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RESEARCH PAPERS

Studies on Preparation of Dry Dates *(chhoharas)*

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Manuscript Received 13 *June* 1977: *Revised* 18 *October* 1977.

Four cultivated dates of at *doka* (hard ripe) stage were cured by dipping in boiling water for 4-10 min and drying in oven at 49±1°C The product obtained was compared with dry dates (*chhoharas*) available in the market. The average weight of the fruit decreased with increase of time of dipping in each cultivar. However, the weight was considerably less than that of market dates. The variable time of dipping did not show any consistent trend for pulp/stone ratio and the market dates displayed higher values than the laboratory cured samples. The moisture percentage of market samples was lower than that of other samples.

Boiling hard ripe (*doka*) date fruits when there is maximum influx of sugars[1,2] for the preparation of *chhoharas* (*Khalaal matbuuk*) is a commercial practice in some of the date-growing regions of the world[3-5]. Dowson[3] stated that 'Zareik' was boiled for ten minutes while 'Halo' required about three times as long. But no work has been done to determine the correct time of boiling for different varieties and its relation with the quality of the product obtained. Dowson and Aten[3] opined that it would be worthwhile for experiments to be made in the preparation of *chhoharas* from dates which usually do not ripen properly.

Dowson and Aten[4] reported that 'Chibchaab' in South Iraq is boiled and this variety is found in all date-growing places along the north-east shore of Persian Gulf and in lower Iraq. They also reported that dates are boiled in Baatima Coast of Muscat to make *chhoharas* which is exported to Pakistan and India.

Variety 'Chibchaab', has been reported by Dowson and Aten[4] to have been used for making dry dates in southern Iraq.

Chohan *et al.*[6] conducted experiments on the boiling of *doka* dates of 'Hillawi', 'Khadrawi', 'Medjool' and 'Thoory' for 4 or 10 min in water and observed no difference in quality of the product due to variance in boiling periods. On the contrary, Kalra *et al*[7] observed that boiling for 6 min resulted in superior *chhohara* than boiling for 2 or 4 min. It was contemplated that dipping in boiling water for longer periods may yield superior quality product. An attempt was, therefore, made to prepare *chhoharas* of 'Medjool', 'Hillawi', 'Khadrawi' and 'Shamran' by dipping the berries in boiling water for 4, 6, 8 and 10 min in each case and to compare the product with the *chhoharas* available in the market.

Material and Methods

The fruits of 'Medjool,' 'Hillawi', 'Khadrawi' and 'Shamran' were harvested as bunches at *doka* stage. Healthy berries of uniform size with perianth intact were loosely tied in muslin and dipped in boiling water, 97°-98°C falling to 95°-96°C when sample was added and using again for 4, 6, 8 and 10 min. Four kilogram fruits were employed for each duration of time under each variety. The treated berries, after draining out the excess water, were spread out in aluminium trays and dried at 49°±1°C in a cross flow air circulation type oven. 'Medjool' was dried for 120 hr and other for 80 hr.

The dried *chhoharas*, thus obtained, were compared with the imported ones. Four samples, A, B, C and D were collected from the local market. Samples A and B were superior and C and D inferior in quality.

Observations were recorded on physical and chemical characteristics. A representative sample comprising twenty berries from each treatment was selected for moisture and sugar determinations. The fruits were deseeded and pulp chopped into small pieces as quickly as possible and mixed for uniformity of the sample. Ten grams of this chopped sample was placed in a petridish and kept in an oven at 65°C for 48 hr (when a constant weight was obtained) for moisture determination. Another 2 g was dipped overnight in 20 per cent ethyl alcohol and the softened pulp crushed in a mortar and pestle. The sugars were extracted with 20 per cent ethyl alcohol over a water bath for two hours. The residue was washed with 20 per cent alcohol several times to ensure complete extraction. The extraction was made, alcohol free by placing it on a water bath for about 4 hr adding distilled water whenever required. Excess of standard neutral lead acetate solution was

added to clarify the solution till precipitation ceased and the volume made to 100 ml. This was filtered and dry sodium acetate was added to the filterate to precipitate excess of lead. Again, it was filtered and the volume was made up to 100 ml. Reducing sugars were estimated in this solution by titrating against mixture of Fehling's solutions A and B and expressed on dry pulp weight basis.

For the determination of non-reducing sugar, 25 ml of clarified and lead-free solution was acidified with 5 ml of HCl and hydrolysed by keeping in a seriological water bath at 68°C for 30 min. After cooling to room temperature, the acidity was neutrilised with sodium hydroxide using phenolphthalein indicator. Total sugars in the reduced form were determined in this solution by titration against Fehling's A and B and non-reducing sugars calculated by multiplying the difference in quantities found before and after inversion with 0.95.

Results and Discussion

The differential boiling periods did not show any apparent difference in colour and appearance within the same variety except in 'Medjool' where 4 min. boiled berries were distinctly darker in colour (brown) than those of longer periods of boiling. The berries of 'Shamran' and 'Hillawi' were more appealing than of 'Khadrawi' which were darker and dull.

Samples A and B from the market had light attractive brown colour like that of 'Medjool' (except 4 min. boiled which were darker). Ridges of the furrows/crinkles were white at places, probably because of rubbing during handling by traders. Unlike samples

TABLE 1. PHYSICAL CHARACTERISTICS OF DRY DATES (*CHHOHARS*)

Treatment time (min)	Weight of fruit (g)	Variation in weight (g)	Pulp content (%)	Stone %	Pulp/Stone ratio	Remarks
			Medjool			
–4	7.40	7.5–7.1	85.25	14.75	5.77	Slightly darker but more appealing & acceptable than market samples C & D
6	7.40	7.5–7.1	85.43	14.57	5.86	Light attractive brown colour, pulp thick. Taste and flavour good.
8	7.20	7.4–7.0	84.83	15.17	5.59	
10	7.10	7.3–7.0	85.02	14.98	5.68	
			Hillawi			
–4	4.90	5.2–4.1	77.14	22.86	3.37	Light brown attractive colour, Pulp thin, but good in taste and flavour.
6	4.70	5.1–4.1	77.02	22.98	3.35	
8	4.80	5.1–4.0	77.31	22.69	3.40	
10	4.70	5.0–3.9	77.02	22.98	3.35	
			Khadrawi			
–4	5.05	4.9–4.3	84.17	15.93	5.31	*Chhoharas* darker in colour than of Hillawi and Shamran. Pulp thin, but acceptable.
6	5.00	4.9–4.3	84.40	15.60	5.41	
8	4.55	5.0–4.2	84.41	15.59	5.41	
10	4.32	5.0–4.3	84.25	15.75	5.35	
			Shamran			
–4	4.49	5.6–4.3	80.84	19.16	4.22	Berries light brown and attractive. Pulp thin like Hillawi. Taste and flavour good.
6	4.75	5.5–4.3	81.05	18.95	4.28	
8	4.30	5.6–4.1	79.10	20.90	4.25	
10	4.15	5.4–4.2	81.92	18.08	4.53	
			Imported Dates			
Sample A	8.23	13.8–6.2	86.64	13.36	6.46	Attractive light brown colour, Pulp thick with good taste. Size variable.
Sample B	8.20	13.1–2.6	85.97	14.03	6.14	
Sample C	5.70	6.4–3.9	86.68	13.32	6.47	Dull reddish brown. Unattractive.
Sample D	4.75	6.6–1.7	86.73	13.27	6.58	Taste towards soft dates—not characteristic of *chhohara*.

C and D, samples A and B were clean without extraneous matter. There was a great variation in size; more so in sample B, which showed that no grading had been exercised.

The pulp in samples A and B was very close to the stone and was thicker than that in case of 'Hillawi' and 'Shamran'. It had more pleasant taste unlike the, *chhoharas* of all the varieties. The product of this research station was slightly leathery and required more force for chewing.

Samples C and D were dull reddish brown and unattractive. These were semi-dry type rather than *chhoharas* and presumably could be under-boiled or low temperature treated dates.[7] They tasted more like the reducing sugar type of dates (*pind*) rather than non-reducing sugar type (*chhoharas*).

The data on physical attributes, e.g. weight, pulp and stone percentage of fruits are presented in Table 1.

Weight of fruit: Average weight of the cured fruit generally decreased as the time of dipping in boiling water increased (Table 1). There was great variation in the weight of berry. When compared with the market dates, the weight of *chhoharas* prepared by us was considerably less than those of samples A (8.23 g) and B (8.20 g). It was noted that the *chhoharas* obtained from the market had a much greater variation in weight whereas those prepared at this research station did not have such variation because of prior selection of fruits for uniformity. The values ranged from 13.75 to 6.15 and 13.06 to 2.62 g for market samples A and B; and from 6.44 to 3.85 and 6.59 to 1.65 g for samples C and D, respectively (Table 1).

Pulp/stone ratio: The *chhoharas* prepared had lower per cent pulp and correspondingly higher stone percentage than those obtained from the market. Among the cured dates, 'Medjool' had the highest pulp weight

TABLE 2. DRY MATTER, MOISTURE AND SUGAR CONTENT IN DRY DATES

Treatment time	Dry matter	Moisture	Sugars (dry pulp basis)		
			Reducing	Non-reducing	Total
(min)	(%)	(%)	(%)	(%)	(%)
		Medjool			
4	94.02	5.98	23.32	47.34	73.16
6	93.73	6.27	21.19	50.86	74.72
8	94.70	5.30	19.71	52.38	74.86
10	94.83	5.17	18.21	52.76	74.73
		Hillawi			
4	95.23	4.77	14.81	59.98	78.07
6	95.35	4.65	14.47	60.70	78.39
8	95.41	4.59	11.26	65.31	80.00
10	95.48	4.52	9.98	68.29	81.86
		Khadrawi			
4	94.65	5.35	16.92	55.11	75.24
6	94.52	5.48	16.10	56.96	76.00
8	94.42	5.58	15.37	60.46	79.00
10	94.36	5.64	14.33	64.24	81.95
		Shamran			
4	93.00	7.00	18.21	52.35	73.32
6	91.35	7.65	16.70	53.98	73.52
8	92.22	7.78	15.43	56.90	75.21
10	92.12	7.88	15.20	57.93	76.16
		Imported dates			
Sample A	97.00	3.00	14.77	58.09	75.83
Sample B	96.00	4.00	16.70	54.37	73.93
Sample C	94.51	5.49	29.33	41.70	73.21
Sample D	93.31	6.69	28.96	39.90	70.95

followed by 'Khadrawi', 'Shamran' and 'Hillawi'—the latter two being almost similar in this respect. The seeds of 'Medjool' were as heavy as those of 'Hillawi', while those of 'Khadrawi' were the lightest. So, pulp/stone ratios of 'Medjool' and 'Khadrawi' were similar and higher than those of 'Shamran' and 'Hillawi'. The market dates had highest value (pulp/stone ratio) because of the lowest per cent seed content.

The data on chemical constituents in respect of different samples have been presented in Table 2.

Dry matter and moisture: The mean per cent value for dry matter in dates cured at Abohar, irrespective of various timings of dipping in boiling water was 94.32, 95.36, 94.49 and 92.42 for 'Medjool', 'Hillawi', 'Khadrawi' and 'Shamran' (Table 2) respectively; whereas the values were 97.0 and 96.0 for market samples A and B respectively. Moisture percentage in dates cured at Abohar and those subjected to different duration of boiling did not vary much. Samples A and B had lesser per cent moisture than all other samples. It may be due to their long storage in shops. Samples C and D could not have lost as much moisture because of greater per cent reducing sugars.

Sugars: The reducing sugars decreased and non reducing sugars increased when the time of dipping in boiling water increased. Per cent total sugars also showed some increase with the enhancement of time of dipping but the difference was not much. The market samples A and B contained less reducing sugars (14.77 and 16.70 per cent) as compared to samples C and D (29.33 and 28.96 per cent). The values for non-reducing sugars were *vice versa* to that of reducing sugars. However, total sugars did not differ much. The difference in reducing sugars content in superior (A and B) and inferior (C and D) dates may partly be due to conditions of boiling.

It was noted that immersion of *doka* dates for less period or in water at low temperature resulted in a product containing high reducing sugars.[7] Apart from that, the enzyme invertase which is known to convert sucrose into glucose and fructose may be more active in inferior dates due to its varietal characters because this enzyme is also known to be active during storage.[3]

Further, the analyses of market dates have revealed that these could be boiled dates and not dry dates in the true sense. Dry dates actually got dried on the palm itself without passing through soft stage.[3] Dry dates are cane sugar dates and have little or no reducing sugars.[8,9]

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Objective Methods for Studying Cookability of Tur Pulse *(Cajanus cajan)* and Factors Affecting Varietial Differences in Cooking

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Cooking of pearled *tur* (*Cajanus cajan*) in boiling water increased the water uptake steadily. Cooking beyond 30 min. led to progressively higher dispersion of solids into the cooking water. Water uptake (in the intial phase of cooking) and dispersion of solids into the cooking medium (in the later stages of cooking) under standard conditions of cooking could be considered as objective indicators of cooking quality; the test was conducted with four varieties of pearled *tur*.

Cooking tests on pearls prepared from ten varieties of *tur* indicated high correlartion between cooking time and the contents of of calcium, magnesium, pectin and phytin and the P.C.M.P. number calculated according to the formula of Muller.

Pulses form an important adjunct to Indian diets contributing to a significant proportion of the protein requirement of the diet. Major proportion of the pulses consumed in India is in the form of *dhal* (dehusked split pulse) which is cooked into a soft mash by boiling in water. The cooking time for different *dhals* varies from 30 to 60 min.[1,2] Varietal differences in cooking quality are known to exist even in the same pulse.[3-5] Attempts have been made earlier to establish a relationship between cookability and chemical composition especially in respect of peas and beans.[6-12] Varietal differences in cooking quality of *tur* (*Cajanus cajan*) have also been described by Shankaran and Srinivasan[5] and Rathnaswamy *et al*[13], who found a correlation between protein content and cookability. In a recent study[14] on 22 *tur* varieties none of the chemical constituents except phytic acid was found to correlate with cooking time; high phytic acid was found correlated with long cooking time.

The objective of the present investigation was to assess the cooking quality of different varieties of pearled *tur* (dehusked grain without splitting) in relation to their chemical constituents. Methods of assessing cooking quality, apart from cooking time which is somewhat subjective, also needed to be developed. In preliminary observations during cooking of *dhal*, it was observed that the *dhal* absorbed water and increased in size upto a certain period beyond which material from the central part of the cotylendon began to get discharged from the *dhal* and got dispersed in to the cooking water. This increased with further cooking. This indicated that water absorption during the initial phase and material dispersion into the cooking water during the later stage of cooking could be objective indices of cooking quality and were therefore investigated.

It was observed that unlike in rice, where the core of the grain was the last portion to cook, it was the peripheral layer of the cotyledon of *tur dhal* which was the last portion to cook although it was most exposed to water during cooking. The effect of removing the peripheral layers by polishing of the pearled *tur* on the cooking quality of the pulse was also investigated.

Materials and Methods

Pure bred varieties of *tur* were obtained from the pulse breeding centres at Coimbatore, Raichur and Hyderabad. The samples were preconditioned according to the method of Kurien[15] and dehusked in a barley pearler (Corcoran make) to obtain the pearls (dehusked grain without splitting). *Dhals* were also prepared from the pearls. For obtaining polished *tur*, dehusked *tur* pearls were polished in a laboratory grain polisher (Satake make) until about 15 per cent by weight of the *tur* was removed as polishings.

Cookability test: For objective evaluation of cookability, polished and unpolished pearled *tur* from 4 varieties were cooked for different periods and the amount of water absorbed by the pulse as well as solids leached into the cooking water were determined at different stages of cooking. For determining dispersed solids 10 g of pearls were added to 100 ml of boiling water and boiling continued on a hot plate maintaining the level of the water by adding boiling water as and when necessary. After cooking for the required period the cooked pulse samples were transferred into a 22-mesh screen, allowed to strain through and the total

solids in the filtrate determined.[16] For determination of water uptake, the cooked samples were centrifuged at 3000 rpm for 15 min and after decanting the supernatant the residue was weighed and increase in weight determined. The hydration was expressed as ratio of water absorbed per gram of the pulse taken for cooking. Cooking time was determined by noting the time in minutes required for soft cooking of the pulse as assessed by pressing the cooked pulse between two glass slides until no hard material was found.

Dehusked *tur* samples in ten varities were also analysed for their content of calcium, magnesium, total and phytin phosphorus, pectin, and total protein. Calcium and magnesium were determined by EDTA titration method,[17-19]; total and phytin phosphorus colorimetrically[20,21] and pectin by Dekkar's method.[22] Protein was determined by the micro kjeldahl procedure (N× 6.25). The relation of cooking time to the content of calcium, magnesium, phosphorus and pectin was studied by calculating the correlation coefficients. 'PCMP' numbers were also caluclated using the above values as per Muller.[6] Both formula A $\frac{\text{(Free pectin (Ca}+\frac{1}{2}\text{ mg)}}{\text{Phytin}}$ and formula B (Free pectin+Ca+$\frac{1}{2}$Mg—Phytin) were used for calculation of the PCMP numbers. Correlation between cooking time and PCMP numbers was also determined.

Results and Discussion

A study of the progressive changes during cooking of the *tur dhal* indicated that when some hydration and swelling is reached (about 20-25 min), a thin layer peeles out from the inner side of the cotyledon. There was slight cracking at this point and progressive removal and dispersal of pulse material occurred with continued cooking. In the final stages of cooking only a thin layer of the peripheral side of the cotyledon remained. This part therefore appeared to be the most difficult portion to cook in the pulse.

The water uptake as also the dispersed solids for 4 varieties are presented in Fig. 1. The dispersed solids as also the water uptake increased continuously with progressive cooking. If, therefore the dispersed solids or water uptake in a pulse is determined after definite period of cooking (30-40 minutes) these values would represent a measure of cookability of the pulse. Among the four varieties studied, SA-1 and Co-1 had better cookability than 'C-11' or PT-301' as evidenced by marked differences in hydration and dispersed solids. There were also clear differences between the polished and unpolished pearled grains both in dispersibility and hydration characteristics (Fig. 1), further confirming that the peripheral constituents of the pulse contained substances which are relatively slow or difficult to hydrate.

Table 1 presents data on 10 pure bred varieties of pearled *tur* with regard to their cooking characteristics and also their chemical composition. They are arranged in decreasing order of their cookability as measured by cooking time. It is observed that easy cooking varieties

TABLE 1. CHEMICAL COMPOSITION AND COOKING QUALITY OF PEARLED TUR

Variety	Cooking time (min)	Water uptake at 20 min. (g/g)	Dispersed solids at 40 min. (%)	Ca (mg %)	Mg (mg %)	Total P (mg %)	Phytin P (mg %)	Pectin as galacturnic acid (mg %)	Protein (NX6.25) (%)	PCMP X 10 (A)	PCMP (B)
5039	32	1.50	80.0	124	76	306	236	4.0	22.0	0.81	3.42
SA-1	34	1.42	82.4	118	82	255	196	4.5	20.5	0.93	3.60
647	35	1.40	80.5	136	80	262	209	7.0	22.8	1.48	3.95
4399	40	1.30	70.6	142	106	285	230	6.5	21.0	1.42	4.52
CO-1	42	1.24	71.5	128	143	325	244	5.2	21.8	1.15	4.85
T-72	44	1.30	69.8	153	106	272	198	4.8	21.6	1.34	5.25
C-28	46	1.10	66.5	155	120	228	176	6.8	20.5	2.11	5.33
148	49	0.90	65.2	171	115	230	168	8.9	20.0	2.92	5.43
C-11	57	0.60	54.3	172	145	218	153	8.3	19.0	3.46	6.50
PT-301	68	0.52	47.8	198	152	236	185	9.4	18.5	3.60	7.10

PCMP (A) = Pectin (Ca+$\frac{1}{2}$ Mg)/Phytin; PCMP (B) = Pectin+(Ca+$\frac{1}{2}$ Mg)—Phytin.

24 *Correlation coffiecient between cooking time and the various constituents are:* Calcium, +0.4450 NS; Magnesium, +0.8167**; Total P, -ve 0.5885 NS; Phytin P, -ve 0.6115*; Pectin +0.8058**; Protein -ve 0.8505***; PCMP(A) +0.9221***; PCMP (B) + 0.9838***; Dispersed solids -ve 0.9845***; and Water uptake -ve 0.5739 NS.

NS: Not significant; *, **, ***: Significant at 5, 1 and 0.1% respectively.

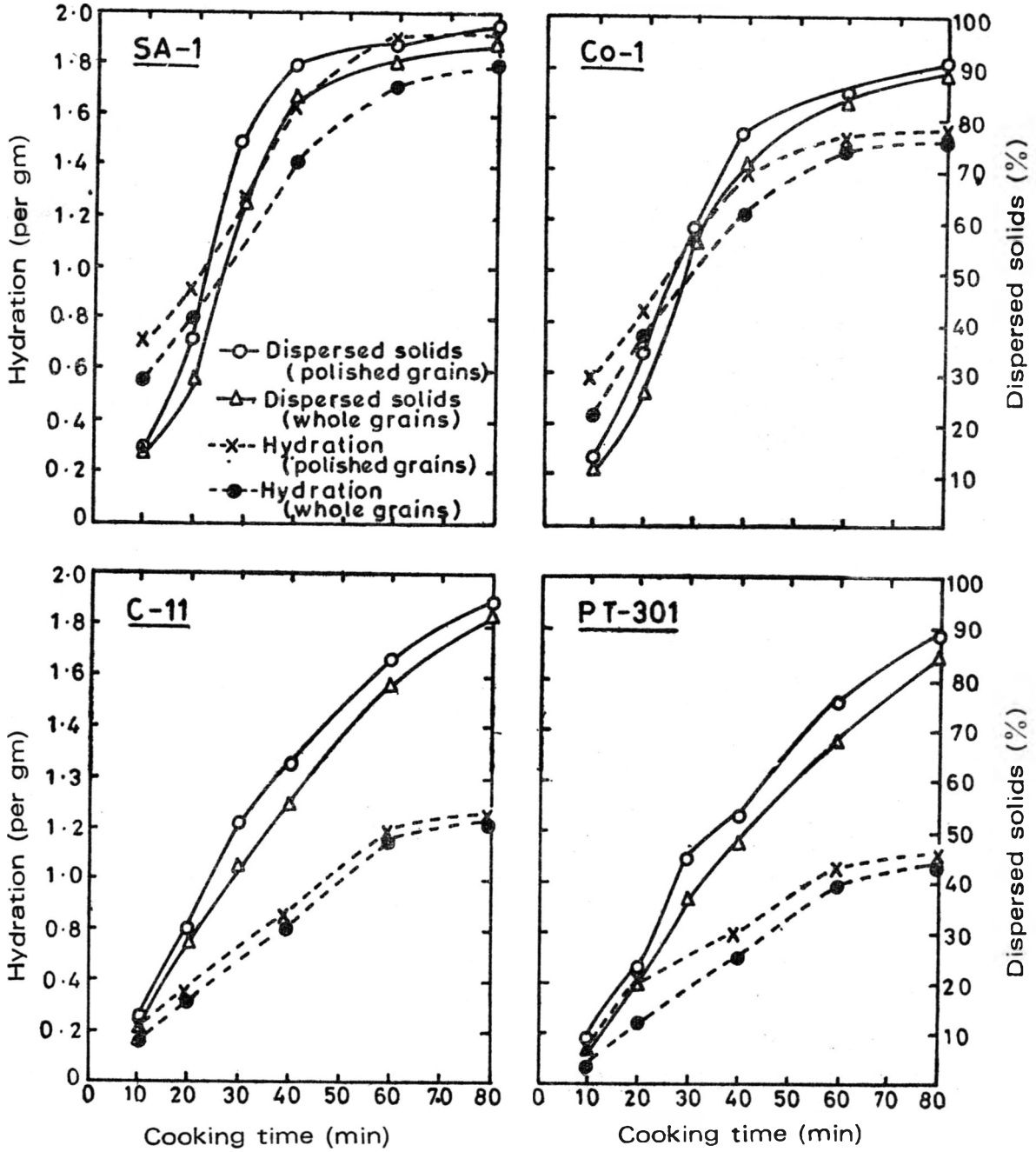

Fig. 1. Hydration and dispersed solids during progressive cooking of four varieties of polished and unpolished pearled tur.

have higher water uptake and more solids got dispersed at 40 min while poor cooking varieties such as 'C-11' and 'PT-301' have lower water uptake and less solids, are dispersed indicating that these parametres are good indicators of differences in cookability between the varieties. The coefficients of correlation between cooking time and the dispersed solids and water uptake are –0.984 and –0.573 respectively. Based on these data, the level of dispersed solids appears to be a better index of cookability than water uptake during cooking.

