REG. No. 24918 / 64
ISSN: 0022 - 1155
CODEN: JFSTAB

JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

ASSOCIATION OF FOOD SCIENTISTS & TECHNOLOGISTS (INDIA)

Vol. 31, No. 5 September-October 1994

AFST (I) EDUCATION AND PUBLICATION TRUST (REGD)

Objectives :

* **To promote the following activities in the areas of Food Science, Food Technology, Food Engineering and Utilization/Treatment of Food Industry By-products/Wastes :**
  * Research and development activities.
  * Improved publication of information.
  * Popularization among students, professionals and general public.
  * Publication of literature and text books.
* **Other major activities in the above specific subject areas are :**
  * To recognize excellence in R & D,
  * To provide adequate publicity and support to training programmes.
  * To arrange seminars, symposia and special lectures by eminent scientists,
  * To institute and award scholarships and fellowships to deserving students.

For Scholarships/Fellowships, Grants, Seed Fund for Book Publication and other particulars, please contact :

Ex-officio Secretary
AFST (I) Education & Publication Trust
AFST (I) Office, CFTRI Campus,
Mysore-570 013, India.

✳ Discount Sales ✳
Back-Issues of
"Journal of Food Science and Technology"

Few copies of some of the back-issues of the 'Journal of Food Science and Technology' are available at Discount Rates.

For further details, please contact :

Honorary Secretary, AFST (I)
CFTRI Campus, Mysore-570 013, India

INDEXED AND SELECTIVELY ABSTRACTED IN

* *Current Contents-Agriculture, Biology and Environmental Sciences*
* *Indian Food Industry*
* *NCI Current Contents*
* *Chemical Abstracts*
* *Biological Abstracts*
* *Food Science and Technology Abstracts*
* *Food Technology Abstracts*
* *Dairy Science Abstracts*
* *Nutrition Abstracts and Reviews-Series A-Human and Experimentals*
* *International Packaging Abstracts*
* *PIRA CD-ROM-Paper, Printing and Packaging Database*
* *Online PIRA Databases-Data-Star, Dialog, Orbit Search Service, PFDS Online and STN*
* *Fisheries Review*
* *Cambridge Scientific Abstracts-Microbiology, Biotechnology, Health and Safety Science*
* *Food Adlibra Dialog File 79.*
* *Food Adlibra Alerting Bulletin*
* *Food Adlibra Current Awareness Supplements for Food Science and Seafood*
* *Food Adlibra Current Awareness Supplement for Snacks and Confectionery*
* *Biology Digest*
* *CABS Online database (Database host BRS Information Technologies)*
* *Current Advances Journals of CABS series "Current Awareness in Biological Sciences", all the relevant journals*
* *NAPRALERT-Online Access via Bitel, Interest Compuserve, Prodigy and Phone Modem*
* *NAPRALERT-Off-line Access*
* *AGRIS Database of FAO*
* *The Engineering Index Monthly*

JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

Volume 31 Number 5 September-October 1994

C O N T E N T S

REVIEW

Methods for the Determination of Bioavailability of Trace Metals : A Critical Evaluation
B.S. Narasinga Rao 353

RESEARCH PAPERS

Potential of the Biological Control of Aflatoxin Contamination in Developing Peanut (*Arachis hypogaea* L.) by Atoxigenic Strains of *Aspergillus flavus*
M. K. Chourasia and R. K. Sinha 362

Studies on Dehydration of the Seeds of Green Field Bean (*Dolichos lablab* Var. lignosus)
K. S. Jayaraman, D. K. Das Gupta and N. Babu Rao 367

Studies on the Characteristics of Some Products from Tamarind (*Tamarindus indica*) Kernel
Sila Bhattacharya, S. Bal, R. K. Mukherjee and Suvendu Bhattacharya 372

Puffed Soya as a Snack Food : Acceptability and Nutritive Value
S. Kanchana and S. Neelakantan 377

Effect of Methods of Juice Extraction from Kinnow Mandarin on the Composition and Quality of Juice, Pomace and Peel
R. E. Lotha and D. S. Khurdiya 380

Physico-chemical and Processing Quality of Four New Mango Hybrids in Comparison to Two Commercial Cultivars
I. N. Doreyappa Gowda, K. H. Ramanjaneya, C. P. A. Iyer, M. D. Subramanyam and M. R. Dinesh 385

Optimization of the Process for *Kalakand* Manufacture and Extension of its Shelf-life
I. Suresh and Y. K. Jha 389

Effect of Particle Size, Moisture Content, Pressure and Temperature on the Physical and Thermal Properties of Soybean
B. L. Mandhyan and S. Prasad 395

Journal of Food Science and Technology, devoted to original R & D contributions in all branches of Science, Technology and Engineering of Foods and Food Products, is a bimonthly publication of the Association of Food Scientists and Technologists (India), Mysore. Review papers are also published to a limited extent.

No part of the journal should be reproduced without written permission of the Editor.

Photocopying of the author's article by author is, however, exempted only when done for distribution among scientific and technological community.

The Editor reserves the privilege of editing the manuscript and adding or deleting relevant parts, to make it suitable for publication in the Journal.

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

Manuscripts for publication, books for reviewing and matter concerned with advertisements in the Journal should be addressed to the Editor, Journal of Food Science and Technology, AFST (I), CFTRI Campus, Mysore-570 013, India.

The Instructions to Authors are published in the January-February issue of the journal. These are required to be followed *in toto*. No deviation is accepted.

New members of AFST (I) are entitled to receive 'Journal of Food Science and Technology'(JFST) or 'Indian Food Industry' (IFI)- free of cost.

Members opting for IFI can subscribe to 'Journal of Food Science and Technology' at a concessional rate.

Those members who were earlier getting or had opted for IFI, can now change the option (once in a year only), to get gratis copies of 'Journal of Food Science and Technology', if they so desire.

Advertisements from manufacturers and dealers of chemicals, glassware, instruments, machinery as well as publishers/distributors of books/periodicals are accepted. The rates for appearance in six issues in a year are :

Back or Inside Cover Page : Rs.10,000/-

Full Page : Rs. 6,000/-

Half Page : Rs. 4,000/-

Correspondence regarding subscription and membership rates should be addressed to the Executive Secretary, AFST(I), CFTRI Campus, Mysore-570 013, India.

All payments shall be made by Demand Draft or Money Order in favour of the Executive Secretary, AFST(I), CFTRI Campus, Mysore-570 013. India.

In case of Indian Institutions and nationals, the subscription through agents is not entertained.

Effect of Drying of Vermicelli in Hot Air Oven on Its Cooking Quality
R. Vetrimani and Rahim **400**

Effect of Salt and its Blend with Polyphosphates on the Quality of Buffalo Meat and Patties Under Hot, Chilled and Frozen Conditions
A.S.R. Anjaneyulu, N. Sharma and N. Kondiah **404**

Biological Evaluation of the Effects of Traditional Processing Methods on Protein Quality of Fishes (*Heterotis niloticus* and *Chrysichthys nigrodigitatus*)
Onimawo Akhakhia Ignatius **409**

RESEARCH NOTES

Characteristics of Yoghurt-like Cultured Milks
Geetha C. Jayan and Mohammed Habibulla Khan **413**

Relationship of Husk Content of Paddy with Grain Dimension and Weight
Sulochana Suryamoorthy and P. Pillaiyar **416**

Use of Globin Protein in Microbiological Media for Enumeration of Aerobic Viable Cell Counts
M. Hazarika **418**

Microflora of Some Dried Spices and Condiments Sold in Maiduguri Market, Nigeria
Iro Nkama, M. H. Badau, E. K. Collison, W. Mian, J. O. Igene and C. A. Negbenebor **420**

Processing of Soybean for Use as *Dhal*
V. M. Pratape and H. V. Narasimha **423**

Quality Characteristics of Some Marketed Indigenous Milk Products : Major Constituents and Mineral Composition of *Rabri*
T. K. Chatterjee, S. Sarkar and G. Biswas **426**

Frying Quality of Six Varieties of Potato
Suneeta Pant and K. Kulshrestha **428**

***Spirulina Platensis* as Retinol Supplement for Protection Against Hexachlorocyclohexane Toxicity in Rats**
L. V. Venkataraman, G. Suvarnalatha, M. K. Krishnakumari and Pius Joseph **430**

Quantification of Qualitative Baudouin Test for the Detection of Sesame Oil
R.K. Chavan, V.S. Ghole and M. Dikshit **433**

BOOK REVIEWS **435**

AFST (I) NEWS **438**

INDIAN FOOD INDUSTRY : CONTENTS

ANNUAL CHANGE IN AFST(I) PRESIDENTSHIP

DR. P. NARASIMHAM

THE AFST(I) PRESIDENT FOR 1994-95

Helms of AFST(I) in the Strong Hands of a Dynamic, Humane and Committed Food Technologist from CFTRI

Dr. P. Narasimham, Scientist, Fruit and Vegetable Technology Department, Central Food Technological Research Institute, Mysore-570 013, India, has taken over charge as President of the Association of Food Scientists and Technologists (India) on September 3, 1994, at a grand function organised during ICFoST '94, in the Indian Agricultural Research Institute, New Delhi, India.

Soon after his induction, Dr. Narasimham stressed the need for bringing about effective solutions to challenging problems faced by R&D Institutions and Food Industries, particularly in the changing scenario in the country and the world-over, as a focal-point of activities during 1994-95. Dr. Narasimham thanked AFST(I) members for the trust bestowed upon him, and sought their active and harmonious cooperation for achieving this goal.

As a member of earlier and present Central Executive Committee of AFST(I), and also as Editor of the Journal of Food Science and Technology, I am honoured to introduce Dr. Narasimham.

Dr. Pattisam Narasimham, born on October 19, 1936 at Visakhapatnam in Andhra Pradesh, had his B.Sc. (Hons.) and M.Sc. Degrees from Andhra University, Waltair, in 1956 and 1957, respectively. After working in a First Grade College, at Vizianagaram (1957-58) and at Central Tobacco Research Institute, Rajahmundry (1958-61), Dr. Narasimham joined CFTRI, Mysore, in July 1961. Since then, he has smoothly climbed on the ladder of success not only in R&D achievements, but also in attaining higher positions.

Dr. Narasimham has, on deputation from October 1968 to July 1972, worked on nutritional and hormonal interactions in potato and *Capsicum* in relation to chip making quality and apical dominance, respectively, under Belgian Government Scholarship, and was awarded D.Sc. degree in May 1972 by the University of Brussels, Belgium, with distinction.

Major R&D achievements of Dr. Narasimham include : (1) successful completion of 12 R&D projects on different fruits and vegetables, (2) development of evaporative cooling storage systems, (3) vapour heat treatment method for sprout suppression in potatoes, (4) controlled low temperature vacuum dehydration method for diced vegetables, and (5) efficient process for incorporation of flavour into fried fruit/vegetable chips.

Dr. Narasimham has published over 90 research papers in National/International journals and also three chapters in the books published by reputed publishers. Dr. Narasimham has guided 9 Ph.D. and 6 M.Sc. students in the faculties of Applied Botany, Food Science, and Food Technology of University of Mysore, and also served as an external examiner for Ph.D. of a number of Universities.

Dr. Narasimham has been the recipient of YEZDI AWARD (1984) and K.U. PATEL AWARD (1988), instituted by the All India Food Preservers' Association, New Delhi, for his quality work in the area of fruit and vegetable processing.

Dr. Narasimham has travelled widely across the globe. He was invited by the International Potato Centre, Lima, Peru, to participate in the Asian Potato Association II and III Conferences and also chaired the session on Post-harvest Technology of Potato at Bandung, Indonesia. On invitation from FAO/WHO, he has participated in the CODEX ALIMENTARIUS V Session on Quality Standards for Fresh Tropical Fruits and Vegetables, held in Mexico during September 5-9, 1994.

Besides being a Life Member of AFST(I), Dr. Narasimham has served AFST(I) as Honorary Secretary during 1981-82. AHARA-82, the First International Conference was held and publication of Indian Food Industry was initiated during this tenure. He was also Vice-President, Headquarters, during the year 1992-93, when another International Conference, IFCON-93, was conducted.

Dr. Narasimham is actively associated with the Journal of Food Science and Technology since 1981. He was the Editorial Board Member of the Journal from 1981 to 1988 and again from 1992 onwards. He is one of the best referees for the papers on Fruits and Vegetables submitted to the journal and is endowed with the ability to correctly assess the paper for its worth for publication in a very unbiased fashion.

Dr. Narasimham is also very thorough in editing the manuscripts. He has been a constant supporter to me in improving the journal to its present stature, thereby earning my respect and admiration. I am confident that he will take AFST(I) to still greater heights.

Dr. Narasimham is a good sportsman and has represented CFTRI in Shanti Swarup Bhatnagar Tournaments for basket ball and contract bridge. He also enjoys playing badminton and table tennis.

Dr. Narasimham is known to be forthright and outspoken in his clean and clear dealings. A rare combination of being dynamic and also humane is exemplified in him, along with a total commitment to the cause. He has always been the champion for any right cause for creating a congenial and improved working atmosphere in CFTRI/CSIR.

Dr. Narasimham's efforts are totally supported by his charming better-half, Mrs. Rajyalakshmi, who is a talented renowned artist known worldwide for fine and graphic arts. Dr. Narasimham says that all his achievements are due to the inspiration and support from Mrs. Rajyalakshmi.

On behalf of AFST(I), the readers of the Journal, and also on my own behalf, it is my privilege to welcome and felicitate Dr. Narasimham and the new Central Executive Committee members (as specified on back cover). I wish all the success to this talented and dedicated team in fostering further all-round growth of AFST(I) and its activities.

B.K. LONSANE
Editor
Journal of Food Science
and Technology

REVIEW J. Food Sci. Technol., 1994, Vol. 31, No. 5, 353-361

Methods for the Determination of Bioavailability of Trace Metals : A Critical Evaluation

B.S. NARASINGA RAO
11/4, M-Block, Kakatiyanagar, Habsiguda, Hyderabad-500 007, India.

Trace elements are essential for a wide range of body functions and diet is the main source of trace elements to meet human's daily requirements. Since most of the trace elements belong to transition group of elements, they possess characteristic chemical properties like low solubility in the alkaline pH of the duodenum, which limit their absorption from the gut. Thus, their bioavailability from foods, which is affected by a number of dietary factors, is an important consideration in trace element nutrition. The bioavailability of trace elements can be determined *in vivo* by extrinsic tagging of food with a radio isotope of the element, using an animal model or an *in vitro* model. These methods have been developed and extensively used to determine the bioavailability of food iron. Although some of these methods have been extended to a limited extent to zinc, these have yet to be applied to other trace elements. The methods available for the determination of bioavailability of trace elements, their basis, reliability and sensitivity are critically reviewed. The need for developing appropriate *in vitro* methods for other trace elements, including both essential and toxic elements has been stressed.

Keywords : Iron, Trace metals, Bioavailability, *In vitro* methods, *In vivo* methods, Accuracy, Limitations.

Trace elements are micro-nutrients, which are essential for a wide range of body functions in higher animals (Underwood 1977). Hitherto, fourteen trace elements including iron have been identified as essential to humans and other higher animals (Underwood 1977) (Table 1). Of these, nine trace elements (Fe, Cr, Co, Cu, I, Mn, Mo, Zn, Se) have been known to be essential for some time and the essentialities of the other five trace elements (Ni, Si, Sn, V, F) have been recently established (WHO 1973). So far as, trace element deficiency in man is concerned, deficiencies of only seven trace elements, viz., Fe, I, Zn, Co, Cu, Cr, Se, have been encountered among population groups (WHO 1973).

The main sources of these elements for humans are the foods they consume, as a part of their daily diet. Several of these trace elements, although essential at low concentrations, may become toxic (Table 2) at higher levels of intake (Anke and Groppel 1987). Besides these essential trace elements, diet may also contain toxic elements like Hg, Pb, Cd, Al (Table 2), due to environmental contamination (Prasad 1976).

Human requirements of some of these trace elements have been established (WHO 1973). Since humans derive these trace elements entirely through the habitual diet, their bioavailability, besides the contents, constitute an important consideration in meeting nutritional needs of the trace elements (WHO 1973). This is particularly so in the case of metallic trace elements.

Bioavailability of trace metals depends mainly upon the nature of the diet from which these are derived and also on the age, sex and the nutritional status of the individual (Underwood 1979). Bioavailability is also an important determinant of toxicity of heavy metals, present as contaminants in foods (Prasad 1976).

Bioavailability, or absorption, of trace metals in humans can be estimated either directly or by employing an animal, or an *in vitro* model (Fox et al. 1991). Measurement of absorption of trace metals from food in humans is quite tedious and expensive. Somewhat similar considerations also hold good for the use of an animal model. *In vitro* methods, on the other hand, are quite rapid and less expensive. A well designed and properly validated

TABLE 1. TRACE ELEMENTS IN HEALTH AND DISEASE

Essential trace elements				Toxic elements	
Transition metals		Other metals			
Vanadium	- V	Tin*	- Sn	Fluorine +	- F
Chromium	- Cr	Silicon*	- Si	Selenium+	- Se
Manganese+	- Mn	Non-metals		Aluminium	- Al
Iron	- Fe	Fluorine*	- F	Cadmium	- Cd
Cobalt	- Co	Selenium	- Se	Mercury	- Hg
Nickel	- Ni	Iodine	- I	Lead	- Pb
Copper	- Cu				
Zinc	- Zn				

*Recently established as essential, + Excess intake toxic.

TABLE 2. CLASSIFICATION OF TRACE ELEMENTS

Characteristics	Trace elements
Biologically essential but not toxic	I, Zn, Cr, Co, V, Mo, Si
Essential at low conc. but toxic at higher conc.	F, Se, Mn
Toxic elements	Hg, Pb, Cd, Al

method can have reliable predictive value.

In vitro methods available for the determination of bioavailability of trace metals in foods and diets, their reliability and predictive potential are discussed critically in the present review. As a prelude to a critical discussion of the *in vitro* methods for assessing the bioavailability of trace metals, their chemistry, in so as far as it relates to the physiology and biochemistry of their absorption and the factors influencing them, are also briefly reviewed.

Chemistry of trace metals

Except for non-metal trace elements like I, Se, F and metals like Sn and Si, most of the essential trace metals, viz., V, Cr, Ni, Mn, Fe, Co, Cu, Zn and Mo, belong to the transition metal group of the periodic table. They possess characteristic chemical properties which distinguish them from other elements (Moeller 1952; Pauling 1953). These properties have considerable bearing on their intestinal absorption, transport in the blood, and metabolic as well as biochemical functions in the body. Some of the relevant chemical properties of these trace metals are :

1. In these elements, the (n-1) d orbitals are preferentially filled, 'ns' arrangement remaining constant or nearly constant. This electronic arrangement in the atoms of these elements is responsible for many of the chemical properties, which distinguish them from other metals.

2. They have several valencies, which permit them to form several types of compounds, and different types of coordination compounds.

3. Several of the elements of this group exist in two electronic states, namely, oxidized and reduced form, which help them to take part in biological redox reactions.

4. The salts of these trace metals are unstable in solutions of pH 7.0 and get precipitated as hydroxides. This property has a restraining influence on their absorption from the small intestine, where the pH is 7.0. They, therefore, show limited absorption, as compared to alkali metals or non-metals.

5. They form insoluble carbonates and phosphates, which remain insoluble in the alkaline pH of the small intestine.

6. They are all capable of forming coordinating compounds. This enables them to form metal complexes with proteins, nucleic acids and other biological compounds. They form complexes with more than one anion. Unlike simple salts, these complexes are soluble in the alkaline pH of the gut and this helps their uptake and transport across the mucosal membrane. The transport of these metals is facilitated by their protein complexes. The activation of several enzymes in the body depends upon their forming complexes with these metals.

7. The amphoteric metals like V, Cr, Mn, Sn and Mo, can form complex anions, which can form salts with cations.

Bioavailability/absorption of trace metals

The essential trace metals are required by the body only in very small amounts (WHO 1973) and the quantity of these trace metals absorbed from diets in the gut is also correspondingly quite small. The limited absorption of these elements from the gut may be related to the limited capacity of the body to excrete them. Further, these elements, being poorly soluble in water, are hardly eliminated through urine. The main sources of excretion of these elements, therefore, are through bile (entero hepatic circulation) and desquamation of cells containing these elements from the gut or from the body surface (skin) (Forth and Rummel 1975). Low absorption of these trace metals perhaps serves as a protective mechanism against any toxicity due to their excessive accumulation in the body. A similar consideration also applies to the absorption of toxic metals present in foods as contaminants. The bioavailability/absorption of these trace metals is greatly influenced by a number of dietary factors, some of which promote and others inhibit absorption. Age, sex and the nutritional status of the individual with respect to the trace metal, also influence their absorption. The mechanism of intestinal absorption of these metals is complicated, and differs widely from that of the non-metal and other elements like alkali metals.

Physiology of absorption of trace metals

Physiology of absorption of some of the trace metals like iron has been extensively studied (Forth and Rummel 1973). The physiological process of the absorption of other trace metals, because of similarity in their chemical properties, may follow that of iron. The physiology of intestinal absorption of iron, as it is understood today (Narasinga Rao 1981), is briefly as follows :

There are three main phases of iron absorption : (i) the intraluminal phase, where the food is digested by the gastric and pancreatic enzymes and the iron is released in a soluble form; (ii) the mucosal phase in which iron is taken up by the

mucosal cell and transported across to the serosal side, or retained in the mucosal cell as a protein complex; and (iii) the corporal phase in which the iron is taken up by the transport protein in plasma (transferrin) on the serosal side of the mucosal cell and carried to the liver. A schematic diagram of the process of trace metal absorption, as currently understood in the case of iron, is given in Fig. 1.

Intraluminal phase of iron absorption

The most important step in the intraluminal phase of iron/trace metal absorption is its release from food and maintaining it in a soluble form at the alkaline pH (7.0) existing in the duodenum. During the passage of food through gastro-intestinal (GI) tract, iron is first released from food and insoluble iron salts are converted into a soluble and ionized form by the gastric juice, which has a pH of around 1.5. Most of the food iron (as 50%) is released in a soluble form in the stomach. However, during the passage of food from stomach to deodenum, the pH increases from 1.5 to 7.0, due to duodenal secretions. As a result, most of the ferric iron gets precipitated as hydroxides, phosphates and carbonates, unless prevented by the presence of the suitable chelating agents present in the food (Charley et al. 1963). Reduced form of iron, i.e., ferrous iron, however, is not so readily precipitated and a significant proportion of which will still be in a soluble form at pH 7.0 (Charley et al. 1963). This is the reason why ferrous salts are better absorbed than ferric salts (Moore et al. 1944). It is the iron which is present in a soluble form in the duodenum, and the upper part of jejunum, which is available for absorption (Forth and Rummel 1973, 1975).

Certain compounds, like ascorbic acid, reducing sugars, amino acids, dicarboxylic acids and hydroxy acids as well as other chelating agents, like EDTA, polyphosphates, etc., when added extraneously, can keep the iron in a soluble form by preventing its precipitation at the neutral or alkaline pH existing in the duodenum (Brozovic 1975; Forth and Rummel 1975).

In contrast, other agents, like phosphates, phytates (in the presence of Ca and Mg ions) and tannins, precipitate iron at the neutral pH. Phytate, in fact, forms, soluble complex with iron at pH 7.0 but the phytate-iron complex gets precipitated in the presence of Ca and Mg ions (Subbarao and Narasinga Rao 1983). Vegetable foods contain significant amounts of phytates and tannins, which are not normally present in animal foods (Cook et al. 1972). Iron from animal foods is better absorbed than from vegetable foods (Cook et al. 1972). Proteins in meat also enhance iron absorption (Jacobs and Greenman 1969). It is the balance of promoters and inhibitors of absorption as well as their relative affinity for iron, which determine the proportion of dietary iron that will be in a soluble form in the duodenum and consequently available for absorption.

The next step in the intestinal absorption of iron/trace metal, which is present in a soluble form in the duodenum, is its uptake by the brush border

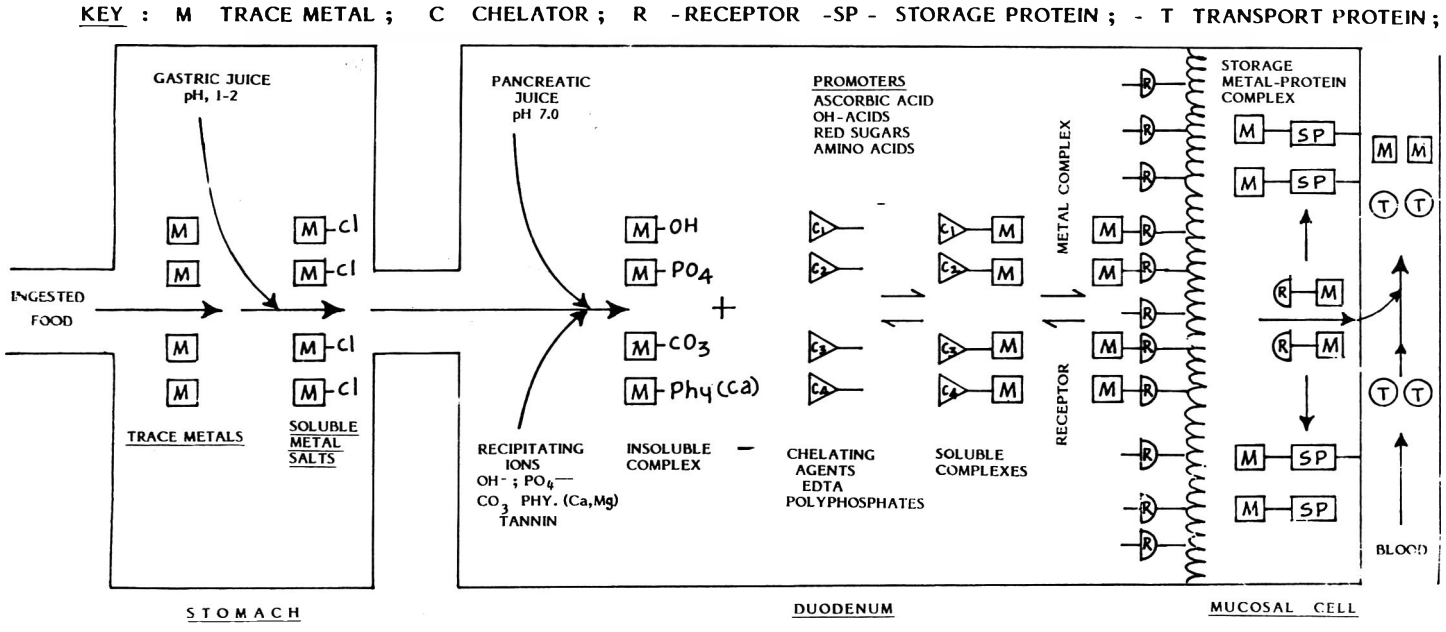

Fig. 1. Schematic representation of the intestinal absorption of trace metals as typified by iron. M : Trace metal ; C : Chelator; R : Receptor; SP : Storage protein; T : Transport protein.

receptor and its transport across the mucosal cell (Greenberger et al. 1969). The amount of iron transferred from the gut lumen depends upon; (a) the abundance of receptors on the brush borders, and (b) the binding capacity of iron to the receptor, *vis-a-vis* the binding capacity of iron to the chelate, which keeps iron in soluble form. The receptor population increases in iron deficiency, the increase being more in the distal than in the proximate part (Linder and Munro 1977). The efficiency with which brush border receptors take up iron from different chelators has been studied in rats (Narasinga Rao and Subbarao 1992). The receptor on the brush border competes for iron with ligand and gut lumen, and the amount of iron taken up depends upon the relative affinity of iron for the ligand and the receptor (Table 3). The iron so taken up by the receptors is transported across the mucosa, and delivered to plasma transferrin on the serosal side (Forth and Rummel, 1975). The iron, not transferred, is stored in the mucosal cell as ferritin.

The area of greatest controversy concerning iron absorption is the mechanism of transport of iron across the mucosal cell (Linder and Munro 1977). Heme iron and lipid-soluble iron complex can enter the mucosal cell directly (Hallberg and Solvell 1967).

The mechanism of intestinal absorption of other trace elements is not as well understood as that of iron. Absorption of several transition elements present in food has been reported to be low, like that of iron. Because of the similarity of chemical properties, several of the trace metals, like Zn, Cu, Mn, Ni etc., of the transition series can be expected to behave like iron with respect to their solubility in the gut at pH 7.0, and their uptake and transport by the gut mucosa. However, non-metal trace elements and trace metals like chromium which are present in food in a complex form are absorbed more efficiently (Mertz and Roginski 1971).

The known behaviour of a trace metals in the gut provides a basis for development of an *in vitro* method for estimating their bioavailability.

