JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

ASSOCIATION OF FOOD SCIENTISTS & TECHNOLOGISTS, INDIA

VOL. 12 NO. 1 JANUARY–FEBRUARY 1975

ASSOCIATION OF FOOD SCIENTISTS AND TECHNOLOGISTS

(INDIA)

The Association is a professional and educational organization of Food Scientists and Technologists

AFFILIATED TO THE INSTITUTE OF FOOD TECHNOLOGISTS, USA

Objects:

1. To stimulate research on various aspects of Food Science and Technology.
2. To provide a forum for the exchange, discussion and dissemination of current developments in the field of Food Science and Technology.
3. To promote the profession of Food Science and Technology.

The ultimate object is to serve humanity through better food.

Major Activities:

1. Publication of a bi-monthly—Journal of Food Science and Technology.
2. Arranging lectures and seminars for the benefit of members.
3. Holding symposia on different aspects of Food Science and Technology.

Membership:

Membership is open to graduates and diploma holders in Food Science and Technology, and to those engaged in the profession. All the members will receive the Journal published by the Association. Regional branches of the Association have been established in Eastern, Northern, Central and Western zones of India.

Membership Subscription				**Annual Journal Subscription**		
Life Membership		**Rs**	**250**	**Inland**	**Rs**	**60**
Corporate Members				**Foreign:**		
(for firms, etc.)	**(per year)**	**Rs**	**250**	**Surface Mail**	**$**	**15**
Members	**,,**	**Rs**	**15**	**Air Mail**	**$**	**22.50**
Associate Members						
(for students, etc.)	**,,**	**Rs**	**10**			
Admission	**,,**	**Re**	**1**			

For membership and other particulars kindly address

The Honorary Executive Secretary
Association of Food Scientists and Technologists, India
Central Food Technological Research Institute, Mysore 13, India

Editor
P. B. Rama Rao

Associate Editors
K. A. Ranganath
N. Subramanian
N. Chandrasekhara
J. V. Shankar
B. A. Satyanarayana Rao
Y. N. Lakshman

The Journal of Food Science and Technology is a bimonthly publication of the Association of Food Scientists and Technologists, India (AFST) issued in February, April, June, August, October and December.

The Editor assumes no responsibility for the statements and opinion expressed by the contributors.

Manuscripts for publication and books for reviewing in the Journal should be addressed to the Editor, Journal of Food Science and Technology, AFST, Central Food Technological Research Institute, Mysore-570013. The Editor reserves the privilege of editing the manuscript to make it suitable for publication in the Journal.

Correspndence regarding subscriptions and advertisements should be addressed to the Executive Secretary, AFST, Central Food Technological Research Institute, Mysore-570013 India. Payment may be made by cheque, draft, postal or money order in favour of Exe. Secretary, AFST.

Executives of the AFST

President
T. N. Ramachandra Rao

Vice-Presidents
S. V. Pingale
B. P. Baliga
K. C. Dé
T. R. Sharma

Secretary
V. H. Potty

Joint Secretary
M. V. Sastry

Treasurer
E. S. Nambudiri

JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

Volume 12 Number 1 Jan.–Feb. 1975

CONTENTS

สถาบัน กสิกรรมการ
1 1 ม.ค. 2518

REVIEW PAPER

Analysis of Some Important Factors Affecting Sorption of Fumigants by Food Commodities

G. S. DHALIWAL

Department of Processing & Agricultural Structures, Punjab Agricultural University, Ludhiana

The term 'sorption' first introduced by McBain[1], is used to describe the total uptake of a gas resulting from the attraction and retention of molecules by any solid material present in the system[2]. In a fumigation system, the fumigant gases are held back and retained by the commodity to which they are exposed. The dosage calculated from the weight of fumigant and volume of space in the fumigation chamber is seldom attained due to sorption of fumigant gas by the commodity being fumigated. The effectiveness of a fumigant depends on its concentration in the gaseous phase available to the insect during exposure period. Therefore, it is necessary to obtain sufficiently high concentration of a fumigant throughout the period of exposure to give a satisfactory kill of insects present. The sorptive capacity of the commodity must be satisfied before an effective concentration of fumigant can be maintained in the air space. The rate at which sorption occurs and the amount sorbed determine the amount of fumigant which remains in the gas phase and is available to the insect that is being fumigated. Therefore, a knowledge of the amount of fumigant which is sorbed by a commodity and hence is not available to build up an effective concentration in the air space is necessary in calculating the total amount of fumigant to be applied.

The phenomenon of sorption can broadly be divided into two categories, *viz.*, physical sorption or physisorption, and chemical sorption or chemisorption. In case of physical sorption, the amount of fumigant sorbed could be recovered after prolonged aeration. In other words, physical sorption is reversible in nature because the forces involved, often referred to as Van der Waal's forces, are weak. On the other hand, chemical sorption involves a chemical reaction between gas molecules and the constituents of the material, which results in a change in the constitution of the parent molecules. This change is irreversible. Physical sorption is again of two types, i.e. adsorption and absorption. Adsorption signifies the attachment of molecules of a gas on the surface of the material, whereas absorption is said to occur when the gas molecules enter into solution with the aqueous or lipid phase of the material and are held there by capillary forces[3].

Sorption of a particular fumigant is known to be affected by a variety of factors. An analysis of some of the most important factors is presented in the following pages for critical appraisal and understanding as these could play a major role in adjusting the dosages of a fumigant to be applied under different conditions.

1. Temperature

The temperature of the commodity being fumigated has a marked effect on the amount of fumigant sorbed during a particular exposure period. Generally, physical sorption decreases with the increase in temperature, whereas chemical sorption tends to increase. A number of studies have proved this contention. The experiments on carbon disulphide with wheat have indicated that the recoverable fumigant is less strongly sorbed at high temperatures and is presumably held by predominantly physical forces[4]. Sorption of carbon tetrachloride by wheat and corn was greatest at 50°F and least at 90°F.[5] Similarly, sorption of ethylene dibromide, methyl bromide, acrylonitrile and chloropicrin by wheat was found to increase with the decrease in temperature from 25 to 4.5°C.[6] As the temperature was reduced from 25 to 13°C, ethylene dibromide was highly adsorbed and retained for many days in the fumigated apples[7]. This fact has important practical implications. This is one of the reasons for the dosage of fumigant to be increased to kill insects as the temperature of fumigation is lowered.

Chemical sorption of fumigants gets enhanced at higher temperatures. Experiments on methyl bromide with wheat at different temperatures have revealed that sorption of the fumigant is increased with temperature, indicative of chemical sorption[8]. As the temperature of fumigation is reduced from 25 to 4°C, there is proportionately less fixed bromide residues in fruits[9]. Lindgren *et al.*[10] found an increase in the bromide content of wheat as the temperature during fumigation was raised from 10 to 32°C. Sorption of phosphine by cereal products

rises when temperature is increased. For example, the percentage sorption by wheat is 1.1 at 4°C, 6.1 at 24°C and 22.5 at 35°C[11]. Similarly, increase in temperature from 50 to 90°C resulted in increase in sorption of phosphine by middlings, shorts, bran, semolina, germ and gluten of wheat from 9.5 to 33.0, 16.0 to 28.0, 32.8 to 42.2, 9.5 to 24.5, 4.5 to 9.5 and 85.2 to 100 per cent respectively[12]. This is characteristic of chemical sorption.

2. Moisture Conten

Sorption of fumigants, in general increases with an increase in the moisture content of the commodity. This is shown by the results of several studies. An increase in moisture content of wheat from 10 to 16 per cent resulted in increased sorption of hydrogen cyanide by 1.7 times[8]. The sorption of methyl bromide by onion seed also increased with moisture content over the practical storage range[13]. With the increase in moisture content of wheat from 9 to 17 percent, sorption of hydrogen cyanide was found to increase two-fold[14]. There was also a considerable increase in sorption of ethylene oxide and methyl bromide by wheat with the increase in moisture content from 9 to 17 per cent[15, 16]. Increasing the moisture content of wheat from 13 to 18 per cent more than doubles the total sorption of carbon disulphide[4]. Sorption of methyl bromide by groundnut was found to increase with the increase in moisture content from 5 to 14 per cent[17]. Sorption of hydrogen cyanide and methyl bromide by wheat and corn also increased with the incrase in moisture content from 10 to 15 per cent[5]. However, little difference was shown in the sorption of carbon tetrachloride by wheat of different moisture contents. Berck and Solomon[6] found that chloroform, acrylonitrile and ethylene dibromide were strongly sorbed by wheat at 16 and 20 per cent moisture contents than at 12 per cent. Sorption of methyl bromide by 15 different commodities was increased with increase in moisture content from 9 to 16 per cent[18].

The results obtained by Lindgren *et al.*[10] showed that there was a five-fold increase in sorption of methyl bromide by wheat with a 6 per cent increase in moisture content. Increase in moisture content of wheat from 9.0 to 18.5 per cent increased the uptake of ethylene dibromide and ethylene dichloride from 31 to 91 and 8 to 50 per cent, respectively[19]. However, sorption of carbon tetrachloride was least affected by the change in moisture content. Berck[11] observed that with the increase in moisture content of wheat from 12.5 to 15.0 per cent, sorption of phosphine incresed from 4.8 to 29.4 per cent. Sorption of posphine by wheat was found to increase from 20 to 60 per cent as the moisture content was increased from 9 to 17.5 per cent[12]. Sorption of phosphine and methyl bromide by wheat or corn also increases with the increase in moisture content from 9 to 15 per cent[20]. It is clear from the aobve discussion that sorption of a fumigant by food commodities is closely related to their moisture content. It is believed that when proteins imbibe water, the peptide linkages undergo a partial 'uncooling' process with the result that amino acid grouping become more reactive to gas molecules that diffuse into the cells[3]. Thus, free moisture assists in chemisorption by proteins. It is, therefore, essential that the moisture relationship of a commodity with the fumigant must be taken into consideration before deciding the dosage to be applied.

3. Pressure

Sometimes reduced pressure or 'vacuum' techniques of fumigation are employed for disinfestation of stored commodities. Therefore, any change in the rate of sorption due to low pressure used in vacuum fumigation might necessitate modification of the dosage of fumigant otherwise applied at atmospheric pressure. With this objective in mind, several workers have studied the effect of reduced pressure on sortion of some fumigants. Sinclair and Lindgren[21] found that hydrogen cyanide sorption values for atmospheric fumigation of citrus fruits were a little less than half as great as those for partial vacuum fumigation (65 cm), showing that capacity to sorb hydrogen cyanide increased as pressure was reduced. Sorption of methyl bromide was to the tune of 101 ppm at reduced pressure and 75 ppm at atmospheric pressure, probably due to more rapid penetration of fumigant into the grains under reduced pressure[22]. El Nahal[16] reported that sorption of methyl bromide under reduced pressure was significantly more marked than at atmospheric pressure. There is also greater sorption of hydrogen cyanide by wheat at low pressure[14]. Moreover, Bhambani[23] has shown that sorption of hydrogen cyanide by *Calandra granaria* is from 1.5 to 3 times as great at 2 cm pressure as at atmospheric pressure. It is expected that sorption of hydrogen cyanide by insects and wheat would follow a similar pattern which indicates that sorption is increased at reduced pressure. As the release of residual fumigant absorbed by commodities is also known to be increased at reduced pressures[24, 25], Muthu *et al.*[26] employed air-washing tachnique to use residual methyl bromide for subsequent fumigations in the series. It was found that in the 24-hour exposure series, residual concentrations in air were low due to prolonged sorption by the commodities with the result that not more than two fumigations could be attempted with the initial dosage of 32 mg/l. However, in the varied-exposure series, 3 fumigations could be attempted with the above initial dosage of the fumigant. Since some of the authors also claim that there may be little or no effect of reduced pressure on

sorption[27, 28] or it may even be reduced at lower pressure[22, 29, 39], this problem needs to be further investigated.

4. Exposure Period

Exposure period is the time for which a fumigant is allowed to come in contact with the commodity to be fumigated. Sorption of fumigants has been found to increase with the increase in exposure period. Sorption of hydrogen cyanide by citrus fruits increased with the increase in exposure period[21]. Similarly, uptake of methyl bromide by wheat fumigated for 48 hr was more than 8 times greater than for wheat fumigated for 2 hr[10]. Berck[11] reported that with the increase in exposure period from 1 to 3 days, sorption of phosphine by whole wheat grains, wheat starch and wheat germ was increased from 4.8 to 33.2, 12.3 to 16.8 and 12.1 to 37.5 per cent respectively. As the exposure period is increased from 2 to 24 hours, sorption of phosphine, methyl bromide, ethylene dibromide and hydrogen cyanide increased from 1 to 2, 15 to 43, 78 to 88 and from 84 to 93 per cent respectively[20]. A similar trend in the increase in sorption of these fumigants by corn, with the increase in exposure period, has been noted in the above investigation[20]. In a study carried out in India, sorption of phosphine by wheat was increased from 15 to 24 per cent when the exposure period was increased from 72 to 120 hours[31, 32]. These results clearly indicate that sorption of fumigants by food commodities increases with the increase in the duration of the exposure period.

5. Load Factor

It has experimentally been determined that the size and composition of the load in the fumatorium also determine the degree of sorption of a fumigant. With the increase in the number of boxes of oranges from 9 to 19 in a fumatorium, sorption of methyl bromide, ethylene dibromide, ethylene chlorobromide and hydrogen cyanide was increased from 14.8 to 26.2, 65.2 to 84.6, 54.5 to 77.6 and from 67.4 to 77.8 per cent respectively[21]. Doubling the weight of commodity has been found to reduce the amount of free phosphine by 50 per cent and increase, but not double. the percentage of gas sorbed[11]. Vincent and Lindgren[20] found that with a 20 per cent load of wheat in a fumatorium, the drop in concentration of phosphine, methyl bromide, ethylene dibromide and hydrogen cyanide was 2, 43, 88 and 93 per cent respectively of the theoretical concentration (100 per cent) applied to wheat with 15 per cent moisture content at 80°F. However, with an 80 per cent load, the drop in concentrations was 11 per cent for phosphine, 86 per cent for methyl bromide and more than 95 per cent for both ethylene dibromide and hydrogen cyanide. A similar trend in the drop in concentration of these fumigants due to sorption by corn at different load factors has been noted in the above study[20]. It may be inferred from the above discussion that at any given time point, the sorption of a fumigant would be increased with the increase in load factor.

6. Chemical Nature of Commodity

The chemical nature of a substrate plays a major role in determining the rate of sorption of fumigants. The literature is full of references indicating the differential sorptive capacity of various commodities. For example, less methyl bromide is sorbed by wheat than by peanuts and soybeans[13, 33]. Results with carbon tetrachloride showed that wheat sorbed about twice as much vapour as barley, while sorption by yellow maize was nearly twice as that by wheat[34]. Sorption of methyl bromide by oats and wheat was about twice than by barley, and sorption by yellow maize was about twice than by wheat[35]. The low sorptive capacity of wheat, in comparison with that of walnuts and almonds is also reported[21]. The drop in concentration of carbon tetrachloride, methyl bromide and hydrogen cyanide was greater in the presence of corn than in wheat[5]. Similarly, the drop in concentration of phosphine and methyl bromide was more in case of corn than in wheat[20]. The rate of sorption of methyl bromide by wheat, barley and rice was much less than by flax and milo[18]. Baskaran and Mookherjee[36] studied the sorption of phosphine by wheat, gram and groundnut using the bioassay technique. The trend of their results showed that groundnut sorbed more of the gas than gram or wheat.

Several studies have been carried out to determine the chemical constituents of commodities that are responsible for greater uptake of fumigants. It has been shown that sorption of phosphine by wheat gluten powder, middlings, bran and shorts is greater than by wheat starch, germ and flour[11]. This has been attributed to the relatively higher content of proteins and minerals in the former four commodities. The reactivity of phosphine with Cu, Fe, Hg, Ca, Mg, Zn, Al and other metals has already been established[37]. Materials rich in protein such as gluten (85 per cent), soy flour (52 per cent) and fish protein concentrate (75 per cent) have been found to sorb more phosphine than those low in protein content such as wheat starch (0.2 per cent)[12]. In India, Muthu *et al.*[38] studied sorption of phosphine by various commodities and showed that black gram sorbed 100 per cent phosphine thereby proving the contention that protein rich foods have greater capacity to sorb phosphine. In this context, it may also be mentioned that chemical sorption of methyl bromide has been related to

-SH groups in flour protein[39] and to methylation of amino acids of wheat protein[40, 41]. Bromide residues that resulted from fumigation with methyl bromide increased with increasing the protein content of mill fractions[42]. The high retention of methyl bromide by avocados is positively correlated with the high fat and oil content of the fruit[21]. Similarly, amounts of ethylene dibromide sorbed are also greatly increased by the presence of fat in the seeds[2]. Based on the above discussion, it may be said that commodities rich in proteins, fats and minerals tend to sorb higher quantities of fumigant gases.

7. Particle Size of Commodity

Reduction in the particle size of the commodity through cracking, grinding or milling favours increased sorption of fumigants. It has been shown that less methyl bromide is sorbed by whole than by milled wheat[43, 44]. El Rafie[4] found that sorption of carbon disulphide was higher by ground than by whole grains. Methyl bromide was sorbed more rapidly by cracked than by whole kernel wheat[17]. Lindgren *et al.*[10] reported that mean average concentration of methyl bromide in the presence of whole kernel wheat was 28 mg/l, while for the fractions (bran, shorts, flour and middlings) it was 19 mg/l, indicating greater sorption by finely ground fractions. Berck[19] showed that even moderate decrease in particle size of wheat grains by grinding very markedly increased the uptake of ethylene dichloride, carbon tetrachloride and ethylene dibromide. Similarly, sorption of phosphine was found to be significantly increased with the reduction in particle size of substrates like wheat and oats[11].

The increase in uptake of fumigants in the preceeding examples may not entirely be due to the multiplication of surface area by the decrease in particle size. It may presumably be mainly due to the exposure of more reactive sites due to grinding and milling of commodities. In this context, it is thought that the exposure of reactive endosperm appears to have a greater influence on sorption rather than multiplication of surface area as such[19]. Therefore, it seems that chemical nature of a commodity is a major factor influencing sorption and may predominate over physical factors such as particle size. However, a more exact explanation of forces that affect sorption of fumigant gases by food commodities is needed.

Conclusion

Sorption is an extremely important factor affecting the successful outcome of fumigation. Under a given set of conditions, sorption determines the dosage of fumigant to be applied because the amount of fumigant used must be sufficient to satisfy total sorption during treatment and also to leave enough free gas to kill insects. The rate and amount of sorption of a fumigant are influenced by several factors. Therefore, a certain fumigant must be tested with each commodity concerned under different conditions of temperature, moisture, pressure, grain load, exposure period, etc., before recommendations for treatment can be drawn up. The dosage applied should be adjusted taking into consideration the loss of fumigant due to sorption under different conditions.

References

1. McBain, J. W., *Nature, Lond.*, 1926, **117**, 550.
2. Monro, H.A.U., *Manual of Fumigation for Insect Control*, FAO Agricultural Studies No. 79, Rome, 1969, 381.
3. Berck, B., *World Rev. Pest Control*, 1964, **3**, 156.
4. El Rafie, M.D., *J. Sci. Fd Agric.*, 1954, **5**, 536.
5. Lindgren, D.L. and Vincent, L.E., *J. econ. Ent.*, 1960, **53**, 1071.
6. Berck, B. and Solomon, J., *J. agric. Fd Chem.*, 1962, **10**, 163.
7. Dumas, T., *J. agric. Fd Chem.*, 1973, **21**, 433.
8. Lubatti, O.F. and Harrison, A., *J. Soc. chem. Ind. Lond.*, 1944, **63**, 353.
9. Monro, H.A.U., *Res. Fmrs.*, 1960, **5**, 3.
10. Lindgren, D.L., Gunthur, F.A. and Vincent, L.E., *J. econ. Ent.*, 1962, **55**, 773.
11. Berck, B., *J. agric. Fd Chem.*, 1968, **16**, 419.
12. Berck, B. and Gunthur, F.A., *J. agric. Fd Chem.*, 1970, **18**, 148.
13. Lubatti, O.F. and Smith, B., *J. Soc. chem. Ind., Lond.*, 1948, **67**, 297.
14. El Nahal, A.K.M., *J. Sci. Fd Agric.*, 1953, **4**, 517.
15. El Nahal, A.K.M., *J. Sci. Fd Agric.*, 1954 a, **5**, 205.
16. El Nahal, A.K.M., *J. Sci. Fd Agric.*, 1954 b, **5**, 369.
17. Somade, H.M.B., *J. Sci. Fd Agric.*, 1955, **6**, 799.
18. Lindgren, D.L. and Vincent, L.E., *Adv. Pest Control Res.*, 1962, **5**, 85.
19. Berck, B., *J. agric. Fd Chem.*, 1965, **13**, 248.
20. Vincent, L.E. and Lindgren, D.L., *J. econ. Ent.*, 1971, **64**, 122.
21. Sinclair, W.B. and Lindgren, D.L., *J. econ. Ent.*, 1958, **51**, 891.
22. Heuser, S.G., *J. Sci. Fd Agric.*, 1959, **10**, 93.
23. Bhambani, H.J., 1952, Ph.D. Thesis, University of London.
24. Brown, W.B., *Vacuum*, 1958, **6**, 75.
25. Brown, W.B. and Heuser, S.G., *J. Sci. Fd Agric.*, 1953, **4**, 378.
26. Muthu, M., Srinivasan, K.S. and Majumder, S.K., *Food Technol.*, 1961, **15**, 295.
27. Heuser, S.G. and Hedley, R.B., *Pest Infest. Res.*, 1952, 32.
28. Brown, W.B. and Heuser, S.G., *J. Sci. Fd Agric.*, 1953, **4**, 48.
29. Mackie, D.B., *Mon. Bull. Calif. Dep. Agric.*, 1931, **20**, 299.
30. Lorenz, M., *Food Ind.*, 1935, **7**, 474.
31. Dhaliwal, G.S. *Studies on the Toxicity and Residues of Phosphine*, 1972, Ph.D. Thesis, I.A.R.I., New Delhi.
32. Dhaliwal, G.S., *Entomologists' Newsl.*, 1973, **3**, 2.

33. Cotton, R.T., *Pests of Stored Grain and Grain Products*, Burgess Publishing Company, Minn., 1963, 318.
34. Heuser, S.G. and Thomas, C.E., *Pest Infest. Res.*, 1953, 27.
35. Brown, W.B., Heseltine, H.K. and Pearson, J.D., *Pest Infest. Res.*, 1954, 28.
36. Baskaran, P. and Mookherjee, P.B., *Indian J. Ent.*, 1971, **33**, 23.
37. Van Wazar, J.R., *Phosphorus and Its Compounds*, Interscience Publishers, New York, 1958, Vol. I, 171.
38. Muthu, M., Narasimhan, K.S. and Majumder, S.K. In Proceedings of the First All India Symposium on Progress and Problems in Pesticides Residue Analysis, Ludhiana, 1973, 301.
39. Page, A.B.P. and Lubatti, O.F., *Chemy. Ind.*, 1940, **59**, 172.
40. Bridges, R.G., *J. Sci. Fd Agric.*, 1956, **7**, 305.
41. Winteringham, F.P.W., Harrison, A., Bridges, R.G. and Bridges, P.M., *J. Sci. Fd Agric.*, 1955, **6**, 251.
42. Gibich, J. and Pederson, J.R., *Cereal Sci. Today*, 1963, **8**, 345.
43. Brown, W.B., Heseltine, H.K., Devlin, J.J. and Greer, E.M., *Milling*, 1961, **137**, 401.
44. Winteringham, F.P.W. and Harrison, A., *J. Soc. chem. Ind., Lond.*, 1946, **65**, 140.

RESEARCH PAPERS

Effect of Moisture on Chemical and Rheological Properties of Stored *Atta* in Relation to *Chapathi* Baking Characteristics

S. S. ARYA, K. S. PREMAVALLI, R. K. LEELA, D. B. PARIHAR AND H. NATH
Defence Food Research Laboratory, Mysore

Manuscript Received: 20 *August* 1973

Effects of controlled moisture on storage changes in chemical, rheological and chapati baking properties of *atta* are reported. At 8.6 per cent moisture no appreciable changes in sugars, proteins and lipids were observed but storage at 12.5 and 15.9 per cent moistures was associated with decreases in total sugars, polar lipids, glutenin and salt soluble proteins. Changes in rheological properties of stored *atta* in relation to chapati baking characteristis are discussed.

Moisture, temperature and oxygen concentration mainly influence the chemical and microbial deterioration during storage of cereal grains and their milled products[1]. The storage behaviour of *atta* in various types of packaging materials under high humid field conditions (37°C/90 per cent RH) simulated in laboratory and also under actual field conditions was reported earlier[2,3]. It was observed that changes in chapati baking characteristics of stored *atta* were mainly governed by the rate of moisture ingress in different packaging materials. As such studies on the chemical, rheological and chapati baking properties of stored *atta* having moisture contents ranging from 8.5 to 15.9 per cent representing the typical moisture limits encountered during transportation and storage under hot/dry and hot/humid climates, have been reported in this paper.

Materials and Methods

Moisture equilibration and storage: Commercial wheat *Sharbati* (*Tricticum vulgare*) was milled in a flour mill (*chakki*) and sifted through a 30 mesh sieve to remove bran. The initial 8.6 per cent moisture content of *atta* was increased to 12.5 and 15.9 per cent by keeping at 90 per cent R.H. The equilibriated samples were stored in 2.5—kg lots in tins with air tight lids in an incubator maintained at 37°C±1°C.

Analysis: After 10 and 20 weeks' storage, the samples were analysed for moisture, reducing and total sugar and diastatic activity by the AACC methods[4]. Glutenin, gliadin, proteins soluble in 5 per cent potassium sulphate, free and bound lipids, lipid galactose and phosphorus were determined by the methods described earlier[4]. Thin layer chromatography of lipids was performed on Silica gel-G plates activated at 120°C for 2 hr and developed in a system consisting of chloroform, methanol and water (65:35:4)[5]. Starch samples were prepared by cold water washing method[6] and their digestibility were determined by gravimetric method of Gates and Sandstedt[7] using pancreatin.