There were variations in the chemical composition of the varieties with respect to calcium, magnesium, total phosphorus and phytin phosphorus. Generally there was trend of an increase in the cooking time of the pulse with an increase in calcium, magnesium and pectin and a decrease in the total and phytin phosphorus as well as protein. Varieties like '5039' and 'SA-1' which are easily cookable (short cooking time) had lower content of calcium, magnesium and pectin and a higher content of phytin phosphorus than varieties like 'C-11' and 'PT-301' with long cooking times. The PCMP numbers based on these constituents was lower for the

former group than for the latter hard cooking types of *tur*. Varieties with higher protein content had lower cooking times which is in accordance with the result of Rathnaswamy *et al.*[13]

Correlation between cooking time and the various constituents is presented in Table 1. It is seen that correlation between cooking time and the chemical constituents is higher for magnesium, pectin and protein and the PCMP numbers A and B. The PCMP number based on formula B was found to be better correlated to the cooking time although Muller found a better correlation between cookability and PCMP number (formula A) in the case of peas.

These results generally agree with the ealier observations on the cooking quality of peas and beans in relation to their chemical composition.[6-12] However, our data are at variance with the recent observations of Sharma *et al*[14] on *tur*. While these authors have reported that the cooking quality is positively correlated with phytic acid content, our results show a negative correlation. This apparent discrepancy is probably to be explained by the fact that our analysis pertains to dehusked *tur* while the data of Sharma *et al* relate to whole grains which includes the husk also.

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Instantaneous Determination of Moisture Content in Ghee

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Investigations were conducted to establish the relationship between various physical properties (optical and electrical) and moisture content of ghee. The absorption of light energy through ghee at near infrared wavelength above 950 nm was found satisfactory for determining the moisture content of ghee instantaneously. Dielectric constant of ghee proved to be a significant factor for establishing a useful relationship with moisture content of ghee. It can also be exploited to record and control the moisture content of ghee being manufactured by continuous ghee making machine.

Accurate determination of moisture content in ghee is important since its presence affects the quality and shelf life. Moreover, its presence in ghee in amounts greater than 0.3 percent will lead to prosecution under the P.F.A. rules. At present moisture in ghee is determined by drying to constant weight in an oven. Being a slow process this cannot be used for instant control of moisture in ghee during manufacture. In consequence,

determination of the heating process of cream or butter is left entirely to the experience of the workers.

The present investigations were carried out to obtain accurate data on the variation with moisture content of the optical and electrical properties of ghee such as, refractive index, absorbance of light and dielectric constant. The objective was also to see whether a precision instrument was possible to develop for determining the moisture in ghee accurately and instantaneously.

Materials and Methods

Ghee was prepared from the unsalted butter of cow milk in a stainless steel double-jacketted kettle. Samples of progressively lower moisture contents were withdrawn every 10 min. and solidified to obtain uniform moisture distribution. These constituted the test materials. The moisture content of each sample was determined by the oven method.[3]

An Abbe refractometer[3,5] (Bellingman and Stanley Ltd., London) was used to record the refractometer readings at a temperature of 40°C and the required angle of refractance was also read on the main and vernier scale.

Absorbance of light was recorded on a systronic 101 colorimeter at a wavelength of 440 nm where absorption is maximum. The ghee samples were maintained at 50°C. Samples (6 ml) were taken in a quartz cell and placed immediately in the colorimeter for recording the observations. To eliminate the effect of the carotene content, which shows as yellowness in the ghee samples, infrared wavelength of 950 nm was selected using a spectronic 20 spectrophotometer[2,6] with tungsten lamp source. The absorption of near infrared energy passing through the ghee sample contained in the quartz cell at 37°C was measired.

The dielectric constant of ghee was measured using a 1615A capacitance bridge.[1,7] The ghee samples maintained at 45°C were taken in the cell. A frequency of 1 KH_z (kilowatt hr) was used for the measurement of capacitance. The readings of capacitance and dissipation factor corresponding to minimum deflection of the nul detector were read directly.

TABLE 1. RELATIONSHIP BETWEEN MOISTURE CONTENT OF GHEE AND PERCENTAGE TRANSMITTANCE AT 950 NM AND 37° TEMPERATURE

Sample no.	Moisture %	Transmittance %	Moisture %	Transmittance %
	Trial 1		Trial 2	
1.	0.578	24	0.562	32
2.	0.493	35	0.504	34
3.	0.428	43	0.432	47
4.	0.383	45	0.359	56
5.	0.352	75	0.283	73
6.	0.260	85	0.201	87

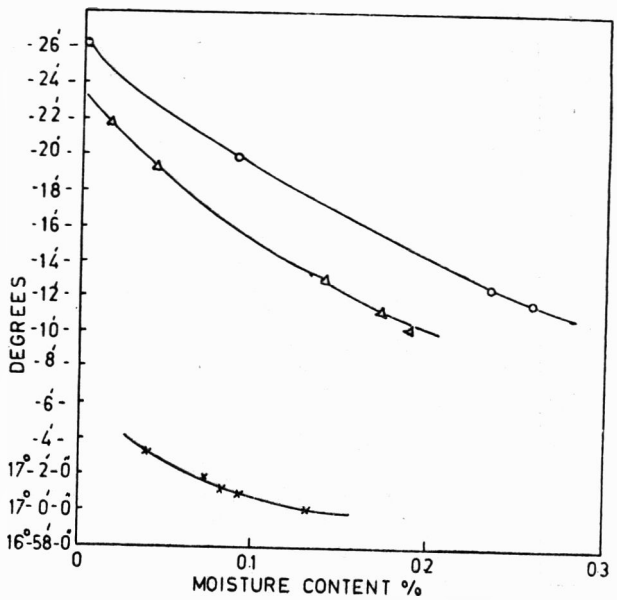

Fig. 1. Relationship between moisture content and refractometer reading.

Results and Discussion

The refractive index of ghee decreases with increase of moisture (Fig 1). However, because of the large

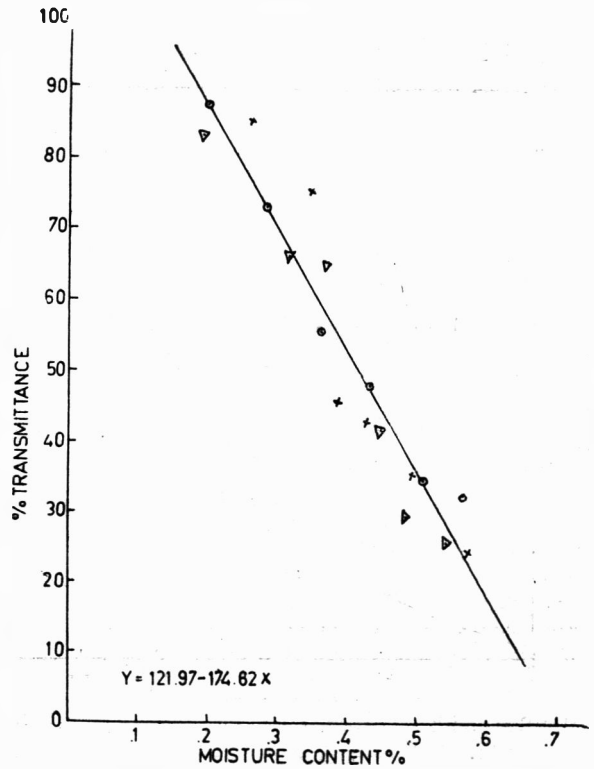

Fig. 2. Relation between transmittance and moisture content at 950 mμ wave length and 37°C

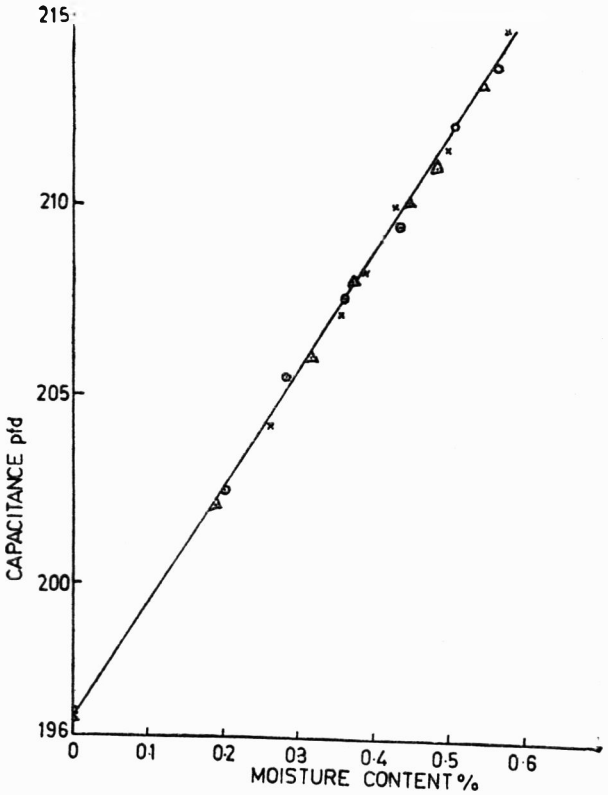

Fig. 3. Relationship between moisture content % and capacitance.

natural variation in the refractive index of genuine ghee, the use of this characteristic for moisture determination will be comparative and not absolute.

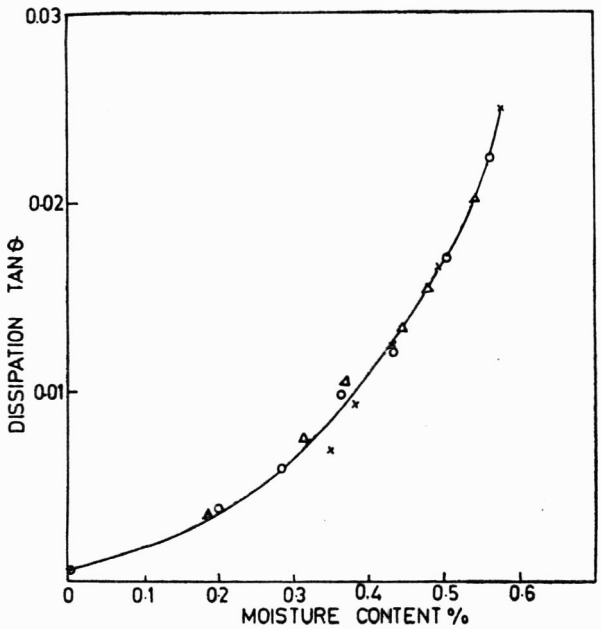

Fig. 4. Relationship between moisture content and dissipation factor.

From Fig. 2 it is clear that with increase of moisture content, the transmittance decreases. It was difficult to calibrate various moisture contents with their respective percentage absorbance of light at a wavelength of 440 nm, because of interference by the yellow colour of carotensoids. A wavelength of 950 nm was used to eliminate the effect of colour, with the results shown in Table 1.

The error in recording the correct observations of absorbance of light could have been reduced tc less than 23.3 percent by using a near infared spectrophotometer at a wavelength of 1900 nm as suggested by Kliman and Pallansch[3], but the instrument to do so was not available.

Fig. 3 and 4 show that values for dielectric constant of ghee increase linearly with increase in moisture content, but in non-linear fashion. These properties can be utilized effectively for measurement of moisture content.

For automatic control and record of the moisture content of ghee, it is suggested that a small bypass stream from the main stream of a continuous ghee making plant is taken first to a temperature-controlled bath and then subjected to a capacitance probe. The bypass stream of ghee is then returned to the mainstream. The changes in capacitance caused by the lowering of the moisture content of ghee during boiling down will affect the frequency of a self-exited oscillator which could be measured by frequency meter and recorded on a chart recorder. These values could also be calibrated directly in terms of the percent moisture content of ghee.

Acknowledgement

The authors are thankful to Dr. D. N. Prasad, Associate Professor (Biophysics) for his valuable help in the conduct of these investigations.

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Effect of Concentration and Temperature on Rheological Properties of Pineapple and Orange Juices

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Rheological properties of pineapple and orange juices were investigated at various concentrations and temperatures. Except at initial concentration, viz. 7° Brix pineapple juice at 30° and 45°C and 13° Brix orange juice at 45°C when they behaved almost Newtonian, both the juices were found to be pseudoplastic. Consistency coefficient, b, increased with a raise in concentration and decreased as the temperature increased whereas the flow behaviour index, n, decreased with increase in concentration in both the cases. Apparent viscosities of these juices were also determined. Pineapple juice was found to be having lower consistency than orange juice at identical conditions.

Rheology is defined as the science of deformation and flow behaviour of matter. The rheology or consistency of a Newtonian liquid like water, milk or clear fruit juices can be chacterized by the term viscosity. Viscosity of non-Newtonian liquids, however, has no meaning as it changes with changing rate of shear, and the consistency should be characterized by more than one parameter. Such consitency of flow constants of some non-Newtonian liquids do not change with the duration of shear rate (such liquids are called time-independent non-Newtonian liquids) and can in general be related by the following equation:

$$\tau = b\gamma^n + \tau_o \qquad \ldots\ldots(1)$$

where, τ = shear stress, γ = shear rate = (du/dr), b = consistency coefficient, n = flow behaviour index and τ_o = yield stress. For Newtonian liquids $\tau_o = 0$ and $n = 1$, reducing b to viscosity normally denoted by μ. Consistency constants are not only important in evaluating the qualities of products, but are also essential in estimating various engineering quantities such as pumping and mixing power, heat transfer coefficients and evaporation rates.

Consistency constants of fruit juices and products depend on concentration and temperature. The literature on consistency constants of fruit juices is rather limited[1-14] considering the types of fruits and their products available. In most of the cases, except at low concentration when the behaviour is Newtonian, the food liquids behaved pseudoplastic in which case

$$\tau = b\gamma^n \qquad \ldots\ldots(2)$$

This paper presents the flow curves and consistency constants of pineapple and orange juices at various concentrations and temperatures. These data were obtained using a narrow gap coaxial cylinder viscometer.

Materials and Methods

Fruit juices: Juice from pineapple and orange was expressed in a manually operated screw press. The juices thus obtained were strained through an ordinary cloth filter to remove suspended solids. In each case, the juice was divided into three portions of which two were concentrated to desired concentrations in a rotary vacuum evaporator. Thus pineapple juice was concentrated from 7° to 22° and 36° Brix and orange juice from 13° to 22° and 33° Brix. The consistency constants were measured within a few hours of juice expression. During the interval, the samples were stored at 4°C.

Narrow-gap coaxial viscometer: The experimental viscometer (Fig. 1) was in general similar to a standard coaxial cylinder viscometer[3,15,16]. The stationary outer hollow cylinder was made of aluminium and had inner diameter of 4.4 cm, height of 7 cm and thickness of 0.3 cm. The cylinder was placed on a tripod stand into a groove for rigid fitting. The inner rotating solid cylinder of stainless steel was 4.1 cm in diameter and 4.0 cm in length. The top of the cylinder had a shaft of 1.6 cm diameter and 10 cm length which passed through two ball bearings supported by a horizontal shaft which was fixed on a frame.

The cylinders were housed in a perspex water bath of 24 cm cube. The water bath consisted of a 2 kw electric heater and thermostat which controlled the temperature of experiment.

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For the measurement of torque, two pulleys fixed to two ball bearings were mounted on shafts on two opposite sides of the cylinders. A thin strong cord having pans on the ends rested on the pulleys and was wound twice around the shaft of the solid cylinders.

For the measurement of revolution per second, a thread was fixed on the top of the shaft of the solid cylinder. The other end carried a light weight to provide sufficient tensions to eliminate error in observations. The thread was supported freely at the level of its fixing with shaft.

To eliminate the error caused by mechanical friction at different points, weights were kept on both the pans to bring them to the same level, and the differential weight noted to cause them to move from this level. This was noted for different weights. It was found that the differential weight required to make them move was always the same. Hence any combination could be used.

In operation, the temperature of the water bath was adjusted to the desired temperature, the sample at the required temperature was placed in the hollow outer cylinder upto a level of 1 cm above the solid inner cylinder. Different weights were added in one of the pans, and the time taken by the loaded pan to traverse the known distance was measured by stop watch in each case. The number of windings was counted.

The shear stress was calculated using the expression[15],

$$\tau_b = \frac{A}{2 R_b^2 l \pi} \qquad \ldots\ldots(3)$$

where, A=torque in dyne-cm, R_b=solid cylinder radius in cm, l=height of the solid cylinder in cm in contant with the liquid. The A was calculated as $w \times R \times 981$, where w=added weight in g, R=radius at which force w acted in cm.

The rate of shear was calculated by the following relationship[3]

$$\gamma_b = \frac{2 R_b N \pi}{\delta} \qquad \ldots\ldots(4)$$

where, δ=gap between stationary and rotating cylinders in cm, and N=revolutions of rotating cylinder per second.

The viscometer was calibrated with 40° and 60° Brix sugar solutions whose consistency constants are known.

The experiments on pineapple and orange juices were conducted at 30° and 45°C, and at three concentrations, 7°, 22° and 36° Brix for pineapple juice, and 13°, 22° and 33° Brix for orange juice. The results presented here are average of three replications.

The shear stress τ *vs*, shear rate γ was plotted on logarithmic paper. The slope of the straight line gave n and the intercept of the straight line on the τ-axis at $\gamma = 1$ sec^{-1} was taken as the constant b.

TABLE 1. RHEOLOGICAL CONSTANTS OF PINEAPPLE AND ORANGE JUICES

Product	Temp. (°C)	Concn (°Brix)	Rheological constants	
			b dynes-sec^n/cm^2	n
Pineapple juice	30	7	0.30	1.00
		22	0.62	0.91
		36	1.30	0.81
	45	7	0.18	1.03
		22	0.49	0.90
		36	1.20	0.805
Orange juice	30	13	0.61	0.86
		22	1.20	0.79
		33	1.40	0.78
	45	13	0.175	1.00
		22	0.790	0.79
		33	1.200	0.78

Results and Discussion

The resulting curves of shear stress, τ *vs*, shear rate, γ, plotted on logarithmic paper are all straight lines, indicating power law or Newtonian nature of the juices (Fig. 2). The consistency constants are tabulated in Table 1.

The flow curves of original pineapple juice of 7° Brix was Newtonian at 30°C, and deviated a little at 45°C showing a little dilatancy. The n was 1.03 (Table 1). At

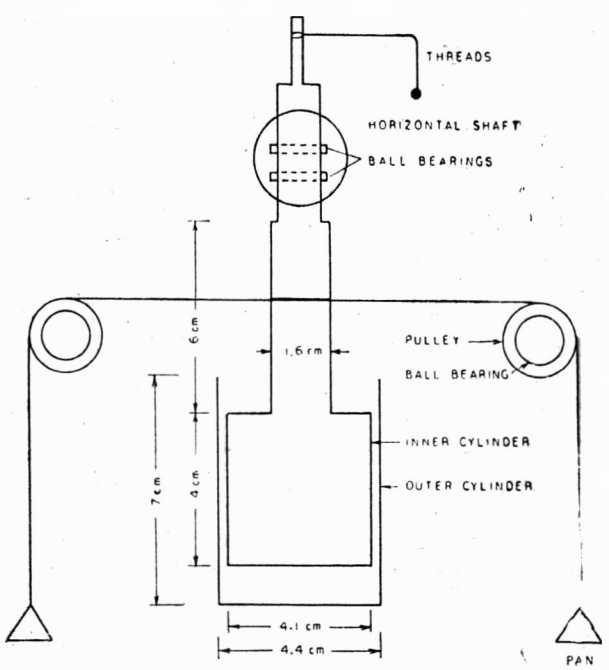

Fig. 1. Schematic diagram of experimental narrow gap co-axial

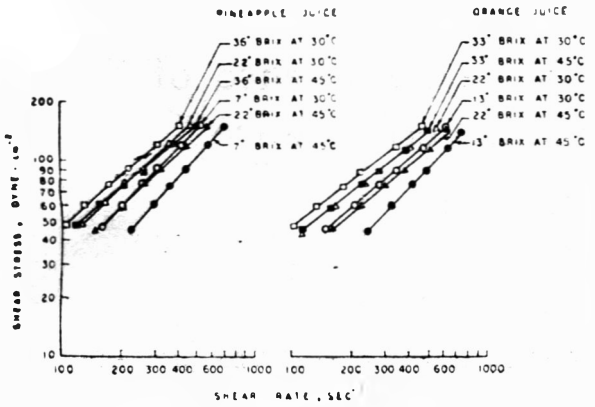

Fig. 2. Flow curves of pineapple and orange juice

all other conditions, the juice had n lesser than 1, i.e., it was pseudoplastic in nature. The pseudoplasticity increased as the concentration increased. The consistency coefficient, b, increased with concentration.

Concentration of pineapple juice remaining the same increasing temperatures decreased n a little except at 7° Brix, and also decreased b. Increasing temperature decreased b of orange juice at all concentrations.

Flow curves of orange juice (Fig. 2) indicated that it was pseudoplastic at all concentrations and temperatures except at 13° Brix and 45°C when it showed Newtonian behaviour. As the concentration increased, consistency coefficient also increased but the flow behaviour index decreased (Table 1). Increase in temperature did not have much effect on flow behaviour index, except at 13° Brix, but appreciably decreased consistency coefficients at all concentrations, more at low concentriatons than higher.

An important term which is some times used in engineering calculations involving non-Newtonian liquids is apparent viscosity which is defined as follows:

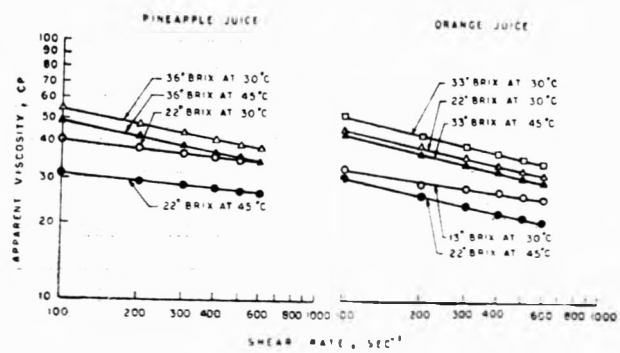

Fig. 3. Apparent viscosities of pineapple and orange juices.

$$\mu_a = \frac{\tau}{du/dr} \qquad \ldots\ldots(5)$$

Substituting the value of τ from equation (2)

$$\mu_a = b\left(\frac{du}{dr}\right)^{n-1} \qquad \ldots\ldots(6)$$

Thus μ_a depends upon shear rate. The values of μ_a for various shear rates for pineapple juice and orange juice are presented in Fig. 3.

It is observed that the apparent viscosity decreased logarithmically as the shear rate increased. Apparent viscosities of concentrated pineapple juice at identical conditions are lower than those of orange juice. Similarly, b values for pineapple juice are lower than those for orange juice. But n values for pineapple juice are higher than those for orange juice at identical conditions indicating that pineapple juice is more pseudoplastic than orange juice. The pseudoplasticity is presumably caused by fine suspended pulp in juices.

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Ultrafiltration of Cottage Cheese Whey; Influence of Whey Constituents on Membrane Performance

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The effect of cottage cheese whey and different fractions of whey on the ultrafiltration process were studied. Different whey fractions were obtained using gel filtration on the Bio Gel P-6 column. The results indicate that whey fraction-I which consists of casein, α-lactalbumin and β-lactoglobulin gave the lowest ultrafiltration flux of the three fractions. Whey fraction-II and III had similar solids content (°Brix) and nearly the same constituents, but whey fraction-II gave a lower ultrafiltration flux than whey fraction-III. The only detected differences to account for the difference in flux decline were a lower ionic strength and the presence of macromolecular protein (i.e. immunoglobulin) in whey fraction-II. There is no evidence of pore-plugging, a conclusion which was supported by the fact that selectivity of the membrane does not increase as flux decline proceeds. However, flux decline may be attributed to membrane compaction and fouling proteinaceous materials which accumulated on the membrane surface. The experiments showed that protein was a major cause of flux decline in the membrane ultrafiltration process. From this study, a two-step process is proposed by combined application of gel fractionation and membrane ultrafiltration to purify and concentrate proteins from cheese whey.

