'Dusheri'), oranges, lemons and blue grapes ('Bangalore blue') were purchased from market. Ascorbic acid, citric acid, benzoic acid, sodium meta-bisulphite and 2, 6-dichlorophenolindophenol and 5, 5'-dithiobis (2-nitro benzoic acid) were from standard chemical firms.

Preparation of orange and lemon squashes: Orange juice was extracted in a screw type juice extractor from washed and peeled oranges while lemon juice was extracted by a cup type stainless steel hand pressed juice extractor from washed and halved fruits. Freshly extracted orange juice had Brix 9° and pH 3.6 while lemon juice had Brix 6° and pH 2.1. Orange juice (1.5 kg) was treated with 2.2 kg of 70 per cent sugar syrup, while lemon juice (1.9 kg) was treated with 3.1 kg 70 per cent sugar syrup to obtain 45° and 46° Brix in the finished products respectively. Another lot of orange juice (2.2 kg) of 9° Brix was treated with 0.92 kg 70 per cent sugar syrup to obtain 27° Brix in the end product. The pH of orange squash was 3.2 while that of lemon squash was 3.5. The squashes were heated to 90°C for 3 min, cooled and treated with sodium metabisulphite (350 p.p.m.) and ascorbic acid (100-500 p.p.m.).

Preparation of mango and grape beverages: Mangoes

were washed, peeled and flesh was separated from stones using stainless steel knife and passed through 2 mm mesh sieve in a pulper. 'Alphanso' pulp had Brix 14°, pH 4.1 and titratable acidity 0.66 while 'Dusheri' pulp had Brix 26°, pH 5.3 and titratable acidity 0.17. 'Alphanso' mango pulp (2 kg) was treated with 25 per cent sugar syrup (2.4 kg) while 'Dusheri' mango pulp (2.4 kg) was treated with 12 per cent sugar syrup (1.8 kg) to obtain 20° Brix in the beverage. The pH of the finished beverage was adjusted with citric acid to 2.9 and 2.7 in 'Alphanso' and 'Dusheri' beverages respectively.

Blue grape juice was extracted from washed fruits in stainless steel juice extractor and had Brix 11°, pH 3.7. Juice (2.6 kg) was treated with 25 per cent sugar syrup (1.04 kg) to obtain 15° Brix in the beverage. The pH was adjusted to 3.4 with citric acid.

Mango and grape beverages were pasteurised by heating at 90°C for 3 min and cooled. Mango beverage was treated with sodium metabisulphite (350 p.p.m.) and ascorbic acid (100 p.p.m.) while grape beverage was treated with benzoic acid (600 p.p.m.) and ascorbic acid (100 p.p.m.). The pasteurised grape beverage was filtered through a muslin cloth to remove the coagulated material resulted from heating.

Packaging and storage: One hundred ml of squash/beverage was packed in 125 ml ground glass stoppered (B-14) bottles. One set was stored as such without any treatment while in the second set one piece (10 cm × 25 cm) of polyethylene film and in the third set one piece (10 cm × 25 cm) of polypropylene film was immersed in the squash/beverage in each glass bottle. The ratio of volume (ml) of the squash to surface area (cm) of film was 1:5. All the bottles were stoppered and sealed with wax and stored at room temperature (15-35°C).

Preparation of orange oil emulsion system: Orange oil emulsion was prepared by adding cold pressed orange oil (20 g) polyoxyethylenesorbitan monolaurate (60 g) in double distilled water (920 ml). The above mixture was homogenised (Ultrasonic Laboratory Homogeniser, Type 4005, England) and aliquots (100 ml) were stored in 125 ml glass bottles both with and without polyethylene or polypropylene film pieces immersed in emulsion as described for squashes.

Analysis: Ascorbic acid, benzoic acid and titrable acidity were determined by AOAC procedures[6]. Browning was determined by the method of Meydav *et al*[7]. in citrous squashes and beverages and Mannheim *et al*[5]. in mango and grape squashes. Limonene was analysed according to Scott and Veldhuis[8] in squashes/beverages, while in orange oil emulsion, it was analysed by gas liquid chromatography (CIC Baroda) using DEGS columns, flame ionization detectors and nitrogen as carrier gas. During analysis, the oven temperature was maintained at 120°C while injector and detector temperatures were 200°C. To determine limonene absorbed by plastic films, these were washed with distilled water and treated with 100 ml ether in stoppered glass bottles and left overnight. Aliquots of ether extracts were injected in gas chromatograph to measure the concentration of d-limonene. Total carotenoids and anthocyanin were determined by methods described earlier[5,9]. Sulphur dioxide was measured by the method of Humprey *et al*[10]. The results presented in Tables 1 to 7 are means of at least three replicates along with their standard deviations. The statistical significance of the results was tested by student 't' test.

Results and Discussion

Non-enzymic browning and degradation of flavouring compounds, pigments and ascorbic acid are the major causes of deterioration in stored fruit beverages and squashes. Accordingly, changes in browning intensity, ascorbic acid, carotenoids, anthocyanin and limonene contents were used

TABLE 1. EFFECT OF PLASTIC FILM ON NON-ENZYMIC BROWNING IN FRUIT SQUASH/JUICE STORED AT ROOM TEMPERATURE (15-35°C)

Storage period (days)	Storage system	Orange 45° Brix	Orange 27° Brix	Lemon 46° Brix	Mango Alphanso 20° Brix	Mango Dusheri 20° Brix	Blue grape 15° Brix
0		0.10 ± 0.01	0.07 ± 0.00	0.20 ± 0.00	0.13 ± 0.01	0.12 ± 0.00	0.14 ± 0.01
30	GB	0.15 ± 0.02	0.12 ± 0.01	0.19 ± 0.01	0.17 ± 0.01	0.16 ± 0.01	0.20 ± 0.01
30	GB+PE	0.17 ± 0.01	0.16 ± 0.01	0.23 ± 0.01	0.16 ± 0.00	0.22 ± 0.01	0.20 ± 0.01
30	GB+PP	0.18 ± 0.01	0.21 ± 0.00	0.25 ± 0.01	0.18 ± 0.02	0.21 ± 0.01	0.22 ± 0.01
90	GB	0.16 ± 0.01	0.17 ± 0.00	0.24 ± 0.00	0.18 ± 0.01	0.19 ± 0.01	0.24 ± 0.00
90	GB+PE	0.20 ± 0.01	0.19 ± 0.01	0.27 ± 0.01	0.22 ± 0.01	0.25 ± 0.00	0.28 ± 0.02
90	GB+PP	0.21 ± 0.01	0.24 ± 0.01	0.28 ± 0.01	0.22 ± 0.01	0.26 ± 0.01	0.30 ± 0.01

GB. Glass bottle: GB+PE. Glass bottle containing polyethylene films.
GB+PP. Glass bottle containing polypropylene film.

a. Significant at 99.95 per cent confidence; b. Significant at 99.5 per cent confidence; c. Significant at 97.5 per cent confidence; d. Significant at 95 per cent confidence.

TABLE 2. EFFECT OF PLASTIC FILM ON THE CHANGES IN ASCORBIC ACID (mg/100 g) IN SQUASHES/BEVERAGES STORED AT ROOM TEMPERATURE (15-35°C)

Storage period (days)	Storage system	Orange 45° Brix	Orange 27° Brix	Lemon 46° Brix	Mango Alphanso 20° Brix	Mango Dusheri 20° Brix	Blue grape 15° Brix
0		71.5±1.5	75.2±0.7	32.9±2.7	19.0±0.4	26.6±0.3	16.4±0.0
30	GB	69.5±1.3	72.2±2.7	17.0±1.1	15.8±0.3	17.6±0.6	4.0±0.1
	GB+PE	68.9±0.9	69.1±1.8	15.0±0.4	14.9±0.0	16.6±0.6	3.1±0.1
	GB+PP	69.7±1.1	69.6±1.5	14.6±0.6	15.1±0.0	18.4±0.2	4.0±0.1
90	GB	48.9±4.7	42.2±0.3	7.3±0.7	10.2±0.1	11.6±0.0	3.1±0.1
	GB+PE	48.5±0.8	42.4±0.7	6.5±0.8	10.4±0.2	11.3±0.3	2.4±0.0
	GB+PP	50.8±1.6	41.9±2.7	6.7±0.7	11.3±0.2	11.5±0.4	2.6±0.1

GB, Glass bottle; GB+PE, Glass bottle containing polyethylene films. GB+PP, Glass bottle containing polypropylene film.

as objective indicators of quality changes resulting from polyethylene and polypropylene film contact with fruit squashes and beverages. Changes in browning intensity in fruit beverages and squashes when stored in glass bottles both with and without polyethylene and polypropylene films are given in Table 1. It may be seen that browning intensity increased in all the samples but the rate of change was significantly higher in samples stored with plastic films. Differences among samples stored with polyethylene or polypropylene film pieces were not statistically significant but between control and plastic film treated samples, the differences were significant at 97.5 to 99.95 per cent confidence. This indicates that both polyethylene and polypropylene film *per se* accelerate rate of non-enzymic browning in fruit beverages and squashes during storage. The exact mechanism by which plastic film contact accelerate non-enzymic browning is not well understood; but Mannheim *et al*[3]. have suggested the involvement of oxidised groups present in film surface. These oxidised groups are formed from polymeric chains during film processing and subsequent treatments and may enhance formation of melonoidins by accelerating polymerisation of browning intermediates.

The effect of plastic films on the changes in ascorbic acid content in beverages during storage is shown in Table 2. Though Mannheim *et al*[2]. have reported an accelerating effect of polyethylene film on ascorbic acid degradation in orange juice and in aqueous ascorbic acid solution, in the present study losses in ascorbic acid in fruit squashes and beverages were practically same both in control and polyethylene and polypropylene film treated samples. The losses in ascorbic acid were, however, significantly different in different squashes/beverages but differences between control and plastic film treated samples were not significant in any of the squashes/beverages. After 90 days storage, percentage losses ranged from 29.0 to 32.2 in orange squash, 77.8 to 80.3 in lemon squash 40.5 to 57.5 in mango beverage and 81.1 to 85.4 in blue grape beverage suggesting the role of fruit constituents in the degradation of ascorbic acid. In isolated systems in which solution of ascorbic acid was adjusted to pH 3.5 and stored both with and without plastic films, the rate of degradation was much faster and both polyethylene and polypropylene films significantly ($0.05<p\leq 0.5$) influenced the rate of degradation of ascorbic acid during storage. Differences between control and film treated samples were significant at 99.5 per cent confidence after 10 days and at 95 per cent confidence at 20 days storage. After 20 days of storage, about 74 per cent of ascorbic acid was degraded in control sample as compared to 80 and 78.7 per cent in polyethylene and polypropylene treated samples respectively. Higher rate of ascorbic acid degradation in isolated systems as compared to fruit squashes/beverages may be mainly due to sulphur dioxide which is known to exert antioxygenic action in fruit juices[11,12]. In addition, fruit juice constituents may also exert protective action in ascorbic acid degradation. The reasons for the differential behaviour of plastic films in isolated and fruit beverage systems are not clear; but effect of polyethylene and polypropylene film contact with fruit juices and squashes on ascorbic acid losses, if any, is likely to be rather small.

Plastic film-fruit beverage contact also did not significantly affect the rate of degradation of carotenoids (Table 4). Relatively, the rate of degradation of carotenoids was higher in mango beverages than in orange beverages under identical storage conditions. On the other hand, plastic films slightly

TABLE 3. EFFECT OF PLASTIC FILM ON THE DEGRADATION OF ASCORBIC ACID (mg/100 g) IN AQUEOUS MODEL SYSTEM STORED AT ROOM TEMPERATURE (15-35°C)

Storage period (days)	Glass bottle	Glass bottle + PE	Glass bottle + PP
0	96.5±0.5		
10	51.1±0.7	47.3±0.4[b]	47.9±0.3[b]
20	25.1±0.9	19.5±3.5[d]	20.6±2.2[a]

b, Significantly different from control at 99.5 per cent confidence.

TABLE 4. EFFECT OF PLASTIC FILMS ON THE CHANGES IN TOTAL CAROTENOIDS (μg/g)/ ANTHOCYANINS (μ g/g) AT ROOM TEMPERATURE (15-35°c)

Storage period (days)	Storage system	Orange 45° Brix	Orange 27° Brix	Mango Alphanso 20° Brix	Mango Dusheri 20° Brix	Blue grape 15° Brix 20° Brix (anthocyanin content)
0		7.6±0.1	11.4±0.4	37.6±0.2	48.5±0.5	5.2±0.0
30	GB	7.0±0.4	8.4±0.1	27.5±0.3	40.5±0.3	2.7±0.1[b]
	GB+PE	7.0±0.2	8.8±0.5	26.4±0.4	38.2±0.4	1.9±0.2[b]
	GB+PP	6.8±0.2	10.0±0.5	27.6±0.4	38.5±0.4	2.2±0.1[c]
90	GB	5.9±0.4	9.0±0.1	21.6±0.3	36.6±0.5	1.4±0.2
	GB+PE	6.9±0.1	9.5±0.0[a]	21.6±0.5	35.5±0.6	0.9±0.1[c]
	GB+PP	6.4±0.3	9.5±0.2[a]	22.8±0.7	35.9±0.1	1.2±0.1

GB. Glass bottle; GB+PE. Glass bottle containing polyethylene films. GB+PP. Glass bottle containing polypropylene film.

b. Significant at 99.5 per cent confience; c. Significant at 97.5 per cent confidence.

but significantly accelerated the rate of storage degradation of anthocyanins in blue grape beverage (Table 4). The rate of degradation of anthocyanins in blue grape beverage was higher in contact with polyethylene film as compared to polypropylene film. Previously, Thakur and Arya[9] have reported that storage degradation of anthocyanins in blue grape squash was highest in polyethylene pouches followed by polypropylene and aluminium foil laminate pouches. They have explained the differential rates based on oxygen permeability of the three packaging materials. The results of the present study, however, suggest that in addition to oxygen permeability of the plastic films, their contact *per se* with blue grape beverage may influence the storage degradation of anthocyanins.

Most important factor influencing the quality loss of fruit products is the change in their flavour which may be due to change in the concentration of natural flavouring compounds or due to formation of some off-flavouring compounds from the degradation of fruit constituents. Limonene is an important constituent of the flavour of citrus fruits. In the present study, interaction of polythylene and polypropylene films on the limonene concentration in orange and lemon squashes was studied (Table 5). Both polyethylene and polypropylene films significantly ($0.05<p<0.25$) reduced the concentration of limonene in squashes during storage. After 30 days storage, the decrease in limonene in various squashes ranged between 17.4 and 47.9 per cent in control samples as compared to 56.2 and 65.6 per cent losses in contact with plastic films. The differences in limonene concentration in control and plastic film treated samples were highest after 15 to 30 days storage. During subsequent storage, differences in control and plastic film treated samples decreased probably as a result of oxidation of d-limonene. Since the level of available oxygen was same in control and plastic film treated samples, the initial rapid disappearance of limonene from beverages stored with plastic films suggests absorption of limonene by the films. This was further confirmed by emulsifying distilled cold pressed orange oil in water and storing the aqueous emulsion in glass bottles both with and without plastic films immersed in the emulsion. After regular intervals, the composition of volatiles in aqueous emulsion as well as in films was determined by GLC. The data on volatile composition (Table 6) suggest that flavouring compounds are absorbed by the polyethylene and polypropylene films and the amounts absorbed were in proportion to the thickness and weight of the film. The data suggest that absorption of flavour volatiles by plastic films is significant and this may affect the flavour intensity of fruit beverages stored in plastic film or rigid plastic packages.

TABLE 5. EFFECT OF PLASTIC FILMS ON CHANGES IN d-LIMONENE (mg/100 g) IN ORANGE AND LEMON SQUASHES STORED AT ROOM TEMPERATURE (15-35°C)

Storage period (days)	Storage system	Orange 45° Brix	Orange 27° Brix	Lemon 46° Brix
0		15.5±0.3	25.0±0.7	14.6±0.3
30	GB	12.8±0.0	14.1±0.1	7.6±0.8
	GB+PE	6.8±0.2[c]	8.6±0.0[a]	5.3±0.1[c]
	GB+PP	5.2±0.0	8.6±0.0[a]	5.1±0.3
90	GB	6.9±0.1[a]	5.0±0.1[a]	6.8±1.0[b]
	GB+PE	5.0±0.0[a]	3.9±0.1[a]	4.4±0.8[a]
	GB+PP	4.9±0.1[a]	4.0±0.1[a]	4.2±0.8[a]

GB. Glass bottle; GB+PE. Glass bottle containing polyethylene film; GB+PP. Glass bottle containing polypropylene film.

a. Significant at 99.95 per cent confidence; b. Significant at 99.5 per cent confidence; c. Significant at 97.5 per cent confidence.

TABLE 6. CHANGES IN THE CONCENTRATION OF d-LIMONENS (mg/100 g) IN ORANGE OIL-WATER EMULSION AND PLASTIC FILMS IMMERSED IN IT DURING STORAGE AT ROOM TEMPERATURE (15-35°C)

Storage period (days)	Concn of d-limonene in emulsion			Concn of d-limonene absorbed into plastic film	
	Glass bottle	Glass bottle + Polyethylene (400 gauge)	Glass bottle + Polyethylene (600 gauge)	Polyethylene (400 gauge)	Polyethylene (600 gauge)
0	8.9±0.4	—	—	0.0	0.0
13	7.1±0.3	6.8±0.1	6.5±0.1	0.4±0.0	0.7±0.1
30	5.7±0.3	4.3±0.2*	4.1±0.2*	0.6±0.0	0.9±0.1
60	4.8±0.2	3.3±0.2*	3.2±0.2*	0.6±0.0	0.9±0.1

*Significantly different from control at 97.5 per cent confidence.

Sulphur dioxide and benzoate are widely used as antimicrobial compounds in fruit juices and squashes. Their absorption by plastic film may deplete their concentration in beverages and this may render them susceptible to microbial spoilage. The changes in sulphur dioxide and/or benzoate concentration in fruit beverages with and without plastic films during storage are given in Table 7. Neither polyethylene nor polypropylene film significantly affected the sulphur dioxide or benzoate level in fruit squashes and beverages. In isolated systems too consisting of sodium metabisulphite solutions at pH 3.4, polyethylene and polypropylene films did not influence the concentration of sulphur dioxide upto 30 days storage. Fruit acids measured as titratable acidity were also not affected by the plastic film contact. The titratable acidity of orange squash (45° brix), orange beverage (27° Brix), lemon squash (46° Brix), mango (Alphanso) beverage (20° Brix) and mango (Dusheri) beverage (20° Brix) were 0.57±0.04, 0.78±0.02, 1.89±0.03, 0.86±0.02 and 0.70±0.02 respectively and remained practically same throughout the 90 days storage at room temperature both in control and plastic film treated samples.

The contact of polyethylene and polypropylene films with fruit beverages, however, did not result in perceptible changes in colour, flavour, consistency and overall acceptability upto 90 days storage at room temperature (15-35°C) as determined by triangular taste panel tests. Only about 20-30 per cent of the taste panel members could correctly identify the control samples from polyethylene and polypropylene treated samples. Rest of the taste panel members (70 per cent) were unable to indicate any difference between control and treated samples despite significant differences in browning intensity and limonene content. Mannheim *et al*[3]. have, however, reported that storage of orange juice in sealed glass jars both with and without polyethylene strips caused a significant taste difference after 14 days. In the present study, no perceptible taste differences as a result of polyethylene or polypropylene contact were observed in any of the fruit beverage even after 90 days storage despite significant differences in browning intensity and limonene content. The results of the present study suggest that though both polyethylene and polypropylene film contact with orange, mango, lemon and grape beverages results in accelerated rate of browning and anthocyanin degradation as well as depletion of flavouring compounds in stored beverages, the overall impact on fruit juice quality is limited and may not be perceptible to common consumer upto 90 days storage under ambient conditions. The

TABLE 7. EFFECT OF PLASTIC FILM ON THE CHANGES IN CONCENTRATION OF SULPHUR DIOXIDE/BENZOIC ACID (ppm) IN FRUIT SQUASHES STORED AT ROOM TEMPERATURE (15-35°C)

Storage period (days)	Storage system	Orange 45° Brix	Orange 27° Brix	Lemon 46° Brix	Mango Alphanso 20° Brix	Mango Dusheri 20° Brix	Blue grape 15° Brix (Benzoic acid)
0		325±2	308±3	282±6	365±1	367±1	535±3
30	GB	313±4	215±9	189±4	256±0	230±0	490±5
	GB+PE	328±3	217±6	199±1	270±0	234±1	495±4
	GB+PP	343±4	219±6	195±6	275±3	236±1	481±5
90	GB	250±5	121±1	138±1	155±1	109±6	463±4
	GB+PE	273±8	103±4	125±1	144±1	97±1	460±2
	GB+PP	264±8	90±0	133±6	149±0	101±1	463±3

GB. Glass bottle; GB+PE. Glass bottle containing polyethylene film; GB+PP. Glass bottle containing polypropylene film.

faster deterioration in fruit beverages when packed in plastic film packages as observed in previous studies[1] may have resulted mainly from increased oxygen transmission rate which has very deleterious effect on fruit beverages.

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References

1. Gheradi D S, Packaging and quality, *Proceedings of the International Congress of Fruit Juice Producers*, Munich, Germany, 1982.
2. Mannheim C H and Havkin M, Shelf life of aseptically bottled orange juice, *J Fd Proc Preserv*, 1981, **5**, 1.
3. Mannheim C H, Miltz J and Letzter A, Interaction between polyethylene laminated cartons and aseptically packed citrus juices, *J Fd Sci*,1987, **52**, 737.
4. Durr, P Schobinger U and Waldvogel R, Aroma quality of orange juice after filling and storage, *Alimenta*, 1981, **20**, 91.
5. Arya S S Madhura C V Premavalli K S and Vidyasagar K, Suitability of flexible packaging materials for packaging of fruit squashes, *Indian Fd Ind*, 1984, **3**, 17.
6. *Official Method of Analysis*, Association of Official Analytical Chemists Washington D.C 1970, II Edn.
7. Meydav S Saguy I and Kopelman I J, Browning determination in citrus products, *J agric Fd Chem*, 1977, **25**, 602.
8. Scott W C and Veldhuis M K, Rapid estimation of recoverable oil in citrus juice by bromate titration, *J Ass of analyt Chem*, 1965, **49**, 628.
9. Thakur B R and Arya S S, Studies on stability of blue grape anthocyanins, *Int J Fd Sci Technol*, 1989, **24**, 321.
10. Humprey R E Melbourne H W and Hinze W, Spectrophotometric determination of sulfite with 4, 4' dithiopyridine and 5, 5' dithiobis (2-nitro benzoic acid), *Analyt Chem*, 1970, **42**, 698.
11. Maeda E E Mussa D M D N, Stability of vitamin C (L-ascorbic acid) in bottled and canned orange juice, *Fd Chem*, 1986, **22**, 51.
12. El-Ashwah E T Tawfik M A EL-Hashimy F S Raouf M S and Sarhan M A, Chemical and physical studies on preserved Benzahir lime juice *Sudan J Fd Sci & Technol*, 1981, **13**, 64.

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Effect of Moisture Content on Angle of Repose and Bulk Density of Selected Foodgrains

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The angle of repose for sorghum, pearl millet, finger millet, Kodo millet, fox tail millet and little millet increased linearly with the increase of moisture content and the bulk density decreased linearly for all the grains. Regression equations were fitted and the regression coefficients ranged from 0.90 to 0.99.

Engineering properties of foodgrains are more important for the post-harvest operations. Among the various properties, angle of repose and bulk density of grains are the most important properties involved in the design and construction of silos, storage bins, handling equipment, hoppers, etc. These properties vary with the moisture content of the grain and such information is highly useful for the designers as the grains undergo various post-harvest operations at different moisture contents[1]. Many reports about these properties for the cereals and other crops in general are available[2-7] and only limited work has been done for the foodgrains reported in this study.

The bulk density of wheat, barley, oats, popcorn kernels and faba bean decreased with increase in moisture content[2-5]. The length, width, thickness and porosity for rough rice and long grains also decreased linearly with moisture content[6]. The angle of repose of faba bean and pigeon pea increased with increase in moisture content[4,7]. In this study, the angle of repose and bulk density of the selected foodgrains were determined at different moisture levels.

Materials and Methods

The crops and their variety used in the experiments are as follows:

Sorghum *(Sorghum vulgare)* var. 'Co 18'

Bajra/pearl millet *(Pennisetum typhoides)* var. 'KM 2',

Ragi/Finger millet *(Eleusine coracana)* 'Co 10' Haraka/ kodo millet *(Paspalum scrobiculatum)* Local, Navane/Fox tail millet *(Setaria italica)* Local, Save/little millet *(Panicum miliare)* Local

The experiments were conducted in the moisture range of 10 to 30 per cent (wb) in all the crops. To condition the samples for lower moisture contents, grains were dried in a mechanically ventilated oven with grain layer and temperature not exceeding 15 mm and 45°C respectively. The desired moisture content of the sample was obtained by drying the sample to the weight and calculated as per Bist[8]. The moisture determination was done according to the AACC procedure[9]. The higher moisture contents of the samples were obtained by adding calculated amount of distilled water[8]. The lower moisture content samples were kept in air tight containers and the samples with higher moisture contents were stored in polythene bags and kept in the refrigerator at 5°C and these samples were shaken well for one minute after every 6 hr to equilibrate the moisture.

Angle of repose was determined using the experimental set up shown in Fig. 1. The grain filled in the grain holder was allowed to fall on the circular plate of known diameter and a natural heap is obtained. By coinciding the pointer to the heap, the height of the heap was noted from the scale provided. From the diameter and height of heap, the angle of repose was calculated as:

$$\text{Angle of repose } \theta = \tan^{-1}\frac{(2h)}{d}$$

Where, d = diameter of the plate/heap, cm

h = height of the heap, cm

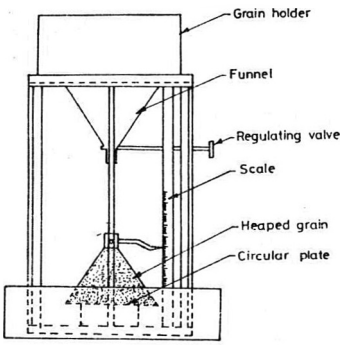

Fig. 1. Angle of repose apparatus

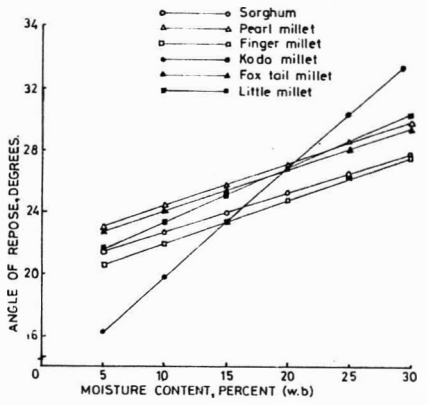

Fig. 2. Effect of moisture content on angle of repose of foodgrains.

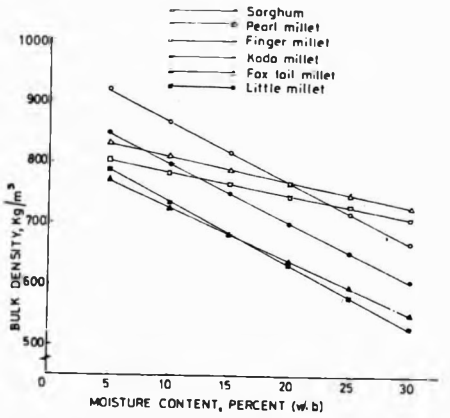

Fig. 3. Effect of moisture content on bulk density of foodgrains.

For replicating the experiments, three circular plates of different diameters were used and also the experiments were replicated thrice for each disc or plate.

Bulk density was determined by filling gently a container of known volume with the grain and taking the corresponding weight. From the volume and weight the bulk density was calculated as,

$$= \delta \frac{W_2 - W_1}{v} \text{ kg/m}^3$$

Where δ = Bulk density, kg/m^3; v = Volume of container, m^3; W_1 = Weight of empty container, kg; W_2 = Weight of the container filled with grain, kg

A circular container of 9.62×10^{-6} m^3 volume was used in the experiments and the mean values of the three replications are reported. The wall effect of the container was neglected in this study.

Results and Discussion

The angle of repose for the selected foodgrains viz., sorghum, pearl millet, finger millet, kodo millet, fox tail millet and little millet are determined at different moisture contents ranging from 10 to 30 per cent (wb). The effect of moisture content on angle of repose is shown in Fig. 2. The angle of repose increased linearly with the moisture content in all the crops. Except for kodo millet, the rate of increase of angle of repose is uniform for all the other crops which is exhibited by the approximately parallel lines. The angle of repose increased by 1 to 1.4 degrees for every 5 per cent increase in the moisture content. Upto 20 per cent moisture content (wb), the angle of repose was the highest for pearl millet followed by little millet, fox tail millet, sorghum, ragi and kodo millet. Beyond 20 per cent moisture content (wb), kodo millet has the highest angle of repose. The linear regression equations formed between the angle of repose and moisture content for the crops and the correlation co-efficient of the fit are given in Table 1.

The effect of moisture content on bulk density of various foodgrains under study is given in Fig. 3. The bulk density decreased linearly with the moisture content in all the grains; however the rate of decrease is uniform as exhibited by the approximate parallel lines. For all the grains except pearl millet and ragi, the rate of decrease is uniform as exhibited by the appropriate parallel lines. The effect exhibited by the moisture content on pearl millet and ragi is less. The bulk density decreased at the rate of 30 kg/m^3 and 50 kg/m^3 for every 5 per cent increase in moisture content of pearl millet and ragi and other grains. The bulk density of sorghum was the highest followed by pearl millet, ragi, kodo millet, fox tail millet and little millet upto 23 per cent moisture content (wb). At higher moisture contents (above 23 per cent, wb) pearl millet and ragi exhibited the highest bulk densities. The linear regression equations connecting the moisture content

TABLE 1. LINEAR REGRESSION EQUATION OF ANGLE OF REPOSE AND MOISTURE CONTENT

Grains	Variety	Regression equation	Correlation coefficient
Sorghum	Co 18	$Y_1 = 20.1644 + 0.2542x$	0.99
Pearl millet	Km 2	$Y_1 = 21.7256 + 0.2736x$	0.98
Finger millet	Co 10	$Y_1 = 19.251 + 0.2773x$	0.99
Kodo millet	Local	$Y_1 = 12.7063 + 0.7111x$	0.97
Fox tail millet	Local	$Y_1 = 21.6566 + 0.2605x$	0.99
Little millet	Local	$Y_1 = 19.8774 + 0.3514x$	0.97

Y_1 = Angle of repose, degrees; x = moisture content, percent, wb.

TABLE 2. LINEAR REGRESSION EQUATION OF BULK DENSITY AND MOISTURE CONTENT

Grains	Variety	Regression equation	Correlation coefficient
Sorghum	Co 18	Y = 967.9 − 9.9 x	0.99
Pearl millet	Km 2	Y = 854.5 − 4.2 x	0.98
Finger millet	Co 10	Y = 826.1 − 3.9 x	0.99
Kodo millet	Local	Y = 883.7 − 9.2 x	0.90
Fox tail millet	Local	Y = 815.5 − 8.6 x	0.95
Little millet	Local	Y = 849.6 − 12.7 x	0.97

Y = Bulk density, kg/m^3; x = moisture content, percent, wb.

and bulk density are given in Table 2.

From this study, it is concluded that the angle of repose and bulk density increase and decrease linearly with moisture contents for all the millets studied. The effect of moisture content on angle of repose of kodo millet is more than the other crops. Further, the effect of moisture content on bulk density of pearl millet and ragi is less than the other crops.