TABLE 3. Km, Vmax AND V/K RATIO AT MINIMUM LIGAND/ IRON RATIOS INDICATING RELATIVE AFFINITY OF IRON TO BRUSH BORDER RECEPTORS OF RAT INTESTINE AND TO DIFFERENT LIGANDS

Ligand	Km	Vmax	V/K	L/I
Ascorbic acid	16.7	100.0	5.98	2
Tripolyphosphate (TPP)	41.7	51.3	1.23	1
DOPA	74.1	90.9	1.23	3
Phytate	95.0	74.0	0.78	4
Nicotinic acid hydroxymate	142.9	100.0	0.70	2
Caffeic acid	38.5	18.5	0.48	1
Trimetaphosphate (TMP)	100.0	45.5	0.48	1
Sodium hexa meta-phosphate (SHMP)	40.0	26.7	0.417	2
Tetra sodium pyrophosphate (TSPP)	32.8	4.76	0.145	1
EDTA	17.2	1250.0	0.07	3
Phosphate glass	66.7	4.35	0.07	
Citrate	109.0	6.7	0.06	3

Methods for the determination of bioavailability of trace metals

The bioavailability of dietary trace metals is the most limiting step in their utilization in the body and hence an important consideration in meeting their dietary requirements by man. Accurate estimation of absorption of these trace elements, therefore, assumes great nutritional significance. Numerous reliable methods have been developed over the years to measure the bioavailability of trace metals (O'Dell 1984). Such knowledge is essential for (i) establishing the dietary intake of trace elements to meet the physiological requirements; (ii) monitoring the effect of technological processing of foods on the bioavailability of trace elements; and (iii) formulating diets with maximal bioavailability of trace elements by reducing inhibitors and increasing enhancers of their absorption.

There are mainly three approaches for determining the bioavailability or absorption of trace elements: (i) measurement of *in vivo* absorption directly in human subjects by employing either a chemical balance or a radioisotopic technique; (ii) use of an animal mode for predicting the bioavailability; and (iii) use of an *in vitro* method with a reliable predictive capability.

The available methods for determining the bioavailability of trace metals, their accuracy, reliability and sensitivity are critically discussed below :

***In vivo* method for the determination of trace element absorption in humans**

Chemical balance method : The classical chemical balance method in human volunteers has been used in the past to determine the absorption of iron and other trace metals from habitual diets (Hussain and Patwardhan 1969; Nageswara Rao and Narasinga Rao 1980). The chemical balance

TABLE 4. BIOAVAILABILITY (%) OF IRON BY THE *IN VITRO* METHOD AND ITS CORRELATION WITH VALUES OBTAINED BY *IN VIVO* EXTRINSIC TAG METHOD

Diet	Iron content (mg)	Stomach (pH 1.35) Soluble	Stomach (pH 1.35) Ionizable	Small intestine (pH 7.5) Soluble	Small intestine (pH 7.5) Ionizable (X)	*In vitro* extrinsic tag method (Y)	Calculated from prediction equiv.
Rice lunch	8.2	35.4	25.6	26.8	5.9	3.6	3.3
Wheat	10.5	33.1	26.3	24.0	4.3	2.7	2.5
Rice lunch	6.0	48.0	25.3	21.3	6.7	3.8	3.6
Wheat breakfast	7.3	34.3	30.3	15.0	4.4	2.1	2.6
Ragi diet	9.2	48.9	29.3	11.3	2.1	1.6	1.5
Sorghum diet	11.0	46.4	38.2	10.1	2.1	1.7	1.7

Correlation between X Y - 0.94

Prediction equation : Between % ionizable at pH 7.5 (X) and *in vivo* percent absorption (Y)-Y = 0.4827 + 0.470X

method, even when carefully conducted, yields rather high values for % absorption of trace metals (Fe, Mn, Zn etc.,), which is normally attributed to cumulative errors (Brozovic 1975). This is due to the fact that a larger proportion of the ingested dietary trace metal is excreted in faeces and only a small proportion is absorbed. Absorption is then computed as the difference between dietary intakes and a large faecal excretion tends to be overestimated. Further, chemical balance method, which is carried out over a short period of 3-4 days, does not take into account the loss of trace metal over a longer period of time, viz., 10-12 days, through desquamation of intestinal cells containing the metals derived from food. Also, when the absorbed trace metal is excreted into gut through bile, and subsequently lost through faeces, the chemical balance method does not account for the endogenous metal lost in the faecal excretion; hence, it may, underestimate the absorption, as has been demonstrated in the case of Ca absorption in rats (Shenolikar and Narasinga Rao 1968).

Radioisotopic extrinsic tagging technique : Realizing the above limitations of the chemical balance methods, radioisotopic method was introduced, whereby the actual quantity of the trace metal absorbed and retained in the body is measured by a whole body counter (Cook et al. 1972). This method ideally requires the trace metal, present in food, to be biosynthetically labelled with a suitable gamma ray emitting isotope of the metal. All foods in a meal will have to be labelled to the same specific activity to obtain a correct estimate of absorption from the whole meal. This indeed is a formidable task. Therefore, an alternative simple method viz., extrinsic tagging method was introduced. This is now successfully employed to measure iron absorption from diets (Cook et al. 1972). The extrinsic tagging technique has been clearly validated employing a food (biosynthetically labelled) with one of the isotopes of iron (Fe^{55}), to which another radio isotope of iron (Fe^{59}) is added as an extrinsic tag (Cook et al. 1972; Bjorn-Rasmussan et al. 1973). The extrinsic tagging method, for example, in the case of iron, involves spiking a meal with tracer quantity of Fe^{59} labelled salt ($Fe^{59}Cl_3$) in a solution, and feeding the meal to volunteers, on an empty stomach, after an overnight fast. The subjects are counted in a whole body counter, immediately after the meal, and also 12-14 days later.

The body retention of iron can also be estimated by measuring the total radioactivity in the circulating blood, since most (>90%) of the absorbed iron is incorporated into red blood cells. The body retention of radio-iron during the final counting, as a % initial dose, provides a fairly accurate estimate of percent of absorption from the test meal. A large amount of reliable data on iron absorption, from habitual diets of different countries, have accumulated over the past two decades. In India also, iron absorption from habitual diets, based on different cereals and millets, has been determined using the extrinsic tag method (Narasinga Rao et al. 1983) and the data are given in Table 4. It can be seen that iron absorption from habitual meals in India varies from 1-5%, depending upon the predominant cereal in the diet. These are in contrast to 7-24% (mean 10%) absorption reported earlier using the chemical balance method (Hussain and Patwardhan 1959). A simultaneous comparison (Narasinga Rao et al. 1983) of dietary iron absorption values, by the extrinsic tagging technique, with those obtained by the chemical balance method, in the same volunteers gave three times higher values for iron absorption by the chemical balance method than those obtained by the extrinsic tagging technique (Table 5).

TABLE 5. A COMPARISON OF IRON ABSORPTION FROM WHOLE DAY'S DIET DETERMINED BY EXTRINSIC TAG AND CHEMICAL BALANCE METHOD AND *IN VITRO* BIOAVAILABILITY

Diet	Iron intake mg/day	*In vivo* absorption %		*In vitro* bioavailability
		Extrinsic tag	Chemical balance	
Rice based diet with milk	30.0	3.64±0.14	9.25±1.94	3.13
Mixed cereal-based diet with milk	42.0	3.45±0.27	8.69±2.83	3.68
Rice-wheat-meat diet	33.5	2.66±0.39	5.97±0.12	2.53
Rice-wheat-fish diet	28.8	2.70±0.47	5.78±0.88	2.67

Although the extrinsic tag technique is well validated and widely used to measure food iron absorption, it is yet to be applied systematically to other trace metals, although some limited effort has been made to apply the extrinsic tag technique to measure Zn absorption from food (Puar Mrunalini Devi 1983). Suitable stable isotopes also can be used in place of radioisotopes to study trace metal absorption, using the extrinsic tagging technique and this would avoid radiation hazard to the subjects. Use of stable isotopes in the study of iron (Kaltwasser et al. 1991) and of zinc (Fox et al. 1991) has been reported. But the use of stable isotopes in the bioavailability study would be more complex and expensive than the use of radioisotopes.

The *in vivo* methods (for iron absorption) involving the extrinsic radio isotope tagging technique in human subjects provide the most reliable estimate of true absorption. Such data would be most valuable for establishing the dietary intake of trace metals (iron) for meeting their daily requirements in man. These *in vivo* isotopic methods are very expensive, time-consuming and require sophisticated equipment for their measurement like whole body counter, liquid scintillation counter for the radioactive isotopes, and isotope ratio mass spectrometer for the stable isotopes. However, for routine monitoring of bioavailability of foods during processing, or during formulations of different diets or feeds, and in food enrichment/fortification programmes, simpler, rapid and less expensive methods are needed. For this purpose, methods based on an animal model using chicks or rats and *in vitro* methods have been developed.

Animal model for studying trace metal bioavailability : Small animals like rats and chicks have been extensively used to evaluate the bioavailability of iron from foods and feeds (Fritz et al. 1970; Pla et al. 1973; Fritz and Pla 1972; Fox et al. 1981) and for monitoring changes in bioavailability, if any, during processing of foods. Several criteria – like growth, regeneration of haemoglobin in depleted animals, body retention of trace metal after feeding the test food– have been used in assessing the bioavailability of a given food in the animal model. The disadvantage of using an animal model for estimating the bioavailability of food iron is that the results obtained in animals, including rats, chicks, dogs, guinea pigs do not correlate to humans. These animals unlike man, do not discriminate between ferrous and ferric iron (Fritz et al. 1970; Narasinga Rao et al. 1977); and hence the bioavailability data obtained cannot be directly applied to man. A comparative study of dietary iron absorption in rats, guinea pigs, monkeys and human subjects, using an extrinsic tag technique, revealed that monkeys behave like man in iron absorption and therefore, monkeys can be used as a suitable model for evaluating iron bioavailability from human diets (Narasinga Rao et al. 1977). Even though the use of experimental animals to estimate the bioavailability of trace metals like iron, is more convenient than conducting the studies directly in man, these are still time consuming and expensive. Although the results obtained in animals cannot be applied directly to man, they would be quite useful to monitor alterations in the trace element (iron) bioavailability during processing of foods and for formulating animal feeds with maximal bioavailability. There is, however, a need for a simpler and more rapid method for estimating the bioavailability of iron and other trace metals in foods as well as in diets, and to assess changes therein. *In vitro* methods for estimating the extent of bioavailability of iron and other trace metals in foods, can, however, meet the above requirement to a great extent. This need has been met by the recent development of a fairly reliable *in vitro* method for iron and zinc.

In vitro *method for determining bioavailability of iron and other trace metals :* There have been continued efforts to develop *in vitro* methods for estimating the bioavailability of iron and other trace metals like zinc. Efforts to develop *in vitro* methods, mostly for iron and to a lesser extent zinc, have been quite successful, and these methods will be discussed. The same principle can be applied to develop *in vitro* methods for measuring the bioavailability of other trace metals.

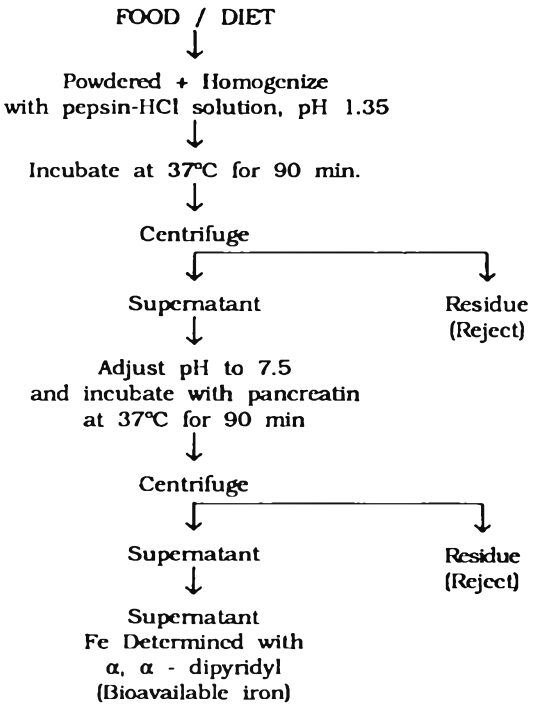

Fig.2. A scheme for the *in vitro* determination of bioavailable iron from foods and diet

For routine screening of foods and diets for the bioavailability of trace metals, *in vitro* methods are ideally suited, since they are relatively inexpensive and fast.

An *in vitro* method, based on the extraction of foods with a solution of α-dipyridyl for measuring available by iron in food, was first proposed by Shackleton and McCance (1936) and this was designated as ionizable iron. Later, pepsin-HCl soluble iron from foods was proposed as a method for estimating the available iron (Jacobs and Greenman 1969). None of these methods was quite satisfactory, as the values obtained did not correlate with values obtained by the *in vitro* methods. The reason for this is that the methods did not simulate the actual process, the food was subjected to, during its passage through the gastrointestinal tract. Narasinga Rao and Prabhavati (1978) proposed an entirely new approach for the *in vitro* estimation of bioavailability of iron in foods. The proposed *in vitro* method mimicked the conditions to which the food is subjected in the gut, namely the pepsin - HCl digestion of the food in the stomach at pH 1.5 followed by a pancreatic digestion at pH 7.0 in the duodenum. Iron extractable with α-α-dipyridyl from the pancreatic digest was taken to represent the bioavailable iron as shown schematically in Fig. 2. The effects of factors (tannin, phytate, phosphate), which are known to inhibit, and those that promote (ascorbic acid, cystein, fructose) absorption, when tested in the *in vitro* system, were found to mimick exactly their anticipated effects (Table 6). The final proof of the reliability of the proposed *in vitro* method was the correlation of the values for percent *in vitro* bioavailability with the percent iron absorption values obtained by the *in vivo* method. The iron bioavailability from different diets obtained by the *in vitro* method correlated highly (r=0.9) with those obtained by the extrinsic tag method of iron absorption from these diets in men volunteers (Table 4.) If bioavailable iron, relative to that of ferrous sulphate was considered by both the *in vitro* and the *in vivo* methods, the correlation was found to be still higher (r=0.9995).

These observations provide enough confidence in the proposed method as to its reliability and predictive value. In this study, soluble iron and ionizable iron were estimated both in the pepsin-HCl digest at pH 1.5 as well as in the pancreatic digest at pH 7.0. As seen from data in Table 4, the correlation was poor in all these cases, except in the case of ionizable iron of the pancreatic digest. Although a considerable proportion of dietary iron is released in a soluble form in the gut, only a fraction of this, which can be taken up by the gut receptor, represents the absorbable iron (Linder and Munro 1977). Extraction of the pancreatic digest with α-α-dipyridyl somewhat mimics this transfer.

The sensitivity of the *in vitro* method can perhaps be further improved by spiking the food initially with a tracer dose of $^{59}FeCl_3$, and finally extracting the iron from the pancreatic digest, at pH 7.0, with α-α-dipyridyl in an organic phase (amyl alcohol or ethyl acetate) and measuring both the colour and the radioactivity in the organic phase.

TABLE 6. THE EFFECT OF ABSORPTION PROMOTERS AND INHIBITORS ON *IN VITRO* AVAILABLE (IONIZABLE) IRON IN FOODS

Iron source	Absorption promoters or inhibitor added	Percent *in vitro* available iron
	Promoters	
Red gram *dhal* (*Cajanus cajan*)	Nil	23.4
	Ascorbic acid 1:5 molar ratio	37.8
Rice (*Oryza sativa*)	Nil	5.2
	Meat extract (25 ml)	12.7
	Inhibitors	
Brown sugar	None	19.2
"	Phytic acid 24 mg/100g	4.9
"	Tannin 100 mg/100g	9.0

Another *in vitro* model for predicting the available iron has been proposed by Monsen et al (1978). This is based on the available data on *in vitro* absorption of iron from foods measured by the extrinsic tag technique, and the known effects of inhibitors and promoters present in food on iron absorption. This method has a limited practical value, as it is impossible to take into account all the inhibitors and promoters present in all the food components in a fixed meal.

In vitro *method for measuring bioavailability of other trace metals :* There is a need to extend the principles of the *in vitro* method developed for iron to establish methods to estimate the bioavailability of other trace metals in foods. The processing steps would be the same, but the complexing agent used and the colour developed in the final step (pancreatic digest at pH 7.0) would be different for different trace elements.

An *in vitro* method has, in fact, been developed for food zinc, employing a protocol similar to that used for iron. Zinc, in the suitable fraction of the pancreatic digest, was measured by an atomic absorption spectrophotometer, or after initially spiking with radioactive zinc (Zn^{65}), and measuring the radioactivity in the supernatant, following pancreatic digestion at pH 7.0 (Puar Mrunalini Devi 1983). The validity of this *in vitro* method was established by comparing the *in vitro* values with the values of *in vivo* absorption measured in monkeys, using an extrinsic tagging technique. An *in vitro* method to estimate the bioavailability of Zn in foods, based on the uptake of soluble zinc by rat intestinal mucosa (Reinhold et al. 1974), or uptake by intestinal strip, or everted gut sac has been proposed earlier (Becker and Hoekstra 1971).

Toxic metals and their bioavailability

Need for an in vitro *method* : There has been much concern about the hazards of contamination of foods and drinking water by toxic elements like Pb, Al, Cd, Cu etc., due to environmental pollution. Only the contents of these elements in foods and water are measured to assess their hazards (Anke and Groppel 1987). It is known that these toxic metals are poorly absorbed, depending upon the chemical form of the toxic metal and the dietary factors. In assessing the hazard of such contamination of the foodchain by these toxic elements, both the contents and their bioavailability, i.e., absorption from the gut into the body, are important. On occasions, the metal contamination of extraneous origin may be in the form of insoluble metal or its oxide, and this may be hardly absorbed. It has been reported that iron contamination, due to dust and soil, as encountered in many foods, is hardly available as measured by the *in vitro* method (Prabhavati and Narasinga Rao 1981). Therefore, there is a need to develop reliable *in vitro* methods to estimate the bioavailability of toxic elements in foods to assess their real hazards in terms of their increased body burden. *In vitro* method, whose reliability has been established by comparing with *in vivo* absorption in animal model like monkey, would be valuable in screening foods contaminated with toxic metals, and in assessing their hazards to population consuming such contaminated foods.

Practical utility of in vitro *methods for estimating the bioavailability of trace metals:* Establishing reliable *in vitro* methods for estimating the bioavailability of trace metals in foods has several advantages and will have wide applications in nutrition, food technology/science and food toxicology. The *in vitro* method, which has been properly validated against an *in vivo* method, should be rapid, reliable, less expensive, capable of being routinely employed in any standard laboratory. Some of the important applications of *in vitro* methods are as follows :

1. Screening procedure to estimate the bioavailability of essential trace metals in a wide range of foods and diets.
2. Identification of foods, diets and food combinations with good bioavailability of essential trace elements, as well as for using the information for planning diets, and for giving dietary advice.
3. Formulation of different types of diets, with a view to maximizing the bioavailability of the essential trace elements.
4. Monitoring the effects of food processing at the home and industry levels, with emphasis on the bioavailability of trace elements, in addition to testing of the effect of food additives on bioavailability.
5. Selection of an appropriate source of any given trace element, which would be useful for developing a fortification programme.
6. Assessment of the extent of hazards of toxic metals contaminating the foodchain, by assessing their potential absorbability, besides estimating their actual contents in foods.

References

Anke M, Groppel B (1987) Toxic action of essential trace elements (Mo, Cu, Zn, Fe, Mn). In: Bratter P, Schramel P (eds) Trace Element Analytical Chemistry in Medicine and Biology, Vol 4, Watter de Gruyter, Berlin, pp. 201-236

Becker WM, Hoekstra WC (1971) The intestinal absorption of zinc, In: Skoryna SC, Waldran Edward D (eds). Intestinal Absorption of Metal Ions, Trace Elements, Pergamon Press, New York, pp. 229-256

Bjorn-Rasmussen E, Hallberg L, Walker RB (1973) Food iron Absorption in Man. II. Isotopic exchange of iron between labelled foods and between a food and an iron salt. Am J Clin Nutr 26: 1311-1319

Brozovic B (1975) In: McColl I, Sladen GE (eds). Intestinal Absorption in Man. Academic Press, London, pp 263-314

Charley PJ, Shore E, Saltman P (1963) Studies in the regulation of intestinal iron absorption. J Lab Clin Med 61:397-410

Cook JD, Layrisse M, Martinez-Torres C, Walker R, Monsen E, Finch CA (1972) Food iron absorption measured by extrinsic tag. J Clin Invest 51:805-815

Forth W, Rummel W (1973) Iron absorption. Physiol Rev 53:724-792

Forth W, Rummel W (1975) Gastrointestinal absorption of heavy metals. In: Forth W, Rummel W (eds). Pharmacology of Intestinal Absorption of Drugs, Vol. II. Pergamon Press, Oxford, pp 599-746

Fox MRS, Jacobs RM, Jones AOL, Fry Jr BE, Rakowska M, Hamilton RP, Harland BP, Stone CL, Tao SH (1981) Animal models for assessing bioavailability of essential and toxic elements. Cereal Chem 58:6-11

Fox TE, Fairweather-Tait SJ, Eagles J, Warf SG (1991) Intrinsic labelling of different foods with stable isotopes of zinc (^{67}Zn) for use in bioavailability study. Br J Nutr 66: 57-63

Fritz JC, Pla GW (1972) Vitamins and other nutrients. Applications of the animal haemoglobin repletion test to measurement of iron availability in foods. J Assoc Off Anal Chem 55:1128-1132

Fritz JC, Pla GW, Roberts T, Boetine JW, Hove EL(1970) Biological availability in animals of iron from common dietary sources. J Agric Food Chem 18:647-651

Greenberger NJ, Bakerzak SP, Ackerman GA (1969) Iron uptake by isolated brush borders. Changes induced by alterations in iron stores. J Lab Clin Med 73:711-721

Hallberg L, Solvell L (1967) Absorption of haemoglobin iron in man. Acta Med Scand 181:335-354

Hussain R, Patwardhan VN (1959) The influence of phytate on the absorption of iron. Indian J Med Res 47:676-682

Jacobs A, Greenman DA (1969) Availability of food iron. Br Med J 1:673-676

Kaltwasser JP, Hansen C, Oelike Y, Werner E (1991) Assessment of iron bioavailability using stable ^{54}Fe. Eur J Clin Invest 21:436-442

Linder MC, Munro HN (1977) The mechanism of iron absorption and its regulation. Fed Proc 36;2017-2023

Mertz W, Roginski EE (1971) Chromium metabolism: The glucose tolerance factor. In: Mertz W, Cornatzer (eds) Newer Trace Elements in Nutrition. Marcel Dekker, New York, pp. 126

Moeller T (1952) Inorganic Chemistry - An Advanced Text Book, John Wiley and Sons, Inc., New York

Monsen ER, Hallberg M, Hegsted DM, Cook JD, Mertz W, Finch CA (1978) Estimation of available dietary iron. Am J Clin Nutr 31:134-141

Moore CV, Dubach R, Menich V, Roberts HK (1944) Absorption of ferrous and ferric radioactive iron by human subjects and by dogs. J Clin Invest 23:755-762

Nageswara Rao C, Narasinga Rao BS (1980) Absorption and retention of magnesium and some trace elements by man from typical Indian diets. Nutr Metab 24:244-254

Narasinga Rao BS, Prabhavati T (1978) An *in vitro* method for predicting the bioavailability of iron from foods. Am J Clin Nutr 31:169-195

Narasinga Rao BS (1981) Physiology of iron absorption and supplementation. Br Med Bull 37:25-30

Narasinga Rao BS, Shivprasad J, Vijayasarathy C (1977) Animal model to study iron availability from human diets. Br J Nutr 37:451-456

Narasinga Rao BS, Subba Rao K (1992) Studies on the role of iron binding ligands and the intestinal brush border receptors in iron absorption. Ind J Biochem Biophys 29:214-218

Narasinga Rao BS, Vijayasarathy C, Prabhavati T (1983) Iron absorption from habitual diets of Indians studied by the extrinsic tag technique. Ind J Med Res 77:648-657

O'Dell BL (1984) Bioavailability of trace elements. Nutr Rev 42:301-308

Pauling L (1953) General Chemistry, 2nd ed. WH Freeman and Company Inc., San Francisco

Pla GW, Harrison BN, Fritz JG (1973) Comparison of chicks and rats as test animals for studying bioavailability of iron with special reference to use of reduced iron in enriched bread. J Assoc Off Anal Chem 56:1369-1373

Prabhavati T, Narasinga Rao BS (1981) Contaminant iron in foods and its bioavailability predicted by the *in vitro* method. Ind J Med Res 74:37-41

Prasad AS (ed) (1976) Trace Elements in Human Health and Disease. II. Essential and Toxic Elements, Academic Press, New York

Puar Mrunalini Devi (1983) Essential trace element profile and zinc availability in Indian foods and diets. Ph.D. Thesis, The M.S. University of Baroda, India

Reinhold JG, Parsa A, Karimian N, Hammick JW, Ismail Beigi F (1974) Availability of zinc in leavened and unleavened whole meal wheaten breads, as measured by solubility and uptake by rat intestine *in vitro*. J Nutr 104:976-982

Shackleton L, McCance AA (1936) The ionizable iron in foods. Biochem J 30:582-591

Shenolikar IS, Narasinga Rao BS (1968) Influence of dietary protein on calcium metabolism in young rats. Ind J Med Res 56:1412-1422

Subba Rao K, Narasinga Rao BS (1983) Studies on iron chelation by phytate and the influence of other minerals on it. Nutr Rep Int 29:1101-1106

Underwood EJ (1977) Trace Elements in Human and Animal Nutrition. 4th ed. Academic Press, New York

WHO (1973) Trace Elements in Human Nutrition, Technical Report Series No. 532. World Health Organization, Geneva

Received 31 January 1994; revised 6 June 1994; accepted 6 June 1994

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 362-366

Potential of the Biological Control of Aflatoxin Contamination in Developing Peanut (*Arachis hypogaea* L.) by Atoxigenic Strains of *Aspergillus flavus*

H.K. CHOURASIA*[1] AND R.K. SINHA
Mycotoxin Research Laboratory
University Department of Botany, Bhagalpur University, Bhagalpur-812 007, India.

In greenhouse experiments, simultaneous inoculation of root regions of 1 to 2-week old peanut plants with toxigenic and atoxigenic strains of *Aspergillus flavus* resulted in lower levels of aflatoxin B_1 in the peanut kernels at maturity, than those in plants inoculated with the toxigenic strains alone. Of the seven atoxigenic strains tested, six strains showed reduction in aflatoxin production to varying extents. Pre-inoculation of atoxigenic strains (1 day earlier resulted in greater inhibition of aflatoxin production. However, toxin level was not much reduced, when the atoxigenic strain was introduced 1 day after the toxigenic strain. Inoculation of an atoxigenic strain at 5-fold higher spore concentration, within 12 h of toxigenic strain inoculation, led to a significant reduction in aflatoxin B_1. The results suggest the potential of atoxigenic strains of *A. flavus*, in biological control, against pre-harvest aflatoxin contamination of developing peanuts, subject to practicability of the approach.

Keywords : Aflatoxin B_1, *Aspergillus flavus*, Peanut, Biological control, Atoxigenic and toxigenic strains.

Aflatoxins, the toxic metabolites of *Aspergillus flavus* Link and *A. parasiticus* Speare, pose serious health hazards as potent carcinogens to humans and domestic animals, because of their frequent occurrence in agricultural commodities including cereals and spices (Rehana et al. 1979; Misra 1987; Jones 1977; Mixon 1980; Kilman 1989; Mayura et al. 1985). Production of aflatoxin is strain-specific as well as host-specific (Joffe 1969; Cotty 1989a). Peanut (*Arachis hypogaea* L.) is unique among the crop plants, as the flowers are fertilized above the ground, but the gynophore (peg) is extended, ultimately pushing the developing embryo into the soil. The soil immediately surrounding the pod, i.e. the geocarposphere, harbours a wide spectrum of microflora, including *Aspergillus flavus*, which exert their effects on the keeping quality of the pod (Garren 1966; Kloepper and Bowen 1991).

Aflatoxin contamination of peanut during post-harvest manipulations is very common throughout the world (Garren et al. 1969; Subrahmanyam and Rao 1974; Mehan and McDonald 1983; Kshemkalyani and Patel 1988). Strategies to combat the infestation through chemical agents have been in vogue in different countries (Mixon et al. 1984; Bowen and Backman 1989), but their effectiveness is still questionable (Diener et al. 1982). In recent past, introduction of living organisms with the pathogenic counterpart for effective inhibition/ elimination of the latter from the ecological niche (biological control) has been successfully exploited for the control of plant diseases (Schneider 1984; Lindow 1987; Yeh et al. 1988). Aflatoxin production was found to be inhibited by *A. niger*, when the fungus was co-inoculated along with *A. flavus*, onto autoclaved corn (Wicklow et al. 1980) or autoclaved peanuts (Ashworth et al. 1965). However, there has been scanty information on the potential bio-agents against pre-harvest contamination of aflatoxigenic fungi on peanuts (Dorner et al. 1990).

The objective of the present study was to evaluate the potentiality of some atoxigenic strains of *A. flavus* for inhibition/elimination of aflatoxin B_1 in peanut plants, under greenhouse experimentation.