Ultrafiltration is a process which is capable of separating components of a solution largely on the basis of molecular size. It employs membranes which pass solvent and solutes of low molecular weight, but which retain solutes and colloidal matter of higher molecular weight. Ultrafiltration (as well as reverse osmosis) can be applied to food and dairy processing in the form of concentration, purification or fraction of certain components in the food systems. Several individuals have reported the results of investigations of the feasibility of using these techniques to concentrate and fractionate various types of cheese whey[1-3].

Use of ultrafiltration in the dairy industry is particularly promising. Whole and skim milk, for example, can be concentrated by ultrafiltration to yield a concentrate unaltered in taste, texture or nutritive value.[4] Cheese whey can be ultrafiltered to yield a nutritive protein concentrate and an ultrafiltrate from which the lactose can be recovered readily in high purity. Whey is a major cause of water pollution wherever cheese or casein is made throughout the world.

The membrane plays the most critical role in the process. By varying the properties of the membrane, one can control the retention or passage of certain solutes in addition to water. When the solute molecules are large, for example, the proteins, the osmotic pressure is quite small and a membrane with relatively large pores can be used at low operating pressure. Low pressure operation avoids use of costly and complex high pressure equipment.

This paper presents results with ultrafiltration membranes and gel filtration to fractionate cottage cheese whey. The greatest impediment to the use of ultrafiltration is decline in flux. Flux decline is a decrease in permeation rate through the membrane during operation. The effects of the major constituents of whey in contributing to the decrease in permeation rate during ultrafiltration were studied and the results are communicated in this paper.

Materials and Methods

Ultrafiltration system: The ultrafiltration cell and membranes were manufactured by Amicon Corporation, Lexington, Mass, U.S.A. A schematic diagram of the ultrafiltration system is shown in Fig. 1. Pressure was suplied by an N_2 gas cylinder. The assembly has facilities to circulate the feed at a constant pressure of 20 psi and flow rate of 27 ml/min through the ultrafiltration cell. The retentate was returned to the feed tank and permeate was measured and collected separately. The membranes (type PM-10) used had a nominal molecular weight cut-off level of 10,000 and were non-cellulosic synthetic polymers.

Feeds: Feed materials for use in ultrafiltration studies were selected in relation to the hypothesis regarding causes of flux decline. These included:

(*i*) *Deionized distilled water* (DDW): Distilled water was deionized by mixed resin cartridge.

(*ii*) *Lactose solution* (L): 4.7 per cent lactose solution was prepared by dissolving the lactose powder in deionized distilled water.

(*iii*) *Cottage cheese whey* (W): Whey was used as the

principal reference feed, because the study was directed towards explaining the decrease in flux during ultrafiltration of whey.

(*iv*) *Whey fractions* (WF): Cottage cheese whey was fractionated on a Bio Gel P-6 column into three fractions and these were designated as:

Peak I=whey fraction—I=WF.I

Peak II=whey fraction—II=WF.II

Peak III=whey fraction—III=WF.III

Gel fractionation of cottage cheese whey: A 10×152 cm column was used for the fractionation of whey. The column was packed using hydrated Bio Gel P-6 (mesh size 50, Bio-Rad, Richmond, California, U.S.A.). The eluant flow rate was maintained at 90-95 ml/min. Deionized distilled water was used as the eluant. The effluent was monitored at 280 nm, using an ISCO, model 222, UV analyzer and recorder.

Chemical analysis of whey, whey fractions and ultrafiltrate: Chemical analysis of whey for lactose was carried out by the polarimetry method of Sharp and Doob[5], protein and non-protein nitrogen by the Semi-microkjeldahl method[6], fat by model D-Mojonnier milk tester, titratable acidity (calculated in terms of lactic acid) by titration with 0.1 N NaOH, ash by incineration at 600°C, calcium by Perkin-Elmer and atomic absoprtion spectrophotometer and phosphorus by the method of Harris and Popat[7].

Identification of protein components by gel chromatography and acrylamide disc gel electrophoresis: The gel chromatographic system used is one which has been reported by Patel and Adhikari[8]. The elution patterns of proteins of different samples were compared to those of native cottage cheese whey.

Polyacrylamide-urea-2-mercaptoethanol (PAG-urea-ME) gel was prepared according to the method of Davis[9]. Protein samples of 100 lambdas were placed between the large pore gel and small pore gel. The current was adjusted to about two to five milliamps per tube.

Results and Discussion

Chemical analysis of whey, whey fractions WF. I, WF. II and WF. III and their ultrafiltrates are summarized in Table I. These include determination of lactose, total nitrogen, non-protein nitrogen, total protein, titratable acidity, pH, Ca and P. Ash and fat were determined only in whey. Fat in the cottage cheese whey was found to be 0.03 percent.

Gel chromatographic analysis on Bio Gel P-100 (Fig. 2) shows that whey contains four major fractions. The peaks I, II, III and IV have been reported[8,10,11] to represent predominantly casein, α-lactoglobulin, β-lactalbumin and low molecular weight fractions respectively. Peak IV represents the non-protein low molecular components which were not precipitated by 20 per cent trichloroacetic acid. In addition to these peaks, the pattern also shows a shoulder just before the casein peak. This is probably due to the presence of macromolecular protein (e.g. immunoglobulin) and bovine serum albumin eluted at the void volume.

The gel chromatographic data are supported by the

TABLE 1. CHEMICAL ANALYSIS OF WHEY, WHEY FRACTIONS AND THEIR ULTRAFILTRATES

Sample	Lactose	Nitrogen			Total protein	pH	Titratable acidity	Ca	P	Ash	°Brix
		Total	NPN	Protein	(%N×6.38)		mg/ml	mg/ml	mg/ml		
	%	%	%	%			%			%	
Cottage cheese whey	4.55	0.149	0.047	0.102	0.65	4.40	0.58	1.38	0.89	0.84	7.60
Ultrafiltrate	4.41	0.045	0.040	0.005	0.03	4.45	0.43	1.38	0.87	—	6.60
Fraction-I (WF-I)	0.08*	0.072	0.008	0.064	0.42	5.15	0.04	0.01	0.04	—	0.50
Ultrafiltrate	0.06*	0.007	0.006	0.001	0.01	5.20	0.02	0.01	0.03	—	0.05
Fraction-II (WF-II)	2.11	0.024	0.018	0.006	0.04	5.00	0.08	0.72	0.38	—	3.20
Ultrafiltrate	2.08	0.017	0.015	0.002	0.01	5.00	0.17	0.26	0.37	—	3.00
Fraction-III (WF-III)	2.32	0.026	0.023	0.003	0.02	4.80	0.26	0.56	0.44	—	3.30
Ultrafiltrate	2.26	0.024	0.023	0.001	0.01	4.80	0.25	0.56	0.44	—	3.25

*mg/ml

*Analysis not done

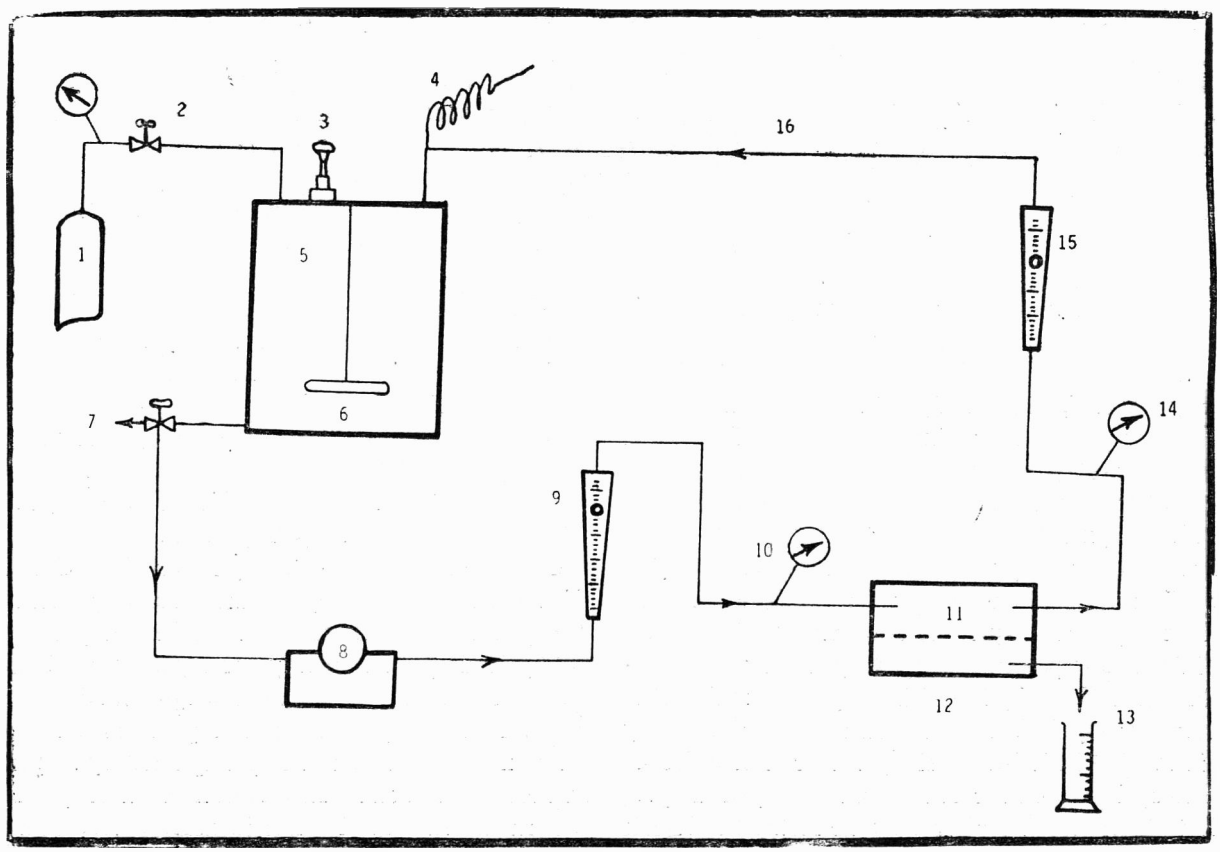

Fig. 1. A schematic diagram of the ultrafiltration system.

1, N_2 gas cylinder; 2, Valve; 3, Pressure release (safety device); 4, Thermocouple; 5, Feed tank; 6, Magnetic stirrer; 7, Sampling valve; 8, Peristaltic pump; 9, Flow meter-F_1; 10, Pressure gauge-P_1; 11, Membrane (PM-10); 12, UF cell; 13, Ultrafiltrate; 14, Pressure gauge-P_2; 15, Flow meter-F_2; 16, Return feed line.

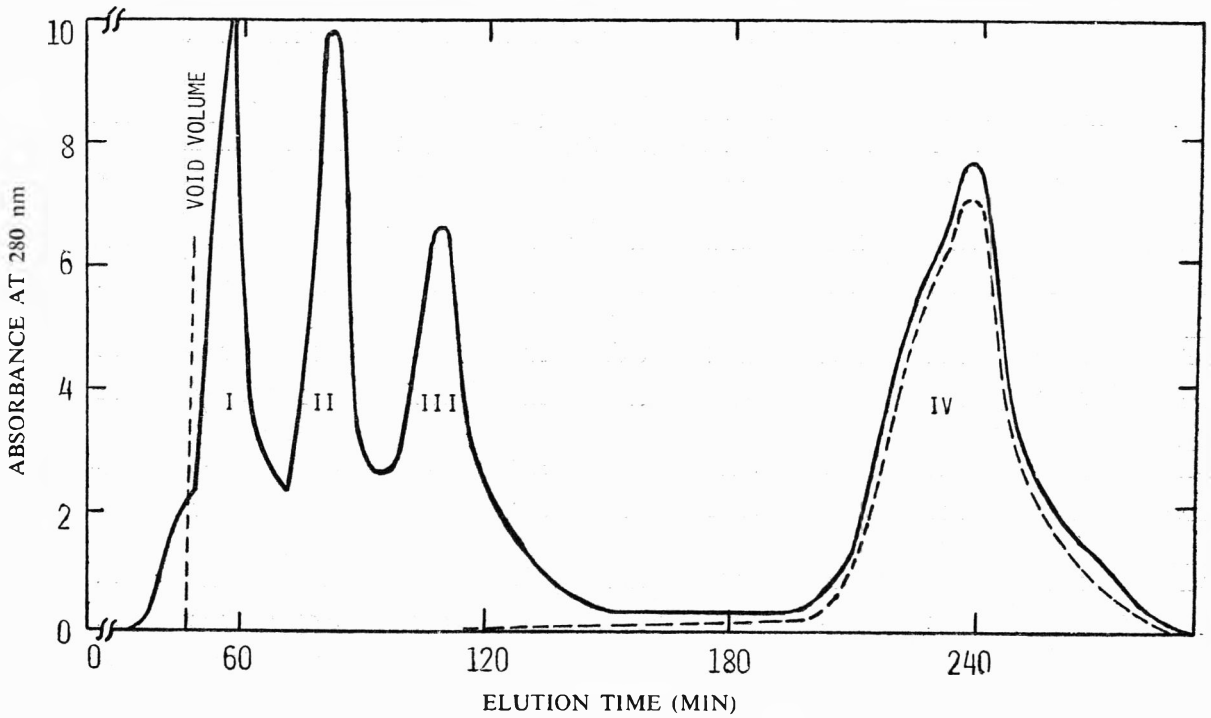

Fig. 2. Gel chromatographic analysis of cottage cheese whey (W) and ultrafiltrate.
———— Feed; - - - - - - - - Ultrafiltrate

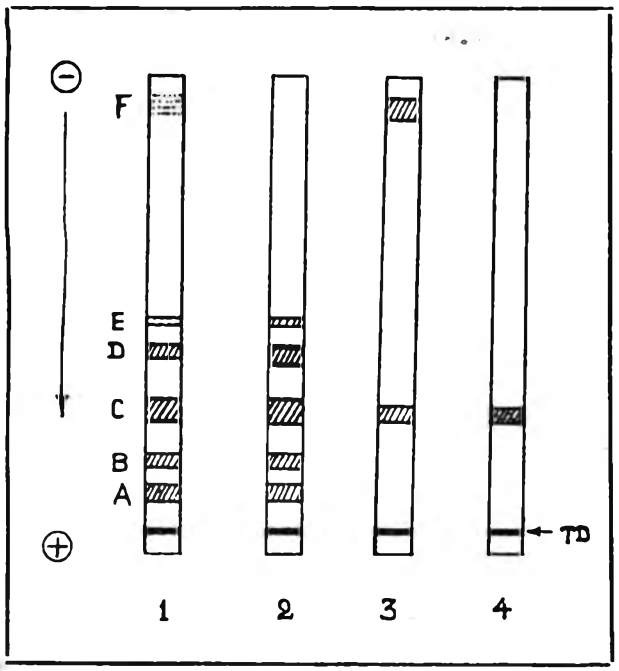

Fig. 3. Gel electrophoresis analysis of cottage cheese whey, whey fraction-I, II and III

1, Cottage cheese whey (W); 2, Whey fraction-I (WF. I); 3, Whey fraction-II (WF. II); 4, Whey fraction-III (WF. III).

A, β-lactoglobulin-A; B, β-lactoglobulin-B; C, α-lactalbumin; D, casein; E, Bovine serum albumin (BSA); F, Immunoglobulin; TD, Tracking dye.

gel electrophoresis analysis of whey. The gel electrophoresis (Fig. 3) indicates that the whey feed consists mainly of β-lactoglobulin (A & B), α-lactalbumin, casein with a small amount of bovine serum albumin (BSA) and near the origin a faint band indicates immunoglobulin. The identifications are based on comparisons with the standard proteins and previously published data by Sinha and Mikolajcik.[12]

Cottage cheese whey was fractionated on Bio Gel P-6 into three fractions (Fig. 4), collected separately as fraction I, II and III and then concentrated to the

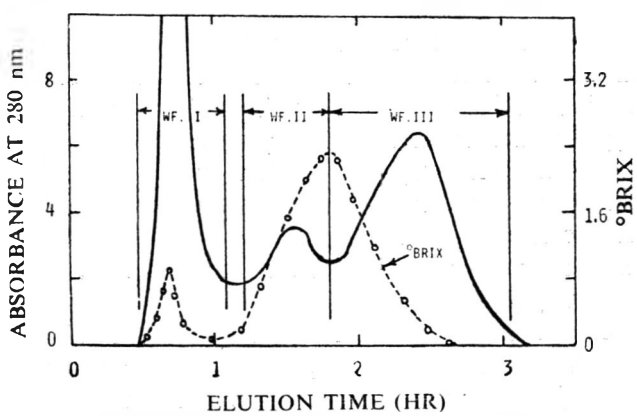

Fig. 4. Gel fractionation of cottage cheese whey (W) on Bio Gel P-6.

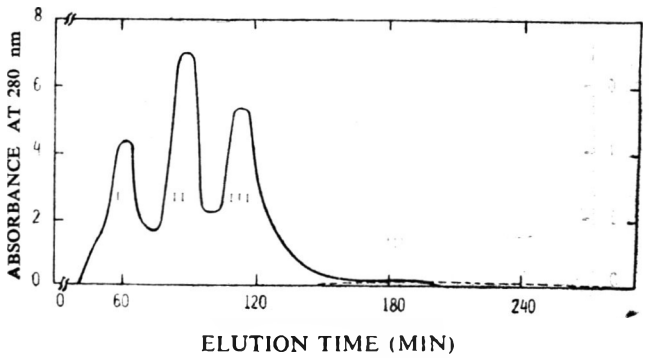

Fig. 5. Gel chromatographic analysis of whey fraction-I (WF.I).
————, Feed
- - - - - - - -, Ultrafiltrate

original amount of whey. Samples of each fraction were chromatographed on Bio Gel P-100 (Fig. 5, 6 & 7) and analyzed on gel electrophoresis. On the basis of Fig. 2, 3, 5, 6, and 7 the protein components of the fractions were identified as:

WF.I=Casein, β-lactoglobulin, α-lactalbumin.

SF.II=Immunoglobulin, α-lactalbumin, low molecular weight components.

WF.III=α-lactalbimun, low molecular weight components.

Chemical analysis of three fractions WF. I, II and III (Table 1) shows that most of the proteins were collected in WF. I, and little distributed into WF. II and WF. III. However, lactose, acids, Ca and P are present in trace amounts in WF. I. The solids (°Brix) in WF. II and WF. III are mainly of lactose. The pH of WF. III is lower than the two other fractions because of higher per cent of titratable acidity in this fraction.

Ultrafiltration flux rate data for feeds of DDW, Lactose, whey, WF. I, II and III are shown in Fig. 8. The permeation rate with DDW as the feed was taken as the standard test of the condition of the membrane. Each membrane was characterized by a 30 min ultrafiltration operation with DDW as a feed. It was then soaked in water for two hours, and again used for ultrafiltration of different feeds. After that it soaked

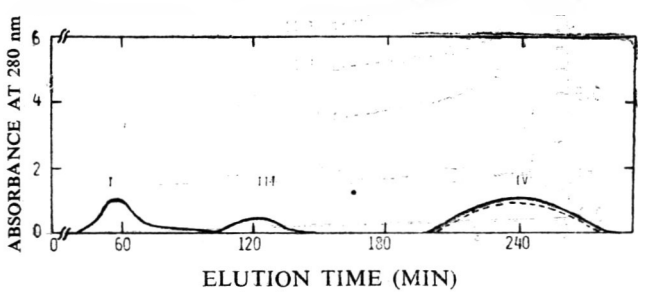

Fig. 6. Gel chromatographic analysis of whey fraction-II (WF. II) and ultrafiltrate.
————, Feed
- - - - - - - -, Ultrafiltrate

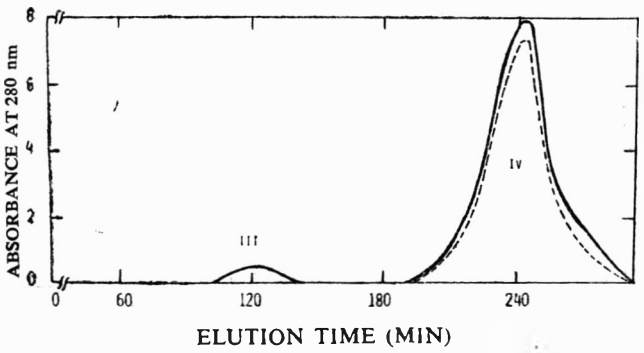

Fig. 7. Gel chromatographic analysis of whey fraction-III (WF. III) and ultrafiltrate.

--------, Ultrafiltrate
——————, Feed

overnight (15 hr) and again was tested to demonstrate the recovery of flux with DDW. The water experiments after overnight soaking of the membrane give an idea of how much the membrane is affected by a given feed.

Lactose (4.7 °Brix) has a high flux compared to all the other feeds (except DDW), while whey has the lowest ultrafiltration flux. WF. I gave the lowest flux among all three fractions. Fractions II and III have more or less the same total solids, i.e. 3.2 and 3.3 °Brix respectively, which is mainly contributed by lactose. The distinct difference is the presence of macromolecular (immunoglobulin) protein in the WF. II. Furthermore, this fraction has lower Ca, P and acids, so that it has low ionic strength. These two factors may contribute to the low ultrafiltration flux from WF. II. In addition, the protein content decreases from fraction I to III, the average molecular weight of the proteins decreases from fraction I to III and the extent of phosphoproteins (casein) also decreases from fraction I to III. All these factors may also be attributed to the decline in the flux rate from the feeds of fraction III to I. Thus, fractions showing differences in the flux rate show differences in the molecular weight, content and type of proteins.

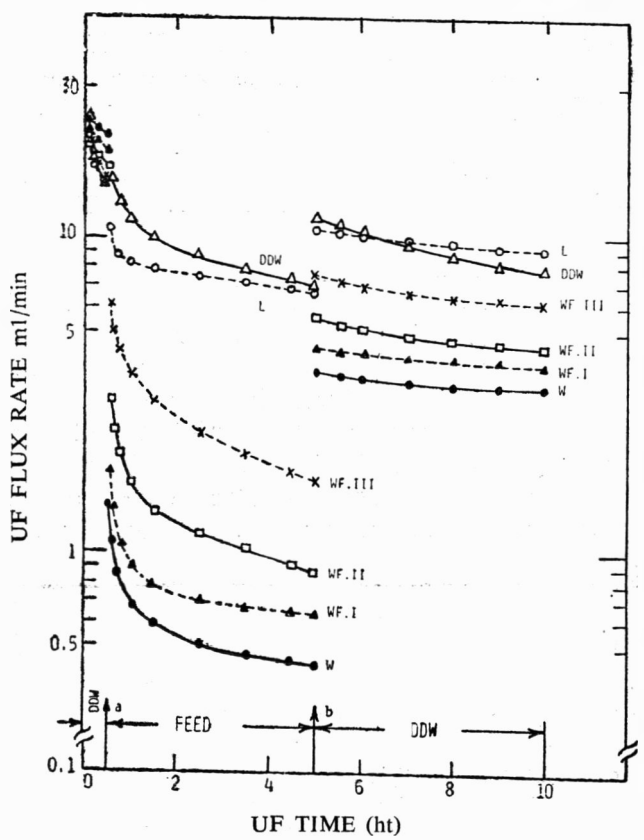

Fig. 8. Ultrafiltration flux rate from DDW, L, W and WF. I, II and III.

At a = membrane soaked in water for 2 hr
At b = membrane soaked in water for 15 hr

The presence of a macromolecular protein in WF. II is rather surprising as well as interesting. Being a high molecular weight protein it should be eluted in WF I. Elution in WF. II might be caused by precipitation of this protein within the gel column as the ionic strength of this fraction drops during separation. The band of acids and salts, which travels through the column behind the proteins, may redissolve the deposited protein and cause the protein to appear at the leading edge of the salt peak (Fig. 2). This was confirmed using high ionic strength eluant instead of DDW (Patel, P. C., *Unpublished data*, University of California, Davis, U.S.A.)

Occasionally, it was observed that some membranes allow α-lactalbumin to permeate even though the PM-10 membrane has a nominal cut-off at molecular weight 10,000. In this kind of more open membrane, the initial ultrafiltrate and end ultrafiltrate samples checked for concentration of α-lactalbumin permeated. In both cases was found the same amount of α-lactalbumin. Thus, it indicates there is no evidence of pore plugging of the membrane.