References

1. Mohsenin N Nuri, *Physical properties of plant and animal materials* Gordon and Breach Science Publishers, New York, 1980. 3rd Edn.
2. Browne D A, Variation of bulk density of cereals with moisture content, *J agric Engng Res*, 1962, **17**, 268.
3. Hangn C G Lien R M Hares R E and Ashman R B, Physical properties of popcorn, *Trans ASAE* 1976, **19**, 620.
4. Fraser B M Verma S S and Muir V E, Some physical properties of faba bean, *J agric Engng Res*, 1978, **23**, 160.
5. Brusewitx G H, Density of rewetted high moisture grains, *Trans ASAE*, 1975, **18**, 935.
6. Wratten F T Poo.e W D Chesness J L Bal S and Rama Rao V, Physical and thermal properties of rough rice, *Trans ASAE*, 1969, **12**, 801.
7. Shepherd H and Bhardwaj R K, Moisture dependent physical properties of pigeon pea, *J agric Engng Res*, 1986, **35**, 227.
8. Bisht B S, Grain Moisture meters and their calibration, *Proceedings of the Course on Instrumentation for Testing of Agricultural Machinery*, C.I.A.E., Bhopal, September 1986, 295.
9. *Approved Methods Moisture Determination*. American Association of Cereal Chemists. St. Paul. Minn. U.S.A., 1976. 44-15 A.

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Colour Reduction in Food Products Containing Microalgae

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Drum-dried *Scenedesmus obliquus* and sun-dried *Spirulina platensis* were separately pulverised and sampled followed by subsequent fractionation of each alga by dry and wet sieving as well as by use of coulter counter. The colour analysis of each of the fraction as well as that of the total sample of each alga was individually carried out by use of Hunterlab colorimeter. Reflectance from similar size fractions was higher for *Spirulina* by a value of 4.13 as compared to *Scenedesmus*. It was found that to increase reflectance significantly and thus produce correspondingly less coloured products, the most suitable algal particle diameter is between 10 and 40 μ m. *Spirulina* reflects lesser colour compared to *Scenedesmus* at comparable particle size.

The biotechnology for mass production of the green alga *Scenedesmus obliquus* and the cyanobacterium *Spirulina platensis* for use in foods and feeds has been established.[1-3] There are no antinutritional constituents and the nucleic acids constitute only 4-6 per cent on dry weight basis. Use of algal dried powder at levels of 5 to 15 per cent in traditional foods has been shown to be safe. Despite this, only few algae containing preparations such as noodles, ravioli, fruit pudding, algae based juice[4], protein and vitamin food supplements[5] and health foods have been developed. Recently, algae used in this study have also been incorporated in wheat flours for the preparation of baked and extruded products[6]. It was found that the dark colour imparted by the algae to these products adversely affects their acceptability.

The physical state of the incorporated algal material like its particle size affects the appearance[6-8]. The present study describes the effect of particle sizes on the visual colour response by examining the individual powdered algal fractions i.e, without incorporation of wheat flour which if mixed with the alga is bound to dilute the colour of end product as in wheat baked and extruded preparations[6].

Materials and Methods

Scenedesmus obliquus (drum-dried) and *Spirulina platensis* (sun-dried) were produced according to standard methods[1-3]. Fig 1 illustrates the process flow sheet for the procedure followed in this study. The algae were pulverised separately in a hammer mill using 1.0 mm mesh vibratory sieves and then passed through a RETSCH sampler at an optimum rotor rpm of 2860. These samples were fractionated by dry and wet sieving using vibratory sieve shakers of RO-TAP type with mesh ranging from 5 to 800 μ m. In case of *Spirulina*, wet sieving was repeated to interpret the characteristic abnormal behaviour of its plot (Fig 2) which strongly deviates especially from that of *Spirulina* itself by dry sieving. These were named as I and II sieving (Tables 2 and 3). These Tables relate to colour data obtained by further investigation on fractions of *Spirulina* at its lower and higher ranges of particle diameters respectively. In case of wet sieving, nearly 2 to 3 g of alga was used for efficient dispersion with sufficient amount of water. This amount was based on very low capacity of sieves while using a low density material like algae here in question.

Determination of percentage of particles and their diameters in a given fraction obtained below 40 μ m was made by employing a coulter counter (Coulter Electronics Ind., Chicago, USA) and determinations repeated three times. By taking series of voltage pulse counts at selected threshold level, the resulting data were directly plotted as relative weight percentage vs. particle diameter. Colour measurements of each of these fractions were carried out using Hunterlab Colorimeter D25A-3 (Hunterlab, Fairfax, Virginia, USA), for closer reliability of estimate.

Results and Discussion

The fractionation data obtained by wet and dry sieving as well as by use of coulter counter have been plotted as percentages of particles vs their specific particle diameter (Fig 2). About 29 g of material was handled in case of dry sieving. The percentage of algae passing or remaining on each sieve was calculated and a loss (1 to 1.4 g) was noted in each

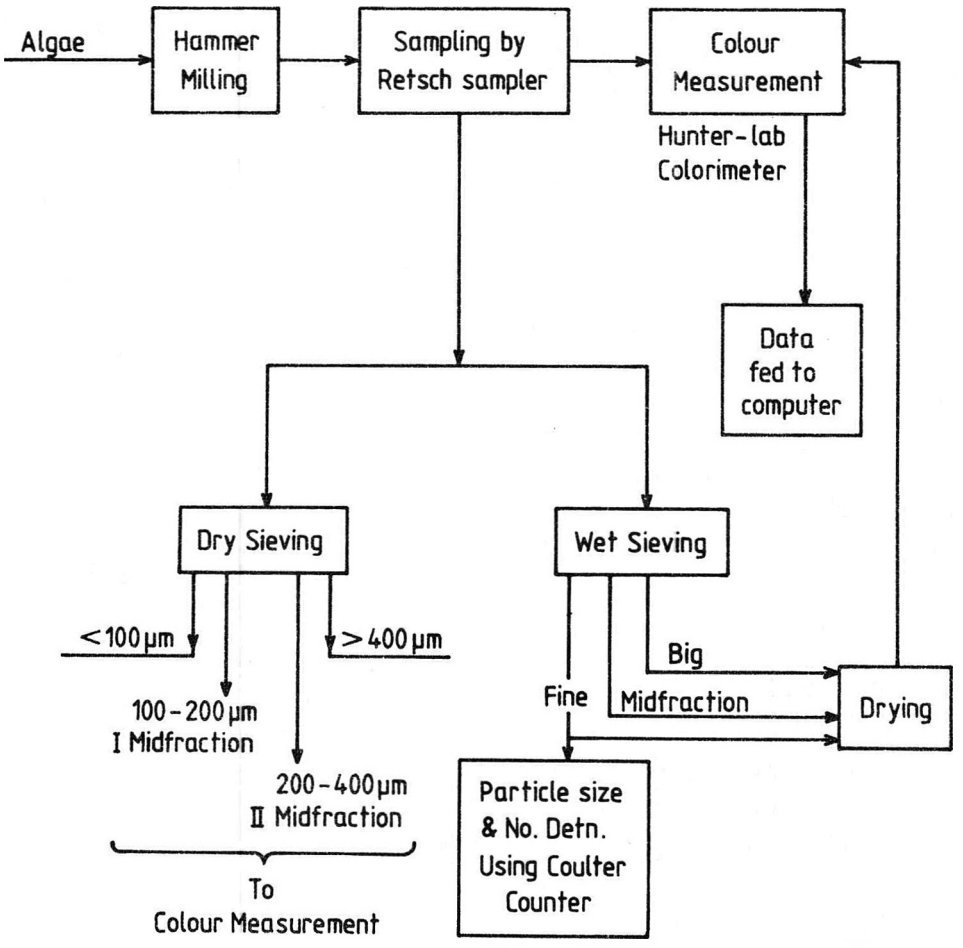

Fig. 1. Flowsheet for determination of effect of visual colour as function of algal particle size.

fractionation experiment. Only *Scenedesmus*, but not *Spirulina* showed reproducibility by both fractionation methods. This needed determination of particle size by coulter counter to evaluate individual particles down to 1.5 μm without agglomeration. Such tendency of coalescence in case of *Spirulina* occurs in the presence of water during wet fractionation. This attribute of *Spirulina* has been observed during culturing this alga and confirmed by the characteristic plot (a,b) of coulter counter data (Fig 2). According to the behaviour of the curve for *Spirulina* dispersed in water, there is an agglomeration of cells at every level of particle diameter giving almost a straight line. The use of coulter counter has given a clear picture of particle diameter illustrating almost one third of the initial part of 'ab' (Fig 2) as nearly similar to dry fractionation curve. The steep and concave nature of the latter portion of plot is probably attributable to the dilectric constant of the dispersing agent lower than water. Steepness is indicative of higher percentage of lower diameter particles i.e., from 3.5 to 6 μm. These particles specifically have very low percentage in *Scenedesmus* samples.

Tables 1, 2 and 3 give the mean values of more reproducible data of colour measurements in the Hunterlab colorimeter coordinates L, a and b. The L value corresponds to lightness and varies from 100 for perfect white to zero for black.

The overall colour reflectance higher by a value equivalent to 4.13 (Tables 1, 2 and 3) was observed in *Spirulina*. This phenomenon is probably caused by configuration factor during colour measurement. In general, the overall reflectance from any particle relatively larger irrespective of the type of alga was less than that from smaller size particles and is only observable at a specific level of particle diameter and below.

This fact is strengthened by this investigation which shows a higher value of L for lower range of particle diameters (Tables 1 to 3). An increase in the value of L is only possible when the particles have the much lower diameters between 10 and 40 μm (Table 2) along with almost similar shooting up of yellowness that is favourable for lightness. The value of greenness changes only marginally.

A constant decline of values of 'L' with increase in particle size could not be observed (Tables 1, 2 and 3) especially when the fractionated particle diameters of range 40 to 315 μm

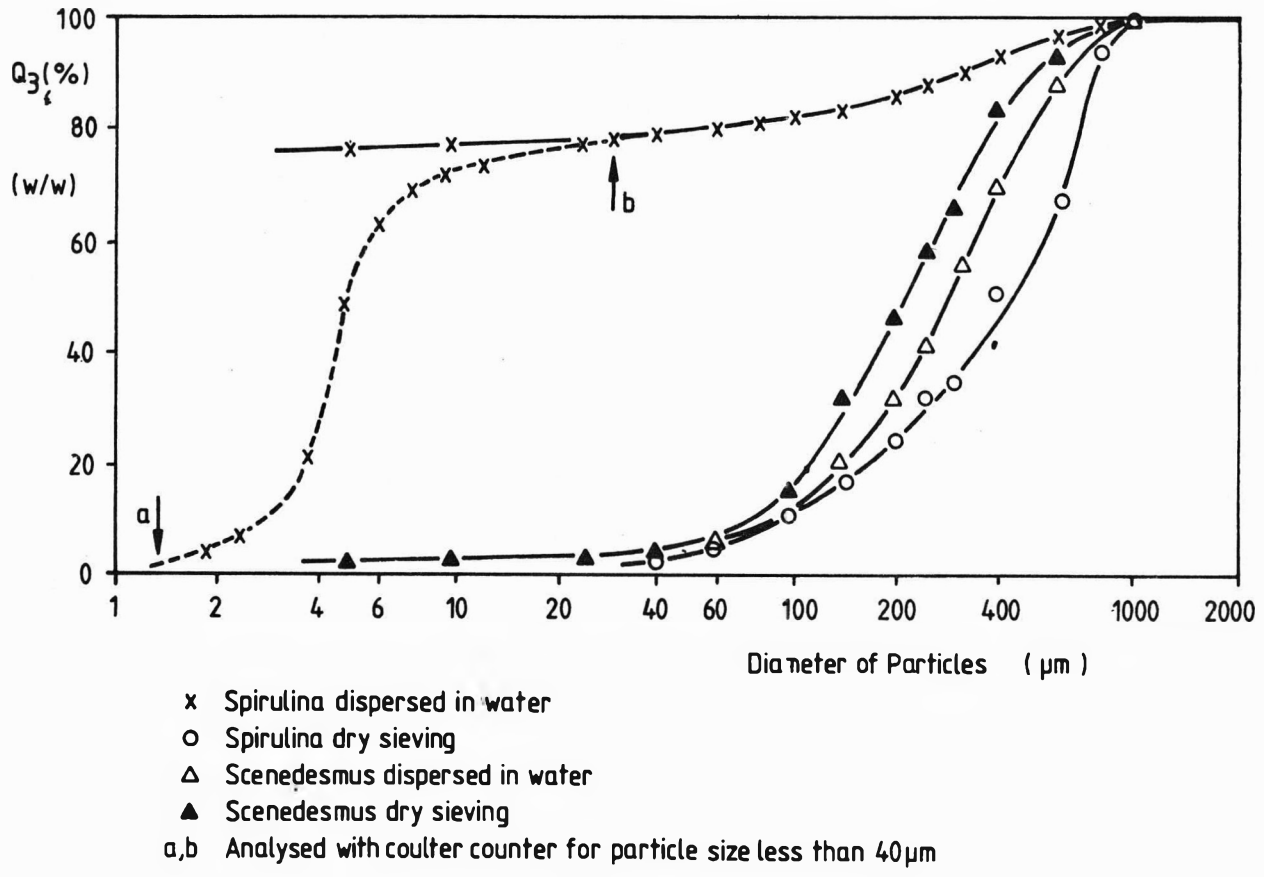

Fig.2. Particle size distribution of algae.

were compared with that of 315 μ m. (Table 2). This is attributable to the combined factor of diffusion and mirror effect of light due to change in particle configuration when observed as a lump of divided particles. This was applicable to the homogenised mass and the angle of viewing also affects visual response.

Incorporation of water as in dough preparation is expected to destroy the mirror effect resulting in decrease of reflectance and subsequent darkening of the product. Nevertheless, in conclusion, comparatively a lighter coloured baked and extruded wheat product[6] with less final moisture content than conventional[6] results with algal particle of diameters between 10 and 40 μ m. This is especially true if *Spirulina* is incorporated at 5 per cent level[6]. *Spirulina* gives lesser colour compared to *Scenedesmus* at same particle sizes.

TABLE 1. COLOUR ANALYSIS ON *SCENEDESMUS OBLIQUUS*

Sample	Read off mean values on Hunterlab coordinates a	b	L
Total sample fractionated	−3.18	5.20	22.47
>100 − 100 (μm)	−4.34	7.29	23.60
>100 < 140 ,,	−3.56	5.65	22.36
>140 < 250 ,,	−3.19	5.12	22.41
>250 < 400 ,,	−2.79	4.45	22.17
>400 < 800 ,,	−2.65	3.92	20.63

TABLE 2. COLOUR ANALYSIS ON *SPIRULINA PLATENSIS* (FIRST SIEVING)

Sample	Read off mean values on Hunterlab coordinates a	b	L
Total sample fractionated	−5.47	7.35	26.60
>10< 40 (μm)	−5.56	10.32	31.20
>40 − 315 ,,	−5.08	5.89	24.37
>315 ,,	−4.97	5.65	26.70

TABLE 3. COLOUR ANALYSIS ON *SPIRULINA PLATENSIS* (SECOND SIEVING)

Sample	Read off mean values on Hunterlab coordinates a	b	L
Total sample fractionated	−5.47	7.35	26.60
>100 − 100 (μm)	−5.49	7.10	25.29
>100 < 140 ,,	−5.13	6.08	25.38
>140 < 250 ,,	−4.98	5.88	24.42
>250 < 400 ,,	−4.94	5.84	25.61
>400 < 800 ,,	−4.71	5.25	24.35

References

1. Eecker E W and Venkataraman L V, Production and utilization of the blue-green alga *Spirulina* in India, *Biomass*, 1984, **4**, 205.
2. Becker E W, Biotechnology and exploitation of the green alga *Scenedesmus obliquus* in India, *Biomass;* 1984, **4**, 1.
3. Benemann J R, Tillet D M, and Weissman J C, Microalgae biotechnology, *Tr Biotechnol*, 1987, **5**, 47.
4. Gross U and Gross R, Acceptance and product selection of food fortified with microalga *Scenedesmus*, *Archiv fur Hydrobiologie Ergebnisse der Limnologie*, 1978, **11**, 174.
5. Donati M, Protein-vitamin supplement food, *PCT Internat Patent Applica* WO 87/00731 AI 1987.
6. Nigam B P, Venkataraman L V, Seibel W, Brummer J M, Seiler K, and Stephan H, Algenzusatze Zu Weizenbrot and Weizenextrudaten, 1985, **39**, 53.
7. Zwingelberg H, Particle size distribution in rye-whole meals, *Muhle Mischfuttertech*, 1974, **112**, 1.
8. Anusuya Devi M, and Venkataraman L V, Supplementary value of the proteins of blue green algae *(Spirulina platensis)* to rice and wheat proteins, *Nutr. Rep Intl*, 1983, **28**, 1029.
9. Arbeitsgemeinschaft Getreideforschung (Hrsg.): *Standardmethoden fur Getreide, Mehl und Brot*, 6th Edn, Detmold, 1978, **57**.

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Reducing the Polyphenols and Phytate and Improving the Protein Quality of Pearl Millet by Dehulling and Soaking

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Whole and dehulled upto 8.10 to 15.84% pearl millet were soaked in 0.2 N HCl. Reduction of 95.0 to 97.7% in soaking time of dehulled grains over whole was observed for comparable degree of reduction of the polyphenolic pigments. The ash and crude fibre were significantly decreased during dehulling and soaking. The polyphenolic pigments and phytate phosphorus were reduced to 66.9 to 71.3 and 60.0 to 74.0% respectively, in grains dehulled and soaked in 0.2 N HCl from 45 to 20 min, as against 67.6 and 14.8%, respectively, in grains undehulled and soaked in water for 15 hr. The prolamines (3.33%), glutelins (2.87%) and albumin and globulin (1.65%) increased significantly during processing of grains. The significant increase in the recovery of soluble proteins from 61.1 to 78.6% and *in vitro* protein digestibility (IVPD) from 66.3 to 82.8% was also observed on dehulling and soaking the grains.

The pearl millet (*Pennisetum americanum* (L.) Leeke) is one of the most important cereals ranking sixth in the world's cereal production and is widely cultivated in Asia, Africa and United States[1]. It is primarily grown in the hot, drought-prone arid and semi-arid regions and in India it is the fourth most important staple food crop after wheat, rice and sorghum[2]. But unfortunately, it has remained a food only for economically weaker sections primarily due to its coarseness and grey to yellow green colour which imparts bitter taste[3,4]. This is one of the reasons for its poor acceptability by rice/wheat eaters.

The polyphenolic pigments present in the outermost layers (bran) of the grains not only impart grey colour but also limit protein utilization. Morever, phytate present in peripheral layers of the grain also limit minerals and protein utilization. The removal of bran containing these pigments and phytate to obtain a white flour is the major objective in pearl millet processing. Dehulling and soaking of grains could be used to reduce these anti-nutrients. Soaking grains in dilute HCl (0.2 N) for 15 to 24 hr was found to reduce a major portion of these pigments[5,6]. Reichert and Youngs[7], however, observed 40 hr soaking time in 0.1 N HCl. They further observed that if grains were dehulled to about 10 per cent and soaked in 0.2 N HCl and sour milk (pH 4.3) the time required to bleach the millet grains to a colour comparable to the sour milk soaked millet grains was only 5 to 10 min. However, not much information is available on effects of dehulling on per cent reduction in soaking time in 0.2 N HCl over undehulled and also on reduction of these pigments and phytate. Attempts have been made in this study to find out the changes in polyphenols and phytate and protein fractions and *in vitro* digestibility of pearl millet due to dehulling and soaking, and the results are discussed in this paper.

Materials and Methods

The grains of pearl millet (variety 'BJ-104') of 1988-89 produce were purchased from the local market and cleaned. A sample (100 g) was soaked in 300 ml (w/v) 0.2 N HCl for 15 hr and washed twice with water to remove the residual HCl. For dehulling, a sample (500 g) each was scarified in laboratory scarifier (Osaw make) for 1 min (8.10 per cent), 2 min (11.56 per cent) and 3 min (15.84 per cent). The degree of dehulling in per cent was determined by the amounts of fines passing through a 20 — mesh screen. The dehulled (scarified) grains (25 g) each were soaked in 75 ml (w/v) of 0.2 N HCl for 5, 10, 15, 20, 25, 30, 35, 40 and 45 min, then filtered and optical density of the filtrate measured at 400 nm according to Naikare *et al*[5]. The soaking was done at room temperature (~28°C). The time of efficient extraction was fixed by comparison. For further studies, samples (200 g) of each were soaked for a predetermined period, drained, washed twice with water to remove residual HCl and vacuum dried to 14 per cent moisture. The dried grains were then ground to pass through 0.25 mm screen and stored in air tight plastic bottles at 4°C until use.

The crude protein, crude fat, crude fibre and ash contents were determined on dry weight basis[8]. Carbohydrates were calculated by deducting protein, fat, fibre and ash from the dry weight. All values are expressed in per cent. The polyphenolic pigments in the flour samples were determined by the method of A.O.A.C[8] as modified by Cristensen[9] and expressed as tannic acid. Since the phosphorus present in

phytate (phytic acid) is 28.20 per cent, the phytate phosphorus was determined by the method of McCance and Widdowson[10] as described by Chauhan[11]

The proteins of these samples were fractionated into three Osborne and Mendel[12] fractions as modified by Nagi *et al*[13]. The *in vitro* protein digestibility (IVPD) of defatted samples was determined by calculating the difference between the amount of nitrogen in the sample before and after hydrolysis with 0.2 per cent pepsin at 37°C for 24 hr as per A.O.A.C[8].

Results and Discussion

The combined effects of dehulling and soaking of pearl millet in either water or 0.2 N HCl for varying lengths of time are depicted in Fig. 1. In undehulled sample, the time required to leach out maximum polyphenolic pigments (67.6 per cent) was observed to be 15 hr. After 15 hr up to 24 hr the leaching of polyphenolic pigments was observed to be more or less constant. Reichert and Youngs[7] soaked whole pearl millet grains in excess of 0.2 N HCl for 6, 15, 21 and 24 hr and found that the whitened grains were approximately 12, 51, 70 and 86 per cent respectively. Naikare *et al.*[5] and Panwal and Pawar[6] also found maximum extraction of polyphenolic pigments (65 to 70 per cent) from undehulled pearl millet grains after soaking in 0.2 N HCl 15 hr. The time required for similar extraction of polyphenolic pigments from dehulled samples was found drastically reduced to 45, 25 and 20 min in grains dehulled upto 8.10, 11.56 and 15.84 per cent, respectively. The reduction in soaking time was observed to be 95.0, 97.2 and 97.7 per cent in 8.10, 11.56 and 15.84 per cent dehulled grains respectively, over underhulled one. The pericarp of undehulled grains was impervious to penetration of 0.2 N HCl which might have acted as a physical barrier. On the other hand in dehulled grains, the penetration of 0.2 N HCl in grains was rapid and this resulted in quick removal of polyphenolic pigments. Similar results are reported on pearl millet by Reichert and Youngs[7]. It could be said that a combination of suitable degree of dehulling and soaking in dilute acid can be practised in dry mill to overcome the problem of grey discolouration.

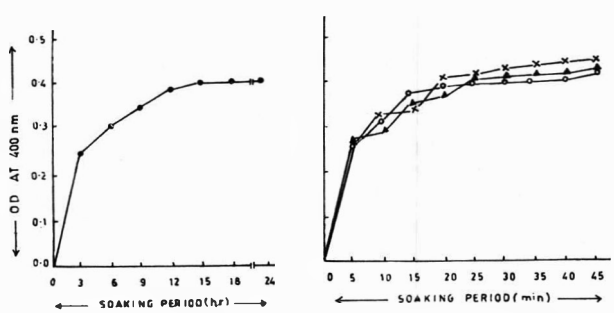

Fig.1. Extraction of polyphenolic pigments from whole and dehulled pearl millet grains at different times (whole ●——●, dehulled for 8-10% o——o, 11.56% Δ—Δ 15.84% ×——×.

The data presented in Table 1 show that all the proximate principles were decreased due to dehulling and soaking. The decrease was observed to be most significant in ash and crude fibre. On dehulling, the peripheral layers of the grains which contribute most of the crude fibre and mineral contents, were removed and this might have accounted for their major loss. The ash content was also found decreased on dehulling of pearl millet by Olatunji *et al*[14]. The leaching of minerals in the 0.2 N HCl can not also be ruled out and this could have probably been further accelerated the rate of decrease of minerals.

The data presented in Table 1 show that pearl millet contained a good amount of polyphenols expressed as tannic acid (0.136 per cent). During dehulling and soaking pearl millet grains, a significant amount of polyphenols was decreased. The reduction in undehulled and 15 hr soaked sample was 67.6 per cent whereas in dehulled at varying degrees and soaked for 45, 25 and 20 min samples were 66.9, 69.1 and 71.3 per cent, respectively. The polyphenols, as mentioned earlier, are found in outermost layers of grains, and are removed during the process of dehulling. The leaching of polyphenols in the 0.2 N HCl has also occurred and this could be the probable reason for their highest decrease in samples dehulled and soaked.

The data presented in Table 1 further show that pearl millet was rich in total phosphorous which significantly decreased from 3.16 to 1.79 mg/g after dehulling and soaking. The phytate phosphorous also decreased from 1.35 to 0.35 mg/g. The decrease in phytate phosphorous as per cent of the total phosphorous was almost 50 per cent. In pearl millet, the phytate phosphorous is concentrated in the outer layers i.e. bran and hence normal dehulling could remove appreciable amounts of phytate. The removal of phytate was observed to be more in samples dehulled and soaked than the sample only dehulled. During soaking, phytate being soluble in aqueous solutions at lower pH values, it gets destroyed by phytase. The destruction of phytate was found most significant due to the combined effects of dehulling and soaking. In such samples, the mechanical effects of dehulling become favourable for phytate and phytase to come into contact during soaking. The phytase activity is also increased in grains during soaking. Our observations are in confirmity with the reports available on various cereals[15].

It is clear from the data presented in Table 2 that these protein fractions collectively amounted to 7.85 per cent, which were found to be 61.1 per cent of the total crude proteins. The similar results were obtained by Sawheny and Naik[16] and Dahia and Kapoor[17] on pearl millet. It was further observed that when pearl millet grains were dehulled and soaked in 0.2 N HCl for 20 min, the recovery of soluble proteins was found to be increased from 61.1 to 78.5 per cent. The recovery of soluble proteins was also found to increase in sample soaked for 15 hr in water. This increase in soaked,

TABLE 1 EFFECT OF DEHULLING AND SOAKING OF PEARL MILLET ON PROXIMATE COMPOSITION, POLYPHENOLS AND PHYTATE CONTENT OF FLOURS[a]

Degree of dehulling (%)	Soaking period (min)	Ash (%)	Crude fat (%)	Crude protein (N×6.25) (%)	Crude fibre (%)	Carbohydrates (by diff.) (%)	Polyphenols (as tannic acid) (mg/g)	Total P (mg/g)	Phytate P (mg/g)	Phytate P as % of total P
0	0	2.42	4.21	12.84	1.50	79.03	1.36	3.16	1.35	42.7
0	900[b]	2.29	4.29	12.75	1.45	79.22	0.44	2.49	1.15	46.2
8.10	45	0.97	4.18	12.70	0.82	81.33	0.45	2.24	0.54	24.1
11.56	25	8.79	4.16	12.42	0.76	81.87	0.42	1.77	0.47	26.6
15.84	20	0.72	4.17	12.10	0.62	82.39	0.39	1.79	0.35	19.6
SE±		0.005	0.041	0.207	0.013	0.132	0.910	0.008	0.004	—
CD (P=0.05)		0.022	NS	NS	0.036	0.520	0.042	0.035	0.016	—

a Mean of triplicate determinations, expressed on dry weight basis.
b Soaking in distilled water. Rest of soaking times in 0.2 N HCl

TABLE 2. EFFECT OF DEHULLING AND SOAKING OF PEARL MILLET ON PROTEIN FRACTIONS AND IVPD[a]

Degree of dehulling (%)	Soaking period (min)	Albumin + globulin (%)	Glutelin (%)	Prolamin (%)	Total soluble proteins (%)	Protein recovery (%)	IVPD (%)
0	0	1.65	2.87	3.33	7.85	61.13	66.33
0	900[b]	1.96	3.04	3.78	8.78	68.86	82.10
8.10	45	1.86	3.01	3.48	8.35	65.74	78.45
11.56	25	1.93	3.22	3.97	9.12	73.42	82.70
15.84	20	2.05	3.28	4.18	9.51	78.59	82.95
SE±		0.034	0.021	0.016	0.037	—	0.304
	CD (P=0.05)	0.135	0.055	0.965	0.155	—	1.955

a Mean of triplicate determinations, expressed on dry weight and total crude protein basis.
b Soaking in distilled water. Rest of the soaking times in 0.2 N HCl

and dehulled samples could be due to removal of polyphenolic pigments and phytate. The breaking down of polyphenols-protein and phytate-protein complexes could have also occurred which might have made more protein available in soluble form. The lower recovery of soluble protein in control sample indicated that polyphenols and phytate might have interferred with extraction of proteins in Osborne solvents possibly by forming complexes. The results are in good agreement with those of Ramachandra *et al.*[18] in finger millet and Chavan[19] on sorghum.

The IVPD was also found significantly increased from 66.3 to 82.1 per cent in 15 hr soaked sample and to 82.9 per cent in dehulled and 20 min soaked sample (Table 2). The polyphenols and phytate were significantly removed during soaking and dehulling (Table 1) and this could have improved the IVPD. The observations in the present investigation are supported by the studies of Ramachandra *et al.*[18] who have reported direct relationship between polyphenol levels and IVPD in finger millet.

It can be finally concluded that dehulling followed by soaking pearl millet grains in dilute acid could efficiently remove polyphenols and phytate and improve recovery of soluble protein and its digestibility *in vitro*.

References

1. Salunkhe D K, Chavan J K and Jadhav S J. *Nutritional and Processing Quality of Sorghum*, Oxford and IBH Pub. Co, New Delhi, 1984, 273.
2. Singh P Singh U Eggum B O Kumar K A and Andrews D J. Nutritional evaluation of high protein genotypes of pearl millet (*Pennisetum americanum* (L.) Leeke). *J Fd Agric*, 1987, **38**, 41.
3. Desikachar H S R. Processing of maize, sorghum and millets for food *uses*, *J Sc. Ind Res*, 1975, **34**, 131.
4. Reichert R D. The pH- sensitive pigments in pearl millet, *Cereal Chem*, 1979, **56**, 291.
5. Naikare S M Chavan J K and Kadam S S. Depigmentation and utilization of pearl millet in preparation of cookies and biscuits. *J Maharashtra Agric Univ*, 1986, **11**, 90.
6. Panwal J H and Pawar V D. Effect of soaking pearl millet in acid on the bleaching and functional properties of flours. *J Fd Sci Technol*, 1989, **26**, 79.
7. Reichert R D and Youngs C G. Bleaching effect of acid on pearl millet, *Cereal Chem*, 1979, **56**, 287.
8. *Official Methods of Analysis*, Association of Official Analytical Chemists, Washington DC, 1975, 12th Edn.
9. Cristensen K D. *Improving Plant Proteins by Nuclear Techniques*, 1974, IAFA, Vienna.

10. McCance R S and Widdowson E M, Phytin in human Nutrition, *Biochem J*, 1935, **29**, 2694.
11. Chauhan G S, *Studies on the Processing of Rice-Legume Blends Using Extrusion Technology*, 1982, Ph.D. Thesis, Punjab Agric University.
12. Obsorne T B and Mendel L B, Nutritional properties of maize kernels, *J biol Chem*, 1914, **10**, 1.
13. Nagy D Weildeim W and Hixon R W, Factors affecting solubility of corn proteins, *Cereal Chem*, 1941, **18**, 514.
14. Olatungi O Akinrele I A Erwards C C and Koleoso O A, Sorghum and millets processing and uses in Nigeria, *Cereal Fds Wld*, 1982, **27**, 277.
15. Reddy N R Sathe S K and Salunkhe D K, Phytates in legumes and cereals, *Adv Fd Res*, 1982, **28**, 1.
16. Sawheny S K and Naik M S, Amino acid composition of protein fractions of pearl millet and the effect of nitrogen fertilization on its proteins, *Indian J Genet Pl Breed*, 1969, **29**, 395.
17. Dahiya S and Kapoor A C, Effect of storage on the protein quality of pearl millet flour, *Nutr Rep Internat*, 1983, **28**, 1351.
18. Ramachandra G Virupaksha T K and Shadaksharaswamy M, Relationship between tannin levels and *in vitro* protein digestibility in finger millet (*Eleusine coracana* Gaerth), *J Agric Fd Chem*, *1977*, **25**, 1101.
19. Chavan J K, *Investigations on Tannin-Protein Complexes in Grain Sorghum (Sorghum vulgare L.)*, 1978, Ph.D. Thesis, Marathwada Agric University.