Materials and Methods

Fungal strains and growth conditions : Strains of *A. flavus* were obtained from peanut geocarposphere, taken from peanut research plots at the Wiregrass sub-station of the Alabama Agricultural Experiment Station, Auburn University, USA, and their toxigenic potentials were tested. Strains AU 15 and AU 21 produced good amounts of aflatoxin B_1, both in culture and in developing peanut pod (22, 15, 30 and 52 µg/g, respectively), while strains AU 12, 16, 19, 32, 55, 69 and 72 were atoxigenic (detectable level of aflatoxin B_1, being 10 µg/g). Cultures were maintained on potato-dextrose-agar (Difco Laboratories, Detroit, Michigan) and stored at 4°C. Conidia were collected by flushing 5-day old cultures in a sterile 0.01% solution of Triton X-100. Suspensions were adjusted

* *Corresponding Author.* [1]*Present address : Plant Pathology Division, Central Institute of Medicinal and Aromatic Plants, P.O. CIMAP, Lucknow-226 015, India.*

to $3x10^6$ spores/ml, as enumerated by a hemacytometer (Petroff Hausser counting chamber, The American Optical Co, Washington DC.) and 0.5 ml was used for inoculation.

Inoculation of peanut : Sound mature peanut kernels were surface-disinfested by agitating in 20% household bleach (Clorox; active ingredient 5.25% NaOCl, Clorox Co., Oakland, California) at 150 rpm, on an orbital shaker, for 1 h, followed by four to five rinses in sterile water, and drying at 25°C for 1 h in open petri dishes in a laminar flow hood. Surface-disinfested kernels were germinated in a greenhouse in 3-l pots containing promix (Premier Peat, Riviere duLoup, Quebec, Canada). Promix was moistened and autoclaved twice before use. At 7 days after emergence of plant from promix (at two leaves stage), root region of each plant was inoculated with an adjustable pipette (Gilson Co, Inc., Worthington, Ohio), having a disposable tip, carrying 20 µl spore suspension of either toxigenic or atoxigenic *A. flavus* strains.

The co-inoculation experiment was performed by inoculating root region either with 20 µl spore suspension of a single strain, or with 20 µl spore suspension of the toxigenic strain, followed by the same amount of the atoxigenic strain. To evaluate the effect of prior colonization of fungus on the toxic potentiality of the strain, radicles inoculated with one strain were subsequently (after 24 h) inoculated with 20 µl conidial suspension of the second strain. To test the ability of an atoxigenic strain to influence pod contamination by a toxigenic strain, root regions were inoculated with 4 µl conidial suspension of a toxigenic strain, as this was the critical concentration for the toxin production in peanut pods, below which no toxicity was observed (unpublished data), and then re-inoculated at the same site with 20 µl spore suspension of an atoxigenic strain after 1, 2, 4, 8 or 12 h.

In all the tests, peanut pods were harvested at maturity (14 weeks after inoculation) and dried at 60°C for 48 h. Dried kernels were kept at room temperature in sealed plastic bags. All the experiments were performed twice, with six replicates for each treatment in each experiment.

Aflatoxin analysis : The levels of aflatoxin B_1 in peanut kernels were determined by reversed phase high pressure liquid chromatography (Waters Associates, Inc, Milford, Massachusetts) by the method of Stubblefield and Shotwell (1977). The mobile phase consisted of HPLC grade acetonitrile : tetrahydrofuran : water (10:6:84, v/v/v), adjusted to pH 3.9 with acetic acid. The flow rate was 2 ml/min. Detection was by fluorescence in a model 470 fluorescence detector (excitation at 360 nm and emission at 418 nm). Quantification of peak area was done using Baseline software (Millennium 2010, Millipore Corporation, Massachusetts). Standards of aflatoxin B_1, B_2, G_1 and G_2 (Sigma Chemical Co, St. Louis, Missouri) were run through the complete derivatization procedures. Typical retention times in this liquid chromatograph system were 3.5, 4.5, 7.0 and 10.5 min, respectively.

Statistical analysis : Computation of data was performed using statistical analysis system (SAS Institute Inc, Cary, North Carolina). All multiple comparisons were subjected to analysis of variance. Toxin values were log transformed (log X+1), when necessary to homogenize variances among treatments. Treatment replicates from two experiments were ranked, and the ranks were subjected to split-plot analysis (Milliken and Johnson 1984). In tests comparing atoxigenic strains, the test was considered as main plot, while the strain as sub-plot. In tests evaluating the effect of challenge with an atoxigenic strain, after brief infection by a toxigenic strain, the test was the main plot and the treatment (no challenge or challenge after 1, 2, 4, 8, or 12 h) was the sub-plot. Significant differences among mean values of the treatment were determined with the LSD test for split-plot analyses.

Results and Discussion

Out of the seven atoxigenic strains tested, six strains reduced the production of aflatoxin significantly in peanuts, when inoculated with strain AU 21 (Table 1). Inoculation of root regions

TABLE 1. EFFECT OF VARIOUS ATOXIGENIC STRAINS OF *ASPERGILLUS FLAVUS* ON AFLATOXIN CONTAMINATION OF PEANUT KERNELS BY A TOXIGENIC STRAIN[a]

Atoxigenic strain	Aflatoxin B_1 content, µg/g[b]	
None	48.20	x
AU 69	32.50	xy
AU 72	25.15	y
AU 19	20.85	yz
AU 55	11.30	yz
AU 16	7.16	yz
AU 12	3.47	yz
AU 32	0.88	z

[a]Developing peanut plants were inoculated first with toxigenic strain AU 21 and 30 min later with an atoxigenic strain. [b]Values are averages of six replicates made during two tests. Values followed by the same letter are not significantly different by the LSD test for split-plot analyses. Analyses were performed on ranks assigned to values within tests before analysis.

of developing peanut plants with strain AU 32, however, exhibited no aflatoxin production or negligible (<50 μg/g) amount of aflatoxin B_1 in peanut kernels (data not presented). When peanut plants were inoculated with toxigenic strain AU 21 and then re-inoculated in the same site at intervals of 1, 2, 4, 8 and 12 h with 5-fold more conidia of atoxigenic strain AU 32, a significant (P=0.05) reduction in aflatoxin B_1 was noticed.

Appreciable levels of aflatoxin B_1 were produced in peanut kernels inoculated with strain AU 15 or strain AU 21 (Table 2). However, co-inoculation of plants with conidia of toxigenic and atoxigenic strains in equal proportions showed a marked reduction in aflatoxin B_1 production. The reduction in toxin as a result of co-inoculation with AU 15 was greater, than that with strain AU 21 (Table 2). The production of aflatoxin was completely prevented by introducing strain AU 32 into the root regions, 24 h before inoculation, with an equal quantity of conidia of strain AU 15 or strain AU 21 (Table 2). The root regions were inoculated with a toxigenic strain, 1 day before inoculation, with strain AU 32. However, this had no marked effect on the inhibition of toxin quantity in peanut kernels.

Aspergillus flavus varies widely in aflatoxin-production ability, which is apparently unrelated to the capability of the strains to infect and colonize the host tissue (Cotty 1989b). The potentiality of atoxigenic strains to outcompete the toxigenic strains in greenhouse experiments with cotton and maize have been reported (Brown et al. 1990). Atoxigenic strains of *A. flavus* are endemic to peanut fields and are suitably adapted to the hot and dry conditions, that are equally needed for colonization of peanut geocarposphere by toxigenic strains. The geocarposphere soil is considered to be the major source of *A. flavus* infection of peanut before harvest, from which *A. flavus* enters into the developing peanut fruit, after penetration of the stem, flower (ovary, style and stigma), peg, pod wall and testae (Diener 1989). Atoxigenic strains, once applied in sufficient quantities, have the potential to proliferate on the peanut carposphere, and this can be exploited for biocontrol strategy of aflatoxin contamination. Greenhouse experiments in the present study substantiate such a possible use of atoxigenic strains for biocontrol programmes.

TABLE 2. AFLATOXIN CONTENT OF PEANUT KERNELS INOCULATED WITH TOXIGENIC AND ATOXIGENIC *ASPERGILLUS FLAVUS* STRAINS INDIVIDUALLY OR IN COMBINATION

Strain	Toxigenicity	Aflatoxin B_1 content of kernels, μg/g[a]			
		Inoculated alone	Coinoculated with strain AU 32	Inoculated 24 h after strain AU 32	Inoculated 24 h before strain AU 32
AU 15	+	16.0 c	0 d	0.0 d	18.2 c
AU 21	+	59.5 a	7 b	0.8 d	65.0 a
AU 32	-	0 d	-	-	-

[a]Detection limit = 10 ng/g. Values are means of six replicates. Means followed by the same letter do not differ significantly (P = 0.05) by Fisher's least significant difference test. Data were log-transformed before analysis.

The atoxigenic strain reduced aflatoxin contamination by 90 to 100%, when root regions of peanut plants were co-inoculated with toxigenic (AU 15 and AU 21) and atoxigenic strains. Inoculation of peanut plants with these toxigenic strains, 24 h after the inoculation of atoxigenic strain, produced remarkable reduction (90 to 100%) in aflatoxin production. Dorner et al (1990) have also recorded similar results, while working with a biocompetitive agent as an effective management strategy for pre-harvest aflatoxin contamination. The strategy involved the incorporation of an atoxigenic strain of *A. flavus* into the peanut soil of an environmental control plot facility. The biocompetitive agent maintained a dominance over the toxigenic strains of *A. flavus* for the three year period, with no further addition of fungal propagules after the first year. This treatment also resulted in a significant reduction in aflatoxin in peanuts, as compared to non-treated controls.

The mechanism of reduction of aflatoxin production by atoxigenic strain is, however, not yet fully known. Recently, Cotty et al (1990) have attributed such a phenomenon in cottonseed to the mutational behaviour of the strain, showing inability to reduce nitrate. Alternatively, the reduction in aflatoxin might be due to the nutritional competition, altering the levels of oxygen or carbon dioxide between the atoxigenic and toxigenic strains, thereby exhibiting pronounced changes in growth, sporulation and toxin production in toxigenic *A. flavus* (Landers et al. 1967). The inhibition of aflatoxin synthesis in the toxigenic strain by atoxigenic strains of *A. flavus* has also been reported by Drew and Demain (1977). They found that proteins are degraded to amino acids by the competing fungal proteases. Some of these amino acids serve as nitrogen sources, while others serve as a source of carbon, if other carbon sources are limited. When amino acids are used as carbon sources, large amounts of ammonia may be liberated, inhibiting the aflatoxin production (Goldblatt and

Dollear 1977). Earlier, Ciegler et al (1966) and Masimango et al (1978) have attributed this effect to the degradation, detoxification or absorption/ adsorption of toxin by atoxigenic strains of *A. flavus*. Mycelia of atoxigenic strains can degrade the toxin elaborated by the toxigenic strains of *A. flavus*, possibly via fungal peroxidase (Doyle et al. 1982).

The occasional production of low levels of aflatoxins in peanut kernels, when inoculated with atoxigenic AU 32 strains, may have been caused by chance contamination of toxigenic strain into the root regions, before or during inoculation. Such introduction is possible, as *A. flavus* sporulates profusely on the inoculated site, and several experiments performed simultaneously in the same greenhouse might have led to contamination by the toxigenic strain. However, this cannot rule out the possibility of unstable nature of some atoxigenic strains that can produce some amounts of toxin under certain conditions. Several workers (Diener and Davis 1986; Bilgrami et al. 1988) have highlighted the inconsistent behaviour of toxigenic strains under varying cultural conditions. Strain stability should, therefore, be an important criterion in the selection of biocontrol strains. Efforts should be made to develop genetically and physiologically stable atoxigenic strains for biocontrolling the aflatoxin production in agricultural crops. Detailed investigations are desirable to bring the advantages of this greenhouse experiment to a field level and to evaluate the practicability of the approach.

Acknowledgements

Authors thank Prof. Barry J. Jacobsen, Head, Department of Plant Pathology, Alabama Agricultural Experiment Station, Auburn University, USA, for providing necessary experimental facilities. Financial assistance to H.K.C. provided by the Department of Education. Government of India, New Delhi, in the form of Post-Doctoral fellowship is gratefully acknowledged.

References

Ashworth LJ, Schroeder HW, Langley BC (1965) Aflatoxins : Environmental factors governing occurrence in Spanish peanuts. Science 148: 1228-1229

Bilgrami KS, Sinha SP, Jeswal P (1988) Loss of toxigenicity of *Aspergillus flavus* strains during subculturing - A genetic interpretation. Current Sci 57:551-552

Bowen KL, Backman PA (1989) Effectiveness of fungicides for control of mycotoxigenic fungi and mycotoxins in peanut. Phytopathology 79:1188

Brown RL, Cotty PJ, Cleveland TE (1990) Effect of atoxigenic strains of *Aspergillus flavus* on preharvest and postharvest aflatoxin contamination of maize kernels. Phytopathology 80:1020

Brown RL, Cotty PJ, Cleveland TE (1991) Reduction in aflatoxin content of maize by atoxigenic strains of *Aspergillus flavus*. J Food Prot 54:623-626

Ciegler A, Lillehoj EB, Peterson RE, Hall HH (1966) Microbial detoxification of aflatoxin. Appl Microbiol 14:934-939

Cotty PJ (1989a) Effects of cultivar and boll age on aflatoxin in cottonseed after inoculation with *Aspergillus flavus* at simulated exit holes of the pink bollworm. Plant Dis 73:489-492

Cotty PJ (1989b) Virulence and cultural characteristics of two *Aspergillus flavus* strains pathogenic on cotton. Phytopathology 79:808-814

Cotty PJ, Bayman P, Bhatnagar D (1990) Two potential mechanisms by which atoxigenic strains of *A. flavus* prevent toxigenic strains from contaminating cottonseed. Phytopathology 80:994

Diener UL (1989) Preharvest aflatoxin contamination of peanuts, corn and cottonseed - A review. Biodeterioration Res 2:217-225

Diener UL, Davis ND (1986) Biology of *Aspergillus flavus* and *A parasiticus*. In : Zuber MS, Lillehoj EB, Renfro BL (eds) Aflatoxin in Maize - Proceedings of the Workshop. Centro Internacional De Mejoramiento De Maiz Y Trigo, El Batan, Mexico, pp 33-39

Diener UL, Pettit RE, Cole RJ (1982) Aflatoxins and other mycotoxins in peanuts. In: Pattee HE, Young CT (eds) Peanut Science and Technology. American Peanut Research and Education Society, Inc, Yoakum, Texas, pp 486-519

Dorner JW, Cole RJ, Blankenship PD (1990) The use of a biocompetitive agent to control preharvest aflatoxin in drought stress peanuts. In: Porter DM, Dickens JW (eds) Proceedings of the American Peanut Research and Education Society, Inc, Yaokum, Texas, 22:34-39

Doyle, MP, Applebaum RS, Brackett RE, Marth EH (1982) Physical, chemical and biological degradation of mycotoxins in foods and agricultural commodities. J Food Prot 45:964-971

Drew SW, Demain AL (1977) Effect of primary metabolites on secondary metabolism. Ann Review Microbiol 31: 343-356

Garren KH (1966) Peanut (groundnut) microflora and pathogenesis in peanut pod rot. Phytopathol Z 55:359-367

Garren KH, Christensen CM, Porter DM (1969) The mycotoxin potential of peanuts (groundnuts) : The USA viewpoint. J Stored Product Res 5:265-273

Goldblatt LA, Dollear FG (1977) Review of prevention, elimination and detoxification of aflatoxins. Pure Appl Chem 49:1759-1764

Joffe AZ (1969) Aflatoxin produced by 1,626 isolates of *Aspergillus flavus* from groundnut kernels and soils in Israel. Nature 221:492

Jones BD (1977) Aflatoxins and related compounds. In: Wyllie TD, Morehouse LG (eds) Mycotoxic Fungi, Mycotoxins and Mycotoxicosis, Vol, 1, Marcel Dekker, Inc, New York, pp 131-143

Kilman S (1989) Spreading poison. Wall Street Journal 23:1

Kloepper JW, Bowen KL (1991) Quantification of geocarposphere and rhizosphere effect of peanut (*Arachis hypogaea* L.). Plant and Soil 136:103-109

Kshemkalyani SB, Patel GS (1988) Investigation of aflatoxin contamination in commercial groundnuts. J Food Sci Technol 25:364-365

Landers KE, Davis ND, Diener UL (1967) Influence of atmospheric gases on aflatoxin production by *Aspergillus flavus* in peanuts. Phytopathology 57:1086-1090

Lindow SE (1987) Competitive exclusion of epiphytic bacteria by ice-*Pseudomonas syringae*. Appl Environ Microbiol 53:2520-2527

Masimango N, Remacle J, Ramaut JL (1978) The role of adsorption in the elimination of aflatoxin B_1 from contaminated media. Eur J Appl Microbiol Biotechnol 6:101-105

Mayura K, Basappa SC Sreenivasamurthy V (1985) Studies on some factors affecting aflatoxin production by *Aspergillus flavus* and *A parasiticus*. J Food Sci Technol 22:126-129

Mehan VK, McDonald D (1983) Mycotoxin Contamination in Groundnut-Prevention and Control. In: Bilgrami KS, Prasad T, Sinha KK (eds) Proceedings of the Symposium on Mycotoxin in Food and Feed. The Allied Press, Bhagalpur, pp 237-250

Milliken GA, Johnson DE (1984) Analysis of Messy Data. Van Nostrand Reinhold, New York

Misra N (1987) Mycotoxins in spices III. Investigation on the natural occurrence of aflatoxins in *Coriandrum sativum* L. J Food Sci Technol 24:324-325

Mixon AC (1980) Comparison of pod and seed screening methods on *Aspergillus* spp infection of peanut genotypes. Peanut Sci 7:1-3

Mixon AC, Bell DK, Wilson DM (1984) Effect of chemical and biological agents on the incidence of *A. flavus* and aflatoxin contamination of peanut seed. Phytopathology 74:1440-1444

Rehana F, Basappa SC, Sreenivasa Murthy V (1979) Destruction of aflatoxin in rice by different cooking methods. J Food Sci Technol 16:111-112

Schneider RW (1984) Effects of non-pathogenic strains of *Fusarium oxysporum* on celery root infection by *F. oxysporum* f. sp. *apii* and a novel use of the Lineweaver - Burk double reciprocal plot technique. Phytopathology 74:646-653

Stubblefield RD, Shotwell OL (1977) Reverse phase analytical and preparative high pressure liquid chromatography of aflatoxins. J Assoc Off Anal Chem 60:784-790

Subrahmanyam P, Rao AS (1974) Occurrence of aflatoxin and citrinin in groundnut (*Arachis hypogaea* L.) at harvest in relation to pod condition and kernel moisture content. Curr Sci 43:707-710

Wicklow DT, Hesseltine CW, Shotwell OL, Adams GL (1980) Interference competition and aflatoxin levels in corn. Phytopathology 70:761-764

Yeh SD, Gonsalves D, Wang HL, Namba R, Chiu RJ (1988) Control of papaya ringspot virus by cross protection. Plant Dis 72:375-380

Received 12 January 1993; revised 27 December 1993; accepted 29 December 1993

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 367-371

Studies on Dehydration of the Seeds of Green Field Bean (*Dolichos lablab* Var. *lignosus*)

K.S. JAYARAMAN*, D.K. DAS GUPTA AND N. BABU RAO
Defence Food Research Laboratory, Mysore-570 011, India.

Seeds of fresh green field bean (*Dolichos lablab* var. *lignosus*) were dehydrated under sunlight, in solar cabinet, hot air cabinet and by high temperature short time (HTST) pneumatic drying as well as deep-fat-frying. The products were evaluated for drying and rehydration characteristics, other quality and chemical parameters besides shelf-stability. Sun-drying resulted in a significantly greater loss of chlorophyll (70-75% as compared to 15-20% in other modes) and in higher browning as well as lipid oxidation, besides poor rehydration characteristics due to shrinkage. HTST drying and frying imparted porosity and improved drying as well as rehydration, although with increased butterflying(seed splitting) of the seeds. Pretreatment with sugar reduced butterflying and seed coat separation. The dried seeds were shelf-stable at room temperature and 37°C for more than 6 months in flexible laminate pouches.

Keywords : Green field bean seeds, Solar drying, Hot air drying, High temperature-short time drying, Deep-fat-frying, Rehydration, Quality characteristics, Sugar pretreatment, Shelf-life.

Fresh, green, field bean seeds (*Dolichos lablab* Var. *lignosus*), commonly referred to as *avare* and *mochai*, are popular in the states of Karnataka and Tamil Nadu, where these are consumed as vegetables, and relished for their culinary properties and flavour. The green bean has a short season with limited shelf-life. No attempt has been made so far to preserve the tender fresh seeds to extend their availability during off-seasons, and ensure convenience of use, although some studies have been done on peas (Gangopadhyay and Choudhari 1979; Kanawade and Narain 1993). Traditionally, sun-drying has been used for drying most of the mature legume seeds (Salunkhe et al. 1985). However, application of mechanical dehydration methods is necessary for better retention of the quality attributes of fresh green seeds of legumes intended for use as vegetable, since drying by prolonged direct exposure to solar radiation leads to adverse changes in colour, texture and flavour, thereby resulting in a product with poor quality and shelf-stability (Bolin and Salunkhe 1982; Sharma et al. 1987).

The present paper reports the results of studies, conducted on the dehydration characteristics of fresh green field bean seeds by different methods, and the comparative evaluation of the dried products for rehydration, organoleptic qualities and shelf-stability. It also includes experiments on deep-fat-frying to obtain a ready-to-eat snack and on the effect of pretreatment with cane sugar on the rehydration characteristics.

Materials and Methods

Raw materials and pretreatments : Pods of fresh, green, field bean, procured from the local market, were washed thoroughly in running tap water and de-podded manually. The seeds were soaked in 2% (w/v) sodium carbonate solution (pH 11.6) for 30 min, drained, washed free of carbonate and then blanched in boiling water containing 0.1% magnesium oxide, 0.1% sodium bicarbonate and 0.3% potassium metabisulphite (pH 7.1) for 5 min. In experiments involving pretreatment with sugar, the blanched beans were soaked in twice the quantity of 20% refined cane sugar solution, for 1 h at room temperature (25-30°C, 55-65% RH) prior to drying.

Drying : The blanched seeds were dried by different processes. The material was spread on aluminium trays (tray loading 3 kg/m^2; 0.8 m x 0.4 m tray size) and dried by direct exposure to sunlight in the open to a final moisture content of 7%. The material was spread on wire-mesh trays (size 0.8 m x 0.4 m) with a tray loading of 3 kg/m^2 and dried to a final moisture content of about 5% at 40-60°C in a solar cabinet, with an indirect heating mode using three flatplate collectors, as per design described earlier by Jayaraman et al (1992). The material spread on aluminium trays (0.8 m x 0.4 m size), with a tray loading of 4.5 kg/m^2, was dried to 5% moisture content in an electrically heated cabinet drier (Kilburn, Calcutta), with a capacity of 12 trays at 60-70°C and air velocity of 75 m/min. The seeds were subjected to an initial high temperature-short time (HTST) drying in a specially designed pneumatic drier, as described by Jayaraman et al (1980), at 160°C for 6 min to reduce the moisture content to 40%. This was followed by finish drying in a fluidized bed drier (Chem Pharm, New York; capacity 2 kg; air flow

* Corresponding Author

rate 450 m/min) at 60°C to a final moisture of 5%. The material was also fried for 7 min in eight times the weight of hydrogenated vegetable oil at a put-in temperature of 175°C and frying temperature of 120°C to a final moisture content of 5%.

Samples were drawn periodically during drying and the moisture content was determined by powdering and drying in an air oven at 105°C to a constant weight (Ranganna 1986). Dehydration ratio was determined by dividing the weight of blanched material by the weight of dried material (Van Arsdel and Copley 1964). Bulk density was determined by measuring the volume of 50 g dried seeds in a 250 ml measuring cylinder and expressed as g/ml. Extent of seed splitting (butterflying) during drying was calculated by dividing the number of split seeds by the total number of seeds and multiplying by 100.

Rehydration studies : Cooking time was determined by the time taken for the product to become soft in the core, as determined by pressing between thumb and forefinger, when 5 g material was boiled in 100 ml water. Rehydration ratio and coefficient were determined by adding 5 g material to 100 ml boiling water, bringing to boil, simmering for 10 min, filtering over a Buchner funnel and weighing immediately. Rehydration ratio was calculated as the ratio of the weight of material after and before cooking. Rehydration coefficient was obtained from the formula: weight of rehydrated sample x (100-moisture content in sample before drying) + (weight of dried sample - weight of moisture in dried sample) x 100 (Ranganna 1986).

Storage studies : Shelf-stability of the dehydrated seeds was evaluated by packing in paper (40 gsm) - aluminium foil (0.02 mm) - polyethylene (37.5 micron) laminate pouches and storing at three temperatures, viz., 0°C (control), room temperature (19-35°C) and 37°C. Samples were drawn periodically and analyzed for non-enzymatic browning (NEB), sulphur dioxide content and thiobarbituric acid (TBA) value.

Analytical methods : Proximate analysis and total chlorophyll were determined by AOAC methods (1984). Sulphur dioxide was determined by iodimetric method (Pearson 1973), and the TBA value by the method of Tarladgis et al (1960). NEB was determined (Hendel et al. 1950) by measuring the optical density at 420 nm in Spectronic 20 (Bausch and Lomb, USA) of a 5% (w/v) aqueous extract obtained by soaking the powdered material for 1 h at room temperature, with occasional stirring and after filtering through Whatman No. 41 filter paper.

Results and Discussion

Drying characteristics : Data on drying characteristics by different drying methods are given in Table 1. Sun or solar cabinet-drying took 11-12 h, spread over a period of two days, while the time could be reduced to 6.5 h in hot air cabinet drying and 2 h in HTST pneumatic drying combined with fluidized bed drying. The slower rate of moisture loss in solar cabinet drying on the first day was apparently due to low temperature caused by evaporative cooling because of initial load of wet material and to low air flow rate, while on the second day the trend was reversed due to higher temperature attained inside the cabinet (Fig. 1). The fastest rate of drying in HTST drying was due to the high temperature and air flow rate used. Similarly, frying could be completed in 7 min due to flashing of moisture by intimate contact of individual seeds with hot oil. There was no significant difference in dehydration ratio among the seeds dried by various methods, which showed values of

TABLE 1. DRYING, REHYDRATION AND OTHER QUALITY CHARACTERISTICS OF GREEN FIELD BEAN DRIED BY DIFFERENT METHODS

Parameter	Sun-dried	Solar cabinet-dried	Hot air-dried	HTST-dried	Deep-fat-fried
Dehydration ratio	2.5 ±0.12	2.9 ±0.11	2.8 ±0.1	2.8 ±0.10	2.1 ±0.1
Bulk density, g/ml	0.96 ±0.02	0.81 ±0.02	0.83 ±0.01	0.47 ±0.02	0.42 ±0.01
Cooking time, min	15 ±1.0	14 ±0.8	12 ±0.5	8 ±0.5	5 ±0.4
Rehydration ratio	2.0 ±0.05	2.4 ±0.05	2.3 ±0.06	2.8 ±0.06	2.3 ±0.07
Rehydration coefficient	0.69 ±0.02	0.80 ±0.03	0.76 ±0.02	0.91 ±0.03	0.78 ±0.02
SO_2, ppm	350 ±10	850 ±15	960 ±12	980 ±12	300 ±10
Browning, E_5% 420 nm	0.25 ±0.02	0.09 ±0.01	0.09 ±0.01	0.09 ±0.01	0.14 ±0.02
Chlorophyll,* mg/100g, MFB	4.9 ±0.3 (26.8)	15.9 ±0.9 (86.9)	15.5 ±0.6 (84.7)	15.0 ±0.5 (82.0)	14.6 ±0.4 (80.0)
TBA, mg malonaldehyde/ kg material	0.51 ±0.06	0.05 ±0.005	0.05 ±0.004	0.05 ±0.004	0.06 ±0.005
Appearance	Shrunk, light brown	Shrunk, light green	Shrunk, light green	Slightly puffed light green	Slightly puffed light green

* Figures in parentheses represent % retention of chlorophyll as compared to raw (18.3 mg/100 g, MFB). Values reported are average of three determinations.