TABLE 1. CHANGES IN SUGARS, PROTEINS, DIASTATIC ACTIVITY AND STARCH DIGESTIBILITY OF ATTA SAMPLES STORED AT DIFFERENT MOISTURE LEVELS AT 37°C

Moisture%		8.6		12.5		15.9	
Storage period (weeks)	Initial	10	20	10	20	10	20
Reducing sugar (mg maltose/10 g flour)	46.4	45.7	47.6	59	55.1	54.8	52.3
Non-reducing sugar (mg sucrose/10 g flour)	227.8	225.9	211.4	194.1	186.8	95.2	19.4
Diastatic activity (mg maltose/10 g flour/hr at 30°C)	405.6	412.1	410.2	399.8	410.7	407.2	429.6
5% K_2SO_4 soluble proteins (%)	2.30	2.29	2.31	2.21	2.02	1.83	1.68
Gliadin (%)	4.26	4.27	4.30	4.32	4.34	4.06	4.11
Glutenin (%)	3.43	3.44	3.47	3.38	3.33	2.79	2.59
Starch digestibility*	68.0	—	67.9	—	66.0	—	60.8
Mould count (colonies/g)	10–29	253	239	731	12430	3392	391,800

*Per cent hydrolysis by pancreatin.

Rheological properties: Farinograph and Extensograph curves were drawn using standard AACC procedures[4] and water absorption, dough development time, mixing tolerance index, valorimeter value extensibility and resistance to extension were calculated.

Chapati baking: Chapati baking tests were made on laboratory scale from 300 *g atta*. Dough was prepared by adding water, 200 ml and salt, 3 g to 300 g *atta* and by hand kneading for 5 min. Pieces of dough (45g) were rolled into circular discs of 15 cm diameter and baked on a hot plate at 190±10°C for 40 sec followed by puffing in an electric puffer for 20 sec. The texturometer curves (General Foods Corporation, U.S.A.) were drawn on samples from central and peripheral portions of chapaties. From the curves, data on hardness and cohesiveness were computed.

Results and Discussion

Chemical changes: It is seen from Table 1 that reducing sugar content remained constant in samples with 8.6 per cent moisture but it increased in samples with higher moisture content. A maximum increase of 26.7 per cent was observed in sample with 12.5 per cent moisture after 10 weeks storage. Decrease of non-reducing sugar content was more pronounced in samples containing 12.5 and 15.9 per cent moisture. Bottomley *et al.*[8] have related the changes in non-reducing sugar in corn stored under high humidity to their conversion into reducing sugars by the enzymes secreted by growing moulds. In the present study increases in reducing sugar were much less than those expected from the corresponding decreases in non-reducing sugar indicating their further utilisation during storage in samples containing 12.5 and 15.9 per cent moisture. Since high mould counts have been associated with high respiratory activity[9], changes in sugars may be attributed to the increased respiratory activity of moulds in high moisture samples. The original mould count of 10-30 colonies per g increased to 13,000 and 410,000 colonies per g in 12.5 and 15.9 per cent moisture samples respectively after 20 weeks of storage.

In vitro digestibility of starch by pancreatic enzymes remained almost constant during storage in samples having 8.6 per cent moisture but it decreased in samples having 15.9 per cent moisture. This may be due to inhibition of pancreatic amylase by mould metabolites.

The changes in protein fractions were not significant in samples stored at 8.6 per cent moisture but 12.5 per cent moisture samples showed lesser amounts of potassium sulphate soluble proteins. Both glutenin and salt soluble proteins decreased during storage in 15.9 per cent moisture samples. Similar changes were observed previously[2, 10].

The changes in free and bound lipids, lipid phosphorus and galactose and free fatty acids are shown in Table 2. Morrison *et al.*[11] have reported that storage at 25° and 37°C caused significant decrease in water saturated butanol extractable lipids due to the separation of water soluble parts of lipid molecule by lipolysis. In the present study, 12.5 per cent moisture samples showed considerable losses in free lipids which could not be accounted for the separation of water soluble part of

TABLE 2. CHANGES IN LIPIDS OF ATTA STORED AT VARIOUS MOISTURES AT 37°C

Moisture %		8.6		12.5		15.9	
Storage period (weeks)	Initial	10	20	10	20	10	20
Free lipids	1639	1588	1592	1470	257.2	565.4	189.9
Lipid galactose (mg/100 g of flour)	10.5	10.5	10.3	5.8	1.2	3.3	0.86
Lipid phosphorus ,,	12.6	12.6	12.4	—	2.7	—	2.6
Fat acidity (mg KOH/100 g flour)	14.1	30.7	73.9	46.7	39.9	35.5	26.9
FFA (% oleic acid)	4.1	9.5	22.2	15.2	73.9	29.9	73.6
Bound lipids	466.1	460.7	395.8	339.7	319.5	302.0	87.8
Lipid galactose (mg/100 g of flour)	10.5	10.5	10.3	8.2	5.4	2.9	1.2
Lipid phosphorus (mg/100 g of flour)	1.8	1.8	1.7	—	1.7	—	0.2
Fat acidity (mg KOH/100 g flour)	15.5	16.6	11.6	11.5	13.2	15.8	5.1
FFA (% oleic acid)	15.9	17.2	—	16.1	18.0	24.3	27.7

the lipid molecules only. Probably in higher moisture samples the fatty acids liberated by the lipolysis might have been metabolised by microorganisms especially by moulds. High mould counts, musty odour and decreases in petroleum ether soluble lipids in *atta* sample containing 12.5 and 15.9 per cent moisture indicate degradation of fatty acids by moulds. Fat acidity expressed as mg potassium hydroxide per 100 g flour does not correlate with storage deterioration in higher moisture samples but when expressed as percentage free fatty acids (percentage oleic acid) it indicates more precisely deteriorative changes. This indicates that even though percentage of free fatty acids in lipids is higher but total free fatty acids are less in higher moisture samples. Pomeranz[12] has also reported higher losses in polar lipids than the corresponding increases in free fatty acids.

The polar wheat flour lipids play an important role in determining the chapati baking characteristics of *atta*. The percentage free phospholipids have shown high correlation with the texture of chapaties[13]. Their ability to form both electrovalent and hydrophobic linkages between glutenin and gliadin in dough has been reported to be responsible for their beneficial effects in baking[14]. Therefore changes in lipid phosphorus and galactose were followed during storage and individual constituents of these lipids separated by thin layer chromatography. It is observed that lipid phosphorus and galactose decreased in samples having 12.5 and 15.9 per cent moisture but remained unchanged in 8.6 per cent moisture sample. It may be seen from Fig I that petroleum ether extractable lipids of samples with 12.5 and 15.9 per cent moisture did not have detectable amounts of phosphotidylcholine, phosphotidylserine and phosphotidylethanolamine. Digalactosyl diglyceride was present in sample having 12.5 per cent moisture but it was absent in the sample having 15.9 per cent moisture after 20 weeks storage. The monogalactosyldiglyceride was present in all the samples, though its spot intensity was much less in samples having 15.9 per cent moisture. The disappearance of phospholipid spots and simultaneous decrease in lipid phosphorus indicates the deacylation of both the fatty acid moities from the lipid molecule making it insoluble in lipid solvents. The bound polar lipids were less susceptible to storage damage than free polar lipids. The bound polar lipid from samples having 12.5 per cent moisture had detectable amounts of phosphotidylcholine, phosphotidyl serine, phosphotidyl ethanolamine but none of these fractions were present in samples having 15.9 per cent

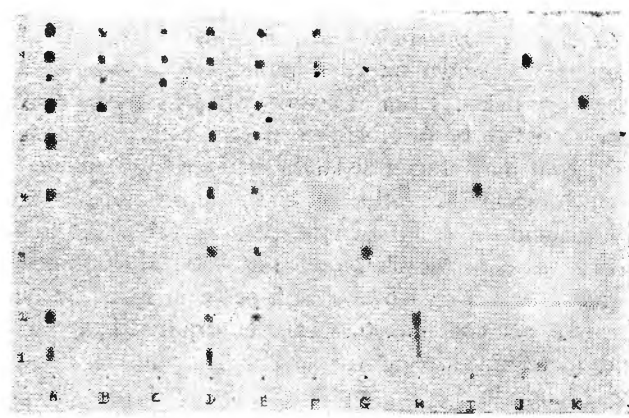


Fig. 1 TLC of polar lipids of *atta* samples after 20 weeks storage at 37°C with different moisture levels. A, B, C, free lipids and D, E, F, bound lipids of samples having moisture 8, 6, 12.5 and 15.9 respectively; G, phosphotidyl ethanolamine; H, phosphotidyl serine; I, phosphotidyl choline; J. monogalactosyl diglyceride; K, digalactosyldiglyercide. Irrigating solvent, chloroform: methanol: water (65:25:4) at 4°C; spots visualised by exposing to iodine vapours. Tentatively identified as: 1, phosphotidyl serine; 2, unidentified; 3, phosphotidyl ethanolamine; 4, phosphotidylcholine; 5, unidentified; 6, digalactosyldiglyceride; 7, unidentified; 8, monogalactosyldiglyceride; 9, unresolved non-polar lipids.

TABLE 3. FARINOGRAM AND AMYLOGRAM DATA OF ATTA STORED AT VARIOUS MOISTURE LEVELS AT 37°C AFTER 20 WEEKS

	Initial	After storage at below indicated moisture levels 8.6%	12.5%	15.9%
Water absorption (%)	71.3	79.0	80.0	66.0
Valorimeter value	52	60	61	Beyond the scale
Dough development time (min)	4.5	5.5	7	25
Mixing tolerance index (min)	0.5	1	1	15
Gelatinisation viscosity (B.U., Amylograph)	680	1000	600	400

TABLE 4. EXTENSOGRAM VALUES OF ATTA STORED AT VARIOUS MOISTURE LEVELS AT 37°C AFTER 20 WEEKS

	Initial	After storage at below indicated moisture levels 8.6%	12.5%	15.9%
Extensibility (m.m.)	125	77.5	77	60
Resistance to extension (B.U.)	490	770	495	290
Area (cm^2)	76.2	63.0	44.5	22.5

moisture content. Pomeranz *et al.*[14] have also reported comparatively less damage to polar bound lipids during storage.

Changes in rheological and chapati baking characteristics: Since volume and puffing characteristics of chapaties baked from different wheat varieties have been found to be positively correlated with valorimeter value and maximum resistance to extension[13], changes in rheological properties of *atta* during storage were studied and the results are presented in Tables 3 and 4. There was considerable increase in water absorption of stored *atta* having 8.6 and 12.5 per cent moisture but the 15.9 per cent moisture sample required less water and increased mixing for attaining optimum dough consistency in Farinograph test. Since during dough making protein bodies hydrate and swell and due to shearing action get elongated imparting maximum dough consistency, decreased water absorption and increased mixing indicate decreased water imbibing capacity and swelling of proteins in stored *atta*. This may be due to decreased glutenin and salt soluble protein as observed in the present study (Table 1). During storage extensibility and extensogram area decreased at each moisture level but stored *atta* having 8.6 per cent moisture had increased resistance to extension indicating its better puffing characteristics during chapati baking

TABLE 5. TEXTURE* OF CHAPATIES PREPARED FROM ATTA STORED AT DIFFERENT MOISTURE LEVELS AT 37°C FOR 20 WEEKS

Moisture %	Hardness (cm) Centre	Periphery	Cohesiveness Centre	Periphery
8.6	5.6	13.4	0.89	0.94
12.5	6.2	13.0	0.94	0.95
15.9	10.3	16.4	0.96	0.93

*Hardness has been expressed as the height of the first peak in cm. Cohesiveness is the ratio of the areas under the second peak over the area under first peak and is a direct function of the work needed to overcome the internal bonds in the material.

than the *atta* stored at 12.5 and 15.9 per cent moisture. Chapati made from 15.9 per cent moisture *atta* had harder texture as compared to those made from lower moisture *atta* (Table 5). Chapaties baked from 12.5 per cent moisture *atta* had inferior aroma and flavour in contrast to those prepared from lower moisture *atta*. This adverse effect on baking quality of *atta* stored at higher moistures may be due to the disappearance of polar lipids and changes in proteins.

References

1. Milner, M., Geddes, W.F., *Storage of Cereal Grains and Their Milled Products*, Am. Ass. Cereal Chemists, St. Paul, Minn, 1954, 152.
2. Arya, S.S., Mohan, M.S. and Nath, H., *J. Fd Sci Technol.*, 1971, **8**, 134.
3. Premavalli, K.S., Leela, R.K., Arya, S.S., Parihar, D.B. and Nath, H., *J. Fd Sci. Technol.*, 1973, **10**, 27.
4. *Cereal Laboratory Methods*, American Association of Cereal Chemists, Minnesota, 6th Edition, 1957.
5. Daftary, R.D. and Pomeranz, Y., *J. Fd Sci.*, 1965, **30**, 577.
6. Wolf M.J., *Methods in Carbohydrate Chemistry*, Vol. IV, Edited by Whistler, R.L., Academic Press, New York, 1964, 6.
7. Gates, R.L. and Sandstedt, R.M., *Cereal Chem.*, 1953, **30**, 413.
8. Bottomley, R.A., Christensen, C.M. and Geddes, W.F., *Cereal Chem.*, 1952, **29**, 53.
9. Hummel, B.C.W., Cuendet, L.S., Christensen, C.M. and Geddes, W.F., *Cereal Chem.*, 1954, **31**, 143.
10. Daftary, R.D., Pomeranz, Y. and Sauer D.B., *J. agric. Fd Chem.*, 1970, **18**, 613.
11. Clayton, T.A. and Morrison, W.R., *J. Sci. Fd Agric.*, 1972, **23**, 721.
12. Pomeranz, Y., *Cereal Sci. Today*, 1971, **16**, 119.
13. Arya, S.S., Vidyasagar, K., Parihar, D.B. and Nath, H., communicated to *J. Fd Sci. Technol.*
14. Pomeranz, Y., Finney, K.F. and Hoseney, R.C., *Baker's Digest*, 1970, **22**, 44.

Changes in Berry Weight, Organic Acids and Sugars during Ripening and Storage of Pusa Seedless Grapes Treated with Ethrel (2-Chloroethyl-Phosphonic Acid) and Growth Retardants*

R. M. PANDEY AND M. M. RAO**
Indian Agricultural Research Institute, New Delhi

Manuscript received: 22 *April* 1974

Changes in *Pusa Seedless* grapes treated with Ethrel and CCC/Alar after lag phase of berry development were followed during the periods of ripening and storage at both room temperature (30°–40°C) and low temperature (0–1°C and 85–95% RH) conditions. The study revealed that the treatments reduced the berry weight and affected the organic acid metabolism. The level of malic acid was higher and that of tartaric acid lower in Ethrel-treated fruit. No hastening of ripening was noticed and the sugar/acid ratio was lesser than control at harvest. In the case of growth retardant treated fruit, the dissipation of malic acid during ripening was slower and consequently the ripening process was affected. The sugar accumulation was slow and berries contained less sugar at harvest. During storage, the rate of loss in sugar content of treated berries was slower than that of control.

Ethrel, an ethylene-releasing compound and growth retardants are being widely used for regulation of fruit ripening. Hastened ripening of grapes has been reported by Ethrel treatment. Growth retardants have successfully controlled the ripening of apples[1] and inhibited the senescence of certain vegetables[2]. The mechanism of action of these chemicals is, however, still not clear. Since the studies on their effect on metabolism of major constitutents have received only a limited attention, the present study was undertaken.

Materials and Methods

Twelve-year old uniformly growing *Pusa Seedless* vines of the Institute orchard were selected for the experiment. One hundred bunches of uniform size and maturity were tagged for each treatment. The bunches were sprayed with aqueous solutions of Ethrel and growth retardants (with 0.1 per cent Tween. 20 as wetting agent) on May 23, 1972, when the berries had just passed through their lag phase (Stage II) of development. This stage was observed[3] to be confined between 5th and 6th week of berry development following anthesis. The different treatments were: Ethrel (2-Chloroethyl phosphonic acid), 250 and 500 ppm; CCC (2-Chloroethyl trimethyl ammonium chloride), 500 ppm and Alar (succinic acid 2, 2-dimethyl hydrazide), 1000 ppm. These treatments have been designated as Ethrel-250, Ethrel-500, CCC-500, and Alar-1000 in the following text.

Storage studies were done on 4 kg of grape bunches harvested 9 weeks after anthesis (which is the normal stage of harvest for this variety) placed in two layers in the specially designed wooden crates, which were stacked in cold room (0-1 °C and 85-95 per cent RH).

A separate set of crates was also stacked under room temperature (RT 30–42°C and 50–60 per cent RH) conditions.

Samples of berries were collected at intervals for analysis. At every sampling average berry weight was determined by recording the weight of 100 berries picked up from middle region of 30–40 bunches. The berries of the middle portion of the bunch are known to be more uniform in size and maturity. The organic acids and sugars were determined as described[4]. The data of the fresh weight of berry were computed to 'single berry' on the basis of average weight of berry at the respective sampling.

Results and Discussion

Changes in berry weight: In general, the average berry weight was lower in all the treated fruits (Table 1).

* A portion of the doctoral thesis of the second author submitted to the Post-Graduate School, Indian Agricultural Research Institute, New Delhi.

** Present address: College of Agriculture, Dharwar.

TABLE 1. CHANGES IN BERRY WEIGHT OF PUSA SEEDLESS GRAPES TREATED WITH ETHREL AND GROWTH RETARDANTS AFTER LAG PHASE (6 WEEKS AFTER ANTHESIS) DURING RIPENING AND STORAGE

Stage of determination	Control		Ethrel-500 ppm		Ethrel-250 ppm		CCC-500 ppm		Alar-1000 ppm	
	Berry wt mg	Rate of increase(+) or loss(−) in berry wt	Berry wt mg	Rate of increase(+) or loss(−) in berry wt	Berry wt mg	Rate of increase(+) or loss(−) in berry wt	Berry wt mg	Rate of increase(+) or loss(−) in berry wt	Berry wt mg	Rate of increase(+) or loss(−) in berry wt
During ripening: (weeks after anthesis)										
7 weeks	625	+199	633	+207	615	+189	657	+231	469	+ 43
8 ,,	900	+275	933	+300	1000	+385	835	+178	899	+430
9 ,,	1146	+246	1127	+194	1040	+ 40	1050	+215	1002	+103
*During storage:** (days in storage)										
At RT(30–42°C)										
3 days	1070	− 76	1047	− 80	983	− 57	988	− 62	931	− 71
7 ,,	933	−137	923	−124	866	−117	880	−108	835	− 96
At 0–1°C										
10 ,,	1071	− 75	1042	− 85	969	− 71	988	− 62	925	− 77
20 ,,	1039	− 32	1019	− 23	943	− 26	973	− 15	905	− 20
30 ,,	1008	− 31	956	− 63	914	− 29	939	− 44	887	− 18

*Separate lots were stored under RT (room temperature) and cold storage.

The retardation of berry growth was more marked in Alar-treated fruit than in CCC-treated fruit. Weaver and Pool[5] observed an increase in the size of the carignane berries by Ehtrel treatment (at 1000 ppm) at a stage when at least a few berries in the cluster had started softening. This stage probably corresponds to the stage of termination of lag phase (Stage II) of berry development. In the present study also, Ehtrel was treated after the termination of lag phase but the treatment reduced the berry weight. These conflicting results may be due to varietal differences, especially with regard to the endogenous levels of ehtylene. This assumption may be supported by the fact that berry growth was retarded by the application of growth retardants, which are known to interfere with the biosynthesis of ethylene[1].

In storage, no difference in the general trend of loss in berry weight in different treatments was observed.

Changes in organic acids: The two predominant organic acids were malic acid and tartaric acid. In

TABLE 2. CHANGES IN ORGANIC ACIDS* IN PUSA SEEDLESS GRAPES TREATED WITH ETHREL AND GROWTH RETARDANTS AFTER LAG PHASE (6 WEEKS AFTER ANTHESIS) DURING RIPENING AND STORAGE**

Stage of determination	Control		Ethrel-500 ppm		Ethrel-250 ppm		CCC-500 ppm		Alar-1000 ppm	
	Malic acid	Tartaric acid	Malic acid	Tartaric acid	Malic acid	Tartaric acid	Malic acid	Tartaric acid	Malic acid	Tartaric acid
	mg/per berry									
During ripening: (weeks after anthesis										
7 weeks	5.1	6.0	3.2	1.6	1.0	2.3	5.5	1.8	3.0	1.1
8 ,,	2.7	7.2	1.9	3.9	1.8	5.8	6.0	4.4	3.4	4.9
9 ,,	1.1	7.3	1.6	3.6	2.9	6.7	3.1	5.6	3.6	4.0
During storage:@ (days in storage)										
At RT(30–42°C)										
3 days	5.6	6.0	5.8	8.2	7.1	3.3	6.9	6.9	7.8	4.6
7 ,,	7.8	7.5	5.5	4.3	6.6	4.4	4.6	4.9	5.5	3.5
At 0–1°C										
10 days	7.1	6.4	5.8	3.5	5.8	3.3	3.6	3.7	4.3	2.6
20 ,,	2.9	5.8	2.8	2.8	3.2	3.4	4.3	3.9	4.5	4.3
30 ,,	8.1	6.2	6.3	3.4	6.6	3.9	3.8	3.2	2.3	3.2

*Includes salt forms also. **Mean of duplicate samples @ Separate lots were stored under RT (room temparature) and cold storage

TABLE 3. CHANGES IN REDUCING SUGARS AND SUGAR/ACID RATIOS* IN PUSA SEEDLESS GRAPES TREATED WITH ETHREL AND GROWTH RETARDANTS AFTER LAG PHASE (6 WEEKS OF AFTER ANTHESIS) DURING RIPENING AND STORAGE**

Stage of determination	Control		Ethrel–500 ppm		Ethrel–250 ppm		CCC–500 ppm		Alar–1000 ppm	
	Sugar mg/berry	Sugar/ acid ratio	Sugar mg/berry	Sugar/ acid ratio	Sugar mg/berry	Sugar/ acid ratio	Sugar mg/berry	Sugar/ acid ratio	Sugar mg/berry	Sugar/ acid ratio
During ripening: (weeks after anthesis)										
7 weeks	40	3.6	43	8.9	46	13.9	34	4.7	19	4.6
8 ,,	104	10.5	86	14.8	100	13.1	63	6.1	78	9.4
9 ,,	166	19.8	142	27.3	137	14.3	126	14.5	116	15.3
During storage@. (days in storage)										
At RT(30–42°C)										
3 days	150	12.9	147	10.5	134	12.9	118	8.6	115	9.3
7 ,,	127	8.3	114	11.6	118	10.7	99	10.4	112	12.4
At 0–1°C										
10 days	160	11.9	147	15.8	124	13.6	124	17.0	121	17.5
20 ,,	130	14.9	141	25.2	108	16.4	117	14.3	117	13.3
30 ,,	121	8.5	125	12.9	107	10.2	115	16.4	102	18.5

*The acid refers to sum total of malic acid and tartaric acid.

**Mean of duplicate samples.

@Separate lots were stored under RT (room temperature) and cold storage.

general, there were higher levels of malic acid and lower levels of tartaric acid in treated grapes (Table 2). There was a tendency for a rise in malic acid level in all the treated fruits except in Ethrel-500 and consequently the levels at harvest were higher than in control. The levels of tartaric acid in the treated fruit showed a fluctuating trend in storage but the general lower level as observed at harvest was maintained throughout the storage period. It is not clear as to how the treatments affected the organic acid metabolism especially with regard to the biosynthesis and translocation of tartaric acid and dissipation of malic acid.

Changes in reducing sugars: Ethrel-treated berries showed a tendency for higher rate of sugar accumulation immediately following treatment (Table 3) but the content did not reach the level of control at the normal time of harvest (June, 12). The sugar content was the least in Alar-treated fruit followed by CCC-treated fruit. The sugar/acid ratios remained lower in the growth retardant-treated fruits.

In storage, the rate of loss in sugar content was slower in all the treated fruits. The rate was the least in the case of CCC treatment.

Effect on ripening and senescence: In the present study, Ethrel did not hasten the ripening of berries when treated after lag phase of berry development. Hale *et al*[6]. observed hastened ripening when treated at the end of Stage II or during early Stage III of berry development, but when the treatment was given at a later stage, the maturity was delayed. In a separate study by the authors[7] Ethrel was treated at three different stages viz., pre lag (Stage I), lag (Stage II) and post lag (Stage III) phases of berry development. The results showed that the treatment at Stage II raised the sugar/acid ratio and hastened the ripening by a week. These results suggest that the attainment of higher sugar/acid ratio or the early ripening may be dependent upon the maintenance of certain balance of endogenous ethylene levels, especially during lag phase.

The lower rate of loss of sugar and the tendency for slower rate of loss in berry weight during storage in the treated fruits may be considered to be indices of retarded berry senescence. If this is so, then these chemicals could be employed to delay senescence in grapes provided the stage of treatment could be so timed as to avoid their interference with sugar accumulation.

Acknowledgement

Grateful acknowledgements are made to the Indian Council of Agricultural Research and Department of Atomic Energy for award of fellowship to the second author for doctoral studies and to Dr R. N. Singh, Head, Division of Horticulture, I.A.R.I., New Delhi, for providing facilities.

References

1. Looney, N.E., *Pl. Physiol.*, 1969, **44,** 1127.
2. Halevy, A.H., Dilley, D.R. and Wittwer, S.H., *Pl. Physiol.*, 1966, **41,** 1085.
3. Rao M.M., *Studies on Physiological and Biochemical Factors Associated with Development, Ripening and Senescence of Pusa Seedless Grapes*, 1973, Ph.D. thesis, I.A.R.I., New Delhi.
4. Rao, M.M., Pandey, R.M., and Singh, R.N., *Progr. Hort.*, 1974, **6,** (1), 5.
5. Weaver, R.J. and Pool, R.M., *J. Amer. Soc. hort. Sci.*, 1971. **96,** 725.
6. Hale, C.R., Coombe, B.G. and Hawker, J.S., *Pl. Physiol.*, 1970, **45,** 620.
7. Rao, M.M., Pandey R.M. and Singh, R.N., *South Indian J. Hort.*, 1975, **22,** (In press).