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A Study on Drying Behaviour of Rings from Different Apple Cultivars of Himachal Pradesh

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Three pollinizing varieties of apple viz. 'Red Gold', 'Golden Delicious' and 'Granny Smith' were pretreated with SO_2 as anti-browning agent before sun-drying and dehydration as apple rings. Sun-drying retained moisture content between 14.5-16.1%, titrable acidity between 1.17-2.70% (DWB), reducing sugars between 48.2-53.9% DWB), total sugar between 65.5-69.9% (DWB) and ascorbic between 2.5-7.5 mg/100 g, whereas on dehydration they ranged betweer 14.2-16.8%, 1.23-2.73%, 47.7-54.8%, 67.9-75.3% and 2.5-12.5 mg/100 g respectively. Total SO_2 retention varied between 96-288 p.p.m during dehydration which was lower in sun-dried rings (48-224 p.p.m). There was a proportionate decrease in SO_2 content during storage in all the lots greatly influencing the nutritional value of the products. Higher SO_2 content resulted in better ascorbic acid retention and overall quality of the product during 180 days storage. Optical density (O.D at 440 nm) taken as index of browning increased with the decrease in SO_2 content. On the basis of yield, appearance and taste, dehydrated product and 'Golden Del cious' among cultivars have given better dried products. Among different treatments, 2500 p.p.m SO_2 dip of apple rings resu ted in best dried product on sun-drying and dehydration as well as after 180 days storage.

Apple (*Malus domestica*, Borkh) is a widely grown commercial fruit crop of Himachal Pradesh, Jammu & Kashmir and hills of Uttar Pradesh. In Himachal Pradesh, many fold increase in apple production during the last 15-20 years has resulted in increased surplus and processing grade apples. Large quantities of apple varieties viz. 'Golden Delicious', 'Red Gold' and 'Granny Smith' which are essential for pollinizing delicious varieties are produced; the major portion of this crop is either sold at uneconomical or marginal rates or go waste.

With the objective of economic utilization of this surplus fruit, study was undertaken to find out the suitability of these varieties for drying. Browning of cut fruits owing to presence of polyphenols is one of the major problems in apple drying. It was shown earlier that the darkening of fruit tissues in air is due to an enzymatic oxidation of phenolic substances present in the tissues[1]. No satisfactory substitute to sulphur dioxide has been found for the preservation of colour and flavour in the dried fruits, although, many have been tested. Important marketing countries such as Germany and Japan have regulations that substantially limit the use of SO_2 in low moisture foods and within the United States, there are increasing demands for SO_2 free dried fruits[2]. In India, 'Lal Amri', 'Golden Delicious', 'France-Kashmir', 'Red-Pippin' and 'Yellow-Pippin' varieties have been found to be satisfactory for dehydration[3]. Present study was made to try varieties with less demands for table purposes and to minimise the SO_2 level in the dried apple rings without deterioration of physico-chemical characteristics. The quality retention in sun-dried and mechanically dried rings was compared.

Materials and Methods

Three cultivars of apple viz. 'Red Gold'. 'Golden Deiicious' and 'Granny Smith' were procured directly from the orchards located at Dochi village in Shimla district of Himachal Pradesh. Fruits for drying were selected when they developed characteristic fruity flavour, colour and attained the total soluble solids (T.S.S) 11.5 to 13.5° Brix and the fruit pressure between 12 and 15 lb (Table 1). This was done after 15 to 45 days after harvest. The fruits after washing, peeling and coring were made into rings of about ½ cm thickness with a hand operated slicer. Peeling was done with a hand peeling knife and coring with a cork borer to remove undesired portions. The fruits were kept submerged in 1 per cent sodium chloride and 0.5 per cent citric acid solution for about 10-15 min during preparation until each lot was ready for treatment.

Two kilograms each of freshly weighed apples and prepared into rings were given separate treatments of steam blanching for 3 min (DT_2 and ST_2), 60 min dip in each of 500 p.p.m. (DT_3 and ST_3), 1000 p.p.m. (DT_4 and ST_4) and 2500 p.p.m. (DT_5 and ST_5) sulphur dioxide solution made from Potassium-meta bisulphite and exposure to sulphur fumes in sulphuring chamber with apple rings in single layer in wooden

TABLE 1. PHYSICO-CHEMICAL CHARACTERISTICS OF FRESH FRUITS AT THE TIME OF PREPARATION

Variety	Firmness (lb)	Size equito-rial (mm)	Sp gr (wt./vol. (ratio).	Non-edible (%)	Moisture (%)	Total soluble solids (Brix)	Acidity (%)	Red-ucing sugars (%)	Total sugars (%)	Ascorbic acid (mg/100 g)
Red Gold	12.0	67.2	0.76	17.5	84.6	12.8	0.23	7.32	9.55	3.5
Golden Delicious	12.5	66.1	0.83	16.7	85.4	13.5	0.34	7.61	10.30	6.5
Granny Smith	15.0	69.1	0.80	18.9	86.5	11.5	0.45	7.54	8.89	5.0

trays for 45 min with 5g sulphur per kg of fruit (DT_6 and ST_6) before dehydration and sun-drying respectively. ST_1 to ST_6 indicates six pretreatments before sun-drying and DT_1 to DT_6 for similar six pretreatments before dehydration. One lot of rings which was not given any pretreatment was kept as control (DT_1 and ST_1). Dehydration was done in a cabinet drier with a tray load of 750g rings per square foot at a temperature 60±2°C. The rings were dehydrated to 14-17% per cent moisture content in 8 hr. Sun-drying was done in the open sun for comparative studies when the day temperature ranged between 22-28°C. Sun-drying was done in 23-24 sun hours to a constant weight. During drying, the rings were weighed at interval of one hour and the weight plotted against time to study the drying pattern (Fig. 1 and 2). Each treatments was replicated twice. The rings from each treatments were filled in separate polyethylene bags without closing and kept in a bin for 24 hr for equilisation of moisture; 120g of these rings from each treatment were packed into separate 300 gauge polyethylene bags for analysis after 180 days storage at ambient temperature between October 1984 and May 1985. The minimum and maximum temperature and relative humidity during storage period varied between 8 and 30°C and 47 and 78 per cent respectively.

The diameter, weight, volume and texture of the fruits were determined on 10 fruits of each cultivar. Fruit firmness was measured with pressure tester (Model FT 327 having 7/16 inches plunger). The total soluble solid (T.S.S.) contents were recorded with Erma hand refrectometer. Acidity was determined by method described in A.O.A.C.[4] and expressed as malic acid. Moisture was determined by oven drying[5]. Sulphur dioxide was determined by Monier William's A.O.A.C. method[4]. Reducing and total sugars were estimated by Lane and Eynon's method[6]. Ascorbic acid was determined by xylene extraction method[5]. Non-enzymatic browning was measured by the method given by Ranganna[5]. Sensory evaluation was made by a panel of judges using composite scoring test modified proforma for appearance(20), flavour(20) and texture(10) and expressed histographically (Fig. 3).

Results and Discussion

'Red Gold' and 'Golden Delicious' apples took 15 and 30 days respectively after harvest to develop desirable fruity flavour and fruit pressure whereas 'Granny Smith' variety took about 45 days to develop this flavour at room temperature but the fruit pressure was slightly higher than the other two varieties. The physico-chemical characteristics of the apple cultivar at the time of preparation of apple rings are given in Table 1. Highest specific gravity and ascorbic acid content were recorded in 'Golden Delicious' and lowest in 'Red Gold' apples.

Rate of drying: Rate of drying was faster in the steam blanched samples which may probably be due to disorganization of fruit tissues by steam, thereby, releasing the turgor pressure which is responsible for holding the fruit moisture. Dehydration was accomplished in 8 hr, whereas it took 23-24 sun hours to sun-dry the apple rings to constant weight. Almost parallel reduction in the moisture contents

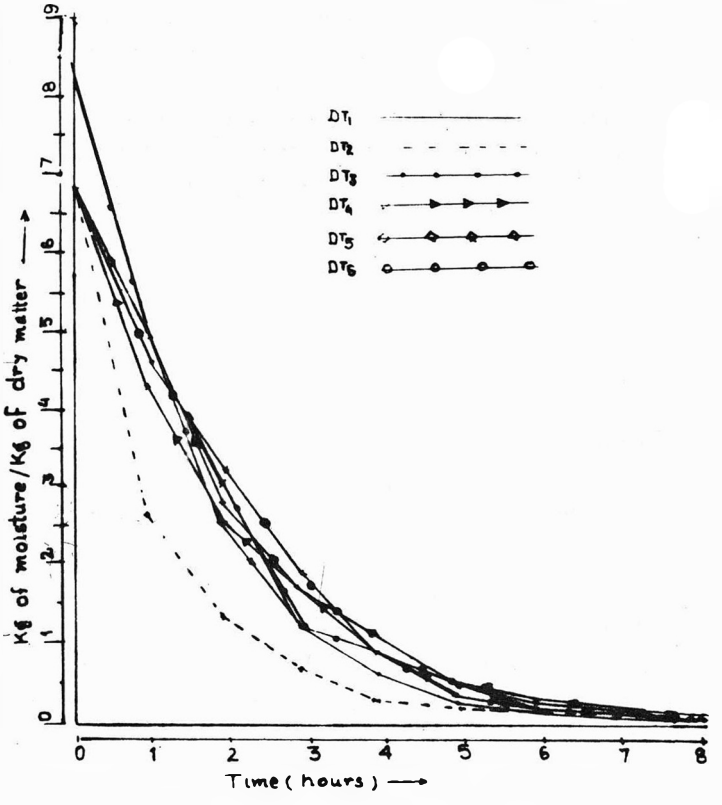

Fig. 1. Rate of dehydration in apple rings.

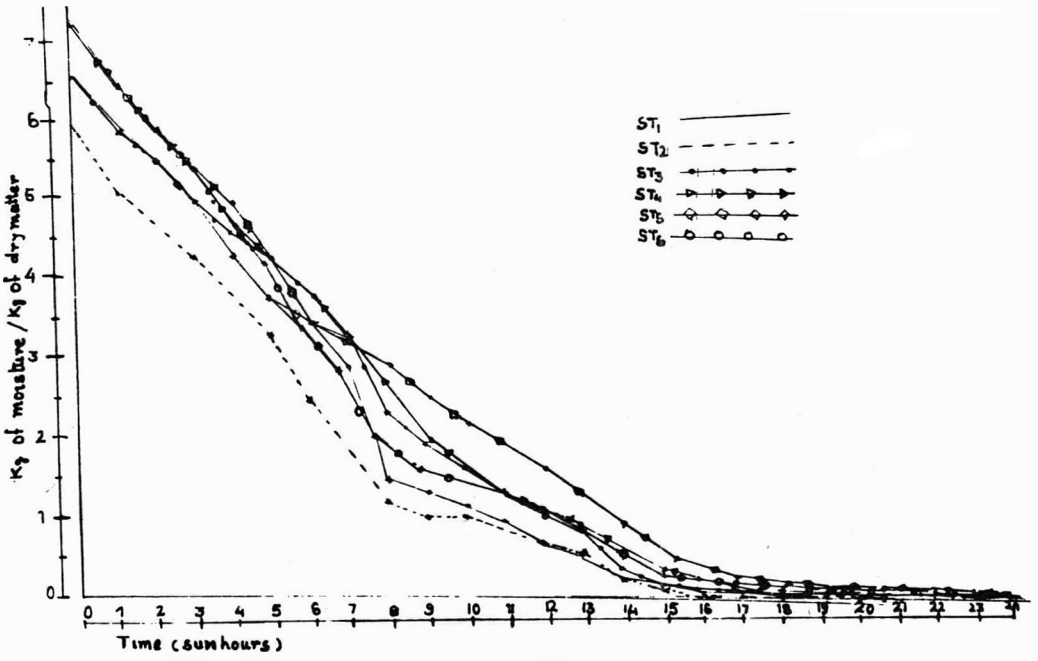

Fig. 2. Rate of sun-drying in apple rings.

of apple rings in the three varieties under study was observed. The average percentage of yield of the dried rings obtained from different treatments on sun-drying was 10.65, 10.72, 10.69 and on dehydration 10.79, 10.87 and 10.81 from 'Red Gold', Golden Delicious' and 'Granny Smith' respectively.

Composition of dried product: Maximum moisture content was retained in samples treated with higher dose of sulphur dioxide (SO_2) in all the three varieties under similar drying conditions (Table 2), which appears to be due to the protective effect of SO_2 on the moisture content. During storage, there was continuous reduction in moisture content indicating thereby that polyethylene does not provide barrier against moisture loss. Retention of SO_2 varied between 9.9 and 24 per cent in dehydrated and between 6.4 and 11.2 per cent in the sun-dried apple rings. This is similar to early reports that as little as 5 per cent SO_2 might be retained under slow drying conditions and upto 40 per cent if water removal was rapid[7]. During storage for 180 days, a continuous reduction in the total sulphur dioxide was observed.

Like in fresh fruits, maximum acidity was recorded in the dried rings of 'Granny Smith' and minimum in 'Red Gold'

TABLE 2. EFFECT OF PRETREATMENT, DRYING AND STORAGE ON MOISTURE CONTENT AND TITRABLE ACIDITY

Variety	Storage period (days)	Pretreatments											
		DT_1	DT_2	DT_3	DT_4	DT_5	DT_6	ST_1	ST_2	ST_3	ST_4	ST_5	ST_6
		Moisture (%)											
Red Gold	0	14.8	14.5	15.0	15.6	16.0	16.3	14.7	14.8	15.0	14.5	15.3	15.4
	180	10.7	10.3	11.2	11.9	12.9	12.9	10.5	10.7	10.9	10.4	11.6	11.4
Golden Delicious	0	14.6	14.2	14.8	14.2	16.3	16.8	15.4	15.6	15.0	15.0	15.5	15.9
	180	9.3	8.9	9.5	9.6	11.4	11.5	10.2	10.0	10.3	10.1	10.2	10.3
Granny Smith	0	14.5	14.4	15.2	16.0	16.4	16.6	16.0	15.0	15.8	15.5	15.7	16.1
	180	8.5	8.4	9.3	10.2	9.8	10.0	9.2	9.0	9.0	9.2	9.4	10.2
		Acidity (%)											
Red Gold	0	1.24	1.26	1.25	1.27	1.23	1.53	1.17	1.27	1.19	1.18	1.17	1.45
	180	1.15	1.17	1.18	1.19	1.16	1.42	1.05	1.15	1.06	1.07	1.05	1.32
Golden Delicious	0	1.30	1.41	1.32	1.41	1.31	1.77	1.30	1.42	1.32	1.32	1.33	1.85
	180	1.21	1.26	1.20	1.26	1.20	1.64	1.20	1.26	1.20	1.20	1.20	1.69
Granny Smith	0	1.96	2.12	2.08	2.15	2.15	2.73	1.84	1.98	1.83	1.89	1.89	2.70
	180	1.79	2.02	1.99	2.04	2.04	2.61	1.66	1.82	1.65	1.66	1.66	2.63

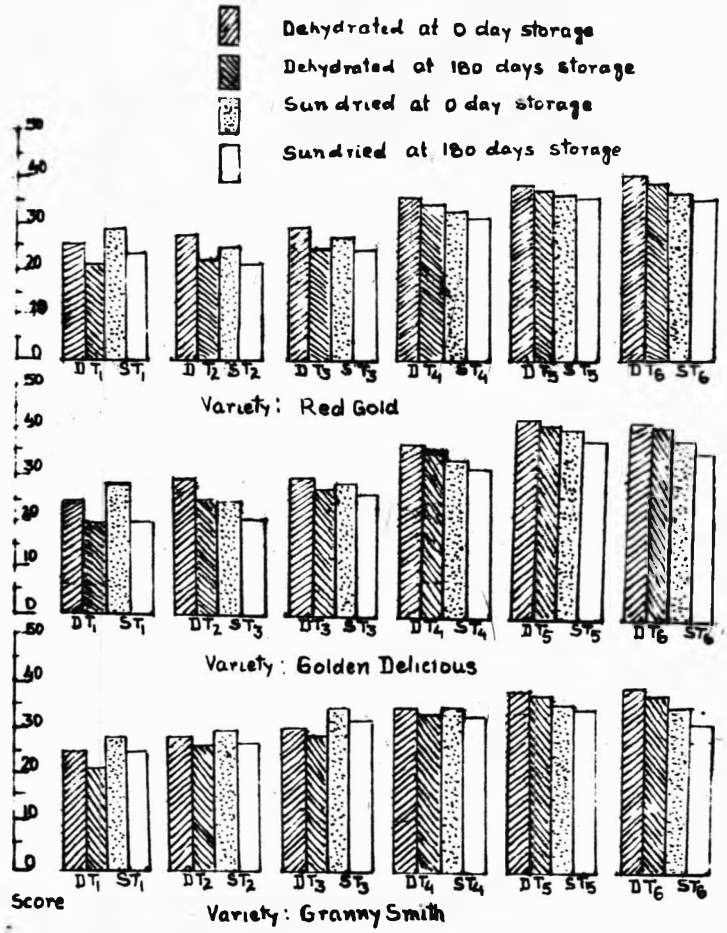

Fig. 3. Sensory evaluation of dried apple rings after drying and storage.

TABLE 3. EFFECT OF PRETREATMENT, DRYING AND STORAGE ON THE REDUCING AND TOTAL SUGARS IN THE DRIED APPLE RINGS (% DRY WEIGHT BASIS)

Variety	Storage period (days)	Pretreatments											
		DT_1	DT_2	DT_3	DT_4	DT_5	DT_6	ST_1	ST_2	ST_3	ST_4	ST_5	ST_6
		Reducing Sugars (% DWB)											
Red Gold	0	48.4	47.7	49.0	48.6	48.5	49.1	48.7	48.5	48.5	49.0	48.2	49.1
	180	50.2	51.8	50.0	51.3	51.6	51.9	50.5	51.1	50.5	51.6	50.6	51.0
Golden Delicious	0	51.3	53.5	53.4	53.1	51.6	54.8	51.7	52.0	53.7	52.8	53.9	52.8
	180	54.0	54.7	55.8	54.6	53.7	56.1	53.7	54.4	54.5	54.7	54.7	54.5
Granny Smith	0	48.8	49.1	50.4	49.7	50.8	49.7	50.5	49.7	51.5	50.1	51.8	49.8
	180	53.5	53.3	55.6	54.3	53.4	54.8	54.2	53.2	55.9	54.1	53.6	52.4
		Total Sugars (% DWB)											
Red Gold	0	67.7	69.7	68.6	68.2	68.5	68.5	67.6	68.3	68.8	67.9	67.8	69.1
	180	68.1	70.1	68.1	68.3	69.7	67.8	66.3	69.5	68.4	68.7	66.4	68.8
Golden Delicious	0	72.0	75.3	72.8	73.3	70.6	73.3	69.1	68.4	69.9	68.9	69.5	69.9
	180	72.6	74.3	73.5	73.9	70.3	73.7	68.7	69.6	69.1	68.6	70.3	69.6
Granny Smith	0	68.1	66.1	66.8	65.9	69.6	69.3	65.9	65.5	66.9	66.5	67.9	69.2
	180	66.8	68.5	67.8	66.4	68.0	70.1	64.5	65.2	67.7	66.8	66.3	66.5

(Table 2). Maximum acidity was found in sulphur fumigated dried apple rings (DT_6 and ST_6) and minimum in control. The increase in acidity after sulphuring rings is due to oxidation of free SO_2 to H_2SO_3 in the intercellular spaces. The slight decrease in acidity during storage might be due to its conversion into sugars. A proportional increase in reducing and total sugars was observed in the dried rings compared to fresh samples. Dehydrated samples contained slightly more total sugars than the corresponding sun-dried samples which may be due to loss of sugars in fermentation during long period of sun-drying. Slight increase in reducing sugars during storage might be due to conversion of non-reducing sugars into reducing sugars with passage of time (Table 3).

Like in fresh fruits, maximum ascorbic acid was observed in the dried rings of 'Golden Delicious' and minimum in 'Red Gold' (Table 4). More ascorbic acid was found in samples containing high residual SO_2 after drying and storage for 180 days. Retention of ascorbic acid was more in dehydrated than in sun-dried samples. During storage, there was a continuous reduction in ascorbic acid. Optical density (OD) which represents the index of browning of dried apple rings was affected by all treatments and methods of drying (Table 4). As expected maximum O.D. indicating more browning was observed in control and minimum in dried rings with high residual SO_2 content. There appears to be more browning in sun-dried sulphur fumigated samples (ST_6) as compared to dehydrated fumigated samples (DT_6). Steeping in 2500 p.p.m. SO_2 solution (ST_5 and DT_5) appears to be preferable for better colour retention.

Sensory evaluation: The dried apple rings from 'Golden Delicious' was adjudged best due to highest score obtained in appearance and taste in corresponding treatments of recommended doses followed by 'Red Gold' and 'Granny Smith'. Pretreatments with SO_2 improved the quality of the product. Control samples got minimum score and mean scores increased proportionately with increase in SO_2. Sun-dried samples were lighter in colour as compared to dehydrated samples. This is similar to earlier findings that sun-drying causes large losses in carotene content[8]. During storage, there was reduction in scores. However, samples containing SO_2 showed less reduction in mean scores in comparison to low or no SO_2 and retained their good quality throughout the storage period of 180 days.

TABLE 4. EFFECT OF PRETREATMENT, DRYING AND STORAGE ON THE ASCORBIC ACID, BROWNING AND RETENTION OF TOTAL SULPHUR DIOXIDE

Variety	Storage period (days)	Pretreatments											
		DT_1	DT_2	DT_3	DT_4	DT_5	DT_6	ST_1	ST_2	ST_3	ST_4	ST_5	ST_6
		Ascorbic acid (mg/100g) DWB)											
Red Gold	0	2.5	3.5	5.0	5.0	6.5	7.5	2.5	3.0	3.0	3.0	5.0	5.0
	180	—	—	—	—	—	—	—	—	—	—	—	—
Golden Delicious	0	5.0	7.5	7.5	7.5	12.5	10.5	3.5	5.0	5.0	7.5	7.5	5.0
	180	—	—	—	—	2.0	1.5	—	—	—	—	—	—
Granny Smith	0	3.0	3.5	5.0	6.0	10.5	7.5	2.5	5.0	5.0	6.0	7.5	4.5
	180	—	—	—	—	—	2.5	—	—	—	—	—	—
		Browning (O.D. at 440 nm)											
Red Gold	0	.036	.22	.018	.009	.009	.009	.052	.052	.046	.018	.009	.018
	180	.086	.066	.061	.086	.032	.027	.081	.081	.076	.056	.036	.036
Golden Delicious	0	.086	.097	.076	.022	.009	.009	.081	.071	.032	.032	.009	0.32
	180	.215	.252	.081	.046	.018	.018	.108	.108	.061	.056	.036	0.46
Granny Smith	0	0.061	.032	.046	.22	.009	.009	.056	.022	.036	.036	.018	0.27
	180	.071	.086	.061	.076	.013	.013	.086	.125	.071	.061	.022	.046
		Residual sulphur dioxide (p.p.m. FWB)											
Red Gold	0	—	—	96	124	248	120	—	—	48	64	160	72
	180	—	—	28	64	132	32	—	—	—	8	64	8
Golden Delicious	0	—	—	96	192	288	112	—	—	56	112	224	64
	180	—	—	32	86	152	40	—	—	—	16	116	—
Granny Smith	0	—	—	120	156	256	180	—	—	48	72	208	96
	180	—	—	24	64	144	80	—	—	—	—	64	64

For DT and ST see text.

References

1. Onslow M W. The oxidising enzymes of some common fruits, *Bioch*, 1920, **14,** 541.
2. Roberts A C and McWeeny J D, The uses of sulphur dioxide, *J Fd Technol.* 1972, **7,** 221.
3. Saxena S K Parekh C M and Girdhari Lal, Some Technological Aspects of Drying and Dehydration of Apples. *Bull CFTRI,* Mysore 1956, **5,** 24.
4. *Official Methods of Analysis,* Association of Agricultural Chemists, Washington, DC. 1970.
5. Ranganna S, *Mannual of Analysis of Fruits and Vegetable Products* Tata McGraw Hill Pub. Co.Ltd. New Delhi 1977, 1.
6. Lane J H and Eynon L, Determination of reducing sugars by Fehlings' solution with methylene blue as an indicator. *J Soc Chem Ind,* 1923, **42,** 327.
7. Mc Bean D McG Pitt J I and Johnson A A, Retention of absorbed sulphur dioxide in fruit tissue during drying. *Fd Technol,* 1865, **19(9)** 141.
8. Desroier N W and Desrosier J N, *The Technology of Food Preservation* AVI Publ. Co., Inc. Westport Connecticut 1982th Edn. 238.

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Osmotic Dehydration of Pineapple

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Water loss from pineapple increased with the increase of sucrose solution temperature and concentration, the former having much more effect for the range of values tested. The sugar gain increased up to 50°C and then fell rapidly; it also increased with the increase in solution concentration. The solute diffusion in pineapple was analysed by Magee's model.

The factors which affect the solute and moisture diffusion are: (i) the type of osmotic agent (ii) the solution concentration (iii) the sample: solution ratio (iv) the osmosis time (v) the osmosis temperature (vi) the solution agitation and (vii) the geometry of the material. In this study, only the effects of 2, 4 and 5 were investigated.

Ponting *et al.*[1] studied various factors affecting the osmotic dehydration of apple chips. The results were expressed as mass reduction without measuring the soluble solids diffusion into the sample and temperature was the main influence on dehydration rate. In a pilot scale study, Farkas and Lazar[2] found a complex empirical relationship between percent mass reduction (μ) and temperature (T), sugar concentration(c) and time(t) in osmotic dehydration of 'Golden Delicious', apple pieces. Hawkes and Flink[3] defined parameters for analysis of osmotic dehydration to measure the overall exchange of solute and water. Data on total mass reduction and soluble solids gain are given by Islam and Flink[4]. Magee, Murphy and Hassaballah[5] developed a model for solute diffusion during osmotic dehydration of apple slices in sucrose solution, where the solid gain divided by water content(W). M is a function of the rate constant(k), time (t) and a constant (A),

$$M = k\sqrt{t} + A \qquad \ldots\ldots (1)$$

or of the difference in sucrose content after time t divided by water content (W) at the same time.

$$M = \frac{S(t) - S(O)}{W(t)} \qquad \ldots\ldots (2)$$

A relationship was established in the form:

$$k \text{ (mole kg}^{-1} \text{ min}^{-1}) = T^{1.40}\, c^{1.13} \qquad \ldots\ldots (3)$$

The rate parameter(k) was related to temperature by Arrhenius equation at different sucrose solution concentrations (c). The average activition energy for the process was 28.2 KJ mole^{-1}. Lenart and Flink [6] suggested that osmosis comes to equilibrium (i.e. net transport stops) when the water activities of the sample and the osmotic solution are equal.

Materials and Methods

'Giant kew' (African) varieties of pineapple were used in the experiments. Slices of 6.5 mm thickness prepared from cored pineapple were threaded on a rod and lowered into a static sucrose bath so that they were completelely immersed. The initial slice: solution mass ratio was between 1:10 and 1.15. The concentration of sucrose was varied from 40 to 70 per cent (w/v). Four or five slices were immersed in each sucrose solution at 19-20°C and the mass reduction of one slice was recorded against contact time. The water content and total solids were measured gravimetrically on other slices after different contact times. The slices were quickly rinsed and gently blotted with tissue paper to remove surface water before weighing. For measuring solid content, vacuum oven drying was done at 70°C for 5 to 6 hr. A sucrose concentration of 60 per cent (w/v) was used at water bath temperatures from 20 to 65°C.

To analyse the data, the three parameters-mass reduction(μ), water loss(ω) and solid gain(δ) were calculated. The mass reduction at time(t) was the net mass loss of the sample on an initial mass basis:

$$\mu = \frac{(O) - m(t)}{m(O)} \times 100 \qquad \ldots\ldots (4)$$

Water loss(ω) was the net water loss at time(t) on an initial mass basis:

$$\omega = \frac{W(O) - W(t)}{m(O)} \times 100 \qquad \ldots\ldots (5)$$

The solid gain(δ) was the net solid transported into the sample on an initial mass basis:

$$\delta = \omega - \mu \qquad \ldots\ldots (6)$$

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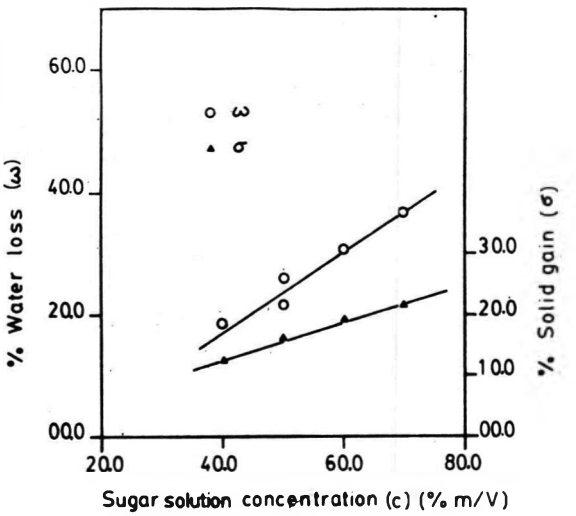

Fig. 1. Water loss(ω) and soluble solid gain (δ) for osmosis at room temp. (20°C) for contact time 5 hours.

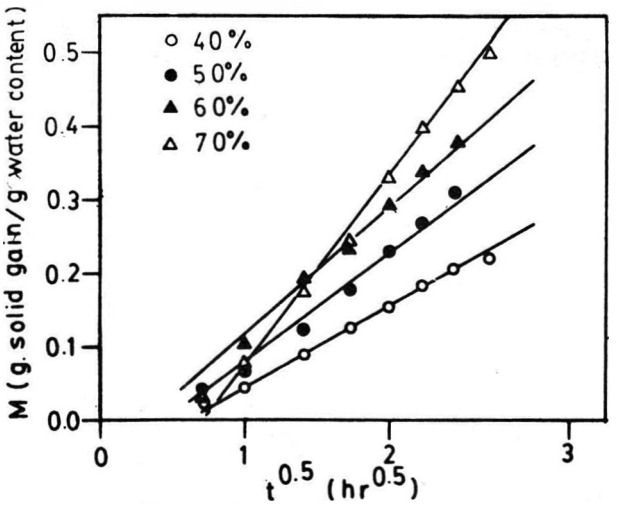

Fig. 2. M(g.solid gain/g.water content) in pineapple slices as a function of square root of contact time at room temperature for different sugar concentrations.

Results and Discussion

Ponting *et al.*[1] and Farkas and Lazar[2] used mass reduction for analysing the osmotic dehydration process. But, analysis by using mass reduction will not give the exact situation of the process because mass reduction(μ) is not the same as the water loss(ω). μ equals ω only when there is no diffusion of solids into the samples ($\delta = 0$). The per cent moisture content of fresh pineapples were 84.2, 84.9, and 89.9 per cent (wet basis).