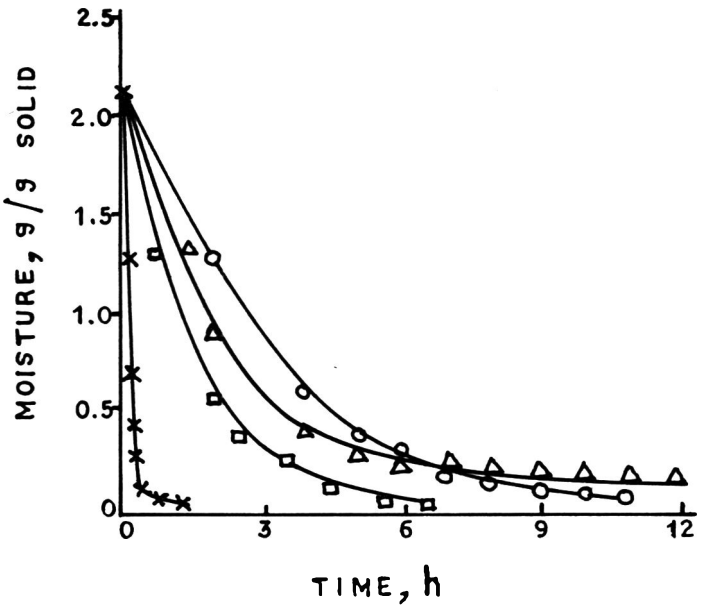

Fig.1 Drying curves for green field bean. Δ—Δ : Sun-drying, O—O :Solar cabinet drying, □- - -□ : Hot air-cabinet drying, X—X : HTST pneumatic drying

2.5 to 2.9, except in frying, which gave a value of 2.1, apparently due to fat absorption.

Bulk density was highest (0.96 g/ml) in case of sun-drying, thereby indicating considerable shrinkage, as compared to that in solar cabinet and hot air-drying. It was lowest for fried (0.42) and HTST dried (0.47) seeds, thereby showing significant expansion (puffing) of the tissue and the consequent increased bulk, as compared to other drying methods. This was further confirmed by visual observation, which showed slightly puffed appearance in HTST-dried and fried seeds. The seeds had a shrunk appearance in case of other drying methods. Also, the sun-dried seeds were light brown in colour, thereby indicating a significant loss of chlorophyll, as compared to the appealing light green colour exhibited by the seeds dried by other methods.

Rehydration characteristics : The sun-dried and solar cabinet-dried beans got cooked in 14-15 min, while hot air-dried seeds required 12 min. This is apparently due to higher shrinkage in the former, due to prolonged drying (Table 1). In contrast, HTST- dried and deep-fat-fried beans reconstituted in 8 and 5 min, respectively, due to higher porosity brought about by the flashing of moisture during the HTST drying/frying process.

Sun-dried beans exhibited lower rehydration ratio and coefficient, as compared to other drying methods. The HTST- dried seeds showed highest values, thereby indicating tissue shrinkage due to slow drying, which acted as an impediment to complete rehydration in sun-drying. This problem was overcome to a significant extent in HTST method, due to the expansion of the tissue. Although the fried beans resembled those obtained by HTST method in rehydration quality, the slightly lower values recorded in the former were apparently due to leaching of fat during cooking. There was, however, a considerable increase in butterflying (seed splitting) and external seed coat separation in both HTST-dried and fried seeds. The hot air cabinet-dried seeds showed about 28% butterflying, which increased to 40-42% in HTST- dried as well as fried seeds.

Pretreatment with sugar, prior to hot air drying, was found to significantly reduce butterflying and seed coat separation to a negligible level, besides improving the flavour and rehydration characteristics. Rockland and Metzler (1967) have made similar observations in case of lima beans.

Quality attributes : In spite of the same level of incorporation of sulphur dioxide (1250 ppm) in the initial blanched green beans, there was a significant loss of sulphur dioxide in sun-dried beans (Table 1), with concomitant development of browning in the dried product. In contrast, the samples dried in solar cabinet, under hot air and by HTST method, showed no signs of browning and significantly higher levels of sulphur dioxide retention. This is further confirmed by the higher NEB values in the sun-dried seeds (Table 1). A similar decrease in sulphur dioxide level was also recorded in fried beans, apparently due to exposure to hot oil. However, the product showed no visible browning.

Retention of chlorophyll was between 82 and 87% in solar cabinet, hot air-cabinet or HTST dried products, and consequently, these samples exhibited the appealing light green colour of the fresh seeds. In contrast, sun-dried seeds showed only 27% retention, with no visible green colour. Significant loss of chlorophyll was also observed in earlier studies on sun-dried green peas (Jayaraman et al. 1991) and vegetables like french beans, okra and bitter gourd (Jayaraman et al. 1992). The fried bean also retained the green colour with merely 20% loss in chlorophyll.

There was a 10-fold increase in the TBA value in the sun-dried beans as compared to that in the seeds dried by other methods. The product also showed a distinct rancid odour, which was absent in the samples from other drying methods. These

TABLE 2. PROXIMATE COMPOSITION OF RAW AND HOT AIR DRIED GREEN FIELD BEAN

Principle	Raw	Hot air-dried
Moisture, %	62.9 ± 2.4	5.2 ± 0.4
Ether extract, %	0.3 ± 0.05	0.5 ± 0.05
Protein (N x 6.25), %	10.5 ± 0.5	29.0 ± 1.2
Carbohydrate, (by difference), %	24.0 ± 3.1	59.3 ± 1.9
Total ash, %	1.4 ± 0.13	3.7 ± 0.16
Crude fibre, %	0.9 ± 0.05	2.3 ± 0.06
Calorific value, KCal/100 g	141 ± 15.0	357.7 ± 12.7

Values reported are average of three determinations.

findings confirm our earlier reports that direct exposure to sun brings about accelerated lipid oxidation in several vegetables, as evidenced by higher TBA values (Jayaraman et al. 1991, 1992).

Table 2 gives the proximate composition of the hot air-dried green beans, as compared to that of the fresh beans. The dehydrated green beans had high protein and carbohydrate contents, with negligible fat, and thus could serve as a good source of protein. The deep-fat-fried bean containing 22.4% fat was suitable for direct eating as a fried snack, or for incorporation in quick cooking traditional vegetable curry mixes.

Storage behaviour : Storage over a period of 6 months in paper-aluminium foil-polyethylene laminate pouches at different temperatures indicated that the solar cabinet, hot air cabinet and HTST-dried beans showed insignificant changes in browning, TBA value and sulphur dioxide level (Table 3).

Acknowledgement

The authors are thankful to Dr. (Mrs.) Rugmini Sankaran, Director, for keen interest and permission to publish the paper.

References

AOAC (1984) Official Methods of Analysis, 14th ed. Association of Official Analytical Chemists, Washington, DC

Bolin HR, Salunkhe DK (1982) Food dehydration by solar energy. CRC Crit Rev Food Sci Nutr 16 : 327-354

Gangopadhyay H, Chaudhari DR (1979) Comparative studies on dehydration of peas in fluidized bed and conventional tray drier. J Food Sci Technol 16:206-207

Hendel CE, Bailey GF, Taylor DH (1950) Measurement of non-enzymatic browning of dehydrated vegetables during storage. Food Technol 4:344-347

Jayaraman KS, Das Gupta DK, Babu Rao N (1991) Quality characteristics of some vegetables dried by direct and indirect sun drying. Indian Food Packer 45(1):16-23

Jayaraman KS, Das Gupta DK, Babu Rao N (1992) Solar drying of vegetables-Quality improvement using cabinet with multiple flat plate collectors and pretreatments. In:Mujumdar AS (ed) Drying of Solids. International Science Publisher, New York, pp 405-432

TABLE 3. BROWNING, TBA VALUE AND SO_2 RETENTION IN DEHYDRATED GREEN FIELD BEAN DURING STORAGE IN PFP AT DIFFERENT TEMPERATURES

Sample	Storage period, months	Browning, E_5% 420 nm			TBA value, mg malon/kg			SO_2 content, ppm		
		0°C	Room temp	37°C	0°C	Room temp	37°C	0°C	Room temp	37°C
Solar cabinet-dried	Initial	0.09 ±0.004	0.09 ±0.004	0.09 ±0.004	0.05 ±0.003	0.05 ±0.003	0.05 ±0.003	850 ±15	850 ±15	850 ±15
	3	0.10 ±0.005	0.11 ±0.005	0.10 ±0.004	0.11 ±0.005	0.11 ±0.006	0.11 ±0.01	700 ±10	624 ±10	546 ±12
	6	0.10 ±0.004	0.11 ±0.005	0.14 ±0.008	0.17 ±0.01	0.17 ±0.01	0.19 ±0.02	620 ±8	580 ±10	500 ±6
Hot air cabinet-dried	Initial	0.09 ±0.005	0.09 ±0.005	0.09 ±0.005	0.05 ±0.004	0.05 ±0.004	0.05 ±0.004	960 ±20	960 ±20	960 ±20
	3	0.10 ±0.006	0.11 ±0.006	0.12 ±0.008	0.11 ±0.01	0.11 ±0.01	0.11 ±0.008	780 ±12	700 ±15	700 ±13
	6	0.10 ±0.006	0.13 ±0.008	0.13 ±0.01	0.17 ±0.02	0.19 ±0.02	0.19 ±0.025	700 ±12	620 ±12	620 ±14
HTST-dried	Initial	0.09 ±0.005	0.09 ±0.005	0.09 ±0.005	0.05 ±0.005	0.05 ±0.005	0.05 ±0.005	980 ±18	980 ±18	980 ±18
	3	0.10 ±0.006	0.10 ±0.005	0.13 ±0.008	0.11 ±0.01	0.11 ±0.015	0.16 ±0.01	700 ±15	700 ±16	700 ±16
	6	0.10 ±0.005	0.10 ±0.006	0.16 ±0.01	0.21 ±0.02	0.21 ±0.03	0.21 ±0.026	640 ±16	640 ±18	640 ±15

Values reported are average of three determinations.

Jayaraman KS, Gopinath VK, Ramanathan LA (1980) Development of quick-cooking dehydrated pulses by high temperature-short time pneumatic drying. J Food Technol 15:217-226

Kanawade VL, Narain M (1993) Effect of pretreatment and drying air temperature on quality of peas dehydrated in fluidized bed dryer. J. Food Sci. Technol 30:118-120

Pearson D (1973) Laboratory Techniques in Food Analysis, 1st ed. Butterworths, London

Ranganna S (1986) Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd ed. Tata McGraw-Hill Publishing Co. Ltd., New Delhi

Rockland LB, Metzler EA (1967) Quick cooking lima and other dry beans. Food Technol 21:344-348

Salunkhe DK, Kadam SS, Chavan JK (1985) Postharvest Biotechnology of Food Legumes. CRC Press, Inc., Florida

Sharma S, Ray RA, Sharma VK (1987) Comparative study of solar dryers for crop drying. Invention Intelligence 22 (3-4) : 105-113

Tarladgis BG, Watt BM, Younathan MT, Dugan Jr LR (1960) A distillation method for quantitative determination of malonaldehyde in rancid foods. J Am Oil Chem Soc 37 : 44-48

Van Arsdel WB, Copley MJ (1964) Food Dehydration, Vol. 2. The AVI Publishing Co. Inc., Westport, Connecticut

Received 10 April 1993; revised 27 December 1993; accepted 29 December 1993

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 372-376

Studies on the Characteristics of Some Products from Tamarind (*Tamarindus indica*) Kernel

SILA BHATTACHARYA*[1+], S. BAL[1], R.K. MUKHERJEE[1] AND SUVENDU BHATTACHARYA[2+]
[1]Post Harvest Technology Centre and [2]Agricultural Engineering Department
Indian Institute of Technology, Kharagpur - 721 302, India

Suitability of incorporating tamarind kernel powder (TKP) in bread, biscuit and jelly was evaluated. Breads showed a decrease in specific volume and springiness with increase in TKP level, in contrast to increased bread hardness. However, the cohesiveness remained unaffected. Incorporation of TKP also affected the hardness, crispness and thickness of biscuits considerably, though the taste and flavour were only slightly affected. Both bread and biscuits, with up to 15% TKP in flour mix, were acceptable to the taste panel. TKP jelly had a grade between 80 and 85, while the gel strength remained unaffected by added citric acid. Comparison of sensory scores showed non-significant difference between TKP and pectin jellies. Thus, the low-cost TKP could be a good substitute for costly pectin for making jelly.

Keywords : Tamarind kernel powder, Incorporation in bread, biscuit and jelly, Effect on rheology and sensory characteristics, Textural properties, Gel strength.

Tamarind (*Tamarindus indica*), a common tree legume, is grown extensively in India mainly for its sour fruit pulp, but partly for its seed as well. The latter, about 34% by weight of the fruit, has many uses (Rao and Srivastava 1974). One major use is in the textile and jute industries in the form of tamarind kernel powder (TKP) as a sizing material; it is also used in microbial production of lipids (Jambhulkar and Shankhapal 1992; Lewis and Neelakantan 1964). In addition, it finds use in cosmetics, pharmaceuticals (Forest Research Institute, Dehra Dun, India 1955) and feed industries (Reddy et al. 1986). Attempts have also been made to produce protein concentrates or meals (Rao and Subramanian 1984a; Marangoni et al. 1988) or to use TKP as a substitute for pectin in the preparation of jelly (Bhattacharya et al. 1983). Besides, the presence of proteinase inhibitors in TKP has also been documented (Vishnu Bhat and Pattabhiraman 1985). Jambulkar and Shankhapal (1992) reported that microbial production of lipid is possible using TKP. However, the full potential of the seed kernel or kernel powder for edible uses has not been investigated systematically.

The chemical composition of TKP, and its functional as well as nutritional properties, (Bhattacharya 1990) suggest its potential for use as a food or feed ingredient. The rheological behaviour of TKP suspensions has been reported earlier (Bhattacharya et al. 1991). The present paper describes the results of a study on the subjective and objective evaluation of a few products (bread, biscuit and jelly), prepared with TKP as an ingredient.

* *Corresponding Author.* *Present Address : Central Food Technological Research Institute, Mysore 570 013, India.*

Materials and Methods

One hundred kg of tamarind (*Tamarindus indica*) seeds were procured from the local market. These were cleaned, washed free from the pulp, dried in shed (12-14% moisture) for about a week, with occasional stirring and turning to prevent mould infestation, and stored in air tight metal containers until use. Tamarind kernel powder (TKP) was prepared after roasting, dehulling and grinding of the seed, according to procedures described earlier (Bhattacharya et al. 1991). The TKP had the following composition (%) : moisture 6.1, proteins (Nx6.25) 18.4, fat 7.7, ash 2.8, crude fibre 2.6 and carbohydrates (by difference) 62.4.

Bread : Breads were prepared from wheat flour as well as from wheat flour + TKP blends (5, 10, 15 and 20% levels), according to Campos and El-Dash (1978). Loaves, from 100 g dough pieces, were baked for 20 min at 200°C. Two baking tests were performed. The baked loaves were allowed to cool to room temperature (30±1°C) and sealed in polyethylene packets. Loaf volume was measured by the method of mustard seed displacement (D'Applonia and Youngs 1978). Sensory evaluation and textural measurements were carried out within 3 and 5 h of bread making, respectively.

Textural properties of bread : Control and TKP incorporated samples (25 mm x 25 mm x 25 mm), free from crusts and hard edges, were evaluated for textural parameters (Bourne 1982), like hardness, springiness, elasticity and cohesiveness, by using an Instron universal testing machine (Model TM-M, Instron Corpn., Canton, USA) at room temperature (30 ± 1°C). Textural parameters were

measured for two successive bites with 50% compression and reported as means of eight samples along with the range of standard deviations. The Instron machine was operated under the following conditions : full load scale 5 kg, calibration load 1 kg, chart speed 20 cm/min, and downward and upward cross-head speeds 10 and 20 cm/min, respectively.

Biscuit : Biscuits (salty types), like bread, were also prepared from wheat as well as from wheat flour plus TKP blends (15, 25 and 35% levels), according to Sultan (1976) with two baking tests.

TKP jelly : Samples of 16 g roasted TKP were thoroughly mixed individually with 100 ml water, followed by addition of 680 g sugar and another 900 ml water, before mixing again. The mixture was transferred to a stainless steel beaker (2 l), boiled for 45 min, before adding 5 g citric acid. Following filtration through a muslin cloth, the suspension was allowed to set in a bottle after addition of a trace of permitted colour (sunset yellow) and flavour (pineapple). If and when required, sodium benzoate (140 ppm) was added prior to setting as a preservative (AOAC 1980). For comparison, a standard pectin jelly was prepared under identical conditions, substituting TKP by 8 g (85 grade) pectin (SISCO Research Laboratories, Bombay). Both jellies were made in triplicates.

Gel strength : Gel strength was measured by the knife-raising method, similar to that suggested by Ranganna (1977). Fifty ml gel suspension, prior to setting, was poured into a jelly glass containing a knife and allowed to cool at 25°C for 24 h. The relative gel strength was then compared with standard pectin jellies of 200, 150, 100 and 50 grades. Gel strength was reported as the time required to raise the knife from the bottom of the 50 ml jelly of 3 cm thickness by a weight of 50 g (applied by a lever system). The reported values are means of six observations.

Jelly grade : Jelly grade was determined (Ranganna 1977) by taking 1 g TKP with varying (80-100 g) levels of sugar and preparing jellies, as described earlier. These were then compared with standard 100 grade pectin jelly (SISCO Research Laboratory, Bombay), based on physical observation, by pressing with a finger and by scooping with a spoon. Triplicate observations were made.

Gel setting rate : In order to determine the gel setting time (Ranganna 1977), about 50 ml gel suspension, prior to setting, was poured into a 100 ml beaker at room temperature (28-30°C) and the time required for complete setting of the jelly was noted, using a stop watch. Complete setting was judged by inverting the beaker, by pressing with a finger and by scooping with a spoon, as described earlier. Triplicate observations were made.

Sensory evaluation : Sensory evaluation of bread, biscuit and jelly samples was carried out on a 9-point Hedonic scale (Ranganna 1977) (9: like extremely; 1: dislike extremely), where a score of 5 points was the limit of acceptance. The panelists were asked to score appearance, texture, taste, flavour, and overall acceptability of coded samples. The taste panels consisted of 10, 10 and 20 judges for bread, biscuit and jelly, respectively. They were also asked to comment specifically on the texture of bread, crispness of biscuits and on the body of the jelly.

Computation and statistical evaluation : Duncan's Multiple Range test (DMRT) and 't' test (Little and Hill 1978) were applied to analyze the differences in the experimental observations.

Results and Discussion

TKP bread: Results on physical, textural and sensory characteristics of the bread samples are presented in Table 1. The specific loaf volume decreased with increase in the level of TKP in the

TABLE 1. PHYSICAL, TEXTURAL AND SENSORY CHARACTERISTICS OF TKP-FORTIFIED BREAD

	Level of TKP fortification, %					
	0	5	10	15	20	SEM ±
Specific volume, cm^3/g	4.1	3.4	3.1	2.5	2.4	-
Moisture content, %	39.2	39.2	40.3	41.0	41.8	-
Textural parameters						
Hardness, (kg)	0.61^a	1.41^b	3.43^b	3.87^b	5.55^c	0.19
Springiness, mm	8.43^a	6.78^b	7.28^b	6.70^b	6.60^b	0.23
Cohesiveness, dimensionless	0.228^a	0.234^b	0.238^a	0.233^a	0.284^a	0.025
Sensory characteristics						
Appearance	7.60^a	7.33^a	7.38^a	6.61^b	4.83^c	0.18
Texture	8.22^a	8.17^a	7.28^b	5.61^c	4.22^d	0.28
Taste	8.39^a	8.39^a	8.33^a	8.22^a	8.06^a	0.19
Flavour	8.44^a	6.44^b	6.78^b	6.22^b	5.06^c	0.38
Overall acceptability	8.56^a	8.44^a	7.56^b	6.00^c	4.00^d	0.25

Values in horizontal rows with different superscripts differ significantly ($p \leq 0.05$) according to Duncan's Multiple Range Test. SD values ranged from ±0.03 to ± 1.48 for sensory characteristics and from ±0.051 to ± 1.08 for textural parameters, while df (SEM) are 40 and 45, respectively.

flour mix. The breads became slightly more squat and compact, while the grain became more dense, and the resilience to finger pressure decreased. The correlation was highly significant ($r = -0.983$, $p \leq 0.01$). TKP had higher protein content than wheat flour, and therefore, one would perhaps expect TKP bread to give a higher loaf volume. However, it is not the total quantity of protein in the flour mix, but the relative proportion of gluten and its appropriate development, that permit expansion of the dough during fermentation and early stages of baking (Shakuntala and Sadaksharaswamy 1987). The increasing levels of TKP, while increasing the total proteins, also proportionately reduced the wheat gluten in the mix, thereby possibly reducing the loaf volume.

Among the sensory attributes, the score for appearance decreased significantly ($p \leq 0.05$) with TKP level above 10% and the bread became unacceptable at 20% TKP level. Bread texture did not change significantly upto 10% replacement, but deteriorated rapidly above 10% TKP. The bread became too dense and compact in case of 20% TKP and was rejected by the judges. The taste score or mouthfeel remained unaffected due to TKP fortification, although flavour was adversely affected even at 5% TKP level. Addition of TKP negatively influenced the overall acceptability of the breads, but the judges accepted breads upto a level of 15% TKP. Instances of an uncertain odour adversely affecting the flavour of foods are not rare. A person not used to a food item may show an adverse response at the first bite due to an apparently uncertain flavour, but may develop an acquired taste at the second and subsequent bites, and end up liking the item. A case in point, for instance, is bitter gourd, a vegetable liked by many in India.

Table 1 also presents results of the objective analysis of the textural parameters of the breads. Hardness, measured as the peak resistance offered by the bread samples during compression, changed significantly from the control bread even at 5% level of TKP fortification, and the breads became tough. Springiness or elasticity, a measure of the quickness of recovery when the compressive force is removed, decreased with increase in the level of TKP fortification. Cohesiveness, a measure of the force required to tear apart a bread sample, did not change significantly from that of the control sample, although it tended to increase slightly, when the blending level reached 20%.

Correlation studies (results not presented) revealed that the overall acceptability of the bread had high correlation with appearance, texture and taste, but non-significant relationship with flavour.

TABLE 2. PHYSICAL AND SENSORY CHARACTERISTICS OF TKP-FORTIFIED BISCUITS

	Level of TKP fortification, %					
	0	5	10	15	20	SEM
Physical parameters						
Thickness	5.08[a]	5.14[a]	5.10[a]	4.67[b]	4.28[c]	0.06
Spread ratio	9.96[a]	9.71[a]	9.83[a]	10.87[b]	11.89[c]	0.14
Spread factor	100.0[a]	97.5[a]	98.7[a]	109.2[b]	117.7[c]	1.44
Sensory characteristics						
Appearance	8.42[a]	8.17[a]	8.17[a]	7.42[b]	6.67[c]	0.20
Taste	8.50[a]	8.58[a]	8.42[a]	8.17[a]	8.00[a]	0.10
Crispness	8.58[a]	8.25[a]	7.08[b]	6.17[c]	4.75[d]	0.22
Overall acceptability	8.67[a]	8.50[a]	7.00[b]	5.33[c]	4.50[d]	0.24

Values in horizontal rows with different superscripts differ significantly ($p \leq 0.05$) according to Duncan's Multiple Range Test. SD values ± 0.06 to ± 1.9, df (SEM=55)

TKP biscuit : Results on physical and sensory characteristics of TKP-fortified biscuits (Table 2) showed that the appearance of TKP-fortified biscuits was adversely affected ($p \leq 0.05$). Beyond a blending level of 15% TKP, the biscuits turned golden brown to dull brown. The taste of the biscuits did not differ significantly ($p \leq 0.05$), except at 35% TKP level, where a slight beany flavour reduced the score. There was a progressive reduction in the crispness of biscuits with increasing TKP level. Biscuits with 35% TKP became hard and lacked the characteristic crispness, thereby reducing the sensory score to below acceptance level (≤ 5). Similar results were also observed for overall acceptability, thereby indicating a close correlation between the two sensory traits. Results of the compression tests on prepared biscuits also showed fewer cracking points and increased hardness at 35% TKP level, as compared to the control (Fig 1).

Among the physical characteristics, thickness of the biscuits was significantly affected ($p \leq 0.05$) above 15% TKP fortification. It decreased with increasing level of fortification. Hence, expansion was reduced during baking, but spreading increased during shaping, as indicated by a significant ($p \leq 0.05$) increase in spread ratio and spread factor for the sample containing more than 15% TKP. Correlation studies showed crispness to be highly correlated with thickness, spread ratio and spread factor, the latter two being negatively related to each other.

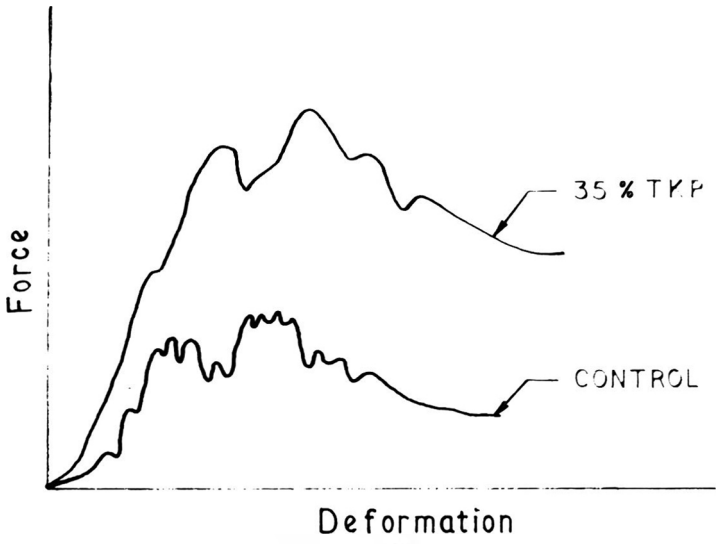

Fig. 1. Pattern of force-deformation curves of biscuits during compression in Instron (not to scale)

Among the sensory attributes, overall acceptability had significant relationship ($p \leq 0.01$) with other sensory characteristics, including crispness. Thus, judges liked the biscuits upto 15% TKP incorporation, while the biscuits were disliked beyond this level. Based on the sensory overall acceptability, biscuits upto 15% TKP level, therefore, could be considered acceptable.

TKP jelly : TKP was also used as a substitute for pectin in synthetic jelly. The prepared jelly was found to have a grade between 80 and 85. The organoleptic scores of both pectin and TKP jellies are shown in Table 3. No significant organoleptic difference ($p \leq 0.05$) was noted in their overall acceptability. The data suggest that TKP can be used as a substitute for pectin in the preparation of jelly.

The effect of addition of citric acid on gel strength is shown in Fig 2. Citric acid had a negligible effect on gel strength of TKP jelly, while its effect on pectin jelly increased sharply upto 0.2% of added citric acid and only slightly thereafter. It may also be noted that, for the amounts of citric acid added (0-1.0%), the maximum gel strength of pectin jelly was only slightly higher than that of

TABLE 3. SENSORY CHARACTERISTICS OF PECTIN AND TKP JELLIES BY ORGANOLEPTIC TESTS

Attribute	Pectin jelly	TKP jelly	Remarks
Appearance	8.75	8.48	No significant differences noted
Texture	8.53	8.33	
Taste	8.45	8.68	
Flavour	8.65	8.18	
Overall acceptability	8.73	8.35	

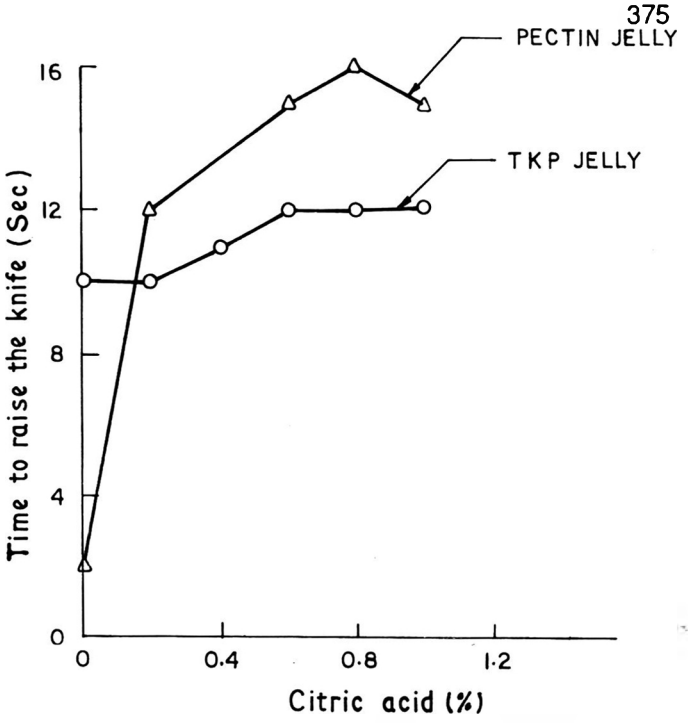

Fig.2 Effect of citric acid on gel strength of TKP (0—0) and pectin (Δ—Δ) jellies

TKP jelly, thereby indicating a relatively softer consistency of the latter.

Overall, TKP, with its good gelling property, high protein content (18.4%) and low cost (about Rs. 5 per kg), could be a good substitute for pectin in the preparation of jelly.