A low profile slime formation or gel deposit was observed for fresh cottage cheese whey in this study. However, in the feeds of whey fractions a proteinaceous deposit or gel like materials were accumulated on the membrane surface during ultrafiltration. Similar findings are also reported by Fenton-May *et al.*[13]. It appears that accumulation of proteinaceous materials and membrane compaction itself may be attributed to the decline of flux during the ultrafiltration process. The accumulation on the membrane was mostly protein, including macromolecules (i.e. immunoglobulin), casein and whey proteins.

Since flux is the most important parameter affecting the size and cost of a plant, controlling flux decline is of major commercial importance. The mechanical properties of ultrafiltration membranes under compression are of particular interest, since they are related to

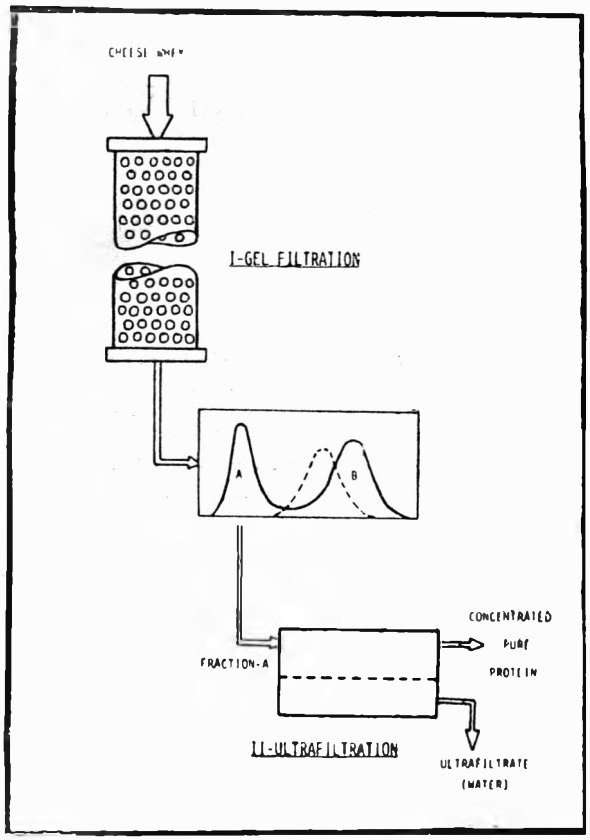

Fig. 9. A schematic diagram of proposed two-step process where:
Fraction-A = casein + β-lactoglobulin + α-lactalbumin
Fraction-B = low mol. wt. non-protein components
– – – – – – – = lactose + salts + acids

the stresses encountered by the membrane under operating conditions. A membrane is also likely to become clogged by the proteins, as its pore sizes approach the molecular size of those proteins. As the ultrafiltration process proceeds, the gel formation takes place because the solvent carries with it solutes (proteins) which are rejected at the membrane surface, resulting in an accumulation of proteinaceous materials on the membrane. Also the nature of the membrane and the constituents of the feed are important factors playing a major role in flux decline during the membrane ultrafiltration.

A proposed two-step process: By combined application of gel filtration and membrane ultrafiltration, one could purify and concentrate proteins from cheese whey. By eliminating lactose, salts, acids and low molecular weight non-protein fractions very pure proteins could be obtained. Using only the membrane ultrafiltration process, it is difficult to obtain pure protein concentrate; some of the lactose, salts, acids, etc. still remain in the final concentrate. With the introduction of the gel filtration step, these residuals are eliminated in the first step. The proposed two-step process is illustrated in Fig. 9. The cheese whey may be employed at the top of the column and the whey constituents may be divided into two major fractions:

Fraction-A = consists of casein + β-lactoglobulin + α-lactalbumin

Fraction-B = consists of low molecular weight non-protein fraction

Lactose, salts and acids will be eluted after fraction-A (using gel column having exclusion limit 4,000-6,000 mol wt.), so they could be separated easily in fraction-B. Fraction-A would then be used as a feed for the ultrafiltration process. By suitably fabricating the membrane pores at molecular weight cut-off 12,000-14,000. the proteins can be retained and concentrated into very pure protein.

Acknowledgement

Appreciation is expressed to Mr. Gregory Costa for his helpful suggestions and for kindly reviewing this manuscipt.

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Factors Influencing the Malting Quality of Indian Wheats

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Maltability of three varieties of wheats ('C 273', 'WG 357' and 'PV 18') as influenced by germination at 20°C for 3, 5 and 7 days with and without gibberellic acid (GA) was investigated. Malt and extract yields and levels of the amylolytic and proteolytic enzymes were increased perceptibly by GA. The alpha-amylase activities (SKB units) in 3-day control malts of 'C 273', 'WG 357' and 'PV 18' were: 17.3, 70.2 and 30.2 as compared with 122.1, 115.2 and 112.2 of the corresponding GA-malts. Kolbach index values of these malts increased from 33.0, 32.3 and 33.2 to 52.9, 49.9 and 47.1, respectively, due to GA. Germination for 5 and 7 days caused further increases in these values. The conversion times of the malts were also substantially reduced by GA. The worts were clear and filtered normally.

Literature on the malting of wheats is sparse compared with barley. There is a scope for developing wheat based malt industry in the country in view of the increased production of this cereal in recent years. From 10.4 million metric tonnes of wheat produced in 1966[1], the present production is estimated at 28 million metric tonnes. Germination was considered to be an important factor responsible for enzyme production in Hard Red Winter wheat according to Fleming *et al.*[2]. Information on the factors influencing the maltability of indigenous spring wheats was lacking. This investigation was, therefore, carried out. Besides the effect of germination time, the varietal and gibberellic acid (GA) interactions in relation to yield and quality of malt have been reported in this paper.

Materials and Methods

Three varieties of commercially important wheats, namely 'C 273, 'WG 357' and 'PV 18' (1972–73 crop) were obtained from the Punjab Agricultural University, Ludhiana. The grains of 'C 273' and 'WG 357' are amber coloured whereas those of 'PV 18' are red. The samples were cleaned and preserved in air-tight containers for use in various tests.

Test weight: Grieners balance was used to determine the hectoliter weights. Average weights of duplicate 1000-kernel lots were recorded.

Germination capacity: One hundred kernels of each variety in quadruplicate were placed in petridishes on thick filter papers. Water was sprayed lightly at intervals to ensure germination. The tests were carried out in a germinator at 20°C. The germinated seeds were counted and removed daily.

Water sensitivity: Wheat kernels (100 in each case) in triplicate were placed in petridishes lined with Whatman No. 1 filter paper, and wetted with 2,4, 6, 8 and 10 ml of water respectively, and allowed to germinate at 20°C. The number of germinating kernels were recorded daily and removed from the petridishes. Difference between the percentage of maximum number of kernels which germinated in 4 ml and 8 ml petridishes, are expressed as water sensitivity[3].

Steeping characteristics: Samples (50 g) of each variety was put in cloth bag and steeped in water at 20°C. The increase in weight of steeped kernels at intervals of 6 hr over a period of 48 hr was expressed as moisture per cent.

Starch: Polarimetric method based on extraction of starch from the samples with saturated solution of calcium chloride, as described by Frazer *et al.*[4]., Frazer and Holmes[5] and by Frazer and Hoodless[6], was followed.

Moisture, ash and protein ($N \times 5.7$) contents were determined according to the AACC methods[7]. The crude fibre was determined by the AOAC method[8].

Experimental malting: The varieties were given preliminary washing with 0.05 per cent aqueous lime solution, to prevent incidence of fungus on the grains during germination. Test maltings were done on one kg lots of each variety steeped in distilled water (20°C) until the moisture content reached 42 per cent. The steep water was changed at 6 hr intervals to ensure aeration. The steeped grains were drained thoroughly prior to germination in specially designed four compartment wooden boxes with wire mesh (No. 12) bottoms for thorough aeration during germination. The boxes, loosely covered with polythene sheets, were placed in the germinator at 20°C and saturated humidity to avoid undue evaporation of moisture from the grains. Germination was arrested after 3, 5 and 7 days. To determine

the effect of gibberellic acid (GA), 1-kg lots were steeped to about 42 per cent moisture. but the last 5 hr steeping was done in GA solution (10 ppm). The malts were dried in a through-flow drier at 40°C. The roots were removed by gentle rubbing followed by sifting. The malts and roots were weighed tc determine yield and losses. The malt samples were preserved in air tight containers at low temperature for evaluation of quality.

Moisture: This was determined in accordance with AOAC method[8].

Diastatic power (DP) Weighed aliquot (25 g) of ground malt was extracted with 500 ml of dilute sodium chloride solution (0.5 per cent). The diastatic power was determined using buffered starch solution as prescribed in the AOAC procedure[8]. The values are expressed as degrees Lintner (°L).

Alpha-amylase activity: The ICC method as described by Perten[9] was followed. The values are expressed as SKB units.

Proteolytic activity: This was determined by the method of Ayre and Anderson[10]. The values are expressed as mg N/100 g malt.

Cold-water extract: This was determined according to the IOB method.[11] Ground malt (25 g) was digested with 250 ml water containing 20 ml of 0.1N ammonium hydroxide solution for three hours at 21°C. From the specific gravity of the filtrate at 15.5°C, the yield of extract was calculated.

Hot-water extract: An automatic standard VLB* mash bath was used for mashing test samples according to the AOAC procedure[8]. The yield of extract was determined by the EBC method[12]. Conversion time (min), speed of filteration, colour of wort (EBC) units, clarity of wort and soluble nitrogen in the wort were also determined as described by Singh and Bains[13]. The degree of modification in the malt was expressed as Kolbach index calculated by the expression:

100 × total wort-soluble N/total malt N.

The results are expressed on moisture-free basis.

Results and Discussion

The results of physico-chemical characteristics of the varieties of wheat are given in Table 1.

The grains of 'WG 357' were bolder than those of 'C 273' and 'PV 18' varieties as shown by the 1000-kernel weights. The hectoliter weight which depends on the shape and texture of grains was highest, (72.1 kg) in the case of 'C 273', and lowest (68.9 kg) of 'PV 18'. The starch contents were 68.7, 70.6 and 71.6 per cent in 'C 273', 'WG 357' and 'PV 18' varieties, respectively. Inspite of their quite high protein content, the amount of starch was far more than usually contained in barley[14].

Table 1. PHYSICO-CHEMICAL CHARACTERS OF WHEAT VARIETIES

Variety	Hectoliter wt. (kg)	1000-kernel wt. (g)	Ash (%)	Crude fibre (%)	Protein (%)	Starch (%)
C 273	72.1	38.3	1.9	2.2	14.8	68.7
WG 357	70.2	42.1	1.8	2.2	14.5	70.6
PV 48	68.9	31.7	1.7	2.0	12.6	71.6

Starch in malt is useful in the preparation of syrup. Protein content is of value as a source of soluble nitrogen nutrients for the yeast in case the malt is used for fermentation. The differences in the ash and fibre contents of the varieties were negligible.

Germination capacity and water sensitivity: There were significant difference in the germination capacity and water sensitivity of the varieties (Table 2). Maximum germination (92 per cent) was shown by 'WG 357' followed by 'C 273' (82 per cent) and 'PV 18' (80 per cent). Water sensitivity was 9 per cent in the case of 'C 273' but negligible in case of 'WG 357' and 'PV 18', which germinated well with 6 ml water and equally well in an environment of 8 to 10 ml water.

Table 2. GERMINATION CAPACITY AND WATER-SENSITIVITY OF THE WHEAT VARIETIES

Variety	Germination (%)	Water-sensitivity (%)
C 273	82	9
WG 357	92	0
PV 18	80	1

Steeping characteristics: The steeping behaviour of the varieties when immersed in 20°C water is illustrated in Fig. 1. From the steeping curves, it is clear that 'C 273' and 'WG 357' varieties took an average of 48 hr to attain about 42 per cent moisture as compared to 36 hr required by 'PV 18'.

Yield of malt: Among the varieties, 'PV 18' gave the highest yield of 92.7, 89.9 and 87.8 per cent malt when germinated for 3, 5 and 7 days as compared to other two varieties (Table 3). Application of GA increased the yield of malt of 'C 273' by 2 to 3 per cent, of 'WG 357' by 1.5 to 2.0 per cent and 'PV 18' about 2 per cent similar to the increased yield of barley malt as reported by several workers[13,15,16].

Apportioning the losses to various factors during malting of wheat, it is seen that GA treatment reduced

*Versuchs—und Lehranstalt fur Brauerei, Berlin 65.

TABLE 3. EFFECT OF GIBBERELLIC ACID AND GERMINATION TIME ON THE YIELD AND PHYSICAL CHARACTERISTICS OF WHEAT MALT

Germination (days)	Treatment	Hectoliter wt (kg)	1000-kernel wt (g)	Malt yield (%)	Steeping (%)	Losses (%) roots (%)	Respiration (%)
				C 273			
3	Control	58.3	36.7	87.6	0.80	1.34	10.25
	(+) GA	55.1	36.1	90.8	0.87	1.18	7.17
5	Control	56.2	36.5	85.7	0.82	1.65	11.86
	(+) GA	54.2	35.0	88.0	0.85	1.50	9.64
7	Control	54.7	34.8	83.5	0.87	2.00	13.66
	(+) GA	53.0	33.9	85.5	0.89	1.71	11.92
				WG 357			
3	Control	55.7	40.1	85.8	0.89	1.26	12.08
	(+) GA	53.8	37.6	87.0	0.81	1.04	11.11
5	Control	55.2	38.2	84.7	0.85	1.55	12.84
	(+) GA	51.6	36.6	86.2	0.90	1.33	11.54
7	Control	54.5	37.8	82.1	0.88	1.84	11.15
	(+) GA	51.2	36.1	83.5	0.88	1.66	13.95
				PV 18			
3	Control	54.0	29.1	92.7	0.51	1.55	5.26
	(+) GA	52.3	28.7	95.6	0.61	1.22	3.06
5	Control	52.6	29.1	89.9	0.53	2.00	7.54
	(+) GA	50.7	28.3	92.8	0.50	1.58	5.12
7	Control	52.0	28.2	87.8	0.56	2.41	9.24
	(+) GA	50.2	28.0	89.7	0.54	1.81	7.91

the overall malting losses of the varieties when germinated for different times (Table 3). The steeping losses were of similar order in all the varieties, but major losses have been ascribed to respiration which increased as the time of germination increased from 3 to 7 days. The application of GA decidedly reduced respiration losses depending on the variety, being the highest for 'WG 357' as compared to those of 'PV 18' which were the lowest. Losses attributed to root growth increased (1.38 to 2.08 per cent) as germination was extended from 3 to 7 days. Corresponding losses in GA treated samples varied from 1.14 to 1.72 per cent, respectively. Respiration losses increased from 8.19 to 12.68 per cent for similar periods of germination compared to 7.11 to 11.26 per cent in the case of GA treated malts. PV 18 variety was conspicuous by its lowest respiration losses (5.26 to 9.24 per cent) over a 7-day germination which were further reduced to 3.06 to 7.91 per cent by GA. Overall malting

TABLE 4. EFFECT OF GIBBERELLIC ACID AND GERMINATION TIME ON THE YIELDS OF COLD AND HOT WATER EXTRACTS OF WHEAT MALTS

Germination (days)	Treatment	Extract yield (%) Cold water			Hot water		
		C 273	WG 357	PV 18	C 273	WG 357	PV 18
3	Control	17.5	22.7	14.0	84.0	82.0	78.1
	(+) GA	30.0	27.5	22.2	86.4	85.5	85.2
5	Control	20.9	20.9	16.0	79.0	78.0	78.0
	(+) GA	32.7	30.1	24.1	83.2	83.0	84.8
7	Control	22.7	24.4	18.3	79.0	82.5	79.6
	(+) GA	34.0	33.0	25.0	84.5	83.6	81.8

TABLE 5. EFFECT OF GIBBERELLIC ACID AND GERMINATION TIME ON THE QUALITY OF WORTS*

Germination (days)	Treatment	Conversion time (min)			Wort colour (EBC)			Nitrogen (%)		
		C 273	WG 357	PV 18	C 273	WG 357	PV 18	C 273	WG 357	PV 18
3	Control	25	11	15	2.00	2.00	2.00	0.83	0.80	0.71
	(+) GA	7	5	10	< 2.25	2.75	2.75	1.32	1.22	1.01
5	Control	20	12	15	2.25	2.75	2.01	0.97	0.98	0.90
	(+) GA	< 5	5	10	2.75	< 3.00	2.75	1.55	1.46	1.10
7	Control	14	9	15	3.00	4.25	2.25	1.16	1.14	0.93
	(+) GA	4	5	7	4.00	4.25	3.50	1.68	1.58	1.12

*Worts clear and filteration normal.

losses of barley have also been reported[13,15,16] to be considerably reduced by GA.

Increased losses with the duration of malting of wheat have been reported by Dickson and Geddes[17].

Test weights: There was a notable change in hectoliter weights of malts compared to those of corresponding wheats. Collating the results of Tables 1 and 3, it is seen that the hectoliter weights of 3-day control malts of 'C 273' declined from 72.1 kg to 58.3 kg, of 'WG 357' from 70.2 kg to 55.7 kg and of 'PV 18' from 68.9 kg to 54.0 kg, respectively. The decreased hectoliter weights are attributed to the porous nature of kernels caused by germination during which digestion of cell wall constituents accompanied by root and respiration losses occur (Table 3). The compact ungerminated grains develop friable and soft texture on malting. As seen from the 1000-kernel weights (Table 3). the malted grains were distinctly lighter in weight than the original wheats (Table 1). GA further reduced the hectoliter and 1000-kernel weights of the malts indicating greater modification of the grains of each variety.

Malt from 'C 273' developed consistently higher diastatic power (155°L to 170°L) on germination from 3 to 7 days as compared to the values of 124°L to 153°L for 'WG 357' and 94°L to 109°L for 'PV 18' malts. GA treatment elevated the diastatic activity very considerably in all cases. When germination time was extended from 3 to 7 days, the DP of GA 'C 273' malt increased from 210°L to 245°L, of 'WG 357' from 135°L to 224°L and of 'PV 18' from 128°L to 174°L, respectively. There was a steep increase in the DP of 'WH 357' when germination was allowed for 7 days in case of GA malt. Diastatic activity determination primarily reflects the beta-amylase status of malt.

Contrary to the diastatic power of 'C 273', the 3-day germination increased the alpha-amylase activity but for this variety which was the lowest (17.3 SKB unit) compared with 71.2 and 30.2 units of 'WG 357' and 'PV 18' varieties, respectively. There was about three fold increase in the alpha-amylase activity of 'C 273' on extending germination to 7 days, corresponding increases being much less in case of 'WG 357' and 'PV 18' wheat malts (Fig. 2). The most remarkable effect of GA was 'C 273' variety whose alpha-amylase activity increased from 17.3 to 122.1 SKB units in 3-day germination as compared to 71.2 to 115.2 units and 30.2 to 112.2 units

TABLE 6. EFFECT OF GIBBERELLIC ACID AND GERMINATION TIME ON THE MODIFICATION-KOLBACH INDEX (KI) OF WHEAT MALTS

Germination (days)	Treatment	Kolbach index (soluble N% of total malt N) C 273		WG 357		PV 18	
		KI	Increase (%)	KI	Increase (%)	KI	Increase (%)
3	Control	33.0	—	32.3	—	33.2	—
	(+) GA	52.9	60.3	49.9	54.5	47.1	41.9
5	Control	37.8	—	39.9	—	42.7	—
	(+) GA	61.0	61.4	59.2	48.4	50.6	18.5
7	Control	45.4	—	45.4	—	43.4	—
	(+) GA	65.8	44.9	64.7	42.5	52.5	20.9

KI—Kolbach index

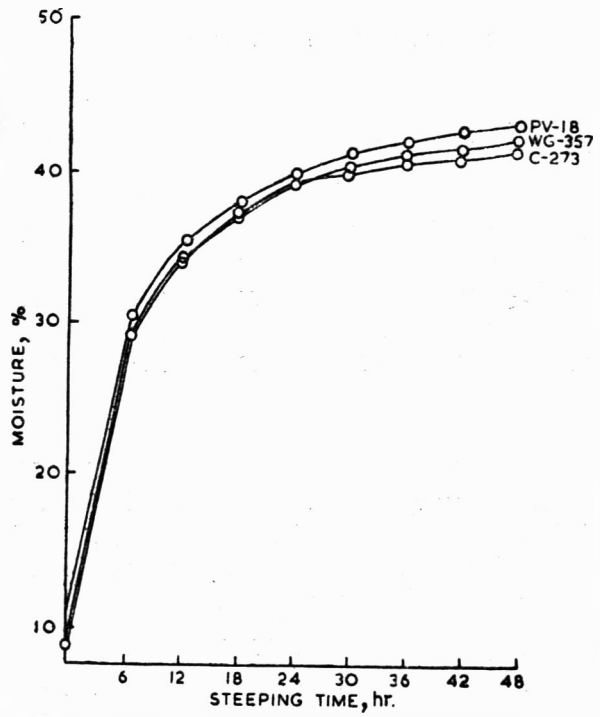

Fig. 1. Moisture uptake (%) of different varieties of wheat steeped in 20°C water.

of 'WG 357' and PV 18' malts, respectively. Greatly increased activity of alpha-amylase in five commercially important US wheats was observed by Jefferson and Rubenthaler[18] using 50 ppm of GA in steep water.

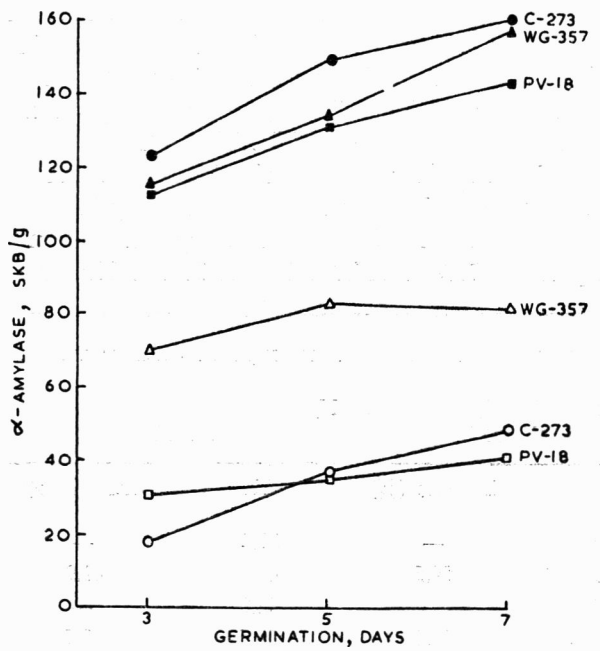

FIG 2 EFFECT OF GIBBERELLIC ACID AND GERMINATION ON THE α-AMYLASE ACTIVITY (SKB) OF WHEAT MALTS

CONTROL GA

There was minor increase in the proteolytic activity of the malts when germinated for 3 and 5 days without GA. Extending germination to 7 days resulted in more than doubling the proteolytic activity of the malts (Fig. 3). Under similar conditions, 'C 273' malt develcped relatively higher proteolytic activity than those of 'WG 357' and 'PV 18'.

The beneficial effect of GA generating higher amylolytic and proteolytic activities of wheat malts was notable as the treatment improved the malting potential of 'PV 18' which was water sensitive and suffered from poor germination and lower enzyme content as a consequence.

Extract yields: The cold water extracts of the 3-day malts of 'C 273' and 'PV 18' wheats increased by about 60 per cent due to GA as compared to 15 per cent of 'WG 357'. The hot water extracts of the varieties increased uniformly when GA was applied. The yields of extract were maximum (Table 4) in 3-day GA malt but declined in 7-day germinated malts of 'C 273', 'WG 357' and 'PV 18' by 0.5, 1.9 and 3.4, per cent, respectively. Comparatively, the increases in cold water extracts were more conspicuous than in the hot water extract of malt, though GA contributed to improve the overall yields. The cold water extracts of GA malt showed hardly any relation to the hot water extracts. The cold water extract determination is recommended by IOB method[11] as an index of potential extract yield of barley malt.