Effects of sucrose concentration: The effect of sucrose concentration on water loss (ω) and solid gain(δ) was initially identified only by 5 hr contact time experiment (Fig. 1) before analysing by Magee's model. A 20°C the water loss(ω) and solid gain(δ) increased linearly with the increase of sucrose concentration at 5 hr contact time Fig. 1) and linear regression gave a relation with r = 0.98,

$$\omega = 0.61\ c - 6.12 \text{ at } T = 20°C \quad \ldots\ldots (7)$$

The values of M are plotted against the square root of contact time in Fig. 2. The slopes of the straight lines are the rate parameter(k) of the process. The rate parameters(k) plotted on a logarithmic scale against sucrose concentration(c). The power law regression equation gave the best fit with r = 0.984:

$$k = 4.15 \times 10^{-4}\ c^{1.51} \quad \text{at } 20°\ C \quad \ldots\ldots (8)$$

Effects of sucrose temperature: Water loss( ) increased linearly with increase of sucrose temperature(T) for 5 hr contact time (Fig.3) and linear regression gave a relation with r = 0.96,

$$\omega = 0.59\ T + 19.95 \quad \text{at } c = 60\% \quad \ldots\ldots (9)$$

Solid gain(δ) increased up to 50°C and then fell sharply, which is very difficult to interpret (Fig. 4). It is not normal to find diffusion rates falling with increasing temperature. The reason might be that the cell wall, composed of cellulose and pectin, increase its permeability at higher temperature. The soluble solids diffusion during osmosis depends mainly on molecular size, ionic state and solubility of solute in water. The rate of sucrose diffusion in potato did not change much with increasing sucrose concentration whilst NaCl diffusion rapidly increased with the increase of salt concentration[4]. Sucrose having a larger ionic radius cannot diffuse as easily through the cell membrane and thus the approach to osmotic equilibrium is achieved primarily by flow of water from the cell. Since the water loss(ω) was higher at the higher temperature, the osmotic equilibrium was achieved by flow of water from the cell rather than by solid diffusion. Solid concentration became nearly constant above 60°C which indicated negligible increase in the rate of sucrose diffusion above 60°C. For analysing diffusion of solids, Magee's model[5] was used and the values of M have been plotted

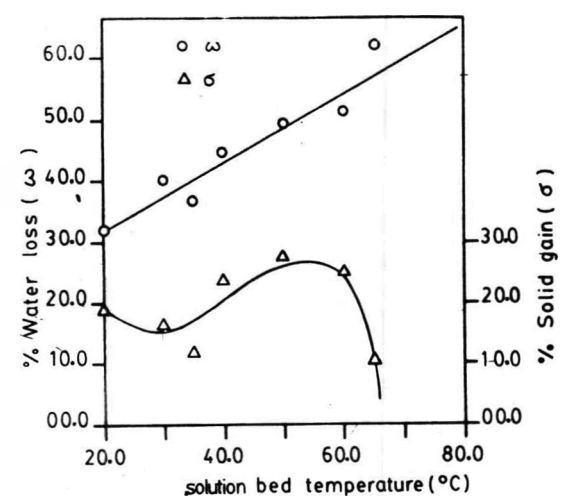

Fig. 3. Water loss(ω) and solid gain (δ) for osmosis of pineapple in 60% solution for 5 hour contact time.

against the square root of contact time in Fig. 4. The rate parameter(k) increased up to 50°C and fell above 50°C.

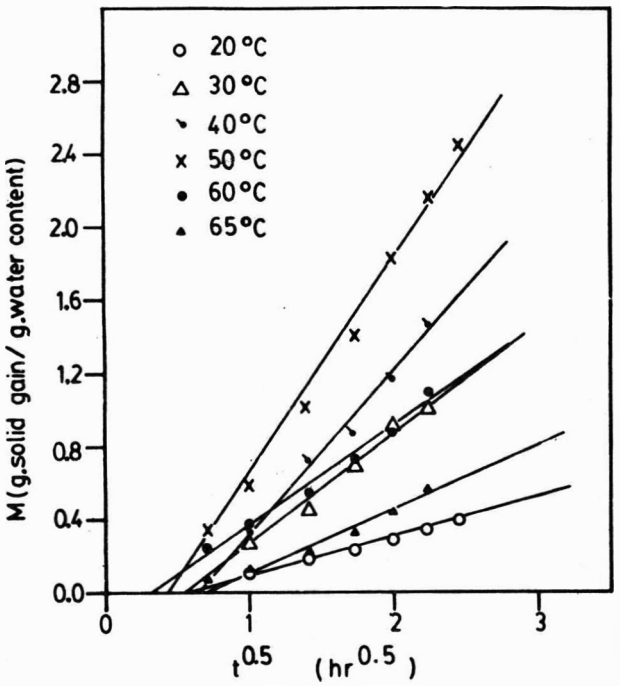

Fig. 4. M(g.solid gain/g.water content) in pineapple slices as a function of the square root of contact time with 60% (m/v) sugar solution at different temperatures.

The water loss(ω) from pineapple slices increased linearly with increasing sucrose solution concentration(c) and with increasing temperature(T). The rate of sucrose diffusion as a function of solution concentration and temperature analysed using the Magee's model. The sucrose diffusion as a function of solution temperature followed the Magee's model but the rate parameter(k) increased up to 50°C and then fell.

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References

1. Ponting J D Watters G G Forry R R Jackson R and Stanley W L, Osmotic dehydration of fruits, *Fd Technol*, 1966, **20**, 125.
2. Farkas D F and Lazar M E, Osmotic dehydration of apple pieces; Effect of temperature and syrup concentration on rates, *Fd Technol*, 1969, **23**, 688.
3. Hawkes J and Flink J M, Osmotic concentration of fruit slices prior to freeze dehydration, *J Fd Process Preser*, 1978, **2**, 265.
4. Islam M N and Flink J M, Dehydration of potato: ii. Osmotic concentration and its effect on air drying behavior, *J Fd Technol*, 1982, **17**, 387.
5. Magee T R A Murphy W R and Hassaballah A A, Internal mass transfer during osmotic dehydration of apples slices in sugar solution, *Ir J Fd Sci Technol*, 1983, **7**, 147.
6. Lenart, A Flink J M, Osmotic concentration of potato. I Criteria for the end-point of the osmosis process, *J Fd Technol*, 1984, **19**, 45.

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Supplementation of Glycerolysed Oils and Alpha-Amylases in Breadmaking. III. Changes in Water Soluble Components During Ageing of Bread

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The effect of incorporation of glycerolysed groundnut oil/cottonseed oil and/or optimal alpha-amylases on reducing sugar content and water extractable components of bread during storage was investigated. Alpha-amylases significantly increased the reducing sugar content of bread crumb. Total soluble solids, alcohol insoluble solids, total hydrolysable carbohydrates and polysaccharides other than starch significantly increased due to ageing of bread for 72 hr. Soluble starch decreased in the control bread. However, it increased when supplemented with glycerolysed oils. Amylase content increased on supplementation with amylases. However, it decreased on ageing.

Starch in wheat flour is a very important factor affecting the quality of bread. The reviews[1,2] on the problem of bread staling generally mention a decrease in the soluble crumb starch. Modification of starch by alpha-amylase action alters the rate of crumb firming[3-5]. Several workers[6-11] have reported that monoglycerides and other surfactants form insoluble complexes with amylose and amylopectin fractions. Complex formation checks the diffusion of more soluble amylose fraction from the starch granule.

The purpose of present investigation was to obtain information concerning the nature of changes in soluble extractives during ageing of bread supplemented with both glycerolysed oils and alpha-amylases.

Materials and Methods

Baking: Straight dough method of bread making simulating commercial 400g loaf as described earlier was followed with or without glycerolysed oils and alpha-amylase as supplements[12].

Freeze-drying of crumb: Peripheral layers of fresh and stored (72 hr) loaves were removed. Bread slices were cut into small bits and freeze-dried under high vacuum in mini-lyophilizer for 8 hr. The dried crumb pieces were coarsely ground using pestle and mortar, powdered fine in the Kamas AB Mill (Sweden) and stored in polyethylene bags in refrigerator.

Free reducing sugars: Free reducing sugars were determined according to A.A.C.C[18] method using freeze-dried crumb powder.

Total soluble solids: This was extracted according to the method of Schoch and French[14] but by filtration of contents through Whatman No. 1 filter paper instead of centrifugation.

Alcohol-insoluble solids (AIS): This fraction was precipitated with ethyl alcohol using the procedure of Schoch and French[14] and precipitate was washed with acetone.

Amylose and starch: Juliano's[15] method was followed for determining amylose. The starch content of alcohol-insoluble solids was determined by using NOVO amyloglucosidase enzyme. A.A.C.C[13] method was followed with subsequent measurement of glucose with Nelson's[16] method.

Results and Discussion

Reducing sugars: The results of reducing sugar content of bread crumb as influenced by glycerolysed oils, alpha-amylase supplements and storage are presented in Table 1. The alpha-amylase supplements significantly ($P \leq 0.01$) increased the reducing sugar content of bread crumb. The reducing sugar accumulation as compared to the control was 28.9, 26.3 and 18.4 per cent for wheat malt, fungamyl and bacterial amylases, respectively. Glycerolysed oils and storage did not have any significant effect (Table 2).

Total soluble solids: After storage for 72 hr, there was an appreciable increase in total soluble solids consisting of soluble starch, pentosans and starch degradation products in bread crumb (Table 1). The effect of glycerolysed oils and alpha-amylase supplements on total soluble solids was not found to be significant. Results of present investigation are in accordance with the study of Jackel *et al.*[18].

Alcohol-insoluble solids (AIS): There was a significant increase in AIS recovered from stored bread crumbs (Table 1). The increase in AIS as a result of storage of glycerolysed groundnut oil bread crumb with wheat malt and fungamyl supplements was 16.7 and 4.4 per cent, respectively.

Starch, amylose and other polysaccharides: The soluble

TABLE 1. EFFECT OF GLYCEROLYSED OILS, ALPHA-AMYLASE SUPPLEMENTS AND STORAGE ON WATER EXTRACTABLE COMPONENTS

Glycerolysed oil (g/100g)	Storage (hr)	Control	Wheat malt	Fungamyl	Bacterial
		Reducing sugars as maltose, %			
Control (0.0)	3	3.8	4.9	4.8	4.5
	72	3.9	4.8	5.0	4.7
G G O (0.5)	3	4.3	5.0	5.0	4.5
	72	4.0	4.7	4.9	4.6
G C O (0.5)	3	4.3	5.0	4.7	4.5
	72	4.3	4.8	4.8	4.7
Glycerolysed oils		**Total soluble solids, %**			
Control (0.0)	3	10.9	10.0	14.2	15.0
	72	18.9	15.9	16.9	17.0
G G O (0.5)	3	7.6	11.3	11.8	11.7
	72	18.2	18.0	15.5	18.0
G C O (0.5)	3	10.8	12.4	9.6	11.3
	72	15.1	16.8	14.2	13.2
		Alcohol insoluble solids (AIS), %			
Control (0.0)	3	3.2	4.6	5.9	6.6
	72	10.1	5.2	6.2	8.5
G C O (0.5)	3	4.1	6.0	4.5	5.0
	72	7.5	7.0	4.7	7.0
G C O (0.5)	3	3.2	5.9	3.8	5.1
	72	10.2	10.7	7.7	8.9
		Soluble starch, %			
Control (0.0)	3	1.67	2.63	2.79	4.03
	72	1.50	2.35	2.75	3.99
G G O (0.5)	3	1.90	3.08	1.58	2.48
	72	3.77	3.22	2.02	2.87
G C O (0.5)	3	1.39	2.55	1.35	2.35
	72	4.98	4.51	3.14	3.58
		Amylose in water-soluble starch, %d.b.			
Control (0.0)	3	10.18	14.06	16.84	18.86
	72	9.30	12.76	14.55	10.53
G G O (0.5)	3	10.00	13.96	16.45	18.54
	72	9.20	13.04	15.84	15.68
G C O (0.5)	3	10.07	13.72	16.30	18.29
	72	9.24	12.19	15.60	15.92
		Hydrolysable carbohydrates, %			
Control (0.0)	3	3.20	4.20	5.68	6.48
	72	8.54	4.58	5.85	6.80
G G O (0.5)	3	4.10	5.86	3.92	4.91
	72	7.18	5.66	4.06	6.02
G C O (0.5)	3	3.12	5.79	3.86	5.07
	72	9.82	9.63	6.91	8.82
		Polysaccharides*, %			
Control (0.0)	3	1.53	1.57	2.89	2.45
	72	7.04	2.23	3.10	2.81
G G O (0.5)	3	2.20	2.78	2.34	2.43
	72	3.41	2.44	2.04	3.15
G C O (0.5)	3	1.73	3.24	2.51	2.72
	72	4.84	5.12	3.77	5.24

*Polysaccharides % = Alcohol insoluble solids % — Starch, %

Average of duplicate determinations G C O — Glycerolysed groundnut oil G C O — Glycerolysed cottonseed oil.

TABLE 2. ANALYSIS OF VARIANCE FOR VARIOUS COMPONENTS

Source of variance	D.F	Mean Sum of Squares						
		Reducing sugars	TSS	AIS	Soluble starch	Amylose	Hydrolysable carbohydrates	Other poly-saccharides
Glycerolysed oils	2	0.015	7.455	2.295	0.290	1.075	4.170	2.270
Alpha-amylases	3	0.780**	0.766	2.147	1.170	56.327**	1.047	0.540
Storage	1	0.030	155.540**	53.400**	4.940*	22.850**	31.920**	9.166**
Error	17	0.024	3.439	2.536	0.767	1.850	2.280	1.283

starch content varied from 1.35 to 4.03 per cent in fresh bread crumb without/with alpha-amylases (Table 1). The crumb starch decreased in control loaves after storage for 72 hr. However, starch content increased in stored bread loaves supplemented with glycerolysed oils with and without alpha-amylases, as monoglycerides present in glycerolysed oils are adsorbed on starch molecules rendering them more soluble whereby they do not allow the hydrogen bonding and check the retrogradation of starch.

Of the soluble starch fraction in total soluble solids, 9.24 to 18.86 per cent was composed of amylose (Table 1) and rest amylopectin. Alpha-amylase supplements had significant effect in increasing the amylose content. However, the effect of glycerolysed oils was not significant (Table 2). Amylose content decreased significantly with storage, resulting in increase in amylopectin content of starch. The results are in accordance with the study of Morad and D'Appolonia[19]. Of the total soluble solids, 3.12 to 6.48 per cent was constituted by hydrolysable carbohydrates which were found to increase during storage (Table 1). Hydrolysable polysaccharides other than starch may be presumed to be the pentosans (Table 1). The quantity of pentosans (difference between total carbohydrate and starch) increased during storage. These data agree with those reported by Gilles *et al.*[20] and Ghiasi *et al.*[21].

It is concluded that glycerolysed oils and alpha-amylase have a definite effect to counteract the firming of bread during ageing.

References

1. Geddes W F and Bice C W, The role of starch in bread staling, QMC. 17-10. War Department. Office of Quartermaster General, Washington, D C 1946.
2. Maga J A, Bread staling, *Crit Rev Fd Technol*, 1975, **5**, 443.
3. Jackel S S, Retarding bread firming through the use of heat stable enzymes, *Bakery Prod Market*, 1969, **4**, 122.
4. Schultz A S Schoonover F D Fisher R A and Jackel S S, Retardation of crumb starch staling in commercial bread by bacterial alpha-amylase, *Cereal Chem*, 1952, **29**, 200.
5. Miller B S and Johnson A, Fungal enzymes in baking, *Bakers Dig*, 1955, **29**, 95.
6. Krog N and Nybo Jensen B, Interaction of monoglycerides in different physical states with amylose and their antifirming effects in bread, *J Fd Technol*, 1970, **5**, 77.
7. Lagendijk J and Pennings H J, Relation between complex formation of starch with monoglycerides and the firmness of bread, *Cereal Sci Today*, 1970, **15**, 354.
8. Kim Y J and Robinson R, Effect of surfactants on starch in a model system, *Starke*, 1979, **31**, 293.
9. DeStefanis V A, Ponte J G, Chung F H and Ruzza N A, Binding of crumb softners and dough strengtheners during breadmaking, *Cereal Chem*, 1977, **54**, 13.
10. Schoch T J, Starch in baking products, *Bakers' Dig*, 1965, **39**, 48.
11. Surfactants in baked foods - Current practices and future trends, *Cereal Fd World*, 1988, **33**, 405.
12. Bajwa U and Bains G S, Supplementation of glycerolysed oils and alpha-amylases in bread making. II. Effect of baking quality and firmness of bread, *J Fd Sci Technol*, 1988, **25**, 220.
13. *Approved Methods*, American Association of Cereal Chemists, St. Paul, MN, USA 1976.
14. Schoch T J and French D, Studies on bread staling, Cereal Chem, 1947, **24**, 231.
15. Juliano B O, A simplified assay for milled-rice amylose, *Cereal Sci Today*, 1971, **16**, 334.
16. Nelson N J, A photometric adaptation of somogyi method for determination of glucose, *J biol Chem*, 1944, **153**, 357.
17. Dubois M, Gilles K A, Hamilton J K, Rabers, P A and Smith F, *Analyt. Chem*, 1956, **28**, 350.
18. Jackel S S, Schaeder W E and Schultz A S, On the changes in the soiuble solids and carbohydrates of bread crumb during the aging of conventional and bacterial alpha-amylase supplemented white breads, *Cereal Chem*, 1953, **30**, 522.
19. Morad M M and D Appolonia B L, Effect of surfactants and baking procedure on total water solubles and soluble starch in bread crumb, *Cereal Chem*, 1980, **35**, 419.
20. Gilles K A Geddes W F and Smith F The carbohydrates of the Gramineae. XI. The constitution of water-soluble polysaccharides derived from bread crumb, *Cereal Chem*, 1961, **38**, 229.
21. Ghiasi K Hoseney R C Lineback D R, Characterization of soluble starch from bread crumb, *Cereal Chem*, 1979, **56**, 485.

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Suitability of Some Packaging Materials for Packing *Sandesh*

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The effect of various packaging materials such as folding paper board cartons, polystyrene containers, high density polyethylene bags, nylon-6 pouches and tin cans on the shelf-life of soft grade buffalo milk *sandesh* stored at 30 ± 1°C with 70% RH ('A' condition) and 7 ± 1°C with 90% RH ('B' condition) was studied. At both the storage conditions the maximum chemical, microbiological and organoleptic deterioration were found in the *sandesh* samples packaged in the folding paper board cartons followed by polystyrene containers, high density polyethylene bags and nylon-6 pouches. Tin cans showed the best results. At 'A' storage condition *sandesh* packaged in folding paper board cartons and tin cans became unacceptable on sixth day with respect to flavour but their extent of deterioration differed in the two packages. At 'B' storage condition *sandesh* remained acceptable upto 30 days in folding paper board cartons and 45 days in tin cans. Efforts were also made to prepare *sandesh* free from staphylococci but it was not successful. Acceptability of *sandesh* during storage reduced mainly due to flavour deterioration.

Sandesh is one of the most popular *chhana* based milk sweetmeats of Eastern region particularly in West Bengal and some parts of Assam, Bihar, Orissa and Tripura[1]. The popularity of this sweetmeat is gradually spreading to the other parts of the country also[2]. Varieties of *sandesh* are available in the market which may be broadly classified into three main groups viz. soft grade *(Narampak)*, hard grade *(Karapak)* and high moisture grade *(Kachhagolla)* depending upon their physical qualities and chemical composition[3]. Of these, soft grade *sandesh* is the most selling and popular variety. *Sandesh* is usually prepared from cow's milk because it produces soft body with fine and uniform grains size product while buffalo milk as such leads to hard and coarse textured sweet which are considered as defects in soft grade *sandesh*[4]. In India, about 52 per cent of the total milk produced is from buffaloes[5] and dairy plants prefer to buy it because of its high total solids content. Method was, therefore, developed to utilise buffalo milk for the production of soft grade *sandesh*. Like most other indigenous milk products, soft grade *sandesh* is also known for its limited shelf-life, not exceeding a few days is a major constraint in its marketing to distant places. Folding paper board cartons are generally used as the main packaging materials for *sandesh* which is an age old practice. For the past few decades, packaging industries have made a significant stride. As a result of this, varieties of packaging materials are now available in market which differ with each other in their physico-chemical properties and these may bring about some changes in the shelf-life of *sandesh*. But the information available in the literature on this product is very scanty and unfortunately no work so far has been reported which deals with the effect of packaging materials on the shelf-life of *sandesh*. In view of the above short comings, an attempt was made to study the influence of a few selected packaging materials on the shelf-life of buffalo milk soft grade *sandesh*.

Materials and Methods

Production of sandesh: Buffalo milk was obtained from the Experimental Dairy of this Institute. In the production of *sandesh*, milk was filtered, standardized to 4 per cent fat, boiled for 5 sec, diluted it with water (30 per cent by volume of milk), cooled to 37°C, coagulated with 0.5 per cent citric acid solution, strained, *chhana* pressed for 10 min, *chhana* ground to smooth paste, divided *chhana* into two equal lots, sugar added (30 per cent by weight of total *chhana*) with first lot of *chhana* in a double jacketed steam kettle, raised the temperature of *chhana* and sugar mixture to 70°C in 15 min by vigorous stirring and scraping with the help of a specially made flat type light wooden ladle, added the second lot of *chhana*, heat the mixture to 60°C in about 10 min by constant stirring and scraping as earlier, cooled the content to 37°C in 10 min. *Sandesh* samples prepared by this process were used in the present studies. Fifty litres of standardized milk were taken in each batch for *sandesh* making and each treatment was repeated 4 times.

Type of packages used: In all, 5 packaging materials viz. folding paper board cartons (FPBC), polystrene containers (PC) high density polyethylene bags, (HDPB) nylon-6-pouches (N-6-P) and tin cans (TC) were selected on the basis of their physico-chemical properties and cost, each of 250g capacity with the thickness of 0.038, 0.079, 0.008, 0.008 and 0.041 cm, respectively for the experiments. The

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TABLE 1. EFFECT OF PACKAGING MATERIALS ON CHEMICAL ATTRIBUTES OF *SANDESH* DURING STORAGE AT 30°C AND 70 PER CENT RH

Packaging type	Storage period (days)	Moisture (%)	Titratable acidity (%)	pH	Free fatty acids (%)	Peroxide* value	Free fat (%)
FPBC	0	27.06	0.65	5.99	0.25	0.46	64.78
	2	25.74	0.82	5.87	0.45	0.62	69.89
	4	25.02	0.95	5.83	0.49	0.69	72.15
	6	24.39	1.04	5.79	0.57	0.57	74.04
PC	2	26.28	0.79	5.30	0.39	0.59	69.35
	4	25.87	0.86	5.86	0.52	0.62	70.49
	6	25.31	0.93	5.82	0.56	0.66	72.98
HDPB	2	26.49	0.76	5.93	0.37	0.56	68.94
	4	26.07	0.82	5.86	0.48	0.61	69.87
	6	25.78	0.89	5.84	0.52	0.64	72.53
N-6-P	2	26.03	0.73	5.95	0.35	0.54	67.25
	4	25.47	0.79	5.92	0.42	0.59	69.36
	6	25.05	0.85	5.87	0.47	0.62	71.84
Tin cans	2	26.87	0.70	5.97	0.33	0.51	66.93
	4	26.49	0.76	5.96	0.39	0.57	68.98
	6	26.12	0.81	5.93	0.43	0.60	71.04

FPBC: Folding paper board cartons; PC: Polystyrene containers; HDPB: High density polyethylene bags; N-6-P, Nylon - 6 pouches.
Average of 4 replicates
*Milli equivalents of peroxide per kg of fat

TABLE 2. EFFECT OF PACKAGING MATERIALS ON CHEMICAL ATTRIBUTES OF *SANDESH* DURING STORAGE AT 7°C AND 90 PER CENT RH

Packaging type	Storage period (days)	Moisture (%)	Titratable acidity (%)	pH	Free fatty acids (%)	Peroxide* value	Free fat (%)
FPBC	0	27.06	0.65	5.99	0.25	0.46	64.78
	15	24.81	0.90	5.87	0.37	0.59	68.53
	30	23.24	1.13	5.81	0.45	0.63	72.86
	45	22.23	1.29	5.71	0.52	0.68	73.64
	60	20.43	1.45	5.59	0.58	0.72	74.35
PC	15	26.18	0.85	5.94	0.36	0.57	67.40
	30	24.97	0.97	5.85	0.44	0.62	71.30
	45	24.04	1.26	5.74	0.50	0.66	72.65
	60	22.96	1.34	5.63	0.56	0.70	74.04
HDPB	15	26.83	0.79	5.95	0.35	0.55	67.21
	30	26.31	0.92	5.90	0.42	0.59	70.60
	45	25.71	1.08	5.79	0.48	0.64	72.51
	60	25.18	1.22	5.68	0.53	0.69	73.97
N-6-P	15	25.64	0.74	5.94	0.33	0.54	66.92
	30	24.36	0.79	5.88	0.38	0.58	69.93
	45	23.56	0.86	5.79	0.42	0.63	72.06
	60	22.58	0.93	5.72	0.49	0.67	73.02
Tin cans	15	26.93	0.71	5.95	0.30	0.52	66.40
	30	26.87	0.76	5.89	0.34	0.56	68.15
	45	26.82	0.84	5.84	0.39	0.60	70.26
	60	26.76	0.89	5.79	0.45	0.64	71.96

Average of 4 replicates

*Legend as in Table 1 *Milliequivalents of peroxide per kg of fat

size of FPBC and PC was same (9×9×4.2 cm), similarly, the dimension of HDPB bags and N-6-P was also identical (16×12); while the TC were round in shape (diameter 7.7 cm, height 5 cm). These packages were procured from the various renowned packaging producers and convertors of the country. Out of these, TC considered as the most ideal packages, were used as the reference. The structure of N-6-P was made up of nylon-6 (base material)/C × A-148 (bonding material)/LDPE (innermost layer). This combination is of recent origin and full of promise FPBC with parchment paper lining were chosen because of common popularity in the market.

Sterilization of packages: The inner portions of the HDPB, N-6-P and PC with lids were first cleaned thoroughly with "Teepol" detergent solution and then they were chemically sterilized with 0.5 per cent hydrogen peroxide solution. This solution was kept in contact with the product surface sides for 5 min. FPBC were sprinkled with the 0.5 per cent hydrogen peroxide solution. The packaging materials were then air-dried. The whole operation was carried out in a packaging room as far as practicable under aseptic conditions immediately before packaging the *sandesh* samples. The tin cans and lids were first cleaned thoroughly in hot detergent solution and then rinsed with hot water. Finally, the cans and lids were sterilized in a hot air oven at 165 to 170°C for at least 2 hr before use[6].

Storage of sandesh: Freshly prepared *sandesh* samples were filled aseptically into the presterilized packaging materials as per requirement and sealed immediately. The sealed packages were stored under two different conditions for the present studies viz., A) 30 ± 1°C with 70 per cent RH in a refrigerated humidity cabinet and B) 7 ± 1°C with 90 per cent RH in a refrigerator. *Sandesh* samples stored under 'A' condition were analysed at an interval of 2 days until spoiled and samples stored under 'B' condition were analysed after every 15 days upto 60 days.

Milk analysis: Fat content in milk was estimated by Gerber method[7].

Chemical analysis of sandesh: Moisture content was determined by oven drying method[8], titratable acidity (TA) by the procedure of Sachdeva and Rajorhia as described for *burfi*[9], pH with the help of a digital pH meter, free fat (FF) by the recommended procedure of Hall and Hedrick as mentioned for powder milk[10] and free fatty acids (FFA) as per IS method for ghee[11] with some minor modifications. In this case, the mixture of *sandesh* and ethanol was boiled on a water bath with vigorous agitation and filtered through Whatman No. 1 filter paper. The filtrate was titrated in hot with 0.1N NaOH solution using phenolphthalein indicator. The peroxide value was estimated according to the IS procedure for ghee[11] with some modifications. Here, 30 g sample was weighed in a glass stoppered conical flask and 75 ml of chloroform added to it. The flask was shaken vigorously to dissolve fat and allowed to stand for 4 hr with occasional shaking. Contents of the flask were filtered through Whatman No. 1 filter paper and the filtrate was evaporated under vacuum. The residual fat was used for the determination of peroxide value (PV) and expressed in terms of milli equivalents of peroxide oxygen per kg of fat. In all these tests, the *sandesh* samples were mashed thoroughly with the help of a stainless steel grater before weighing.

Microbiological analysis of sandesh: The total viable counts (TVC), coliform counts and yeast and mould (Y and M) counts were enumerated by following the procedures of APHA[12] using tryptone dextrose yeast agar, violet red bile agar and potato dextrose agar respectively. Spore counts were carried out as per BS method[13]. Staphylococci counts were made according to the procedure of APHA on *staphylococcus* S-110 agar medium as described by Chapman[14].

Sensory evaluation of sandesh: On the basis of preliminary trials, the packaged samples stored under 'A' conditions were evaluated for sensory characteristics after an interval of 0, 2, 4 and 6 days whereas those stored under 'B' conditions were examined at an interval of 0, 15, 30, 45 and 60 days. The sensory quality of the *sandesh* samples was evaluated by a panel of 7 trained judges using the classical 9 - point Hedonic scale[15]. The samples were examined in terms of flavour, body and texture, colour and appearance and overall acceptability separately.

Results and Discussion

Chemical changes: All the samples showed a progressive increase in total acidity, free fatty acids, peroxide value and free fat contents during storage under both 'A' and 'B' conditions irrespective of their type of packages (Tables 1 and 2). On the contrary, the moisture and pH of *sandesh* samples decreased continuously with the increase in storage period under both the conditions of storage. However, in all the cases their degree of change varied considerably depending upon the type of package used and storage period. The rate of spoilage was more pronounced at storage condition 'A' than 'B'. Again the changes in chemical attributes of *sandesh* under both the storage conditions were maximum in FPBC followed by PC, HDPB, N-6-P and TC. Packaging of *sandesh* is largely influenced by its low cost. These cartons are essentially used as carry home containers. TC though quite expensive, proved to be best package, N-6-P also seems to provide a very potent substitute for TC as a package for *sandesh*. The common chemical deteriorative factors during storage were oxidation, lipolysis and acid development. Similar types of findings were also reported in stored *khoa* samples by the earlier workers[16-17]

Microbiological changes: The growth of micro-organisms in *sandesh* was faster at condition 'A' than 'B' (Tables 3 and 4). At both the storage conditions, maximum microbial deterioration was observed in the product packaged in FPBC followed by PC, HDPB and N-6-P. The product

TABLE 3. INFLUENCE OF PACKAGING MATERIALS ON MICROBIOLOGICAL QUALITY OF *SANDESH* STORED AT 30°C AND 70 PER CENT RH

Packaging type	Storage period (days)	Counts/g of sample			
		TVC	Spore	Staphylococci	Y & M
FPBC	0	5.1×10^3	8.0×10^1	7.9×10^2	5.0×10^1
	2	9.4×10^4	2.5×10^3	2.7×10^3	9.9×10^1
	4	8.2×10^5	3.6×10^3	4.6×10^3	1.5×10^3
	6	9.7×10^6	4.8×10^3	9.4×10^3	2.3×10^3
PC	2	6.8×10^4	2.2×10^3	2.0×10^3	8.5×10^2
	4	5.3×10^5	3.1×10^3	3.4×10^3	1.2×10^3
	6	6.9×10^6	4.0×10^3	6.1×10^3	1.9×10^3
HDPB	2	4.7×10^4	1.8×10^3	1.8×10^3	7.2×10^2
	4	3.2×10^5	2.7×10^3	3.1×10^3	9.8×10^2
	6	5.0×10^6	3.3×10^3	5.8×10^3	1.4×10^3
N-6-P	2	3.1×10^4	1.6×10^3	1.4×10^3	6.6×10^2
	4	1.8×10^5	2.2×10^3	2.8×10^3	8.7×10^2
	6	2.6×10^6	2.8×10^3	4.5×10^3	1.2×10^3
Tin cans	2	1.7×10^4	1.2×10^3	1.3×10^3	6.0×10^2
	4	3.8×10^4	1.8×10^3	2.4×10^3	7.9×10^2
	6	8.7×10^5	2.1×10^3	3.2×10^3	9.8×10^2

Values are average of 4 replicates
Coliforms were absent.
*Legend as in Table 1. Y & M = yeast and mould

TABLE 4. INFLUENCE OF PACKAGING MATERIALS ON MICROBIOLOGICAL QUALITY OF *SANDESH* STORED AT 7°C AND 90 PER CENT RH

Packaging type	Storage period (days)	Counts/g of sample			
		TVC	Spore	Staphylococci	Y & M
FPBC	0	5.1×10^3	8.0×10^1	7.9×10^2	5.0×10^1
	15	9.9×10^3	7.5×10^2	6.1×10^3	5.4×10^2
	30	3.7×10^4	3.2×10^3	1.3×10^4	6.6×10^2
	45	8.9×10^4	3.9×10^3	2.5×10^4	9.1×10^2
	60	6.7×10^5	4.6×10^3	6.4×10^4	1.2×10^3
PC	15	8.9×10^3	6.9×10^2	5.8×10^3	5.1×10^2
	30	2.6×10^4	2.8×10^3	1.2×10^4	6.0×10^2
	45	7.7×10^4	3.1×10^3	2.2×10^4	8.3×10^2
	60	5.3×10^5	3.7×10^3	4.1×10^4	1.0×10^3
HDPB	15	8.1×10^3	5.2×10^2	4.3×10^3	3.4×10^2
	30	1.9×10^4	2.1×10^3	9.7×10^3	5.6×10^2
	45	6.8×10^4	2.6×10^3	1.8×10^4	7.8×10^2
	60	4.2×10^5	2.9×10^3	2.6×10^4	9.1×10^2
N-6-P	15	7.8×10^3	4.6×10^2	2.2×10^3	2.2×10^2
	30	1.3×10^4	1.8×10^3	5.1×10^3	5.3×10^2
	45	5.0×10^4	2.2×10^3	8.7×10^3	7.0×10^2
	60	2.5×10^5	2.5×10^3	1.2×10^4	7.8×10^2
Tin cans	15	7.2×10^3	2.7×10^2	1.5×10^3	1.0×10^2
	30	9.8×10^3	4.5×10^2	3.8×10^3	5.0×10^2
	45	3.2×10^4	6.8×10^2	6.7×10^3	6.3×10^2
	60	9.5×10^4	7.3×10^2	9.8×10^2	7.2×10^2

Values are average of 4 replicates
Coliforms were absent.
*Legend as in Table 1. Y & M = yeast & mould

TABLE 5. EFFECT OF PACKAGING MATERIALS ON SENSORY QUALITY OF *SANDESH* STORED UNDER 30°C AND 70 PER CENT RH AND 7°C AND 90 PER CENT RH.