References

AOAC (1980) Official Methods of Analysis, 13th ed. Association of Official Analytical Chemists, Washington, DC

Bhattacharya Sila (1990) A study on the processing and utilization of tamarind (*Tamarindus indica*) kernel for food uses. Ph.D. Thesis, Indian Institute of Technology, Kharagpur

Bhattacharya S, Gangophyay H, Chaudhury DR (1983) Tamarind kernel powder as pectin substitute in food industries. Proceedings of National Conference on Fruits and Vegetables Processing Industry, Association of Food Scientists and Technologists (India), Calcutta, pp 61-64

Bhattacharya Sila, Bal S, Mukherjee RK, Bhattacharya Suvendu (1991) Rheological behaviour of tamarind (*Tamarindus indica*) kernel powder suspension. J Food Eng 13:151-158

Bourne MC (1982) Food Texture and Viscosity-Concept and Measurement, Academic Press, New York

Campos JE, El-Dash AA (1978) Effect of addition of full fat sweet lupine flour on rheological properties of dough and baking quality of bread. Cereal Chem 55:619-627

D'Applonia BL, Youngs VL (1978) Effect of bran and high protein concentrate from oats on dough properties and bread quality. Cereal Chem 55:736-743

Forest Research Institute, Dehra Dun, India (1955) Tamarind has many uses. Indian Farming 5(8):21-22, 24

Jambhulkar V, Shankhapal KV (1992) Effect of minerals on lipid production by *Rhizopus nigricans* and *Penicillium nigricans* on tamarind kernel powder. J Food Sci Technol 29:333-335

Lewis YS, Neelakantan S (1964) The chemistry, biochemistry and technology of tamarind. J Sci Indus Res 23:204-206

Little TM, Hill MJ (1978) Agricultural Experimentation : Design and Analysis. John Wiley and Sons, New York

Marangoni A, Alli I, Kermasha S (1988) Composition and properties of seeds of the tree legume *Tamarindus indica*. J Food Sci 53:1452-1455

Ranganna S (1977) Manual of Analysis of Fruit and Vegetable Products. Tata McGraw Hill Publishing Co., New Delhi

Rao KH, Subramanian N (1984) Nitrogen solubility and functional properties of tamarind seed kernel proteins. Proceedings of National Symposium on Protein Foods and Feeds, Madras, India, pp 67-84

Rao PS, Srivastava HC (1974) Tamarind. In: Whistler RL (ed) Industrial Gums. Academic Press Inc., New York, pp 370-411

Reddy DV, Prasad DA, Reddy BS, Charyulu EK (1986) Effect of replacing maize with tamarind seed or rice polish on the performance characteristics and nutrients utilization by *desi* pigs. Indian J Animal Sci 10:108-112

Shakuntala MN, Sadaksharaswamy M (1987) Foods : Facts and Principles, Wiley Eastern Ltd., Delhi

Sultan WJ (1976) Practical Baking, 3rd ed. The AVI Publishing Co. Inc., Westport Conn

Vishnu Bhat A, Pattabhiraman TN (1985) Action of proteinase inhibitors in six under utilized seeds on human and bovine pancreatic proteinase. J Food Sci Technol 22:277-281

Received 25 September 1991; revised 29 December 1993; accepted 31 December 1993

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 377-379

Acceptability and Nutritive Value of Puffed Soya as a Snack Food

S. KANCHANA AND S. NEELAKANTAN*
Department of Food Science and Nutrition,
Agricultural College and Research Institute, Madurai-625 104, India.

Seven varieties of soybeans were evaluated for their potential in making puffed soya snack. Soaking of soybean for 2 and 3 h in a solution containing 5% salt plus 3% sodium bicarbonate was found to completely eliminate flatus compounds in 'CO 1' and 'Local' varieties, respectively. The formulated puffed soya snack provided 40% proteins, 19.0% fat and 420 Kcal energy/100 g product. The puffing process reduced beany flavour and bitter taste, in addition to the elimination of flatus compounds. The crisp and tasty puffed soya was found to be well accepted. Data revealed that puffed soya can be introduced as a protein-rich snack food, and as a substitute for other costly nuts.

Keywords : Soybean varieties, Puffed soya snack, Flatus compounds, Puffing characteristics, Organoleptic properties, Nutritive value.

Protein-calorie malnutrition (PCM) amongst children is prevalent in some parts of the country (Subramanian 1983). Many efforts have been undertaken to ameliorate this socio-economic problem. One of these is the formulation of high protein foods (Aiyar 1984). Soybean is becoming increasingly popular in many States including Tamil Nadu. Soybean contains high amounts of fat and proteins, although there are some differences in varieties (Sood et al. 1977, Subramanian 1983). Popularizing soybean in the diet will help in combating protein-calorie malnutrition in children to a certain extent.

Children need extra food for their growth and metabolism. Therefore, snacks for the children should be nourishing and contribute a fair share of needed nutrients. There are an almost unlimited number of wholesome snacks that can be easily prepared and stored (Aiyar 1984; Das 1992). Puffed cereals and legumes, mixed with roasted oilseeds and desiccated coconut (salted and spiced), are a few popular snack foods. Among the nuts, cashew and groundnut are commonly used, but are costly. Hence, a need exists to find out cheaper substitutes. Soybean, which is available at a low price and in plenty, would be a potential substitute (Subba Rao and Prasannappa 1989). Although soybean has some undesirable constituents like trypsin inhibitors (Bianchi et al. 1983), the information available on processing of soybean for food use could be judiciously adopted to get rid of these factors and to have delicious puffed soybean. This will provide ample scope for the direct utilization of soybean as a nutritious snack food. The results on the puffing characteristics of seven varieties of soybeans and the elimination of flatus compounds in the snack foods are reported in the present paper.

Materials and Methods

Soybean varieties 'Hardee', 'UGM 34', 'UGM 30', 'Khsb 2' and 'MACS 124' were obtained from the School of Genetics, Tamil Nadu Agricultural University, Coimbatore. These were grown in the year 1991 at Coimbatore during the *kharif* season. Variety 'CO 1' was obtained from Sakthi Soyas Ltd., Coimbatore, and the 'Local' variety was purchased in Madurai market in the year 1991.

Preparation of puffed soybean : The process developed by Subba Rao and Prasannappa (1989) was adopted for the puffing of soybeans, with slight modifications. Preliminary trials were conducted to optimize conditions for the puffing of soybean varieties 'CO 1' and 'Local'. Thereafter, all the varieties were puffed under optimized conditions and organoleptically evaluated. Puffing of soybean was done after different soaking periods, viz., 30, 45, 60, 75, 120 and 180 min in a solution containing 5% common salt plus 3% sodium bicarbonate. After the completion of the soaking period, the excess solution was drained-off and the soybean was puffed for 4 to 5 min in a hot sand bath maintained at 250°C. The puffed bean was sieved using a metal sieve BS 20 and cooled. The husk was removed and the bean was split into *dhal* manually by rubbing. The split *dhal* was winnowed to obtain puffed soy *dhal*. The organoleptic evaluation was carried out by a panel of ten untrained judges for colour, flavour, texture, taste and overall acceptability on a Hedonic scale rating, using 4.0 as the maximum score.

* *Corresponding Author*

TABLE 1. MEAN ORGANOLEPTIC SCORES OF THE PUFFED SOYBEAN AFTER DIFFERENT SOAKING PERIODS

Quality attributes	Soaking period, min															
	30	45	60	75	120	180	SED	CD	30	45	60	75	120	180	SED	CD
	'CO 1' variety								'Local' variety							
Colour	2.5	2.6	3.5	3.5	3.6	3.8	.036	.080*	3.0	3.0	3.0	3.6	3.6	3.7	.020	.044*
Flavour	3.0	3.6	4.0	4.0	4.0	4.0	.036	.080*	3.7	3.7	3.7	4.0	4.0	4.0	.014	.032*
Texture	3.0	3.6	3.0	3.5	4.0	4.0	.038	.084*	3.7	3.7	3.7	3.7	3.9	4.0	.018	.040*
Taste	2.0	2.3	3.2	3.5	3.9	3.4	.069	.152*	3.2	3.2	3.2	3.6	3.9	3.5	.031	.069*
Overall acceptability	2.5	2.8	3.2	3.5	3.9	3.5	.041	.091*	3.2	3.2	3.2	3.6	3.9	3.5	.013	.030*

* Significant at 5% level.

Physico-chemical analysis : Moisture and ash were determined according to standard AOAC (1984) methods. Protein was determined by the micro-Kjeldhal method using the factor 6.25 (Pearson 1976). Fat was determined as per Hart and Fischer (1971). The physical parameters like weight, volume and bulk density were estimated in the raw and puffed soya samples as per Subba Rao and Prasannappa (1989).

The method described by El Faki et al (1984) was followed for the estimation of flatus compounds by *in vitro* gas production experiment. Samples were fermented anaerobically by *Clostridium perfrigens* and the quantity of gas produced was measured directly in air-tight syringes. One hundred ml of the sterilized and cooled Clostridial medium broth (Subba Rao 1977) was taken in 250 ml conical flasks. The soybean samples, after various treatments, were added aseptically at 1% level to this broth. One ml of the actively growing *Cl. perfringens* inoculum was transferred into the broth through a sterile pipette. The flasks were incubated at room temperature for 24 h under static condition. Four ml of the incubated broth was drawn into syringes, which were fixed with a hypodermic needle. The needles were plunged into sterile rubber stoppers to provide air tightness. All the syringes, were incubated at room temperature (30-40°C). After 48 h of incubation, the gas produced was directly read off from the calibrations on the syringe. The results were expressed as ml of gas produced per 4 ml broth.

Results and Discussion

The mean scores of the organoleptic properties of puffed soybean are given in Table 1. It was observed that soaking for 2 h in 5% salt plus 3% sodium bicarbonate solution, prior to puffing, was optimum for the puffing of soybean. Statistical analysis of the data revealed significant differences in the organoleptic properties of the varieties.

The effect of soaking on the flatus compounds revealed that soaking periods of 3 and 2 h were necessary for the 'Local' and 'CO 1' varieties to completely eliminate the flatus compounds. Soaking the dry beans for 14 h in water resulted in appreciable losses of sucrose, raffinose and stachyose as a result of diffusion. Ku et al (1976) reported that the addition of 0.5% sodium bicarbonate during cooking of the beans accelerated the removal of oligosaccharides. Bianchi et al (1983) observed that soaking and subsequent cooking for 1 h in water decreased the soybean oligosaccharide contents by 85%.

Under these optimized conditions of soaking in 5% salt plus 3% sodium bicarbonate solution for 2 h, all the varieties were puffed and organoleptically evaluated. The results are given in Table 2. The varieties, 'Local', 'CO 1', 'Khsb 2' 'UGM 30' obtained maximum scores, followed by 'MACS 124', 'Hardee' and 'UGM 34'. The differences in the organoleptic properties between varieties were highly significant statistically. The puffing quality of the soybean was determined based on the bulk density. The initial volume of the raw soybean ranged

TABLE 2. MEAN ORGANOLEPTIC SCORES OF DIFFERENT VARIETIES OF PUFFED SOYBEAN

Variety	Quality attributes				
	Colour	Flavour	Texture	Taste	Overall acceptability
'Khsb w'	3.5	3.6	3.6	3.6	3.6
'UGM 30'	3.5	3.6	3.6	3.5	3.6
'UGM 34'	2.6	3.6	3.4	2.5	2.9
'MACS 124'	3.6	3.6	3.6	3.3	3.3
'Hardee'	2.9	3.6	3.4	3.3	3.4
'Local'	3.7	3.8	3.9	3.8	3.8
'CO 1'	3.6	3.8	3.8	3.7	3.7
SED	0.17	0.10	0.12	0.12	0.14
CD	0.64*	0.37*	0.45*	0.45*	0.52*

Soaking of soybean was done for 120 min in 5% salt plus 3% sodium bicarbonate solution.

* - Significant at 5% level

TABLE 3. CHEMICAL COMPOSITION OF PUFFED SOYA SNACK (g%)

Variety	Moisture	Protein	Fat	Ash
'Khsb 2'	1.35	43.8	19.3	5.8
'UGM 30'	1.35	42.0	18.2	5.9
'UGM 34'	1.08	40.2	19.0	6.2
'MACS 124'	1.60	40.2	18.9	6.8
'Hardee'	1.65	42.0	19.7	6.8
'Local'	1.23	38.5	19.9	6.1
'CO 1'	1.36	40.2	19.3	6.1
SED	0.03	0.30	0.19	0.19
CD	0.12**	1.13**	0.71**	0.71**

Soaking of soybean was done for 120 min in 5% salt plus 3% sodium bicarbonate solution.

** Significant at 1% level

TABLE 4. FLATUS COMPOUNDS IN RAW AND PUFFED SOYBEAN

Variety	Flatus compounds, volume of gas produced/4 ml broth	
	Before puffing	After puffing
'Khsb 2'	7.1	0.3
'UGM 30'	8.3	0.1
'UGM 34'	7.3	0.5
'MACS 124'	7.5	0.6
'Hardee'	7.1	0.5
'Local'	7.0	1.0
'CO 1'	7.3	0.6
SED	0.15	0.09
CD	0.57**	0.33**

Soaking of soybean was done for 120 min in 5% salt plus 3% sodium bicarbonate solution. ** Significant at 1% level

between 74 and 75 ml per 50 g and the bulk density before puffing ranged between 0.63 and 0.68 g/ml. The volume increase after puffing ranged between 116 and 123 ml per 50 g and the bulk density ranged between 0.38 and 0.44 g/ml. This indicates good puffing of all the varieties tested.

The data on the chemical constituents of puffed soybean are given in Table 3. Statistical analysis of the data revealed a highly significant difference between the varieties analyzed for their chemical constituents. The protein content ranged between 38.50 and 43.75%, while the fat content varied from 18.16 to 19.85 %.

It was found that the gas production was significantly reduced by soaking and puffing treatments, in case of all the varieties of soybean tested (Table 4). The oligosaccharides, being soluble in water, are leached out in the soak water and hence get eliminated. Soaking has been traditionally practised in India for many foodgrains; e.g., before grinding in the preparation of *idli* (fermented and steamed rice food), *dosa* (fermented and fried rice food) and *sundal* (soaked and steamed pulse food). (Susheelamma and Rao 1974). Salunkhe (1982) has also reported that germination, soaking, cooking and autoclaving considerably reduced the amounts of oligosaccharides in the beans.

Acknowledgements

The authors are thankful to M/s Sakthi Soyas Ltd., Coimbatore and the Director, School of Genetics, Tamil Nadu Agricultural University, Coimbatore, for providing the soybean samples. The authors wish to thank Dr. G. Sridharan, Professor, Department of Microbiology, Christian Medical College Hospital, Vellore, for providing a pure culture of *Cl. perfringens*. S. Kanchana thanks Tamil Nadu Agricultural University for a Senior Research Fellowship.

References

Aiyar AS (1984) Scope for promotion of soy products in India. Indian Food Industry 3:3-7

AOAC (1984) Official Methods of Analysis, 14th ed. Association of Official Analytical Chemists, Washington, DC

Bianchi MIP, Silva HC, Campos MAP (1983) Effect of several treatments on the oligosaccharide content of a Brazilian soybean variety *Glycine max* (L) Merrit. J Agric Food Chem 31:1363-1364

Das HK (1992) Crisp and spicy soybean snack. J Food Sci Technol 29:387-389

El Faki MA, Bhavanishankar TN, Venkataraman LV, Tharanathan RN, Desikachar HSR (1984) Presence of an inhibitor factor to gas production by *Clostridium perfringens* in husks of chick pea, cowpea and horsegram. J Food Sci Technol 21:259-261

Ku S, Wei MP, Steinberg AI, Hymowitz T (1976) Extraction of oligosaccharides during cooking of whole soybean. J Food Sci Technol 4:361-364

Hart AM, Fischer HJ (1971) Modern Food Analysis, Springer Verlag, Heidelberg

Pearson D (1976) The Chemical Analysis of Foods. Churchill Livingston, Edinburgh

Salunkhe DK (1982) Legumes in human nutrition - Current status and future research needs. Curr Sci 5:387-394

Sood DR, Wagle DS, Nainawatee HS, Gupta VP (1977) Varietal differences in the chemical composition of soybean. J Food Sci Technol 14:177-178

Subba Rao, Prasannappa G (1989) Studies on the physico-chemical parameters of expanded soybean. J Food Sci Technol 20:252-254

Subba Rao NS (1977) Soil Microorganisms and Plant Growth. Oxford and IBH Publishing Co., New Delhi

Subramanian N (1983) Processed food for better nutrition at lower operational cost, In: Neelakantan S (ed.) Proceedings of Workshop on Poverty and Malnutrition. Arul Jothi Printers, Coimbatore, pp 281-285

Susheelamma NS, Rao MVL (1974) Surface active principle in blackgram and its role in the texture of leavened foods containing the legume. J Food Agric 25:665-673

Received 7 September 1992; revised 24 December 1993; accepted 3 January 1994

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 380-384

Effect of Methods of Juice Extraction from Kinnow Mandarin on the Composition and Quality of Juice, Pomace and Peel

R.E. LOTHA AND D.S. KHURDIYA*
Division of Fruits and Horticultural Technology,
Indian Agricultural Research Institute, New Delhi-110 012, India.

As the quality of kinnow mandarin products is affected by the methods of juice extraction, five different methods of juice extraction, viz., hydraulic pressing (HP), hand reaming (HR), using screw type juice extractor (SE), crushing without peel (CWP), and crushing with peel (CP) were evaluated. The juice yield was in the range of 36.36 to 48.40%. The pomace possessed variable amounts of pectin, and the peel contained pectin and essential oil. The CP method yielded the highest amount of juice and had the highest values for total soluble solids, ascorbic acid, pectin, cloudiness, viscosity and pulp content, but had the lowest acidity. A strong positive relationship existed between the pulp content and cloudiness of the juices. The sugars were not much influenced by the methods of extraction. A tremendous effect was, however, noticed on the carotenoid and Hunter colour values of the juices. The juice obtained from CP method was not acceptable due to its intense bitterness, while the juices obtained by hydraulic pressing and hand reaming were not bitter.

Keywords : Kinnow mandarin, Juice extraction methods, Juice recovery, Juice quality, Bitterness, Ascorbic acid, Pomace, Juice and peel composition.

Kinnow mandarin cultivation has assumed greater importance and popularity among North Indian citrus growers, and a large acreage is being brought under its cultivation particularly in Punjab, Haryana, Rajasthan and Himachal Pradesh (Chundawat et al. 1978; Mann 1978). Availability of large quantities of fruit might, over a short harvesting period, pose problems for efficient marketing and utilization, owing to the perishable nature of the fruit. Some studies have also been done on the effect of harvesting periods on shelf-life and quality of kinnow fruits (Nagar 1993).

Even though a few methods have been in use for the extraction of citrus juices, only screw type juice extractor is used to extract the juice from kinnow mandarin (Pruthi 1978; Ramteke and Eipeson 1990) . Reports have also appeared on the thermal processing of kinnow juice and its shelf-life (Ranote et al. 1993; Nath and Ranganna 1977). No detailed investigation has been conducted on the effects of different extraction methods on the physico-chemical composition of juice, pomace and peel. Hence, the present investigation was carried out and the data are reported in the present paper.

Materials and Methods

Juice extraction : Fresh kinnow mandarin fruits were procured from the local market. After sorting and thorough washing with water, the fruits were subjected to five different methods of juice extraction. In hydraulic pressing (HP), the juice from the manually peeled fruits was extracted in a hydraulic rack and cloth press (Johnston Automation Co., New Delhi) at 150 kg/sq cm pressure using a filter cloth. In hand reaming (HR), the fruits were cut into two halves and the juice was then extracted by pressing and rotating the cut halves against a hand reamer (plastic, locally made). Using screw type juice extractor (SE), the manually peeled fruits were fed into a power operated extractor (screw type, Gardner Corporation, New Delhi) for the extraction of the juice. In case of crushing without peel (CWP), the manually peeled fruits were crushed in a fruit mill (Amos Maschinenfabrik K.G. Masch. Art F11 Masch-Nr. 133, Germany) and passed through a pulper (Baby Pulper, Gardner Corporation, New Delhi) having 0.078 cm mesh sieve. For juice extraction by crushing with peel (CP), the whole fruits with peel were used as described for CWP. The juices extracted by HP, HR and SE methods were passed through a 18 mesh sieve. In all the cases, the juices were heated to 90°C, bottled, sealed, held for 5 min in hot water (90°C) and allowed to cool under the fan.

Physico-chemical characteristics : The recovery of juice, pomace, peel and preparatory loss were expressed as % of the original fruit weight. The total soluble solids (TSS) of the samples were recorded using a refractometer (Mark II, Abbe, Leica Inc, Buffalo, New York) at 20°C. The pH was measured at 20°C. Ascorbic acid was determined by 2, 6-dichlorophenol indophenol visual titration method

* Corresponding Author

(Freed 1966). Sugars were estimated by the method of Lane and Eynon (1923). The acidity, carotenoids and pectin (as calcium pectate) were determined by the methods described by Ranganna (1986). Viscosity was measured at 25°C in viscometer (Digital, Brook Field Engineering Laboratories, Inc, Stoughton, Mass) and expressed as centipoise units (CPU) as described by Ranganna (1986). The colour was measured on Hunter L, a, b scale using colorimeter (Gardner colourgard system /05, Pacific Scientific, Silver Spring) and expressed as total colour = $\sqrt{(L)^2+(a)^2+(b)^2}$ and hue angle $\phi = \tan^{-1}$ b/a (Ranganna 1986; Little 1975). For cloudiness, the juice was centrifuged for 10 min at 360 x **g** (Krop et al. 1974) and % transmission of the supernatant was measured at 660 nm in a 1- cm cuvette in a Spectrophotometer (Model CL-24, Elico, Hyderabad). The density was expressed as mass by volume. The peel oil was extracted from the kinnow peel by hydrodistillation method (Lotha 1992), until the oil was fully extracted and expressed as % of the peel. Sensory evaluation for bitterness was judged by a panel of 7 staff members on a 5- point scale (Larmond 1977). Kinnow juice was also made into nectar and squash (Lotha 1992; Lal et al. 1986) to evaluate their bitterness. Squash contained 40% juice, having 45° Brix and 1.0% acidity, while nectar contained 40% juice, but 15° Brix and 0.3% acidity. The squash was preserved in sulphur dioxide (350 ppm) and nectar by heat processing (90°C).

Results and Discussion

Recovery of juice, pomace and peel : It is evident from the data (Table 1) that the recovery of juice, pomace and peel was greatly influenced by the methods of juice extraction. The juice yield was in the range of 36.36 to 48.40%, similar to the values reported by other workers (Jawanda et al. 1973; Bhuller 1982). Maximum juice recovery was obtained by CP method, followed by CWP, HP, SE and HR methods. High juice recovery by CP and CWP methods might be due to additional juice from the peel and juice sacs. The next bext juice recovery by HP method is probably due to complete removal of the juice from the juice sacs. The low percentage of juice in the HR method could be due to incomplete breaking of the juice sacs. The pomace yield ranged from 12.94 to 42.47%, against a range from 20.11 to 47.10% reported earlier (Bal and Chohan 1983; Jawanda et al. 1973; Pruthi 1978). Higher % of pomace obtained in CP method was due to the contribution by peel content, as whole fruit was crushed and pulped in this method. The low % pomace in HR method was obviously due to the removal of the juice sacs and membranes at the time of reaming. High percentage of peel got in the method can be justified similarly.

The peel recovery ranged from 26.65 to 40.86% and this is higher than that reported by Pruthi (1978), but lower than that observed by Sethi et al (1980). The small differences in the peel recovery by HP, SE and CWP methods, where the peels had been removed in the same manner, might be due to the differences in the thickness of the peel and size of the fruits. The preparatory loss was minimum in HP method (1.95%), followed by SE method. The three methods, viz., HR, CWP and CP, showed other similar preparatory losses.

Physico-chemical characteristics of pomace and peel : The methods of juice extraction have significantly influenced some of the physico-chemical characteristics of pomace and peel (Table 2). The higher TSS observed in pomace, obtained by CWP and CP methods, showed that crushing the fruits with or without peel increased TSS. Pomace from HR method had the lowest TSS, because less solids

TABLE 1. EFFECT OF METHODS OF JUICE EXTRACTION ON % YIELDS OF JUICE, POMACE AND PEEL

Extraction methods	Juice, %	Pomace, %	Peel, %	Preparatory loss, %
Hydraulic pressing	46.11	23.90	28.04	1.95
Hand reaming	36.36	12.94	40.86	9.84
Using screw type juice extractor	39.94	26.65	26.65	6.76
Crushing without peel	47.14	14.10	29.00	9.78
Crushing with peel	48.40	42.47	-	9.13

TABLE 2. EFFECT OF METHODS OF JUICE EXTRACTION ON THE IMPORTANT CONSTITUENTS OF POMACE AND PEEL

Extraction methods	Pomace			Peel	
	TSS, %	Acidity, %	Pectin %	Pectin, %	Oil, %
Hydraulic pressing	10.0	0.65	6.04	7.94	0.40
Hand reaming	9.0	0.92	4.58	7.84	0.30
Using screw type juice extractor	10.5	0.78	4.64	7.92	0.40
Crushing without peel	11.0	0.74	8.36	7.93	0.40
Crushing with peel	11.0	0.55	8.96	-	-

TABLE 3. EFFECT OF METHODS OF JUICE EXTRACTION ON THE PHYSICO-CHEMICAL COMPOSITION OF KINNOW MANDARIN JUICE

Extraction methods	TSS, %	pH	Acidity, %	Pectin, %	Viscosity, CPU	Density, g/ml	Ascorbic acid, mg/100 ml	Reducing sugars, %	Sucrose, %	Total carotenoids, mcg/100 g	Beta-carotene, mcg/100 g
Hydraulic pressing	10.45	3.50	0.79	0.34	4.85	1.00	18.48	4.38	3.70	6.38	2.16
Hand reaming	10.90	3.39	0.79	0.54	6.80	1.00	16.97	4.68	3.57	19.23	8.26
Using screw type juice extractor	10.70	3.54	0.74	0.97	19.05	1.02	18.30	4.18	3.99	18.07	6.01
Crushing without peel	12.00	3.67	0.71	1.52	89.00	1.03	20.27	4.65	4.07	20.14	11.34
Crushing with peel	12.25	3.85	0.54	3.56	600.00	1.03	26.50	4.83	3.69	31.70	10.56

had come out from the juice sacs and membranes. The acidity was maximum in pomace from HR method, which had the minimum pectin and TSS, thereby indicating that the organic acids were present mostly in the juice portion. The low acidity in the pomace from CP method might be due to the presence of high proportion of flavedo and albedo portions. The high pectin content in pomace from CP and CWP methods indicated that the peel, juice sacs and membranes had been crushed to a greater extent.

The pectin content of kinnow peel was similar in case of all the methods of juice extraction. The pectin values observed are higher than that in the earlier reports (Pruthi et al. 1961; Pruthi 1978; Rouse and Knoor 1971). The oil contents of the peels, which were removed in the same manner in HP, SE and CWP methods, were similar (0.40%), but the HR method, where the peel had a large portion of albedo, juice sacs and membranes, had 0.30% peel oil. Similarly, the pomace of the CP method contained 0.23% peel oil. The peel oils of 1.0 and 2.35% have been reported in kinnow by Pruthi et al (1984) and Chaliha et al (1963), respectively.

Composition of kinnow juice : The TSS of the juice was higher in case of CP and CWP extraction methods. The HR, SE and HP methods showed similar TSS values, which were lower, than those in the juice obtained by CP and CWP methods (Table 3). The pH of the juices extracted by different methods ranged from 3.39 to 3.85, the values being higher than those reported in an industrially produced mandarin juice (Piccolo et al. 1983). The acidity of the juices ranged from 0.54 to 0.79%. The highest and the lowest acidities were recorded in juices extracted by HP and CP methods, respectively.

Pectin contents of the juices ranged from 0.34 to 3.56% (Table 3). The highest and lowest pectin contents of the juice were recorded in case of CP and HP methods, respectively, which might be due to the presence of peel portion in the juice in the former case. In orange juice, 0.52% pectin has been reported (Ramteke and Eipeson 1990). The juice from CP method showed 123.7 times more viscosity than the least viscous juice from HP extraction method. The viscosity of the juice has a positive correlation with its pectin content. The densities of the juices obtained from CP and CWP extraction methods were more than those from rest of the methods, but the differences were not significant.

Ascorbic acid contents of juices obtained by different extraction methods were in the range of 16.97 to 26.50 mg/100 ml. This is in agreement with the values reported by Jawanda et al (1973), though a wider range was reported by Singh et al (1978) and Pruthi et al (1984). The highest and lowest ascorbic acid contents were observed in the juices extracted by CP and HR methods, respectively. The other methods had more or less similar amounts of ascorbic acid. This showed that the peel also contributed to the ascorbic acid content of the juice.

Only small differences were observed in reducing sugars and sucrose of the juice extracted by the different methods. The minimum total carotenoid and beta-carotene were recorded in the juice from HP method, while maximum contents were in case of CP and CWP methods. Higher beta-carotene in juice from CWP method, but lower value in CP-extracted juice, indicated that the beta-carotene came mostly from the crushed juice membranes and sacs. It also indicated that the high total carotenoid would not necessarily mean high beta-carotene (Table 3).