Colour Content of Turmeric Varieties and Studies on Its Processing

M. N. KRISHNAMURTHY, R. PADMABAI, C. P. NATARAJAN AND S. KUPPUSWAMY
Central Food Technological Research Institute, Mysore-13

Manuscript Received: 8 *May* 1974

Seventeen turmeric varieties covering a period of two seasons and eight commercial varieties were examined for total colour content. Studies on the effect of different processing conditions on the volatile oil and colour content revealed no appreciable loss of these constituents. Boiling or slicing or peeling the rhizomes reduced the drying time considerably. Boiling the rhizomes for an hour before drying was found to be optimum. Slicing and drying of turmeric for the manufacture of oleoresin or for making into a powder is suggested.

India is the largest producer of turmeric and different varieties are grown in different regions. The literature available is covered by various reviews [1-4]. Sufficient data are not available on the effect of boiling on the colour content and volatile oil content. In this paper certain studies carried on drying and the effect of different processing conditions on volatile oil and total colour and also colour content of different varieties of turmeric are reported.

Materials and Methods

Both cured and uncured samples of various turmeric varieties from Research Stations in Andhra, Maharashtra and Kerala were obtained. The cured samples were powdered to pass through 20 mesh sieve for the estimation of colour. The uncured samples were cured by boiling in water for an hour and dried before analysis. The colour of turmeric was estimated in duplicate by ASTA method[5] and the total colour was expressed as curcumin. The standard curcumin used in the estimation was isolated in our laboratory which compared very well with a standard curcumin obtained from Koch Laboratory, London. Total colour content of two important turmeric species *Curcuma longa* (11 samples) and *Curcuma aromatica* (8 samples) have been estimated by this method. Colour content of some commercial varieties of Andhra Pradesh and variation in colour content of 17 turmeric varieties in two successive years obtained from a research station in Kerala are reported (Table 1 and 2).

Using turmeric rhizomes obtained from a local farm, different processing methods like boiling in water for 30 min to 3 hr; boiling in 0.1 per cent sodium carbonate solution for an hour; abrasive peeling for different length of time; slicing and sun drying or artificial drying; slicing and drying after boiling in water or steaming at 5 psi, were tried. For slicing the turmeric rhizomes, a mechanical slicer was used to cut into $\frac{1}{4}$in. thick slices. For peeling, an abrasive peeler (Hubard) was used. By adjusting the operation time of the machine it was possible to standardize the peeling time as 30 sec

TABLE I. TOTAL COLOUR CONTENT OF CURED TURMERIC SAMPLES FROM ANDHRA PRADESH

Variety	% Curcumin*
Seethampeta Agency	2.2
Chayapasupu araku	2.1
Tekurpeta Cl/1-1	2.2
Armoor	2.3
Kasturi	1.7
Kesari	3.3
Vontimitta	1.8
Duggirala Local	3.4

*Represents total colour expressed as % curcumin on moisture free basis.

TABLE 2. COLOUR OF TURMERIC SAMPLES IN TWO SEASONS FROM HORTICULTURAL RESEARCH STATION, KERALA

Variety	Expressed as % curcumin*		Average
	1968	1969	
Armoor	2.92	3.22	3.07
Amisthapani kothepele	3.90	3.95	3.93
Kodur type	3.07	3.43	3.25
Sugandham	3.25	3.50	3.38
Chayapasupu	2.16	2.48	2.32
T. Sunder	4.02	4.53	4.28
Vontimitta	3.43	3.87	3.65
Duggirala local	4.02	4.68	4.35
Tekurpeta	1.72	1.97	1.85
Nandyal type	4.1	3.00	3.55
Etamukala	3.87	4.97	4.42
Kuchipudi Buck	2.78	1.82	2.30
G.L. Puram I	—	4.02	4.02
Rajpuri local	3.26	3.87	3.56
G.L. Puram II	2.68	3.80	3.24
Wynad local	—	4.02	4.02
Karhadi local	3.43	3.51	3.47

*Represents total colour expressed as % curcumin on miosture free basis.

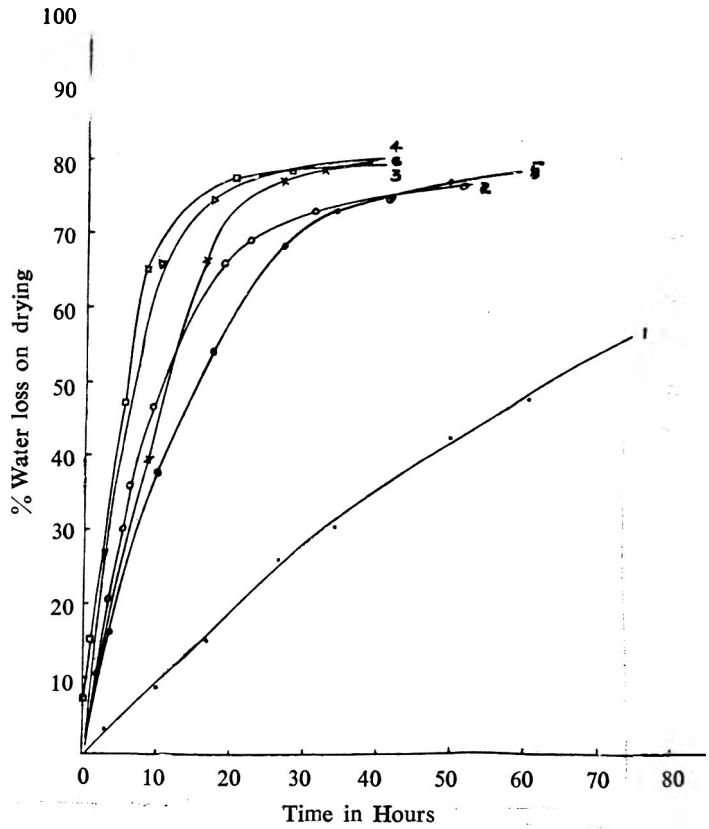


Fig. 1. Effect of different processing conditions on the drying rate (sun drying, 1 kg. tray load). 1, Dried as such; 2, steamed for an hour; 3, boiled for an hour; 4, peeled and boiled for an hour; 5, abrasive peeled for 30 sec; 6, sliced to ¼In. thick slices.

to get desirable peeling with minimum loss. Drying trials were done both in sun as well as by using cross flow driers.

Volatile oil content by Clavenger method and total colour content by ASTA method[5] were estimated in the samples after processing by different methods. The drying rates under different processing conditions are given in Fig 1. For maturity studies six varieties of turmeric harvested between September and January were obtained from the Research Station in Kerala. After curing, colour content was estimated and typical results are reported in Fig. 2.

Fresh rhizomes were sliced and the rind portion near the outer skin and the central core were separated. The colour in each of these was extracted with hot ethanol, and on equivalent basis the absorption curves were determined as shown in Fig. 3.

Results and Discussion

The curcumin content (total colour expressed as curcumin) of the two important turmeric species, *Curcuma longa* and *Curcuma aromatica* varied from 3.0–3.9 and 1.2 to 1.5 per cent respectively. Curcumin content in various Selection varieties (23 samples) received from Tasgaon Turmeric Research Station (Maharashtra) ranged from 2.3 to 4.4 per cent. The samples obtained in two seasons from Horticultural Research Station, Ambalavayal (Kerala) indicated 1.85 to 4.4 per cent variation in curcumin. The same variety did indicate in some cases different values in the two successive years (Table 2). The curcumin content of commercial samples from Andhra Pradesh varied from 1.7 to 3.4 per cent (Table I).

The processing conditions like boiling, steaming, peeling and slicing showed no significant difference in the volatile oil or total colour after drying. Boiling or steaming the rhizome, however, reduces the drying time and gives better appearance to the dried product. Slicing considerably reduces the drying time and as a method of processing this may have an advantage over the conventional drying of fingers, especially for making into powder, or for oleoresin production. This aspect should be further examined by the industry. The control samples dried without any treatment was wrinkled in appearance and was difficult to polish. Boiling also ensures even distribution of colour in the rhizomes. In commercial practice, different methods are being adopted without proper control over the curing process.

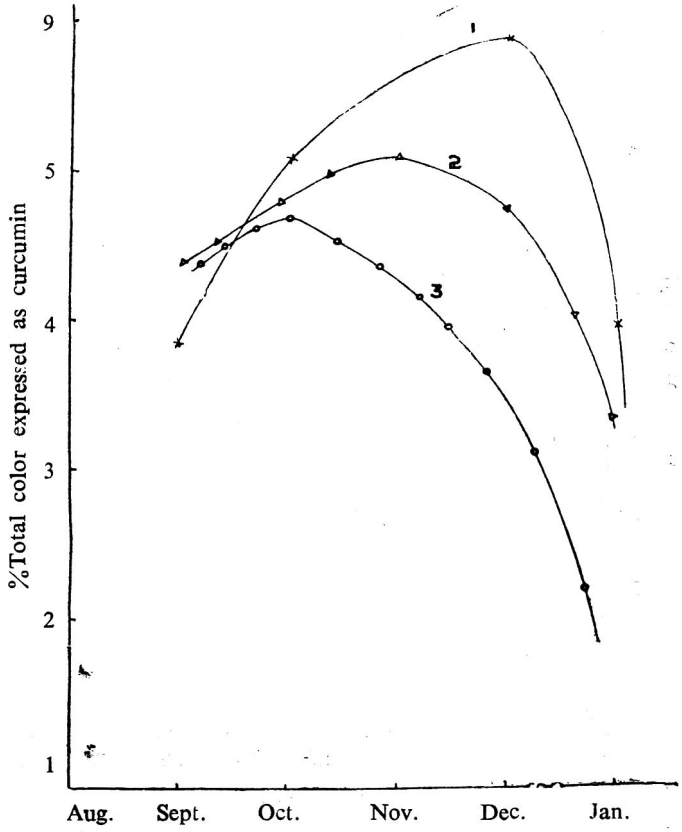


Fig. 2. Colour content of turmeric varieties at different maturity. 1, Wynad local; 2, Karhadi local; 3, Kuchipudi.

The trials indicated that rhizomes boiled in water for an hour give satisfactory product as compared to the commercial methods involving prolonged boiling. Sun drying of slices, gave a slightly surface bleached product compared to mechanically dried slices which was brighter in colour.

The colour in the core of fresh turmeric was more than that in the rind portion. However on boiling, there was an even distribution of colour. Boiling results in quicker drying, gives a uniformly coloured product and the rhizomes become hard as a result of gelatinization of starch. This property perhaps makes the cured samples less susceptible to insect attack as observed in the storage trials of cured and uncured samples.

The maturity studies indicated that the colour content increases in the turmeric harvested in November and December and later on tends to decrease. Variations, however, were noticed in the different varieties. It is thus necessary to critically study and fix the time of harvest for each variety in the different regions of cultivation.

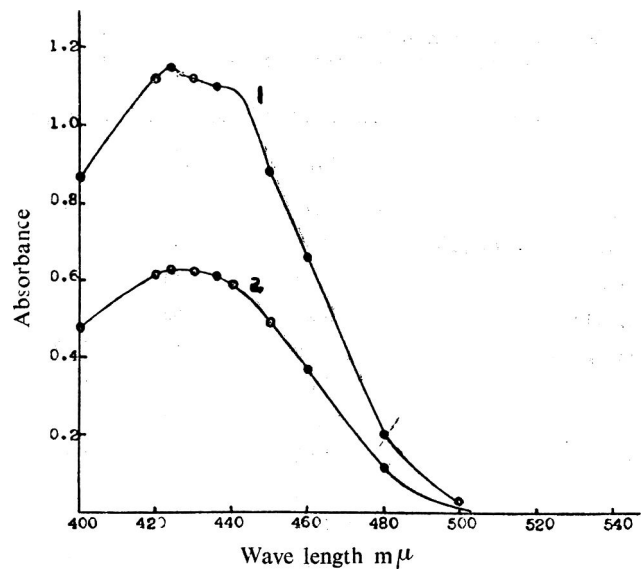


Fig. 3. Absorption spectra of total colour; 1, core portion; 2, rind portion.

Acknowledgements

The authors wish to acknowledge their thanks to the Officer-in-charge, Horticultural Research Station, Ambalavayal, Kerala; Turmeric Research Station, Nandyal, Karnool District, Andhra Pradesh and Turmeric Research Scheme, Tasgaon, Maharashtra for kindly supplying the samples.

References

1. Aiyadurai, S.G., ICAR *A Review of Research on Spices and Cashewnut in India*, Regional Office, Ernakulam, 1966, 19.
2. *Marketing of Turmeric in India*, Agricultural Marketing Series No. 148, Directorate of Marketing & Inspection, Ministry of Food & Agriculture, Nagpur, 1965.
3. Yagnanarayana Ayer, A.K., *Field Crops of India*, Bangalore Printing & Publishing Co. Ltd., 1966, 289.
4. Desikachar, H.S.R., Sreenivasan, M. and Subramanyam, V., *Res. Ind.*, 1959, **4**, 172.
5. *Official Methods of Analysis*, American Spice Trade Association, New York, 1960.
6. *Annual Reports*—1969 and 1971 CFTRI, pp. 36, 35.

Manufacture and Freezing Characteristics of Spray Dried Ice Cream Mix

V. C. SOOD* AND M. R. SRINIVASAN
National Dairy Research Institute, Karnal-132001

Manuscript Received: 24 *June* 1974

Ice cream mixes with only 50 per cent sugar could be satsfactorily spray dried to about 2 per cent moisture content at inlet and outlet air temperatures of 160° and 100°C respectively. Increase in the inlet air temperature or sugar content resulted in intense caramelisation. The average loose and packed bulk density was 0.32 and 0.50 g/ml respectively. The average free fat was 14.2 per cent and solubility 94.2 per cent. Reconstitution was extremely difficult at room temperature, but was progressively easeir at higher temperatures. The best quality ice cream was obtained from high fat mixes reconstituted at 50°C. All batches could be easily frozen to 100 per cent overrun. The quality of ice cream was not as good as ice cream prepared from fresh ingredients, but was quite acceptable Few suggestions to improve the quality of ice creams from low and medium fat dried mixes have been included.

The demand for ice cream in India is maximum during summer when the availability of fresh milk and cream are minimum. This leads to widespread adulteration and sale of a substandard product in the market. It also offers an economic outlet for the utilisation of seasonal and regional surpluses of milk so common in India. Coulter[1], Pyenson[2] and Corbett[3] have reviewed the work done in U.S.A. during world war II. Attempts made by Jain[4] has resulted in excessive charring of sugar and fat separation on the rollers, when the roller drying process was used.

The primary objective of this work was to standardise the composition and the processing parameters for drying of ice cream mix from buffalo milk solids by the spray drying process. The freezing characteristics and the quality of ice cream prepared from the dried mix was also evaluated.

Materials and Methods

The composition of three grades of ice cream (low, medium and high fat mixes) selected for tihs study is given in Table 1. These compositions are most commonly used throughout the world. The ingredients were thoroughly mixed in an aluminium can at about 50°C, heated to 70°C, filtered, homogenised in a double stage homogenizer (175 kg/cm^2 at the first and 35 kg/cm^2 at the second stage) and pasteurised at 80°C for 15 min. The mixes were cooled over a surface cooler and aged overnight at 5°C. The mixes were heated to about 70°C before drying in an Anhydro spray dryer. The operating conditions of the dryer have been discussed in the course of the discussion.

The dried mixes were analysed for moisture and fat[5] and for bulk density and free fat[6] and for solubility by the method of Howat *et al.*[7] while preparing the ice cream the dried mixes were reconstituted in water, with the addition of remaining 50 per cent sugar, to total solids corresponding to the grade of mix. The reconstituted mixes were allowed to hydrate for 30 min and then frozen in a batch freezer to 100 per cent overrun using natural vanilla flavour. The ice cream samples were judged for flavour, body and texture and melt down characteristics.

TABLE 1. COMPOSITION OF THREE GRADES OF ICE CREAM MIXES SELECTED FOR SPRAY DRYING

	Low-fat	Medium-fat	High-fat
Fat %	8.0	10.0	14.0
Serum solids %	12.0	12.0	10.0
Sugar %	14.0	14.0	16.0
Gelatin %	0.3	0.3	0.3
Sodium citrate %	0.25	0.25	0.25

*Present Address: Department of Agricultural Engineering, Indian Institute of Technology, Kharagpur-721302.
N.D.R.I. Publication No. 74-79.

ห้องสมุด กรมวิทยาศาสตร์

TABLE 2. COMPOSITION AND QUALITY OF SPRAY DRIED ICE CREAM MIXES

Batch No.	Grade	Drying air temp °C	Fat %	Moisture %	Bulk density g/ml		Free fat %	Solubility %	Colour	Flavour
					Loose	Packed				
1	Low-fat	200	27.3	2.2	0.29	0.49	11.2	84.5	Pale-yellow	Caramelised
2	Medim-fat	200	35.2	2.4	0.32	0.50	21.5	75.7	,,	,,
3	High-fat	200	41.9	1.5	0.32	0.49	33.2	76.5	,,	,,
4	Low-fat	160	29.5	2.0	0.32	0.51	15.1	90.3	Light-cream	Excellent
5	Medium-fat	160	33.4	1.6	0.30	0.50	11.8	94.5	,,	,,
6	High-fat	160	40.9	1.5	0.32	0.50	15.8	97.9	,,	,,

Results and Discussion

The first objective of this study was to standardise the composition of mixes and the operating conditions of the spray dryer to obtain a good quality product with low moisture content. For the preliminary trials, a medium fat mix containing 36 per cent solids but without sugar was prepared. A part of it was diluted to 27 per cent solids and to another part 3 per cent sugar was added. The three batches were dried at inlet air temperature of 160–170°C while varying the outlet air temperature from 100 to 108°C. The moisture content in all cases was less than 2.5 per cent as desired[6], and even lesser in the batch with sugar. The packed bulk density was 0.32, 0.33 and 0.35 g/ml for the mixes with 27, 36 and 39 per cent solids respectively. The reconstitutability of the mix with sugar was better. It was, therefore, decided to maintain the outet air temperature at 100°C and incorporate as much sugar as possible to get a product of low moisture content, high bulk density and better reconstitutability. Inlet air temperature of 200°C was also tried to increase the capacity of the dryer.

A medium fat mix with full sugar dried at the inlet air temperature varying from 160–200°C, resulted in intense caramelisation, burnt flavour and sticking to the walls of the spray dryer. The attempt to dry mixes with full sugar was, therefore, dropped. The sugar level was reduced to 50 per cent in the final trials. The reduction in total solids was made up by proportionately increasing the quantity of all the ingredients in the mix. One batch each of low, medium and high fat mixes with 50 per cent sugar were dried at two inlet air temperatures of 160 and 200°C, and outlet air temperature of 100°C. The results of analysis have been presented in Table 2.

Moisture content: The moisture content was considerably less than 2.5 per cent as desired[6] and as low as 1.5 per cent in high fat mixes. This works out to 2.5 to 3.0 per cent on fat free basis. The moisture content was independent of the inlet air temperature.

Bulk density: The bulk density was independent of the composition of the mix and the inlet air temperature. The average loose and packed bulk densities were 0.32 and 0.50 g/ml respectively.

Free fat: The free fat varied from 11.2 to 33.2 per cent. It was higher in medium and high fat mixes dried at inlet air temperature of 200°C, showing excessive fat destabilisation. However a similar increase in free fat with increase in total fat content was not observed for batches dried at 160°C.

Solubility: The solubility varied from 75.7 to 97.9 per cent. The very low solubility for the batches dried at inlet air temperature of 200°C was obviously due to heavy protein denaturation at that temperature. The generally low solubility in all batches for a spray dried product resulted from the cumulative heat denaturation of proteins during the concentration of skim milk in a batch evaporator for the manufacture of skim milk powder used in this study, subsequent batch pasteurisation of the liquid mix, preheating before spray drying, and packing of the dried mix without cooling because the dryer did not have powder cooling equipment. Added sugar might also have had some destabilising effect on proteins. The composition did not seem to affect solubility. It would be possible to have higher solubility values when the product is manufactured industrially.

Colour and flavour: The batches dried at inlet air temperature of 160°C had light cream colour and excellent flavour, but those dried at 200°C had dull pale yellow colour and strong caramelised flavour. The fat

TABLE 3. EFFECT OF TEMPERATURE OF RECONSTITUTION ON THE FREEZING CHARACTERISTICS AND QUALITY OF ICE CREAM

Reconst. temp. °C	Whipping time min.	Drawing temp. °C	Overrun %	Body and texture
15	8	-5.0	100	Good
50	6	-3.0	100	Excellent
60	5	-2.0	100	Fair
70	5	-2.0	100	,,
80	5	-2.0	100	,,

TABLE 4. FREEZING CHARACTERISTICS AND QUALITY OF ICE-CREAM PREPARED FROM SPRAY DRIED ICE CREAM MIXES

Batch No.	Whipping time (min.)	Drawing temp. °C	Flavour	Body & texture	Melt down
1	5	-4.5	Cooked	Icy	Watery
2	6	-4.0	Burnt	Coarse	Foamy
3	5	-4.5	Burnt	Good	Good
4	3	-5.0	Good	Coarse	Foamy
5	4	-4.5	,,	,,	,,
6	5	-4.0	,,	Good	Good

Batch number discriptions as in Table 2.

level in the mixes did not influence the colour and flavour.

The results on free fat, solubility, colour and flavour, discussed herein, indicate that the inlet air temperature of 200°C was not suitable for drying ice cream mixes even with 50 per cent sugar. But inlet air temperature of 160°C gave a satisfactory product at all fat levels.

Reconstitution and freezing: Reconstitution was extremely difficult at room temperature but was progressively easier at higher temperatures. That could be due to melting of free fat on the surfaces of the powder particles. Ageing of mix at 5°C for 6 hr, after reconstitution at room temperature had practically no effect on dispersibility, freezing characteristics and the quality of ice cream. The freezing time was same, but whipping was faster for samples reconstituted at higher temperatures (Table 3.) That resulted in poor body and texture due to poor air dispersion during whipping. The lower drawing temperature indicated a lower viscosity of the semi frozen slush which could also result in the development of coarse texture during hardening.

Reconstitution at 50°C resulted in excellent body and texture of ice cream and was, therefore, adopted for further evaluation of freezing characteristics and quality of ice cream prepared from all the six batches of dried mixes (Table 4). The drawing temperature varied from -4 to -5°C. The time taken for whipping varied from 3 to 6 min. The flavour of the first three batches dried at 200°C was considered as cooked or burnt, but the flavour of the last three batches dried at 160°C was quite acceptable. The body and texture and melt down was better for the high fat mixes, which resulted in better acceptability of these lots by consumers. Other samples developed a coarse texture and had foamy melt down. It was felt that the quality of ice creams prepared from low and medium fat mixes can be improved by increasing the total solids in the reconstituted mixes or reducing the overrun. Use of stabilisers of vegetable origin could also help to improve the body and texture because of the rapid hydration of these stabilisers. The problem of caramelised or cooked flavour could be tackled by using stronger flavours like coffee and chocolate, etc.

Acknowledgements

The first author acknowledges with thanks the award of a Junior Research Fellowship by Indian Council of Agricultural Research during the tenure of this project. The encouragement and help given by Mr O. Samlik, F.A.O. expert and Mr J. L. Bhanumurthi, Research Officer, is also thankfully acknowledged.

References

1. Coulter, S.T., *Ice Cream Rev.*, 1946, **30**, 94.
2. Pyenson, H., *Ice Cream Rev.*, 1946, **30**, 54.
3. Corbett, W.J., *Food Indust.*, 1948, **20**, 534.
4. Jain, S.C., Ph.D. Thesis, 1966, Agra University.
5. *Laboratory Manual, Methods of Analysis of Milk and Its Products*, Milk Industry Foundation , Washington, 1959.
6. Hall, C.W. and Hedrick, T. I., *Drying of Milk and Milk Products*, AVI Pub. Co.. Westport, Connecticut, 1966.
7. Howat, G.R., Smith R. Waite and Wright, N.C., *J. Dairy Res.*, 1939, **10**, 488.

Storage Stability of Spray Dried Ice Cream Mix

V. C. Sood and M. R. Srinivasan
National Dairy Research Institute, Karnal-132001

Manuscript Received: 24 *June* 1974

Spray dried ice cream mixes of three fat levels and two drying conditions were investigated for changes during storage to evaluate their shelf stability. Half of the samples were double gas packed. All the samples were stored at 37±1°C to simulate the extreme tropical climate. The samples dried with inlet air at 160°C and gas packed showed greatest resistance to browning, decrease in solubility and increase in TBA values. The fat level did not have any effect on these changes. Moisture decreased and free fat increased slightly. The increase in free fat was more in gas packed samples. Development of oxidised flavour could not be detected in either the dried mixes or the ice cream prepared from these, eventhough TBA values increased considerably. The shelf life of the product has been estimated to be about 6 months in air packing and more than a year in gas packing when stored at room temperature.

Dried ice cream mix is very rich in milk fat compared to whole milk powder and, therefore, is more prone to oxidative deterioration during storage. Hence, all precautions applicable to the manufacture of whole milk powder of good shelf stability are equally applicable to dried ice cream mix viz., high preheat treatment, low moisture content, prompt cooling of the product after drying, gas packing and low temperature storage.

Browning, oxidation and staling are the common defects that develop during storage. Pyenson and Tracy[1] found that high forewarming temperature helped to prolong the keeping quality and retard the development of oxidised flavour. Tarassuk and Jack[2] found this effect to be associated with fat. Kunkel *et al.*[3] found that increase in moisture content between 1.0 to 4.5 per cent had much greater influence on the rate of deterioration at 60°C, than had the increase in oxygen level between 0.5 to 40.0 per cent. Tarassuk and Jack[4] observed that browning in general was accompanied by uptake of oxygen, production of carbon dioxide, increase in titratable acidity, increase in reducing groups, very marked decrease in solubility, development of caramelised flavour, and increase in moisture content in advanced stages of browning especially in powders with low moisture content. This study was carried out to evaluate the shelf stability of spray dried ice cream mix under different conditions of storage.

Materials and Methods

Six batches of spray dried ice cream mixes of three fat levels and two drying conditions (Table 1) were packed in 100-g and 1-kg tins. Half of the packs were double gas packed with nitrogen according to the method of Lea, *et al.*[5] The samples were stored in an incubator at 37±1°C to simulate the worst storage conditions likely to be encountered during the summer months in tropics. The samples were analysed at intervals of 0, 30, 45 and 60 days for flavour, colour, moisture, free fat, solubility and thiobarbituric acid (TBA) value.