Packaging type	Storage period (days)	Flavour	Body & texture	Colour & appearance	Overall acceptability
FPBC	0	8.0	8.0	7.5	8.0
	2	7.0	6.5	6.5	7.0
	4	6.0	6.0	6.2	6.0
	6	4.0	5.0	5.5	5.0
	15	6.5	6.9	6.7	6.5
	30	6.3	6.5	6.0	6.0
	45	4.5	5.6	5.4	4.8
	60	4.0	4.0	5.0	4.0
PC	2	7.0	6.7	6.8	7.2
	4	6.2	6.4	6.3	6.2
	6	4.3	6.2	6.0	5.3
	15	7.1	7.2	7.0	7.0
	30	6.5	7.0	6.2	6.5
	45	5.3	6.0	5.6	5.4
	60	4.4	4.5	5.2	4.5
HDPB	2	7.3	6.9	6.7	7.4
	4	6.4	6.6	6.5	6.5
	6	4.5	6.4	6.2	5.0
	15	7.4	7.4	7.1	7.3
	30	7.0	7.2	6.5	7.0
	45	5.5	6.5	6.2	5.8
	60	4.7	6.0	6.0	4.8
N-6-P	2	7.5	7.1	6.8	7.3
	4	6.5	6.7	6.6	6.4
	6	4.6	6.5	6.5	5.2
	15	7.5	7.5	7.2	7.5
	30	7.0	7.0	6.8	7.3
	45	5.7	7.0	6.5	6.0
	60	4.9	6.5	6.0	5.0
Tin cans	2	7.8	7.4	7.1	7.5
	4	6.8	7.0	6.8	6.7
	6	4.9	6.7	6.7	5.5
	15	7.9	7.9	7.4	7.8
	30	7.5	7.5	7.2	7.5
	45	6.2	7.3	6.9	7.1
	60	5.4	6.8	6.5	5.5

Figures shown against 2, 4, 6 and 15, 45, 60 days indicate storage conditions 30°C and 70 % RH and 7°C and 90 % RH respectively

Average of 4 replicates
Legend as in Table 1

packaged in TC exhibited the lowest microbial growth at both the storage conditions. The total viable count (TVC) and staphylococci counts had the major increase at both the storage conditions. Spores and yeast and mould counts were also increased with enhanced storage though at a slow rate as compared with the growth of TVC and staphylococci counts. During the investigation, it was experienced that with possible precautions also *sandesh* samples could not be made free from staphylococci organisms. Survival of staphylococci bacteria in skim milk powder was also observed by Crossley and Campling[18] after the milk was spray-dried even at 210°C. Further, the presence of staphylococci organisms in skim milk powder and several other indigenous milk products were also reported by various researchers[19-22]

Changes in sensory quality: The effect of packaging materials on the sensory quality of *sandesh* during storage

are highlighted in Table 5. The sensory scores decreased progressively as the storage period increased at both the storage conditions. The rate of spoilage was faster in samples stored under condition 'A' than 'B'. *Sandesh* packaged in FPBC and stored under condition 'A' became unacceptable on the sixth day itself but under condition 'B' was acceptable upto 30 days.

The price per piece (250 g capacity) of FPBC, HDPB N-6-P, PC and TC was worked out to rupees 0.14, 0.18, 0.25, 1.00 and 2.50 respectively. Therefore, to fill 250 g *sandesh* the above additional expenses were met depending upon the types of packages used.

References

1. De, S, *Outlines of Dairy Technology*, Oxford University Press, Delhi, 1980, 416.
2. Rajorhia G S and Sen D C, Problems of milk sweets trade in India, *Indian Dairyman*, 1987, **39**, 283.
3. Sen D C and Rajorhia G S, Current status of *sandesh* production in India, *Indian Dairyman*, 1985, **37**, 453.
4. Sen D C, *Technological Studies on Production and Packaging of Sandesh from Buffalo Milk*, 1987, Ph.D. Thesis, Kurukshetra University.
5. Sindhu J S and Singhal O P, in *Buffalo production and Health - A compendium of latest research information based on Indian studies*, by ICAR, Krishi Anusandhan Bhavan, Pusa, New Delhi - 110 012, 1988, 263.
6. Kumar G and Srinivasan M R, Effect of packaging and storage on the sensory characteristics of *khoa* samples, *Indian J Dairy Sci*, 1982, **35**, 132.
7. SP : 18. ISI *Handbook of Food Analysis*, Indian Standards Institution, Manak Bhavan, New Delhi, 1981, Part XI, 64.
8. *Specification for Natural Cheese, Processed Cheese, Processed Cheese Spread* and *Soft Cheese*, IS: 2785 - 1979 Indian Standards Institution, Manak Bhavan, New Delhi, 1979.
9. Sachdeva S and Rajorhia G S, Studies on the technology and shelf-life of *burfi*, *Indian J Dairy Sci*, **35**, 513.
10. Hall C W and Hedrick T I, *Drying of Milk and Milk Products*, AVI Publishing Company, INC, Westport, 1971, 229.
11. *Indian Standard methods of sampling and test for ghee (butterfat)*, IS: 3508-1966 Indian Standards Institution, Manak Bhavan, New Delhi, 1966.
12. *Standard Method for Examination of Dairy Products*, American Public Health Association, Washington, D.C., 1978, 14th Edn.
13. *Methods of Microbiological Examination of Dairy Purposes*, BS: 4285-1968 British Standards Institution, British Standards House, London, 1968.
14. Chapman C H, A Single culture medium for selective isolation of plasma - coagulating staphylococci and for improved testing of chromogenesis, plasma coagulation, mannitol fermentation and stone reaction. *J Bact*, 1946, **51**, 409.
15. Amerine M A Pangborn R M and Roessler E B, *Principles of Sensory Evaluation of Food*, Academic Press, Inc., New York, 1965.
16. Rao O V Singh S and Singh Surjan, Effect of packaging materials on the keeping quality of *khoa*, *J Fd Sci Technol*, 1977, **14**, 152.
17. Davies W L, *Indian Indigenous Milk Products*, Thacker Spink and Co., Calcutta, 1940.
18. Crossley E L and Campling M, The influence of certain manufacturing processes on the *Staphylococcus aureus* content of spray dried milk, *J Appl Bacterial*, 1957, **20**, 65.
19. Ghodekar D R, *Microbiological Quality of Dried Milks*, 1977, Ph.D. Thesis, Bombay University.
20. Ghodekar D R, *Microbiological Studies on Some Indigenous Milk Products (khoa, burfi, peda)*, 1969, M.Sc. Dissertation, Bombay University.
21. Kahlon S S and Grover N K, Incidence of Staphylococci in milk products sampled from Ludhiana, *Indian J Dairy Sci*, 1984, **37**, 381.
22. Mandokhot U V and Garg S R, Market quality of *khoa*, *burfi* and *pera*, A critical review, *J Fd Sci Technol*, 1985, **22**, 299.

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A Study on the Preparation of Intermediate Moisture Meat*

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A study was planned to develop a safe, effective and cheap preservation system for extending the storage life of meat at ambient temperature using the principle of intermediate moisture (IM) meat technology. A processing procedure was standardised by infusion soaking of buffalo meat samples in a solution of humectants: glycerol (2.0%) and sodium chloride (10.0%), chemical preservatives: trisodium citrate (2.0%) and sodium benzoate (0.2%) followed by mild heat treatment and air drying. Mean, % net yield of IM product was 49.67. Samples revealed pH in the range of 5.72 to 5.79, water activity of 0.84 to 0.88, % moisture of 47.52 to 42.73 and % residual salt content of 10.97 to 9.58. Sensory evaluation indicated no spoilage in the IM meat samples during the ambient temperature storage of two months with acceptable palatability.

Intermediate moisture (IM) meats are partially dehydrated meats with suitable concentrations of dissolved solids to bind the remaining water sufficiently to inhibit the growth of bacteria, moulds and yeasts[1]. IM meats offer several unique advantages for meat preservation and new product development suitable for ambient temperature storage[2]. They can be easily moulded and packaged in a simple way. The scope and the problems encountered in the IM meats were reviewed by several authors[3-6]. Studies conducted so far involved use of humectants like glycerol[7,8] and sugars[9] at 10 to 30 per cent level to decrease the water activity. But the humectants at higher levels affect the flavour in the finished product[5]. To overcome this problem, it was suggested to raise the 'safe water activity' level through the combined action of lower levels of humectants, addition of permitted chemical preservatives[10,11] and mild heat treatment[2] to enable development of microbiologically stable and palatable IM products. Several authors[2,12,13] had suggested combining several sub-optimal parameters or hurdles to control spoilage in meat products. Hence, a study was planned to prepare intermediate moisture meat involving low levels of humectants, combinations of approved chemical preservatives, heat treatment and surface drying.

Materials and Methods

About 2 kg of meat from the thigh muscles of a buffalo *(Bos bubalis)* carcass was collected for processing into IM meat. A total of seven batches were prepared involving muscles from seven buffalo carcasses on different days. The samples were made into uniform cubes of approximately 2.5 cm. Visible fat depots were removed and the meat cubes were mixed thoroughly and immersed in the infusion solution contained in autoclave sterilized high density polyethylene tubs. The composition of the infusion solution is furnished in Table 1. Meat sample and the infusion solution used were in the ratio of 1: 1.5 respectively.

The samples immersed in the soak fluid were allowed to equilibrate for 24 hr at room temperature (22-40°C) with stirring at frequent intervals. The tubs were covered with lids for protection from contamination. At the end of the equilibration period, meat cubes were separated and weighed. Later, they were transferred to clean enamel trays and subjected to heating in a pre-heated electric hot air oven maintained at 80°C for 1 hr. After cooling to room temperature, the fluid released during cooking was separated and the weight of meat was recorded. The heat processed samples were surface-dried under an electric fan to reach moisture levels of 40 to 50 per cent. The IM sample was

TABLE 1. COMPOSITION OF THE INFUSION SOLUTION

Ingredients	% (W/W) composition
Sodium chloride (food grade)	10.00
Glycerol, AR	2.00
Trisodium citrate, AR	2.00
Sodium benzoate, LR	0.20
Sterilized potable water	85.80

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divided into five equal parts, wrapped closely in polypropylene bags by evacuating as much air as possible manually and stapled for storage at room temperature. One package was analysed immediately to study the physico-chemical paramaters stated below after processing. The remaining four packages were code numbered and analysed, one each at the end of storage periods of first, second, third and fourth fortnights at room temperature.

About 10 g of meat sample was slurried in 50 ml distilled water and the pH was recorded using an electronic digital pH meter (Biochem model PM 79).

Water activity was estimated indirectly by measuring the equilibrium relative humidity (ERH) with the help of an electric digital temperature and humidity meter. The principle of salt crystal liquefaction test[14] was applied in this study. About 70 g of sample made into uniform pieces of 0.25 cm cubes was spread at the bottom of a 250 ml conical flask fitted with a glass stopper and allowed to equilibrate at 25 ($\pm$ 0.5)°C for about 5 hr. The ERH was estimated with the digital temperature and humidity meter (Casella, London - Model-6900). The instrument was calibrated at every recording with the help of standard saturated salt solutions[15].

Moisture content was estimated by drying the sample at 100 $\pm$ 2°C for 16 hr[15].

Residual salt content was analysed as per the ISI procedure[16].

The IM meat samples at the end of fortnightly storage periods were rehydrated in sterilized potable water for 5 hr with occasional stirring to remove excess salt, glycerol and other chemical preservatives[5]. The rehydrated IM samples were soaked in a solution of spices (pepper 1.5 W/V; garlic 1.0 W/V and potable water 97.5 percent) and cooked in a pressure cooker at 15 lb pressure for 7 min. The cooked samples were presented to a 5- member taste panel for evaluation of tenderness, juiciness and flavour on a 5- point Hedonic scale (1 = very undesirable and 5 = very desirable). The panel also evaluated uncooked samples at the same time for odour (presence of spoilage) on a similar scale. The scores given by the five members were averaged. The data were analysed as per the procedures of Snedecor and Cochran[17].

Results and Discussion

It was found in preliminary trials that incorporation of glycerol beyond three percent was imparting objectionable flavour in cooked IM meats even after thorough resorption before cooking. Hence, glycerol was incorporated at two percent only to safeguard flavour and palatability. Webster *et al.*[18] reported that increase in sodium chloride content resulted in suppression of bacterial growth irrespective of changes in pH and water activity. Synergistic inhibitory action of organoleptically acceptable levels of sodium citrate and sodium benzoate in combination with glycerol and sodium chloride (salt) was also observed[18] on the growth of *Staphylococcus aureus*, *Bacillus subtilis*, *Streptococcus faecalis* and *Clostridium perfringens* at 37°C. It was noticed that salt at 10 per cent level and above in combination with two per cent glycerol and other preservatives with mild heat treatment resulted in IM meat with good shelf-stability at ambient temperature and acceptable palatability. Samples in the preliminary study revealed total bacterial load of 1448, coliforms of 18 and yeast and mould count of 8 per gram when analysed immediately after processing and the same at the end of 30 days of ambient temperature storage were 896, 12 and 6 per gram respectively. *Staphylococcus aureus* and salmonella were absent at the beginning as well as at the end of storage period.

Incorporation of salt at higher level would have taste problems if the product is cooked and consumed as such. But excess salt can be removed easily by resorption as suggested for glycerol-salt desorbed IM meats[5]. Further, meat products with higher salt content are not uncommon. Chinese dry sausages were reported to contain 9.5 to 10.9 per cent salt[19]. As the principles involved in the IM meat processing are better understood, further studies can bring down the level of sodium chloride needed to be incorporated for shelf-stability at room temperature. The processing procedure standardised in this study was found to be satisfactory and no spoilage was reported by the taste panel members during the storage period of two months.

During the equilibration period, meat had picked up weight by about 34.63 per cent as salt at higher levels hydrates proteins and retains moisture[20]. When the equilibrated samples were subjected to oven heating, a decrease in the weight to an extent of 40.97 per cent was noticed. To stabilise the shelf-life of meat at ambient temperatures, moisture level was reduced by exposing the samples for surface-drying by evaporation under an electric fan. The duration of this stage

TABLE 2. MEAN VALUES* OF PHYSICO-CHEMICAL PARAMETERS IN "IM" MEAT DURING AMBIENT TEMPERATURE STORAGE

Parameters	Storage periods					
	Before processing	After processing	1st fortnight	2nd fortnight	3rd fortnight	4th fortnight
pH	5.94 (0.13)	5.79 (0.20)	5.74 (0.19)	5.72 (0.27)	5.76 (0.28)	5.79 (0.26)
Water activity	0.98 (0.01)	0.85 (0.05)	0.84 (0.04)	0.84 (0.04)	0.87 (0.01)	0.88 (0.22)
Moisture (%)	74.89 (0.88)	47.52 (7.46)	46.18 (6.71)	42.73 (6.18)	44.17 (7.09)	45.43 (7.68)
Residual salt (%)	0.32 (0.03)	10.97 (1.31)	10.70 (1.02)	10.49 (0.81)	10.25 (0.58)	9.58 (0.45)

Figures in parentheses indicate standard deviation.
*Each value represents average of seven observations.

TABLE 3. SENSORY SCORES* IN COOKED "IM" MEAT SAMPLES

Parameters	Storage periods (fortnights)			
	1st	2nd	3rd	4th
Odour	3.7 (0.10)	3.7 (0.10)	3.7 (0.11)	3.7 (0.11)
Tenderness	4.1 (0.11)	4.1 (0.10)	4.3 (0.11)	4.3 (0.11)
Juiciness	4.2 (0.16)	4.0 (0.16)	4.0 (0.16)	3.5 (0.11)
Flavour	3.8 (0.14)	3.8 (0.14)	3.9 (0.11)	3.9 (0.10)

Figures in parentheses indicate standard deviation.
*Each mean value represents average of seven observations.

depended on the humid conditions of the weather at the time of processing which ranged from 48 to 72 hr. The mean per cent yield or the per cent weight after surface-drying was 49.67

pH remained almost constant in the IM meat samples during the storage period of two months at ambient temperatures. Water activity ranged between 0.84 and 0.88. Per cent moisture in the samples before processing was about 74.89 whereas in the IM meat samples, it ranged between 42.73 and 47.52. A slight and gradual decrease in residual salt content in the IM meat samples was noticed (Table 2) with increase in storage period.

In sensory evaluation, IM meat samples were rated close to fairly fresh in odour, fairly tender in tenderness, fairly juicy in juiciness and close to fairly desirable in flavour (Table 3). Palatability of IM meat products can be improved in a variety of ways. Cooking in traditional Indian methods with spices and other flavour adjuants and special recipes would definitely make IM meat more acceptable. It has the potential to become a variety product with shelf-stability at room temperature. Further studies are needed to reduce salt levels in the infusion solution by incorporating additional hurdles to microbial and enzymic spoilage through introduction of naturally occurring antimicrobial agents of muscle to produce palatable and ready-to-eat intermediate moisture meat products with shelf-stability at ambient temperatures.

References

1. Hollis F Kaplow M Klose R and Halik J, Parameters of moisture content for stabilisation of food products, *Tech Rept* 1968 69-26 FL. U.S. Army Natick Laboratories, Natick, Massachusetts.
2. Brockmann M C, Intermediate moisture foods, *Food Dehydration* by W B Van-Arsedel, M J Copley and A I Morgan, Jr. (Eds) The AVI Publishing Co., Inc. Connecticut, 1973, 489.
3. Kaplow M, Commercial development of intermediate moisture foods, *Fd Technol*, 1970, **24**, 889.
4. Karel M, Technology and application of new intermediate moisture foods, *Intermediate moisture foods* by R Davies, G G Birch and K J Parker (Eds) Applied Science Publishers Ltd., London, 1976. 4.
5. Ledward D A, Intermediate moisture meats, *Developments in Meat Science* by R A Lawrie, (Ed) Pergamon Press, London 1981, Vol 2, 159.
6. Erickson L E, Recent developments in intermediate moisture foods, *J Fd Protect*, 1982, **45**, 489.
7. Muguruma M Ueda Y Yasuda I Nakamura T and Munate M, Changes of proteins in intermediate moisture meats during the processing of products (studies on factors related to the properties of intermediate moisture meats. Part I) *J Jpn Soc Fd Technol*, 1986, **33**, 21.
8. Sampath Kumar R, *Studies on the Shelf-life of Glycerol Desorbed Intermediate Moisture Mutton*, 1983. M.V.Sc. Thesis, Tamil Nadu Agricultural University.
9. Purnomo H, Buckle, K A, and Edwards R A, A preliminary study on a traditional intermediate moisture beef product, *J Fd Sci Technol*, 1983, **20** 117.
10. Cerrutti F, Resnik S L, Seldes A and Ferro-Fontan C, Kinetics of deteriorative reactions in model food systems of high water activity, glucose loss, 5-hydroxymethyl furfural accumulation and fluorescence development due to non-enzymic browning, *J Fd Sci*, 1985, **50**, 627.
11. Petriella C, Resnik S L, Lozano R D and Chirife J, Kinetics of deteriorative reactions in model food systems of high water activity colour changes due to non-enzymatic browning, *J Fd Sci*, 1985, **50**, 622.
12. Lueck E, *Antimicrobial Food Additives* Springer-Verlag, Berlin, 1980, 35.
13. Smith J L and Pintauro N D, New preservatives and future trends, *Developments in Food Preservatives* by R H Tilbury, (Ed) Applied Science Publishers Ltd., London, 1980, Vol I, 137.
14. Northolt M D and Heuvelman C J., The salt crystal liquefaction test. - A simple method for testing the water activity of foods, *J Fd Prot*. 1982, **45**, 537.
15. *Official Methods of Analysis*, Association of Official Analytical Chemists, 13th Edn., Washington, DC, 1980.
16. *Specification for Mutton and Goat Meat Canned in Brine*, IS: 1743-1973, Indian Standards Institution, New Delhi.
17. Snedecor G W and Cochran W G, *Statistical Methods*, Oxford and IBH Publishing Company, Calcutta, 1968. 6th Edn.
18. Webster S N Fowler D R and Cooke R D, Control of a range of food related microorganisms by a multi-parameter preservation system, *J Fd Technol*, 1985, **20**, 311.
19. Leistner L and Diesel J, Chinese raw dry sausage, An alternative technology, *Mitt. Bundes Fleisch Kulmbach* 1986 No. 92 6919.
20. Poulane E J and Terrell R N, Effects of salt levels in prerigor blends and cooked sausages on water binding, released fat and pH, *J Fd Sci*, 1983, **48**, 1022.

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Studies on Shelf Life and Utilisation of Ghee Residue

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The nutritive value of the ghee residue obtained from Anantapur dairy showed the protein content to be 34.8%, fat 60.4%, calcium 0.124% and phosphorus 0.539%. The shelf life of the ghee residue stored in plastic, glass and tin containers for 90 days showed no significant changes in free fatty acid content, peroxide value and tintometer readings, though the storability was better in glass and tin containers as compared to plastic ones. Ghee residue could replace 100% of butter in cakes and the incorporation in cakes, biscuits and a few supplementary foods improved the flavour and the acceptability scores.

In the process of ghee making about 2 to 3 per cent residue on the weight of the melted ghee is reported to be obtained[1]. This by-product contains caramelised milk sugar, heat affected milk proteins and milk fat, in addition to mineral salts that are immensely valuable in human nutrition[2]. At the household level it is used for spreading over chapaties or for mixing with rice/dhal. But the ghee manufacturing plants discard it as waste or sell at low prices as poultry feed.

The objectives of the present study were to determine the nutrient composition and the physico-chemical changes taking place during storage, and find out the most suitable container for storage of ghee residue and the scope for its utilisation in the bakery products.

Materials and Methods

Ghee residue produced by the Anantapur dairy was analysed for moisture, ash and fat by AOAC method, protein by micro-kjeldahl method, calcium by titrimetric method and phosphorus by Fiske and Subbarao method as described by Hawk, Oser and Summerson[3].

The physico-chemical changes in the sample during storage for 90 days in plastic and glass containers at room temperatures such as free fatty acids (F.F.A.) Peroxide value, (PV) Reichert Meissl value, Polenske value, and colour were determined by ISI methods[4].

The fat used in eggless cakes and biscuits was substituted by ghee residue at 50 and 100 per cent levels and foods like porridges were supplemented with ghee residue at 20 per cent level. The products were subjected to organoleptic evaluation by a panel of 10 trained judges and the scorers were asked to assign a numerical rating for each of the characteristics like appearance, colour, flavour, texture and taste. The score card contained a descriptive term assigned to each point on the scale as an aid to the scorer as shown below:

Excellent 3; Good 2; Fair 1; Unacceptable 0.

The same panelists participated in testing the samples throughout the study period. The panelists belonged to the age group of 20 to 35 yrs.

The list of recipes standardized included:

Cakes
Milk cake
Chocolate cake
Sponge cake
Fruit cake
Banana cake
Coconut cake
Dates cake
Orange marmalade cake
Plum cake
Semolina cake

Biscuits
Sweet biscuit
Cornflake crackle
Lemon coconut cookie
Melting moment
Peanut biscuit
Honey coconut biscuit
Cheese biscuit
Fruity cornflake biscuit
Ginger biscuit
Coffeenut biscuit

Other recipes
Rice porridge
Ragi porridge
Methi roti
Ragi cha poli

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TABLE 1. NUTRIENT COMPOSITION OF GHEE RESIDUE

Constituent	(%)
Moisture	3.6
Protein	34.8
Fat	60.0
Ash	2.1
Acid insoluble ash	0.2
Calcium	0.1
Phosphorus	0.5

Results and Discussion

The nutrient composition of the ghee residue is given in Table 1. The moisture content was found to be 3.6 per cent, the ash content 2.1 per cent and acid insoluble ash content 01.8 per cent. The fat (34.8 per cent) and protein (64.0 per cent) contents were quite high. In spite of denaturation of proteins during the process of ghee making, the amino acid composition of the residue as reported by Singhal and Mudgal[5] is encouraging except for lysine which is not found to be biologically available. But the lysine supplementation, as in the case of any cereals, improves its protein efficiency ratio. Its high fat content points to the need for tapping this as a calorie source. The total poly-unsaturated fatty acids (PUFA) and phospholipid contents were found to be more in lipids of ghee residue than in ghee[6]. The calcium and phosphorus contents were found to be 124 and 540 mg per cent respectively.

The free fatty acids increased (Table 2) from the initial value of 0.50 to 0.67 and 0.65 per cent in the samples stored in clear glass and tin containers respectively and a slightly higher increase (0.83 per cent) was found in that stored in plastic containers.

The peroxide value which determines the oxidative rancidity of fat during storage showed no appearance till 30 days of storage but increased thereafter to 1.40 in the samples stored in glass and tin containers. But this increase was much higher (2.07) in that stored in plastic containers.

TABLE 2. EFFECT OF STORAGE IN DIFFERENT CONTAINERS ON QUALITY OF GHEE RESIDUE

Storage period (days)	Free fatty acids (% oleic acid)			Peroxide value (m.eq./1000g)		
	Plastic	Glass	Tin	Plastic	Glass	Tin
0	0.50	0.50	0.50	0	0	0
15	0.52	0.53	0.51	0	0	0
30	0.53	0.54	0.56	0	0	0
45	0.68	0.60	0.59	0.52	0.41	0.45
60	0.74	0.62	0.60	0.97	0.61	0.72
75	0.87	0.65	0.63	1.24	0.96	0.97
90	0.83	0.67	0.65	2.07	1.40	1.40

Utilisation of ghee residue in baked products: Incorporation of ghee residue in baked products like cakes and biscuits was found to bring down the cost by 10 to 14 per cent of the basic recipe at the household level depending upon other ingredients. This would definitely be much higher at the commercial scale of production. By 50 and 100 per cent substitution of butter with ghee residue, the initial total fat content of 10g in the basic recipe of cake could be reduced to 8.7 and 7.5g respectively. This cuts down the empty calories and improves the protein calories making it valuable for growing children. It was also found that there was a considerable increase in protein, calcium and phosphorus contents in all the recipes with ghee residue.

Though the distinct colour of the ghee residue could not be masked in most of the recipes except in chocolate cakes and coffeenut cookies, the variations were scored higher than the basic ones.

The mean score obtained for the basic recipes was 2.16 which rose to 2.34 and 2.40 with 50 and 100 per cent ghee residue substituted cakes respectively ($t = 4.8$). In the case of biscuits substitution of butter with ghee residue at 50 per cent level increased the mean score from 2.0 for basic recipes to 2.2 but this increase was not statistically significant ($t = 0.724$). But substitution at 100 per cent level was rated lower than the basic recipe.

Similarly, recipes such as methi (fenugreek) roti, ragi (finger millet) chapathi, rice porridge and ragi porridge incorporated with ghee residue as a supplement were rated higher than the basic recipe. Thus, it was found that the colour of the ghee residue does not mar the acceptability in any case. On the contrary, the ghee flavour in the residue improves the aroma of the products.

The beneficial effects of utilising the ghee residue in various preparations like cakes, biscuits and other foods open up a promising future for food industries.

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References

1. Viswanathan K, Thirumala Rao S D and Reddy B R, Recovery of ghee from ghee residue, *Indian J Dairy Sci*, 1973, **4**, 245.
2. Srinivasan M R and Anantakrishnan C P, *Milk Products of India*, National Dairy Research Institute, Bangalore, 1964, 26.
3. Raghuramulu N, Madhavan Nair K and Kalyanasundaram S (Eds) *A Manual of Laboratory Techniques*, National Institute of Nutrition, Jamai-Osmania, Hyderabad, 1983, 31-33, 137-38, 140-41.
4. *Methods of Sampling and Test for Oils and Fats*. ISI: 548-1984 Indian Standards Institution, New Delhi, 29-30, 45-46, 57-63 and 70-71.
5. Singhal K K and Mudgal V D, Amino acid composition of some agro-industrial by-products, *Indian J Anim Sci*, 1983, **53** 652.
6. Santha I M and Narayanan K M, Characterisation of ghee residue lipids, *Indian J Dairy Sci*, 1978, **31** 365.

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Interrelationship Between Sensory and Instrumental Data on Texture of Khoa

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Relationships between sensory texture descriptors and Instron texture profile (TP) parameters for Khoa were studied to derive psychorheological models facilitating prediction of sensory texture from instrumental measurements. Significant correlations were observed between Instron hardness, and sensory firmness, crumbliness, stickiness and smoothness. While Instron gumminess and chewiness showed similar or even better correlations with different sensory texture descriptors, Instron springiness, cohesiveness and adhesive force exhibited relatively smaller correlations. Regression analysis indicated that combination of two or more TP parameters could be more useful in predicting various sensory texture descriptors particularly firmness, crumbliness and chewiness. Of all TP parameters, only adhesiveness bore a definite correlation ($P<0.05$) with the overall sensory texture score (OTQ) of Khoa, the relevant prediction equation explaining about 23% of OTQ. However, all TP parameters included in the multiple regression analysis could predict about 60% variation in OTQ ($P<0.05$), which could be considered substantial in view of the complexity of the product's texture.

Instrumental analysis of food texture has come of age as is evidenced by increasing application of various empirical and imitative methods towards measurement of texture of a variety of foods and food products both in research and quality control[1,2]. Principally favoured for their simplicity, versatility and precision, these methods aim at replacing the sensory texture measurement which is time consuming and often less reproducible. Hence, despite the fact that texture is basically a sensory attribute perceived as a "response to different kinds of physical and physio-chemical stimuli"[3], many attempts have been made to measure the kinesthetic properties of certain foods by instruments, and then to correlate them[4-8]. While these attempts have met with varying degrees of success[5], meaningful studies on psychorheology aspects of food products bringing out significant interrelationships between the sensory texture perception and instrumental measurement can potentially revolutionize the quality control programmes lending them greater reliability together with simplicity.