A strong positive relationship existed between the pulp content of the juice and cloudiness (Fig.

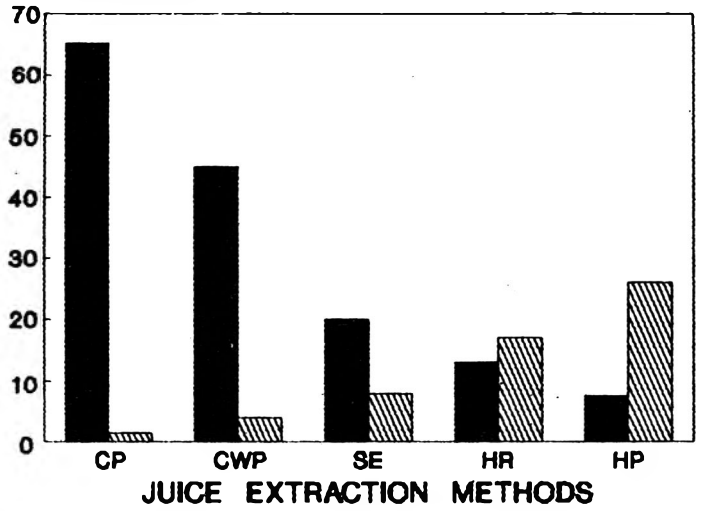

Fig. 1 Effect of methods of juice extraction on the pulp and cloudiness. ■ : Pulp, ▨ : Transmission.

1). Thus, the cloudiness increased with increase in the pulp content. The maximum pulp content was observed in juice obtained by CP method, followed by CWP, SE, HR and HP methods. A significant effect on pulp contents of juices by the extraction methods was also observed. Mohsen et al (1986) have also reported the influence of the method of juice extraction on the pulp content. Colour on Hunter scale also differed significantly with the methods of juice extraction (Table 4). The juice from CP method gave the highest values for lightness, yellowness, total colour and hue angle, though it was poorer in redness values. The attractive and bright colour was observed in the juice obtained by CWP method, which is corroborated by its highest redness values and lowest hue angle. It is inferred that the presence of peel is more responsible for yellowing in the juice. HP method gave a very poor and dull coloured juice, while the other methods (HR and SE) gave an average coloured juice.

TABLE 4. EFFECT OF METHODS OF JUICE EXTRACTION ON THE HUNTER COLOUR OF KINNOW MANDARIN JUICE

Extraction methods	L (light-ness)	+a (red-ness)	+b (yellow-ness)	Total colour	Hue angle*, degrees
Hydraulic pressing	42.23	3.39	20.30	46.98	5.99
Hand reaming	57.93	9.91	33.09	67.44	3.34
Using screw type juice extractor	60.53	10.18	32.04	69.24	3.35
Crushing without peel	63.73	13.01	33.99	73.39	2.61
Crushing with peel	77.68	4.04	46.42	90.58	11.41

* Hue ($\phi = \tan^{-1} b/a$)

TABLE 5. EFFECT OF METHODS OF JUICE EXTRACTION ON THE BITTERNESS OF KINNOW MANDARIN JUICE, NECTAR AND SQUASH

Extraction methods	Bitterness, mean score		
	Juice	Nectar	Squash
Hydraulic pressing	0	0	0
Hand reaming	0	0.12	0
Using screw type juice extractor	0.50	0.25	0.12
Crushing without peel	1.87	0.25	0.12
Crushing with peel	4.37	2.12	1.62
CD (5%)	0.56	0.63	0.54

The methods of juice extraction had a significant effect on the bitterness of kinnow mandarin juice, nectar and squash (Table 5). The juice obtained from HP and HR methods, and squash prepared from these juices as well as nectar prepared from HR extracted juice, were not bitter at all. Juice from SE method, nectar from the juice obtained by HR, SE and CWP methods and squash from SE and CWP methods, had traces of bitterness, but were acceptable. The juice obtained by CWP and CP methods and nectar as well as squash made from juice extracted by CP method, had significantly high mean scores for bitterness and these were unacceptable.

Conclusion

The methods of juice extraction influenced the physico-chemical characteristics of kinnow mandarin juice, pomace and peel. The juice obtained by HP method was without any bitterness, but poor in all other quality attributes. The CP extracted juice was too bitter, but rich in all other quality attributes. Blending of these two may result in a good quality juice, nectar and squash. It may even be possible to have juice extracted by CWP method in a similar fashion. On the other hand, pomace and peel were found to be good sources of pectin and oil.

References

Bal JS, Chohan GS (1983) A study on distribution and quality of different sized kinnow mandarin oranges harvested at optimum maturity. J Food Sci Technol 20:321-322

Bhuller JS (1982) Determination of maturity standards for mandarin at Dhaulakuan in Himachal Pradesh. Punjab Hortic J 22:35-40

Chaliha BP, Barua AD, Gohain A, Siddappa GS (1963) Studies on the utilization of Assam lemon- Preliminary observations. Indian Food Packer 17(3):5-7

Chundawat BS, Gupta AK, Singh BP (1978) Storage behaviour of different grades of kinnow fruit. Punjab Hortic J 18:156-160

Freed M (1966) Methods of Vitamin Assay. Association of Vitamin Chemists Inc, Inter Science Publishers, New York

Jawanda JS, Arora JS, Sharma JN (1973) Fruit qualities and maturity studies of kinnow mandarin at Abohar. Punjab Hortic J 13:3-12

Krop JJP, Pilnik W, Faddegon JM (1974) The assay of pectin esterase by direct gas chromatographic methanol determination - Application to cloud loss studies on citrus juices. Lebensm Wiss Technol 7:50-52

Lal G, Siddappa GS, Tandon GL (1986) Preservation of Fruits and Vegetables. Indian Council of Agricultural Research, New Delhi

Lane JH, Eynon I (1923) Determination of reducing sugars by Fehlings solution with methylene blue as an indicator. J Soc Chem Ind 42:142-146

Little AC (1975) Off on a tangent. J Food Sci 40:410-411

Larmond L (1977) Laboratory Methods of Sensory Evaluation of Food, Publication 1637. Canada Department of Agriculture, Ottawa

Lotha RE (1992) Studies on processing and storage of kinnow mandarin juice. Ph.D. Thesis, Indian Agricultural Research Institute, New Delhi

Mann SS (1978) Harvesting and storage of kinnow fruits. Punjab Hortic J 18:154-155

Mohsen SM, El-Hoshing FSA, El-Ashmawei AG (1986) Effect of method of extraction and pasteurization of grapefruit juice: Properties and its volatile components. Egyptian J Food Sci 14:397-407

Nagar PK (1993) Effect of different harvesting periods on shelf-life and quality of kinnow fruits. J Food Sci Technol 30:44-45

Nath N, Ranganna S (1977) Determination of thermal process for canned mandarin orange segments. J Food Sci Technol 14:113-114

Piccolo A, Mammi M, Licandro G (1983) Industrially produced mandarin juice. Essenze Derivati Agrumari 53:47-58

Pruthi JS (1978) Processing technology of kinnow mandarin. Punjab Hortic J 18:199-202

Pruthi JS, Manan JK, Saroja S, Chikkappaji KC (1984) Studies on the utilization of kinnow and Malta oranges. J Food Sci Technol 21:123-127

Pruthi JS, Parekh CM and Lal G (1961) An integrated process for the recovery of essential oil and pectin from mandarin orange waste. Food Sci 110:372-378

Ramteke RS, Eipeson WE (1990) Storage studies on Coorg mandarin juice concentrates packed in various containers. J Food Sci Technol 27:368-371

Ranganna S (1986) Handbook of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw Hill Publishing Co. Ltd, New Delhi

Ranote RS, Saini SPS, Bawa AS (1993) Evaluation and thermal process and shelf-life of kinnow juice. J Food Sci Technol 30:88-91

Rouse AH, Knorr LL (1971) Evaluation of pectins from Florida lemons harvested from young trees. Citrus Ind 52(9):10-14

Sethi V, Anand JC, Saxena SK (1980) Kinnow orange in juice and beverages making. Indian Hortic 25(3):13-15

Singh BP, Gupta AK, Chundawat BS (1978) Effect of various treatments of storage of kinnow fruits. Punjab Hortic J 18:61-63

Received 10 July 1993; revised 29 December 1993; accepted 4 January 1994

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 385-388

Physico-chemical and Processing Quality of Four New Mango Hybrids in Comparison to Two Commercial Cultivars

I.N. DOREYAPPA GOWDA*, K.H. RAMANJANEYA, C.P.A. IYER, M.D. SUBRAMANYAM AND M.R. DINESH
Indian Institute of Horticultural Research, Bangalore-560 089, India

Four new mango hybrids, 'Arka Aruna (H-10)', 'Arka Puneet (H-13)', 'Arka Anmol (H-17-3)' and ('H-51)', developed at the Indian Institute of Horticultural Research, Bangalore, were compared with two commercial cultivars, 'Alphonso' and 'Totapuri' to assess their physico-chemical and processing characteristics. 'Arka Puneet' and 'Arka Anmol' were very much comparable with 'Alphonso' with respect to fruit weight, volume, breadth, total soluble solids, pH, acidity, reducing sugars, total sugars, viscosity and quality of canned juice. Fruits of 'Arka Anmol' were slightly longer than 'Alphonso' and had lower firmness, whereas 'Arka Puneet' had good firmness at ripe condition. All hybrids gave marginally higher pulp yield and possessed lower peel, stone and fibre contents. Carotenoid contents of all hybrids were significantly lower than those of 'Alphonso', but higher than those of 'Totapuri', except in case of 'Arka Aruna'. Vitamin-C content was also significantly lower in all hybrids, except in 'H-51'. 'Arka Aruna' had higher fruit weight, volume, breadth and possessed lower fibre content, than all other hybrids and varieties. Both 'Arka Aruna' and 'H-51' were not suitable for canned juice preparation.

Keywords : Mango, New hybrids, Physico-chemical characters, Processing quality, Canned juice, Spongy tissue.

Although many varieties of mangoes are grown in India, very few are suitable for both table and processing purposes (Iyer et al. 1991). Of these, 'Alphonso' is the leading one in demand, due to its excellent quality and aroma (Golap and Bandopadhyay 1975). Since it fetches extremely high price as a table fruit, the processing industry finds it difficult to procure 'Alphonso'. The high cost of 'Alphonso' mango also leads to costlier processed product. Further, the incidence of spongy tissue in 'Alphonso' affects the export of fresh mangoes, and also the yield of pulp or slices for canning purposes (Iyer et al. 1991). Besides, the effect of freeze-drying on the quality of 'Alphonso' has been studied (Ramamurthy and Bangirwar 1979). The other variety that is being processed on a large scale is 'Bangalora or Totapuri'. It is a high yielder, with regular bearing habit, and has a mild flavour, which finds favour in many foreign countries (Iyer et al. 1991).

Earlier attempts to develop varieties which are regular bearer, dwarf and with ability to yield fruits similar to 'Alphonso' and of desirable skin colour, but are free from spongy tissue have resulted in five promising hybrids, out of which two are in pre-release stage (Anon 1992). Some studies on the suitability of other hybrids for processing quality of mango hybrids have been reported (Amba Dan et al. 1985; Khurdiya and Roy 1985). In the present study, four selected hybrids were tested against two leading commercial varieties, 'Alphonso' and 'Totapuri' and the results are reported in this paper.

* Corresponding Author

Materials and Methods

Physical characteristics of the fruits : Fully mature fruits were harvested and allowed to ripen at room temperature. Properly ripened fruits (10 Nos.) of each hybrid or variety were randomly selected and average fruit weight, length, breadth and firmness were recorded using a balance (Tulaman, Hyderabad) vernier caliper (Mitutoyo, Japan) and fruit pressure tester (FT327, EFFEGI, Italy), respectively. After washing in running tap water, fruits (20 kg) were hand-peeled and the pulp was removed completely from peel as well as stone by using a stainless steel knife. Pulp was blended in a Waring blender and passed through a 30 mesh stainless steel sieve to remove fibres. The weights of different fruit components and yield of fine pulp were noted.

Chemical composition of pulp : The strained pulp samples were chemically analyzed for acidity, reducing and total sugars, vitamin C and carotenoids by AOAC (1984) methods. The viscosity of the pulp was determined by a viscometer (LVTD, Brookfield, USA), while total soluble solids were recorded using a hand refractometer (Erma, Japan, O-32° Brix).

Canning of mango juice : Juice (45% pulp, 20° Brix and 0.3% acidity) was prepared from strained pulp, heated to 85°C, filled hot in open top sanitary cans (1 lb, plain) and sealed by using a double seamer (MB_1, Metal Box, England). Sealed cans were held for 15 min in boiling water and promptly cooled in running water. The canned juice was

TABLE 1. DESCRIPTION AND SPECIAL CHARACTERISTICS OF NEW HYBRIDS/COMMERCIAL VARIETIES OF MANGO

Hybrid/ variety	Parents	Skin colour	Pulp colour	Fruit yield, tonnes/ha	Special characteristics
'Arka Aruna (H-10)'	'Banganapalli' and 'Alphonso'	Yellow with reddish tinge at stalk end	Cream colour	17	Regular bearer; free from spongy tissue; suitable for high density planting
'Arka Puneet (H-13)'	'Alhonso' and 'Banganapalli'	Yellow with reddish tinge at stalk end	Deep orange	9	Firm flesh; good flavour and keeping quality; free from fibre, spongy tissue and fruit fly
'Arka Anmol (H-17-3)'	'Alphonso' and 'Janardhan Pasand'	Uniform golden yellow	Orange	9	Very good keeping quality; free from spongy tissue; good sugar-acid blend; uniform yellow skin colour on ripening
'Hybrid-51'	'Alphonso' and 'Banganapalli'	Greenish yellow	Yellow	8	Soft pulp; less fibrous; high TSS
'Alphonso'	Commercial variety of Maharashtra	Orange yellow	Deep yellow	7	Excellent flavour; good keeping quality; canning/processing characters
'Totapuri'	Commercial variety of South India	Yellow with reddish tinge at stalk end	Light yellow	16	Poor fruit quality; very good keeping quality

analyzed as in case of the pulp.

Sensory evaluation of canned mango juice : It was carried out by a panel of 10 judges, using the Hedonic scale having score for colour (30), consistency (30) and flavour (40). All the data were analyzed statistically using completely randomized design (CRD) with four replications and means were compared at probability levels of 5% and 1% (Sundararaj et al. 1972).

Results and Discussion

Physical characteristics: The physical characteristics of the new hybrid fruits and commercial cultivars are presented in Tables 1 and 2. Significant differences were observed in fruit weight, volume, length, breadth, firmness, peel and fibre content of different hybrids/varieties. Fruit weight and volume were significantly higher in 'Arka Aruna' and these were minimum in 'Alphonso'. The weights of other hybrids were not significantly different from 'Alphonso', but they were lower than that of 'Totapuri'. All the fruits were significantly shorter and smaller in breadth than 'Arka Aruna' and 'Totapuri', while the differences in shortness among themselves were not significant except in case of 'Arka Anmol'. The differences in breadth between 'Arka Puneet', 'Arka Anmol', 'H-51' and 'Alphonso' were not significant. 'Totapuri', 'Alphonso' and 'Arka Puneet' had a comparatively better fruit firmness at ripe condition. All the hybrids recorded higher pulp yield and lower peel, fibre as well as stone content than those of 'Alphonso', but the differences were statistically not significant for stone content and pulp yield. However, the difference was significant for peel content. The peel content of 'Arka Anmol' was only half of that of 'Alphonso', while it was higher in 'Arka Aruna'. The fibre content of pulp varied considerably and all hybrids

TABLE 2. PHYSICAL CHARACTERISTICS OF NEW HYBRIDS AND COMMERCIAL CULTIVARS/VARIETIES OF MANGO

Variety/ hybrid	Fruit weight, g	Volume, ml	Length, cm	Breadth, cm	Firmness, lbs/sq. inch	Pulp yield*, %	Peel, %	Stone, %	Fibre, %
'Arka Aruna'	682	723	13.0	9.0	7.3	65.2	16.3	15.8	0.4
'Arka Puneet'	257	222	9.1	7.0	12.0	67.9	14.2	14.9	0.9
'Arka Anmol'	258	222	10.4	6.3	7.6	68.6	10.3	14.7	1.9
'Hybrid-51'	253	345	8.8	7.0	7.8	68.7	12.3	13.0	1.1
'Alphonso'	216	225	7.7	6.6	13.2	57.7	20.3	17.3	2.3
'Totapuri'	353	382	12.8	7.4	15.5	62.7	17.8	12.8	3.8
SEM ±	33	26	0.6	0.3	0.8	3.7	1.5	2.8	0.4
CD at 5%	103.8	81.8	2.0	1.1	2.5	NS	4.7	NS	1.2
CD at 1%	147.7	116.4	2.9	1.6	3.5	-	6.7	-	1.7

* Pulp that was available for processing after discarding over ripe/spongy tissue/stone weevil affected portion., NS - Non-significant

TABLE 3. PHYSICO-CHEMICAL COMPOSITION OF MANGO PULP AND CANNED JUICE OF NEW HYBRIDS AND COMMERCIAL CULTIVARS/VARIETIES

Variety/ hybrid	TSS, °Brix	pH	Acidity, %	Reducing sugars, %	Total sugars, %	Carotenoids, mg/100 g	Vitamin C, mg/100 g	Viscosity, cpu
				Pulp				
'Arka Aruna'	19.4	4.3	0.3	6.2	11.3	0.7	3.1	4750
Arka Puneet'	20.3	4.2	0.4	5.4	12.0	6.3	5.1	8100
'Arka Anmol'	18.2	4.1	0.4	4.3	12.3	7.3	4.2	6286
'Hybrid-51'	20.6	4.1	0.3	4.3	15.2	7.0	35.0	4460
'Alphonso'	18.8	4.2	0.4	4.8	11.2	11.5	51.4	7266
'Totapuri'	14.6	3.8	0.4	3.5	9.3	3.7	8.5	10323
SEM ±	0.5	0.1	0.1	0.6	0.4	1.0	7.9	980
CD at 5%	1.6	0.2	0.1	0.1	1.2	3.3	24.9	3088
CD at 1%	2.3	0.3	0.1	0.1	1.7	4.6	35.4	439
				Canned juice				
'Arka Aruna'	20.8	3.4	0.3	6.6	17.2	0.2	2.4	1061
Arka Puneet'	20.8	3.9	0.3	4.6	17.9	2.1	2.4	3238
'Arka Anmol'	20.9	3.6	0.3	4.7	18.7	2.2	2.8	1326
'Hybrid-51'	21.0	3.8	0.3	2.3	12.9	2.4	6.7	1285
'Alphonso'	20.8	3.6	0.3	2.9	17.0	5.1	13.1	1671
'Totapuri'	20.8	3.5	0.3	3.3	16.3	1.7	12.1	1183
SEM ±	0.3	0.1	0.1	0.5	1.3	0.2	1.3	164
CD at 5%	NS	0.2	NS	1.7	NS	NS	4.0	517
CD at 1%	-	0.3	-	2.4	-	-	5.6	735

possessed very low fibre, and it was less than 1% in case of 'Arka Aruna' and 'Arka Puneet'.

Chemical composition of pulp : Significant differences were observed in chemical composition of pulp extracted from different hybrids/varieties (Table 3). All the hybrids had significantly higher TSS than 'Totapuri' and were comparable to 'Alphonso'. 'Arka Aruna' and 'H-51' had significantly lower acidity, while the rest were comparable to 'Alphonso'. Reducing sugars and total sugars content were maximum in 'Arka Aruna' and 'H-51', respectively. All the hybrids had significantly lower carotenoids than 'Alphonso', but more than in 'Totapuri' (except in case of 'Arka Aruna'). The vitamin C contents of all hybrids were lower than 'Alphonso' and 'Totapuri' (except in 'H-51'). 'Arka Puneet' recorded significantly higher viscosity than 'Alphonso', but it was lower than 'Totapuri'. 'Arka Anmol' also possessed better viscosity, while it was considerably low in other hybrids.

Chemical composition of canned mango juice: Though the total sugar and carotenoids varied considerably, the differences were not statistically significant. All the hybrids possessed significantly lower vitamin C contents than the commercial cultivars. Reducing sugar was maximum in 'Arka Aruna' due to its higher reducing sugars in pulp. Viscosity of canned juice was lowest in 'Arka Aruna' and maximum in 'Arka Puneet', while the rest of the hybrids and varieties were comparable to 'Alphonso' (Table 3).

Sensory quality of canned mango juice : The score for colour was lowest in 'Arka Aruna' and highest in 'Alphonso'. 'Arka Aruna', 'Totapuri' and 'H-51' scored poorly for consistency, probably due to the lower viscosity of the juice, whereas the hybrids, 'Arka Puneet' and 'Arka Anmol' were comparable to 'Alphonso' (Table 4). The flavour score was maximum in 'Arka Puneet', 'Arka Anmol' followed by 'Alphonso'. The overall acceptability score was minimum in 'Arka Aruna' due to its poor performance in terms of colour, consistency and

TABLE 4. SENSORY QUALITY OF CANNED MANGO JUICE

Variety/ hybrid	Sensory quality			
	Colour, 30	Consistency, 30	Flavour, 40	Total, 100
'Arka Aruna'	13.0	20.0	24.0	57.0
Arka Puneet'	23.0	23.5	27.0	73.5
'Arka Anmol'	23.0	23.4	27.0	73.4
'H-51'	22.0	21.7	24.3	68.0
'Alphonso'	25.0	22.0	26.8	73.8
'Totapuri'	19.0	20.3	24.0	63.3
SEM ±	0.5	0.6	1.0	1.0
CD at 5%	1.7	1.9	3.2	3.3
CD at 1%	2.5	2.7	4.6	4.7

flavour, whereas maximum score was in 'Alphonso', closely followed by 'Arka Puneet' and 'Arka Anmol'. Though the hybrids, 'Arka Puneet' and 'Arka Anmol' scored slightly lesser than 'Alphonso' due to the lower carotenoids content, they possessed good flavour and consistency, which made them comparable to 'Alphonso' variety for canned juice preparation. 'Totapuri' and 'H-51' performed poorly in sensory evaluation due to poor colour, low consistency and moderate flavour.

From these results, it is evident that new hybrids 'Arka Puneet (H-13)' and 'Arka Anmol (H-17-3), can be used for canned juice preparation, for obtaining a product which is nearly comparable in qualities to 'Alphonso'.

Acknowledgements

The authors are grateful to Dr. R.M. Pandey, Director, IIHR. Bangalore, for encouragement. Thanks are due to Mrs. Sarojini Jalali and Mr. K. Reddeppa for technical assistance.

References

Amba Dan, Adsule PG, Iyer CPA, Subramanyam MD (1985) Suitability of some mango hybrids for processing for export. Acta Hort 231(2):776-781

Anon (1992) Research Programmes and Progress. Information Bulletin No. 1, Indian Institute of Horticultural Research, Bangalore

AOAC (1984) Official Methods of Analysis, 14th ed. Association of Official Analytical Chemists, Washington, DC

Golap AS, Bandyopadhyay, C (1975) Comparative assessment of aromatic principles of ripe 'Alphonso' and 'Langra' mango. J Food Sci Technol 12:262-265

Iyer, CPA, Subramanyam MD, Dinesh MR (1991) 'Padiri' - A promising mango variety for processing. Indian Food Packer 45(1): 13-15

Khurdiya DS, Roy SK (1985) Studies on processing quality of mango hybrids developed at IARI. Acta Hortic 231(2):709-714

Ramamurthy, MS, Bangirwar, DR (1979) Effect of freezing methods on the quality of freeze dried 'Alphonso' mangoes. J Food Sci Technol 16:234-236

Sundararaj N, Nagaraju S, Venkata Ramu MN, Jagannath MK (1972) Design and Analysis of Field Experiments. University of Agricultural Sciences, Hebbal, Bangalore

Received 27 July 1993; revised 21 December 1993; accepted 17 January 1994

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 389-394

Optimization of the Process for *Kalakand* Manufacture and Extension of its Shelf-life

I. SURESH AND Y.K. JHA*
Department of Food Sciences and Technology,
G.B. Pant University of Agriculture and Technology, Pantnagar-263 145, India

Three levels of sugar and fat as well as three coagulants, were selected on the basis of market survey, for optimizing *kalakand* manufacture. For these factors, the optimum levels were selected on the basis of sensory characteristics and textural properties. Buffalo milk standardized to 6.0% fat, with added sugar and citric acid at 7 and 0.2% resulted in a highly acceptable quality product, with significant improvements ($P<0.01$) in sensory scores. The standardized products containing 0.20 and 0.25% potassium sorbate were stored at 30 and 37°C for studying the storage behaviour, based on sensory, microbiological and chemical changes. Potassium sorbate at both the concentrations increased the shelf-life of *kalakand* from 3 to 24 days at 37 and 30°C, respectively. The chemical changes in terms of pH, titratable acidity, lactic acid, tyrosine content, free fatty acids and peroxide value showed faster deteriorative trends in the control samples at both the temperatures, as compared to *kalakand* treated with potassium sorbate. Microbial growth, which is closely related to the flavour deterioration, was strongly inhibited by potassium sorbate.

Keywords : *Kalakand*, Alum, Aged whey, Storage, Potassium sorbate, Biochemical changes, Textural changes, Anti-microbial agent.

The technology for the production of a number of indigenous milk products in India is confined to home and cottage scales. Milk-based Indian sweets have established consumer markets in other countries as well. However, the products suffer from variation in keeping quality and poor storage stability. A need exists to upgrade such technologies for large scale industrial production. The existing cottage scale production technology of *kalakand* (a milk-based sweet consisting of milk solids, cooked along with sugar to a thick consistency) results in variations in the qualities and unpredictable shelf-life (Dwarakanath and Srikanta 1977, Magadum et al. 1988, Upadhyay et al. 1984; Venkata Subbiah and Dwarakanath 1985). *Kalakand* is a rich source of energy, milk proteins, minerals and other essential growth promoting factors. Scientific evidence, elaborated with systematic storage study, is likely to add new dimensions in the studies on *kalakand*. Gill and De (1974) used citric acid and sugar at 0.05 and 6.0%, respectively, in the production of *kalakand*. Srinivasan and Rajorhia (1976) suggested that *danedar khoa* could be used to manufacture *kalakand*. Dwarakanath and Srikanta (1977) prepared *kalakand* using tartaric acid, whereas Dharam Pal and Gupta (1985) used 0.02% citric acid to produce *kalakand* of same characteristics as prepared from *danedar khoa*. So far, no systematic scientific studies have been reported on the storage behaviour of *kalakand*. Therefore, the present study was undertaken to optimize the manufacturing process and to study the storage behaviour of *kalakand* (containing anti-microbial agent) at different temperatures.

* *Corresponding Author*

Materials and Methods

Buffalo milk, obtained from Livestock Research Centre of the University, was standardized to 6% fat and 9.0 to 9.5% solid-not-fat (SNF). Standardization of *kalakand* manufacture was done on the basis of market survey, sensory evaluation and textural properties, with respect to the concentration of sugar and fat as well as the type and amount of the coagulant. Three levels of sugar (7, 9 and 11%) and fat (4, 5 and 6%) as well as three coagulants at three levels (0.01, 0.02 and 0.03% citric acid; 1, 2 and 3% aged whey; 0.017, 0.035 and 0.053% alum) were studied. *Kalakand* was manufactured as per the standardized process (Fig. 1).

Samples were evaluated for sensory characteristics on a 9-point Hedonic rating scale (Larmond 1982) by 12 panelists. Statistical analysis (ANOVA) was done as described by Larmond (1982). Textural profile analysis was done by using Instron Universal Testing Machine (model No. 6021, Type N 1189, Japan) as per the procedure described by Bourne et al (1966). The textural properties were measured as per the method described by Ranganna (1986).