The samples were judged for the development of oxidised flavour after reconstituting 10 g of sample in 90 ml water at 50°C, but no taste panels were used. Colour index was judged by comparison with the modified colour standards of Kashmiri Lal[6]. Moisture was determined by the method given in Laboratory Manual[7]. The samples were analysed for free fat, solubility and TBA value by the methods of Hall and Hedrick[8], Howat *et al.*[9] and Keeney and Bassette[10] respectively.

Table 1. Specifications of the spray dried ice cream mixes used for storage studies

Batch No.	Grade	Drying air temperature (°C)		Fat %	Moisture %
		Inlet	Outlet		
1	Low-fat	160	100	29.5	2.0
2	Medium-fat	160	100	33.4	1.6
3	High-fat	160	100	40.9	1.5
4	Low-fat	200	100	27.3	2.2
5	Medium-fat	200	100	35.2	2.4
6	High-fat	200	100	41.9	1.5

*Present address: Department of Agricultural Engineering, Indian Institute of Technology, Kharagpur-721302.
N.D.R.I. Publication No. 74–78.

The results have been summarised in Table 2.

TABLE 2. CHANGES IN COLOUR INDEX, MOISTURE FREE FAT, SOLUBILITY AND T.B.A. VALUE OF SPRAY DRIED ICE CREAM MIXES DURING STORAGE AT 37±1°C

Batch No.	Fresh	Air-packed days			Gas-packed days		
		30	45	60	30	45	60
		(*a*) Colour index*					
1	2-	2-	2-	2-	2-	2-	2--
2	2-	2-	2-	2-	2-	2-	2-
3	2-	2-	2-	2-	2-	2-	2
4	4-	4-	4	4+	4-	4-	4+
5	5-	5	5+	5+	5-	5	5+
6	5	5	5	5+	5	5	5
		(*b*) Moisture (%)					
1	2.0	1.7	1.5	1.0	1.6	1.6	0.8
2	1.6	1.6	1.5	1.4	1.6	1.5	1.5
3	1.5	1.5	1.5	1.2	1.4	1.4	1.3
4	2.2	2.1	1.9	1.4	2.1	1.8	1.5
5	2.4	2.4	1.7	1.2	2.4	1.9	1.7
6	1.5	1.5	1.3	1.2	1.4	1.2	1.0
		(*c*) Free fat (% of total fat)					
1	15.1	15.7	15.8	16.1	16.0	16.2	16.6
2	11.8	11.7	11.7	11.6	11.7	11.7	11.8
3	15.8	15.9	15.8	15.8	16.0	16.2	16.5
4	14.2	14.8	14.9	15.3	15.4	15.7	15.9
5	21.5	23.3	25.4	26.7	25.2	25.4	27.3
6	33.2	40.0	41.7	42.8	44.2	45.2	46.2
		(*d*) Solubility (%)					
1	90.3	89.8	89.4	89.0	89.9	89.6	89.3
2	94.5	93.9	93.5	93.2	94.1	93.8	93.6
3	97.9	97.4	97.2	96.9	97.6	96.6	97.4
4	84.5	83.7	83.0	81.7	84.0	83.5	82.0
5	75.7	73.8	72.5	71.3	74.5	73.7	73.0
6	76.5	76.0	76.7	75.2	76.1	75.9	75.7
		(*e*) T.B.A. value (absorbence at 443 nm)					
1	0.62	0.76	0.80	0.83	0.74	0.78	0.82
2	0.54	0.63	0.66	0.75	0.60	0.63	0.73
3	0.55	0.72	0.74	0.73	0.59	0.61	0.63
4	0.57	0.74	0.86	0.89	0.67	0.72	0.79
5	0.50	0.55	0.57	0.65	0.53	0.64	0.66
6	0.62	0.73	0.78	0.84	0.73	0.75	0.89

*Wherever exact matching was not possible, the difference has been shown with a + or − sign.

Results and Discussion

Colour: Very little change in colour index was observed during storage. The samples dried at inlet air temperature of 160°C and gas packed showed greatest resistance to browning. The higher drying air temperature, apart from giving a deeper colour to the fresh product, also accelerated the rate of browning during storage. The faster colour development in air packed samples indicated the participation of oxygen in the reaction as observed by Tarassuk and Jack[4].

Moisture: The moisture did not change much during first 30 days of storage. Then a decrease in moisture content was observed in all samples, more so in air packed samples and samples having a higher moisture content. It was contrary to the findings of Tarassuk and Jack[4]. That could be due to either increase in bound water or participation of water in some chemical reactions after the initial induction period of 30 days. Similar trend was observed in colour index. It would be necessary to study these observations in greater detail for further elucidation.

Free fat: Free fat increased only slightly during storage. The increase was more in samples dried with inlet air at 200°C. The stickiness of the product also increased during storage. The free fat increased more in gas packed samples, possibly due to rupture of some fat globule membranes during the evacuation process. However, this did not result in faster deterioration of the gas packed samples, possibly due to the high free fat level at initial stages.

Solubility: The decrease in solubility was faster in air packed samples, and in samples dried at inlet air temperature of 200°C. That followed the trend of changes in colour index supporting the findings of Tarassuk and Jack[4]. However, the overall decrease in solubility was less than 2 per cent, not high enough to adversely affect the quality of ice cream prepared from these samples.

TBA value: The TBA values at the beginning of storage studies were surprisingly very high. The sample size had to be reduced to 0.2 g as against 1.0 g suggested by Keeney and Bassette[10] for skim and whole milk powders. This would need detailed investigation for possible interactions with the added sugar. The TBA values showed a steady increase throughout the storage period. The increase was slower in the beginning for the gas packed samples, but seemed to pick up towards the end of the storage period.

However, oxidised flavour could not be detected in any sample even at the end of the storage period. The inlet air temperature of drying did not have any perceptible influence on either the increase in TBA values or flavour. The failure to detect oxidised flavour inspite of a considerable increase in TBA values during storage may be due to the inhibition of stale and oxidised flavours by the products of browning reaction as pointed out by Tarassuk and Jack[4].

From the foregoing discussion, it can be safely concluded that spray dried ice cream mixes would remain in good condition for about 6 months if air packed and more than a year if gas packed when stored at room temperature. That would satisfactorily meet the normal marketing time required by the industry. Spray drying with inlet air temperature of 160°C, however, resulted

in a better quality product with more resistance to deterioration during storage. For further confirmation, ice cream was prepared from the 1 kg packs at the end of the storage period and no significant deterioration in flavour and quality of ice cream could be detected.

Acknowledgement

The first author acknowledges with thanks the award of a Junior Research Fellowship by Indian Council of Agricultural Research during the tenure of this project.

References

1. Pyenson, H. and Tracy, P.H., *J. Dairy Sci.*, 1946, **29**, 371.
2. Tarassuk, N.P. and Jack, E.L., *J. Dairy Sci.*, 1946, **29**, 486,
3. Kunkel, R.W., Coulter, S.T. and Combs, W.B., *J. Dairy Sci.*, 1946, **29**, 488.
4. Tarassuk, N.P. and Jack, E.L., *J. Dairy Sci.*, 1948, **31**, 255.
5. Lea, C.H., Moran, T. and Smith, J.A.B., *J. Dairy Res.*, 1943, **13**, 162.
6. Kashmiri Lal, 1968, M. Sc. dissertation, Punjab University.
7. *Laboratory Manual, Methods of Analysis of Milk and Its Product*, Milk Industry Foundation, Washington, 1959.
8. Hall, C.W. and Hedrick, T.I., *Drying of Milk and Milk Products.*, AVI Pub. Co., Westport, Connecticut, 1966.
9. Howat, G.R., Smith R. Waite and Wright, N.C., *J. Dairy Res.*, 1939, **10**, 488.
10. Keeney M. and Bassette, R., *J. Dairy Sci.*, 1959, **42**, 945.

Detoxification of Groundnut Oil

T. SHANTHA AND V. SREENIVASA MURTHY
Central Food Technological Research Institute, Mysore-570013

Manuscript Received: 13 *September* 1974

A method for removing aflatoxin from crude groundnut oil has been developed after studying the efficiency of several extractants such as sodium chloride solution, aqueous acetone, sodium hydroxide and ammonia. Among these sodium chloride proved to be best suited for the purpose as it was a cheaper and simpler extractant presenting no difficulty during the detoxification process.

Unrefined groundnut oil is the fat of choice of a large section of the population in India because of its cheapness and delicate aroma. Analysis of market samples of groundnut oil revealed that the oil invariably carried significant quantities of aflatoxin, the well known carcinogen. It has also been shown[1] that the toxin in the oil medium is fairly stable to heat and is carried over by the material fried in it in significant quantity. Food materials fried in unrefined groundnut oil have, therefore, become an important source for aflatoxin toxicity. Although refined oil is free from the toxin, the preference for unrefined oil, especially among low and middle income groups, necessitates the detoxification of oil without increasing its cost. This communication presents some data obtained on the usefulness of different extractants in removing aflatoxin from groundnut oil.

Materials and Methods

A. Etractants used:

Sodium chloride	..	10%
Sodium hydroxide	..	0.08%
Ammonia	..	28% (liquor ammonia)
Acetone	..	30% (in water)

B. Extractions: The oil is mixed thoroughly with the extractant with the help of an electrical stirrer and allowed to stand for phase separations. The aqueous and the oil phases are collected separately for toxin estimation. The variables of temperature, extractant to oil ratio, duration of extraction, etc., tried in each experiment are indicated in the tables.

Acetone concentration in treated oil was determined by the method described in Elementary Practical Organic Chemistry[3].

Results and Discussion

Aflatoxin content of oils from domestic and commercial origin are given in Table 1. Except for two samples which had negligible or no toxin all others contained aflatoxin B_1 the values ranging from 0.01 to 2.60 ppm. The efficiency of different extractants in removing aflatoxin is indicated in Table 2. The results reveal that 80–95 per cent of the toxin present in oil can be removed by shaking it with either N/50 sodium hydroxide or aqueous sodium chloride, or acetone.

But the emulsion formed by these extractants with the oil makes oil separation incomplete affecting thereby its

recovery. In the refining process sodium chloride wash at high temperatures helps to minimise this loss. In spite of this, the refined oil is sold at 20-25 per cent higher price than crude oil. In view of this acetone and sodium chloride seem to be more useful extractants as they do not form stable emulsions.

TABLE 1. AFLATOXIN CONTENT IN MARKET SAMPLES OF GROUNDNUT OIL

No.	Aflatoxin (ppm)	No.	Aflatoxin (ppm)
1	Negligible	12	0.17
2	0.17	13	0.16
3	0.05	14	0.11
4	0.01	15	0.33
5	0.33	16	0.01
6	-ve	17	0.16
7	0.17	18	0.16
8	0.11	19	0.33
9	0.17	20	0.16
10	0.17	21	0.16
11	2.6	22	0.16

Detailed studies were therefore conducted to standardise ideal conditions for maximum removal of aflatoxin from the oil by using these two extractants and the results are given in Table 3. Although 70 per cent acetone is widely used for toxin extraction in aflatoxin analysis, high cost of acetone and its high inflammability limit its use in commercial practice. Hence its efficiency at lower levels were examined. The results in Table 3 show that 30 per cent aqueous acetone can remove 20 per cent of the toxin with least emulsion and reduced problems of fire hazard. Repeated extraction or increasing extractant to oil ratio can remove more toxin. Table 4 confirms this expectation. But, retention of acetone and its odour by the treated oil is another serious problem that limits its usefulness. Results in Table 5 show that heating the oil in a water bath at 85–90°C for 30 min helps to vapourise 75–85 per cent of acetone. But heating the oil at 100°C ensures elimination of all acetone from the oil.

Results in Table 6 show that extraction with 10 per cent sodium chloride solution is the ideal extractant for removing about 85 per cent of the toxin, with least emulsion problems and maximum oil recovery. Sodium chloirde wash is being commercially utilised in oil refining to break emulsions and hence this treatment can easily be adopted commercially. Results of some batches of oil extraction are presented in Table 7. The toxin removal in all these trials was around 85–88%.

As an inexpensive method of detoxification of the oil, extraction with sodium chloride solution shows a great promise. The operation is simple, which involves stirring of the oil with sodium chloride solution at 80°C. Heating helps in more efficient toxin extraction as well as in reducing the viscosity of the oil and minimising the

TABLE 2. EFFICIENCY OF DIFFERENT EXTRACTANTS IN REMOVING AFLATOXIN FROM THE OIL

	Extractants	Oil to extractant ratio	Aflatoxin removal (%)	% Recovery of oil	Remarks
1.	Water	1:1 (4 times)	50	70	High emulsion. Poor oil recovery
2.	N/50 NaOH	1:0.6	95–100	80	Turbid oil. Can be clarified with $CaCl_2$.
3.	28% NH_3*	1:0.03	60–75	75	Oil turns brown. Forms emulsion. Oil recovery poor.
4.	28% NH_3 + H_2O_2 (20 vols) (1.0+0.03)	6:1	60		Lot of emulsion which is difficult to break
5.	(*a*) 10% NaCl*	1:1	80–90	95	Requires repeated wash (6 times). Min. emulsion.
	(*b*) 10% NaCl*	1:4	80–85	92	Minimum emulsion loss. Oil recovery 90%.
6.	30% Acetone in water *a*)	1:1	30	95	Less emulsion;
	d)	1:4	80	95	Good oil recovery.

*Mixture heated to 90°C for 30 minutes.

TABLE 3. REMOVAL OF AFLATOXIN WITH INCREASING CONCENTRATION OF ACETONE IN WATER

% Acetone in water	Aflatoxin in the wash (ug)	% Removal of aflatoxin from oil
10	4	5
20	4	5
30	13	20
40	13	20
50	13	20

Oil: solvent ratio is 1:1; single wash, swirling with hand. Initial toxin content of oil is 0.16 ppm.

TABLE 4. AFLATOXIN REMOVAL FROM THE OIL WITH INCREASING SOLVENT TO OIL RATIO

Oil:30% acetone	% Aflatoxin removal
1:1	30
1:2	60
1:4	80

(Solvent mixed with oil for 10 minutes with a magnetic stirrer). Initial toxin content of the oil is 0.16 ppm.

TABLE 5. ACETONE CONTENT OF THE OIL EXTRACTED WITH AQUEOUS ACETONE

Sample No.	Before heating	After heating in boiling water	After heating over flame
	(ml)	(ml)	(ml)
1	4.2	1.6	0.0
2	10.5	1.07	0.0
3	5.2	1.18	0.0
4	6.5	1.6	0.0

TABLE 6. EFFICACY OF SODIUM CHLORIDE SOLUTION IN EXTRACTING TOXIN FROM THE OIL

	Concent of NaCl	Oil:NaCl	No. of extractions	% Removal of aflatoxin
1	Saturated	2 : 3	4	66
2	,,	1 : 1	1	50
3	½ saturated	1 : 1	1	50
4	½ saturated	1 : 4	1	50
*5	10%	1 : 4	1	85

*Oil continuously stirred with the solvent for 30 min. at 65°C

TABLE 7. EFFICIENCY OF 10 PER CENT SODIUM CHLORIDE SOLUTION IN REMOVING THE TOXIN FROM THE OIL OF DIFFERENT TOXIN LEVEL

Initial toxin content (ppm)	Vol. of oil (ml)	Vol. of NaCl* (Lit.)	Final vol. of oil (ml)	Final toxin content (ppm)	% Removal of aflatoxin
1.33	2570	10	2300	0.16	88
0.16	1000	4	950	0.02	88
0.2	1250	5	1200	0.03	85

*Oil to sodium chloride ratio is 1 : 4

emulsion losses. This has also the advantage of being used in households as it is a readily available chemical.

References

1. Dwarakanath, C.T., Sreenivasa Murthy, V. and Parpia, H.A.B., *J. Fd Sci. Technol.*, 1969, **6**, 1.
2. Pons, W.A. (Jr.), Cucullu, A.F., Lee, L.S., Robertson, J.A., Franz, A.D. and Goldblatt, L.A., *J. Ass. Off. agric. Chem.*, 1966, **49**, 554.
3. Vogel, A.I. *A Text Book of Elementary Practical Organic Chemistry*, 3rd Edition, Longmans, 1956, 831.

The Nutritive Value of Leaf Proteins Isolated from the Leaves of Different Crop Plants

S. K. MUNSHI[1], D. S. WAGLE[2], AND V. K. THAPAR[3]
Department of Chemistry and Biochemistry, Punjab Agricultural University, Ludhiana-141004.

Manuscript Received: 14 *September* 1974

The leaf proteins isolated from the leaves of cauliflower, cowpeas and berseem were fed at 15% protein level to 3-day protein starved rats. The rats lost in body weight, liver weight and liver total nitrogen and xanthine oxidase activity, in protein starvation. Regeneration with casein displayed maximum values in terms of body weight, liver weight, liver total nitrogen and liver total xanthine oxidase activity than with leaf protein concentrate (LPC) from berseem, cowpeas and cauliflower. However, cauliflower LPC was found to be better than the other LPC preparations.

Pirie[1] indicated that leaf protein concentrates (LPC) when properly dried were as good a supplement as fish meal in a protein limiting diet for pigs. Potentialities of food proteins from green vegetation have been shown by Singh[2]. The effects of the source of raw materials for leaf protein concentrates and the methods of drying on the protein value of leaf proteins have been investigated by Duckworth and Woodham[3] in chicks and rats. When the methods of drying of the concentrates did not involve high temperatures (82–94°C), the product made from mixed grasses, kale, barley leaves, rye leaves and vetch were of uniformly high nutritive value and were similar to soyabean meal as a source of protein. Damage to nutritive value of LPC on drying has been demonstrated by Subbarau and Singh[4] and Munshi *et al.*[5] However, drying at 100°C in a fast current of air did not impair its quality[4]. Studies regarding supplementation of LPC with methionine[6], processing conditions[4] and amino acid composition[7] have also been attempted.

More sustained work on leaf proteins is necessary to know the crops suitable for the preparation of leaf proteins, and to determine the best form in which these may be incorporated in to human diets. In this communication, attempts were made to evaluate LPC isolated from different sources viz., cauliflower (*Brassica oleracea*), cowpeas (*Vigna sinensis*) and berseem (*Trifolium alexandrinum*) and compared with casein which was kept as reference protein by feeding to protein depleted rats.

Xanthine oxidase (Xanthine: oxygen oxidoreductase EC 1.2.3.2.) activity in rat liver has been used as parameter of study which is a good index of the biological value of individual proteins[8, 11].

Materials and Methods

Thirty albino rats of 80–90 g body weight were divided into 6 groups of 5 rats each. One group was sacrificed as control and the rest were protein fasted for 3 days sacrificing one group for obtaining the protein starved status of the animals. The remaining 4 groups were then offered for 6 days diets (Table 2) containing casein and LPC from cauliflower, cowpeas and berseem at 15% protein level. The management of animals, handling of tissue samples and the methods followed for the preparation of LPC and various estimations have already been described[5]. The composition of proteins is given in Table 1. Simple analysis of variance was applied for testing the significance of means.

TABLE 1. COMPOSITION OF PROTEINS

Proteins	Crude protein[1] (%)	Moisture (%)	Ether extract (%)	Ash (%)	Crude fibre (%)
Casein	87.56	3.80	0.48	—	—
Berseem LPC[2]	52.00	6.00	7.25	9.32	0.38
Cowpeas LPC	54.70	5.25	3.10	9.92	0.53
Cauliflower LPC	42.18	5.85	6.50	7.84	0.48

[1] Crude protein (N×6.25) [2] LPC (Leaf protein concentrate)

Present address:
[1] Regional Fruit Research Station, Punjab Agricultural University, Abohar-152116.
[2] Department of Chemistry and Biochemistry, Haryana Agricultural University, Hissar-125004.
[3] Directorate of Research.

TABLE 2. COMPOSITION OF EXPERIMENTAL DIETS AT 15% PROTEIN LEVEL

Ingredients	Protein free (%)	Casein (%)	Cauliflower LPC (%)	Cowpeas LPC (%)	Berseem LPC (%)
Vitamin mixture[1]	1.00	1.00	1.00	1.00	1.00
Salt mixture[2]	4.00	4.00	4.00	4.00	4.00
Hydrogenated fat[3]	10.00	10.00	7.70	9.16	7.92
Casein	—	17.50	—	—	—
Cauliflower LPC	—	—	35.56	—	—
Cowpeas LPC	—	—	—	27.42	—
Berseem LPC	—	—	—	—	28.85
Starch	85.00	67.50	51.74	58.42	58.23

[1] Vitamin mixture: Chapman *et al.*[19]

[2] Salt mixture as given by Oser.[20]

[3] Hydrogenated fat (Dalda), prepared by Hindustan Lever Ltd. Bombay.

Results and Discussion

With 3 days of protein starvation a decrease in body and liver weight was observed (Fig 1). Such losses in protein starvation for body weight,[9, 10] liver weight[6] and those of other organs like kidney, spleen and skeltal muscle[11] are well documented. Realimentation with casein and the LPC from cauliflower and cowpeas at 15 per cent protein level for 6 days resulted in body and liver weight gains; casein giving the maximum response. Whereas berseem LPC refeeding has caused further decrease in body weight (Fig 1, A) and failed to show any gain in liver weight (Fig 1, B). However, the data for liver weight calculated on per cent body weight (Fig 1, C) have indicated significant increase ($P < 0.05$) in berseem refeeding after 3 days of protein starvation (Table 4). Amongst the leaf protein isolates, cauli flower LPC has given better gains in body and liver weights when compared with berseem and cowpeas LPCs. Such findings of repletion of body constituents have also been cited by other investigators.[10]

It is well known that when an animal changes from a high to low protein diet or *vice-versa*, it loses or gains body proteins. A major fraction of nitrogen loss occurred in the liver with protein deprivation (Fig 2, A). In protein starvation, liver proteins contribute to the protein loss[12]. When the protein depleted animals were refed for 6 days casein or the LPC diets, there occurred an increase in liver total nitrogen. The values when expressed per total liver stand significantly lower for berseem LPC ($P<0.01$) and cowpeas LPC ($P<0.05$) refed animals

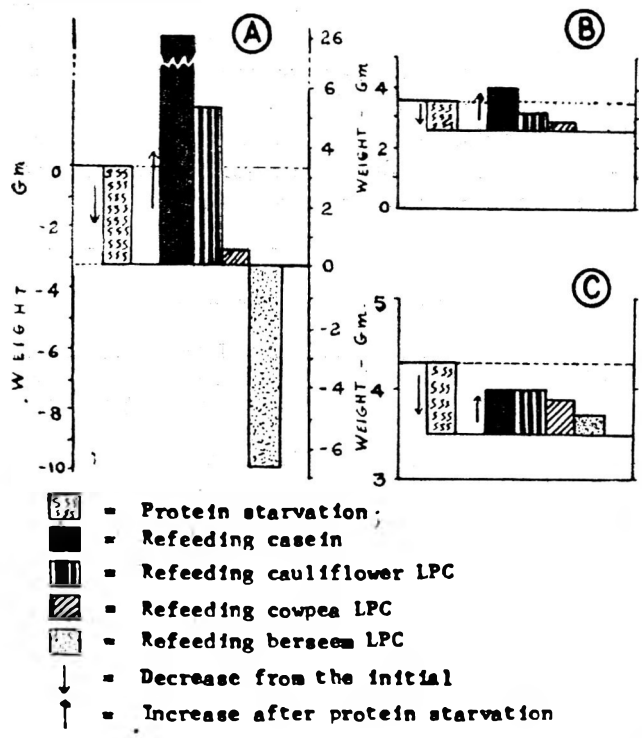


Fig. 1. Effect of protein starvation for 3 days and refeeding the diets at 15% protein level for 6 days to the rats on (*A*) body weight gain or loss, (*B*) total liver weight and (*C*) liver weight per 100 g. body weight.

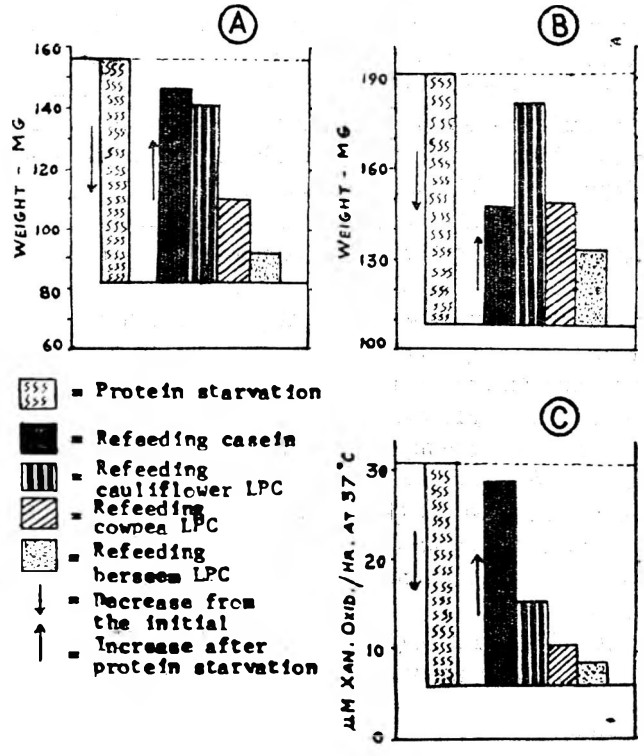


Fig. 2. Effect of protein starvation for 3 days and refeeding the diets at 15% protein level for 6 days to the rats on (*A*) liver total nitrogen, (*B*) liver total nitrogen per 100 g. body weight and (*C*) total liver xanthine oxidase activity.

when compared with casein refed group (Table 4); cauliflower LPC being nearly equal to casein (Fig 2, A). However, these results when expressed as per cent body weight (Fig 2, B) a reverse trend was noted; the values for LPC from cauliflower being significantly higher ($P<0.05$) than casein (Table 4). Such results have already been observed in our previous experiment[13]. Amongst the experimental diets from LPC, cauliflower was better utilised for tissue protein synthesis than cowpeas and berseem. Higher liver nitrogen content with casein feeding have also been observed by Allison[14].