Successfully established psychophysical models could be of considerable significance also to development of new or 'imitation' products and process modifications for existing products, since these necessitate predicting how the food system will react under certain conditions. This would be particularly relevant to indigenous milk products such as Khoa which, hitherto manufactured by traditional processes only on small scales, are proposed to be produced on large scales by introducing technological innovations.

This paper discusses interrelationships between sensory descriptors and Instron texture profile parameters of Khoa.

Materials and Methods

Preparation of Khoa samples: Twenty-two lots of Khoa were prepared from pooled buffalo milk (standardized to a fat-SNF ratio of 0.6) using a stainless steel steam kettle. The extent of dehydration was so controlled as to obtain a product with varying composition (28.1 - 43.8 per cent moisture, 20.8 - 28.0 per cent fat, 14.9 - 18.9 per cent protein and 8.5 - 28.7 per cent of total protein, water dispersible protein). Varying titratable acidity of the initial milk (0.15 - 0.17 per cent lactic acid) together with the compositional variations ensured a wide range of the textural characteristics in Khoa.

Instrumental and sensory texture analyses: Cylindrical samples of Khoa (19 mm dia, 20 mm height) were subjected to texture profile analysis[7] using an Instron Universal Testing Machine, Model 4301, fitted with a 100 N load cell and operated in a two-bite compression (20 per cent) mode with a cross-head speed of 50 mm/min and chart speed of 100 mm/min. Hardness of the product ranged from 0.244 to 9.081 N, cohesiveness from 0.350 to 0.738, adhesive force from 0.043 to 0.327 N, springiness from 4.5 to 8.3 mm gumminess from 0.176-4.961 N and chewiness from

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0.880-32.246 N. mm. Evaluated by a panel of 10 trained judges using a 100-point unstructured linear rating scale (scores 1 and 100 representing the lowest and the greatest intensity, respectively), Khoa samples exhibited varying degrees of different sensory texture descriptors; elasticity ranged from 29.5 to 63.5, crumbliness from 11.7 to 75.2, firmness from 13.8 to 99.0 stickiness from 17.6 to 80.5, chewiness from 23.8-70.7, smoothness from 19.8 to 68.5 and overall texture quality from 27.3 to 75.0. The sensory and instrumental data thus generated were subjected to statistical analysis in order to develop correlations and multivariate linear and log-linear (power function) relationships[9,10] as follows:

$S = k_o + k_1 I_1 + k_2 I_2 \ldots\ldots\ldots + k_n I_n$, and

$S = k_0 \cdot I_1 K^1 \cdot I_2 K^2 \ldots\ldots\ldots I_n k_n$

where,

S = sensory response,

I_1, I_2, I_n = intensity of instrumental variables,

k_o, k_1, k_2, k_n = parameters computed from the data.

Results and Discussion

Correlations between sensory texture descriptors and instrumental texture profile parameters of Khoa are depicted in Table 1. It can be seen that sensory firmness was highly correlated ($P < 0.001$) with Instron hardness, the log-linear relationship being appreciably higher than the linear one. As shown in Table 2 Instron hardness reflected 86 per cent sensory firmness (Equation 1 vide Table 2). Perry and Carroad[11] noted excellent correlations between sensory and instrumental firmness of cottage cheese. Significant correlations between sensory firmness and Instron hardness have also been observed in Chhana and, to a lesser extent, in Paneer[12].

Table 1 further reveals that Instron hardness also showed significant correlations with sensory crumbliness, stickiness and smoothness, the correlations being higher for log-models. The apparently appreciable correlations between hardness and sensory chewiness and overall texture quality of Khoa were, nevertheless, non-significant. Regression analysis (Table 2) indicated that hardness could account for 53 per cent stickiness. 39 per cent crumbliness and 31 per cent smoothness (Equations 2-4).

Cohesiveness of Khoa measured by Instron was significantly correlated only with firmness ($P < 0.05$), though stickiness also showed a perceptible correlation with it. The lack of appreciable correlation between Instron cohesiveness and sensory crumbliness indicates that the sensorily perceived crumbliness of Khoa, unlike in certain other products, may not necessarily be reflected in Instron measured cohesiveness. While cohesiveness alone could express 23 per cent firmness (Equation 5), together with hardness, it explained 86 per cent firmness (Equation 6) i.e. same as that expressed by hardness alone.

Instron adhesiveness measured as adhesive force was correlated negatively with sensory crumbliness and chewiness, the correlation with the latter being significant ($P < 0.05$ vide Table 1). Thus, adhesiveness accounted for 22 per cent sensory chewiness (Equation 7), but adhesiveness in combination with hardness could predict 40 per cent of chewiness (Equation 8). Instron adhesiveness also appeared to reflect to an appreciable extent, the overall texture quality of Khoa, the relatively small but significant ($P < 0.05$)

TABLE 1. COEFFICIENTS OF CORRELATIONS (γ) BETWEEN SENSORY TEXTURE DESCRIPTORS AND INSTRON TEXTURE PROFILE PARAMETERS OF KHOA (20 d.f.)

Instron parameter	Firmness	Crumbliness	Elasticity	Stickiness	Chewiness	Smoothness	Overall texture quality
Hardness	0.86*** (0.93***)	0.58** (0.62**)	-0.21 (0.01)	-0.62** (-0.73***)	0.31 (0.37)	-0.55 (-0.56**)	−0.32 (-0.18)
Cohesiveness	-0.50* (-0.48*)	-0.15 (-0.12)	0.07 (0.04)	0.34 (0.35)	-0.06 (-0.07)	0.12 (0.09)	-0.15 (-0.09)
Adhesiveness	0.04 (0.05)	-0.38 (-0.38)	0.14 (0.22)	-0.09 (0.02)	-0.46* (-0.47*)	0.39 (0.39)	0.48* (0.45*)
Springiness	0.25 (0.26)	0.45 (0.36)	0.24 (0.28)	-0.07 (-0.04)	0.50* (0.39)	-0.53* (-0.55**)	-0.30 (-0.32)
Gumminess	0.85*** (0.93***)	0.63** (0.67***)	-0.19 (0.12)	-0.62** (-0.74***)	0.37 (0.40)	-0.59** (-0.61**)	-0.34 (-0.22)
Chewiness	0.85*** (0.83***)	0.68*** (0.57**)	-0.16 (0.17)	-0.55** (-0.64**)	0.46* (0.33)	-0.67*** (-0.57**)	-0.41 (-0.35)

* $P \leq 0.05$ ** $P < 00.01$ *** $P < 0.001$

Figures in parentheses are coefficients of correlations for og - linear relationships

TABLE 2. REGRESSION EQUATIONS BETWEEN SENSORY TEXTURE DESCRIPTORS AND INSTRON TEXTURE PROFILE PARAMETERS

Sr. No.	Equation	R (20 df) (Multiple corr. coefficient)	R^2 (Coeff. of determination)
1.	$Fr = 27.638\ H^{0.524}$	0.93***	0.86
2.	$St = 53.904\ H^{-0.333}$	0.73***	0.53
3.	$Cr = 33.378\ H^{0.318}$	0.62**	0.39
4.	$Sm = 49.784\ H^{-0.246}$	0.56**	0.31
5.	$Fr = 19.208\ C^{1.340}$	0.48*	0.23
6.	$Fr = 31.725\ H^{0.556}.C^{0.272}$	0.93***	0.86
7.	$Sch = 27.067\ Ad^{0.256}$	0.47*	0.22
8.	$Sch = 22.667\ H^{0.136}.Ad^{0.283}$	0.63**	0.40
9.	OTQ = 46.083+8.474Ad	0.48*	0.23
10.	Cr = 1.619+7.235Spr	0.45*	0.20
11.	Cr = 4.115H+7.137Spr - 11.523	0.73**	0.54
12.	$Cr = 9.861.H^{0.339}.Ad^{-0.378}Spr^{0.209}$	0.78**	0.61
13.	$Sm = 3.958.10^{2}.Spr^{-1.239}$	0.55**	0.30
14.	$Fr = 11.275.H^{0.502}.C^{-0.084}Spr^{0.468}$	0.94***	0.88
15.	$Fr = 37.472,\ G^{0.584}$	0.93***	0.86
16.	Fr = 28.045+1.949Ch	0.83***	0.69
17.	$Cr = 39.893.G^{0.382}$	0.67***	0.45
18.	Cr = 34.644+1.277 Ch	0.60**	0.36
19.	$St = 44.443.G^{0.375}$	0.74***	0.54
20.	$St = 71.579.Ch^{-0.287}$	0.64**	0.41
21.	$Sm = 43.410.G^{0.297}$	0.61**	0.37
22.	Sm = 57.783-1.293 Ch	0.67***	0.45
23.	Sch = 41.109+0.680 Ch	0.46*	0.21
24.	Sch = 15.484+1.118H-18.155C+6.144 Spr.	0.60*	0.36
25.	$Sch = 16.562.H^{0.128}.Ad^{-0.248}.Spr^{0.214}$	0.64*	0.41
26.	Fr = 17.514+5.736H-46.469C+5.842 Spr	0.90***	0.82
27.	$Sm = 3.404.10^{2}.H^{0.242}.Ad^{0.221}.Spr^{-0.785}$	0.78*	0.61
28.	OTQ = 85.115-38.769C+8.111G-1.961 Ch	0.64*	0.40
29.	OTQ = 53.077+61.789.Ad+7.636G-1.651 Ch	0.67*	0.45
30.	OTQ = $1.076.10^{2}$-20.825H-113.514C +35.610 Ad+2.587Spr +61.688G-0.406 Ch	0.77*	0.60

Fr = Firmness; H = Hardness
St = Stickiness; C = Crumbliness
Cr = Crumbliness; Ad = Adhesivness
Sm = Smoothness; Spr = Springiness
Sch = Sensory chewiness; G = Gumminess
OTQ = Overall texture quality; Ch = Chewiness

* P<0.05 ** P<0.01 *** P<0.001

predictability of the latter from the former being 23 per cent (Equation 9).

Instrumental springiness of Khoa bore significant correlations with sensory crumbliness, chewiness and smoothness. While springiness alone could predict only 20 per cent crumbliness (Equation 10), together with hardness, it accounted for 54 per cent of this texture descriptor of Khoa (Equation 11), and for 61 per cent of it when combined with both hardness and adhesiveness (Equation 12). Inversely related with smoothness, Instron springiness could be expressed in a log-model to explain 30 per cent of this descriptor (Equation 13). It was thus evident that a more granular product tended to be more springy. Similarly, although springiness was not significantly correlated with sensory firmness, in combination with hardness and cohesiveness, it could predict 88 per cent of firmness (Equation 14). However, the non-significant correlation between Instron and sensory measurements of springiness/elasticity of Khoa may be attributed to a relatively low intensity of this attribute of Khoa, which made its sensory perception difficult and hence, less consistent. Desai[12] noticed a similar correlation for Chhana and almost no correlation for Paneer.

As further seen from Table 1, Instron gumminess, a product of hardness and cohesiveness, and Instron chewiness, a product of gumminess and springiness, showed similar or even better correlations than those shown by hardness with all sensory descriptors except elasticity. This points to the significant role played by cohesiveness and springiness, which by themselves were comparatively less important measures of various texture descriptors. Thus, gumminess and chewiness accounted for 86 and 69 per cent firmness, 45 and 36 per cent crumbliness, 54 and 41 per cent stickiness, and 37 and 45 per cent smoothness, respectively (Equations 15-22). Instron chewiness was significantly correlated ($P<0.05$) also with sensory chewiness of Khoa, the corresponding regression exhibiting 21 per cent variation in sensory chewiness as explained by Instron chewiness (Equation 23). Desai[12] reported a slightly higher correlation for Paneer and considerbly higher ($r = 0.82$) for Chhana.

It should, however, be noted that chewiness measured by Instron is taken to represent the sensory chewiness at the bulk level i.e. considering the whole mass or piece of the product taken for a bite, as in the case of pop corn, unlike in Khoa, Chhana and Paneer, which, essentially being granular in nature, exhibit chewiness more at the particle level than at the bulk level i.e. when jaws crushing the piece or bulk come close to each other so that individual grains are crushed. Thus, although the chewiness of individual granules may contribute some of the chewiness of the bulk, it is mainly the hardness, cohesiveness and springiness of these granules that should determine the sensorily perceived chewiness. Hence, the Instron chewiness as measured by the conventional procedure need not necessarily reflect the sensory chewiness of structurally particulate products such as Khoa.

Furthermore, sensory chewiness could be appreciably better predicted by Instron hardness, cohesiveness and springiness taken together (Equation 24) or hardness, adhesiveness and springiness (Equation 25). Similarly, a combination of 3 of the Instron texture profile parameters could account for a greater percentage of sensory descriptors such as firmness and smoothness (Equations 26, 27) than that accounted for by single parameters.

Attempts have been made to correlate one or more of the instrumentally determined texture profile parameters of certain foods with their sensory texture quality[2,7]. However,

as observed in the present study it is relatively easy to find definite relationships between instrumental and sensory data on certain individual attributes of food texture such as firmness and chewiness rather than having a decisive picture of a product texture from its instrumental profile. Table 2 reveals that Instron cohesiveness coupled with gumminess and chewiness explained 40 per cent, and adhesiveness combined with gumminess and chewiness accounted for 45 per cent of the overall sensory texture score of Khoa (Equations 28, 29), whereas as high as 60 per cent of the same could be explained by all the Instron texture profile parameters taken together (Equation 30). In view of the complexity of food texture in general, and difficulties encountered in deriving a meaningful instrumental sensory texture relationship[13], this observed correlation for Khoa can be considered highly appreciable.

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References

1. Voisey P W, Recent advances in texture test instrumentation and their application, in *Food Texture and Rheology* by Sherman P, Academic Press, London, 1979, 65.
2. Timbers.G E and Voisey P W, The Ottawa pea tenderometer and the Ottawa Texture Measuring System: The evolution of a system for quality control and food texture research, in *Food Texture: Intrumental and Sensory Measurement* by Moskowitz H R, Marcel Dekker, Inc., New York, 1987, 65.
3. Peleg M, The semantics of rheology and texture, *Fd Technol*, 1983, **11**, 54.
4. Szczesniak A S, General Foods texture profile revisited - Ten years perspective, *J Texture Studies*, 1975, **6**, 5.
5. Szczesn ak A S, Correlating sensory with instrumental texture measurements - An overview of recent developments, *J Texture Studies* 1987, **18**, 1.
6. Moskowitz H R and Kapsalis J G, Psychophysical relations in texture in *Rheology and Texture in Food Quality* by deMan J M, Voisey P W, Rasper V F and Stanley D W, The AVI Publ. Co, Westport, USA, 1976, 554.
7. Bourne M C, Texture profile analysis, *Fd Technol*, 1978, **32**, 62.
8. Rajpoot N C, Rajalakshmi D and Raghuveer K G, Instrumental and sensory evaluation of mutton and roti, *J Instrument Soc India*, 1981, **11**, 67.
9. Kapsalis J G and Moskowitz H R, Interrelationship between instrumental methods and sensory assessment for food texture in *Developments in Food Science-2* by Chiba H, Fujimaki M, Iwai K, Mitsuda H and Morita Y, Elsevier Scientific Publ. Co., New York, 1979, 327.
10. Moskowitz H R, Relating subjective and instrumental measures a psychophysical overview, *J Fd Quality*, 1981, **4**, 15.
11. Parry C A and Carroad P A Instrument for texture of small cottage cheese and comparison to sensory evaluation, *J Fd Sci*, 1980, **45**, 798.
12. Desai H K, *Rheological Properties of Heat and Acid coagulated Indian Milk Products*, 1988, Ph.D. Thesis, Kurukshetra University.
13. Drake B, Food psychorheology, A speculation of difficulties, in *Food Texture: Instrumental and Sensory Measurement* by Moskowitz H R, Marcel Dekker, Inc., New York, 1987, 167.

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Acorus calamus Rhizomes as a Protectant of Milled Rice Against *Sitophilus oryzae* and *Tribolium castaneum*

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The effectiveness of *Acorus calamus* L. rhizome powder (0.1 and 0.2% w/w) was investigated as a grain protectant against *Sitophilus oryzae* (L.) and *Tribolium castaneum* (Herbst.) in stored milled rice. *S. oryzae* adults suffered negligible mortality at both the levels in initial testing, and showed no progeny development even at 0.1% level. After 3 or 6 months of storage, high mortality was observed at both the levels of *A. calamus* and only a few progeny adults could emerge from 0.1% level. *T. castaneum* adults suffered negligible mortality at all storage intervals. However more than 50% reduction was achieved at 0.1% level. The cooking quality of milled rice did not change even when treated with 0.2% *A. calamus* rhizomes and stored for more than eight months.

Milled rice, like rough rice is prone to attack by various insect pests in storage resulting in considerable loss in both quantity and quality besides the increase in uric acid levels beyond the permissible limits[1]. As mixing of insecticides with milled rice is not recommended, there is a need for safer and economical methods of storage. Insecticides of plant origin, being comparatively safer, offer a promising alternative. The rhizome and the extract of the rhizome of *Acorus calamus* L. is known to exhibit insecticidal activity against household insect pests[2-4] and against pests of stored grains[5-7] in addition to its medicinal value[8-11]. The potential of *A. calamus* rhizome as a grain protectant for paddy[12,13], sorghum, wheat and green gram[14], Bengal gram[15] and pigeon pea[16] has been demonstrated earlier. Keeping in view the above, present studies were undertaken to evaluate the effectiveness of *A. calamus* rhizome as a protectant for milled rice against the rice weevil, *Sitophilus oryzae* (L.) and the red flour beetle, *Tribolium castaneum* (Herbst.) so as to evolve a cheaper, safer and economical method of protecting milled rice at the household level in rural areas.

Materials and Methods

The rhizomes of *Acorus calamus* L. were procured locally, dried at 40°C in a hot air drier and powdered to 60 mesh in a Raymond's hammer mill.

Insects were obtained from laboratory cultures maintained at 28 ± 2°C and 60-75 per cent relative humidity. In all experiments, one week old adults were used. Cultures of *Sitophilus oryzae* were maintained on whole wheat, while those of *Tribolium castaneum* were reared on whole wheat flour enriched with 5 per cent yeast. All the experiments were carried out at the above mentioned temperature and relative humidity.

Samples of rice were cleaned and conditioned in desiccators maintained at 70 per cent relative humidity for 2-3 weeks to bring the moisture content to 13 per cent prior to use for experimental purposes.

To evaluate the effectiveness of powdered rhizomes, 50g samples of rice taken in a 100 ml glass jar containing the powder at concentrations of 0.1 and 0.2 per cent (w/w) were used. There was a common control for both the concentrations and each treatment was quadruplicated; 25 or 20, unsexed adults (seven days old) of *S. oryzae* or *T. castaneum* were placed in each replicate. Mortality counts were made after exposure period of 7 and 14 days, and then the adults were discarded. The emerging progeny were scored every other day until emergence was complete and fecundity (progeny/adult-day) was calculated. Procedure of Kazmaier and Fuller[17] was followed for working out adult-days used in the calculation of fecundity. Reduction in progeny in the two concentrations was calculated as percentage of controls.

In another experiment, larger samples of rice were treated with 0.1 and 0.2 per cent *A. calamus* (w/w). Treated and untreated lots were stored at the above mentioned conditions of temperature and relative humidity for determining the effectiveness of treatment after 3 and 6 months of storage. Details of the experimental procedures followed and observations recorded were the same as described earlier.

Data on productivity and per cent progeny reduction after angular transformations were statistically analysed.

Cooking quality of the 8-month-stored rice was determined according to ISI method.[18] Amount of water required and time taken for cooking, aroma and taste of cooked rice for treated and control samples were compared. Treated samples stored for 8 months were also distributed to volunteers for their cooking trials and their opinions gathered.

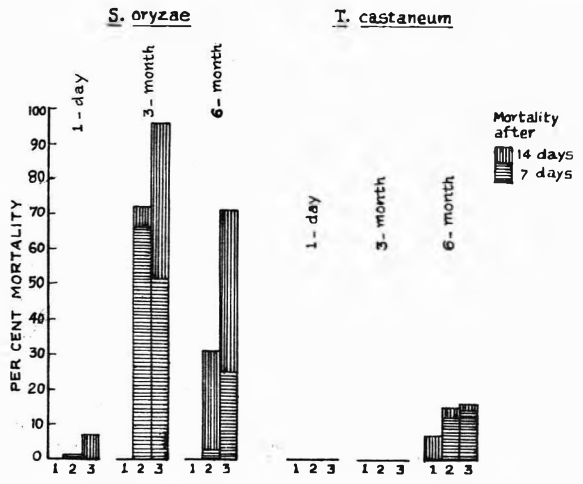

Fig. 1. Susceptibility of *S. oryzae* and *T. castaneum* adults in rice treated with various concentrations of *A. calamus* at different storage periods (1,2 and 3 represent control, 0.1 and 0.2% levels respectively).

Results and Discussion

Effectiveness of A. calamus *1-day after application to rice:* The data on adult mortality of *S. oryzae* and *T. castaneum* are represented in Fig. 1. In initial testing, mortality of both the insects was negligible in both the concentrations after a 14-day exposure period. There was no development of progeny of *S. oryzae* even at the lowest concentration of 0.1 per cent, while a few progeny adults of *T. castaneum* did emerge in both the concentrations (Table 1). Productivity (progeny/adult-day) of *T. castaneum* was significantly low in treatments as compared to controls. Progeny of *T. castaneum* was reduced by more than 58 per cent even at 0.1 per cent level. However, no significant statistical differences existed between the two levels of the protectant tested.

Effectiveness of A. calamus *rhizomes after storage:* After 3 months of storage, 0.1 and 0.2 per cent levels exhibited 72 and 96 per cent mortality of *S. oryzae* adults respectively during 14 days of exposure. However, *T. castaneum* did not suffer any mortality (Fig. 1). No progeny of *S. oryzae* emerged even from 0.1 per cent level. Progeny emergence and productivity of *T. castaneum* was suppressed significantly in comparison with the controls (Table 1). Progeny of *T. castaneum* was reduced by about 50 per cent at 0.2 per cent level.

After 6-month storage, 71 per cent kill of *S. oryzae* was got at 0.2 per cent level during a 14-day exposure, while *T. castaneum* adults suffered 16 per cent mortality (Fig. 1). Progeny development and productivity of *S. oryzae* was suppressed significantly in 0.1 per cent and no progeny could emerge in 0 2 per cent of *A. calamus*. More than 85 per cent reduction in progeny was got even at 0.1 per cent of the protectant (Table 1). Both the levels seem to have retained their effectiveness against *T. castaneum* by significantly suppressing the progeny development as compared to the controls.

Results of the cooking trials with treated rice stored for more than 8 months revealed no changes in cooking quality of cooked rice. Treated samples which were given to

TABLE 1. ADULT EMERGENCE, PRODUCTIVITY (PROGENY/ADULT-DAY) AND PER CENT PROGENY REDUCTION OF *SITOPHILUS ORYZAE* AND *TRIBOLIUM CASTANEUM* IN *ACORUS CALAMUS* TREATED RICE AFTER VARIOUS STORAGE INTERVALS.

Level used (%)	1-day			3-month			6-month		
	Adults emerged	Progeny/ adult-day	Progeny reduction %	Adults emerged	Progeny/ adult-day	Progeny reduction %	Adults emerged	Progeny/ adult-day	Progeny reduction %
				S. oryzae					
Control	61.0	0.18	—	49.5	0.14	—	54.5	0.16	—
0.1	0.0	0.0	90.0 (100.0)	0.0	0.00	90.0 (100.0)	0.75	0.003	85.3 (98.62)
0.2	0.0	0.0	90.0 (100.0)	0.0	0.00	90.0 (100.0)	0.00	0.0	90.0 (100.0)
Test of sig	—	—	—	—	—	—	—	t=15.7 df=6	t-test NS
				T. castaneum					
Control	40.25	0.14[a]	—	33.75	0.12[a]	—	43.75	0.17[a]	—
0.1	11.00	0.04[b]	58.54 (72.67)	17.50	0.06[b]	43.91 (48.12)	16.00	0.07[b]	52.89 (63.43)
0.2	8.50	0.03[b]	62.69 (78.88)	16.25	0.06[b]	45.91 (51.85)	12.25	0.05[b]	58.11 (72.00)
Test of sig	—	CD=0.01 df=11	t-test NS	—	CD=0.02 (df=11)	t-test NS	—	CD=0.03 (df=11)	t-test NS

NS : Not significant

volunteers for their judgement on the quality of the cooked rice were also readily acceptable and no off-flavour was reported by the consumers.

The observed mortality of *S. oryzae* after different storage intervals at tested levels could possibly be attributed to insecticidal activity of the *A. calamus* rhizomes.[2,4,5] The rhizomes have also shown promising results against pests like bird lice, bed bugs and cloth moth by exhibiting 100 per cent mortality on treated birds and cloth[3]. Solvent extracts and oil of *A. calamus* have also been found lethal to adults of *Callosobruchus chinensis* L.[6], *S. oryzae*[7], *Sitotroga cerealella*[19] and ants, *Formica polyctenes* and *F. pratensis*[20].

Data on adult progeny emergence and productivity of *S. oryzae* showed that no progeny could develop in treated rice samples stored for one day or 3 months, and a few progeny adults emerged from treated samples (0.1 per cent) after 6 month storage. Reduction in progeny of *S. oryzae* after storage could be possibly because of the observed high adult mortality, whereas, in treatments giving low adult mortality, the progeny reduction may be attributed to the chemosterilant action of vapours of the oil emanating from the rhizomes. Exposure to vapours of oil has been reported to exhibit chemosterilant activity by reducing the fecundity and causing regression of the terminal folicles in females of *T. castaneum*, *S. oryzae*, *C. chinensis* and *Trogoderma granarium*[21]. Similar effects have also been observed in newly emerged females of *T. granarium*[22] and *C. chinensis*[23]. Vapours of the oil from *A. calamus* rhizomes are also known to cause differential sterility in males of *Musca domestica*[24] and *Dysdercus Koenigii*[25]. The observed suppression of progeny of *T. castaneum* in both the concentrations at various storage intervals could be due to a combined effect of the rhizomes as a larvicide or a chemosterilant. Larvicidal activity of rhizomes and its oil has also been discussed against larvae of *M. domestica* in culture medium[26], *Corcyra cephalonica* (Staint.) on wheat[27] and *Culex* spp. in aquatic medium[28, 29].

While comparing the effectiveness of rhizomes against the two pests, it was found that even the lowest dose afforded almost complete protection of milled rice against *S. oryzae* upto 6 months, while about 50 per cent reduction in progeny of *T. castaneum* was observed. However, in another experiment 1.0 per cent concentration of the protectant was found to afford complete protection against the red flour beetle. More so, treatment of milled rice with 0.2 per cent *A. calamus* rhizome powder and storing for more than 8 months did not change the quality attributes of the cooked rice. Based on the above findings, it can be concluded that *A. calamus* could be recommended as a safe protectant for mixing with milled rice against insect infestation in rural areas where it is cheap and easily available. Besides, it is also safer to non-target species and having fungicidal and medicinal properties[8]. Rhizomes of *A. calamus* are sold in the retail market at Rs. 16 per kg. For treatment of rice at the effective level of 0.2 per cent, 1 kg of the powdered rhizomes will be sufficient for 500 kg of rice. Mixing of the powdered rhizomes also may not require any special gadgets as manual mixing will serve the purpose. The powdered rhizomes can be used time and again as these are known to have long term residual action.

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References

1. Cogburn RR, *Insect Pests of Stored Rice*, in *Rice: Production and Utilization*, by Luh BS, AVI Publishing Company, Inc, Westport, Connecticut, USA, 1980, 289.
2. Mironov US, *Acorus calamus* as an insecticidal and repellant preparations, *Med Parasitol*, 1940, **9**, 408.
3. Subramaniam T V, *Acorus* - a new indigenous insecticide for the household, *Indian J Ent*, 1942, **4**, 238.
4. Paul CF Agarwal PN and Aust A, Toxicity of solvent extracts of *A. calamus* to some grain pests and termites, *Indian J. Ent*, 1965, **27**, 114.
5. Mukherjee T D and Govind R, A plant insecticide - *Acorus calamus*, *Indian J. Ent*, 1959, **21**, 194.
6. Yadava RL, Use of essential oil of *A. calamus* as an insecticide against the pulse beetle, *C. chinensis*, *Z Ang Ent*, 1971, **68**, 289.
7. Teotia, TPS and Pandey GP, Insecticidal properties of rhizomes of sweet flag, *A. calamus* against *S. oryzae*, *Indian J Ent*, 1979, **41**, 91.
8. Wealth of India, *Raw materials*, CSIR, New Delhi, 1985, Vol I:A Rev. Edn, 63.
9. Raj RK, Screening of indigenous plants for anthelmintic action against human *Ascaris lumbricoides*, *Indian J Physiol Pharmacol*, 1974, **18**, 129.
10. Chaudhury G N Kokate C K and Nimbkar A Y, Search for anthelmintics of plant origin: Activity of volatile principles of *Acorus calamus* against *A. lumbricoides*, *Ancient Sci Life*, 1981, **1**, 103.
11. Sharma R D Chaturvedi C and Tewari P V, Helminthiasis in children and its treatment with indigenous drugs, *Ancient Sci Life*, 1985, **4**, 245.
12. Mammen K V Vishalakshi H and Nair M R G K, Insecticidal dusts to control pests of stored paddy, *Agric Res J Kerala*, 1968, **6**, 59.
13. Abraham C C Thomas B Karunakaran K and Gopalakrishna R, Relative efficacy of some plant products in controlling infestation by the angoumois grain moth, *S. cerealella* infesting stored paddy in Kerala, *Agric Res J Kerala*, 1972, **10**, 59.
14. Chander H and Ahmed S M, Potential of some new plant products as grain protectants against insect infestation, *Bull Grain Technol*, 1983, **21**, 179.
15. Pandey N D Singh S R and Tewari G C, Use of some plant powders, oils and extracts as protectants against pulse beetle, *C. chinensis*, *Indian J Ent*, 1976, **38**, 110.
16. Khan M I and Borle M N, Efficacy of some non-toxic grain protectants against the pulse beetle, *C. chinensis*, *PKV Res J*, 1984 **8**, 35.
17. Kazmaier H E and Fuller R G, Ethylene dibromide and methyl bromide (EDB:MB) mixtures as fumigants against *T. castaneum*, *J econ Ent*, 1959, **52**, 1081.
18. *ISI Method for Determination of Cooking Quality of Raw Milled Rice*, IS: 10404-1982. Indian Standards Institution, Manak Bhavan, New Delhi.

19. Teotia T P S and Tewari G C, Insecticidal properties of drupes of dhreek and rhizomes of *A. calamus* against adults of *S. cerealella*, *Indian J. Ent*, 1977, **39**, 222.
20. Schmidt G H and Borchers D, Studies on the sterilizing effects of Indian calamus oil on ants, *Mittenlungen der Deutschen Gerellschaft fur Allangomeine und Ang Ent*, 1981, **3**, 207.
21. Saxena B P Koul O and Tikku K, Non-toxic grain protectants against the stored grain insects, *Bull Grain Technol*, 1976, **14**, 190.
22. Koul O Tikku K and Saxena B P, Follicular regression in *Trogoderma granarium* due to sterilizing vapours of *A. calamus* oil, *Curr Sci*, 1977, **46**, 124.
23. Tikku K Saxena B P and Koul O, Oogenesis in *C. chinensis* and induced sterility by A. calamus oil vapours, *Ann Zool Ecol Ani*, 1978, **10**, 545.
24. Mathur A C and Saxena B P, Induction of sterility in male housefly by vapours of *A. calamus* oil, *Naturwissenschaften*, 1975, **62**, 576.
25. Koul O Tikku K and Saxena B P, Mode of action of *A. calamus* oil vapours on adult male sterility in red cotton bug, *D. koenigii*, *Experientia*, 1977, **33**, 29.
26. Ahmed S M Chander H and Pereira J, Insecticidal potential and biological activity of Indian indigenous plants against *Musca domestica* *Int Pest Control*, 1981, **23**, 170.
27. Chander H and Ahmed S M, Effect of some plant materials on the development of rice moth, *Corcyra cephalonica*, *Entomon*, 1986, **11**, 273.
28. Deshmukh P B Chavan S R and Renapurkar D M, A study of the insecticidal activity of twenty indigenous plants, *Pesticides*, 1982, **16**, 7.
29. Chavan S R Bhat V M Renapurkar D M and Bhide M N, A new larvicide from *Acorus calamus*, *Bull Haffkine Inst*, 1976, **4**, 64.