Standardized product prepared by employing optimum parameters (fat: 6%, citric acid: 0.02%; sugar: 7%) was divided into lots and fortified with potassium sorbate at 0.20 and 0.25% levels. Samples were packed in polyethylene bags (500 g,

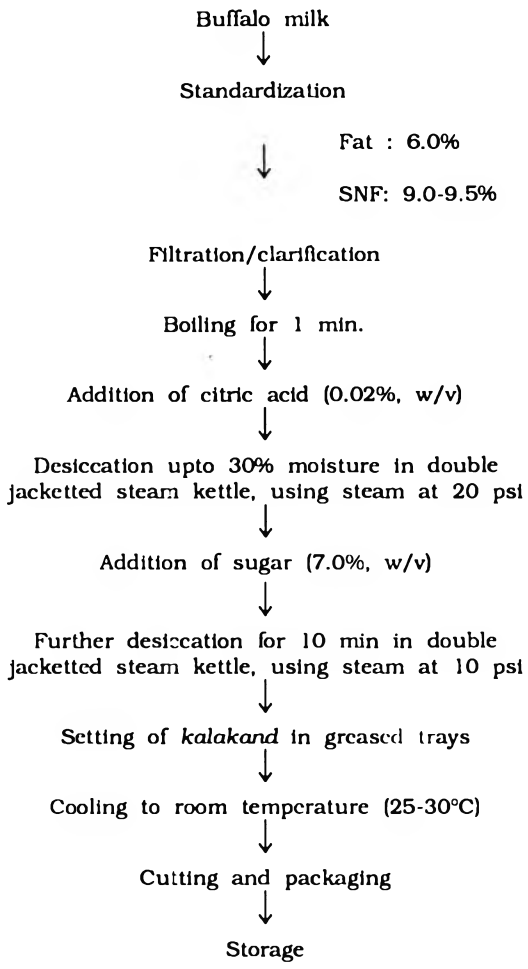

Fig.1. Flow diagram for *kalakand* preparation

95 μ), pre-exposed to UV tube light (30 w, 1/2" Philips, Holland) for 20 min at 30±1°C, and stored in thermostatically controlled incubators at 30±1 and 37±1°C. The changes in sensory, chemical and microbiological qualities of *kalakand* were studied during storage at intervals of 6 and 3 days, respectively, at these temperatures.

The chemical characteristics such as pH, titratable acidity (AOAC, 1975), tyrosine value (Hull 1847), free fatty acids (Ramamurthy and Narayanan 1974) and peroxide value (ISI 1977) were estimated during storage. The method of Ling (1951), as modified by Harper and Randolph (1960), was used for estimating lactic acid. The microbiological changes during storage were assessed by determining standard plate counts, yeast and mould counts and coliform counts (ISI 1980).

Results and Discussion

Kalakand made with 7 and 11% sugar obtained the highest (6.9) and the lowest (4.5) sensory scores (Table 1). The sample made with 9% sugar was rated highly acceptable, but showed inferior colour due to browning. The sample prepared with 11% sugar was criticised for cooked flavour, syrupy body as well as texture and severe browning. All these defects may be attributed to the use of excess sugar. Flink (1983) has also reported the appearance of non-enzymatic browning in sucrose-based systems during freeze-drying and subsequent storage in dry state. This study, in fact, formed the basis for deciding the need for optimizing sugar concentration and the results were found significant (P<0.01). All the samples made with different milk fat levels scored between 6.8 and 7.3 and were rated acceptable. The acceptability was the highest (7.3) in sample made with 6% fat in milk. No significant

TABLE 1. EFFECT OF SUGAR, MILK FAT AND DIFFERENT COAGULANTS ON SENSORY CHARACTERISTICS OF *KALAKAND*

Sensory characteristics	Sugar level in milk, %*			Fat level in milk, %			Level of coagulants,%								
							Aged whey			Citric acid*			Alum*		
	7	9	11	4	5	6	1	2	3	0.01	0.02	0.03	0.017	0.035	0.053
Flavour	6.9	5.1	4.4 Cf	6.6	6.7	6.9	6.9	7.2	6.8 Bi	7.1	7.5	7.0	6.0	7.0	7.3
Body and texture	6.8	5.0	4.3 Sy	6.9	6.9	7.4	7.1 Lt	7.2 Lt	6.3	7.0 Lt	7.5	5.8 Os,Pt,Ig	6.7	7.3 St	5.3 Pt
Colour	6.6	4.6 B	4.5 Sb	7.0	7.0	7.4	6.5	6.8	6.7	6.6	7.7	6.8	6.7	7.3 Pc	6.7 Pc
Overall acceptability	6.9	5.1	4.5	6.8	6.8	7.3	6.8	7.0	6.2	6.7	7.5	6.1	6.7	7.0	7.3
*Significant at 1% level	LSD = 1.019									LSD = 0.583			LSD = 0.891		
	A	B	C							B	A	C	B	A	C
	6.9[a]	5.1[b]	4.5[b]							7.5[a]	6.7[b]	6.1[c]	7.0[a]	6.7[a]	5.3[b]

Any two means not followed by the same letter differ significantly (P<0.01).

B : Browning; Bi : Slight bitterness; Cf : Cooked flavour; Ig : Irregular granules; Lt : Loose texture; Os : Oozing of syrup; Pc : Poor colour; Pt : Poor texture; Sb : Severe browning; St : Sticky;: Sy : Syrup, Average of three determinations.

TABLE 2. EFFECT OF DIFFERENT MILK FAT PER CENT AND COAGULANTS ON TEXTURAL PROPERTIES OF *KALAKAND*

Textural Properties	Milk fat level, %			Level of coagulants, %					
				Aged whey		Citric acid		Alum	
	4	5	6	1	2	0.01	0.02	0.017	0.035
Hardness, Newtons	174.0	118.0	233.0	193.0	159.0	138.0	233.0	70	113
Cohesiveness	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.1	0.3
Springiness, cm	2.9	3.1	3.1	3.0	3.1	3.0	3.1	3.0	3.1
Gumminess, Newtons	52.9	32.1	72.2	50.2	50.2	40.6	72.2	5.3	30.6
Chewiness, New^2 cm	153.4	99.5	223.9	150.5	155.8	121.7	223.9	15.8	94.9

All values are mean of three determinations

differences were observed in *kalakand* samples made from milk containing 4, 5 and 6% fat.

The different levels of citric acid and alum showed significant effects ($P<0.01$) on sensory characteristics. *Kalakand* made with citric acid (0.02%) was rated highly acceptable. Samples prepared using aged whey (3%) were criticised for loose texture and slight bitterness, whereas the product made with alum was criticised for stickiness, irregular granular size, browning, lack of compactness and inferior colour. The samples prepared with 0.01 and 0.03% citric acid were criticised for loose texture and oozing of syrup.

Table 2 reveals that *kalakand* samples, prepared from milk containing 6% fat, rated highly acceptable and showed the highest textural properties. Chewiness, the most desirable characteristic of *kalakand*, was highest in the sample made with 6% milk fat, followed by that made with 4 and 5% fat. Textural properties showed direct correlation with sensory characteristics. The chewiness, gumminess and hardness values were highest in *kalakand* samples prepared with 0.02% citric acid, followed by the samples made with aged whey and alum (Table 2). The cohesiveness was more or less same in all samples, irrespective of type of the coagulant used.

TABLE 3. EFFECT OF POTASSIUM SORBATE ON SENSORY CHARACTERISTICS OF *KALAKAND* DURING STORAGE AT 30 AND 37°C

Treatment	Sensory characteristics	Temperature °C	Days of storage									
			0	3	6	9	12	15	18	21	24	30
Control	Flavour	30	8.3	-	7.3	-	1.0 MF	NA	NA	NA	NA	NA
		37	8.0	6.8	5.0 SO	1.0 MF	NA	NA	NA	NA	NA	NA
	Body and texture	30	8.0	-	8.0	-	1.0	NA	NA	NA	NA	NA
		37	8.0	8.0	8.0	1.0	NA	NA	NA	NA	NA	NA
	Colour	30	8.0	-	8.0	-	1.0	NA	NA	NA	NA	NA
		37	8.0	8.0	8.0	1.0	NA	NA	NA	NA	NA	NA
Potassium sorbate, 0.20%	Flavour	30	8.3	-	7.7	-	7.7	-	6.3	-	5.5	4.0 OF,MF
		37	8.0	7.1	6.7	6.7	6.5	6.3	4.8	4.4 MF	NA	NA
	Body and texture	30	8.0	-	8.0	-	8.0	-	7.7	-	5.6	5.0
		37	8.0	8.0	8.0	8.0	7.6	7.6	7.6	7.6	NA	NA
	Colour	30	8.0	-	8.0	-	8.0	-	6.7	-	5.9	5.5
		37	8.0	8.0	8.0	8.0	7.6	7.5	7.3	7.2	NA	NA
Potassium sorbate, 0.25%	Flavour	30	8.3	-	8.0	-	7.7	-	6.3	-	6.0	4.4 OF,MF
		37	8.0	7.4	7.0	7.0	6.7	6.5	6.3	4.9 MF	NA	NA
	Body and texture	30	8.0	-	8.0	-	8.0	-	7.7	-	5.6	5.0
		37	8.0	8.0	8.0	8.0	7.8	7.8	7.6	7.6	NA	NA
	Colour	30	8.0	-	8.0	-	8.0	-	7.7	-	5.9	5.5
		37	8.0	8.0	8.0	8.0	7.8	7.6	7.6	7.6	NA	NA

MF : Medicine-like flavour; OF : Off-flavour; SO : slightly off-flavour; NA : Not analyzed due to deterioration; - : Not analysed. Average of three determinations.

The textural characteristics of samples made from 3.0% aged whey, 0.03% citric acid 0.05% alum could not be measured due to poor texture of the product. Dharam Pal and Gupta (1985) also noted that citric acid at 0.2% produced best quality *kalakand*.

Table 3 shows the effect of potassium sorbate on sensory characteristics of *kalakand* during storage. Flavour scores decreased at a faster rate in control samples, irrespective of storage temperatures. Control samples were noted normal on 6th and 3rd day at 30 and 37°C and afterwards these were criticised for the presence of medicine-like flavour. Potassium sorbate, when added to *kalakand* at 0.20 and 0.25%, increased the shelf-life up to 24 and 15 days at 30 and 37°C. Afterwards, flavour scores decreased sharply and the products were rated sub-normal. The samples treated with potassium sorbate did not exhibit much changes in body, texture and colour upto 21 days, irrespective of the concentration of potassium sorbate and storage temperature. Higher concentration (0.25%) of preservative did not show any additional advantage on shelf-life of *kalakand*, as compared to the level of 0.2%. These results are in accordance with the findings of Jha et al (1977) and Bhatele (1983).

Initial pH of *kalakand* was 6.1, which decreased at a faster rate in control sample to 5.9 and 5.5 on 6 and 9 days at 30 and 37°C, respectively. Samples treated with potassium sorbate (0.20 and 0.25%) also showed decreases in pH, but at a slower rate in samples at both the storage temperatures (Tables 4 and 5). Titratable acidity and lactic acid content remained constant up to 12 days storage, and thereafter increased at a slower rate. Potassium sorbate (0.25%) was also reported to check the development of titratable acidity and lactic acid in *khoa* (Jha et al. 1977).

Initial tyrosine value in *kalakand* ranged from 3.55 to 3.80 mg/100 g and it increased at a steady rate during storage, irrespective of treatments and temperatures (Table 4 and 5). Initial free fatty acid (FFA) contents was 0.2 and remained constant up to 6 and 3 days of storage at 30 and 37°C, respectively. FFA values increased during the later period at a very slow rate, irrespective of temperatures. These were lowest in potassium sorbate-treated samples (0.25%) at the end of 21 and 24 days at 37 and 30°C, respectively. The shelf-life of *khoa* and *burfi* was also found to improve with the addition of potassium sorbate (Jha et al. 1977; Bhatele 1983). The peroxide value in *kalakand* sample was 0.1 m.eq at zero day storage and it remained constant upto the half of the storage period and then increased at a slow rate, irrespective of treatments and temperatures. It reached to 0.4 after 24 and 21 days of storage at 30 and 37°C, respectively.

It is apparent from the Figs. 2 and 3 that

TABLE 4. EFFECT OF POTASSIUM SORBATE ON THE BIOCHEMICAL CHANGES OF *KALAKAND* DURING STORAGE AT 30°C

Treatment	Parameter	Days of Storage				
		0	6	12	18	24
Control	pH	6.1	5.9	NA	NA	NA
	Titratable acidity, as % lactic acid	0.4	0.5	NA	NA	NA
	Lactic acid,%	0.06	0.13	NA	NA	NA
	Tyrosine value, mg/100 g	3.6	4.5	NA	NA	NA
	Free fatty acids, as % oleic acid	0.2	0.3	NA	NA	NA
	Peroxide value, m eq.	0.1	0.3	NA	NA	NA
Potassium sorbate, 0.20%	pH	6.1	6.0	6.0	5.7	5.5
	Titratable acidity	0.5	0.5	0.5	0.6	0.7
	Lactic acid	0.1	0.1	0.1	0.2	0.2
	Tyrosine value	3.6	4.4	5.0	5.5	6.3
	Free fatty acids	0.2	0.2	0.3	0.4	0.6
	Peroxide value	0.1	0.2	0.2	0.3	0.4
Potassium sorbate, 0.25%	pH	6.1	6.1	6.0	5.9	5.6
	Titratable acidity	0.5	0.5	0.5	0.6	0.6
	Lactic acid	0.1	0.1	0.1	0.1	0.2
	Tyrosine value	3.6	4.3	4.9	5.5	6.2
	Free fatty acids	0.2	0.2	0.3	0.4	0.6
	Peroxide value	0.1	0.2	0.2	0.3	0.4

Units of various parameters are as for control experiment; NA : Not analysed due to deterioration. Average of three determinations.

TABLE 5. EFFECT OF POTASSIUM SORBATE ON THE BIOCHEMICAL CHANGES OF *KALAKAND* DURING STORAGE AT 37°C

Treatment	Parameter	Days of Storage							
		0	3	6	9	12	15	18	21
Control	pH	6.1	6.1	5.8	5.5	NA	NA	NA	NA
	Titratable acidity	0.5	0.5	0.6	0.7	NA	NA	NA	NA
	Lactic acid	0.1	0.1	0.1	0.2	NA	NA	NA	NA
	Tyrosine value	3.8	4.4	4.7	5.1	NA	NA	NA	NA
	Free fatty acids	0.2	0.4	0.5	0.5	NA	NA	NA	NA
	Peroxide value	0.1	0.3	0.3	0.4	NA	NA	NA	NA
Potassium sorbate, 0.20%	pH	6.1	6.1	6.0	5.9	5.9	5.8	5.6	5.5
	Titratable acidity	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.7
	Lactic acid	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
	Tyrosine value	3.8	3.9	4.5	4.7	5.2	5.5	5.7	6.1
	Free fatty acids	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6
	Peroxide value	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4
Potassium sorbate, 0.25%	pH	6.1	6.1	6.0	6.0	5.9	5.8	5.8	5.5
	Titratable acidity	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6
	Lactic acid	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
	Tyrosine value	3.8	3.9	4.3	4.4	4.5	5.0	5.6	5.8
	Free fatty acids	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5
	Peroxide value	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4

Units of various parameters are as for control experiment in Table 4. NA : Not analysed due to deterioration. Average of three determinations.

control samples showed rapid microbial growth at both the temperatures. Potassium sorbate is known to control the growth of bacteria less effectively, than that of yeast and mould (Jha et al. 1977; Rao et al. 1977). Moreover, it did not exhibit any positive effect on coliforms. The increase in the level of potassium sorbate further controlled the increase in the total counts during storage, but at a slower

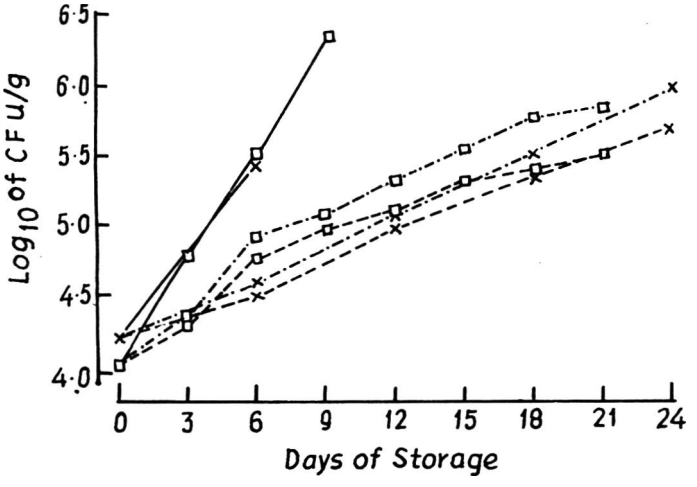

Fig.2. Effect of potassium sorbate on viable counts in *kalakand* during storage

	30°C	37°C
Control	×——×	□——□
0.20% PS	×- - - -×	□- - -□
0.25% PS	×—·—·—×	□—·—·—□

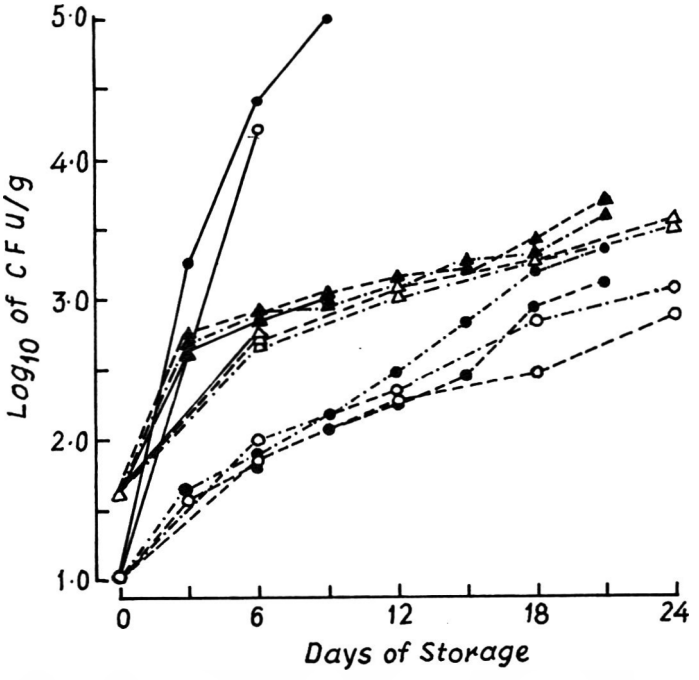

Fig.3. Effect of potassium sorbate on yeast and mould and coliform counts of *kalakand* during storage

	Y & M		Coliforms	
	30°C	37°C	30°C	37°C
Control	O——O	●——●	Δ——Δ	▲——▲
0.20% PS	O- - - -O	●- - - -●	Δ- - - -Δ	▲- - - -▲
0.25% PS	O—·—·—O	●—·—·—●	Δ—·—·—Δ	▲—·—·—▲

rate at both the temperatures. Data in Figs. 2, 3 and Table 3 indicate that the microbial growth pattern followed a reverse trend, in comparison to

sensory characteristics.

References

AOAC (1975) Official Methods of Analysis, 12th ed. Association of Official Analytical Chemists, Washington, DC

Bhatele ID (1983) Studies on the production, packing and preservation of *burfi*. Ph.D. Thesis, National Dairy Research Institute, Karnal, India

Bourne MC, Mayer JC, Han DB (1966) Measurement of food texture by an universal testing machine. J Food Technol 20:522-526

Dharam Pal, Gupta SK (1985) Sensory evaluation of Indian milk products. Indian Dairyman 37:465-476

Dwarakanath CT, Srikant S (1977) Studies on the microbiological quality of traditional Indian sweet-meat products. J Food Sci Technol 14:201-204

Flink JM (1983) Non-enzymatic browning of freeze-dried sucrose. J Food Sci. 48:539-542

Gill LK, De S (1974) Sweets from milk - Recipes, Publication No. 119, National Dairy Research Institute, Karnal

Harper WJ, Randolph HC (1960) Lactic acid in cottage cheese. American Milk Review 22:43-46

Hull ME (1947) Studies on milk proteins. II. Colorimetric determination of the partial hydrolysis of the protein in milk. J Dairy Sci 30:881-884

ISI (1977) Methods of Sampling and Test for Ghee, SP: 19: 3508. Bureau of Indian Standards, New Delhi

ISI (1980) Hand Book of Food Analysis, SP: 18, Part I. Bureau of Indian Standards, New Delhi

Jha YK, Singh S, Surjan Singh (1977) Effect of antioxidants and antimicrobial substances on keeping quality of *khoa*. Indian J Dairy Sci 30:1-6

Larmond E (1982) Laboratory Methods for Sensory Evaluation of Food, Publication No. 1637, Canada Department of Agriculture, Ottawa

Ling ER (1951) The determination of lactic acid in milk. J Sci Agric 2:279-288

Magadum RB, Ananta Krishnan CP, Natarajan AM (1988) Chemical and bacteriological quality of market samples of *kalakand*. Cheiron 17:200-201

Ramamurthy MK, Narayanan KM (1974) Hydrolytic and autooxidative property of buffalo and cow milk fats as influenced by their glyceride structure. J Indian Dairy Sci 24:227-233

Ranganna S (1986) Manual of Analysis and Quality Control of Fruit and Vegetable Products, 2nd ed. Tata McGraw Hill Pub. Co., New Delhi

Rao CO, Singh S, Surjan Singh (1977) Effect of packaging materials on keeping quality of market samples of *kalakand*. Cheiron 17:200-201

Rao CO, Singh S, Surjan Singh (1977) Effect of packaging materials on keeping quality of *khoa*. J Food Sci Technol 14:152-154

Srinivasan MR, Rajorhia GS (1976) The case of *khoa* for a rightful place among dairy products. Indian Dairyman 28:11-15

Upadhyay SM, Dave JM, Sanna Bhadti SS (1984) Microbial changes in stored *Shrikhand* and their application in predicting the sensory quality of the product. J Food Sci Technol 21:208-211

Venkata Subbiah P, Dwarakanath CT (1985) Microbiological quality and growth of *Staphylococcus aureus* in liquid type of traditional Indian sweets. J Food Sci Technol 22:392-397

Received 19 August 1993; revised 21 January 1994; accepted 27 January 1994

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 395-399

Effect of Particle Size, Moisture Content, Pressure and Temperature on the Physical and Thermal Properties of Soybean

B.L. MANDHYAN*[1] AND S. PRASAD[2]

[1]Department of Post-harvest Process and Food Engineering, College of Agricultural Engineering J.N. Krishi Vishwa Vidyalaya, Jabalpur-482 004, India,

[2]Post-harvest Technology Centre, Indian Institute of Technology, Kharagpur-721 302, India.

Variation of bulk density and coefficient of friction of soy particles was studied against particle size and moisture content. The effects of moisture content and temperature on specific heat as well as the effects of temperature, moisture content and particle size on thermal conductivity were studied. In addition, the variation in the viscosity of the soybean oil was evaluated against temperature. Based on these results, suitable regression equations and correlation coefficients were developed to encompass these variations.

Keywords : Soybean, Physical and thermal properties, Bulk density, Coefficient of friction, Specific cake resistance, Specific heat, Thermal conductivity, Viscosity.

Oil recovery is affected by various properties of materials, such as bulk density, coefficient of friction, specific cake resistance, and initial oil content of the oil-bearing material (Koo 1942; Mrema and McNulty 1985; Vadke et al. 1988). These properties are themselves dependent upon the moisture content and particle size of the oil-bearing material.

In this era of high-temperature and short-time treatment of soy particles, Nelson et al (1986) have suggested subjection of soy particles to a temperature of 135°C for 30 sec, for reducing anti-nutritional factors and enhancing the oil recovery during oil expelling. Raising of temperature to such a high level will affect the thermal properties of soy particles. Hence, a study on the variation of thermal properties at high temperatures will give a correct picture of the heat transfer through soy particles and will also help in the estimation of total heat input in the high-temperature, short-time treatment system. Information on these aspects will also be helpful in designing a suitable conditioner for particles in the process for oil recovery. Therefore, the present study was undertaken to evaluate the effect of particle size, moisture content, temperature and pressure on different physical and thermal properties of soy particles.

Materials and Methods

Experimental procedure : Samples of various sizes of soy particles were obtained by running the soy splits (variety 'Soymax') in a small roller mill (Labour Muszeripari Muvek Esztergon, Hungary). The soy particles, thus obtained, were fed into a vibratory mechanical shaker (Scientific Equipment Works, Delhi, India) and the particle size was recorded, based on the average of the aperture of the two sieves, which held the soy particles in between them. The moisture content of the samples was estimated as per IS: 3579-1966 (ISI 1966). The moisture content was varied by soaking the sample and then taking the reading. Bulk density of soy particles was determined using the bulk density measuring balance (Ohaus Scale Corporation, New York, USA). The sample was tapped gently before taking the reading.

The specific cake resistance was determined by the method of Schwartzberg et al (1977). A small compression permeability cell was made and the sample of soybean was kept in it. The load on the cell was varied by using Universal Testing Machine (M/s Mohr Feder Haffag, Mannheim, Germany). The experiment was planned separately for each independent variable, i.e., pressure and particle size, as preliminary trials revealed that the variation of specific cake resistance with combined effect of particle size and pressure can only be encompassed by higher order models; consequently, the prediction of specific cake resistance becomes more difficult. The effect of pressure on specific cake resistance was studied by keeping the sample under desired pressure for 5 min. This was done because oil-bearing material is subjected to pressure for only about 2.5 min in an oil expeller (Mandhyan, 1991). Therefore, it was assumed that there would be no change in specific cake resistance of small particles over such a short period of time.

The specific heat was determined by the

* *Corresponding Author*

TABLE 1. LEVELS OF VARIOUS PROPERTIES CONSIDERED FOR EXPERIMENTATION

Independent variable	Values				
Bulk density					
Particle size, mm	1.0	1.2	1.7	2.2	2.4
Moisture content, % (db)	15.9	20.0	10.0	40.0	44.1
Coefficient of friction					
Particle size, mm	1.0	1.2	1.7	2.2	2.4
Moisture content, % (db)	2.93	5.0	10.0	15.0	17.7
Specific Heat					
Temperature °C	47.6	60.0	90.0	120.0	132.4
Moisture content, % (db)	15.9	20.0	30.0	30.0	40.1
Thermal conductivity					
Particle size, mm	1.0	1.2	1.7	2.2	2.6
Moisture content, % (db)	39.5	60.0	90.0	120.0	140.0
Temperature °C	13.20	20.0	30.0	40.0	46.8
Viscosity and density					
Temperature °C	10 20	30	40	50 60	70 80 90

method used by Alam and Shove (1973). To measure the specific heat at various elevated temperatures, a preliminary trial was conducted. The soy sample was kept in an oven and the loss in moisture was measured, when it achieved desired temperature. In the final trial, the sample of higher moisture content was used to compensate for the loss of moisture during heating. The thermal conductivity was determined as per the method of Jasenky and Bilansky (1973). The viscosity of soy oil was measured by a viscometer (Precision Instrument Co., New Delhi).

Planning of the experiments and regression analysis : All the experiments, except that for specific cake resistance, were planned in central composite rotable design for two or three factors as per Cochran and Cox (1957). The observation at central level was taken four times in two independent variable experiments, and five times in three independent variable experiments. The levels of various independent variables, such as particle size (d, mm) moisture content (M, %) and temperature (T, °C) were decided on the basis of the trials conducted to investigate the effect of these factors on oil recovery and anti-nutritional factors (Mandhyan 1991). Five levels were selected, out of which intermediate levels had equal interval (Table 1). The highest and the lowest levels were calculated by adding or subtracting values of α, respectively, from the central level. Here, α= 1.414 x central level in a two independent level trial and α = 1.682 x central level in a three independent variable trial. Therefore, the highest and lowest levels varied with the number of independent variables.

Second order regression equations were developed for bulk density, coefficients of friction and thermal conductivity. These were tested as per the procedure described by Akhnazarova and Kafarov (1982). Graphs were prepared from these regression models by feeding in 25 various combinations of independent variables for obtaining the values of corresponding dependent property.

Results and Discussion

Bulk density : The effect of particle size and moisture content of bulk density of soy particles (Fig. 1) is encompassed by following equations :

ρ = 779.664 - 172.800 d - 3.90 m + 49.72 d^2 (cc = 0.989) where d = particle size and m = moisture content, % (db). Data show that the bulk density decreases with increase in particle size in the range of 1 to 1.7 mm. Above 1.7 mm, it increases slightly. This may be because of poor compaction of smaller particle sizes (the particles were tapped only gently). However, the bulk density increased due to reduction in porosity at larger particle size.

It is also seen that the bulk density decreases at higher moisture content. This is due to the simultaneous occurrence of two opposing phenomena. The first phenomenon is the reduction of the true density of soy particles due to absorption of water. This is because the true density of water (1 g/ml) is less than that of soybean (1.145 g/ml). Thus, increase in the moisture content decreases the true density of individual particle, thereby reducing the bulk density. The second phenomenon

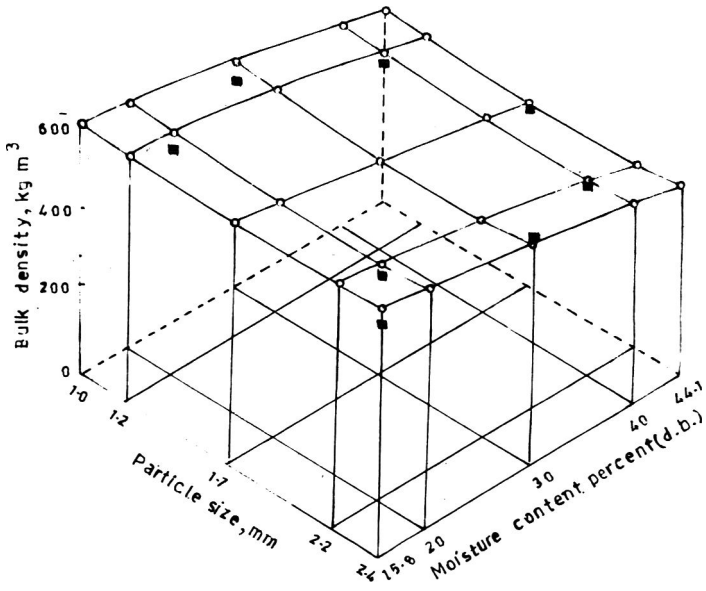

Fig. 1 Effect of particle size and moisture content on bulk density of soybean. ■ : Observed values, O—O : Predicted values.

is the increase in the volume of individual soy particles due to absorption of moisture, thereby decreasing the porosity and increasing the bulk density. Hence, the resultant effect of these two opposing phenomena is the slight decrease in bulk density at higher moisture content.