Liver xanthine oxidase activity decreased significantly ($P<0.01$) on protein starvation for 3 days when the activity was expressed per total liver, per 100 g body weight or per mg nitrogen (Table 3). The total activity of a number of enzymes in the liver viz., cytochrome

TABLE 3. EFFECT OF PROTEIN STARVATION AND REFEEDING LPC DIETS[1] ON FOOD INTAKE AND LIVER XANTHINE OXIDASE ACTIVITY (VALUES ARE MEAN ± S.E. OF MEAN)

Treatments	Food intake (g)	Liver xanthine oxidase activity (μM xanthine oxidised/hr at 37°C)			
		Per g	Per total liver	Per 100 g body weight	Per mg nitrogen
Control	—	8.70±0.13	30.61±1.69	37.63±1.89	0.200±.01
Protein free (3 days)	25.20±0.34	2.28±0.21	5.98±0.49	7.91±0.55	0.07±0.01
Refed casein (6 days)	55.20±2.73	7.19±0.44	28.62±0.16	28.65±0.44	0.20±0.01
Refed berseem LPC (6 days)	34.60±1.26	3.43±0.22	8.76±0.53	12.70±0.71	0.10±0.01
Refed cowpeas LPC (6 days)	42.40±0.46	3.57±0.14	10.06±0.27	13.98±0.12	0.10±0.004
Refed cauliflower LPC (6 days)	50.20±1.96	4.58±0.22	14.75±0.15	18.27±0.69	0.11±0.01
Critical difference 5%	NS	0.65	2.81	3.02	0.03
1%	NS	0.99	4.29	4.60	0.04

[1]Details about diets are given in Table 2.
NS: Not significant.

TABLE 4. LEVEL OF SIGNIFICANCE BETWEEN TREATMENTS

Treatment Vs Treatment	Food intake	Body weight changes	Liver weight		Liver total nitrogen			Liver xanthine oxidase activity			
			Total	Per 100 g body wt.	Per g	Per total liver	Per 100 g body wt.	Per g	Per total liver	Per 100 g body wt.	Per mg nitrogen
Control : PF	—	NS	**	**	NS	**	**	**	**	**	**
PF : A	NS	**	**	**	NS	**	**	**	**	**	**
PF : B	NS	NS	**	**	NS	**	**	**	**	**	**
PF : C	NS	NS	NS	**	NS	*	**	**	*	**	*
PF : D	NS	NS	NS	*	NS	NS	*	**	*	**	*
A : B	NS	**	**	NS	NS	NS	*	**	**	**	**
A : C	NS	**	**	NS	NS	*	NS	**	**	**	**
A : D	NS	**	**	**	NS	**	NS	**	**	**	**
B : C	NS	NS	NS	NS	NS	*	*	**	**	*	NS
B : D	NS	**	**	**	NS	**	**	**	**	**	NS
C : D	NS	**	NS	*	NS	NS	NS	NS	NS	NS	NS

PF : Protein free for 3 days
A : Refeeding casein for 6 days
B : Refeeding cauliflower LPC for 6 days
C : Refeeding cowpeas LPC for 6 days
D : Refeeding berseem LPC for 6 days

* : 5% level of significance
** : 1% level of significance
NS : Not significant

oxidase, succinoxidase, succinic dehydrogenase, Damino acid oxidase, DPN-Cytochrome C reductase, uricase and xanthine oxidase decreased in protein depletion when compared with the *ad libitum* fed controls[15]. Such decreases in xanthine oxidase activity have also been reported by many investigators[8, 16]. Similar decreases in xanthine oxidase activity with protein starvation have also been noted in this study (Fig 2, C) which suggest that the enzyme protein is depleted in protein starvation.

Refeeding casein and LPC diets from cauliflower, cowpeas and berseem to protein starved animals was found to regenerate the enzyme activity significantly ($P<0.01$). But when the values were compared within the refed groups the enzyme activity in the casein refed group was significantly higher ($P<0.01$) than that in the different LPC refed animals. A similar trend within the refed group was noted when the values were expressed per total liver, per 100 g body weight or per mg nitrogen (Table 3). Such increases in xanthine oxidase activity were also noted when the rats were refed with the high quality protein diet to protein starved rats [11, 17]. The data on specific activity of the enzyme shows the same trend as is found in liver total nitrogen. Casein refeeding resulted in the repletion of the enzyme activity and the regeneration of the enzyme activity with the LPC diets showed highest values for cauliflower followed by cowpeas and berseem. The low activity of xanthine oxidase in LPC fed animals may result from a low methionine content in the LPC preparation.[18]

Acknowledgements

The authors express their sincere thanks to Dr. I. S. Bhatia, Senior Professor and Head, for rendering necessary facilities and help during the course of this investigation.

References

1. Pirie, N.W., *Proc. Intern. Conf. Washington. D.C. Aug.*, 1960. Natl. Acad. Sci.; Natl. Res. Council, Pub. 1961, 843, 509.
2. Singh, N., *IInd Intern. Congr. Fd. Sci. Tech.* Warsaw (Abstract) 1966, 19.
3. Duckworth, J. and Woodham, A.A., *J. Sci. Fd. Agric.*, 1961, **12,** 5.
4. Subbarau, B.H. and Singh, N., *Indian J. exptl. Biol.*, 1970, **8,** 34.
5. Munshi, S.K., Wagle, D.S. and Thapar, V.K., *Labdev J. Sci. Tech.* 1974, **12B,** 21.
6. Shurpalekar, K.S., Singh, N. and Sundravalli, O.E., *Indian J. exptl. Biol.*, 1969, **7,** 279.
7. Garcha, J.S., Kawatra, B.L., Wagle, D.S. and Bhatia, I.S., *J. Res, Punjab Agric. Univ. Ludhiana.*, 1970, **7,** 211.
8. Litwack, G., Fatterpaker, P., Williams, J. N. Jr. and Elvehjem, C.A., *J. Nutr.*, 1954, **52,** 187.
9. Kosterlitz, H.W., *Nature* 1944, **154,** 207.
10. Williams, J.N. Jr., *J. Nutr.*, 1961, **73,** 199.
11. Wainio, W.W., Allison, J.B., Kremzner, L.T., Bernstein. E. and Aronoff, M., *J. Nutr.*, 1959, **67,** 197.
12. Muramatsu, K. and Ashida, K., *J. Nutr.*, 1962, **76,** 143.
13. Munshi, S.K., Wagle, D.S. and Thapar, V.K., *J. Res, Punjab Agric. Univ. Ludhiana.*, 1974, In press.
14. Allison, J.B., Wannemachar, R.W. Jr., Banks, W.L., Wunner, W.H. and Breves, R.A., *J. Nutr.*, 1962, **78,** 333.
15. Wainio, W.W., Bertrana, E., Eichel, H.J., Person, P., Frances, L.E. and Allison, J.B., *J. Nutr.*, 1953, **49,** 465.
16. Wagle, D.S., and Sreenivasan, A., *Proc. Symp. on proteins*, Chem. Res. Comm. & Soc. Biol. Chem. (India), 1962, 154.
17. Meikleham, V., Well, I.C., Richert, D.A. and Westerfeld, W.W., *J. biol. Chem.*, 1951, **192,** 651.
18. Tamura, A., *Jap. J. Nutr.*, 1961, **19,** 3.
19. Chapman, D.G., Castillo, R. and Campbell, J.A., *Canad. J. Biochem. Physiol.*, 1959, **37,** 679.
20. Oser, B.L., *Hawk's Physiological Chemistry* McGraw Hill Book Company, New York, 1965, p. 1376.

Methods for Assay of Aflatoxins in Coconut Products

U. SAMARAJEEWA AND S. N. ARSECULERATNE
Department of Bacteriology, University of Sri Lanka, Peradeniya, Sri Lanka

Manuscript Received: 18 *Sept.* 1974

On account of the paucity of data on assay methods for aflatoxin in coconut products, several analytical procedures which have already been established for assay of aflatoxin in peanuts, were studied for their applicability to coconut products. All estimations were done on TLC using at least two solvent systems.

The methods studied appeared to give similar values for aflatoxin content, but the modified 70% aqueous acetone procedure was found to be the most suitable on account of the relative purity of the extracts and convenience. This procedure was applicable to samples containing 0.01 ppm and above; determinations were possible without time consuming column clean-up procedures. For routine assay, a short method together with a correction factor is suggested.

Coconut and its products are important articles of food in tropical countries. Aflatoxin contamination in these products was reported by earlier workers[2, 3]. Various assay methods have been described for aflatoxin in peanuts, but the only report available for coconut products is by Baur and Armstrong[3] on the use of chloroform-water systems. The AOAC has also adopted this method. Baur himself has suggested that the methods used for determination of aflatoxin in other materials cannot be applied directly to coconut products because of differences in the physical state and composition of coconut products as compared with other substrates. An attempt has been made here to study the available methods for their applicability to coconut products.

Materials and Methods

Source of samples: Fresh copra meal samples were collected from mills.

Preparation of samples: The following substrates were used. (*a*) Grated fresh coconut, replicate samples from the same nut. (*b*) Residue left after mechanical expulsion of oil from artificially inoculated fresh coconut (MECM). (*c*) Residue left after solvent extraction of oil from coconut with hexane or petroleum ether (SECM). (*d*) Artificially inoculated, rehydrated copra meal. (*e*) naturally contaminated samples of copra meal collected from mills.

Substrates were artificially inoculated with spore suspensions in 0.1 per cent Tween 80 in distilled water, of *Aspergillus parasiticus* strain NRRL 2999 grown on 'Difco' potato dextrose agar. This strain produced only aflatoxin B_1 and G_1 on coconut medium though it is reported to produce B_2 and G_2 in addition on other media.

The optimum conditions for each method were established with highly contaminated samples, extracts of which had less likelihood of interference with non-aflatoxin material, and for greater accuracy. However these methods were restudied on naturally contaminated copra meal (commercial *poonac*) samples with low levels of aflatoxin.

Two hundred gram of substrates autoclaved in 2 litre flasks at 120°C for 10 min were inoculated with the spore suspension. The flasks were shaken manually every alternate day and steamed for 10 min after a variable period of incubation (3–10 days), to destroy the fungus. The steamed samples were stored at –70°C until assay.

The copra meal samples were ground in a sponge mill. Analysis through BS sieve, of the ground meal showed the following percentage composition in respect of particle size.

Ten mesh retained approximately 10 per cent, 10–20 mesh retained approximately 50 per cent and through 22 mesh approximately 40 per cent.

The particle size of grated coconut was less than 2 mm and was not reduced by grinding or other means. The moisture content of artificially inoculated coconut and naturally contaminated copra meal was 40 and 8 per cent respectively. All experiments were done in semi-darkness at room temperature (26–28°C).

Summary of the extraction methods and solvent systems is given in Table 1.

Estimation: All chloroform extracts were concentrated to 1 ml and were serially diluted in chloroform when necessary. 2.5, 5, 10 and 20 μl of solutions having fluorescence comparable to that of the standard solution, were spotted on 250 μ silica gel G (Merck) TLC plates along with the standard containing aflatoxin B_1 and G_1.

TABLE 1. EXTRACTION METHODS AND SOLVENT SYSTEMS:

Method of / treatment / Solvent system	Shaking with 5 mm glass beads in wrist action shaker. 50 ml of solvent	Homogenisation at high speed for 3 min	Soxhlet extraction for 4 hr siphon rate 10–12 cycles/hr[4].
70% Aqueous acetone	Duration of shaking ½, 1, 2 and 4 hr	3 Successive homogenisations on residue. Solvent volume 50ml and 75 ml. Aflatoxin in residue estimated by MeOH/Soxhlet	
Chloroform: water	—	75 ml chloroform 25 ml water	
Chloroform: water[3]	—	50 ml chloroform 40 ml water 5 successive homogenisations in each case	
Hexane–aq. methanol	—	3 successive homogenisations with 30 ml hexane and 60 ml 55% aqueous MeOH. Aflatoxin in hexane estimated with MeOH and chloroform extraction. Pigments precipitated with basic lead acetate	
Methanol	—	—	2 hr defatting with petroleum ether followed by 4 hr extraction with MeOH. Residual aflatoxin assayed by aq. acetone and repeat MeOH Soxhlet.

Chromatograms were developed in at least two solvent systems to provide greater differentiation of the aflatoxin spots from those of non aflatoxin material. Visual estimations were done under long wave UV light.

Results

Effect of duration of shaking: The amount of aflatoxin extracted by three successive homogenisations was arbitrarily fixed as 100 per cent for comparative evaluation of shaking procedurers. For artificially inoculated copra meal, shaking for 1 hr appeared to extract the maximum amount. With artificially inoculated fresh coconut, the amount extracted increased upto 2 hr but the percentages were lower than for artificially inoculated copra meal.

However in naturally contaminated copra meal samples, only about 60 per cent was extracted even after 4 hr shaking. For all types of samples only about 50 per cent was extracted by 30 min shaking indicating that shaking is less efficient than homogenisation.

Effect of repeated homogenisation on (a) 70% aq. acetone: With artificially inoculated samples of all types two homogenisations removed more than 90 per cent of the acetone extractable aflatoxin while three homogenisations were needed with naturally contaminated samples. The residual aflatoxin left after three homogenisations of artificially inoculated samples was negligible. With naturally contaminated samples (commercial meal) about 20 per cent was left even after three homogenisations.

(*b*) *Chloroform-water:* With artificially inoculated coconut samples, two homogenisations using the Baur ratio of chloroform-water removed more than 90 per cent of aflatoxin whereas the Lee method needed 3 homogenisations.

The chloroform-water method was not pursued with commercial samples as our aim was to investigate methods suitable for routine analysis of aflatoxin especially in naturally contaminated (commercial), samples and to avoid time consuming column clean-up procedures which would have been needed to remove the extraneous matter extracted by this system, from naturally contaminated copra meal.

The optimum values with artificially inoculated samples, were 50 ml chloroform–40 ml water for 10 g of substrate.

(*c*) *Hexane-aqueous methanol:* With this procedure, 3 homogenisations were needed for naturally contaminated commercial samples of copra meal whereas only two homogenisations removed 90% of aflatoxin from artificially inoculated coconut samples. The amount of aflatoxin passing into hexane was less than 5% with

both types of samples. Emulsions formed on shaking the methanol phase with chloroform, were difficult to separate.

(*d*) *Methanol-Soxhlet:* Ninety seven percent of aflatoxin was removed on 4 hr methanol-Soxhlet extraction when residual aflatoxin was assayed by either the aqueous acetone procedure or a repeat methanol Soxhlet extraction. This method could not be adopted for routine assays due to the time factor and the large amount of extraneous matter extracted, but was of great use in experimental work where maximum recovery of aflatoxin was needed.

The following conditions were estabilshed as the optimal for each solvent system, with 10 g portions of substrate and three successive homogenisations with fresh aliquots of solvents:

(*i*) 75 ml of 70% aqueous acetone; (*ii*) 50 ml of chloroform+40 ml water; (*iii*) 30 ml hexane+60 ml aqueous methanol; and (*iv*) 4 hr Soxhlet extraction with 100 ml methanol after a 2 hr defatting with 100 ml of petroleum ether.

Comparison of methods: With a given type of substrate, extraction of replicate portions by homogenisation with the three solvent systems followed by a Soxhlet-methanol extraction of the residue gave approximately the same values (Table 2). With the artificially

TABLE 2. COMPARISON OF METHODS OF AFLATOXIN EXTRACTION (UNDER OPTIMAL CONDITIONS) FOLLOWED BY METHANOL-SOXHLET EXTRACTION OF RESIDUE FROM EACH EXTRACTION

Sample	Aflatoxin ppm in extracts				ppm in residue			
	Acetone	Chloroform water	Hexane methanol		Acetone	Chloroform water	Hexane methano	
Copra meal[a]	250	313	250	48	94	65		
Copra meal[a]	94	63	62	7	11	20		
Fresh coconut[a]	2092	3000	2188	17	50	45		
Fresh coconut[a]	43	44	44	0.6	2	1		
MECM[a]	2625	2500	2219	41	103	168		
Copra meal[b]	0.10	0.11	0.11	0.04	0.04	0.02		

Each value is the average from 4 experiments.
MECM = mechanically expressed cocnut meal
a = artificially inoculated samples
b = naturally contaminated samples.

inoculated samples each method appeared to extract above 90% of aflatoxin; from naturally contaminated samples the amount extracted was about 70%.

Purity of the extracts: The dry weights of extracts of artificially inoculated samples showed relatively high values with the chloroform-water and methanol-Soxhlet methods. In relation to the type of product the values decreased in the order, coconut meal, fresh coconut and copra meal. The lower weights of aqueous acetone and hexane–methanol extracts indicate their relative purity. The variation of purity of extracts with different extraction procedures, was seen on TLC analysis. Methanol-Soxhlet extracts did not give any interfering spots of extraneous matter. The spots from chloroform-water extracts were difficult to quantify on account of oil present (preliminary defatting having been omitted with this method). Only hexane-methoanl and aqueous acetone extracts could be used to quantify the values of 0.01 ppm and above without a column clean up procedure.

Reproducibility of the acetone method: Analysis of artificially inoculated coconut and naturally contaminated copra meal (four samples each extracted by the acetone procedure) showed the following results:

Product	Aflatoxin B content (ppm)	
	Range	Mean±SD
Artificially inoculated coconut	1000–1500	1250±88.3
Naturally contaminated copra meal	0.09–0.14	0.12±0.01

Discussion

Recovery experiments with added aflatoxin were avoided as any extraction procedure might have easily removed added aflatoxin from a substrate in contrast to native aflatoxin in naturally contaminated meal, which may been more inaccessible to extraction either by nature of the particle hardness of the aged meal or conceivably due to binding in natural substrates[6].

Our observations which illustrate these differences between fresh substrates and old commercial ones are: (*a*) shaking of naturally contaminated copra meal with aqueous acetone reemoves only 50–60 per cent of what could be removed by homogenisation whereas with artificially inoculated samples, shaking is as efficient as homogenisation in spite of larger particle size. In artificially inoculated samples with very high aflatoxin levels, what is inaccessible inside may be negligible in comparison with the free aflatoxin that diffuses out; the latter aflatoxin may be extracted readily by mere soaking of the particles; (*b*) three homogenisations with acetone, chloroform-water or hexane-methanol were needed with naturally contaminated samples and only two with artificially inoculated samples; (*c*) the existence of high residual aflatoxin in commercial meals.

These observations indicate that the efficiency of extraction procedures would depend not only on the physical state of the substrates but also on such factors such as age, composition and aflatoxin content which may involve a varying degree of inaccessibility of aflatoxin.

Dry weights of extracts in relation to solvent system: The high dry weights of extracts from chloroform-water systems was probably due to oil and extraneous matter, and complete drying of such extracts to a solid was not possible. With Soxhlet extraction, the bulk of oil was removed by prior defatting and the extracts did not form pastes on drying as in the case of chloroform-water extraction; hence the high dry weights appear to be due to non-oil extraneous matter.

In the hexane methanol and aqueous acetone procedures the preliminary clean up procedure appeared to remove both oil and non-oil extraneous matter giving lower dry weights for coconut meal than for fresh coconut. Extracts with these solvent systems were titratable on TLC without interference by non-aflatoxin material.

Dry weights in relation to substrate: Higher dry weights observed for fresh coconut would be due to oil and extraneous matter which are extracted only by chloroform-water and methanol-Soxhlet systems. Coconut meal too showed the same pattern of dry weights.

With commercial copra meal the dry weights were lower, probably due to low oil content, the oil being removed efficiently by the commercial expellers.

Thus it could be expected that the chloroform-water system extracts high amounts of oil while Soxhlet extracts have high levels of non-aflatoxin material (both of which produce interference on TLC) with naturally contaminated samples with low aflatoxin levels. Only the aqueous acetone extracts of low aflatoxin value samples were observed to give quantifiable fluorescence on TLC without column purification. This value was not altered even after a column purification indicating the suitability of the acetone system; although similar results were obtained with the hexane-methanol method, an advantage of the acetone method was that no inseparable emulsions were formed as with the methanol procedure.

Thus the aqueous acetone procedure with three homogenisations and lead acetate purification could be considered as the best method for routine analysis with commercial solid coconut products. In this procedure the percentage of aflatoxin present in the residue after extraction was approximately 22 per cent. Such a high residual aflatoxin content cannot be accounted for in terms of the aflatoxin trapped in the solvent in the filtered solid because the precentage of the solvent left in the solid was only 10 per cent and that too was largely fresh solvent used for washing the residue. However since routine analytical work will deal mainly with commercial copra meal, we recommend as a time saving measure, the use of a single homogenisation which consistently extracts about 74 per cent of aflatoxin from this substrate together with a correction factor to account for the residual aflatoxin, which, with this product is 1.3 (Table 3). Correction factors may also be applied to other agricultural substrates, to shorten analytical procedures.

TABLE 3. AFLATOXIN B_1 EXTRACTED BY ONE HOMOGENISATION IN 70% AQUEOUS ACETONE AND TOXIN CONTENT OF RESIDUE AS DETERMINED BY METHANOL-SOXHLET EXTRACTION; NATURALLY CONTAMINATED COPRA MEAL

Expt. No.	Aflatoxin B_1 (ppm) in			Aflatoxin B_1 (%) in		
	Acetone extract	Methanol Soxhlet extract	Total	Acetone extract	Methanol Soxhlet extract	Correction factor
1	0.14	0.05	0.19	74	26	1.35
2	0.05	0.02	0.07	71	29	1.40
3	0.13	0.03	0.16	81	19	1.23
4	0.13	0.03	0.16	72	18	1.38
5	0.09	0.02	0.11	72	18	1.22
Ave.				74	22	1.32

Acknowledgements

We thank Mr. C.H.S.R. Bandunatha and Mr. D.M. Hemawardene for technical assistance. We are grateful to Dr. Frank G. Dollear of the Southern Regional Research Laboratory of the US Department of Agriculture, New Orleans, Louisiana, for providing us with the standard samples of aflatoxins and to the Ceylon Coconut Board and the National Science Council of Sri Lanka, for research grants.

References

1. Anon., *J. Ass. off. anal., Chem.*, 1971, **54**, 468.
2. Arseculeratne and de Silva, L.M., *Ceylon J. med. Sci.*, 1971, **20**, 60.
3. Baur, A.J. and Armstrong, J., *J. Ass. off. anal Chem.*, 1971, **54**, 874.
4. Broadbent, J.H., Cornelius, J.A. and Show, G., *Analyst Lond.*, 1963, **88**, 214.
5. Detroy, R.W., Lillehoj, E.B. and Ciegler, A., in *Microbial Toxins*, Ed. Ciegler, A., Kadis, S. and Ajl, S.J., Academic Press, N.Y., 1971, Vol. VI, 61.
6. Lee, W.V., *Analyst* (*Lond.*,) 1965, **90**, 305.
7. *Official Methods of Analysis, Ass. off. agric. Chem.*, Washington, D.C., 1970.

Studies on Papada Based on Blends of Blackgram with Cereals, Pulses and Starches

S. R. SHURPALEKAR AND K. V. L. VENKATESH
Central Food Technological Research Institute, Mysore

Manuscript Received: 11 *November* 1974

A minimum of 20 per cent blackgram is necessary in the recipe to obtain greengram *Papads* of acceptable quality attributes. Desirable levels of spices in *Papad* recipes have also been worked out.

Blackgram flour, in papads can be substituted to the extent of 30 per cent by maize flour, 50 per cent each by rice flour and wheat *maida*, 20 per cent by corn starch and 25 per cent by gelatinised starch or a combination of 5 per cent gelatinised starch and 25 per cent of corn starch. The *papads* based on 80:20 blends of horsegram and blackgram flours when fried had gritty texture and unacceptable taste and a poor diametrical expansion (17 per cent).

Earlier studies[1-4] on *papads* have been confined mainly to evaluation of commercial varieties, recipe development and quality attributes of unspiced blackgram (*Phaseolus mungo*) *papads*, as well as their shelf-life and packaging profile. In the Northern parts of India, however, spiced *papads* based on "Mung" or greengram (*Phaseolus aureus*) are preferred to blackgram *papds*. In practice, greengram *papads* are mostly made in combination with blackgram, which unlike greengram contains mucilaginous principle necessary for obtaining a dough of desired consistency and rolling property. The usage of different combinations of spices has so far been only empirical.

No systematic work has, however, been reported so far on *papads* based on different blends of cereals, pulses and starches like rice, wheat, horsegram, gelatinised starch in the form of rice gruel, etc. The results of such a study are reported in this paper.

Materials and Methods

Preparation of greengram papads: Good quality greengram and blackgram *dhals* (split pulse free from husk) purchased locally were ground into fine flour to pass through 80 mesh. To arrive at the desirable blend for preparing *papads* of acceptable quality attributes and at the same time achieve maximum substitution of blackgram by greengram, 100:0, 80:20, 60:40, 40:60, 20:80, 0:100 blends of greengram and blackgram flours respectively were tried using normal recipes (containing 7 per cent common salt and 1 per cent sodium carbonate on flour basis according to the procedure described earlier[2, 3].

Spicing of greengram papads: Locally purchased chilli powder, asafoetida powder, white pepper powder, black pepper, *jeera* and garlic were tried in a *papad* recipe based on 80:20 blend of greengram and blackgram flours. Cleaned black pepper and *jeera* (free from stalks) were used in the form of flakes of 0.8 and 0.3 mm thicknesses respectively, obtained by passing the same through flaking rolls with required clearances. Garlic powder prepared according to a process[5] developed at this Institute was used.

Ready but moderate degree of perceptibility of particular spices in fried *papads* was taken as the main criterion to arrive at desirable levels after several trials. In the preparation of *papad*, spices like chilli powder, garlic powder, white pepper powder or flaskes of *jeera* and black pepper were dry mixed with the main ingredients. Asafoetida powder was added in the form of a water suspension before kneading all the ingredients into a *papad* dough.

For comparison with the natural spices like pepper and chilli oleoresins extracted from chilli and pepper according to the processes[6, 7] developed at this Institute were also tried at 0.1 to 0.4 per cent levels in the *papad* recipes. The oleoresins were dispersed in small quantity of ethyl alcohol to which a solution of salt and carbonate in water was then added gradually to obtain a uniform suspension. This facilitated proper distribution of the oleoresins throughout the dough.

Effect of storage on expansion characteristics: The diametrical expansion of *papads* based on different blends of blackgram and greengram stored for varying periods in air-tight plastic containers were studied over a period of three moths according to the procedures described earlier[1].

Papads based on blends of blackgram with cereals, pulses and starches: To arrive at maximum possible

substitution of blackgram, trials were carried out using several blends of blackgram with relatively cheaper and commonly used cereals, pulses and starches.