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An Improved Solar Dryer for Fish Drying in the Coastal Belt*

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A 'green-house' type solar dryer of dimensions 3 m × 2.5 m was designed and constructed for fish drying. It has a rigid and hygienic construction consisting of a black-pointed G.I. sheet chamber covered with plexiglass sheets and provided with ventilation holes at the east-west sides and exhaust at the top. The maximum temperature-rise over ambient was 18 to 24°C. The dryer was installed and put to trial for fish drying in a coastal fishing harbour. It was possible to dry fresh fish of mixed variety and size to the desired moisture content within 2 - 3 days. The dryer with a designed capacity of 56 kg fresh fish per batch was suitable for adaptation by fisherman-processor families in the coastal belt.

Sun-drying in the open air is the age-old method of fish preservation widely practised in the coastal belt of India. It is a crude method and yields a poor quality product, mixed with sand and various contaminants, particularly micro-organisms, which often does not meet the requirements of standard fish meal or dry-cured fish. Use of appropriate solar dryers may remove some of these drawbacks of sun-drying, particularly from the point of view of quality.

Some attempts to improve upon the traditional sun-drying of fish in India and other countries have been reported in the literature[1-9]. Some of these solar dryers are much capital-intensive utilising supplementary power sources for circulation of air and, therefore, not within the economic reach of the fisherman community. On the other hand, simple designs, such as drying yards with raised platform may not eliminate completely the drawbacks of the open-beach sun-drying methods. One simple design, polythene tent dryer[4-6], may not be suitable for fish drying in the coastal region where wind velocity is relatively high throughout the year. It was observed by Panduranga Rao *et al.*[6], that high wind velocity adversely affected the air temperature inside the tent so that temperature increased by only 5.5 to 8°C over ambient, whereas an increase of 7 to 20°C over ambient could be achieved by them in still air. Similar observations were made by Sripathy and Balasaraswathi[5]. But provision of air inlets along the sides or bottom of cabinet or box-type solar dryers should be an essential feature of construction for proper ventilation of hot air through and over drying trays or platforms which would help faster drying in the early stages of drying by convection over the fish surface. Furthermore, polythene tents cannot provide a rigid structure and there is chance of polythene tents being shattered by the wind prevailing in the coastal belt. If gaps are provided along the sides of the tent, chances of sand and dirt flying inside the tent and also flies and insects contaminating the product would be high. The development of an improved design of solar dryer based on low-cost but efficient technology is, therefore, imperative for the benefit of fisherman-processor community. This paper describes the design features and test of performance of a solar fish dryer of a structure and capacity suitable for adaptation by fishermen living in the coastal belt.

Materials and Methods

The solar dryer consists of a chamber made of 22 gauge G.I. sheet (3 m × 2.5 m × 0.6 m) painted black and covered with 3 mm thick plexiglass sheets. Fish to be dried is placed on two wire-net trays (2.45 m × 1.0 m) located at a few cm above the floor of the chamber. (Fig 1) Ventilation holes are provided at the top and sides of the chamber. Solar radiation is transmitted through the cover and absorbed by the blackened surface which subsequently heats the air by radiation. Plexiglass (polymethyl methacrylate) sheet has high transmittance and low reflectance at normal and 60 degree incidence[10]. So far durability in the high humidity, saline and sandy atmosphere prevalent in the coastal area is concerned, the performance of plexiglass sheets in the adverse weather conditions for more than a year was found to be satisfactory.

The dryer was aligned east-west lengthwise and erected 0.5 m above the ground. The designed capacity of the dryer with two trays was set at 45 kg per batch on the basis of tray

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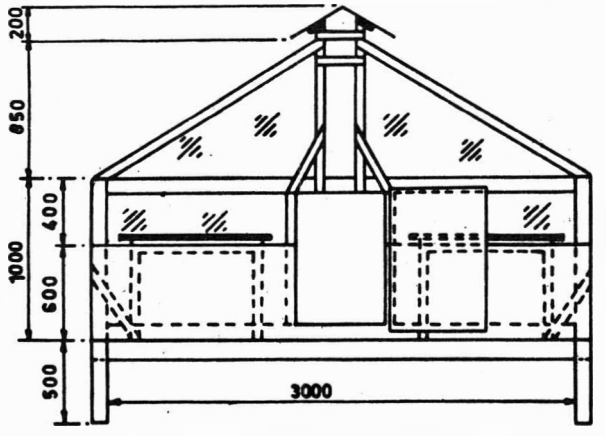

Fig.1. Elevation of the solar Dryer
All Dimensions are in mm
Scale: 1 cm = 25 cm

loading of 0.8 kg/sq.m. An additional capacity of 11 kg can be provided if necessary, in the passage (2.5 m × 0.6 m) in between the trays, where another tray of 1.4 sq.m. area can be pushed in through the door after loading. The passage was provided for ease of loading, unloading and turning over the fish during drying. The fully-covered drying chamber, air inlets and exhaust covered with wire-net and the dryer body erected at a sufficient height above the ground - all these provisions made the dryer free from dust, sand, flies and insects.

For trial experiments, the dryer was erected at Sankarpur Fishing Harbour Project site. Sankarpur is situated in the Bay of Bengal coast of West Bengal, where a newly-constructed fishing harbour has started functioning and varieties of fish suitable for processing by drying are available. Drying was carried out with 12 and 30 kg fish at tray loadings of 2 and 5 kg/sq. m of drying area respectively. Clupeid fish *(clupeid)* of mixed sizes (standard lengths of 5 to 16 cm) were used in all the trials. Fresh fish were washed thoroughly with water and spread on the trays after draining the water. No brine/salt treatment was given to the fish. Drying was continued for 2 - 3 days consecutively with duration of 6 - 7 hr each day. The fish were turned over after each day of drying. Temperatures of ambient air and air inside the chamber and above the trays, humidity of inlet air and wind velocity were recorded. Initial moisture content of raw fish and moisture contents of dry fish at the end of each day were measured.

Results and Discussion

The solar hot air system was studied by measuring air temperature inside the dryer at 15 different locations. The results showed that the rise of air temperature over ambient over the trays was by 18 - 24°C maximum during 11-00 to 15-00 hr in the months of Semptember to April. This was much higher than that reported in the polythene tent dryer[5], probably due to the high value of absorptance of black-painted metal surface. It was further observed that the air temperature above the trays was always higher than that inside the chamber. During 11-00 to 15-00 hr, this difference was 21°C maximum in the West. It indicated that there was appreciable air circulation inside the dryer due to provision of air inlet holes along the East-West sides and exhaust at the roof.

TABLE 1. RESULTS OF FISH DRYING IN THE SOLAR DRYER

Date	Quantity (kg)	Size (cm)	Tray loading (kg/sq.m)	Day	Duration (hr)	Air temp. °C*			Moisture content (% w.b.)		
						Ambient	Inside chamber	Above tray	Smaller size	Larger size	
5-6 March 87									75.70+	75.70+	
	12	8-12	2	Ist	7	26-33	37-44	41-53	46.78	58.20	
				2nd	6	27-33	34-44	43-57	19.05	25.80	
2-3 April 87	30	12-16	5						75.00+	75.00+	
				Ist	7	30-36	33-43	37-52	47.08	50.03	
				2nd	7	31-38	34-46		13.52	17.98	
2-4 Feb. 88									73.40+a	74.60+b	68.40+c
	30	6-10/a	5	Ist	6	23-28	30-40	33-43	61.46	47.08	54.14
		5-7/b		2nd	7	24-28	30-38	32-44	46-44	15.33	26.11
		12-16/c							(46.72)	(16.20)	(25.33)
				3rd	7	24-33	32-50	34-55	34.16	9.28	14.19
									(32.91)	(9.96)	(15.60)

Note. a — *Tapra*, b — *Ruri*, c — *Fasa*. For these fish samples moisture content was determined from weight-loss of 1000g or 500g samples on the basis of initial moisture content. Figures in parentheses indicate moisture content determined by oven-drying method.

* Observations were made during 11-00 to 15-00 hr.
\+ Represent initial moisture content.

Table 1 shows the results of fish drying trials in the solar dryer. It was found that moisture content of fish was reduced to different levels, depending on the size and variety of fish and on number of days. Firstly, the moisture content of smaller size fish was reduced at a rate faster than the larger size ones. Secondly, among the varieties of Clupeid fish the three local varieties showed different results. While *RURI* was dried to about 15 per cent within two days, the *FASA* was dried to about 15 per cent within three days, and in case of *TAPRA*, the final moisture content was about 34 per cent after the three day's drying. Probably the fat content of *TAPRA* and *FASA* was high. The fact that, inspite of the size of *TAPRA* being smaller than that of *FASA* it took longer time of drying, indicated that fat content of *TAPRA* was probably the highest. Performance of the solar dryer was thus satisfactory with respect to moisture reduction to the desired level within 2 - 3 days.

The dry fish having moisture contents in the range of 20 - 26 per cent, can be converted to fish meal by dry rendering. For utilisation as edible dry fish, either further reduction of moisture content to 5 - 10 per cent by drying in consecutive days or salt-curing and then drying is required.

Acknowledgement

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References

1. Chakraborty P K, Technological development of artifiicial and solar drying of fish in India, *Proceedings of the Symposium on Fish Utilisation Technology and Marketing in the IPFC Region*, Bangkok, 1978, 322.
2. Chakraborty P K, Solar drying in conjunction with artificial drying of fish - a feasible proposition, *Seafood Exp J*, 1984, **16**, 3.
3. Prabhu P V, Swaminathan M, Venkataraman R and Bose A N, Investigation on dehydration of some commercial fish in India, *Indo-Pacific Fish Coun Current Affairs Bull*, No.37, 1963.
4. Doe P E, Ahmed M, Muslemuddin M and Sachithananthan K, A polythene tent dryer for improved sun drying of fish, *Fd Technol Austr*, 1977, **29**, 437.
5. Sripathy N V and Balasaraswathi M, Sun drying of salted fish in a polythene tent drier, *Proceedings of Seminar on Harvest and Post-harvest Technology of Fish*, Soc. Fisheries Technologists (India), Cochin, 1985, 559.
6. Pandurunga Rao C C, Basu S and Prasad M M, Studies on solar tent dryer for drying of fish, *Proceedings of the Symposium on Diversification of Post-harvest Technology for low-cost Fish*, Soc. Fisheries Technologists (India) Cochin 1987, 101.
7. Anon, Marine-cum-farm product solar dryer, *Fd Dig*, 1982, 5, 121.
8. Anon, Solar batch dryer, *Fish News Int*, 1983, 22, 45.
9. Anon, Cutting fish losses with solar dryers, *Fd Dig*, 1984, 7, 107.
10. Mathew J, *Design of a Solar Dryer and Study of its Performance for Fish Drying*, 1986, M. Tech. Thesis, I.I.T. Kharagpur.

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MICROBIOLOGICAL QUALITY OF *RASMALAI*

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Twenty five market samples of *rasmalai* showed a very high aerobic plate count which ranged from 10^2-10^6 CFU/g. *Staphylococcus aureus* was the most common isolate (76%) followed by *Escherichia coli* (72%) and *Klebsiella* (68%). The other organisms isolated were species of *Pseudomonas* (52%) *Enterobacter* (44%), *Bacillus* (32%), and *Citrobacter* (8%). However, no correlation could be established between the type of isolate with the total aerobic count. Samples having an aerobic count of 10^3 - 10^4 CFU/g yielded majority of the enteric organisms. Only one isolate of *S. aureus* could be typed with the usual set of phages routinely used for typing clinical isolates.

Rasmalai is a heat concentrated milk product containing around 60 per cent total solids including sucrose as the sweetening agent. The finished product is cooled before serving for varied duration. Since there are no set microbiological standards available for *rasmalai*, in the present study the microbiological quality of *rasmalai* has been investigated.

Fresh *rasmalai* samples from different government approved shops in Chandigarh were collected in sterile wide mouth containers. The samples were brought immediately to the laboratory and processed for bacteriological analysis. Eleven grams of each sample were withdrawn aseptically and transferred to a dilution blank containing 99 ml of sterile normal saline to obtain 10^{-1} dilution. Serial ten-fold dilutions were prepared and 0.1 ml from each dilution was surface streaked in duplicate on pre-poured nutrient agar and MacConkey agar plates respectively for total aerobic and total enteric counts by the spread plate technique of Nottingham *et al.*[10] The viable count of all the plates was determined after 24 hr of incubation at 37°C.

The isolates of *Escherichia coli*, *Klebsiella*, *Enterobacter*, *Citrobacter*, *Pseudomonas*, *Salmonella*, *Shigella*, *Staphylococcus aureus* and *Bacillus cereus* were isolated and identified biochemically according to Bergey's Manual[6] and ISI methods[8]. Enrichment of the samples was done in tetrathionate broth for 24 hr at 37°C for the isolation of *Salmonella* and *Shigella* species. Phenolred-egg yolk-polymyxin agar and Mannitol salt agar were used respectively for the isolation of *B. cereus* and *S. aureus*. Method of Aulisio *et al.*[2] was followed for the isolation of *Yersinia* species. The suspected *Yersinia* colonies were identified biochemically according to Bergey's Manual[6]. *S. aureus* isolates were phage typed at National Staphylococcal Phage Typing Centre, Maulana Azad Medical College, New Delhi, India.

Total aerobic count of fresh *rasmalai* samples (25) varied from 10^2-10^6 CFU/g (Fig. 1). In most cases (48 per cent) the count ranged from 10^3-10^4 CFU/g and the count was greater than 10^5 CFU/g in 24 per cent of the samples. The count of such a magnitude is alarming. The count 10^2-10^5 CFU/g in foods is the infective dose for food-borne pathogens like *Salmonella* sp., *Staphylococcus aureus* and *Bacillus cereus*. The count remained constant in *rasmalai* (prepared from boiled milk), which evidently confirms poor sanitation.

The 89 isolates from 25 *rasmalai* samples belonged to 8 different genera (Fig. 2). A greater variation in the incidence of a kind of a pathogen was observed irrespective of the number of pathogens. The incidence of *S. aureus* was maximum (76 per cent) followed by 72, 68, 52, 44, 32 and

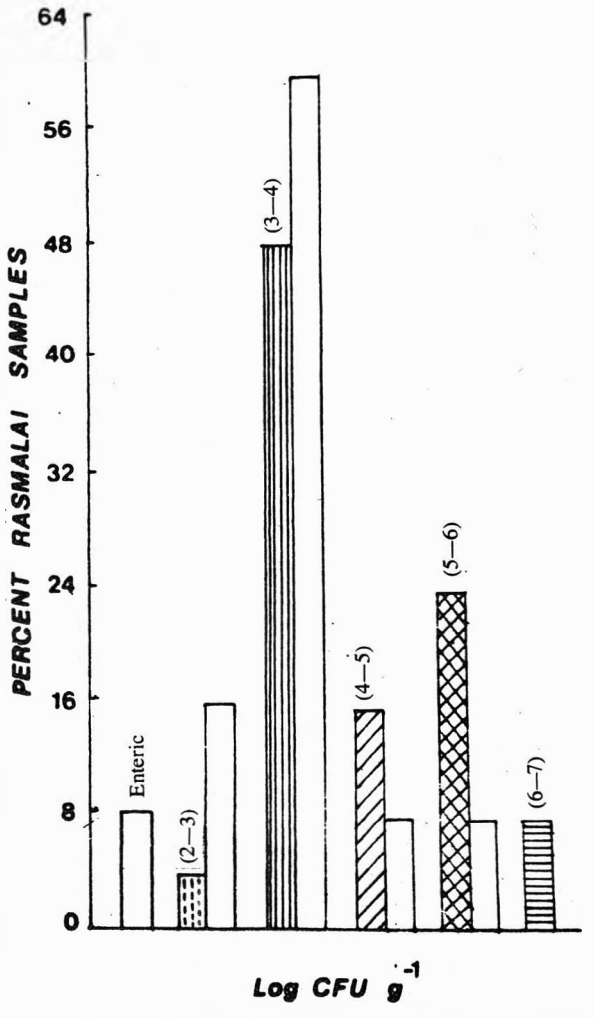

Fig. 1. Distribution pattern of total aerobic mesophiles in relation to total enteric counts. The figure shows variation in log number of total aerob c (0-2), (2-3), (3-4), (4-5), (5-6), (6-7) and enteric counts in *rasmalai*.

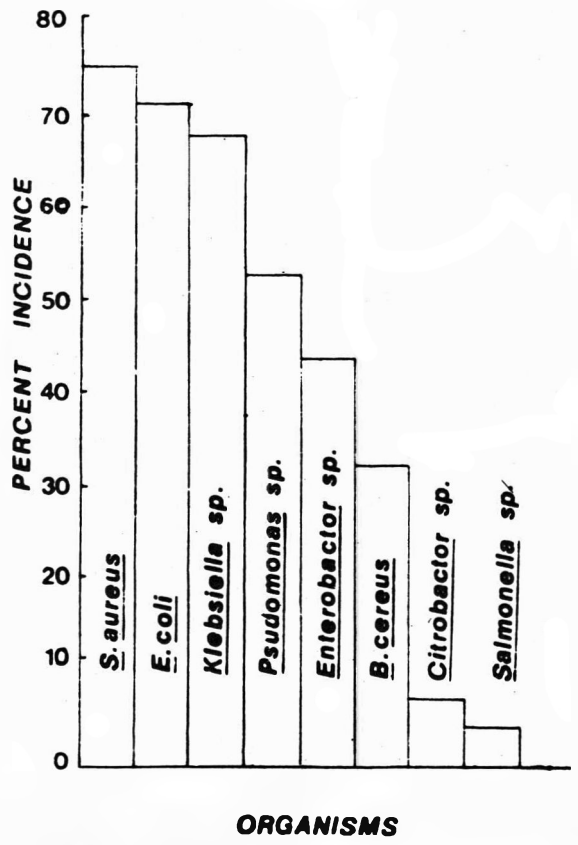

Fig. 2. Incidence of various pathogenic bacteria isolated from *rasmalai*.

8 per cent respectively for *E. coli*, *Klebsiella*, *Pseudomonas*, *Enterobacter*, *Bacillus cereus* and *Citrobacter* sp. About 20 per cent of the samples (5) showed exclusive growth of *S. aureus*, where as no *Shigella* sp. or *Yersinia* sp. could be isolated from any of the samples despite enrichment technique. Only one of the samples was found positive for *Salmonella* sp.

The high incidence of pathogens indicates heavy contamination and thus may be attributed to inefficient manufacturing process (heat-treatment) or post contamination[1,3] or both as is apparent due to the presence of enteric organisms (non sporulating-heat sensitive) in the samples. The *Klebsiella* isolated from the environment are often more diverse genetically than the clinical isolates and have been shown to be of fecal origin with transmissible R-factors[7]. Hence, the presence of *Klebsiellae* in 68 per cent of *rasmalai* samples needs attention as the environmental isolates have been shown to be enterotoxigenic[5].

The significance of Staphylococci as a major food-borne pathogen has been well documented[4]. *S. aureus* is known to grow and produce toxins in foods rich in sugars[11]. High incidence of Staphylococci including enterotoxigenic type have been reported in Indian milk products[1,4,11]. The isolation of *S. aureus* from 76 per cent of the samples further confirms either inefficient manufacturing practices or use of very poor quality milk or both. Surprisingly all the *S. aureus* isolates were non-typable except one by the existing phages used for typing clinical isolates. Either these strains are different from clinical isolates or these strains change their surface receptors after getting into the host and may become typable with the existing set of clinical phages.

The presence of *B. cereus* in 32 per cent of the samples is also risky from the point of view of the safety of consumer as the total number of pathogens may increase further during storage and may also contain toxin. The presence of *Salmonella* though in one sample only also indicates post process contamination. Therefore, it is concluded that the *rasmalai* samples collected from different shops in Chandigarh contained large number of pathogens and the consumer is always at risk of contacting one or the other infection.

References

1. Anand S K and Singh R S, Enterotoxigenic *Staphylococcus aureus* in infant foods, *J Fd Sci Technol* 1987, **24**, 1.
2. Aulisio C C G Mehlman I J and Sanders C, Alkali method for rapid recovery of *Yersinia entercolitica* and *Y. pseudotuberculosis* from food, *Appl Environ Microbiol*, 1980, **39**, 135.
3. Barrett N J, Communicable disease associated with milk and dairy products in England and Wales, *Br Med J*, 1986, **284**, 1761.
4. Ghodekar D R Dudani A T and Ranganathan B, Microbiological quality of Indian milk products *J Milk Fd Technol*, 1974, **37**, 119.
5. Kaur J Kaul M and Chhibber S, Incidence of enterotoxigenic *Klebsiella pneumoniae* in various food groups. *J Fd Sci Technol*, 1988, **25**, 300.
6. King N R and Holt J G, *Bergey's Manual of Systematic Bacteriology*, Williams and Wilkins Company, Baltimore, 1984, 9th Edn.
7. Knittel M D Seidler R J Eby C and Cabe L M, Colonization of the botanical environment by *Klebsiella* isolates of pathogenic origin *Appl Environ Microbiol* 1977, **34**, 557.
8. *Methods for Detection of Bacteria Responsible for Food Poisoning* IS: 5887-1976 (Part-I, III and IV), Indian Stand. rds Institution, New Delhi.
9. Minor T E and Marth E H, *Staphylococcus aureus* and enterotoxin A in cream and butter, *J Dairy Sci*, 1972, **55**, 1410.
10. Nottingham P M Rushbrook A J and Jung K E, The effect of plating technique and incubation temperature on bacterial growth, *J Fd Technol*, 1975, **10**, 273.
11. Varadraj M C and Namburdripad V K N, Extraction and purification of Staphylococcal enterotoxin A from milk and khoa, *Asian J Dairy Res*, 1987, **1**, 197.

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EFFICACY OF CERTAIN FOOD PRESERVATIVES IN THE CONTROL OF CYCLOPIAZONIC ACID PRODUCTION BY *PENICILLIUM GRISEOFULVUM*

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Different food preservatives were screened for their efficacy in the control of cyclopiazonic acid production by *Penicillium griseofulvum*. Sodium metabisulphite, citric acid and propionic acid were found to be effective in the control of *P. griseofulvum* and hence cyclopiazonic acid production.

Cyclopiazonic acid (CPA), produced by species of *Aspergillus* and *Penicillium* has received considerable attention not only in view of its natural occurrence in several agricultural and food commodities[1-3], but also because of its carcinogenic[4], neurotoxic[5,6] and mutagenic[7] activities. Dorner *et al.*,[8] have reported the toxicity of CPA towards broiler chickens. Inspite of this, very little work has been carried out on the control of CPA production. Hence, efficacy of certain food preservatives in the control of growth and CPA production by *Penicillium griseofulvum* was studied.

Monosporic culture of *P. griseofulvum* was grown in 50 ml glucose-asparagine medium (glucose-20g, asparagine-5g, KH_2PO_4—3.4g, $MgSO_4$—1.9g, NaCl—0.0lg and distilled water 1000ml) contained in 250 ml Erlenmeyer flasks, at 27±2°C for 16 days. Different food preservatives (Table 1) were added aseptically to the flasks before inoculation of the fungus. At the end of incubation period, the cultures were harvested on previously dried and weighed Whatman filter paper No. 42 for determining the growth of the fungus. pH of the culture filtrates was also recorded. CPA was extracted from each flask and estimated as described by Rathinavelu and Shanmugasundaram[9].

Table 1 reveals that the food preservatives exerted significant influence on the growth and CPA production by *P. griseofulvum* which, however, varied with the compound. Sodium metabisulphite and propionic acid caused total inhibition of CPA production even at 50 μ g/ml and 10 μ l/ml concentrations respectively. Similarly Lennox and Mc Elroy[10] have reported the inhibitory effect of sodium propionate on the growth and patulin production by *P. expansum*. Benzoic acid also suppressed CPA production. Potassium metabisulphite was effective only at higher concentration (100 μ g/ml). Sodium chloride had only marginal inhibitory effect on CPA production. Citric acid which is a common food preservative was responsible for causing total inhibition of mycelial growth and CPA production at 1600 μ g/ml concentration. Benzoic acid was effective only at higher concentration (400 μ g/ml). Sodium metabisulphite and propionic acid did not permit the mycelial growth, while rest of food preservatives had no significant effect on the growth of the fungus.

TABLE 1. EFFECT OF DIFFERENT FOOD PRESERVATIVES ON GROWTH AND CYCLOPIAZONIC ACID (CPA) PRODUCTION BY *P. GRISEOFULVUM*.

Compound	Concn. (μg or l/ml)	Final pH	Dry wt. (mg)	CPA (μ g)
Benzoic acid	100	7.2	390.0	459
	200	5.0	268.0	385
	400	5.0	nil	nil
Sodium acetate	100	7.4	360.1	289
	200	7.5	340.2	269
	400	7.5	299.1	269
Sodium metabisulphite	50	4.8	nil	nil
	100	4.8	nil	nil
Propionic acid	10	3.5	nil	nil
	20	3.5	nil	nil
Potassium metabisulphite	50	5.0	231.8	330
	100	7.2	157.8	33
	200	7.0	188.2	33
Sodium chloride	100	7.2	368.1	488
	200	7.2	299.4	459
	400	7.2	329.1	297
Citric acid	400	7.2	308.9	169
	800	7.2	259.5	136
	1600	3.8	nil	nil
Control	—	6.6	280.0	470

pH drift was towards alkaline side and final pH in some cases was near neutral. However, the pH remained at 5.0 or below 5.0 when there was not much mycelial growth.

From the present investigations it can be concluded that sodium metabisulphite, propionic acid and citric acid are effective inhibitors of growth of the mycelium and CPA production by *P. griseofulvum* and can be exploited in the protection of maize from the infestation of *Penicillium griseofulvum* and CPA contamination.

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References

1. Still P E Eckardt C and Leistner L, Formation of cyclopiazonic acid by *penicillium camemberti* isolates, *Fleischwirtschaft*, 1978, **58**, 876.
2. Lansden J A and Davidson J I, Occurence of cyclopiazonic acid in peanuts, *Appl Environ Microbiol*, 1983, **45**, 766.
3. Rao B L and Husain A, Presence of cyclopiazonic acid in kodo millet

(Paspalum scorbiculatum) causing "kodua poisoning" in man and its production by associated fungi, *Mycopathologia*, 1985, **89**, 177.

4. Orth R, Mycotoxins of *Aspergillus oryzae* strains for use in the food industry as starters and enzyme producing moulds, *Ann Nutr Aliment*, 1977, **31**, 617.
5. Morrissey R E Cole R R and Dorner W J, The effects of cyclopiazonic acid on pregnancy and foetal development of fischer rats, *J Toxicol Environ Hlth*, 1984, **14**, 585.
6. Van Rensburg S J, Sub-acute toxicity of the mycotoxin cyclopiazonic acid, *Fd Chem Toxicol*, 1984, **22**, 993.
7. Sorenson W G Tucker J D and Simpson J D, Mutagenecity of the tetramic mycotoxin cyclopiazonic acid, *Appl Environ Microbiol* 1984, **47**, 1355.
8. Dorner J W Cole R J Lomax L G Gosser H S and Diener U L, Cyclopiazonic acid production by *Aspergillus flavus* and its effects on broiler chickens, *Appl Environ Microbiol*, 1983, **46**, 698.
9. Rathinavelu A and Shanmugasundaram E R B, Simple colorimentric estimation of cyclopiazonic acid in contaminated food and feeds, *J Ass Off Analyt Chem*, 1984, **67**, 698.
10. Lennox J E and Mc Elroy L J, Inhibition of growth and patulin synthesis in *Pencicillium expansum* by potassium sorbate and sodium propionate in culture, *Appl Environ Microbiol*, 1984, **48**, 1031.

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EFFECT OF STABILIZERS ON THE CONTROL OF WHEY SEPARATION IN FERMENTED BEVERAGES PREPARED FROM SWEET CREAM BUTTERMILK

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In the preparation of fermented beverages using sweet cream buttermilk, wheying off (syneresis) was observed on the surface of the product which was not appreciated on sensory evaluation. Stabilizers were used to mitigate the defect. Pectin, gelatin, carrageenan and sodium salt of carboxymethyl cellulose (CMC) at 0.05 or 0.1% were tried. Gelatin even with lower concentration was found most beneficial followed by CMC and pectin. Carrageenan did not seem to prevent whey separation. Addition of gelatin improved the consistency of the product and stabilized lactic acid gel in fermented beverages.

Attempts have been made to utilize, sweet cream buttermilk (SCBM) the by-product of dairy industry. It has been added in skim milk before drying as market milk extender, used in certain varieties of cheeses, *dahi* and yoghurt[1,2], beverages[3,4] and cultured drink *(lassi)*[5,6]. A fermented beverage was standardised using SCBM and selected starter cultures *viz., Lactobacillus acidophilus, L. bulgaricus* and *Streptococcus thermophilus* either singly or in combination each at one per cent level of inoculum. SCBM for this study was obtained from experimental dairy and was standardised to 4 per cent total solids followed by sterilization, cooling and inoculation. The samples were incubated at 37°C for 24 hr. The fermented beverages prepared from SCBM were found to develop a defect such as whey separation during its incubation and the finished product showed poor appearance.

To control whey separation, use of stabilizers has been recommended. Stabilizers are hydrocolloids of the animal or plant origin, which prevent not only whey separation but also improve the consistency of the product and stabilize the gel against contraction during the pasteurization. Addition of stabilizer also increases viscosity.

Whey separation was controlled by using such stabilizers as pectin, gelatin, carrageenan and sodium salt of CMC. These stabilizers were added either at 0.05 or 0.1 per cent level. SCBM was homogenized before sterilization, and products were prepared as per standardised technique[7] using selected lactic starters (single and in combination).

The amount of whey separated was measured in a graduated tube after centrifugation of samples at 1500 r.p.m. for two min. Sample without stabilizer was used as control.

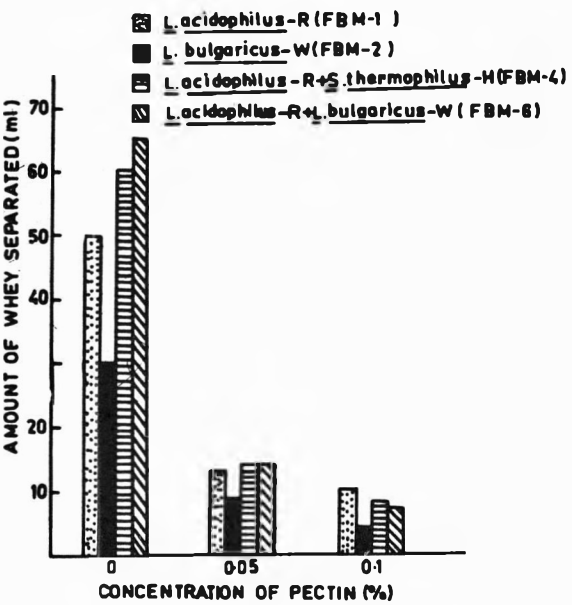

Fig. 1. Effect of pectin on the amount of whey separation in fermented butter milk.