Wort quality: Conversion time of control malts when mashed under specified conditions of the test were generally found high for all the three varieties

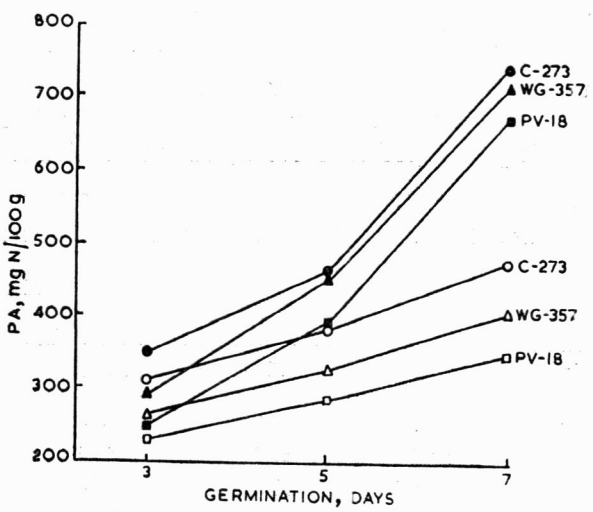

FIG. 3 EFFECT OF GIBBERELLIC ACID AND GERMINATION TIME ON THE PROTEOLYTIC ACTIVITY (PA), mg N/100g OF WHEAT MALTS

CONTROL GA

(Table 5). However, there was a decrease of conversion time from 25 to 14 min in case of 3 and 7 days malts of 'C 273' whereas practically no change occured for the corresponding malt of 'PV 18'. Reduction in the conversion time due to GA in the 3-day malts from 25 to 7 min and from 11 to 5 min was in contrast to that of 'PV 18' malt showing decrease from 15 to 10 min. The conversion time of 'PV 18' malt was higher than those of 'C 273' and 'WG 357'. The worts were clear in all cases but those of GA treatment being slightly more coloured. The speed of filteration was also normal. Soluble nitrogen in the extracts increased substantially in the GA-malts as germination was extended. The 7-day malts had more soluble nitrogen irrespective of variety (Table 5). The increases varied from 59.0 to 44.8 per cent, 52.5 to 38.6 per cent and 43.7 to 20.4 per cent between the 3-and-7-day malt of 'C 273', 'WG 357' 'PV 18' varieties, respectively, when GA was used.

From the Kolbach index values (Table 6) which expresses the degree of modification, it is inferred that with the extension of germination from 3 to 7 days, the values appreciated significantly. The GA-malt values perceptibly exceeded the values of the control malts without GA. Thus, for the 3-day malts of 'C 273', 'WG 357' and 'PV 18', the values were 33.0, 32.3 and 33.2, respectively, which increased to 52.9, 49.9 and 47.1, respectively by GA treatment. An index of 33 is considered adequate for yeast activity in brewing but the values increased considerably as germination was extended to 7 days. In the case of 'C 273' and 'WG 357', GA-malts the increases were higher with the malt of 'PV 18'.

From the foregoing discussion, it seems that wheat malt of greatly improved enzymatic activity, relatively greater yield can be obtained by using GA and restricting germination to 3 to 5 days at 20°C. To obtain malts of high proteolytic activity, the duration of germination can be extended without affecting the malt and extract yields. The investigation has shown that varietal interactions with the malting conditions and GA were apparent. It should be possible to produce malt of desired quality by using GA, even though the germination capacity of wheat may not be as high as normally desired in barley for malting.

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Determination of the Optimum Stage of Maturity of Nendran Bananas for the Preparation of Deep-Fat Fried Chips

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Studies were undertaken to determine the optimum stage of maturity of Nendran (*Musa paradisiaca* Var *Nendran*) banana for the preparation of fried chips. From the physico-chemical data and deep-fat frying trials conducted for the preparation of fried chips during two years, 1972 and 1973, it was inferred that the bananas harvested between 85 and 95 days after the emergence of inflorescence are most suitable for deep-fat frying, into chips. The pulp to peel ratio serves as a good index of maturity. A ratio of 1.71 or more indicates that the banana attained the required maturity for the preparation of chips. The pulp to peel ratio steadily increases with the maturity of the fruit.

The fully matured bananas suitable for deep-fat frying will have a β-carotene content of about 2000 μg/100 g. pH of 5.8 and reducing sugar content of less than 1.5 per cent. The browning in deep-fat fried chips occur when the sugar content is more. A superior product with bright yellow colour is obtained when fried at suitable stage of maturity.

Nendran banana (*Musa paradisiaca* var-*Nendran*) chips are very popular in Kerala State and are processed by deep-fat frying of fully matured unripe bananas. The salted fried banana chips are in good demand for internal and export markets. In the earlier communication[1] a critical study of factors governing quality of Nendran banana chips has been reported. The quality and yield of banana chips depends mainly on the stage of maturity at which the bananas are harvested for deep-fat frying. There is very little published information on this aspect. Hence, systematic studies were undertaken on physico-chemical changes taking place during development and maturation of Nendran bananas and also during deep-fat frying to determine the optimum stage of marutiy for the production of quality chips.

Materials and Methods

Raw material: Eighty Nendran banana plants were tagged during July and August 1972 and subsequently during May and June 1973 at Banana and Pineapple Research Station, Kannara. Tagging was done when the inflorescence was about 40-45 cm long and had just begun to bend downwards. Fruit bunches were picked from 6 plants at random at each picking date, commencing from 60 days after inflorescence, and at every 5-day interval till the banana reached the splitting stage (ripe stage) which at 100 days after the emergence of inflorescence.

Physico-chemical studies: The changes in physical and chemical composition of banana fingers during development and maturation and their suitability for the preparation of fried chips were then studied as follows:

Samples of 3 bananas were drawn from the second row of each of the six bunches to determine the length, circumference, weight of fruit, peel and pulp. The pulp from the same sample was used for the analysis of moisture, starch, total titrable acidity, pH[2], total extractable colour[3], reducing, non-reducing and total sugars[4] The data were recorded upto 100 days after the emergence of inflorescence, when the fruit started ripening and splitting.

Deep-fat frying of chips: Twelve bananas, two each from six of the bunches were picked at random and the chips were fried in coconut oil as follows:

The banana fingers were hand peeled by stainless steel knives and sliced to 1.75 to 2.00 mm thick by an adjustable stainless steel hand slicer. Chipping was done directly over the coconut oil in the frying pan at 160-170°C when the oil reached the smoke point. Frying medium: material ratio was 4:1. Common salt at the rate of 0.6 per cent (w/w added as 20 per cent aqueous solution) was sprinkled over the frying chips in the pan towards the end of frying (after about 4 min of the total frying time of 5 min for 500 g batch). The fried chips were removed from the frying pan drained off the oil and immediately packed in air tight tin containers.

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TABLE 1. PHYSICAL CHANGES OF NENDRAN BANANA DURING DEVELOPMENT, MATURATION AND RIPENING IN 1973 SEASON CROP*

Days after inflorescence	Weight (g)	Length (cm)	Circumference (cm)	Pulp/peel ratio
60	114±3.3	23.3±0.5	11.2±0.2	1.23±0.02
65	117±1.2	23.6±1.5	11.5±0.8	1.35±0.02
70	121±2.2	24.2±0.8	12.0±0.2	1.36±0.02
75	136±1.8	23.6±0.4	12.0±0.6	1.42±0.02
80	138±2.3	24.3±0.4	12.1±0.4	1.52±0.03
85	145±2.7	24.2±0.6	12.5±0.5	1.64±0.02
90	162±3.8	24.2±0.7	13.0±0.4	1.75±0.02
95	177±4.9	24.6±0.8	13.2±0.6	1.77±0.03
100	189±4.6	25.3±0.7	13.4±0.5	1.95±0.03

*Mean of six replications; three bananas in each replication Mean±S.E. Em.

Results and Discussion

Physical changes: Data regarding the changes in weight, length and circumference of Nendran banana fruit during development and maturation in 1973 crop are presented in Table 1.

The average weight of fruit increased from 114 g at 60 days after inflorescence to 177 g at 95 days. The increase in weight of the fruit during maturation was statistically significant at 5 per cent level. On reaching the 100th day, the fruit started splitting and the fruits within the same bunch were at different stages of ripeness

The mean length of the fruit increased from 23.3 cm at 60 days to 24.6 cm at 95 days. The increase in length of the fruit during this period was significant at 5 per cent level. The circumference of the fruit was found to increase during development and maturation from an average of 11.2 cm at 60 days to 13 2 cm at 95 days. But this was not significant at 5 per cent level.

The average pulp to peel ratio was 1 23 at 60 days and there was a steady increase to 1.77 at 95 days (Table 1) There was significant change in pulp to peel ratio during maturation at 5 per cent level. It further rose to 1.84 at 100 days maturity to 1.92 at pale yellow stage and to 2.06 at ripe/yellow stage. Since there is a steady change in pulp to peel ratio during development and maturation, it may serve as a fairly good index for fixing maturity.

Chemical changes: Data regarding the changes in important chemical constituents of Nendran banana during development and maturation are presented in Table 2.

TABLE 2. CHANGES IN CHEMICAL COMPOSITION OF NENDRAN BANANA DURING DEVELOPMENT, MATURATION AND RIPENING IN 1973 SEASON CROP

Days after inflorescence	Moisture %	Acidity w/w %	Starch %	Reducing sugars %	pH of pulp	Total carotenoids β-carotene μg/100 g
60	61.4±0.3	0.07±0.00	35.5±0.5	N.D.	6.0±0.00	200±6
65	61.5±0.3	0.08±0.00	35.4±0.4	N.D.	5.9±0.00	250±16
70	61.5±0.4	0.08±0.00	35.0±0.4	N.D.	5.9±0.00	450±26
75	60.6±0.3	0.08±0.00	36.0±0.6	0.37	5.9±0.1	1318±28
80	60.1±0.5	0.08±0.00	36.1±0.6	0.43	5.8±0.1	1673±62
85	60.9±0.4	0.08±0.00	35.5±0.5	0.63	5.9±0.1	2033±50
90	60.7±0.3	0.08±0.00	35.2±0.4	0.93	5.9±0.1	2200±69
95	62.0±0.6	0.08±0.00	33.6±0.6	1.19	5.8±0.0	2333±57
100	63.7±0.5	0.16±0.07	29.57±1.4	3.67	5.3±0.3	2550±43

N.D. = Not done. Mean±S.E. Em.

TABLE 3. QUALITY EVALUATION OF NENDRAN BANANA CHIPS FRIED AT DIFFERENT STAGES OF MATURITY

Quality	Days after inflorescence								
	60	65	70	75	80	85	90	95	100
Appearance	Not uniform	Not uniform	Not uniform	Not uniform	Fairly uniform	Uniform	Uniform	Uniform	Not uniform
	Dull	Dull	Dull	Dull	Fairly bright	Bright	Bright	Bright	Dull brown
Size	Small	Small	Small	Small	Small	Normal	Normal	Normal	Normal
Colour	Light yellow	Light yellow	Light yellow	Light yellow	Yellow	Bright yellow	Bright yellow	Bright yellow	Brown unattractive
Aroma & taste	Not Normal, starchy	Not Normal, starchy	Not Normal, starchy	Not Normal, starchy	Fairly Normal	Normal	Normal	Normal	Sweetish Not normal
Texture	Crisp	Crisp	Crisp	Crisp	Crisp	Crisp	Crisp	Crisp	Crisp
Organoleptic score									
Max	32	32	42	43	63	84	85	84	42
Min	27	28	36	37	56	75	76	76	35
Mean	30	30	40	40	60	80	80	80	40
Overall quality	Poor	Poor	Fair	Fair	Good	V-good	V-good	V-good	Fair

*Score for acceptability = 55 in all cases.

There was no substantial change in moisture content of pulp which ranged between 60 and 62 per cent, while that of the peel ranged between 85.1 and 86.5 per cent.

The acidity of the fruit pulp which increased by 0.01 per cent during 60 to 95 days of maturity rose to 0.17 and 0.23 at the light yellow and deep yellow ripe stages respectively.

The starch content of the fruit ranged between 35 and 36 per cent during development and maturation upto 90 days, there after it decreased with a corresponding increase in sugar content. A noticeable drop in the starch content was observed during ripening.

There was an increase in reducing sugars from 0.37 per cent at 75 days maturity to 1.19 per cent at 95 days maturity and they further increased during ripening and reached 5.5 per cent when the skin of the fruit was yellow in colour. The increase in reducing sugars was significant at 5 per cent level. The non-reducing sugars appeared only during ripening stage i.e. after 95 days.

The decrease in pH of the fruit pulp was very little during development and maturation; it further decreased during ripening or yellowing. The pH was 5.2 in light yellow fingers and 5.0 in yellow fingers as compared to 6.0 at the initial green stage of development and maturation.

The total colour of the fruit increased during development and maturation. The total colour of the pulp expressed as β-carotene was found to increase from 200 μg/100 g at 60 days to 2320 μg/100 g at 95 days maturity (Table 2). The increase in total colour during development and maturation was statistically significant at 5 per cent level. Thus, the total colour of the pulp may also serve as a good index for fixing maturity of Nendran banana for frying purposes.

Frying trials: Quality of banana chips fried from banana of different stages of maturity are presented in Table 3. At 60 and 65 days maturity, the chips were small and did not have the normal yellow colour. They also gave rather starchy taste. The chips from the fruits at 70 and 75 days were more or less of the same quality or slightly better. The chips fried from bananas at 80 days had improved colour and taste while the chips from bananas at 85 days maturity and onwards, had attained the normal size, colour, texture, aroma and taste. At 100 days maturity, however, the yellow bananas were unfit as browning of chips as a result of increase in sugars in the pulp and other browning reactions was observed. Similar observations were made in 1972 season crop also.

Acknowledgement

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Studies on the Physico-Chemical Characteristics of Fresh Curd (*Dahi*) and Rehydrated Freeze Dried Curd Powder Gels

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The properties of the curd (dahi) and curd powder gels have been compared from the isopiestic study of water vapour adsorption at two different temperatures. From the comparison of the adsorption and desorption curves of one kind of such gels, the appearance of hysteresis due to the irreversible nature of the gel structure is observed in the wide range of relative vapour pressure. At a given pressure, the hydration of fresh curd is always higher than that of curd powder. From the BET plot, the specific surface area of the fresh curd in the gel is found to be roughly twice the value of that for the curd powder. From a comparison of the adsoration-isotherms the values of surface area free energy change, enthalpy change are found to be higher in case of fresh curd gel than that for curd powder gel at two different temperatures and these value also indicate that the interaction of the water at the gel interface is purely physical in nature.

The evaluation of various drying methods for production of curd powder have been discussed in earlier paper[1]. It has been seen that the fresh curd gel (dahi) and the curd gel obtained after hydration of freeze dried curd powder differs considerably in their texture and other physico-chemical properties. Exact representation of the original curd by hydration of curd powder thus seems to be very difficult.

Considerable literature has been accumulated on the adsorption of water vapour on a porous solid such as sillica gel, solid protein, solid cellulose etc. Also experiments were conducted on the adsorption of water vapour by wheat flour and its dough rising capacity as related with its protein content, particle size, ash content etc[2-6].

The entire phenomena of formation of curd gel obtained either by fermentation of milk or by the hydration of dried fermented milk curd depends upon the interaction of water with the protein of milk, which in cross-linking and existence of turn depends upon the surface area exposed, degree of cross linking and existence of capillaries. An attempt has, therefore, been made to account for the sorptive capacity of curd powder on the basis of their physical and chemical structure. The present study also revealed the significant difference between the two types of gels.

Materials and Methods

Preparation of fresh and rehydrated freeze dried curd powder gels: The fresh curd was prepared from whole milk inoculated with *S. thermophilus* as described by Baisya *et al*[7]. Reconstituted freeze dried curd powder gel was obtained by the process described by Baisya *et al*[7]. Fresh curd and freeze dried curd were directly used for the water vapour adsorption study.

Water vapour adsorption study: The isopiestic

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method of measurement of water uptake is based upon the procedure described by Bull and Breese[8] and Chattoraj and Bull[9] and was described in the earlier paper[7].

Results and Discussion

In figure 1 & 2 water vapour adsorption and desorption curves at 20°C for the fresh and rehydrated curd powder gels were compared. In the adsorption experiment water vapour was transferred from the reference solution to the gel attaining isopiestic equilibrium. In the desorption experiment, water vapour from the gel was transferred to the reference solution under this condition. Each curve is sigmoid in shape and may be classified as type II isotherms according to the theory proposed by Braunaer. Emett and Teller (BET). The sigmoid shape according to this theory is expected if the adsorbed water in the gel forms multilayers[10]. In the range of relative humidity 0.3 to 0.9 the adsorption and desorption curves in both types of gels are observed to differ from each other in a significant manner. This is related to the occurence of hysterisis phenomena and the gel structure in this range is not reversible in nature. In the case of pure protein gels such irreversibility[8] occurs only in the range of 0.3 to 0.75. In the curd gel, the milk protein is mixed with other substances like fat, carbohydrates etc. and possibly due to this, the irreversibility property of the gel network has been extended to wider range of vapur pressures.

From the comparison of the adsorption curves, it appears that the water binding capacity of fresh curd at a given p/p_o is always considerably larger than that of the curd obtained from the rehydration of the powder. In the fresh curd, the proteins remaining in native folded form is possibly able to form gel network such that it can imbibe more water in the pores and swell more. In the other hand, during curd dehydration the milk protein may be unfolded and partly denatured due to drastic treatment. The gel formed with the treated protein may lose its capacity to bind more water because of the decrease in the strength of the cross links. According to the BET equation[10].

$$\frac{P/P_o}{x(1-P/P_o)} = \frac{1}{x_m C} + \frac{C-1}{x_m C}\frac{P}{P_o} \qquad \ldots\ldots(1)$$

where xm and C are BET constants. A plot of $\frac{P/P_o}{x(1-P/P_o)}$ against P/P_o both for fresh and rehydrated curd powder gels are shown in figure 3. From the slopes and intercepts of these plots, the xm and C are 0.03 and 14.9 for dehydrated curd whereas corresponding values of these quantities for fresh curd gels are 0.054 and 74.6 respectively. Assuming the cross sectional area of the water molecule to be 10.9 square °A[11] the surface area of these two types of gels are found to be $107.4m^2$/gm and $193.00m^2$/gm respectively. The high value of C obtained in case of fresh curd gel from BET plot is expected in case where energy of adsorption (E_1) is several times higher than the latent heat of condensation (E_2) and that with such a large value of C the intercept is so small (Fig. 3) that it is very difficult to measure it accurately and very little error is introduced if a best straight line through the origin is drawn and the intercept is taken as equal to $1/xm$[12,13]. The surface area in this case is thus estimated both from the intercept of the BET plot as well as by taking slope as $1/x_m$ and both give nearly equal value.

The constant C in the BET equation is related to heat of adsorption in the first adsorbed water layer in the gel (E_1) and latent heat of condensation (E_2) by the following equation[14].

$$C = e^{(E_1 - E_2)/RT} \qquad \ldots\ldots(2)$$

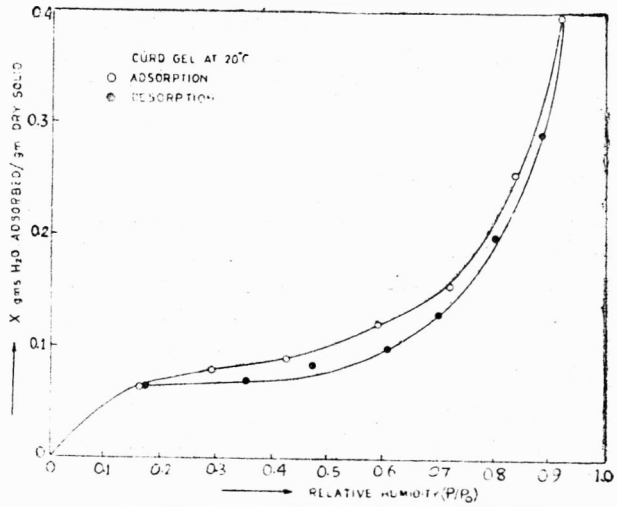

Fig. 1. Adsorption of water vapour by curd (dahi) gel for different values of relative humidity (P/P_o) at 20°C.

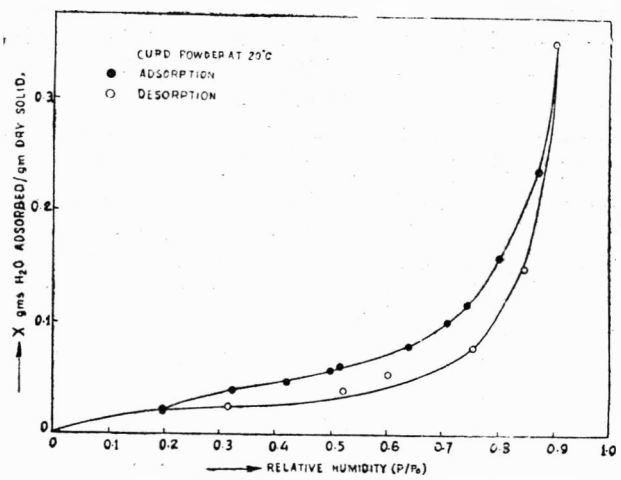

Fig. 2. Adsorption of water vapour by curd powder gel for different values of relative humidity (P/P_o) at 20°C.

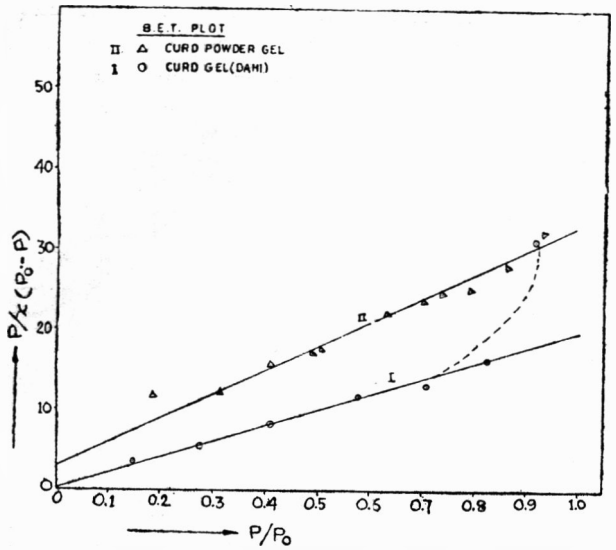

Fig. 3. BET plots for curd powder and dahi gels at 20°C.

The values of E_1 are calculated to be 11.30 K cals/mole and 12.33 K cals/mole for curd powder and fresh curd gel respectively. This low value indicates that the adsorption is physical in nature.

Since curd gel is a swelling system, its surface area determined by the BET method should be checked, by the alternative Harkins and Jura[15] method (HJ) also. The equation for this is—

$$\log \frac{P}{P_o} = B - \frac{A}{V_2} \qquad \ldots\ldots(3)$$

Where V is the amount of adsorbate taken at any pressure P and A and B are constants. A plot of log P/P_o against $1/V^2$ indicates a linear relation between them (Figure 4) over an appreciable range of vapour pressure. For fresh curd gels it gives single straight line over the entire range. The specific surface area (S) of the adsorbent in HJ plot is given by:

$$S = KA^{\frac{1}{2}} \qquad \ldots\ldots(4)$$

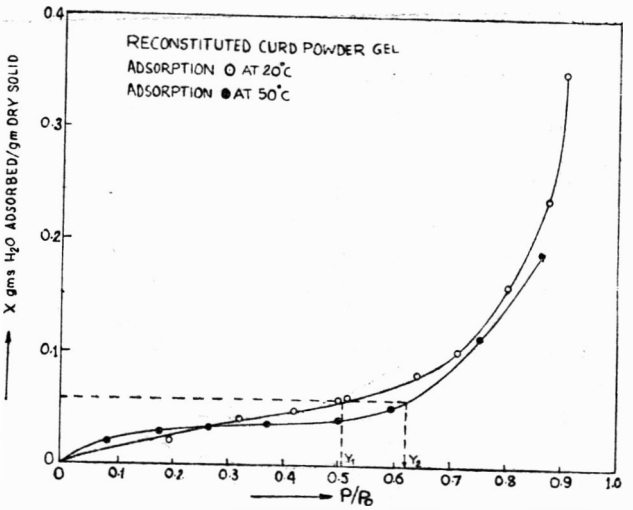

Fig. 5. Water vapour adsoprtion isotherms for curd powder gel at 20° and 50°C.