Maize flour purchased locally, rice flour obtained by grinding *Bangara Sanna* rice and wheat *maida* obtained by milling medium hard wheat in the Laboratory Buhler Mill were used for blending with blackgram flour.

Horsegram (*Dolichos biflorus*) purchased from the local market was soaked for 24 hr and allowed to germinate for 48 hr. After drying in the sun, the material was ground into a fine flour and the husk was removed by sieving.

Commercially marketed corn starch was used as such or in gelatinised form. The gelatinised starch was freeze-dried and ground into fine powder in a Waring Blender.

All the flours or starches were passed through 80 mesh sieve before use.

Papads based on different blends using 7 parts of common salt and 1 part of carbonate were prepared according to the procedure described earlier[4]. In some of the recipes, the normal water addition of 45 per cent was either decreased or increased to get a *papad* dough of desired consistency for easy and smooth rolling of *papads*.

Dough characteristics and papad quality: The handfeel and rolling property of the dough and appearance, texture, taste and diametrical expansion of fried *papads* were considered as the main criteria[1,2].

Results and Discussion

Dough characteristics and papad quality (*Table* 1)*:* The diametrical expansion of *papads* based on only greengram was 27 per cent but *papads* based on remaining blends of blackgram and greengram ranged between 44 and 49 per cent. The optimum water requirements for 40:60 and 20:80 blends of blackgram and greengram other blends.

TABLE 1. DOUGH CHARACTERISTICS AND QUALITY OF PAPADS BASED ON BLENDS OF BLACKGRAM AND GREENGRAM FLOURS

Batch No.	Blackgram flour	Greengram flour	Water* added	Dough characteristics			Fried papad**		Diametrical*** expansion (%)
				Kneading (min.)	Handfeel	Rolling property	Appearance	Taste	
1	100	0	45	2	Soft elastic	Easy to roll	Creamy yellow yellow	Balanced and acceptable	49
2	80	20	45	2	,,	,,	,,	,,	47
3	60	40	45	2½	Soft	,,	Bright creamy yellow & attractive	,,	45
4	40	60	42	2½	,,	,,	,,	,,	46
5	20	80	40	2	,,	,,	,,	,,	48
6	0	100	40	1½	Very soft	Difficult to roll, needs more dusting material, edges crack	,,	Dhal taste	27

*Parts per 100 parts of flour blend

**All *papads* had brittle texture and were crisp to bite

***Percent increase in the diameter on frying.

Though all the doughs were soft to handfeel, the elasticity of the dough, decreased as the proportion of greengram increased. The dough containing only greengram flour lacked elasticity and cohesiveness, was difficult to roll and required more dusting material. Also, the edges of the rolled *papads* had a cracked appearance.

All the *papads* on frying had bright cream yellow colour and attractive appearance. They were crisp to bite and had a balanced acceptable taste, except in the case of 100 per cent greengram *papads*, which had a typical and predominent dhal taste. Therefore, it can be concluded that atleast 20 per cent of blackgram flour is necessary to get *papads* of acceptable quality.

Spicing of papads: From the various trials carried out using different levels of spices the desirable levels of incorporation of spices on the basis of 100 g of 80:20 blend of greengram and blackgram flours arrived at were: chilli powder, 1.0; *jeera* flakes, 20; black pepper flakes, 2; white pepper powder, 1.8; asafoetida powder, 0.2–0.3; and garlic powder, 0.2 per cent. These levels were the ones at which the taste and the flavour of the

spices used in isolation or combination were just perceptible. Various combinations of these spices can be worked out to meet the requirements of the consumer. Spices did not have any deleterious or beneficial effects on the diametrical expansion which ranged between 40 and 52 per cent.

In earlier studies[1] falling off of pepper specks in particular, leaving holes on the *papad* was found to be one of the serious defects. The present studies have overcome this defect by increasing the desirable thickness of spiced *papads* to about 0.8 mm and using flakse of pepper and *jeera* of optimum thicknesses, i.e. 0.8 and 0.3 mm respectively. These spice flakes were also found to minimise powdering of the spices during flaking. Further, the use of black pepper flakes of known particle size resulted in *papads* of better appearance with uniform distribution of bold specks. *Jeera* used in the form of flakes gave the *papads* a characteristic taste of the active principle. It may be noted here that the use of each spice has been maintained at mild to moderate levels.

Use of oleresins in export quality papads: The desirable levels of chilli and pepper oleoresins in *papad* recipe were found to be 0.15 and 0.20% respectively as compared to 1.0 per cent of chilli powder and 2.0 per cent of black pepper. *Papads* containing chilli or pepper oleoresin in place of natural spices had spotless bright creamy yellow and pleasing appearance, and this will increase the export potential of spiced *papads*.

Effect of storage on diametrical expansion of papads: It is interesting to observe that in all the greengram *papads* the diametrical expansion showed an increasing trend during the storage. (Table 2) In most of the cases,

TABLE 2. EFFECT OF STORAGE ON PER CENT DIAMETRICAL EXPANSION OF PAPADS BASED ON DIFFERENT BLENDS OF BLACKGRAM AND GREENGRAM FLOURS

Sl. No.	Main ingredients		Per cent expansion after					
	Blackgram flour %	Greengram flour %	1 day	1 week	2 weeks	1 month	2 months	3 months
1	0	100	23	27	35	40	45	44
2	20	80	35	44	50	52	57	54
3	40	60	36	46	52	55	59	57
4	60	40	40	47	53	54	56	54
5	80	20	43	48	54	56	58	57

*The moisture content of *papads* varied from 13.0-14.0%.

a storage period of 2–4 weeks was found desirable to obtain a maximum possible expansion. In case of *papads* based on different blends, the diametrical expansion increased from initial values of 23–40 per cent to 40–56 per cent during this period. This may perhaps be explained by more complete interaction between the additives and the flour components during storage which is somewhat comparable to improvement in quality as a result of aging in some of the food products.

Papads based on blends of blackgram with cereals, pulses and starches: The recipes for acceptable *papads* with maximum possible substitution of blackgram flour and the evaluation of the doughs as well as the *papads* made therefrom are presented in Table 3. For each substitute replacing blackgram, several blends were tried as in the case of blends of blackgram and greengram described above. Only the recipes found to be acceptable from the point of dough consistency, rolling property, texture, taste and expansion characteristics have been included in the Table.

Though 60–75 per cent of wheat *maida* could be incorporated without affecting the dough characterisrics and organoleptic quality of *papads*, the expansion (24–16 per cent) was significantly low. As such, a maximum of 50 per cent substitution by wheat *maida* is suggested in view of 55 per cent expansion obtained on frying.

When gelatinised corn starch was used to the extent of 25 per cent, the water requirement was as high as 60 per cent. In contrast, 30 per cent of corn starch could be used in the dough using only 50 per cent water. Further, in the same recipe, 5 per cent substitution of corn starch by the same quantity of gelatinised starch increased the water requirement to 55 per cent and diametrical expansion of *papads* to 55 per cent, as compared to 47 per cent for *papads* containing 30 per cent corn starch.

The colour and appearacne of most of the fried *papads* were highly acceptable, while the texture was crisp and the taste acceptable. Only the rice *papads* had a somewhat dull colour. The papads based on recipe containing

TABLE 3. DOUGH CHARACTERISTICS AND QUALITY OF PAPADS* BASED ON DIFFERENT BLENDS OF BLACKGRAM WITH OTHER PULSES, CEREALS AND STARCHES

Ingredients	Blends of papad recipes								
	I	II	III	IV	V	VI	VII	VIII	IX
Maize flour	30								
Rice flour				50					
Wheat flour		50	60						
Horsegram flour									80
Gelatinised starch					25			5	
Corn starch						20	30	25	
Blackgram flour	70	50	40	50	75	80	70	70	20
Water	57.5	45	45	47.5	60	50	50	57.5	45
Dough characteristics	Soft	Soft & elastic	Soft & elastic	Soft	Soft	Soft	Soft	Soft after conditioning	Soft
Rolling property	Easy & smooth	Easy & smooth	Easy & smooth	Easy but edges break slightly	Easy & smooth	Easy & smooth	Smooth	Smooth	Smooth
Expansion (%)	37	55	24	50	51	64	47	55	17

*All the *papads* had bright creamy yellow colour with the exception of rice and horsegram *papads* which had dull straw yellow and dull brownish colour respectively. Except horsegram, the remaining *papads* were crisp to bite and had brittle texture and acceptable taste. Texture and taste attributes of fried horsegram *papads* were unacceptable.

maize had a low diametrical expansion of 37 per cent, while recipes containing rice, wheat and geletinised starch had an expansion of 50–55 per cent. The blackgram papds containing 20 per cent corn starch had a maximum expansion of 64 per cent.

In the case of horsegram *papads* only 20 per cent of blackgram flour was adequate to get a dough of desirable consistency. The *papads*, when fried, were dull brownish in colour and some what gritty. Further, they had unacceptable taste and a poor diametrical expansion of 17 per cent. It may be noted here that the horsegram *papads* are mostly used in the toasted or baked form and not in the fried form.

To summarise, at least 20 per cent of blackgram flour is needed in *papads* based mainly on greengram flour to obtain a dough of desirable properties and *papads* of acceptable quality attributes relating to texture, taste and diametrical expansion on frying. About 25 to 30 per cent of starchy material, 30 to 50 per cent of cereals like maize, rice and wheat could replace blackgram flour in the preparation of *papads* without adversely affecting the handling properties of the doughs as well as the *papad* quality.

Acknowledgement

The authors are thankful to Dr. B. L. Amla, Director of the Institute for his keen interest in the work. The useful discussion with Shri J. V. Prabhakar is gratefully acknowledged.

References

1. S.R. Shurpalekar, K.V.L. Venkatesh, J.V. Prabhakar and B.L. Amla, *J. Fd Sci. Technol.*, 1970, **7**, 100.
2. S.R. Shurpalekar, J.V. Prabhakar, K.V.L. Venkatesh, S. Vibhakar and B.L. Amla, *J. Fd Sci. Technol.*, 1972, **9**, 26.
3. N. Balasubrahmanyam, S.R. Shurpalekar and K.V.L. Venkatesh, *J. Fd Sci. Technol.*, 1973, **10**, 20.
4. N. Balasubrahmanyam, K.V.L. Venkatesh and S.R. Shurpalekar, *J. Fd Sci. Technol.*, 1974, **11**, 79.
5. Indian Patent 134964 on *Improvements in or Relating to Manufacture of Garlic Powder*, 1970.
6. A.G. Mathew, Y.S. Lewis, R. Jagadeeshan, E.S. Namboodari and N. Krishnamurthy, *Flav. Ind.*, 1971, **2**, 23.
7. E.S. Namboodari, Y.S. Lewis and N. Krishnamurthy and A.G. Mathew, *Flav. Ind.*, 1970, **1**, 97.

Brabender Farinograph as a Tool in the Objective Evaluation of Papad Dough

S. R. SHURPALEKAR AND K. V. L. VENKATESH
Central Food Technological Research Institute, Mysore-570013

Manuscript Received: 11 *November* 1974

Brabender Farinograph, has been tried successfully for objective evaluation of dough characteristics of *Papad* recipes based on pulses, cereals and starches. The subjective attributes like handfeel and the dough consistency can be expressed numerically in Brabender Units with suitable adjustments of the farinograph.

Maximum consistency, dough development time, smooth or fluctuating nature and width of the curve and fall in dough consistency recorded on a farinogram were dependent on ingredients and additives used. As indicated by these objective attributes, the doughs based on blackgram flour as such, with sodium carbonate only or its blend with gelatinised starch and salt and carbonate were, in terms of subjective evaluation, somewhat tough and non-cohesive. In contrast, doughs based on blackgram flour blends with rice, maize, corn starch, and greengram in presence of both the additives, namely sodium carbonate and commonsalt, were soft and cohesive.

Spiced or unspiced balckgram (*Phaseolus mungo*) *papads* are popular in the South Indian dietary, while the greengram (*Phaseolus aureus*) *papads* are preferred in the North. The desirable physico-chemical characteristics of the dough and the organoleptical attributes as well as packaging and storage behaviour of *papads* has been studied systematically recently[1-3]. In view of its unique mucilaginous component, blackgram flour has been practically indispensable in all the *papad* recipes[2-4].

Many of the quality parameters relating to *papad* dough have however been based only on subjective assessment such as handfeel, rolling property, etc[2]. No instrument has so far been used to measure objectively the dough characteristics of *papads*. The results of studies undertaken to explore the possibility of using. Brabender Farinograph for objective assessment of consistency of *papad* doughs based on different blends of blackgram with other pulses, cereals and starches are reported in this paper.

Materials and Methods

Ingredients: Quality dhals of blackgram and greengram and *Bangara Sanna* rice purchased from local market were ground to obtain fine flour. Horsegram (*Dolichos biflorus*) purchased locally was processed into flour according to the procedure described earlier[4]. Maize flour purchased locally and gelatinised corn starch and wheat *maida* processed in the laboratory were used in the recipes. Before using, all the flours were passed through 80 mesh sieve. Additives used were edible grade sodium carbonate and common salt.

Preparation of papads: papads were made according to procedures described earlier[2]. For every 100 parts of blends of different flours, 7 parts of common salt and 1 part of sodium carbonate were used. The optimum quantity of water required for preparing the dough was determined after preliminary trials. For comparison, the doughs made in Hobart Kneader as well as Farinograph Kneader were used for the preparation of *papads*.

Evaluation of dough characteristics using a Brabender Farinograph (Model SEW)

Preparation of papads using a mixer: Brabender Farinograph (Model SEW), was used to measure the dough characteristics of *papads* based on different recipes. After preliminary trials, lever position 2 and not the lever position 1 used normally for bread doughs, was selected for the present studies. The 50 g mixer was used for making the dough. Different Farinograph curves (Figs. 1 & 2) run for a period of 10 min. were obtained for different *papad* doughs. For the preparation of *papads*, a duplicate curve was obtained but the dough formed was removed from the mixer, after stopping the mixing at maximum dough consistency. *Papads* were then hand-rolled from these doughs as usual.

Effect of additives on blackgram dough: The behaviour of the blackgram dough as influenced by additives sodium carbonate and common salt was studied using the 50 g Farinograph Mixer in Lever position 2. Farinograph curves for doughs based on (*i*) blackgram flour only (*ii*) blackgram flour + sodium carbonate (*iii*) blackgram flour + common salt and

(*iv*) blackgram flour + sodium carbonate + common salt were obtained with the requisite quantity of water. For this purpose, 50 g of blackgram flour was transferred carefully to the Farinograph Mixer and 0.5 g of sodium

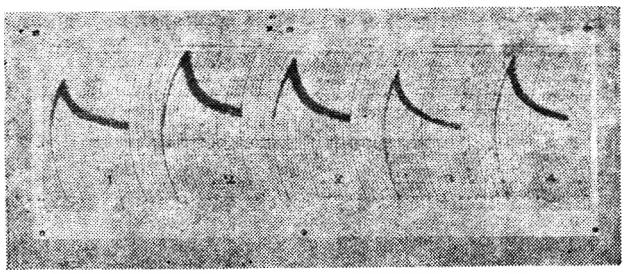


Fig. 1 Farinogram curves for blackgram dough containing 50 per cent water (1), 52 per cent water and 1 per cent sodium carbonate (2 left), 53 per cent water and 1 per cent sodium carbonate (2 right), 50 per cent water and 7 per cent common salt (3) and 50 per cent water, 1 per cent sodium carbonate and 7 per cent common salt (4).

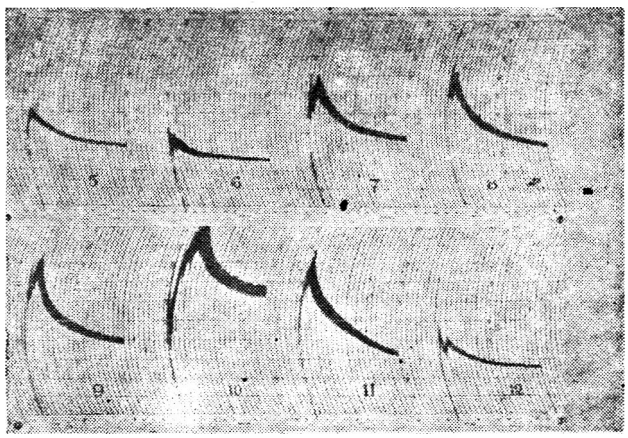


Fig. 2 Farinogram curves for papad doughs based on blends of blackgram: greengram (5), rice (6), maize (7) corn starch (8), corn starch with gelatinised starch (9), gelatinised starch (10), wheat (11) and horsegram (12).

carbonate and/or 3.5 g of common salt dissolved in 25 ml of water were added immediately after switching on the Farinograph Mixer into the fast position and the curves were allowed to run for a period of 10 min.

Criteria for evaluation of papad dough: From the Farinograph curves the maximum dough consistency recorded in Brabender Units, fall in the consistency at the end of 10 min., the width and the pattern of the curve were taken as the criteria for evaluating the dough characteristics. Diametrical expansion of *papads* on frying has been reported as an important quality criterion for fried papads[1]. As such, for comparison, expansion characteristics of the *papads* obtained both from doughs kneaded in the Farinograph Mixer and the normally used Hobart Mixer were studied according to procedures adopted earlier[1].

Results and Discussion

Comparative evaluation of different doughs using Brabender Farinograph: The data regarding dough characteristics as studied on a Farinograph and expansion of *papads* based on different recipes are presented in Table 1.

Effect of additives on blackgram dough: As highlighted earlier[4], blackgram is practically an indispensable ingredient in any *papad* recipe. As such, the effect of additives on the blackgram dough characteristics was studied separately. Further, the preliminary trials indicated that when a level of 45 per cent water (normally used for hand rolled *papad* dough) was used in blackgram dough, the consistency far exceeded the maximum of 1000 B.U., even when lever position 2 was tried. As such, a level of 50 per cent water was used for obtaining farinogram curves in lever position 2, for different recipes based on blackgram as well as its blends, with cereals, pulses and starches. Further, in case of blackgram dough containing carbonate only, 3 per cent extra water was necessary to prevent the curve from exceeding a maximum consistency of 1000 B.U.

It is interesting to note that though 2-3 per cent of extra water was added to the blackgram dough containing carbonate only, its maximum consistency of 950 B.U. was significantly higher than that of blackgram dough without carbonate (750 B.U.) This corroborates with the subjective attributes such as tough and non-cohesive nature of this dough as reported earlier[2]. The toughness of this dough was reduced considerably by the inclusion of 7% common salt which has a mellowing action, thereby improving the rolling property of the dough. Use of both these additives resulted in a dough of desired strength as well as softness and rolling property.

The data presented (Table 2) indicate that there exists no correlation between the maximum dough consistency and the diametrical expansion. The diametrical expansions (45–50 per cent) of *papads* based on doughs containing salt or salt and carbonate were significantly higher than those (10–20 per cent) of *papads* based on blackgram with or without carbonate. It may, therefore, be inferred that a dough consistency of about 900 B.U. is desirable for obtaining maximum diametrical expansion in the case of blackgram *papads*.

Papads based on blends of blackgram with other ingredients (Table 1)

Water requirement for dough preparation: To obtain doughs of desired consistency in a farinograph mixer for smooth rolling of *papads*, the water addition had to be altered only in case of 80:20 blend of greengram and blackgram and 20:80 blend of gelatinised starch and blackgram to 45 and 55 per cent respectively as compared to 50 per cent for all the remaining blends.

TABLE 1. DOUGH CHARACTERISTICS AND EXPANSION OF PAPADS* PREPARED FROM DIFFERENT BLENDS OF CEREALS, PULSES AND STARCHES USING FARINOGRAPH MIXER

Sl. No.	Ingredients	Water added (ml.)	Dough consistency		Dough characteristics***		Diametrical expansion(%)
			Maximum (B.U.)	Time to reach maximum (sec.)	Handfeel	Rolling property	
	Series I						
1	Blackgram flour (50 g) only	25	750	78	Fairly soft but not cohesive	Somewhat difficult to roll, edges crack	10****
2	,, (50 g)+Sodium carbonate (0.5 g)	26	950	112	Tough and cohesive	not Difficult to roll	20****
2a	,, + ,,	26.5	900	92	,,	—	—
3	,, (50 g)+Common salt (3.5 g)	25	820	56	Soft and cohesive	Easy to roll	50
4	,, (50 g)+Common salt (3.5 g)+sodium carbonate (0.5 g)	25	190	68	Soft, cohesive and elastic	,,	45
	Series II						
5**	Blackgram flour (10 g)+Greengram flour (40 g)	22.5	480	37	Soft, but slightly sticky	Easy to roll	45
6**	,, (25 g)+Rice flour (25 g)	25	340	48	Fairly soft	,,	50
7**	,, (40 g)+Maize flour (10 g)	25	640	44	Soft, somewhat sticky and less cohesive	,,	33
8**	Blackgram flour (40 g)+Corn starch (10 g)	25	660	35	Soft, somewhat elastic	Easy to roll	64
9**	,, (35 g)+Corn starch (12.5 g)+ Gelatinised starch (2.5 g)	25	760	49	Fairly soft, only after conditioning	Somewhat difficult to roll	55
10**	Blackgram flour (40 g)+Gelatinised starch (10 g)	27.5	940	74	Somewhat tough	Somewhat difficult to roll	50
11**	,, (25 g)+Wheat flour (25 g)	25	770	39	Very soft, elastic	Very easy to roll	55
12	,, (10 g)+Horsegram flour (40 g)	25	400	—	Soft, but slightly sticky	Easy to roll	17****

*The molsture content ranged between 13 and 15 per cent

**In addition, the recipe for each dough contained 3.5 g of common salt and 0.5 g of sodium carbonate except Sl. No. 12 which did contain any carbonate

***The stickiness of some dough could easily be overcome by using extra dusting material

****Refer to papads made from doughs kneaded in Hobart mixer.

Dough consistency and diametrical expansion: The dough based on wheat blend had excellent diametrical expansion of 55 per cent, while in the case of maize it was only 33 per cent. It is interesting to note that even though, both the doughs based on blackgram blends with rice and horsegram had comparable maximum consistency, the diametrical expansion of papads based on rice (50 per cent) blend was three times that of *papads* based on horsegram (80 per cent) blend. The low consistency of the dough based on horsegram blend may be partly due to the fact that the dough was made according to a traditional recipe without any alkaline additive. The dough characteristics and the expansion of *papads* (Table 1) based on horsegram blend refer only to the dough kneaded in a Hobart mixer and not in the Farinograph mixer.

Though the maximum consistency of 660 B.U. was considerably lower than that (910 B.U.) of a normal blackgram dough, the dough containing 20 per cent corn starch had maximum diametrical expansion of 64

TABLE 2. FARINOGRAPH CHARACTERISTICS: CHANGES IN THE CONSISTENCY OF PAPAD DOUGHS BASED ON DIFFERENT CEREALS, PULSES AND STARCHES

Sl. No.	Ingredients	Final* dough* consistency (B.U.)	Fall in dough consistency* (B.U.)	Width of the farinogram curve		Time taken to reach maximum curve width (sec.)
				Max.(mm.)	Min.*(mm.)	
	Series I					
1	Blackgram flour (50 g) only	495	255	15	9	120
2	,, (50 g)+Sodium carbonate (0.5 g)	585	365	18	10	75
2*a*	,, (50 g)+ ,, (0.5 g)	545	355	16	10	90
3	,, (50 g)+Commonsalt (3.5 g)	485	335	11	6	60
4	,, (50 g)+ ,, (3.5 g)+ Sodium carbonate (0.5 g)	540	370	15	7	60
	Series II**					
5	Blackgram flour (10 g)+Greengram flour (40 g)	330	150	9	3	60
6	,, (25 g)+Rice flour (25 g)	260	80	11	3	30
7	,, (40 g)+Maize flour (10 g)	370	270	14	5	30
8	,, (40 g)+Corn starch (10 g)	335	325	9	4	45
9	,, (35 g)+Corn starch (12.5 g) +Gelatinised starch (2.5 g)	395	365	10	5	150
10	,, (40 g)+Gelatinised starch (10 g)	650	290	14	11	120
11	Blackgram flour (25 g)+Wheat flour (25 g)	325	445	13	5	60
12	,, (10 g)+Horsegram flour (40 g)	260	140	9	2	45

*At the end of 10 min. run

**In addition, each dough (Sl No. 5-11) contained 3.5 g common salt and 0.5 g sodium carbonate. The dough containing horsegram contained only 3.5 g common salt.

per cent and had a comparable handfeel. Use of gelatinised starch (in place of corn starch) increased significantly the dough consistency (940 B.U.), in spite of 5 per cent extra addition of water, and decreased diametrical expansion (50 per cent) of *papads*.

From the results presented in Table 1, it may be inferred that no correlation exists between maximum dough consistency on Farinograph and diametrical expansion. In case of wheat blend though the dough was very soft and elastic, it was relatively strong due to presence of gluten. Further, the dough consistency appears to be dependent on the type of ingredients used for blending with blackgram, e.g. with rice and greengram, the dough is very soft; whereas with maize, corn starch and wheat was soft but somewhat strong and with gelatinised starch alone, it was very strong but somewhat tough.

The data regarding dough consistency and changes in the width of the farinogram curve which indicate weakening of the dough as well as strength of the dough respectively, are given in Table 2.