The results (Fig. 1-4) show that most whey separation took place when carrageenan was used. Apparently, carrageenan was not suitable at low pH. Further, there was thickening tendency when carrageenan was added to SCBM even before completion of incubation. Although, pectin and CMC produced similar results, gelatin was found to prevent

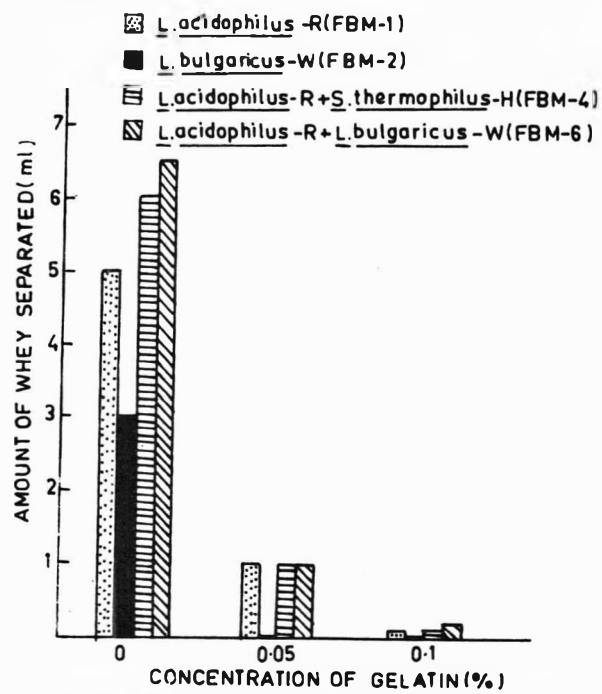

Fig. 2. Effect of gelatin on the amount of whey separation in fermented butter milk.

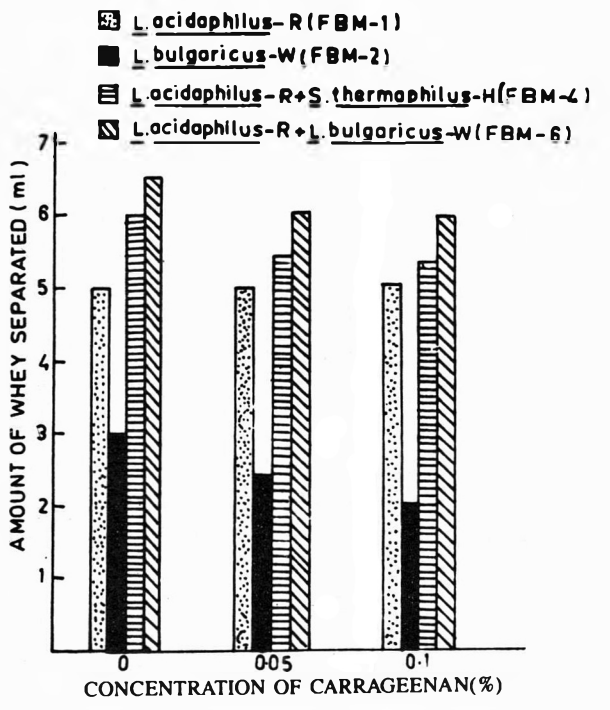

Fig. 3. Effect of carrageenan on the amount of whey separation in fermented butter milk.

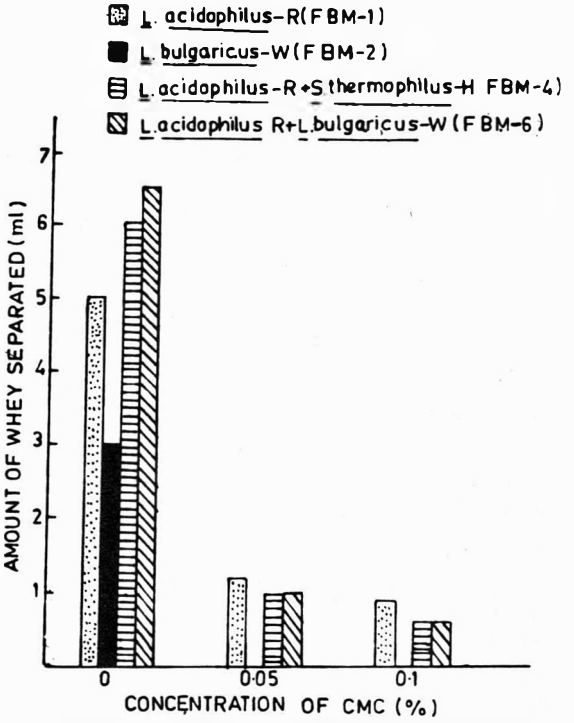

Fig.4. Effect of CMC on the amount of whey separation in fermented butter milk.

the whey separation best. The whey separation decreased as the amount of stabilizer increased. Similar observations were made by Radema and Dijk[8] in yoghurt. Unlike the observation of Leder[9] where gelatin was used at 0.3 to 0.6 per cent level without concomittant increase in milk solids content in yoghurt, high concentration of stabilizers was not found to be suitable in this investigation as it curdled the casein during sterilization. Gelatin at 0.1 per cent level was found to be optimum to control whey separation during the preparation of fermented beverages.

References

1. Pal D. *Utilization of Sweet Cream Butter Milk in Market Milk Industry*. 1982. Ph.D. Thesis. Kurukshetra University.
2. Shreshtha R G and Gupta S K. "Dahi from sweet cream buttermilk". *Indian Dairyman*. 1979. **31**, 657.
3. Lavrenova G S Inozemtseva V F and Bogdanova B A. "Development of 'Tvorog' manufacture from buttermilk". Trudy. Vsesoyuznyi Mauchno-issledovatel' skii institut 'molchonoi Promyshlennosti 1979. No.47 19. 91 (Ru).
4. Gushchina I M and Nikulina A I. Technology of a new buttermilk beverage 'Novinka'. *Vses Mauchno-issledovatel' skii Inst Molch Promys*. 1979. No. 47: 17. 91 (Ru).
5. Deka D D Rajor R B and Patil G R. Studies on the formulation of lassi from soybean and buttermilk. *Egypt J Dairy Sci* 1984 **12** 291.
6. Srivastava M K and Lohani P P. "Utilization of by-products by dairies - whey and buttermilk". *indian Dairyman* 1986, **38**, 221.
7. Chopra R and Gandhi D N. Utilization of sweet cream buttermilk for the preparation of fermented beverages. *Bev Fd Wld*. 1988. **15**, 13.
8. Radema L and Dijk R V. Thickening agents for yoghurt. Model Netherlands Inst. *Zuivelonderzock*. 1973. No.7: 51.
9. Leder K H and Thomasow J. Use of gelatine in yoghurt manufacture *Dtsch Molkerei-Zeitung*. 1973. **94**, 688.

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QUALITY OF PATTIES FROM CHICKEN, MUTTON AND COMBINATION OF MEATS

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Quality of patties made from the meat of spent hens, old sheep and their combination was evaluated. Chicken emulsion had significantly higher pH, protein and emulsion stability than mutton emulsion. Combination of meats had significantly poor emulsion stability, patties yield and greater reduction in patties diameter. Yield and composition of chicken and mutton patties were not different significantly. Appearance, flavour and overall acceptability of chicken patties were significantly better than the patties of combination of meats which were markedly better than mutton patties.

A large number of spent hens from organised poultry farms are disposed of at uneconomical price due to toughness of meat from such birds. Similarly, meat from old sheep is tough and poor in palatability. Hardness of mutton fat also contributes for poor quality emulsion[1]. For effective utilization of tough meat from spent hens and old sheep, appropriate technologies need to be developed for converting them into value added convenience meat products. Several emulsion type of meat products are manufactured with combination of beef and pork or their fat to improve the acceptability[2]. Recently, Bushway *et al*[3]. also demonstrated the use of chicken and mutton blends to process frankfurters. Little quantity of fat is available from spent/old sheep for product processing. As an alternative source of fat, chicken fat available in plenty from spent hens can be used in mutton products formulations. This will facilitate the effective utilisation of by-product (chicken fat) and may improve the acceptability of the mutton products.

The objective of the present study was to compare the quality of emulsion type of patties prepared from meats of spent hens, old sheep and combination of meats and fats.

Meat from aged sheep (5-7 years) and spent layers, slaughtered by traditional halal method was used. The carcasses were hand-deboned within 3 hr postmortem. Mutton samples for each of the 4 trials were used from pooled deboned meat of a carcass. Mutton, spent chicken meat along with gizzard, heart, skin, volk (ova) and abdominal fat and mutton fat were frozen at -10°C for 15 days and used after partial thawing at 5°C for 15 hr.

Meat samples were coarse minced using 8 mm plate of meat mincer (Model 32064, Electrolux, Sweden). Mutton and chicken fats were fine minced using 4 mm plate. Whereas, skin, gizzards and hearts were fine minced twice to reduce particle size For each treatment 2 kg meat emulsion was prepared in Hobart bowl chopper using pre-standardised formulations. Chicken formulation was made using chicken meat and by-products in natural proportion. Mutton formulation contained 80 per cent mutton, 15 per cent mutton fat and 5 per cent whole egg liquid. Combination formulation of chicken and mutton contained 50 per cent each of chicken and mutton formulations. Salt, spices, condiments and added water were common in the three formulations. Tetra sodium pyrophosphate and maida were added at 0.5 and 2.5 per cent levels respectively.

Emuslions were moulded into patties weighing 75 g using petri dish (80 mm diameter and 17 mm height). Patties were cooked to obtain an internal temperature of 70°C in pre-heated oven at 180°C for 20 min. They were turned over after 10 min of cooking. Cooked patties were weighed.

pH and meat emulsion was recorded by directly piercing the combination glass electrode into meat emulsion. Moisture, protein, fat and ash contents of raw emulsion and cooked patties were determined[4]. Emulsion stability was estimated by cooking emulsion samples (25 g) in polyethylene bags at 80°C for 20 min. After draining the exudate, cooked samples were weighed. Stability of the emulsion was reflected inversely with the cooking loss. The diameters of 10 raw and cooked patties for each treatment and trial were recorded with vernier calipers. Yield of cooked patties was expressed in percentage. Shear force values of patties was recorded with the help of Warner Bratzler shear press and force required to shear was expressed in kg per g of sample.

Ten experienced taste panelists of the institute evaluated the sensory attributes of patties such as appearance, juiciness, flavour, texture, mouth coating and overall acceptability using 8-point structured scale, wherein 8=extremely desirable and 1=extremely undesirable. Pooled data from the 4 trails were subjected to one way analysis of variance and critical difference was calculated[5].

pH and protein content of the chicken emulsion were significantly higher and consequently had better emulsion stability (ES) than mutton emulsion. The poor quality of sheep and goat meat emulsions were due to hardness of fat causing poor dispersability[1]. Emulsion stability of combination of meats was also significantly poorer than the ES of either meats. The variation in pH could be attributed to the species differences. Relatively higher pH of the emulsions was due

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TABLE 1. QUALITY OF PATTIES MADE FROM CHICKEN, MUTTON AND COMBINATION OF MEATS

Parameters	No. of observations	Chicken	Mutton	Combination
			Raw emulsion	
pH	4	6.03 ± .02[a]	5.97 ± .01[b]	6.01 ± .02[ab]
Moisture (%)	12	60.19 ± .36[a]	60.87 ± .32[b]	60.36 ± .21[a]
Protein (%)	8	13.91 ± .57[a]	12.67 ± .36[b]	13.14 ± .58[ab]
Fat (%)	8	19.02 ± .76	19.79 ± .62	18.89 ± .55
Ash (%)	8	2.74 ± .04	2.73 ± .06	2.75 ± .08
Emulsion stability (%)	12	3.05 ± .36[a]	6.61 ± 1.03[b]	12.91 ± 1.90[c]
			Cooked patties	
Yield (%)	40	91.53 ± .28[a]	91.03 ± .21[a]	83.78 ± .62[b]
Shrinkage in diameter (%)	40	10.41 ± .36[a]	12.59 ± .44[b]	16.12 ± .50[c]
Shear force (kg/g)	24	0.21 ± .004[a]	0.24 ± .006[b]	0.20 ± 0.006[a]
Moisture (%)	11	56.87 ± .60	57.71 ± .57	57.12 ± .23
Protein (%)	6	16.03 ± .44	15.19 ± .25	16.37 ± .56
Fat (%)	8	20.14 ± .89	19.75 ± .26	19.18 ± .28
Ash (%)	2	3.22	3.17	3.00
			Sensory scores	
Appearance		7.22 ± .10[a]	6.25 ± .10[b]	6.45 ± .14[b]
Flavour		7.07 ± .10[a]	6.05 ± .12[b]	6.45 ± .11[c]
Juiciness		6.65 ± .11	6.60 ± .10	6.57 ± .10
Texture		6.63 ± .13	6.65 ± .10	6.45 ± .09
Mouth coating		7.17 ± .11[a]	6.77 ± 13[b]	6.90 ± .11[ab]
Overall acceptability		6.92 ± .11[a]	6.12 ± .12[b]	6.45 ± .13[b]

Means with same superscript in each row do not differ significantly ($P<0.03$).,
*Sensory scores based on 8-point descriptive scale wherein 8 = extremely desirable, 1 = extremely undesirable.

to addition of tetrasodium pyrophosphate to the formulations[6,7]. Fat and ash contents of raw emulsions were not significantly different among formulations.

Yield of the patties were not significantly different between chicken and mutton formulations (Table 1). However, combination of meats resulted in poor yield possibly due to poor ES than the other formulations. Shrinkage in the diameter of chicken patties was significantly lower than mutton patties followed by patties made with combination of meats. Texture of mutton patties was significantly better as indicated by shear force readings than the patties of other formulations. However, panelists could not record such significant difference in the texture of patties. Proximate composition of the cooked patties were also not significantly different among formulations.

Sensory scores indicated that chicken patties had significantly better appearance, flavour and overall acceptability than mutton patties. Better appearance of chicken patties was due to minimum dimensional changes during cooking and panelists preferred them due to its unique flavour resulting in better overall acceptability. Mutton fat due to its higher amount of saturated fatty acids contribute to mouth coating (lower sensory scores) which affect the product acceptability. Similarly, Carpenter *et al*[9]. reported that a wax or tallow taste was detectable in frankfurters containing higher fat levels of mutton and beef.

Patties made from combination of meats had significantly better flavour and markedly higher overall acceptability than mutton patties. It was also reported that chicken fat produced significantly better flavoured product than mutton fat . This study has indicated that highly acceptable patties could be prepared from the meats of spent hens and old sheep. Further, blends of chicken and mutton or chicken fat in mutton products formulation can be used to improve the flavour and acceptability of mutton products.

References

1. Chattoraj D K Bose A N Sen M and Chatterjee P, Physico-chemical studies on model meat emulsions in relation to the preparation of stable sheep and goat meat sausage, *J Fd Sci*, 1979, **44**, 1965.
2. Pearson A N and Tauber F W, *Processed Meats* AVI Publishing Co Westport, 1984, 2nd Edn.
3. Bushway A A Leconte N B Work T M and True R H, Characteristics of frankfurters prepared from mutton and fowl, *J Fd Sci*, 1988, **53**, 67.
4. *Official Methods of Analysis* Association of Official Agricultural Chemists, Washington, DC, 1980, 13th Edn.
5. Snedecor G W and Cochran W G, *Statistical Methods* Oxford and IBH Publishing Co., Calcutta, 1968, 6th Edn.
6. Bendall J R, The swelling effect of polyphosphates on lean meat, *J Sci Fd Agric*, 1954, **5**, 468.
7. Trout G R and Schmid G R, Effect of phosphate type and concentration, salt level and method of preparation on binding in restructured beef rolls, *J Fd Sci*, 1984, **49**, 687.
8. Carpenter J A Saffle R L and Christian J A, The effects of type of meat and levels of fat on organoleptic and other qualities of frankfurthers, *Fd Technol*, 1966, **20**, 693.
9. Kondaiah N Panda B and Anjaneyulu A S R, Evaluation of type and level of fat in chicken sausage from spent hen meat, *Indian J Poult Sci*, 1987, 22, 30.

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A NOTE ON THE BISULPHITE TREATED DRIED *ACETES*

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Fresh, wet *Acetes* were treated with 0, 0.5, 1.0 and 1.5% concentration of sodium bisulphite solution, for 5 min at 28°C. The material after draining were dried in Torry Kiln to 10% moisture level, packed in sealed air tight containers and stored for 45 days. The samples treated with 0.5 and 1.0% bisulphite solutions decreased from their initial values of 4.18 and 4.61 to 2.46 and 2.88 resp., while those treated with 1.5% bisulphite solution decreased from the initial 4.17 to 3.28 during storage for 45 days. Treating *Acetes* with 1.5% sodium bisulphite prior to drying helped in retention of good colour.

Acetes belong to non-penaeid prawns. Among the various States of India, Maharashtra ranks first in the landings of *Acetes*. It is mainly used in the dried form. At times, the pink astacene colour of the dried *Acetes* fades out during storage and changes into brownish yellow. An attempt has been made to improve the quality of dried *Acetes* by treatment with sodium bisulphite.

Fresh, wet *Acetes* were treated by dipping in sodium bisulphite solution of concentration 0, 0.5, 1.0 and 1.5 per cent levels for 5 min at 28°C. The proportion used was 1 l of solution for 1½ kg of material. The estimated levels of sulphur dioxide were 1000, 2000 and 3000 p.p.m. in 0.5, 1.0 and 1.5 per cent treatments, respectively. The material was drained on the PVC wire mesh trays and then dried in Torry Kiln using air of velocity 250 ft^3 / min and relative humidity with 65 per cent at 42°C. The material was dried until the moisture was around 10 per cent. The dried material was packed in air tight sealed glass containers and kept for storage studies.

The dried *Acetes* was analysed for astacene[1] colour, moisture and sulphur dioxide[2]. All these values were expressed on dry weight basis.

The changes in the astacene colour of the control and the bisulphite treated acetes during storage for a period of 45 days are shown in Table 1. Astacene content in the control samples decreased from its initial value of 4.22 to 2.18. The samples treated with 0.5 and 1.0 per cent bisulphite solutions decreased from their initial values of 4.18 and 4.61 to 2.46 and 2.88 respectively, while those treated with 1.5 per cent bisulphite solution decreased from its initial value of 4.17 to 3.28 during storage for 45 days. The colour of the control samples was yellowish pink compared to the attractive pinkish white colour of bisulphite (1.5 per cent) treated samples. The yellowish pink colour turned brownish by 45 days time. The colour of 0.5, 1.0, and 1.5 per cent bisulphite treated samples was brownish yellow, pinkish yellow with brownish tinge and pinkish yellow, respectively after 45 days. The amount of sulphur dioxide present in the dried material was 22 p.p.m for 1.5 per cent bisulphite treated ones.

Hence treating the *acetes* prior to drying with 1.5 per cent sodium bisulphite solution has beneficial effect in the retention of astacene colour. Loss in astacene colour cannot be totally eliminated by bisulphite treatment.

The authors are grateful to Dr. V.R.P. Sinha, Director, Central Institute of Fisheries Education, Versova, Bombay for the kind permission granted for publishing this work.

References

1. Faulkner M B and Watts B M, Deteriorative changes in frozen shrimp and their inhibition, *Fd Technol*, 1955, **9**, 632.
2. *Official Methods of Analysis*, Association of Official Agricultural Chemists, Washington, DC, 1980, 13th Edn.

TABLE 1. CHANGES IN THE ASTACENE CONTENT AND COLOUR OF SODIUM BISULPHITE TREATED AND UNTREATED *ACETES* DURING STORAGE AT 30°C

Period of storage (days)	Strength of sodium bisulphite solution							
	0% (Control)		0.05%		1.0%		1.5%	
	Astacene (%)	Colour	Astacene (%)	Colour	Astacene (%)	Colour	Astacene (%)	Colour
Initial	4.22	Yellowish pink	4.18	Pinkish white	4.61	Pinkish white	4.17	Pinkish white
5	3.95	Yellowish brown	3.89	Pinkish white	4.24	Pinkish white	4.05	Pinkish white
10	3.46	Yellowish brown	3.59	Pinkish white	3.81	Pinkish white	3.78	Pinkish white
15	3.20	Brownish yellow	3.29	Brownish yellow	3.49	Pinkish white	3.49	Pinkish yellow
45	2.18	Brownish yellow	2.46	Brownish yellow	2.88	Pinkish white	3.28	Pinkish yellow

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BOOK REVIEWS

International Food Regulation Handbook - Policy, Science and Law: by Roger D Middlekauff and Philippe Shubik (Eds), Marcel Dekker, Inc, New York, Price: US$ 180.

The need for international understanding of food regulations is becoming increasingly important in order to improve trade in freshly packaged and processed foods. This requires greater understanding of the policies of different countries, their needs for protection of public, creation of regulations in relation to needs and establishment of an effective mechanism to constantly update the laws and implement them purposefully. The authors of 8 articles on public policy and scientific considerations and 19 articles on statutory requirements have made a valuable effort in bringing together a lot of experience and knowledge. In this they have drawn heavily upon the experience of Europe and United States, and have looked at the world problem predominantly as the affluent countries would see them. Indeed the experiences of advanced countries have much to contribute and their point of view is of importance because they dominate the world trade in food. Often certain developing countries quoted in the book have copied, with little modifications, the regulations of advanced countries, sometimes indiscriminately. The future development of regulations and the views expressed on them bring out important points but they are also coloured, naturally, by the experience of the authors who predominantly belong to and have been influenced by the advanced countries. What is needed more urgent for the developing countries of Asia, Africa (especially South of Sahara) and even some countries of Latin America is to develop regulations to build quality and safety regulations for their traditional foods which are often more nutritious and have been based on their rich culture. Besides, they are the foods of large majority. These countries represent over 70% of the world population but less than 20% of world GDP. This changes the picture considerably. Their approach to the food regulations and consumer protection has to be different - socially, culturally, scientifically, economically, and therefore legally. There is much to learn from the articles on what to do and also for the developing countries what not to do. Future technologies for processing and their regulation for use as well as the products made by their use must of necessity be culture specific with due attention to inter-cultural needs of the changing world. These technologies and products will also have to be environment and ecology protecting.

The book is indeed valuable but could have been richer by including information by authorities from developing countries which have quite advanced food regulations and whose problems call for urgent attention as they represent large majority of humankind. Hopefully such a publication will follow. Science is universal, but technology is the result of interaction of social needs with science. Food is culture and so are the policies and laws based on them to feed and protect the people.

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An Introduction to Tropical Food Science: by H.G. Muller, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge-CB2 2 RU, 1988, Pp.312 Price: 79.50.

The book is a new one and not the paper back edition of the one previously published. Tropical food science, in this book, has been described in three parts. Foundation of food science forms part one, which covers the following chapters:- The nutritive value of food; Digestion and absorption of food: Nutritional needs through life; The texture, colour and flavour of food; and Food microbiology. Part two mainly concerns with composition of foods which describes in detail about cereals and legumes; Fruits and Vegetables; Non-alcoholic beverages; Sugar and other sweetness; and Foods of animal origin. Food preparation and Preservation form the main topics of the part three; which embodies chapters from Kitchen to food factory; Food preparation; Food fermentation; Food preservation; Food additive; and Food hygiene and health.

Maize, rice, yam, cocoyam, cassava, fruits, vegetables, plantation produces, coconut and oil palm are some important food items, and the book describes the effects of atmospheric vagaries on these food items. From the Food Scientists' point, the three well demarketed geographic regions are 1) those countries which are either self-sufficient or food exporting, 2) those countries importing food for them foreign exchange is readily available through their exports and 3) those countries which cannot grow sufficient food and have too little foreign exchange. The book describes a few salient effects of this kind of division.

The book describes in detail basics of food science, some of which are common throughout the world. The book picturesquely describes rural and modern Food Technology; their importance and impact. The book at various relevant places deals with good and bad practices and effects of food.

In short, the book is a good concentrate of "Tropical Food Science" and it is more than an introduction. The book is worth possessing by all of those who learn, teach and practise Food Science.

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Association Scientifique Internationale Du Cafe (ASIC), 12th International Scientific Colloquium on Coffee, A.S.I.C., 42, rue Schoffer, 75116, Paris, 1987; Pp 860; Price: Not mentioned.

In 860 pages, the proceedings of the 12th Colloquium organised by ASIC in Montreux, Swetzerland have been brought out in a very elegant way giving English summary of all papers with full texts in respective languages of the different countries.

All the Coffee producing countries in Central America, Africa, India, Vietnam etc., along with participants from consuming countries like U.S.A., U.K., Canada, France, Switzerland and others were represented.

The main areas covered are Physiology, Chemistry, Technology, Bio-analytical techniques with a major coverage in agronomy, agrotechnics, diseases and parasites and quality in Coffee.

The proceedings are fully covered and hence will be a useful and stimulating exposure to Coffee Researchers all over the world. Thus the Association has done a yeomen service to this plantation crop and should be congratulated on its role.

In a lecture on Physiology, H.P. Würzner reviewed the action of coffee on human performance The compactive blockade adenosine receptors on cell surface by coffee is an accepted mechanism Coffee helps in keeping alertness and vigilance. Personality factors, time of day and motivation are important factors. Prof Ch. Schlatter reviewed the work on effects of coffee on Cardio vascular system. Seven out of ten epidemiological studies conducted were negative. He also detailed the mechanism involving adenosine cell surface receptors for blood pressure modulation. Dr. Wartman pointed out that people who refrain from coffee drinking may feel the disadvantages such as decrements in vigilance, difficulties in doing additional work, taking more time to do routine work etc. Dr. Sivak reviewed the evidence that coffee drinking does not contribute to cancer of pancreas, colon, breast or bladder. Enzymes like trypsinase, lipase and amylase increase. Dr. Coughlin reviewed the safety aspects of methylene chloride used in decaffecination of coffee. No careinogenic effect was noticed. Prof. Abelin narrated the studies done in Germany and Switzerland on gastro-intestinal intolerance.

In Chemistry, quality control and improved analytical determinations were highlighted. H.G. Maier and R.J. Clarke pointed out improved methods of moisture determination and opined that Karl Fisher techniques will be the method of choice. L Kaper presented the work on HPLC method for Caffeine. Better interpretation of Caffeine and chlorogenic acid is possible by spectrometric method as per R Macral. Improved routine analysis of caffeine by HPLC method was possible as per T.Kazi, C.M. Spiro reported on diffusion studies on Coffee components from powder to beverage.

On flavour studies, application of new research tools for identification and localization of coffee off-flavours were worth mentioning. Brazalian Rio Coffee study by J.C. Spadone has shown that 2,4,6 trichloro anisole in small amounts was responsible for off-flavour. The 'Peasy' note in Central African coffee is due to 2,3 isopropyl methoxy pyrazine at concentration of 0.5 to 2.5 ppm as per R. Becker. Changes in chlorogenic acid, during ripening, synthesis of Caffeoyl-quinic acid and their taste properties, quick methods of estimation of organic acids are reported. G.W. Bradbeny detailed the results on oligomer and polymer carbohydrates. The major polymer carbohydrate was shown to be mannan, arbogalactan and glucan and not galacto mannan.

In technology studies on compressed N_2O as a better decaffeinating agent to CO_2, optimal absorbants for decaffeination process, control of odour emission from roasting plants and prevention of powder explosion are noteworthy. Electron microscopic pictures of Reo Coffee were presented by E Dentan. Microbial ecology of Reo coffee by V. Vanos revealed the presence of *A. fumigatus* in all 'rio-taste' beans, *lactobacillus* strains *Streptococci* group along with *Aspergillus*, *Rhizopus* and *Penecillium* were also found.

Maximum work reported has obviously been in the field of Agronomy. Y. Damarly and A. Charrier gave an excellent review of the various researches carried in this field. They mentioned about genetic perticularities of higher plants and their bearing on biotechnological approaches. The remarkable potentialities in future research could be on methods of *in vitro* propagation, selection of variants resisting toxic substances, culture of reproductive cells to produce plants identical to parent, grafting of genetic elements and transgression of interspecific barriers.

Various studies on world coffee perceptions, creation of genetic resources centres with computerised storage of information, somatic embryogenisis, hybridisation, relationship between fertility and meiotic behaviour, haploids of C-canephora are significant studies reported by various workers.

Improved methods of propagation of strains, influence of genetic factors on Caffeine content, somatic embryogenesis studies to understand the mechanism of resistance of coffee leaves to *Hemelia vestratrix* are reported. Improvements in coffee production in Togo by IRRC by adopting package of practices was revealing.

In Physiology, selection of drought resistance varieties of *C. arabica* capable of osmotic adoptation through collection of free proline nitrogen, phosphorus, potassium, calcium and carbohydrate was reported from India. Influence of light, nutrition, water regime, plantation density, growth and yield have been other studies.

The opening address on Agrotechnics detailed improvements in cultivation, plant material selections, planting density and the application mineral fertilisers.

NPK fertilisation in caturra coffee in full sun, response of

fertilisation in springler irrigated coffee and fertilisation practices in Vietnam are worth noting.

Research in diseases and parasites mentioned work in Vietnam on environmental condition and various fungicides on *Hemelia Vestrovtrix*. Accumulation of virulent genes in reducing aggression of strains of Hemeltra, problems of orange leaf rust in Ghana, and effect of trace elements on leaf resistant spices are other studies reported.

One study stressed the need for proper packaging at proper maturity, drying control, proper storage of cherries and other known parameters to ensure quality. Separation and utilisation of defective beans for the preparation of L galactosidase, extraction of lipid soluble serotinene amides and their use in cardiovascular, pulmonary and nervous system. Cafeylquinic acid as an antioxidant and extraction of phenolic substances for their fungicidal and antiseptic properties were also mentioned.

The green colour of coffee is due to the pigment, a polymer of phenolic and amino acids. The blue colour is produced by reaction between quinone of coffeic acid or its esters with α-amino group of amino acids. Observed green colour is due to a mixture of blue pigment and excess of yellow quinone. These pigments are photo sensitive and unstable above 35°C.

Chemical engineering studies on extraction of caffeine and chlorogenic acid aimed at establishing equilibrium curves as a function of temperature and mass ratio.

For drying parchment, a discontinuous drier and a moisture meter have been tried.

Anaerobic biodigestion of effluents have been studied in Colombia. Micro-organisms in raw coffee stored for several months in Bogola have been evaluated. A tamarii, *pencilliun* species, anaerobic *clostuctium perfrigenes* etc. can be eliminated by gamma irridiation without loss of quality. Obviously, the review could not cover all the papers for which the original publication can be seen. The major studies reported in 1987 colloquium on coffee have given sufficient ground to diversify the various areas in coffee research in future years. Unconventional approaches are necessary to improve quality and profitability of cultivation. This compilation will be a useful guide to all Coffee researchers.

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AFST (I) NEWS

Hissar Chapter

The Annual General Body Meeting was held on 20th January 1990. The following office-bearers were elected:

President	:	Dr. A.C. Kapoor
Vice-President	:	Dr. K.S. Yadav
Hony. Secretary	:	Dr (Mrs) N. Khetarpaul
Hony. Treasurer	:	Dr (Mrs) Darshan Punia

INDIAN FOOD INDUSTRY JOURNAL

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INSTRUCTIONS TO AUTHORS

1. Manuscripts of papers (in triplicate) should be typewritten in double space on one side of bond paper. They should be complete and in final form. The paper should not have been published or communicated for publication anywhere else. Research Notes should clearly indicate the scope of the investigation and the salient features of the results. Only *invited* review papers will be published.

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

3. **Abstract:** The abstract should indicate the principal findings of the paper and typed in single space. It should not be more than 200 words and in such a form that abstracting periodicals can readily use it.

4. Use names of chemical compounds and not their formulae in the text. Methods of sampling, number of replications and relevant statistical analyses should be indicated. Footnotes especially for text should be avoided as far as possible.

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

6. **Illustrations:** Graphs and other line drawings should be drawn in Indian ink on tracing paper or white drawing paper preferably art paper not bigger than 20 cm (OY axis) × 16 cm (OX axis). The lettering should be twice the size of the printed letter. Photographs must be on glossy paper and must have good contrast; **three copies** should be sent.

7. **References:** Names of all the authors along with title of the paper should be cited. Abbreviations such as *et al., ibid, idem* should be avoided. References should be serially numbered as superscripts in the order they are cited in the text and the same order should be maintained in the reference list. The titles of all scientific periodicals should be abbreviated in conformity with the World List of Scientific Periodicals, Butterworths Scientific Publication, London, 1962.

   Citation should be as follows (note the underlines also):

   (*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.

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

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Research Notes

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