Where K, the constant for water vapour[16] is taken as 3.83. The surface area for the curd powder are found to be 128.1 m^2/gm and 159.1 m^2/gm respectively for lower and higher pressure regions and the corresponding value for fresh curd gel is 289.2 m^2/gm. The discrepancies of the results calculated in two systems may be related with the swelling of the gel system and also on the

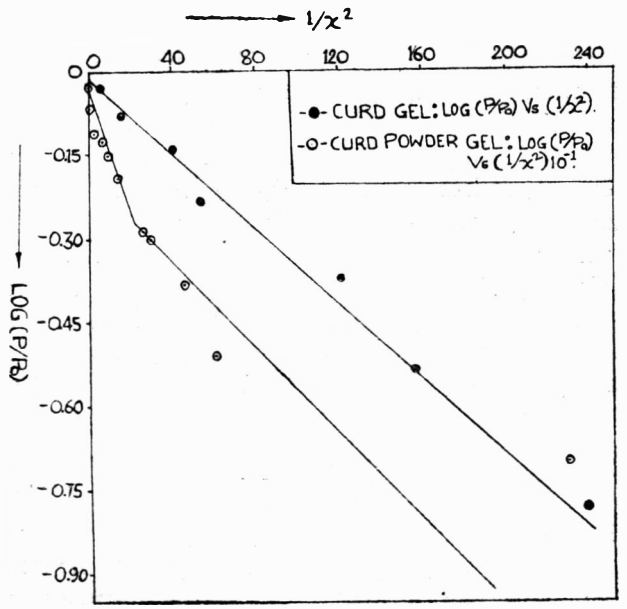

Fig. 4. Harkins and Jura plot for curd powder and dahi gels at 20°C.

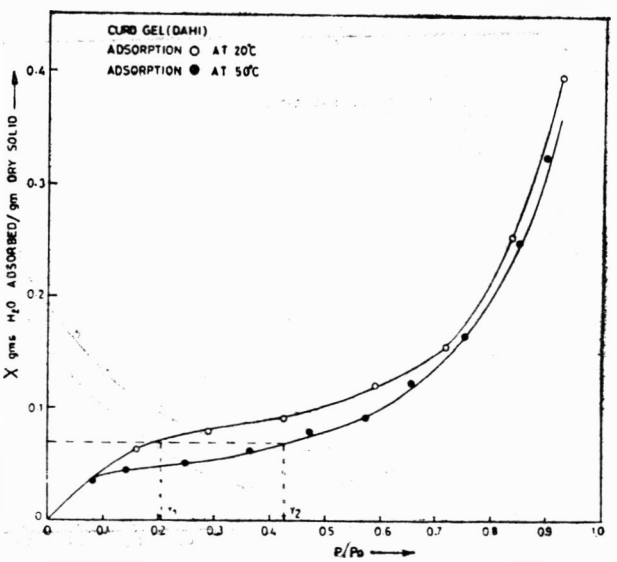

Fig. 6. Water vapour adsorption isotherms for curd (dahi) gel at 20° and 50°C.

different assumptions involved in BET and Harkins Jura Concepts. The equilibrium curve for adsorption of water vapour by curd powder and fresh curd gel at 50°C are shown in figure 5 and 6 respectively. For curd gel the value of x at a given value of P/P_o is observed to decrease significantly with increase of temperature. The same behaviour is also observed for the curd powder

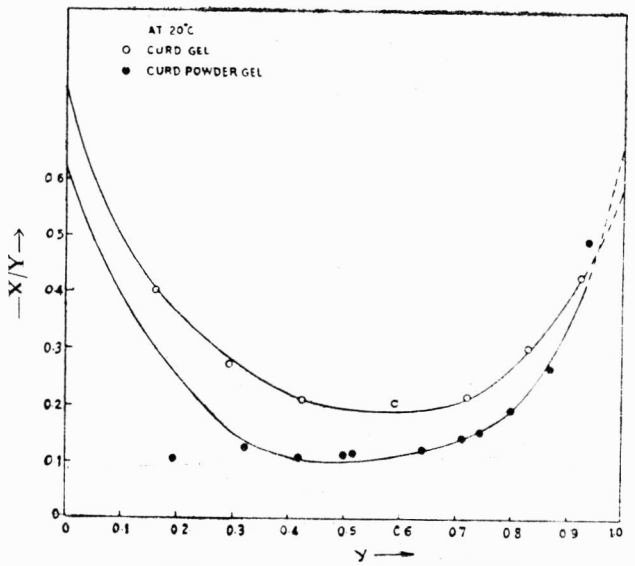

Fig. 7. Plot of X/Y Vs Y for curd (dahi) and curd powder gels at 20°C.

gel provided the relative vapour pressure is higher than 0.25. This again indicates that the major contribution for the adsorption in the curd gel originates from the extensive physical interaction of water with proteins.

Again an isothermal process involving the transfer of water from vapour state to the surface of the adsorbent,

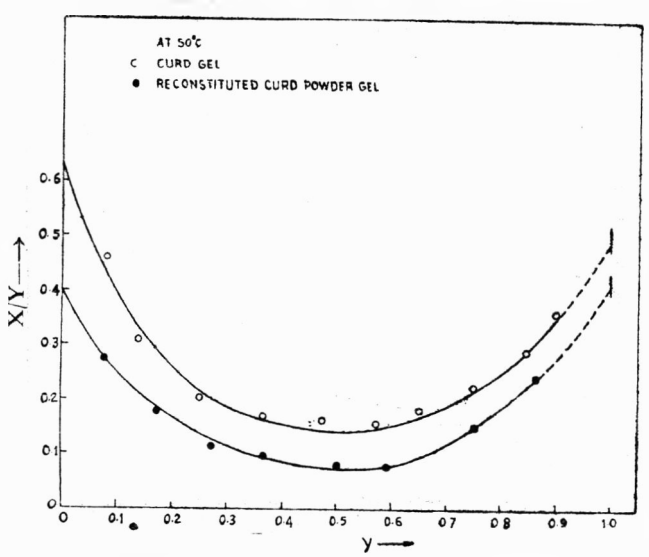

Fig. 8. Plot of X/Y Vs Y for curd (dahi) and curd powder gels at 50°C.

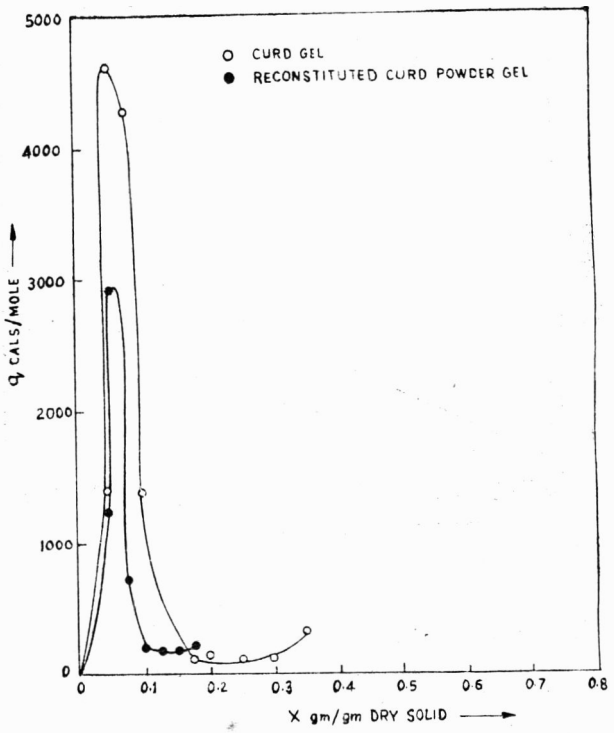

Fig. 9. Plot of q Vs X for curd (dahi) and curd powder gels.

the free energy change, which is usually taken as a measure of the affinity of the adsorbent for the vapour and is given by the equation[17].

$$\triangleleft G = \frac{RT}{M} \int_0^1 a \frac{dy}{y} \qquad \ldots\ldots(5)$$

where 'a' is the amount adsorbed at a relative vapour pressure 'y' and R,T,M have their usual significance. In order to integrate the above equation x/y is plotted against 'y'. The area under the curve (determined by planimeter) is multiplied by RT/M value. The values of free energy change at 20°C for curd powder and fresh curd (Fig. 7) have been calculated to be—7.82 cals/gm and 10.58 cals/gm. respectively. The corresponding free energy change at 50°C (Fig. 8) are found to be—6.56 cals/gm and −10.43 cals/gm for curd powder and fresh curd gel respectively. These values again are not sufficiently high to indicate any chemical interaction.

The heats of hydration of the protein gel can be calculated by the use of Clausius Clapeyron equation and by graphical integration.[17] The partial molal heat of hydration can be written as:

$$-q = \frac{d \triangle H}{d \times} = \frac{RT_1 T_2}{T_2 - T_1} ln \frac{y_1}{y_2} \qquad \ldots\ldots(6)$$

where V_1 and V_2 are relative vapour pressures at temperatures t_1 and t_2 respectively which produce the same extent of hydration of the protein. If 'q' is plotted against 'x' and the area under the curve measured, the integral heat of hydration is found. The curve for 'q' against

TABLE 1. SUMMARY OF THE COMPARISON OF FRESH CURD AND RECONSTITUTED CURD POWDERS-GELS

Curd gel samples	Constant C of BET equation	Monolayer capacity Xm (gm/gm)	Energy of adsorption in first layer from BET concept (K cals/mole)	Surface area (S) from BET plot (m^2/gm)	Surface area (S) from HJ plot (m^2/gm)	Free energy change ($\triangleleft$ G) at 20°C (Cals/gm)	Free energy change ($\triangleleft$ G) at 50°C (Cals/gm)	Change in enthalpy ($\triangleleft$ H) (cals/gm)
Fresh curd gel	74.6	0.054	12.23	193.00	289.2 (produces a single straight line)	–10.58	–10.43	–17.1
Reconstituted freeze dried curd powder gel.	14.9	0.030	11.29	107.4	159.1 (at higher pressure) 128.1 (at lower pressure)	– 7.82	– 6.56	– 7.4

'x' for both reconstituted curd gel and fresh curd gel is shown in Figure 9. The values of $\triangleleft$H found for fresh curd gel and curd powder gel to be—17.1 cals/gm and –7.4 cals/gm respectively.

A summary of comparison of physico-chemical properties of these two types of gels is shown in Table 1. From a comparison of these two types of gels it appears that fresh curd gel is offering more surface area and hence more swelling. Also it is noted that both $\triangleleft$H and $\triangleleft$G for fresh curd gel are higher in magnitude than those for the curd powder gel. It may be concluded, therefore, that the thermodynamic and physico-chemical properties of these two types of gels significantly differ from each other because of the possible difference in the gel structure. The qualitative conclusions derived from the above analysis are based on the assumptions that the compositions of the dry solids in the two types of curds are not different.

Acknowledgement

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Effect of Feeding Methyl Iodide Fumigated Groundnuts on Growth of Albino Rats

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Methyl iodide (MeI) fumigated groundnuts (dosed at 32 mg/L with an exposure of 48 hr) containing 0.38 ppm of physically bound (free) MeI residue, were incorporated into two diets at 12 and 18% protein levels. 21-day old male albino rats (Wistar strain) were fed *ad libitum* on diets for 2 months. Protein efficiency ratio (PER), Food efficiency ratio (FER), Relative growth rate (RGR) and Germ plasm vs. somatoplasm ratio (GSR) were calculated and statistically compared with controls. MeI fumigation did not alter the nutritive value of groundnuts. Histopathological studies revealed no damage to kidney, liver, thyroid and testes.

Methyl iodide (MeI) has been shown to be an effective fumigant for the control of stored products insects.[1] It has also been used in controlling microflora in sorghum.[2] Earlier studies[3] have shown that oil seeds and nuts fumigated with MeI retain high residues as the oil acts as a solvent and protein can bind with MeI chemically. The toxicity of MeI to rats has been reported by Johnson,[4] who administered it orally to determine the LD_{50} and the metabolic pathways of its degradation in the animal. However, no studies appear to have been made on the effect of MeI residue in the diet, when used as a fumigant, for insect control. Here we report the results of a short-term study on the effect of MeI residues in fumigated groundnuts when fed to rats.

Materials and Methods

Groundnuts (8 per cent moisture) were fumigated in desiccators at an insecticidally effective dosage of 32 mg/l for 48 hr.[3] at 27.5°C, followed by two weeks' aeration. Physically bound MeI residue was estimated colorimetrically using the catalytic action of iodide on the oxidation of arsenic (As^{+3}) by cerium (Ce^{+4}) after eluting with ice-cold methanol[5].

Diet composition: The compositions of the unfumigated and fumigated diets used were as follows: (1) Casein 10 per cent and groundnut 25 per cent to provide 18 per cent protein in the diet and (2) groundnut at 37.5 per cent to provide 12 per cent protein in the diet; salt mixture, 2 per cent[6]; vitaminised starch 1 per cent[7] vitaminised oil, 1 per cent (containing vitamin A, D and E); and corn starch to make upto 100 per cent.

Rat feeding experiments: The effect of MeI residues was assessed by the rat growth method of Osborne *et al*,[7] as modified by Chapman *et al*.[8] Thirty two 21-day old male albino rats (Wistar strain) were randomly divided into four groups and fed on these diets for eight weeks. The dry uncooked diet was given *ad libitum*. The weights of rats and food intake were recorded every week. The protein efficiency ratio (PER) (gain in weight/g. of protein intake) was calculated at the end of four weeks[7]. The total intake of MeI, as physically bound residue (pbr) was computed. The other indices calculated (for two months) for the growth performance of rats were Food Efficiency Ratio (FER) (gain in weight/g of food intake) and Relative Growth Rate (RGR) (gain in weight/day/g of weight already attained). Germ plasm *vs.* somatoplasm ratio (GSR) (testes weight/g. body weight) was calculated to see whether the MeI residues affected the testes.

Histopathology: At the end of the studies, all the rats were killed and their liver, kidney and thyroid glands were examined histologically. Testes were examined for effects on spermatogenesis.

Results and Discussion

Rat feeding experiments: Although the pbr of MeI was estimated in the groundnuts, the rat-feeding trial was expected to show the total effect produced both by pbr and cbr (chemically bound residue) left in the groundnut after aeration. The free MeI residue found in fumigated groundnuts after aeration was 0.38 ppm. The calculated intakes of MeI by rats for the 18 and 12 per cent protein diets were 9.2 ± 1.5 and 17.7 ± 3.4 μg per kg body weight per day respectively. Table 1 gives a comparative account of the data analysed statistically.

The 4-week PER values showed that fumigation did not alter significantly the gain in weight per gram of protein consumed whether a 18 or 12 per cent protein diet was provided. The PER and RGR values of the two groups did not differ significantly.

The germplasm percentages were similar indicating that it is unlikely that the fumigated groundnuts would affect the growth of germplasm (testes).

TABLE 1. RESPONSE OF RATS FED ON GROUNDNUTS FUMIGATED WITH METHYL IODIDE

Diet	Initial wt. (g)	Gain in wt. (g)		Protein intake (g)	Food intake (g)	Total residue intake	MeI (pbr) (μg)	PER		RGR	GSR
		4 wk.	8 wk.	4 wk.	8 wk.	4 wk.	8 wk.	4 wk.	8 wk.	8 wk.	8 wk.
Unfumigated groundnut diet with 18% protein (groundnut 25%)	38.8	108.0	190.6	48.8	686.5	—	—	2.11 ±0.20	0.28 ±0.03	0.19	0.11 ±0.01
Fumigated groundnut (Diet as above)	38.8	97.75	183.0	46.5	692.0	24.8 ±2.1	64.5 ±6.3	2.14 ±0.21	0.29 ±0.09	0.19	0.11 ±0.02
Unfumigated groundnut diet with 12% protein (groundnut 37.5%)	38.8	34.43	76.2	23.2	456.2	—	—	1.30 ±0.60	0.17 ±0.05	0.14	0.09 ±0.07
Fumigated groundnut (Diet as above)	38.8	32.62	76.2	23.4	464.8	27.6 ±3.8	66.8 ±6.8	1.30 ±0.26	0.16 ±0.06	0.13	0.10 ±0.06

No pathological changes were observed in liver, kidney and thyroid glands of rats receiving the fumigated groundnut diets. The histological picture of these organs was normal and similar to that of control animals.

The histology of the testes of rats of the treated group was normal, resembling the control group. All the stages of spermatogenesis were observed in the germinal epithelial lining of seminiferous tubules. The lumina of the seminiferous tubules were full of spermatozoa. The microscopic appearance of spermatozoa was normal.

Majumder *et al.*,[9] reported 12 per cent reaction of methionine with MeI compared to 52 per cent with methyl bromide (MeBr), i.e., the extent of reaction of methionine with MeBr is 4.3 times greater than MeI. The possible reaction product (cbr) of MeI with food commodities may be methylated amino acids and inorganic iodides. MeI would also occur as pbr sorbed on the surfaces due to Van der Waal's forces. The rats fed fumigated groundnut diet could be assumed to have been exposed to the total residue (i.e., pbr plus cbr) of MeI.

Johnson[4] in his oral toxicity studies of MeI on rats concluded that repeated daily doses of even 30-50 mg of MeI per kg body weight were without adverse effect. As regards the toxicity of inorganic iodide, the toxicity rating of iodide salt is 3 i.e., moderately toxic.[10] Iodide salts do not share the known erosive action of free iodine, and no human fatalities are known after a single oral dose of the common iodide salts. Ten gram of sodium iodide have been given slowly by the intravenous route without ill effects.[10]

The results of our short term study have shown that it is unlikely that MeI fumigated groundnuts will produce any toxic effect as evidenced by either growth or fertility of male albino rats. Even the higher intake of MeI in the 12 per cent protein diet had no toxic effect. The nutrivive value of the groundnuts were apparently not affected by the treatment.

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Determination of Optimum Dose and Anion-Cation Ratio of the Nutrient Medium for the Growth of *Morchella* Sp. in Submerged Culture

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The growth, in terms of dry weight of *Morchella* sp. was studied in a medium composed of six major elements—N,S,P,K,Ca and Mg by varying nutrient dose level and anion-cation ratio. Pattern of growth followed cube root law. Biomass increased from the third, day upto seventh day and then slowed down. A dose of 500 m. eq./lit. and anion-cation ratio of 0.9 of the nutrient medium was found to be optimum, dose while a higher dose upto 1000 m. eq./lit. and anion-cation ratio ranging from 0.8 to 1.0 did not significantly affect the yield.

Studies on submerged fermentation of mushroom-mycelium *Morchella* sp. in particular, as a source of 'food with flavour' is gaining importance.

To attain a high quality and quantity of mycelial mass, ideal nutritional and cultural conditions are to be provided. Some reports are seen on the influence of nutrient concentration on biomass and the nature of biomass. An increase in total concentration of medium gave a corresponding increase in yield with *Aspergillus niger*,[1] but the increase was not proportional with *Chaetomium convolutum*.[2] A decrease in average cell size of *Bacillus megatherium* was also noticed with a decrease in concentration of nutrients.[3] Dagley and Hinshelwood[4] found that in bacterial cultures, the rate of growth is independent of concentration of nutrient materials over a wider range, while the final crop is directly proportional to the concentration The effect of a complete nutrient medium on the growth of an organism is a combination of two largely independent factors, that is the total amount of nutrients and the relative proprotion of each nutrient in the total.

In a balanced nutrient medium composed of major elements as N,S, P,K,Ca and Mg, anions and cations form two natural groups[6]. Optimisation of anion-cation ratio forms an important step in arriving at a complete nutrient medium. While working with *Aspergillus niger*, Rosselet[5] found 160 m.eq/l. of nutrients as optimum total concentration and 0.2 as the optimum anion-cation ratio of the nutritents in the medium.

Eventhough some reports were published on bacteria and microfungi, no report is seen on the establishment of inter ionic relationship and the interaction of major nutrient elements of a medium in mushroom submerged culture. Hence, in assessing nutritional requirements of the organism, *Morchella sp.* Homes method of systematic variation[6] was utilized here because of its proven simplicity and general usefulness[5].

In this study on *Morchella* sp. an attempt was made to work out the optimum anion-cation ratio and also optimum dose required for obtaining maximum yield.

Materials and Methods

The organism, *Morchella* sp. was originally obtained from Himachal Pradesh Agricultural University, Solan, India. The culture is maintained on potato dextrose agar slants by monthly transfers.

Inoculum was prepared from the mycelium grown on 20 ml liquid medium (Table 1) in 250 ml flasks in still culture. The strength of the medium was 500 m. eq/l. and anion-cation ratio was 0.9, and the rest of the culture conditions were same for all the experiments as described below. Five day old mycelial mats from 2-3 flasks were pooled, washed with sterile distilled water and homogenised in Sorvall omini mixer. It was made upto 400 ml with water and 5 ml of this was used as standard inoculum for 100 ml medium. For growth studies, 100 ml of the basal medium (Table 1) was dispersed in 500 ml Erlenmeyer flasks, sterilised at 1.1 kg/cm^2 for 20 min, inoculated and incubated on a rotary shaker at 250 r.p.m. and one inch stroke for 7 days at room temperature (23-27°C).

Five per cent sucrose was used as the carbon source. Among the six major nutrient elements nitrogen, sulphur and phosphorus were supplied as their corresponding acids, HNO_3, H_2SO_4 and H_3PO_4 whereas potassium, calcium and magnesium as their bases, KOH, $Ca(OH)_2$ and MgO. Basing on some of our preliminary data, percent composition of anions N-S-P was fixed as 50-20-30 and cations K-Ca-Mg as 40-30-30 respectively. Trace elements were supplied to the medium by adding

TABLE 1. COMPOSITION OF THE NUTRIENT MEDIUM OF STRENGTH 500 M.EQ/L. AND ANION-CATION RATIO OF 0.9

	No. of m.eq.	Coefficient of purity	Wt./vol. taken per liter
HNO_3	118.5	6.7	50.4 ml.
H_2SO_4	47.4	9.0	20.9 ,,
H_3PO_4	71.1	17.7	41.1 ,,
KOH	105.2	7.1	41.7 ,,
$Ca(OH)_2$	78.9	1.0	2.9 g
MgO	78.9	1.1	1.8 ,,

$$\text{Wt./vol. taken in g/ml.} = \frac{\text{No. of m. eq.} \times \text{wt. of 1 m.eq.}}{1000} \times \text{coefficient of purity}$$

Per litre of the medium 3ml. of trace element solution was added. from a stock solution containing 0.1% each of $FeCl_3$. 6 H_2O; $ZnSO_4$. 7 H_2O; $CuSO_4$. 5 H_2O; $MnSO_4$. H_2O and $NaMO_4$ $2H_2O$, H_2O.

TABLE 2. YIELD PATTERN OF *Morchella* SP. GROWN IN A MEDIUM OF STRENGTH 500 M.EQ./L. AND ANION-CATION RATIO 0.9**

Incubation time (days)	Final pH*	Mean yield (dry wt.) g/100 ml medium
1	5.0	Negligible
2	4.8	,,
3	4.5	0.126 a
4	4.1	0.347 ab
5	4.4	0.475 b
6	4.2	0.847 c
7	4.7	0.932 cd
8	4.3	1.111 de
9	4.3	1.107 de
10	4.5	1.365 f
11	4.5	1.332 ef

*initial pH of the medium was adjusted to 5.0 with NaOH/HCl.
**Means followed by same letters are not significantly different.

3 ml/l. from the stock solution which contained 0.1 per cent each of $FeCl_3$, 6 H_2O_4; $ZnSO_4$, $7H_2O$, $CuSO_4$, 2 H_2O, $MnSO_4$, H_2O and $NaMOO_4$, 2 H_2O.

To optimise the dose of nutrient medium, solutions of six different strengths, varying from 62.5 to 1000 m.eq./l. were prepared by keeping constant the proportions of six major elements and anion-cation ratio 0.9 (Table 3).

Seven different treatments were planned to get anion-cation ratio of the medium between 0.5 and 1.5 keeping the proportions of the six major elements unchanged. Strength of the medium in all of these treatments was 500 m.eq./l. (Table 4).

In order to find out the effect of different elements on the growth and optimum time of harvest, there appeared a necessity to find out growth pattern of the organism. Hence in a medium having anion-cation ratio of 0.9 and a strength of 500 m.eq./l. growth pattern of *Morchella* sp. mycelium was studied. Other cultural conditions were same as described elsewhere.

After completion of the incubation period, the growth medium was filtered and mycelial pellets were washed with water and dried at 60°C for 24 hr.

A minimum of 10 replicates were kept in each treatment. Total soluble solids were measured by refractometer.