Changes in the dough consistency: The fall in the dough consistency for the blackgram doughs containing salt or carbonate or both were comparable in the range of 335 and 375 B.U. Similar fall was also recorded for blackgram doughs containing corn starch as such or in gelatinised form. As the initial consistency itself was low in the case of blackgram doughs containing greengram, rice or horsegram, the fall in consistency also was low (80–150 B.U.) The weakening effect caused by

TABLE 3. DOUGH CHARACTERISTICS AND EXPANSION OF PAPADS* PREPARED FROM DIFFERENT BLENDS OF CEREALS, PULSES AND STARCH USING HOBART KNEADER

Sl. No.	Ingredients**	Water added (ml.)	Kneading time (sec.)	Dough characteristics		Diametrical expansion %
				Handfeel	Rolling property	
1	Blackgram flour (80) + Corn starch (20)	50	90	Soft, somewhat elastic	Eassy to roll	65
2	Blackgram flour (50) + Wheat flour (50)	45	75	Soft, elastic	,,	55
3	Blackgram flour (70) + Corn starch (25) + Geletinised starch (5) +	50	120	Fairly soft only after conditioning	Somewhat difficult to roll	55
4	Blackgram flour (20) + Greengram flour (80)	40	90	Soft	Easy to roll	43
5	Blackgram flour (50) + Rice flour (50)	45	105	Fairly soft	,,	50
6	Blackgram flour (80) + Maize flour (20)	45	105	Slightly tough	,,	40
7	Blackgram flour (80) + Gelatinised starch (20)	55	120	Somewhat tough	Somewhat difficult to roll	53
8	Blackgram flour (20) + Horsegram flour (80)	45	135	Soft but slightly sticky	Easy to roll	17

*The moisture content of different *papads* ranged between 14 and 16 per cent

**Figures in the parantheses indicate proportions of the main ingredients used in the blend. In addition, each contained 1 part of sodium carbonate and 7 parts of salt per 100 parts of flour.

kneading was maximum (445 B.U.) in the case of dough based on wheat flour blend.

Effect of additives on the strength of blackgram dough: As the pattern of changes in the dough consistency during the fall period of the curve can be observed easily, the width of the curve for different doughs has been recorded for a 10 min. kneading period. The maximum width of farinograms was comparable for most of the blackgram doughs in series I, with the exception of blackgram dough containing commonsalt only. In spite of the 10 min. kneading and 2-3 per cent extra addition of water, the blackgram dough containing carbonate only had considerably larger curve width, corroborating thereby, the toughness of this dough referred to in Table 1. Taking into consideration the different attiributes after subjective as well as objective evaluation, it may be inferred that salt renders the blackgram dough soft while the carbonate imparts toughness or strength to the dough. As such, both these additives are necessary to obtain a dough of desired dough consistency, strength and rolling property.

Strength of doughs based on blackgram blends: Most of the doughs based on different blends had a maximum curve width of 5–7 mm and were found to have the desirable dough characteristics. The weak nature of the dough based on blends containing greengram, rice or horsegram flours is indicated by a lesser curve width of 2–3 mm only. Also, these doughs needed extra dusting material during rolling. The decrease in the curve width, also indicative of the weakening of the dough, was comparatively minimum in the case of doughs, containing starches.

Maximum width of the farinogram which indicates the strength of the dough and dough development pattern was reached within 30–60 sec. for most of the doughs. In the absence of commonsalt, the blackgram dough containing carbonate only required longer time of 90 sec. as compared to 60 sec. required for dough containing salt only or both salt and carbonate. This also corroborates earlier observations[2] regarding the important role of commonsalt in the preparation of a soft and easily rollable dough.

Even though salt so necessary for obtaining a soft dough was included in the *papad* recipe, it is interesting to note that the presence of gelatinised starch increased the dough development time (150 sec.) and curve width (11 mm.) significantly. Also, in addition to larger curve width, blackgram doughs containing carbonate only or gelatinised starch with both carbonate and salt displayed prominent fluctuations in the curve as a result of higher

resistance offered to mixing blades. This brings out the non-cohesive and tough nature of the doughs with respect to rolling characteristics. The blackgram doughs containing greengram or rice showed insignificant fluctuations which may be attributed to the weak nature of the dough.

Hobart mixing vs. Farinograph mixing of papad dough: As the Sigma type mixing blade of Farinograph mixer rotating at 85 r.p.m. differ considerably from the planetary type arm of Hobart mixer (60 r.p.m.), a comparative information on the effect of two modes of kneading on the dough characteristics and the quality of different *papads* was considered necessary. The dough characteristics and quality of *papads* based on different recipes using Hobart and Farinograph mixers are given in Table 3.

Interestingly enough, the desirable level of water addition to obtain doughs of desirable characteristics in a Hobart mixer was 5 per cent less than that required for doughs kneaded in a Farinograph mixer. The kneading time (75–135 sec.) required to reach maximum consistency when dough was kneaded in a Hobart mixer was significantly longer than that (35–49 sec.) observed for most of the doughs kneaded in a Farinograph mixer. The only exception was a dough based on the gelatinised starch blend which required 74 sec. in spite of 5 per cent extra addition of water. Even though 2–3 per cent extra water was added to blackgram dough containing sodium carbonate only, the time (92–112 sec. vide Table 1) taken to reach the maximum consistency was significantly higher as compared to that (68 sec.) required for a normal dough containing both carbonate and salt.

As regards the dough characteristics, the observations were comparable for most of the doughs made in both the mixers. However, the doughs kneaded in a Hobart mixer could be removed as one lump without any stickiness, while the doughs removed from Farinograph mixer could not be removed so easily. With the exception of blackgram doughs containing wheat flour or starches, the remaining doughs were somewhat sticky to handle. Also, in view of the higher level of water addition, most of the doughs kneaded in a Farinograph mixer unlike those made in Hobart mixer required eatra dusting material during rolling. The diametrical expansion of *papads* made using the two modes of kneading were comparable.

The different findings of the present studies are summarised below:

1. Using Brabender Farinograph in lever position 2, subjective parameters like handfeel, and rolling property of the dough can be expressed numerically in Brabender Units to indicate the consistency of the *papad* dough. Time taken to reach the maximum dough consistency, i.e. the dough development time was dependent on the nature of ingredients and additives used in the preparation of the dough. Blackgram dough containing carbonate only and the doughs based on blackgram-starches blends showed higher dough consistency and were comparatively less cohesive and somewhat difficult to roll.

The fall in dough consistency as also the width of the Farinograph curve indicated the weakening changes in the dough consistency, as a result of kneading. The time taken to reach the maximum width of the farinogram curve, i.e. the maximum strength of the dough was dependent on the nature of the ingredients.

The fluctuations observed in the farinogram curve indicated lack of homogeneity or cohesive nature, and toughness of the dough, as a result of higher and non-uniform resistance of ingredients to the mixing blades. Such fluctuations were mainly observed in the blackgram doughs as such or with carbonate only or its blend with gelatinised starch and both carbonate and salt.

There was no correlation between the maximum dough consistency and the diametrical expansion of *papads*.

2. The processing conditions for preparation of the dough of comparable characteristics in a Hobart mixer, which is normally used, or the farinograph mixer differed in the level of water requirement as well as kneading time. The Sigma type mixing blades of the farionograph reduced the dough development time considerably. However, the quantity of water in the dough had to be increased by 5 per cent in order to obtain a dough of desirable as well as measurable consistency.

In conclusion, the subjective parameters used earlier for describing dough characteristics can now be expressed objectively in terms of farinogram characteristics. The findings have highlighted the role of (*i*) salt in softening the dough and (*ii*) carbonate in imparting strength to the dough.

Acknowledgement

The authors are thankful to Dr. B. L. Amla, Director of the Institute for his keen interest in the work. The useful discussion with Shri J. V. Prabhakar is gratefully acknowledged.

References

1. S.R. Shurpalekar, K.V.L. Venkatesh, J.V. Prabhakar and B.L. Amla, *J. Fd Sci. Technol.*, 1970, **7**, 100.
2. S.R. Shurpalekar, J.V. Prabhakar, K.V.L. Venkatesh, S. Vibhakar and B.L. Amla, *J. Fd Sci. Technol.*, 1972, **9**, 26.
3. N. Balasubrahmanyam, S.R. Shurpalekar, and K.V.L. Venkatesh, *J. Fd Sci. Technol.*, 1973, **10**, 20.
4. S.R. Shurpalekar and K.V.L. Venkatesh, *J. Fd Sci. Technol.*, (Communicated)

STUDIES OF PECTIN METHYL ESTERASE ACTIVITY DURING DEVELOPMENT AND RIPENING OF GUAVA FRUIT

Experiments were performed on Lucknow 49 variety of guava fruit to determine the pattern of change in Pectin methyl estersae (PME) activity during growth and ripening. The enzyme activity was insi gnificant for the first 112 days after petal fall after which it rose sharply. Peak PME specific activity was recorded at about 141 days and the activity again showed a decline. The maximum activity stage appears to correspond with the so-called hard green stage in the fruit development. Peak total pectin content was observed to correspond with the peak PME activity.

Guava fruit, a good source of niacin and vitamin C[1] is also important as a commercial source of pectin[2]. Pectin methyl esterase (PME), an enzyme which acts on pectin liberating methoxy groups, has been found to increase in activity during development and maturation of certain similar fruits[3, 4]. Knowledge of the pattern of PME activity during development of a fruit could therefore suggest the right stage of maturity as far as its pectin content was concerned. The present communication describes the experiments conducted primarily, to study the pattern of PME activity during the development and ripening of the guava fruit.

Psidium guajava fruits of Lucknow 49 variety were used in the study. Five trees in the Agriculture College orchard, Nagpur were selected and the fruits were labelled at the time of petal fall. Samples were collected at regular intervals i.e. 15 days in earlier stages and 8 days at later stages. Fruits were weighed, homogenized and analysed for PME activity and total pectin content. The enzyme activity was assayed by the method of Al-Delaimy and Ali[5]. The activity is expressed as meq. of COOH groups liberated/hr/g. fresh wt. Total pectin was determined as calcium pectate by the method of Holt[6]. The unit of total pectin was mg Ca pectate/100 g fresh wt.

Results represented (Fig 1) indicate that growth curve of guava fruit is typically sigmoid as reported for other fruits of the same family[7]. PME activity was insignificant upto 112 days, after which it rose sharply. This rise corresponded with the rapid increase in weight of the fruit. Maximum activity was observed around 141st day, which may be described as the hard green stage. The PME profile obtained is similar to certain other fruits of the same variety. Hobson[3] reported a 40 per cent increase in PME activity in tomatoes as they ripened from mature green to full red stage. Thereafter the

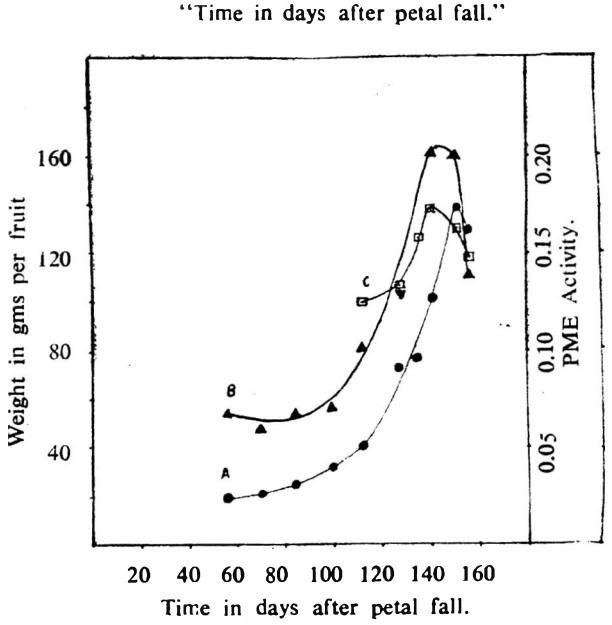


Fig 1. Fruit weight, pectinmethylesterase (PME) activity and total pectin content during development and ripening of guava. Values are averages of 5 fruits taken from 5 trees. A, fruit weight; B, PME activity; and C, total pectin content.

activity showed a decline. Weurman[4] also obtained similar results with pears. He observed that the PME activity was maximum at about two weeks prior to commercial maturity.

Total pectin content of the fruit, determined from 112th day onwards (Fig 1) also indicated similarity between the total pectin content and the PME activity and peak PME activity corresponded with peak total pectin content. It, therefore, appears that this point corresponds to maximum turn over rate of pectin. Since the methoxy index of pectin is considered to be more important than total pectin from the commercial point of view, further investigations on these lines are in progress.

The authors wish to thank the UGC for financial assistance and the authorities of the Govt. Agriculture College, Nagpur for granting permission to collect samples from the College orchard. Authors are also thankful to the Director, Laxminarayan Institute of Technology, Nagpur and Head of the Department of Biochemistry, Nagpur for their interest in the work.

References

1. Chan H.T. Jr., Brekke J.E. and Chang T., *J. Fd Sci.*, 1971, **36**, 237.
2. Ferro R.M.L. and Castelblanco, R.H., *Technologia.*, 1969, 11, 30 (C.A. 1969, **71**, 48482 *b*.)
3. Hobson G.E., *Biochem. J.*, 1963, **86**, 358.

4. Weurman, C., *Acta Bot Neerl.*, 1954, **3**, 100, (C.A. 1954, **48**, 10131 e.)
5. Al-Delaimy K.S. and Ali S.H., *J. Sci. Fd Agric.*, 1969, **20**, 660.
6. Holt, R., *Analyst., Lond.*, 1954, **79**, 623.
7. Hulme A.C. and Rhodes M.J.C. in *The Biochemistry of Fruits and their Products* Edited by Hulme A.C., Academic Press, 1971, Vol. II, p. 335.

Laxminarayan Institute of Technology and University Department of Biocehmistry, Nagpur.
13 *Sept*. 1974.

PRATIMA N. SHASTRI
N, V. SHASTRI

A NOTE ON THE ESSENTIAL OIL AND OLEORESIN OF ZANTHOXYLUM RHESTA

The essential oil and oleoresin yield from carpels and the characteristics of the essential oil from the seeds of Zanthoxylum rhesta DC. are reported.

Zanthoxylum rhesta DC. is a middle sized tree belonging to the family Rutaceae. It is mainly distributed in the Konkan coast of the Indian peninsula and is locally known as *Kaavatte* (Kannada) and *Theppana* (Konkini). The carples are used as a condiment by the people of Konkan area, especially in fish preparations and in coconut *chutneyes*. It is also used widely in pickles as a preservative. The bark of this tree is aromatic and is sometimes used as a substitute for lime and pepper.

The unripe carpels of this tree are strongly aromatic and taste like the rind of fresh orange. They turn light brown in colour on ripening. The seeds are round, black, smooth and shining and are about 4 mm in diameter. Ripe seeds do not have any attractive taste.

The essential oil of this spice (from the carpels and barks) has also some medicinal properties. It is astringent, stimulant and stomachic in nature. It is said to be effective against cholera, dyspepsia, diarrhoea and rheumatism[1]. Roots of this tree also possess similar medicinal properties. The earlier studies[2, 3] on this spice dealt with the yield and properties of its essential oil.

Semiripe carpels were water-distilled for about 16 hr for obtaining essential oil. Ground carpels gave only a poor yield of oil and seeds did not give any oil. Oleoresin was extracted by percolation method from ground carpels using acetone and absolute alcohol.

The data on yield and properties of essential oil and oleoresin are given below:

Carpels

Moisture % (v/w)	8.0
Essential oil % (v/w)	6.7
Oleoresin (acetone) % (w/w)	7.2
Oleoresin (alcohol) % (w/w)	10.8

Seeds

Essential oil %	Nil
Non volatile acetone extract % (w/w)	16.5

The colour esseniial oil is faint yellow with a clear appearance,has a characteristic lemon odour which is fruity and spicy, and also biting and pungent to taste. It is soluble in 80% alcohol in 1:3 ratio. Other properties are as follows:

Sp. gr. 30°C	0.8844
Opt. rotation (α) 30°C	10.1°
Refr. index (30°C)	1.4702
Acid value	7.60
Ester value	30.26
Saponification value	37.86
Ester content %	4.75
Combined alcohol %	2.48

Central Plantation Crops Research Institute, Regional Station, Vittal (S. K.) Karnataka.
29 June, 1974

C. K. MAITHAI

References

1. Watt, G., Dictionary of Economic Products of India, vol. VI, Periodical Experts (1882-1896), 325.
2. Rao, B.S., *J. Indian Inst. Sci.*, 1925, 8A, 174.
3. Bhargawa, P.N., *Proc. Indian Sci. Congr.*, 1949, Part III, 78.

INVESTIGATIONS ON PREPARATION OF NON-DAIRY ICE CREAM

An acceptable ice cream product has been developed by using protein isolate from groundnut in place of milk solids. The cost of this product works out to about half of the milk based ice cream. It has a protein content of 7% as compared to 4% observed in the milk based ice cream.

India produces about 24 million tonnes of milk which is sufficient only to provide a per-capita consumption of 140 ml/day. The milk production will have to be doubled if the recommended requirement of 250 ml/day has to be met. It is absolutely necessary to conserve the available milk supplies through the application of modern technology. An effort has already been made to substitute skim milk powder with plant proteins in the toning of animal milk[1, 2]. Likewise, technology has to be developed for use of plant proteins in different sweets and confectionaries based on milk in order to stretch the available supplies of milk for the vulnerable groups.

India is a tropical country and the demand for frozen foods is on the increase in recent times. Ice cream which was once considered to be a sophisticated item of food is now becoming more popular among the people. Annual production of ice cream in India during 1969 was 1,80,000 tonnes[3].

Attempts have been made earlier to replace milk fat by vegetable hydrogenated fat in ice cream preparations. It would be worthwhile to explore the possibility of substituting milk solids completely so that a satisfactory ice cream product would be obtained thus preserving the precious animal milk for more vital use like infant feeding.

The flow sheet for the production of ice cream from groundnut protein isolate is given in Fig. 1.

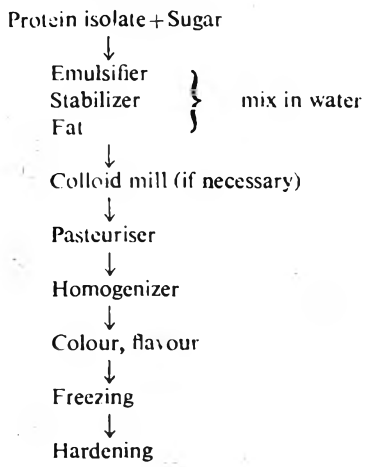


Fig. 1. Flow sheet for the preparation of ice cream

Groundnut protein isolate (neutralised & spray dried) with the required quantity of sugar, fat emulsifier and stabilizer are mixed together. This is dispersed in sufficient quantity of hot water (50–60°C) with continuous stirring to avoid formation of lumps. The emulsion is homogenized after pasteurisation. The product is kept for ageing at low temperature (4°C) before freezing. Desired colour and flavour are incorporated before freezing.

The final product is comparable to the conventional milk ice cream in texture, taste and other organoleptic qualities. The chemical composition of ice cream from milk as well as protein isolate is given in Table 1. The latter has a higher protein content than the former. The process has been successfully tried on a large scale in industrial units and ice cream so prepared has been found quite acceptable.

From the cost point of view also this product works out cheaper than the conventional ice cream apart from the fact that dependance on the skim milk powder is avoided. The recipe along with the cost details are given in Table 2.

TABLE 1. COMPOSITION OF ICE CREAM

Ingredients	Milk ice cream	Protein isolate ice cream
Protein%	4.0	7.0
Fat%	12.0	12.0
Carbohydrate%	20.0	18.0
Calories/100 g.	204	208

TABLE 2. COMPARATIVE COST OF RAW MATERIALS FOR 1KG. MIX

Raw material	Qty. (g)	Cost Milk ice Cream Rs.	Protein isolate ice cream Rs.
Cream	100	1.50	—
Fat	100	—	0.80
Sugar	150	0.30	0.30
Milk solids	120	3.00	—
Protein isolate	120	—	1.44
	370	4.80	2.54

A similar product where only milk fat is replaced by vegetable fat is being marketed in USA under the trade name 'Mellorine'. In the present case, however even the milk protein is replaced and if adopted on a large scale additional milk now being consumed by ice cream manufacturers could be made available for feeding the needy sections of populations. This product also offers possibilities of fortification with vitamins, minerals and essential amino acids for improving its nutritional status. Since ice cream is liked and consumed mostly by children it would be an effective medium for the supply of vegetable protein which is being harnessed in recent years for human consumption.

The author is grateful to Shri M. R. Chandrasekhara, Dr. B. L. Amla and Dr. H.A.B. Parpia, for their keen interest and encouragement during the investigation. The cooperation of the Scientist-in-charge and the staff of Experiment Station-Nagpur, is greatly acknowledged.

Central Food Technological Research Institute, Mysore
B. R. RAMANNA

12 *December*, 1974

References

1. Chandrasekhara, M.R., Ramanna, B.R., Jagannath, K.S. and Ramanathan, P.K., *Fd Technol. Champaign.*, 1971, **25**, 32.
2. Chandrasekhara, M.R. and Ramanna, B.R., *Voeding*, 1969, **30**, 297.
3. Arbuckle, W.R., *Ice cream*, AVI Publication, 2nd Edn. 1972.

BOOK REVIEWS

Processed Meats: by W. E. Kramlich, A. M. Pearson and F. W. Tauber. The AVI Publishing Company, Inc., West Port, Connecticut, 1973, pp. 348.

Meat processing as defined in this presentation includes all manipulations for altering fresh meat for purposes of preservation by curing, smoking, canning, cooking, freezing, dehydration and addition of chemicals and enzymes, but excludes such simple operations like grinding, cutting and mixing which are just additional ways of presenting fresh meat to the consumer.

Historically, meat processing originated in the observation of early primitive man that cooking, sun-drying or salting prolongs the keeping quality of fresh meat. Ice and snow to preserve food was used by early Romans. Modern developments in food processing have undoubtedly received an impetus after development of the concept of canning which was an out come of need for stable foods during the Napoleonic wars. Freezing of meat was accelerated by world War I while irradiation, freeze drying and antibiotic preservation were out growth of necessities created by World War II. The purpose of processing was preservation by inhibiting microbial spoilage. To this overiding purpose, modern developments have added nutrition, flavour, convenience and variety.

Pork was the first meat to be processed in large quantities. Now other meats like beef, mutton and chicken and eggs are also processed into products. Protein isolates from vegetable sources, particularly textured soya protein have resulted in incorporation of these into meat products. A recent development of meat flavours in conjunction with textured vegetable proteins is likely to develop into nonmeat, meat substitutes. Another modern trend is for the processors to have facilities for slaughtering operations also because this adds to the flexibility and better control of raw materials that go for processing. The older practice of purchasing meat from slaughters and processing this is still prevalent on a large scale. The third group in this chain are meat warehouses.

The trend in meat processing is towards development of new and convenience processed and precooked items. This has been accelerated by the relatively large number of women employed outside the home and the consequent lack of time available for preparations of meals. The trend is illustrated by the growth of heat-and-eat preparations like TV dinner, frankfurters, bologna and meat loaves. This trend also depends on the anticipation and ingenuity of the meat processors who can even create such demands. Increased quality consciousness and government regulation on food safety and inspection are also factors in development of meat processing industry. The composition of the meat products in terms of the proximate principles and minor ingredients like minerals and vitamins has been given in detail in Chapter 2. This Chapter could have been included in the end with more emphasis on the changes induced by processing.

The first among the processing methods described is curing in Chapter 3. The purpose and role of the different curing ingredients, salt, sugar and corn syrup, nitrate and/or nitrite, phosphate, erythorbate, monosodium glutamate and hydrolysed vegetable proteins are described first. The characteristics of the three meat pigments, reduced myoglobin, oxymyoglobin and metmyoglobin, are elaborated before describing the development of nitric oxide myoglobin and nitrosohemochromogen. A fairly detailed description of the various methods of curing that are practiced is also included in this Chapter.

The logical sequence next to curing is smoking because cured meats are commonly smoked, and vice versa. All aspects of smoking are dealt with in Chapter 4. Even though the purpose of smoking was added preservation in earlier days, at present the emphasis is on imparting new flavours and creation of new products. Apart from the development of cured meat colour during the slight heating involved in application of smokes, the attractive brown colour on the surface of mans processed meat products due to Maillard reaction, is also enhanced by smoking. The carbohydrate components of wood smoke probably also take part in the browning reaction. The bacteriocidal and static properties of smoke constituents and formation of a thin dry film on the surface are important for preservation. The other aspects are desirable and undesirable constituents of smoke, importance of controlling temperature during smoke generation, application and absorption of smoke, type of smoke houses, type of woods and liquid smoke preparations.

Chapter 5 deals with meat cookery and cooked meat products. In the case of fresh meats, cooking coagulates and denatures the meat proteins, improves palatability by intensifying and production of desirable flavours and altering the texture and destroys most of the bacteria. Apart from these, in processed meat products cooking increases shelf life by destroying bacteria and enzymes, stabilizes cured meat colour and firms the comminuted type products. Cooking changes, particularly development of flavour and tenderness are dependent on species, age, method of cooking, nature of fat and pre-and post-slaugher factors. Generally older animals yield meat that is tougher and strong flavoured. By far the most important aspects of cooked meat flavour are browning, spice and flavouring additives and method of cooking.

A few recipes for cooked meat products are given with some details of preparation.

Chapter 6 describes the different types of meats not necessarily of different species but also different in terms of conventional end use like sausage, canned, variety and smoked meats. Some of the undersirable conditions encountered in raw materials like PSE pork, two toning in hams, sex odour and mutton flavour are also briefly described in this Chapter.

Chapter 7 details the sequence of operations in the manufacture of sausages. By convention sausage is a product made from salted and spiced meat made into a cylindrical form. When the sausage mix is shaped in a mould of rectangular or loaf form, it is known as meat loaf. Characteristic flavour and texture qualities have become conventional with some of the established sausage types. Classification could be into two groups. Coarse ground and fine ground (emulsion type) each group containing subdivisions like fresh, cooked, smoked, dry etc. Sausage making essentially consists of grinding, mixing, suffing and linking. To these basics are added operation like chopping/emulsification, cooking and/or smoking, peeling, drying, fermentation etc. to prepare the different sizes and varieties of sausage that are known. Emulsion type sausages like an frankfurters and bologna are formed by solubilizing the meat protein which acts like an emulsifier of the fat distributed as fine globules. The formation of the emulsion and the result of over chopping of the emulsion, meat short emulsion and break-down of the encapsulating protein layer by too rapid and too high heat have been explained lucidly. Different types of casings available now have been described briefly. Spices and additivies are also mentioned briefly.

The large volume of sausage type products, particularly emulsion type, have led to preblending and computerised liner programming to achieve least-cost formulation. This aspect of the present trend has been elaborated in Chapter 8. Preblending consists of grinding and mixing different sausage ingredients with part or all of the salt and curing ingredients. Several advantages like close control of composition, spoilage, use of hot boned meat, optimisation of use of equipment, retardation of oxidative rancidity and flavour changes, have been realised by judicious preblending. Preblending and computerised linear programming are very often used together. The essential idea underlying linear programming for least cost formulation is to select and determine the quantities of different ingredients available that have to be preblended to obtain a product of the desired quality specification and lowest possible cost. The information needed are (*i*) different ingredients available and their cost, (*ii*) the composition of each ingredient, particularly moisture, protein and fat and (*iii*) the desired quality specifications of the product. The use of computerised linear programming is essentially a management tool to control the quality and economy of the operation by making possible rapid decision on economical combination of ingredients, inventory control and reducing wastes. Computerised linear programing for least cost formulation is no substitute for good judgement, sound scientific principles and knowledge of the functional behaviour of the raw materials. Constraints or limitations have to be determined for the different specifications and ingredients.

Chapter 9 contains many formulations, instructions for preparation and notes on processing, handling and storage of different type of sausages grouped under ground suasages, semi-dry or summer sausages, dry sausages, emulsion-type sausages, liver sausage and braunschweiger and speciality items like loaves.

Chapter 10 details smoked meats like hams, bacon, smoked pork loin, picnic, shoulder butt, corned beef, smoked fresh meat, dried beef, smoked and cured lamb, smoked tongue and pickled pigs feet. The classification of different types of hams is based on internal temperature at finishing, added substances and presence of bone rather than method of curing.

The general principles behind canning, different type of cans, retorts, processing schedules, handling schedules, storage and shelf life, asceptic canning are briefly described in Chapter 11.

Popular canned meat formulations like beef hash, stew, chili con carne, Vienna Sausages, meat balls with gravy, sliced dried beef, luncheon meat, potted meat, hams are described in Chapter 12.

Chapter 13 details methods of analysis for moisture, fat, protein, ash, nitrite, cured meat pigments, phosphate, salt, cereal, soybean flour and soy protein concentrate, lactose corn syrup solids in meat products. Rapid methods of analysis for moisture based on infra red balance and azeotropic distillation and for fat based on acid digestion, X-ray absorption, specific gravity and dielectric measurement of fat in orthochlorobenzene are also described as suitable for some manufacturing situations where these are needed on a number of ingredients. A suggested layout for a routine analytical laboratory for meat products is also included.

Most of the processed meat products belong to three main categories of canned, cured or sausage type products. Some of the other methods of processing like freeze-drying, intermediate moisture type meat products, antibiotic preservation, irradiation, microwave processing, freezing and frozen storage, enzyne tenderization and chemical additives are briefly discussed in Chapter 14.

The author's hope that the book would be useful for students and Processors is very modest. Including bottling of strained foods and a compilation of regula-

tory specifications on composition and additives would have been desirable. The book would be useful for all connected with meat science, technology and industry.

B. R. BALIGA

Food Science: by Norman N. Potter, The AVI Publishing Co., Westport, Connecticut, U.S.A., 2nd Edition, 1973, pp. 706.

This revised book on Food Science by Professor Potter is a veritable encyclopaedia on the subject, covering all known aspects of Food Science and Food Technology. For those who wish to acquaint themselves with the processes involved in the production of various modern food products and the principles underlying the processes, it is an excellent text book.

Because of the large number of chapters, and the variety of subjects dealt with, it is very difficult to review it chapter by chapter. The first 11 Chapters are devoted to Fundamental Aspects like unit processes, heat preservation, food dehydration and food fermentations. Chapters 13 to 20 deal with specific food products like milk, meat, seafoods, grains and fruits. Chapters 21 to 25 deal with general subjects like packaging, food additives and world food needs.

Whatever subject is dealt with, the author gives, at least briefly, something about all the aspects and recent developments. The chapters on food processing are presented so well that, by the time one reads through them, even those who have no previous instruction in the field get a good grasp of the subject. The book is profusely illustrated, giving the reader an insight of the modern food processing industry.

As a text book for new entrants in the field, and as a handy reference book for those who have been in it for several years, the book is found to be extremely useful.

Y. S. LEWIS

Food-Borne Disease: Mathods of Sampling and Examination in Surveillance Progammes, Report of a WHO Study Group—World Health Organization, Technical Report Series No. 543, p. 50.

This is a Report of a WHO Study Group on food borne disease met in Geneva from 17th to 23 July 1973 to discuss methods of sampling and examination in surveillance programmes.

The proceedings have been complied in 8 sections. First seven sections include topics like microbiological food standards, rationale for standardising the microbiological analysis, food borne viruses, fungi and other parasites, monitoring methods and the role of WHO in developing microbiological methods. The last section includes recommendations which provide broad guidelines to effectively implement high hygienic standards of food supplies to the community by suggesting course of action to be taken up by the Governmental as well as private agencies. The value of this report is very much enhanced by a good coverage on methodology, specification of standards, and their limitations, future needs and surveillance programmes and the role of laboratories at the national and International levels. For a public health worker the report gives very valuable information to plan his work to implement high hygienic standards. On its own merit it deserves a place among reference books.

V. SREENIVASA MURTHY.

NOTES AND NEWS

Sadtlar Standard Spectra Collections:

Sadtler Research Laboratories, Inc. Philadelphia, announces publication of the 1975 subscriptions to Sadtler Standard Spectra Collections. These subscriptions will supplement spectra previously published in the Sadtler Standard Infrared Prims, Infrared Grating, Nuclear Magnetic Resonance. Utltraviolet, Raman and Fluorescence spectra collections. The 1975 subscriptions include 2000 IR Prism, 4000 IR Grating, 2000 NMR, 2000 UV, 2000 Raman, and 2000 Fluorescence spectra. These spectra include many simple aliphatic, aromatic, alicyclic and heterocyclic compounds. Each spectrum indicates the chemical name, molecular formula, structual formula, physical and optical constants (when available), source of sample, literature reference (when available), instrumentation and method of sample preparation. For further information about these collection or other Sadtler Reference Spectra Libraries, please address inquiries to Sadtler Research Laboratories, Inc., 3316 Spring Garden Street, Philadelphia, PA. 19104, U.S.A.

Indian Standards Institution

The following standards have been published:

IS:	7143–1973	Crab Meat Canned in Brine	Rs. 4.00
IS:	4307–1973	Fish Meal as Livestock Feed (revised)	Rs. 5.00
IS:	7126–1973	Fenitrothion Dusting Powders	Rs. 4.00
IS:	7121–1973	Carbaryl Water Dispersible Powder Concentrates	Rs. 5.00
		Dry-salted Thread Fin (DARA) and Dry-salted Jew Fish (Ghol) (Revised)	Rs. 5.00

ASSOCIATION NEWS

Seminar on "Adulteration in Foods"

The Bangalore Chapter of the Association of Food Scientists and Technologists held a Symposium on "Adulteration in Foods" on 14th December 1974 in Bangalore. The list of the main speakers and the topics on which they discussed the problem. are given below.

I Session

Main Speaker	Subject
Dr. K. C. Naik Technical Director Clean Food Corporation Ltd., Bangalore.	*Adulteration in Raw Materials*
Dr. B. L. Amla Director, Central Food Technological Research Institute, Mysore.	*Adulteration in Processed Foods*
Dr. S. Varadarajan Chairman and Managing Director Indian Petrochemicals Corporation Ltd., Baroda.	*Adulteration as it affects Manufacturers.*

II Session

Dr. C. P. Hartman Public Analyst Bangalore	*Prevention and Standards*
Mr. C. G. Rama Rao President All Karnataka Hoteliers Association, Bangalore	*Adulteration as it affects Retailers*
Smt. M. R. Lakshamma and Shri. V. T. Sreenivasan Accountant General (Retd.)	*Adulteration as it affects consumers*

The first Session was chaired by Shri Panduranga Setty, President, Association of Food Scientists and Technologists, Bangalore Chapter, the Second session by Shri G. V. K. Rao, Chief Secretary, Karnataka State Government and the third session in which the recommendations and resolutions were discussed and formulated by Dr. K. T. Achaya, Executive Director, Protein Foods and Nutrition Development Association, Bombay. Each topic evoked considerable discussion from the floor in which all the members of the Association and other invitees took an active part.

The Seminar ended with a resolution strongly condemning the evil of adulteration, and suggesting steps at various levels to meet it.

I. Primary Foodstuffs

1.1 Primary foodstuffs like rice, wheat and dhal involve every buyer in the country and are there-

fore of great importance. Lowering of quality would occur by deterioration through inadequate storage, by entry of adventitious materials like pesticides, insecticides or fertiliser residues, and by wilful addition of foreign material like stones or chaff to increase weight or volume.

1.2 Detection of adulteration or of quality deterioration cannot be considered the responsibility of the housewife.

1.3 Primary producers or manufacturers should be obliged to keep records of their operations and movement of finished foodstuffs to enable culprits to be traced.

1.4 Stocks from all ration shops in the country should be subject to inspection and drawing of samples for analysis.

1.5 All public health, municipal and state government laboratories should be modernised with up-to-date instrumentation. Considering the size and value of the food industry, and its basic importance for every citizen, even a 10-fold increase in expenditure can be justified. One analytical laboratory should be set up in each district of every state for this purpose.

1.6 These laboratories should also be used for commercial analysis for and advice to manufacturers and producers.

II. Processed and Packaged Foods

2.1 Despite a higher price, packaged foods have gained public confidence because they are found to carry less adulteration. This is even more true of brand-name products. In a recent Hyderabad study, all vegetable oils in sealed and branded tins were free of adulteration whereas all loose oils were found adulterated.

2.2 Standardisation of quality can easily be incorporated into packaged foodstuffs.

2.3 Based on these concepts, it is suggested that only brand-name unit packaging be permitted so as to pin down responsibility.

2.4 To reduce packaging costs, both manufacturers and research laboratories should work towards innovative and cheap packaging. For many powders or solid foods, paper and foil packaging is sufficient and tins are unnecessary. For items like vegetable oils, the possibility should be explored of dispensing units, just like petrol pumps, which are operated by manufacturers and dispense brand-name products into the consumers own containers. A similar scheme is being considered for milk distribution by the National Dairy Development Board.

2.5 Every manufacturer should be required to employ a qualified food technologist for internal quality control. Alternatively government-appointed technologists could be considered for placement in each food industry, as is now done under the Agmark scheme.

III. Legislative Actions

3.1 The present title of the Prevention of Food Adulteration Act is very negative. It is suggested that the amended Act now being considered by a Joint parliamentary Committee should be called the Food Safety and Quality Act.

3.2 The Act should be administered by the food department rather than by the health authorities.

3.3 The present opportunity for amendment should be used to make the Act a living one, capable of flexibility. The present PFA Act tends to fossilise existing practices. The new Act should be so worded that it is not restrictive in respect of form, function, economics, processing, labelling, etc. If this succeeds, it will help both the manufacturer and the consumer.

3.4 The Act should be so framed as to be not just a prosecuting authority, but an advisory and educating one.

3.5 Methodology should be included in the Act. For the present it would be sufficient simply to state that ISI methodology, which is well standardized, would be employed.

3.6 Specifically the following should be included:

a) Distinction between sub-standard and adulterated foods. The former should be dealt with through show-cause notices and fines, while the later should attract much stronger, penalties.

b) Two independant reports should be obtained before prosecution, and there should be provision for investigation and for an appeal to another analytical laboratory.

c) Adequate qualifications should be laid down for the inspectors, the analysts, and the prosecuting authorities who administer the Act.

d) Prosecution should be directed towards the primary producers; indiscriminate prosecution will not serve the intended purposes.

IV. Consumer Action

4.1 At the centre and in every state in India it is desirable to constitute a Council for Food Preservation and Standards.

These Councils could have a 3-tier structure as follows:

a) *Governing Board* consisting of all interests concerned with food standards, including consumers, to give general policy directions.

b) *Executive Committee* of 5-10 persons to take decisions for translation of policy directions into law.

c) *Technical Committees* formed for specific purposes to advise the Governing Board on special matters; members of these committees could be drawn from a very wide spectrum of scientists, technologists, manufacturers, doctors, public-spirited citizens, etc.

4.2 Consumer Guidance and Citizen Committees should be widely encouraged. They should receive and look into the preliminary complaints by housewives and refer clear cases to the correct enforcement authorities. They should also advise housewives regarding testing and legal advice, and should activate corporation and municipality laboratories for consumer testing.

4.3 Media like newspapers and journals and the cinema should be widely used by consumer guidance societies to feature specific complaints. This has already been done by some womens' magazine to excellent effect.

Seminars:

The AFST, Mysore, in collaboration with CFTRI arranged a Seminar on "Problems in Protein Structure". The Seminar was held on December 20th, 1974; the speaker was Dr. W. Kauzmann, Professor of Chemistry, Princeton University, New Jersey, USA. Another Seminar on "Science and Food Production in China" was also held under the auspices of AFST, Mysore and CFTRI on Tuesday, the 31st December 1974. The speaker was Dr. Bruce Johnson, Professor of Zoology, University of Tasmania, Australia.

The members of AFST, Hyderabad Chapter had met on December 18, 1974 at Community Canning and Preservation Centre, Vidyanagar, Hyderabad to hear a talk on 'Tailor made Fats for Food Industry' from Shri M. Venkateswara Rao, Scientist, CFTRI. Dr. M. Muralikrishna, President, AFST Hyderabad Chapter, had chaired the meeting. and Shri B. Raghuramiah, Hon. Secretary introduced the Speaker to the members Shri Venkateswara Rao spoke on the recent advances in different process in Lipid Technology and on the manufacture of sucrose esters and their use as surface active agent in the manufacture of detergents, in food industry, in cosmatics and in the manufacture of detonators. He suggested that India could explore possibilities of manufacture and expert of sucrose esters. Other aspects discussed included the manufacture of propylene glycol esters, mono-sodium glutamate, and sorbital esters.

New Members

Miss Suchin Pechde, A/16, International Hostel, CFTRI, Mysore.

Smt. Meera Rao Pool Officer, National Institute of Nutrition, Hyderabad-7.

Mr. Piyara Lal Raina, C/o. Biochemistry and Applied Nutrition Discipline, CFTRI, Mysore.

Mr. Maymadem S. George, Rajasekhara Buildings, Top Floor, 5th Main Road, Palace Guttahally,, Bangalore-560003.

Mr. P. J. Bharadwaj, Karnataka Agro Oil Extractions Ltd., Raichur.

Mr. Ramakanwar Bansal, H. No. 2127, Narela, New Delhi-40.

Mr. Hemaraj Kothari, Kothari Consultants, 12, India Exchange Palace, Calcutta-700001.

Mrs. Sreemathi Hariprasad, Senior Technical Assistant, CFTRI, Mysore.

Mr. Rajen Kumar Thakkar, Department of Microbiology, Haryana Agricultural University, Hissar, Haryana.

Mr. Jawahar M. Mehta, Red Heart Products Co. Ltd., 3/5, Syed Mestri Street, Bombay-9.

Mr. Asesh Kumar Chatterjee, M F & PT Discipline, CFTRI, Mysore.

Mr. Israrul Haq Khan, Food Research Section, Babar Mahal, Kathmandu, Nepal.

Mr. C. S. K. Vijaya Kumar, Department of Botany, Andhra University P.G. Centre, Guntur, A. P.

Mr. Thota A. P. Hamsa, Chaya Gardens, Jandrapeta .Post, Ongole Dist, A.P. India.

Mr. N. P. Dani, MF & PT Discipline, CFTRI, Mysore.
Dr. Bhupal Singh, Central Dairy Farm, Aligarh.

Mr. Pradip R. Joshi, 3, Ramacha Got. Satara, Maharashtra.

Mr. Ansuman Hajra, Department of Nutrition, C.S.W.R.I., Avikanagar. Rajasthan.

Mr. N. Sambiah, Manager, Sangam Hotel, Harihar, Karnataka.

Mr. U. J. Kedarnath, Karnataka Fisheries Development Corporation, Kulai, Suratkal, Karnataka.

Mr. Susheel Kumar, Mysore Snack Foods Limited, Bangalore-23.

Miss. T. Padmasini Asuri, 216/29, 6th Main, 4th Block, Jayanagar, Bangalore-11.

Mr. Srinivasa N., No. 17, Hospital Road, Bangalore-53.

Mr. V. Sreenivasa Reddy, No. 1/A, 4th Cross, 6th Main, Wilson Gardens, Bangalore-271.

Mr. K. M. George, M/s. Gecy Food Products, Meenachil, Palai, Kerala.

Symposium on Fish Processing Industry in India

The Symposium on "Fish Processing Industry in India" was held at CFTRI, Mysore on 13th and 14th of February 1975. The Symposium was jointly sponsored by the Association of Food Scientists & Technologists (India) and Central Food Technological Research Institute, Mysore. More than 100 delegates representing manufacturing units, trading business houses, government agencies, technological research centres, quality control agencies, machinery fabricators and ancillary industries took part in the Symposium. The delegates came from different corners of India as well as from Australia, Denmark and Norwegia.

There was an interesting exhibition of fish, fish products, by-products and packaging materials. A Souvenir containing information on fish processing was also released by the organizers.

Dr. B. L. Amla, Director, Central Food Technological Research Institute, Mysore presided over the inaugural function on the morning of 13th February 1975. The inaugural address was delivered by Shri. K. T. Rathod, Chairman, Advisory Committee and Hon'ble Minister of State for Fisheries and Horticulture, Karnataka. Shri. C. P. Natarajan, Chairman, Organizing Committee and Deputy Director of CFTRI highlighted the objectives of the Symposium. The key-note address was delivered by Prof. P. C. George, Joint Commissioner of Fisheries, Ministry of Agriculture, New Delhi. The distingushed gathering was welcomed by Dr. T. N. Ramachandra Rao, President, Association of Food Scientists and Technologists (India) and Emeritus Scientist, CFTRI and vote of thanks was proposed by Dr. V. H. Potty, Hon. Exec. Secretary of the Association and Scientist, CFTRI. The technical discussions were divided into 6 sessions spread over 2 days. Session I, chaired by Shri. G. Lakshminarayana Rao, Director of Fisheries, Karnataka, Bangalore and Co-chaired by Shri. M. Devidas Menon, Director, Integrated Fisheries Project, Cochin was on "Raw Material Resources—Availability, Potentialities and Handling". Seven papers pertaining to various aspects of the above subject were presented and discussed.

The Session II on Freezing of Fish was chaired by Shri. R. Madhavan Nayar, Managing Director, Cochin Company Private Limited and Co-chaired by Dr. H. P. C. Shetty, Director of Instruction, Fisheries College, Mangalore. Three papers covering various aspects of freezing of fish and various seafoods were read, followed by a lively discussion.

Session III was chaired by Shri. M. Jayaraj, Deputy Director of Fisheries, Karnataka, Bangalore and Co-chaired by Dr. M. N. Moorjani, Project Coordinator, Meat, Fish and Poultry Technology Discipline, CFTRI. The subject matter was "Processed Fish Products" when the different aspects of processed fish products were covered through twelve interesting presentations followed by an indepth discussion.

On 14th February 1975, the opening Session was on Traditional Fish Products and By-products." This was presided over by Shri U. Sundar Kini, Technical Consultant, Mukka Oil and Food Industries, Mangalore and Co-chaired by Dr. D. P. Sen, Project-Coordinator, Lipid Technology Discipline, CFTRI, Mysore. Ten papers concerning various traditional fish products and by products utilization were presented and discussed in this session.

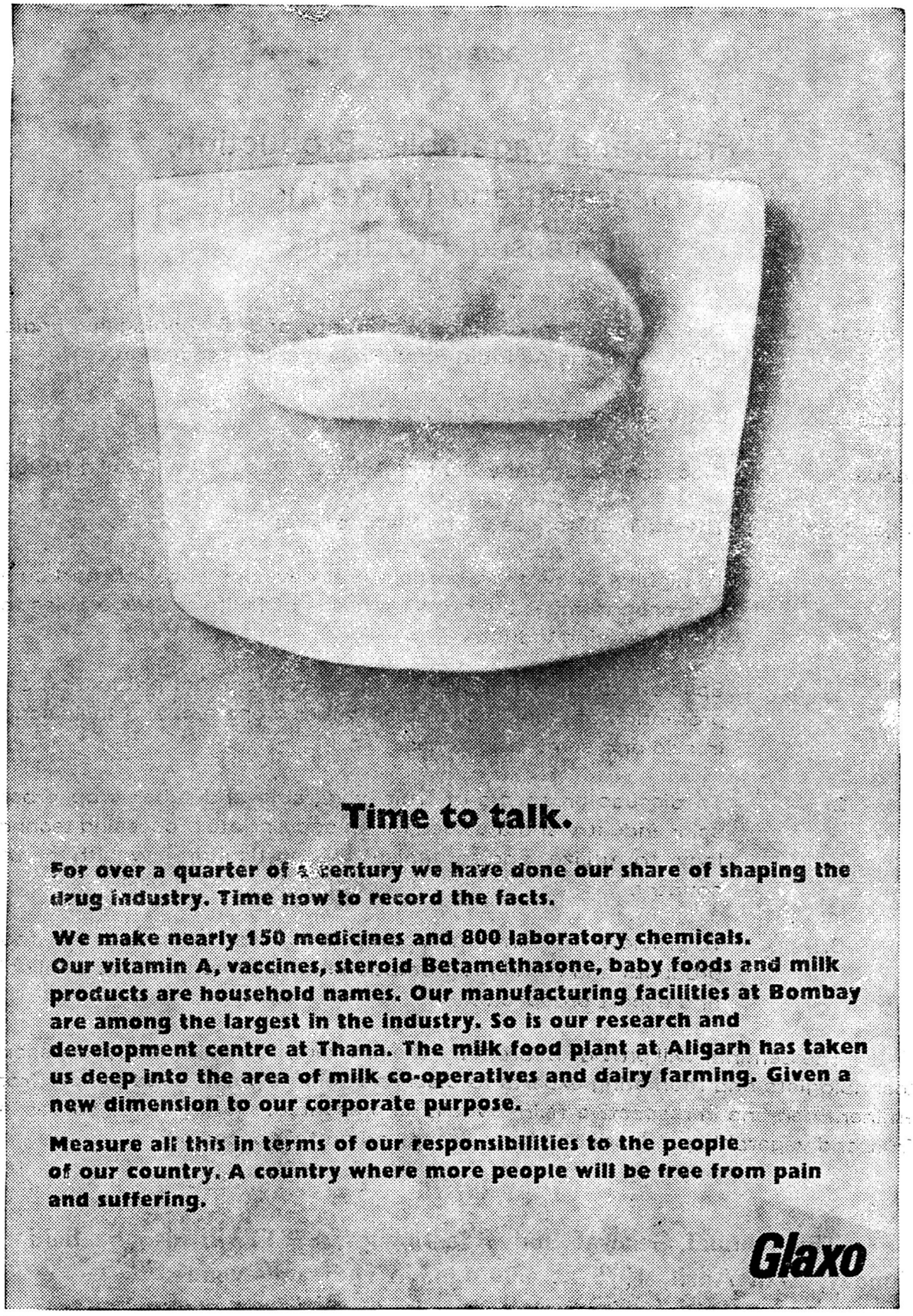
The Machinery and Equipment Needs of Fish Industry was the subject matter of Session V which was chaired by Shri. G. K. Kuriyan, Director, Central Institute of Fisheries Technology, Cochin. There were seven interesting papers highlighting the needs of the industry with respect to machinery and equipment.

The Session VI on Quality Control and Marketing was held under the Chairmanship of Shri. K., Chidambaram, Director, Marine Products Export Deve-

lopment Authority, Cochin and Co-chairmanship of Dr. K. P. Shrivastava, Deputy Director, Export Inspection Agency, Cochin. Both the export and internal marketing aspects as well as the quality control parameters were covered by eleven presentations. The subsequent discussion helped to bring out some of the difficulties in this area and also suggestions to improve the situation.

The concluding Session wich was Chaired by Prof. P. C. George, Joint Commissioner of Fisheries, New Delhi and Co-chaired by Dr. T. N. Ramachandra Rao, President of the Association of Food Scientists and Technologists and Emeritus Scientist, CFTRI, received the recommendations presented by chairman of ecah session. After exhaustive discussions, the recommendations were finalised. It is expected that the Secretariate of AFST would circulate these recommendations widely so that the same can be brought to the attention of those involved in the planning and development of fisheries in India.

It has been proposed to print and publish the Proceedings of the Symposium in the near future.


Time to talk.
For over a quarter of a century we have done our share of shaping the drug industry. Time now to record the facts.
We make nearly 150 medicines and 800 laboratory chemicals. Our vitamin A, vaccines, steroid Betamethasone, baby foods and milk products are household names. Our manufacturing facilities at Bombay are among the largest in the industry. So is our research and development centre at Thana. The milk food plant at Aligarh has taken us deep into the area of milk co-operatives and dairy farming. Given a new dimension to our corporate purpose.
Measure all this in terms of our responsibilities to the people of our country. A country where more people will be free from pain and suffering.
Glaxo

U-G-8

Seminar

"Fruits and Vegetable: Production, Processing and Marketing of Processed Products"

Sponsored by : The Association of Food Scientists and Technologsits (India) jointly with the All India Food Preservers' Association.

Dates : 25th, 26th and 27th April, 1975.

Venue : Diocesan Community Centre, Ashoka Place, New Delhi-110001.

Objectives : The main objectives of the Seminar are:

1. To highlight country's horticultural development with particular reference to meet the growing needs of fruits and vegetables for the processing Industry.

   Special attention will also be given to planning, production and promotion of fruits, vegetables, tuber crops etc. and their scope in arid and semi-arid zones.

2. To discuss prospects of fruit, vegetable and tuber crop processing industry and the need for an appropriate processing technology to utilize and organise the horticultural wealth of the country.

3. To review present marketing practices for processed food products and highlight promotional measures to boost local sale and export prospects.

The Seminar will provide a forum for the growers, horticulturists, processors, technologists and marketing experts to discuss vitalproblems. Lead papers from eminent persons in respective fields would be presented. A display of processed fruit and vegetable products has been organised on this occasion.

The Annual General Body Meeting of AFST will also be held on Sunday, 27th April, 1975 at 4.00 p.m. in the same venue.

INSTRUCTIONS TO CONTRIBUTORS

1. Manuscripts of papers should be typewritten in double space on one side of the paper only. They should be submitted in **triplicate.** The manuscripts should be complete and in final form, since no alternations or additions are allowed at the proof stage. The paper submitted should not have been published or communicated anywhere.

2. Short communications in the nature of letters to the editor 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.

PRINTED AT SHARADA PRESS, MANGALORE

REG. No. 24918/64