Results and Discussion

Growth and growth rate of Morchella: The data on the increase of biomass of *Morchella* is presented in Table 2 show that a measurable amount of growth commenced from the third day of incubation with a rapid increase

TABLE 3. NUTRIENTS AT VARIOUS DOSE LEVELS AND THEIR EFFECT ON THE YIELD OF *Morchella* MYCELIUM IN SUBMERGED CULTURE

Treatment No.	Dose (m. eq./l.)	Composition of major nutrient elements (m.eq.) in medium						Final TSS (%)	Mean yield (g/100 ml).**
		N	S	P	K	Ca	Mg		
1	1000	237.0	94.8	142.2	210.4	157.8	157.8	4.8	2.149 c
2	750	177.7	71.1	106.6	157.8	118.3	118.3	3.4	2.525 d
3	500	118.5	47.4	71.1	105.2	78.9	78.9	2.0	2.297 cd
4	250	59.2	23.7	35.5	52.6	39.4	39.4	3.5	1.216 a
5	125	29.6	11.8	17.7	26.3	19.7	19.7	2.2	1.612 b
6	62.5	14.8	5.9	8.8	13.1	9.8	9.8	3.0	1.071 a
							Std. error 1.094 (18df)		

*initial TSS 5%

**Mean yields followed by same letters are not significantly different

For the calculation of milliequivalent grams, six major elements are taken as nitrate. No. 3/1 = 62; sulphate $SO_4/2 = 48$; phosphate $PO_4 = 31.7$; Potassium K/1 = 39; Calcium Ca/2 = 20 and magnesium Mg/2 = 12.

TABLE 4. DISTRIBUTION PATTERN OF ANIONS AND CATIONS IN THE MEDIUM AND THEIR EFFECT ON THE YIELD OF *Morchella* MYCELIUM IN SUBMERGED CULTURE

Anion cation ratio	Anions	Cations	Composition of major nutrient elements (m.eq) in the medium						TSS Final*	pH		Mean yield** g/100 ml
			N	S	P	K	Ca	Mg	%	Initial	Final	
0.5	166.7	333.3	83.3	33.3	50.0	133.3	99.9	99.9	5	10.0	8.2	0.795 a
0.8	222.2	277.7	111.1	44.4	66.6	11.1	83.3	83.3	2	6.7	8.4	2.322 b
0.9	237.0	263.0	118.5	47.4	71.1	105.2	78.9	78.9	2	5.5	8.2	2.324 b
1.0	250.0	250.0	125.0	50.0	75.0	100.0	75.0	75.0	2	5.2	7.9	2.377 b
1.1	262.0	238.0	131.0	52.4	78.6	95.2	71.4	71.4	5	3.3	6.2	0.928 b
2.2	273.0	227.0	136.5	54.6	81.9	90.8	90.8	68.1	5	2.5	2.5	Traces
1.5	3000.0	200.0	150.0	60.0	90.0	80.0	60.0	60.0	5	2.2	2.1	"

Std. error $\pm$ 0.276 (21 df)

*Initial TSS 5%

**Mean yields followed by same letters are not significantly different.

For the calculation of milli equivalent grams, six major elements are taken as nitrate $NO_3/1 = 62$; sulphate $SO_4/2 = 48$; phosphate $PO_4/3 = 31.7$; Potassium K/1 = 39, Ca/2 = 20 and Magnesium Mg/2 = 12

Strength of the medium 500 m.eq./l.

upto 7th day. There was, however, further increase upto 11th day of incubation although the output was not higher. Maximum yield of 1.365 g per 100 ml medium was observed on 10th day. There is no significant difference between the yields at 10th and 11th day and also between the yields at 7th, 8th and 9th day. The 7th day of incubation was considered as optimum time of harvest.

Fig. 1 shows the plot (dry weight)$^{1/3}$ versus time in days. The straight line obtained shows that the growth follows the cube root law.

$$b = (bi^{1/3} + ct)^3$$

where, b = dry weight at time t;
bi = initial dry weight;
c = constant; and
t = time

The value of constant c obtained in submerged culture of *Morchella* sp. in this study is $0.143 \frac{g^{1/3}}{day}$ upto 6th day of incubation and $0.031 \frac{g^{1/3}}{day}$ after 6th day.

The cube root is followed by pellet forming organisms in submerged culture where the growth is supposed to be three dimensional and the strain of *Morchella* sp. employed here also is pellet forming one and thus follows the same pattern of growth.

Reduction in the growth rate after 6th day may be due to reduced mass transfer rate for nutrients and oxygen as suggested by Emerson,[7] Marshall and Alexander,[8] Yano *et al.*[9] and Pirt[10].

Determination of optimum dose: The yield of mycelium and the changes in total soluble solids of the medium for six doses of nutrients supplied, are presented in Table 3. The data show that the yield increased with an increase in dose from 62.5 to 500 m.eq./l. Further increase in dose did not result in any additional yield although a concentration as high as 100 m.eq./l. did not show any deleterious effect on the yield. Hence a concentration of 500 m.eq./l. was considered as optimum for *Morchella* sp. studied.

Determination of optimum anion-cation ratio: The yield of mycelium, changes in pH and total soluble solids of the medium are presented in Table 4. The results indicate that the growth of the mycelium was poor at anion-cation ratio 1.1 and 0.5 where the initial pH of the medium was 3.3 and 10.0 respectively and there was no growth at ratios of 1.2 and 1.5 where the

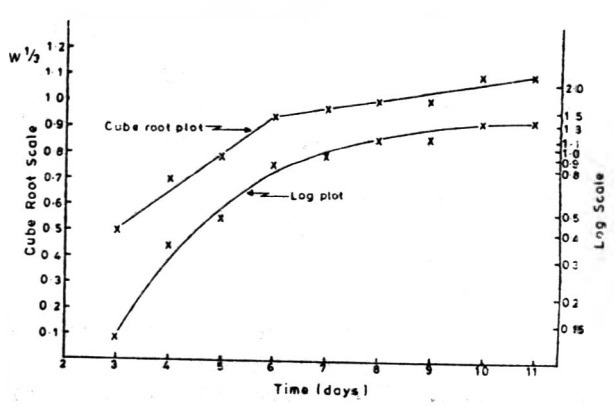

Fig. 1. Plots of increase in dry weight with time.

initial pH was 2.5 and 2.2 respectively. Good growth was observed at ratios of 0.8, 0.9 and 1.0 The yield is maximum at a ratio of 0.9 although not significantly different from the yields at a ratio of 1.0 The optimum anion-cation ratio, is therefore, taken for the nutrient medium used is 0.9, while the optimum range is 0.8 to 1.0

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Heat Losses from Milk Spray Dryers

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Heat losses from the milk spray dryers of two selected milk powder factories were estimated. Major heat loss took place through the exhaust air and only marginal through the dryer walls. The total heat loss was found to be 112802 Kcal/hr and 791540 Kcal/hr respectively in the two plants, accounting Rs. 468.70 and Rs. 3279.50 per day. Of this loss the exhaust air in plants A and B was responsible for Rs. 460 and Rs. 3240 respectively. The heat loss per 100 Kg of powder in terms of rupees was 10.93 (10.73 due to exhaust air) and 0.20 due to dryer walls in one plant and 6.47 (6.39 due to exhaust air and 0.08 due to dryer walls) in the other. Methods are suggested to reduce the heat losses.

As a result of fuel crisis and high cost of fuel in the recent past, there is an increasing consciousness among the dairy plant managers about the optimum consumption of energy in dairy product processing. It has become imperative to identify the factors reponsible for unnecessary excess energy consumption and find the magnitude of loss, so that suitable remedial measures could be accomplished.

The spray drying of milk is comparatively high energy consuming operation in the food industry. It has been reported[8] that 1602 Kcal were required to evaporate 1 kg of water in a spray dryer. In ideally operated spray dryer 1150 kcal would be required at air temperature of 190°C to evaporate one Kilogram of water[1]. The high energy consumption in spray drying would be caused, by, besides others, inefficient utilization of heat and high heat losses.

Heat losses from spray dryers take place in two ways: heat energy associated with the dryer exhaust air and heat losses through the drying chamber surfaces. The dryer exhaust air temperature is about 90-100°C, and there is not much scope in decreasing it, as it would result in unacceptable increase in powder moisture content. However, suitable systems may be thought of to recover this useful heat. The heat loss through the chamber surfaces may also be substantial, and can be decreased economically by providing adequate insulation.

Realizing the importance of the problem, studies were conducted in two milk powder plants employing spray dryers for drying, the results of which with the suggestion for improving the dryer performance are presented here.

Materials and Methods

Plant details: The two plants studied are designated here as Plant A and Plant B. The Plant A spray dryer was of Anhydro make. This co-current dryer uses centrifugal disc atomizer for atomization of milk and steam air heater for heating the air, The chamber of 4.59 m diameter was cylindrical all along its length of 4 m and its bottom had little inclination with hori-

*National Dairy Development Board, Anand-388 001.

zontal. An inverted 'V' shaped stainless steel arm or scraper mounted at the bottom of the dryer removes the powder being deposited on the bottom surface. The scraper rotates at a speed of 2 rpm. The 0.25 cm thick stainless steel inner wall of the dryer was covered with 10 cm thick fibre-glass insulation which itself was covered by a 0.25 cm thick aluminium sheet.

The Niro, co-current spray dryer of Plant B also uses a centrifugal disc atomizer but has a conical bottom. On the outside of the conical portion is mounted a hammer which vibrates this portion on hammering resulting in speedy removal of powder. The dryer wall is made of materials with thicknesses as in the case of the Plant A dryer. The cylindrical portion of the chamber is 8.12 m high with 8.49 m inner diameter. The conical portion of the chamber converges to a 0.89 m diameter pipe after a vertical height of 6 m.

Operating conditions of these spray dryers are given in Table 1.

TABLE 1. OPERATING CONDITIONS OF SPRAY DRYERS

Plant	Drying air temp. (°C)		Wet bulb temp. of the drying air (°C)	Ambient temp. (°C)	Air flow rate (kg/hr)	Powder production rate (kg/hr)
	inlet	outlet				
A	200	90	52	30	7414	237
B	200	80	52	40	78909	2813

Method: Heat loss through the exhaust air: The ambient air is heated to 200°C by isohumid heating process. A part of this added enthalphy is used for drying, and the rest is lost, Thus

$$q_1 = q_2 + q_3 + q_4 \quad \ldots(1)$$

where q_1=enthalpy added into the air; q_2=enthalpy used in drying; q_3=unused enthalpy in the exhasut air; and q_4=heat lost through dryer walls.

The total enthalpy of air, q_A taking 0°C as datum, can in general be written as below:

$$q_A = mC_p t + mH[t_d + \lambda_d + 0.45\,(t - t_d)] \quad ..(2)$$

where m=flow rate of air in kg dry air/hr; C_p=specific heat of air; t=dry bulb temperature of the air in °C; H=specific humidity of air in kg of moisture/kg of dry air; t_d=dew point temperature of the air; and λ_d= latent heat of vaporization of water at t_d.

The q_1 is evidently the q_A of drying air at 200°C minus the q_A of ambient air.

The unused enthalpy of the drying air appears in the dryer exhaust air. In addition the enthalpy used in drying also appears in it in the vapours removed from the milk. Thus in an adiabatically operated dryer there is no change in the enthalpy of the air. The enthalpy of the exhaust air, q_o, can however be written as follows:

$$q_o = m\,C_{po} t_o + m\,H_o[t_{do} + \lambda_{do} + 0.45\,(t_o - t_{do}] \quad ..(3)$$

or $$q_o = m\,C_{po} t_o + m\,H_i[t_{do} + \lambda_{do} + 0.45\,(t_o - t_{do}] + w[t_{do} + \lambda_{do} + 0.45\,(t_o - t_{do})] \quad ..(4)$$

where w=mass of water evaporated from milk in kg/hr and subscripts o and i are used respectively for exhaust and inlet conditions of dryer air. q_3 can now be calculated by subtracting the enthalpy of ambient air, eq (2), from the first two terms of q_o in eq (4). Thus

$$q_3 = m[(C_{po} t_o - C_{pa} t_a) + H_i\{(t_{do} - t_{da}) + (\lambda_{do} - \lambda_{da}) + 0.45\,(t_o - t_a - t_{do} + t_{da})\}] \quad ..(5)$$

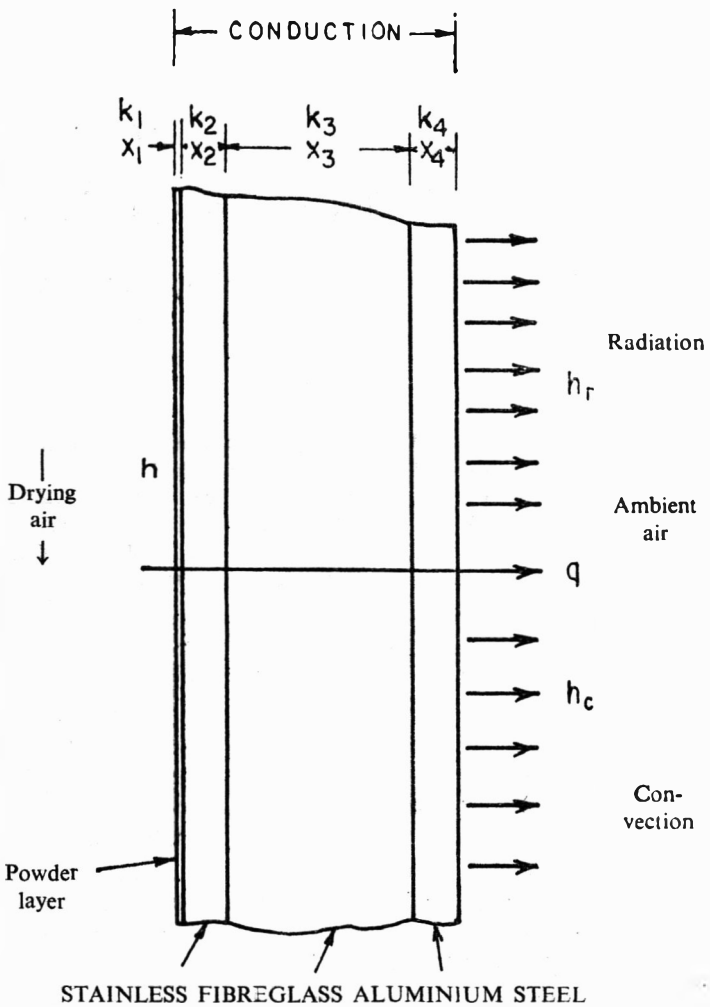

Fig. 1. Diagramatical model of heat loss though spray dryer wall.

where subscript a is used for ambient air.

Equation (5) was used to calculate that part of, enthalpy added to the air in heating process which was not used and was lost to atmosphere through the exhaust air.

Percent total heat loss, heat loss through exhaust air and heat loss through walls were calculated respectively from the following equations:

$$\text{per cent total heat loss} = \frac{(q_3 + q_4)\ 100}{q_1} \quad ..(6)$$

$$\text{per cent exhaust air heat loss} = \frac{100\ q_3}{q_1} \quad ..(7)$$

$$\text{per cent dryer wall heat loss} = \frac{100\ q_4}{q_1} \quad ..(8)$$

An approximate equation has been used[8] for the calculation of overall thermal efficiency as follows:

$$n_o = \frac{(t_1 - t_o)\ 100}{(t_1 - t_a)} \quad ..(9)$$

100 minus n_o would then give approximate percent heat loss. But equation (6) gives more accurate results.

Some of the values used in calculation are given in Table 1. Other values were: for Plant A, $H_i = 0.015$, $t_{do} = 46.5$, $\lambda_{do} = 571$, $C_{pi} = 0.245$, $C_{po} = 0.241$, $t_{da} = 21$, $C_{pa} = 0.24$, $\lambda_{da} = 585.6$ and for Plant B, $t_{do} = 49$, $\lambda_{do} = 569.5$ and other values were same as those for Plant A. The values of C_p at various temperatures were obtained from Perry *et al*[4].

Heat loss through dryer walls: Heat loss through the dryer surface would take place by conduction, convection and radiation (Fig. 1). As the dryer is well insulated, the outside surface temperature would be quite close to the surrounding temperature and hence losses by radiation would be quite small as has been shown later.

The exact equation for heat transfer through cylindrical surfaces includes the effects of radii of different layers. In spray dryers, however, the diameter is much larger in comparison with the thicknesses of construction materials, so that these effects are negligible. The heat loss can then be expressed as follcwing:

$$q = A \triangle t \frac{1}{h} + \frac{x_1}{k_1} + \frac{x_2}{k_2} + \frac{x_3}{k_3} + \frac{x_4}{k_4} + \frac{1}{h_c - h_r}$$

Where, A=heat transfer surface area; $\triangle t$ = overall average temperature difference between dryer air and surrounding; x_1, x_2, x_3, and x_4=thicknesses of powder layer, stainless steel sheet, fibre-glass insulation and aluminium sheet, respectively; k_1, k_2, k_3 and k_4 =thermal conductivities of powder, stainless steel, fibre-glass and aluminium, respectively (Table 2); h=inside forced convection film heat transfer coefficient; h_c=natural convection film heat transfer coefficient; h_r=radiation heat transfer coefficient of the outside surface.

TABLE 2. THICKNESS AND THERMAL CONDUCTIVITY OF DRYER WALL CONSTRUCTION MATERIALS AND POWDER LAYER

Particulars	Stainless steel	Fibre-glass	Aluminium	Powder
Thickness, m	2.5×10^{-3}	1×10^{-1}	2.5×10^{-3}	1.2×10^{-4}
Thermal conductivity, kcal/hr-m-°C.	18	0.045	174	0.4

The value for k is from ref (3)

h_c and h_r can be calculated from the following equations[3].

$$h_c = 1.12\ (\triangle t)^{\frac{1}{3}} \quad ..(10)$$

$$h_r = 0.0412 \in \left(\frac{Ta}{100}\right)^3 \quad ..(11)$$

where, $\triangle t$=temperature difference between outside surface and surrounding, $\in$ = emissivity of aluminium, Tav=average temperature of the outside surface and the surrounding, °K. Inside forced convection film heat transfer coefficient, h, was calculated from the following equation.[3]

$$h = 0.02 \frac{k}{Di} \left(\frac{DiG}{\mu}\right)^{0.8} \quad ..(12)$$

Where, G=mass velocity of the air through the dryer, kg hr-m^2; Di = inner diameter of the dryer, m; k = thermal conductivity of air, kcal/hr-m-°C; and μ = viscosity of air, kg/hr-m. The values of k and μ were taken at average temperature from Perry *et al*[4].

In the dryer of Plant A the powder fell on the bottom and was scraped off by the scraper arm. Thus, in a revolution of the scraper arm the powder thickness on the bottom varied from zero to some maximum, which caused resistance to heat loss. The plant produced 237 kg powder per hour, the dryer diameter was 4.59 m and the scraper arm rotated at 2 rpm. Then the maximum thickness of the powder layer on the bottom in a revolution was calculated as.

$$\left(\frac{237}{60}\right)\left(\frac{1}{2}\right)\left(\frac{1}{0.785\times4.59\times4.59}\right)\left(\frac{1}{\rho}\right)$$

Taking ρ as 0.5 g/cc the thickness was calculated to be $2.4\times10^{-4}m$. Thus the average thickness in a revolution was $1.2\times10^{-4}m$. It is thus seen that the powder layer is too less in thickness to have any effect on $\cup$. Therefore although a thin layer of powder deposits on the bottom of dryer of Plant A. and on the conical portion of the dryer of Plant B the $\cup$ has been considered same all over the dryer.

Cost of heat: Furnace oil was used to generate heat. Furnace oil has calorific value of approximately 9500 kcal/lit. Taking fuel efficiency to be 75 per cent, the approximate cost of heat can be calculated from the following equation:

$$C_H = \left(\frac{1000}{0.75\times9500}\right) C_F \quad ..(13)$$

Where C_H= cost of heat in Rs/1000 kcal, and C_F= cost of furnace oil in Rs/lit.

It may be observed however that the cost of heat C_H calculated from equation (13) does not include fixed and overhead costs which may be from 15 to 35 per cent of the total cost[5]. Taking average figure of 25 per cent total cost of heat is.

TABLE 3. HEAT LOSS FROM SPRAY DRYER WALLS

Plant	Dryer portion	U (kcal/hr-m²-°C)	A (m²)	Δt (°C)	q (kcal/hr)	q_T (kcal/hr)	Heat loss/kg powder produced (k cal)
A	Top	0.2	16.48	170	561	2102	8.85
	Rest	0.2	73.7	105	1541		
B	Top	0.261	56.5	160	2620	9540	3.4
	Rest	0.261	306.77	86.5	6920		

$$C_T = \frac{C_H}{0.75} = 0.1875\ C_F \quad ..(14)$$

Taking cost of furnace oil as Rs. 1.20 per litre the cost of heat comes to about Rs. 0.23 per 1000 kcal. This cost has been used in calculating the loss of heat in terms of rupees.

Results and Discussion

Values of different heat transfer coefficients calculated were: h for Plant A dryer 0.4 and for Plant B dryer 0.78; hc and hr 3.05 and 0.0505 kcal/hr-m^2-°C, respectively, for both the plants. The overall heat transfer coefficient was calculated to be 0.2 for Plant A dryer and 0.261 kcal/hr-m^2-°C for Plant B dryer.

Heat loss took place from all the sides of the dryer. The temperature of the drying air, however, decreased from inlet to outlet. Thus mean temperature difference has been considered for all surface areas except the top area. For heat loss from the top the air temperature is effectively equal to the inlet temperature. Table 3 gives heat transfer surface areas, corresponding temperature drops to be considered for both the plants and heat loss through dryer walls.

Results on heat losses in spray drying at both the plants are presented in Table 4. Total heat loss is 112802 kcal/hr in Plant A and 791540 kcal/hr in Plant B, that is, about 36 and 25 percent of total added heat, respectively. This has resulted in a net loss of approximately Rs. 469 per day to Plant A and Rs. 3280 per day to Plant B. In effect the cost increased by Rs. 10.93 per 100 kg of powder in Plant A and Rs. 6.47 per 100 kg of powder in Plant B.

As can be noted from the Table 4, the major heat loss took place through the exhaust air and only marginal through the dryer walls. Due to the heat loss through the dryer walls, however, Plants A and B are incurring daily loss of Rs. 8.70 and Rs. 39.50, respectively. Although these losses are not much, it might be economical to reduce even these losses by providing more insulation. It is not possible here to suggest the actual economical thicknesses of insulation for these plants due to lack of knowledge of actual cost figures involved. But it can be calculated readily from the following equation[7].

$$(r_2 \log_e \left(\frac{r_1}{r_2}\right) + RK)\sqrt{\frac{2r_2 - r_1}{r_2 - RK}} = \sqrt{\frac{Y(t_o - t_a)\,M\,k}{100000\ \ b}} \quad ..(15)$$

Where, b = cost of installed insulation, Rs/m^2-yr-cm;

k = thermal conductivity of insulation, kcal-cm/hr-m^2-°C;

M = value of heat in rupees per 10^5 kcal, including consideration of fuel cost, capital investment, interest, depreciation, etc.;

R = total thermal resistance (kcal/hr-m^2-°C)$^{-1}$

r_1 = and r_2 = inside and outside radii of insulation, respectively, cm; to and

TABLE 4. HEAT LOSSES FROM MILK SPRAY DRYERS OF PLANTS A AND B

Heat loss in terms of	Heat loss in Plant 'A' thro			'Heat loss in Plant 'B' thro'		
	Exhaust air	Dryer wall	Total	Exhaust air	Dryer wall	Total
kcal/hr	1107,00	2102	112802	782000	9540	791540
% of the added heat	34.9	0.66	35.56	24.7	0.3	25
kcal/100 kg powder	46750	885	47635	27800	340	28140
kcal/100 kg of water evaporated	29150	552	29702	20050	245	20295
Rs/100 kg powder	10.73	0.20	10.93	6.39	0.08	6.47
Rs/100 kg of water evaporated	6.70	0.13	6.83	4.60	0.06	4.66
Heat loss in Rs/day (18 hr day)	460	8.70	468.70	3240	39.50	3279.50

t_a=operating and ambient air temperatures, respectively, °C;

Y=hours of operation per year.

It is possible to improve the overall performance by either increasing the air inlet temperature or decreasing the air outlet temperature or both. Decreasing the air outlet temperature at least in plant B, is not possible since by doing so the moisture content of the powder will increase decreasing the storability of the powder. The air inlet temperature can be increased[2] beyond 200°C, but this will result in the finer powder particles which will give less solubility, and in other, quality losses. The increased capacity will cause less heat loss per Kg of powder, however, the total heat loss through the exhaust air will remain the same so long as the exhaust air temperature is maintained same. It is, therefore, very important to recover this useful heat which otherwise is lost to atmosphere.

Recovery of heat economically from exhaust air however, is not easy because of unfavourable air conditions. Firstly, the exhaust air contains fine particles of milk powder in approximate mass concentration range of 0.02 to 0.15 per cent, or even higher. This powder will deposit on the heat transfer surfaces decreasing the overall heat transfer coefficient tremendously. Secondly, the exhaust air has relative humicity of about 17 per cent and 25 per cent respectively in Plants A and B, and can not be cooled below about 50°C as this would result in condensation of vapour from air. This will cause operating difficulties and decrease the overall heat transfer coefficient. Thirdly, the deposited powder which would strongly stick to the surfaces due to humid air would present cleaning difficulties. And fourthly, the air itself is a poor conductor of heat thereby necessitating large surface areas. All these reasons have discouraged the use of heat exchangers for heat recovery.

One system which may economically and efficiently recover heat from the exhaust air is by employing wet scrubber. In principle, the raw milk is sprayed in a stainless steel chamber through which the exhaust air flows entering at the bottom. The exhaust air heat is used in preheating the milk and also in partially concentrating it. In addition to heat recovery, the system facilitates the removal of powder entrained in the air. The partially concentrated, pre-heated milk may then be concentrated finally in evaporators before feeding to the spray dryer. Work is in progress in this laboratory on such a system.

Other methods may include use of heat pipes, extended surface heat exhangers, etc. for recovering this useful heat. Varshney and Ojha[7] have suggested a number of methods for the conservation of energy in dairy plants including dryers.

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RESEARCH NOTES

PRELIMINARY OBSERVATIONS OF THE TOXICITY OF MORINDIN, A GLYCOSIDE TO COCKROACHES AND HOUSE FLIES

The glycoside, morindin was extracted and purified from the root bark of *Morinda tinctoria* Var, *tamentosa* H. Initial studies on the toxicity reveal promising effects on cockroaches and house flies. Differential sex susceptibility is also observed for both the insects.

The genus *Morinda* is economically very important since various parts of the plant are used in dyeing textiles and pharmaceuticals. Morindin and its aglycone morindone occur in free condition in the root, root bark and heart wood of *Morinda citrofolia*[1,2], *M. parsicaefolia*[3] and *Copriesome astralis*.[4] In the present studies the glycoside morindin 6-primeveroside of Morindone (C_{26} $H_{28}O_{14}$, 1,5,6—trihydroxy 2-methyl anthraquinone) has been extracted and purified from the root bark of *M. tinctoria* var. *tomentose* Hook[5] The stimulatory effect of morindin on isolated heart of cockroach and its mode of action has been reported[6] recently. Since cockroach and housefly are the very common insects found on food commodities, certain preliminary observations made on the toxicity of morindin to these insects are being reported here.

Adult male and female cockroaches *Periplaneta americana* L. and house flies *Musca domestica* nebulo, F. used in the present investigation were reared in the laboratory under controlled conditions. Morindin at different concentrations was dissolved in ethanol (W/V) and a uniform dose of 5 μl test solution per insect was applied. Male and female cockroaches of approximately same size (1-2 g) were separated into batches of 20 each in triplicate and treated intraperitioneally as described by Menusan[7]. To test the toxicity against houseflies, different concentrations of morindin were treated by topical method (0.001 ml/insect) on the dorsal surface of the thoracic region of houseflies. Male and female flies of 3-4 days old were grouped into batches of 20 each in triplicate. Control experiments were carried out simultaneously under similar conditions using ethanol. The mortality counts taken after 24 hr were corrected as per Abbots[8] formula.

The results were subjected to probit analysis[9] and the LD_{50} values read from the regression lines (Table 1.) In case of cockroaches, after the treatment slight excitation was seen followed by knockdown effect in 20-30 min. Similarly with houseflies knockdown effect was observed after 10 min. Further no recovery was noticed among the insects showing knockdown effect.

Studies on the toxicity of morindin revealed promising effects on cockroaches and houseflies. It is interesting to note the differential sex susceptibility of the test insects to morindin. The relative sex susceptibility of cockroaches to morindin is negligible whereas surprisingly, female flies are more susceptible than the males.

The authors are grateful to Prof. Shyam Sunder Simha Head, Department of Zoology, University College, Kakatiya University, Warangal for encouragement and facilities.

TABLE 1. TOXICITY OF MORNINDIN TO COCKROACHES AND HOUSEFLIES

Insect	Sex	Regression equation	LD_{50}
Cockroach	Male	$Y = 154.5X + 26.42$	0.22*
	Female	$Y = 148.1X + 16.80$	0.24*
Housefly	Male	$Y = 44.87X + 4.13$	123**
	Female	$Y = 39.96X + 22.98$	62**

* μg/insect; **ug/g body wt.

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OLIGOSACCHARIDES OF CASHEWNUT

Oligosaccharides of cashewnut extracts were qualitatively analysed by paper chromatography and found to be made up of mostly galactosyl sucroses. The oligosaccharides identified were sucrose, raffinose, stachyose and verbascose.

Cashewnut (*Anacardium occidentale*) is valued for its taste and flavour, particularly after roasting in a fat medium.[1] One of the likely factors responsible for cashewnut flavour development, as in groundnuts[2] may be the free carbohydrates about which there is practically no information. The present paper reports the nature of free oligosaccharides present in cashewnut.

The coarse fat-free meal was successively extracted thrice with 70 per cent aqueous ethanol (1:4 w/v) in a mechanical shaker for twelve hours. Ethanol was removed *in vacuo* and the ethanol free extract after removing salts by deionisation was concentrated, chromatographed (descending) on Whatman 3 MM paper using solvents[3,4] (*i*)1-butanol: ethanol: water (4:1:1), (*ii*) 1-propanol: ethyl acetate: water (*a*) 6:1:3 and (*b*) 7:1:2. The carbohydrates were located using the spray reagents[5,6,7] (*i*) benzidine acetic acid, BAA) (*ii*) benzidine: acetic acid: trichloro-acetic acid (BATA) and (*iii*) urea-hydrochloric acid (UHA).

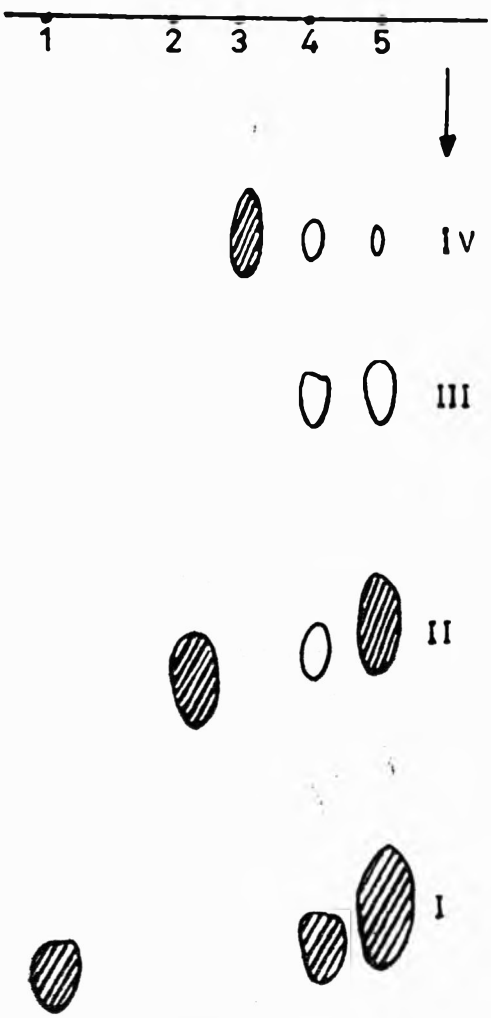

Fig. 1. Paper chromatogram of cashewnut oligosaccharides.

1, Sucrose; 2, Raffinose; 3, Verbascose; (contains trace of stachyose); 4, Green gram extract; 5, Cashewnut oligosaccharides.

I, Sucrose; II, Raffinose; III, Stachyose; IV, Verbascose.

The chromatograms obtained in the above solvents. were similar to that obtained with green gram extracts[8]. Their appearance as brownish and bluish spots with the last two spray reagents (BATA and UHA) and absence of reaction with the first reagent, (BAA) identity of Rf's and homologous nature indicated their similarity to sucrose, raffinose, stachyose and verbascose. The various bands marked 1 to 4 corresponding to sucrose raffinose, stachyose and verbascose, were eluted, concentrated and identified as follows: (Fig. 1.);

Band 1, Rf 0.71 (Solvent *ii* (*b*)) after hydrolysis with acid (0.1 N HCl, 15-20 min at 70°C) and enzyme (dialysed B.D.H. invertase in 0.05 M acetate buffer of pH 5.6 for 24 hr) gave rise to glucose and fructose (identical Rfs with standards in different solvents, specific test for ketose etc.). This compoment is most likely to be sucrose.

Band 2, Rf 0.46 (solvent *ii* (*b*)) after acid hydrolysis[9] (20 per cent acetic acid for 5 hr at 80°C) and enzyme hydrolysis with invertase as described earlier, showed two spots, one corresponding to fructose and the other to melibiose which gave negative test with UHA, positive test with (BAA) and had identical mobility with the standard compound. Further on treatment with a galactosidase preparation from *Agave Vera Cruz*,[10] band 2 gave a spot corresponding to galactose and sucrose (identified by its mobility and hydrolysis to glucose and fructose) indicating that it may be raffinose.

Band 3, Rf 0.36 (solvent *ii* (*b*)) after invertase action showed two spots corresponding to fructose and the other likely to be manninotriose (Rf lower than that of melibiose and negative test with UHA spray). Action with galactosidase resulted in free galactose and raffinose (reducing sugar test negative and ketose test positive, and identical Rf's with authentic compounds in two of the above solvents). This is most likely to be stachyose.

Invertase action on band 4, Rf 0.28 (solvent *ii* (*b*)) was sluggish. But action of galactosidase gave rise to galactose and spots corresponding to stachyose and raffinose (ketose positive, reducing sugar test negative) indicating that it may be verbascose.

Among the oligosaccharides of cashewnut, sucrose seems to be present in the largest amount followed in decreasing order by raffinose, stachyose and verbascose. It is of interest to note that galactosyl sucroses are present in other oil bearing nuts such as groundnut, almond and pistachio.[11]

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I, Dr. J. V. Prabhakar, hereby declare that the particulars given above are true to the best of my knowledge and belief.

J. V. Prabhakar

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BOOK REVIEWS

Safety Evaluation of Chemicals in Food: Toxicological Data Profiles for Pesticides—1. Carbamate and organophosphorus insecticides used in agriculture and public health: edited by G. Vettorazzi and P. Miles-Vettarazzi, World Health Organisation, Geneva, 1975, pp. 61, Price: Sw. Fr. 10.

This small booklet deals with toxicological data of carbamates and organophosphorus compounds extensively used in agriculture and public health. The available scientific information has been systematically classified. These data will be useful for standardising pesticide tolerances and for developing criteria of acceptability as claimed by the authors. While consolidating the information the evidence on which the data are based was also considered.

In a ten-page introduction, the authors have described how the WHO and FAO have strived to collect the necessary data and vividly described the criteria on which the conclusions were drawn and toxicological decisions were taken.

In Table 1, 38 compounds are covered and for each compound references pertaining to biochemical aspects and various toxicity studies have been given. The acceptable daily intake figures along with comments and relevant references are given in Table 2. A list of more than one thousand references are added at the end.

This book contains very useful information in a consolidated form on the widely used carbamates and organophosphorus insecticides and is an excellent reference book.

R. RADHAKRISHNAMURTHY
CFTRI, MYSORE.

Pesticide Residues in Foods: Technical Report Series 612. World Health Organization, Geneva, 1977. 36 pp.

This series brings together information on different aspects of newer as well as certain old pesticides considered by the joint FAO/WHO meeting. One important fact which is discernible from such a report is that, inspite of the importance of pesticides in agriculture and public health, there is not sufficient national or international consciousness about pesticide programs. This is borne out by the scarcity of data on pesticide residues, toxicology, as well as their effects on metabolism and pharmacokinetics in man. This has also been emphasized throughout this report.

The series begins with a short introduction. This is followed by chapters on the general and specific problems associated with allocation of acceptable daily intake (ADI) and maximum residue limits in food commodities and processed foods. Since the pesticidal properties of technical products and formulations are likely to be influenced by the presence of impurities, the committee has stressed the need for information on such major impurities. While considering the reversible cholinesterase inhibition by carbamates, the committee advocated *in vitro* kinetic studies of the enzyme and felt that *in vivo* studies should be interpreted cautiously.

Chapters four and five are mainly concerned with the evaluation of data for establishing ADI and maximum residue limits for both new as well as old pesticides. Out of a total of 14 new compounds, ADI as well as maximum residue limits were allocated to 7 compounds which include acephate, dialifos, edifenphos, methamidophos, carbofuran, pirimicarb, and cartap. For the remaining new compounds neither ADI nor maximum residue limits could be allocated due to insufficient data.

Chapters six, seven and eight are short and deal with the comparison of potential daily intakes of pesticide residues with their ADI's, future line of work and recommendations of the FAO/WHO meeting. This is followed by a comprehensive bibliography and Annexures I and II. Part I of Annex I lists the recommended maximum residue limits for 22 compounds for which ADI or temporary ADI has been established. Where such information is temporary, the year in which further data is required is specified. Part II of Annex I lists guide line levels for 5 compounds. Annex II deals with the recommendations for future work on the compounds discussed in the report.

This report should form a valuable addition to the library.

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Yeasts for Food and other Purposes: Edited by Jeanne C. Johnson, Noyes Data Corporation, N. J. 07656, 1977, pp. 344., price $ 36.

This review details of advanced technical information, eliminating legal and juristic phraseology, on U.S. patents issued since 1970 that deal with yeasts for food and other purposes. In total 168 processes

disclosed in 182 patents are covered. A majority of processes discussed deal with the growth of yeast cells and use of yeast proteins for both food and feed purposes. A number of processes are concerned with the use of yeast in enzymatically modifying other proteins and bakery products. The application of yeasts in the production of chemicals, in condiments and as encapsulating agents are the subjects of discussion of other processes. This book could be used as a guide to U.S. patent literature and as a ready reference by the scientists and industrialists engaged in these fields.

H. N. ASTHANA
CFTRI, MYSORE.

The Science and Technology of Gelatin: edited by A. G. Ward and A. Courts, Published by Academic Press Inc (London) Ltd., 24-28 Oval Road, London, NNI 7DX, 1977, pp 555, price £ 18.00.

The above book is one of a series of specialised monographs in Food Science and Technology of the Academic Press, comprising of a distinguished editorial board.

Collagen as the major protein of all vertebrates, has interested diverse scientists in the basic disciplines of Physics, Chemistry, Biology and Medicine. Gelatin is derived from collagen and in view of its unique functional characteristics has applications in the food, pharmaceutical, photography and other fields. The present monograph has sixteen different chapters starting from the basic structure of collagen, raw materials used and technology of gelatin manufacture, chemistry and chemical modification of gelatin, food, pharmaceutical and photographic uses of gelatin, chemical and physical criteria for gelatin quality.

The book has a wealth of information not only for the specialist such as a food scientist and technologist but also, for the new entrant into the science and technology of gelatin. Although a number of practical applications of gelatin are covered in a vast patent literature some of the essentials have been dug out and presented in sections on technology of gelatin manufacture and chemical reactivity of gelatin.

The literature coverage in most of the chapters is upto about the year 1970, but this does not detract the book as a useful source of information.

There could have been no better choice than Drs. A. G. Ward and A. Courts to edit this book on gelatin. These and other authors dealing with several aspects of science and technology of gelatin are pioneers in the field and were connected in some capacity or other formerly with the British Gelatin and Glue research association.

The reviewer specially recommends this technically excellent monograph to scientists in the Food and Pharmaceutical field.

D. RAJAGOPAL RAO
CFTRI, MYSORE.

Advances in Experimental Medicine and Biology: Vol. 86-A Protein Cross Linking-Biochemical and molecular aspects; Vol. 86-B Nutritional and Medical Consequences, published by Plenum Publishing Corporation, New York, Price: Each Volume $ 59.50.

Crosslinking in proteins may be of natural origin such as in collagen, gluten, keratin or artificially induced, by treatment of proteins with various types of reagents. In view of the profound structural changes that are introduced in the protein as a result of crosslinking and the use of these modified proteins for several purposes, there has been a great deal of interest in this area by scientists in diverse disciplines. This is particularly evident when the contents of the volumes under review are examined.

Volume 86 Part A deals specially with the molecular and biochemical aspects of protein crosslinking. The key to formation "insitu" of crosslinks by treatment of proteins with strong alkali lies in the formation of reactive species of *dehydroalanine* from strategically located thiol or phosphoserine residues in the protein molecule. The dehydroalanine moiety so generated reacts with functional aminogroups or other thiol groups to form lysinoalanine or lanthionine.

Forty three different topics are covered in about 745 pages and these topics can be broadly divided into various categories. Several aspects of thiol disulfide interactions such as (*a*) evolutionery perspective (*b*) renaturation of proteins with disulfide bonds (*c*) role of disulfide bonds in wheat functionality (*d*) antigenicity and disulfide groups (*e*) thiolation and crosslinked insulins and (*f*) introduction of disulfide crosslinked into fibrous proteins and bovine serum albumin have been reviewed. Other data extensively covered in this volume include: (*a*) methods of introduction of artificial crosslinks into proteins (*b*) newer bifunctional reagents for crosslinking (*c*) reaction of specific proteins like

wood, collagen with different reagents (*d*) radiation induced crosslinking (*e*) oxidatively induced crosslinking (*f*) thermodynamics of crosslinks and (*g*) several sections dealing with covalent interaction of DNA and RNA with protein in presence of UV light or chemical reagents, has been considered. Analytical aspects such as GLC, mass spectra of a few cross linked amino acids such as lysinoalanine lanthionine and S-carboxy ethylcasteine have also been considered.

Volume 86 B deals with the nutritional and medical consequences of cross linked proteins. In this volume nearly 40 topics are covered in about 730 pages. After an introduction to the stereo chemistry of cross linking amino acids, there are about ten articles which deal with various aspects of lysinoalanine which include its formation in alkali treated proteins, presence in protein food ingredients and metabolic fate in experimental animals. Specific areas of interest to the food technologist such as nutritional significance of cross link formation during food processing, cross links in heated milk proteins, nutritional consequences of Maillard browning reaction, enzymic hydrolysis of cross linked proteins, cross linked proteins in ruminant nutrition have also been dealt with by experts in the area. Interesting information on the relation of ageing to protein crosslinking is also given.

The task of the editor Dr. Mendel Friedman must have been an ardous one considering the diversity of topics but a remarkably good job has been done. Both the volumes bring most of literature scattered in various sources into a single place and thus makes the volumes indispensable to any worker whether he be a novice or expert in the field of protein crosslinking.

The reviewer strongly recommends both the volumes to all R & D institutions dealing with the area of biochemistry and protein technology. For the individual, the price of the volumes is prohibitive unless he is a specialist who needs constant reference to the literature on protein crosslinking. The reproduction of the text material and figures is uniformly good.

D. RAJAGOPAL RAO
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Spices and Condiments by Dr. J. S. Pruthi, Ludhiana published by National Book Trust India. A-5 Green Park, New Delhi-16, price Rs. 14–50 pp. 270.

It is indeed an irony, as the author points out, that there has never been a book produced on this subject in this country which is the home of spices. Dr. Pruthi's venture is indeed commendable. The handbook covers nomenclature, description, quality, composition and use of spices in food and in medicine. The author himself acknowledges that the book could not be made more comprehensive by including agricultural, technological and other related aspects of processing and storage of spices. These certainly would have been beyond the scope of a handbook. In a first attempt of this type of book there are bound to be deficiencies and errors which would hopefully be rectified in subsequent editions. It would not be out of place to point out some of them. The sketches of spices facing pages 8, 97, and 186 are far from satisfactory. Also some of the photographs could have been reproduced better. Atleast drawings of some unfamiliar spices would have been more informative. It is suggested that details of illustration may be incorporated in the text of each spice instead of inter-spersing at random in the book.

There is a useful bibliography and glossary of technical and medical terms; but the author should avoid oversimplification of the terms e.g., the definitions of carbohydrates and protein are misleading. The botanical names of *Cassia china* appearing on pages 70 and 74 are different. The author could have updated the Annexure II giving the area and production of spices. Figures later than those of 1971–72 should not be difficult for inclusion in 1976.

One suggestion to the publisher. Dr. Pruthi has done extensive work on green pepper and it would have been more appropriate if the publisher had presented the book cover containing the background of the spice in its appropriate colour.

The book is indeed a valuable contribution and will be cherished by workers in the laboratory and in the trade.

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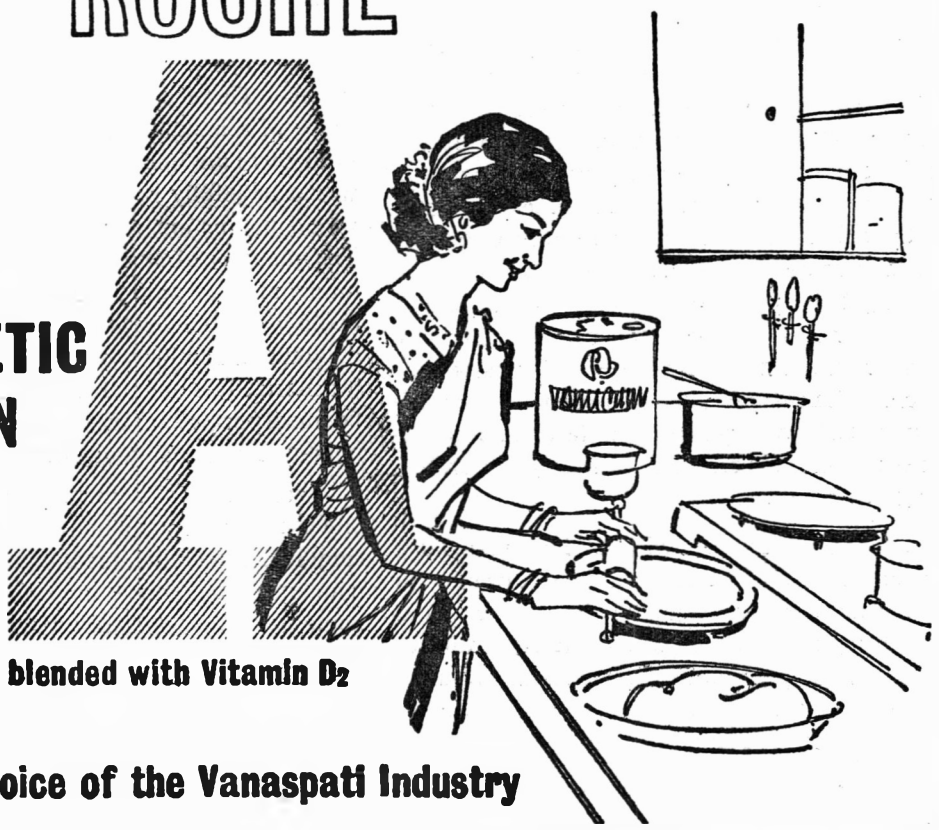

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2. Short communications in the nature of Research Notes should clearly indicate the scope of the investigation and the salient features of the results.

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

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

5. **Tables:** Graphs as well as tables, both representing the same set of data, should be avoided. Tables and figures should be numbered consecutively in Arabic numerals and should have brief titles. Nil results should be indicated and distinguished clearly from absence of data.

6. **Illustrations:** Line drawings should be made with *Indian ink* on white drawing paper preferably art paper. The lettering should be in pencil. For satisfactory reproduction, graphs and line drawings should be at least twice the printed size. Photographs must be on glossy paper and contrasty; *two copies* should be sent.

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

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

   In the text, the references should be included at the end of the article in serial order.

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

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

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

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

   (*d*) *Proceedings, Conferences and Symposia:* As in (*c*).

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

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

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