Coefficient of friction : The effect of particle size and moisture content on coefficient of friction is presented in Fig. 2 and the regression equation developed to predict the coefficient of friction is as follows :

$$f = 0.536716 + 0.26684\ d - 0.027\ M + 0.00012\ M^2 - 0.1096\ d^2 + 0.0076\ Md \quad (cc = 0.985)$$

where d = particle size, mm and M = moisture content, % db. It is observed that coefficient of friction decreases with increasing moisture content. This is because of the fact that the soy particle absorbs more moisture and achieves a round shape with increase in moisture content, thereby decreasing the rolling resistance and resulting in a decrease in the friction. Less variation is observed with respect to particle size.

Along the axis of particle size, it is observed that coefficient of friction increases till 1.2 mm particle size, and subsequently reduces. This may be due to the fact that, at 1.2 mm particle size, the number of plain surfaces and their area might have got optimized and consequently increased the coefficient of friction. At particle size less than 1.2 mm, the particle might be having lesser rolling resistance, while the particle might have slid on its surface at bigger particle sizes. In both such cases, the coefficient of friction gets reduced.

Specific cake resistance : The specific cake resistance of cracked soybean was measured at various particle sizes under the same compressive pressures (Fig. 3). It was found that specific cake resistance was very high at lower particle sizes (5889 x 10^4 meters/kg at particle size of 0.70 mm), then it reduced and again it started rising at larger particle sizes. This phenomenon was due to the fact that smaller particles got settled and compacted, before the flow of any fluid took place, and therefore, offered larger resistance to the flow. However, the larger particles aligned themselves and fitted in the pore spaces after some time of flow, consequently increasing the specific cake resistance. Moreover, the porosity was also less in large particle size, thereby providing less cross sectional area for flow. It was felt that the realignment and compacting for the medium sized particles might have been at optimum values and thus permitted free flow of fluid through the particles, thereby reducing the specific cake resistance.

The variation in specific cake resistance under various compressive pressures is also shown in Fig. 3. It is evident that specific cake resistance increased with pressure upto 73.99 MPa. Beyond this pressure, the rate of increment in the specific cake resistance was very small. This reduction in the increment may be due to full compacting of

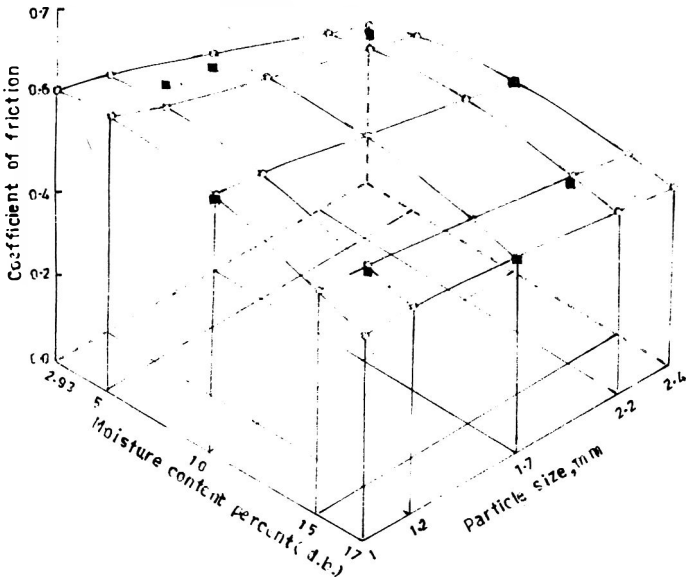

Fig. 2 Effect of moisture content and particle size on coefficient of friction between soybean and galvanized iron sheet. ■ : Observed values, O—O : Predicted values.

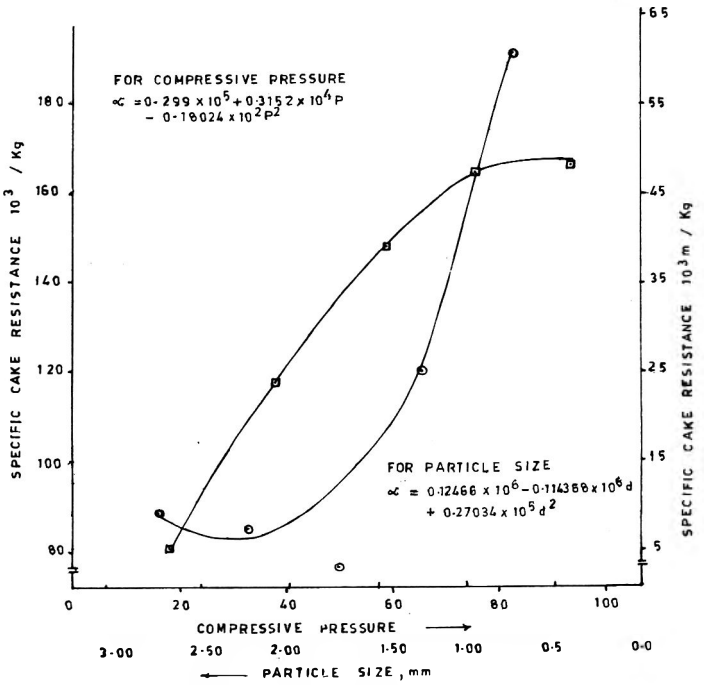

Fig. 3 Effect of compressive pressure and particle size on specific cake resistance of soybean. □——□ : Compressive pressure, O——O: Particle size.

cracked soybeans at that pressure, and consequently it did not permit the flow of oil through it. The variation in specific cake resistance with particle size was measured at atmospheric pressure, while its variation with compressive pressures was measured at a particle size of 1.2 mm. The variation is presented as follows :

$$\alpha = 0.12466 \times 10^6 - 0.114368 \times 10^6 d + 0.27034 \times 10^5 d^2 \quad (cc = 0.9756)$$

$$\alpha = 0.299 \times 10^5 + 0.31512 \times 10^4 p - 0.18024 \times 10^2 p^2 \quad (cc = 0.9981)$$

where, α = specific cake resistance m/kg, d = particle size, mm and p = pressure MPa (Mega Pascals)

Specific heat : The effect of moisture content and temperature on specific heat of cracked soybean is presented in Fig. 4. The following empirical relation has been developed :

$$C = -2.876 + 0.2168M + 0.0305T - 0.0018.9M^2 - 0.000015\ T^2 - 0.000736\ TM \quad (cc = 0.9811)$$

where C = specific heat, M = moisture content, % db and T = temperature, °C.

It is noted that specific heat of soybean varies curvilinearly with moisture content. It increases upto 40% moisture content and then becomes constant. This may be because of the fact that specific heat of water is more than that of soybean. Hence, more the moisture in soybean, the higher will be its specific heat.

The other factor responsible for increasing specific heat with increasing moisture may be the displacement of air due to decreased porosity. The specific heat of air is less than that of soybean. Hence, lesser the amount of pore space, the higher would be the specific heat. It appears that the change in porosity becomes negligible after 40% moisture content (db) and, therefore, the specific heat tends to become constant. Along the axis of temperature, the specific heat reduces slightly at 90°C. This may be due to moisture evaporation at 90°C, which reduces the moisture content and consequently the specific heat. It is emphasized that Alam and Shove (1973) and Watts and Bilanski (1970) have found linear relationship, which may be due to the lower level of moisture content. Non-linearity is observed in the present study at moisture content of above 4%.

Thermal conductivity : The thermal conductivity of cracked soybean was determined at various moisture contents, temperature and particle size. The results are presented in Figs. 5 and 6. The empirical equation developed is as follows :

$$K = 0.08159 + 0.0195 + 0.000619\ M + 0.0003\ T + 4.66 \times 10^{-8}\ T^2 - 0.00011\ dM + 2.2 \times 10^{-7}\ dt + 1.93 \times 10^{-8}\ MT \quad (cc = 0.97)$$

where d = particle size, mm; M = moisture content, % db and T = temperature, °C.

The effect of particle size and moisture content on the thermal conductivity of cracked soybeans is shown in Fig. 5. It is evident that thermal conductivity increased with increasing particle size. This is because the bulk density also increased with increasing particle size, and thus reduced the pore space. Along the axis of moisture content, the thermal conductivity is nearly constant.

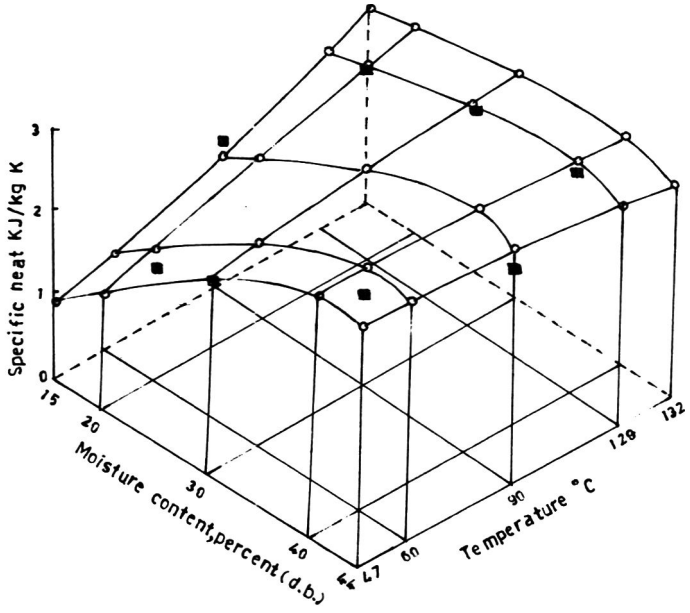

Fig. 4 Effect of moisture content and temperature on specific heat of ground soybean (1.2 mm particle size). ■ : Observed values, O—O : Predicted values.

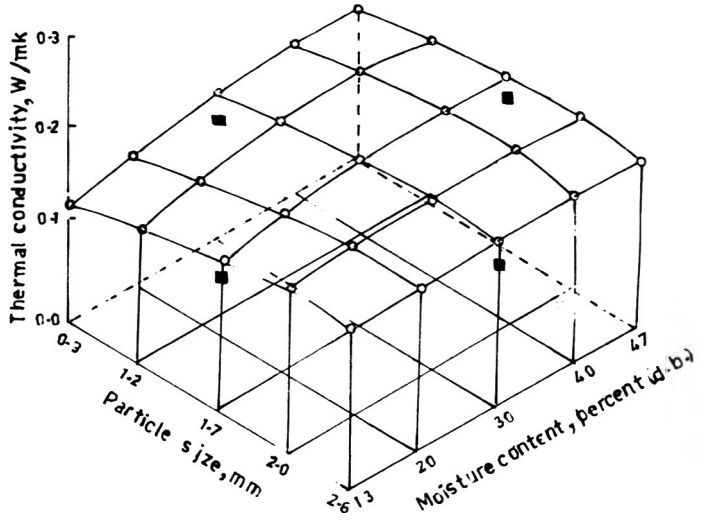

Fig. 5 Effect of particle size and moisture content on thermal conductivity of ground soybean (90 °C). ■ : Observed values, O—O : Predicted values.

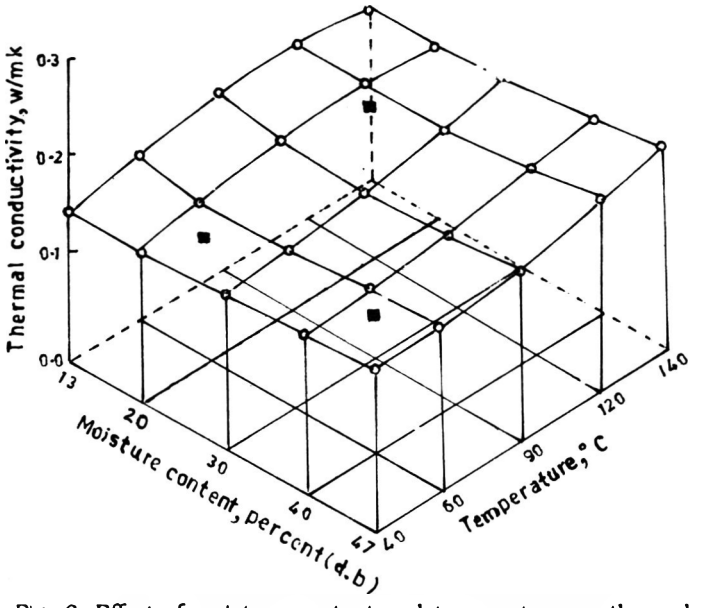

Fig. 6 Effect of moisture content and temperature on thermal conductivity of ground soybean (1.2 mm particle size). ■ : Observed values, O—O : Predicted values.

The effect of moisture content and temperature on thermal conductivity is plotted in Fig. 6. It can be seen that, along moisture content axis, there is not much variation in the thermal conductivity. However, the thermal conductivity increased significantly in a linear fashion along the temperature axis. The reason being that the thermal conductivity of water which is 0.60 W/mk at 20°C rises to 0.694 W/mk at 140°C. (McCabe et al. 1986). Hence, interaction of moisture content and temperature will have more effect on the thermal conductivity of soybean.

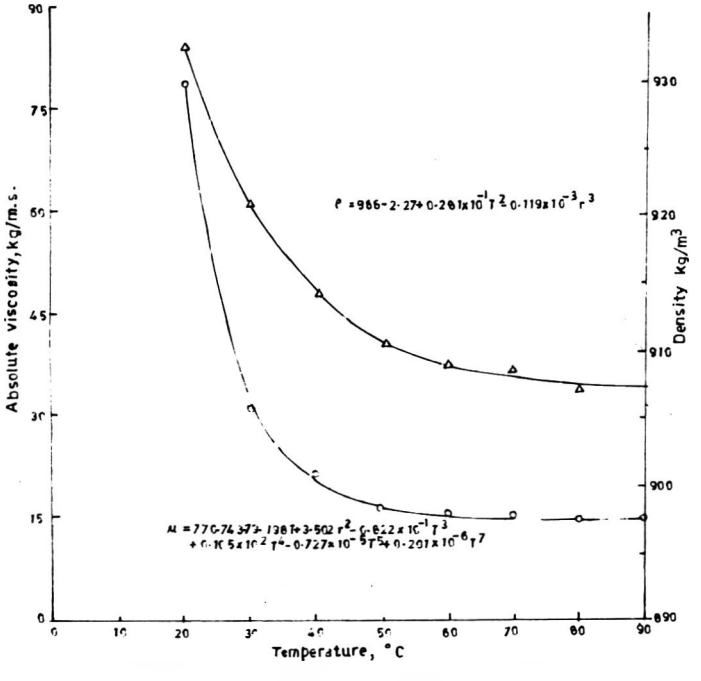

Fig. 7 Effect of temperature on viscosity and density of soy oil. Δ——Δ : Density, O——O: Viscosity.

Viscosity of soy oil : The variation of viscosity and density of mechanically expressed soy oil with temperature is shown in Fig. 7. It can be seen that viscosity reduced considerably between 20 and 30°C. The drop in viscosity continued upto 60°C. From 60°C to 90°C, the reduction in viscosity was negligible. The density of soy oil also reduced from 932 kg/m³ at 20°C to 907.54 kg/m³ at 60°C. However, this rate of reduction became very low between 60 and 90°C. A polynominal equation of sixth order adequately fitted to the experimental data of viscosity. The equation is as follows :

$$\mu = 770.743 - 79{,}198\ T + 3.502\ T^2 - 0.822 \times 10^{-1}\ T^3 + 0.106 \times 10\text{-}2\ T^4 - 0.727 \times 10^{-5}\ T^5 + 0.201 \times 10^{-7}\ T^6 \quad (cc = 0.999)$$

For the experimental data on the density of soy oil (ρ) a polynominal equation of third order could be fitted:

$$\rho = 966.21 - 2.2T + 0.281 \times 10^{-1}\ T^2 - 0.119 \times 10^{-3}\ T^3 \quad (cc\ 0.999)$$

where T = temperature of soy oil in °C.

References

Akhnazarova S, Kafarov V (1982) Experiment Optimization in Chemistry and Chemical Engineering. Mir Publishers, Moscow

Alam A, Shove GC (1973) Hygroscopicity and thermal properties of soybeans. Trans ASAE 16 (4) 707-712

Cochran WG, Cox GM (1957) Experimental Design. John Wiley and Sons, New York

ISI (1966) Indian Standard Methods of Sampling and Tests for Oil and Fats, IS: 3579-1966. Indian Standards Institution, New Delhi

Jasenky A, Bilansky WK (1973) Thermal conductivity of whole and ground soybeans. Trans ASAE 16 (1) 100-103

Koo EC (1942) Expression of vegetable oils. A general equation of oil expression. Ind Eng Chem 34:342-345

Mandhyan BL (1991) Mechanical expression of soy oil and utilization of soy cake as food. Ph.D. Thesis, Indian Institute of Technology, Kharagpur

McCabe WL, Smith JC, Harriot P (1986) Unit Operation of Chemical Engineering, McGraw Hill Book Co, New York

Mrema GC, McNulty PB (1985) Mathematical model of mechanical oil expression from oil seeds. J Agric Engg. 31:361-370

Nelson AI, Wijeratne WB, Yeh SW, We TM, Wei LS (1986) Dry extrusion as an aid to mechanical expelling of oil from soybeans. J Amer Oil Chem Soc 64:1341-1347

Schwartzberg N, Rosenau, JR, Richardson G (1977) The removal of water by expression. AICHE Symposium 13:177-191

Vadke VS, Sasulki FW, Shove CA (1988) Mathematical simulation of oilseeds press. J Amer Oil Chem Soc 65:1610-1616

Watts KC, Bilanski WK (1970) Calorimetric determination of specific heat of soybeans. Canadian Agric Eng 12:45-52

Received 21 May 1993; revised 20 January 1994; accepted 27 January 1994

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 400-403

Effect of Drying of Vermicelli in Hot Air Oven on Its Cooking Quality

R. VETRIMANI AND A. RAHIM*
Baking Technology Discipline,
Central Food Technological Research Institute, Mysore-570 013, India

Vermicelli, made from either refined wheat flour (*maida*) or semolina (*soji*), was subjected to drying in the hot air oven at temperatures ranging from 30 to 95°C for 30 to 60 min at each temperature. The vermicelli samples thus obtained were evaluated for cooking quality. Vermicelli of good quality can be obtained by drying the extruded vermicelli at 30°, 45°, 85° and 95°C for 60, 30, 30 and 60 min, respectively. The results could be of benefit to the small scale manufacturers of vermicelli in improving the quality.

Keywords : Vermicelli drying, Dry heat, Drying conditions, Mixing time, Dough water absorption, *Maida*, *Soji*.

Large scale pasta manufacturing units use sophisticated driers with humidity controls (Anon 1991; Dante 1988; Lirici 1990). The drying technique is so important that it is patented (Pavan 1988). The drying of pasta products is even done at high temperatures for reducing drying time (Olliver 1986; De Stefanis and Sgrulletta 1990). In contrast, small and cottage industries depend on dry heat method, involving uncontrolled temperatures, for drying of vermicelli. This may affect the cooking quality adversely. Therefore, an attempt has been made to standardize the preparation and hot air oven-drying of vermicelli, so as to obtain a better quality product.

Materials and Methods

Refined wheat flour *(maida)* and semolina *(soji)* were procured from local market and analyzed for moisture, total ash, dry gluten, pigment and Kent Jones colour grade by using the standard methods (AACC 1976). The samples (200 g) of these commodities were sieved for 10 min on a mechanical Buhler laboratory plan-sifter and the material collected on each sieve was weighed for calculating the percentages. The sieves used were with mesh openings in the range 62-670 microns (i.e. 670, 460, 340, 219, 129, 112, 85 and 62 microns, corresponding to mesh numbers 32, 45, 60, 6xx, 10xx, 12xx, 15xx and 25p, respectively).

Vermicelli was prepared by mixing 200 g flour or semolina in a Hobart mixer (Model N50) for time intervals varying from 7 to 12 min, with different quantities of water varying from 34 to 42% for *maida* and 28 to 36% for *soji*. The mixing time included 2 min premixing at 58 rpm and the rest of the time at 104 rpm to prepare a dough, which could be easily extruded through a laboratory model cold extruder (Saraswathi Industries, Coimbatore). The extruded samples of vermicelli were held in the open at room temperature (30°C) for 1 h. Subsequently, drying was done for 1 h each at 45°, 55° and 85°C, by spreading the extruded vermicelli samples to a thickness of about 12-15 mm in 32 x 25 x 2.5 cm trays and keeping them in a double chamber hot air oven (42 x 28 x 25 cm), which can be maintained at any temperature between 30 and 240°C, with an accuracy of ±2°C. The drying at 45°, 85° and 95°C was also studied for varying time from 30 to 60 min. The dried samples of vermicelli were then cooled to room temperature and packed in polyethylene pouches (22 x 15 cm size, 350 gauge).

The cooking quality of the vermicelli, made as above, and also of the five popular brands, obtained from local market, was determined as per the standard method (ISI 1976). A-50 gram sample was cooked in 500 ml boiling water for 10 min and placed over a screen to separate cooked vermicelli and the gruel. The cooked weight of vermicelli, which also indicates the amount of water uptake during cooking was determined and expressed as g per 100 g of dry vermicelli sample. The overall quality, with respect to appearance, texture and taste profiles was determined by a panel of six trained judges. Duncan's new multiple range test (Harter 1960) was used to determine the test of significance. The gruel was tested for solids content by evaporating a known weight of drained liquid on a boiling water-bath, till all the water was evaporated, before weighing the solids.

Results and Discussion

Proximate composition and particle size distribution : The data are presented in Table 1. The gluten contents of these commodities show that

*Corresponding Author

TABLE 1. PROXIMATE COMPOSITION OF *MAIDA* AND *SOJI* AS WELL AS THE PARTICLE SIZE DISTRIBUTION IN THESE COMMODITIES

Attribute	*Maida*	*Soji*
Moisture, %	9.8	12.2
Ash, % (db)	0.6	1.2
Gluten, % (db)	8.5	8.1
Kent Jones Colour grade	5.8	-
Pigment, ppm	2.1	1.2
Particle size distribution (μ), %		
< 62	2.8	1.0
62-85	1.8	0.3
85-112	0.2	0.4
112-129	93.0	0.7
129-219	2.1	0.6
219-340	0.1	24.1
340-460	0	65.8
460-670	0	7.1

these belong to soft wheat category. The particle size distribution showed that *maida* had the maximum number of particles (93%) in the size range 112 to 129 μ, while 89.9% of the *soji* particles were in the range of 219 to 460 μ. In each commodity, the particle size distribution, thus, is in a fairly narrow range. Particle size distribution assumes critical importance for proper hydration and dough consistency (Irvin et al. 1981) and thus differences in mixing time of these commodities are expected in the preparation of the dough.

Effect of dough mixing time : The dough mixing time of 7.5 min was found to be optimum in case of *maida* (Table 2), as it resulted in lowest cooking loss and higher cooked weight of the vermicelli. The scores for all the sensory attributes evaluated were also higher with the use of 7.5 min mixing time. In contrast, the optimum dough mixing time in case of *soji* was 10 min. The sensory quality of the product made from *soji* was slightly better than that of the product made from *maida*. The data in Table 2, thus, substantiate the observations that the mixing time varies due to differences in the particle size distribution among the raw materials. Higher hydration time, lower cooking loss and better overall quality for larger particle sized commodity,

TABLE 2. EFFECT OF WATER ABSORPTION AND DOUGH MIXING TIME ON THE COOKING AND SENSORY CHARACTERISTICS OF VERMCILLI* MADE FROM *MAIDA* AND *SOJI*

Water absorption+	Moisture in dry vermicilli,	Cooking quality		Sensory quality**			Dough mixing time***,	Moisture in dried vermicelli,	Cooking quality		Sensory quality		
		Solid loss,	Cooked weight,	Texture	Flavour & taste	Overall quality			Solid loss,	Cooked weight,	Texture	Flavour & taste	Overall quality
%	%	%	g				min.	%	%	g			
Maida-based													
Effect of water absorption							Effect of dough mixing time						
34	8.1	30	447	12.17^{c}	13.80^{b}	6.00^{c}	5.0	9.4	16	398	14.83^{ba}	14.80^{b}	7.20a
36	8.4	20	413	14.00^{b}	13.83^{b}	5.83^{c}	7.5	9.2	13	400	16.00^{a}	16.17^{a}	7.50^{a}
38	8.9	13	404	17.50^{a}	15.80^{a}	8.00^{a}	10.0	9.2	20	366	13.17^{b}	13.30^{b}	5.83^{b}
40	8.7	16	302	13.80^{b}	14.00^{b}	6.80^{b}				SEM	± 0.57	± 0.72	± 0.28
											(15df)	(15df)	(15df)
42	8.9	14	339	16.17^{a}	15.83^{a}	7.17^{ba}							
			SEM	± 0.54	± 0.57	± 0.35							
				(25df)	(25df)	(25df)							
Soji-based													
28	8.8	18	506	11.50^{b}	13.66^{b}	5.50^{b}	5.0	9.7	20	384	13.20^{a}	14.17^{b}	5.87^{a}
30	8.7	14	440	12.16^{ad}	14.00^{b}	5.67^{b}	7.5	9.5	17	375	13.33^{a}	14.20^{b}	6.00^{a}
32	8.9	12	412	14.17^{ab}	13.70^{b}	6.16^{ab}	10.0	9.5	11	388	16.50^{b}	16.00^{a}	7.70^{b}
34	9.1	11	384	15.93^{a}	16.16^{a}	7.66^{a}				SEM	± 0.47	± 0.63	± 0.34
											(15df)	(15df)	(15df)
36	8.9	14	403	13.80^{bc}	13.83^{b}	7.17^{a}							
			SEM	± 0.60	± 0.58	± 0.30							
				(25df)	(25df)	(25df)							

* Vermicelli was dried successively by holding for 1 h each at 30°, 45°, 55° and 65°C.

** Each observation is mean of 6 values, Means in the same column followed by different superscripts differ significantly ($P<0.05$)

*** Added moisture for *maida* dough = 38% and *soji* dough = 34%, 2 min premixing at low speed (58 rpm) for each sample and followed by mixing for 5 to 10 min. at 104 rpm.

\+ With premixing time of 2 min. at 58 rpm, with continued mixing at 104 rpm for 7.5 min. for *maida* dough and 10 min. for *soji* dough.

TABLE 3. INFLUENCE OF DRYING PATTERN ON QUALITY OF VERMICELLI FROM *MAIDA* AND *SOJI*

Drying pattern	Holding time h, Drying temperature, °C				Final moisture,	Cooking quality		Sensory quality*			
	30	45	85	95		Solids loss,	Cooked weight,	Appearance	Texture	Flavour & taste	Overall quality
					%	%	g				
					***Maida*-based**						
1	1.0	1.0	1.0	0.5	7.1	8	419	8.33^{ab}	16.17^{a}	16.30	7.33^{a}
2	1.0	1.0	0.5	1.0	6.6	9	427	8.16^{ab}	16.00^{ab}	16.00	7.00^{ab}
3	1.0	0.5	0.5	1.0	6.9	9	351	8.83^{a}	17.70^{d}	16.67	8.30^{d}
4	1.0	-	1.0	1.0	5.3	9	416	8.00^{b}	15.83^{ab}	15.80	6.83^{ab}
5	1.0	-	1.0	0.5	7.2	13	466	7.67^{b}	14.33^{c}	15.83	5.67^{c}
6	1.0	-	0.5	0.5	7.8	11	497	8.00^{b}	13.30^{c}	15.80	5.80^{c}
							SEM	±0.24 (30df)	±0.39 (30df)	NSD	±0.28 (30df)
					***Soji*-based**						
1	1.0	1.0	1.0	0.5	6.8	8	354	8.67	17.50^{a}	16.30^{a}	7.30^{a}
2	1.0	1.0	0.5	1.0	6.8	9	397	8.50	17.33^{a}	16.17^{ab}	7.67^{a}
3	1.0	0.5	0.5	1.0	6.8	8	418	8.33	17.50^{a}	16.70^{a}	8.50^{c}
4	1.0	-	1.0	1.0	6.2	11	414	8.50	14.17^{b}	14.20^{c}	5.83^{b}
5	1.0	-	1.0	0.5	8.1	14	415	8.16	12.20^{c}	13.67^{c}	5.70^{b}
6	1.0	-	0.5	0.5	8.9	11	524	8.30	14.50^{b}	14.00^{c}	5.80^{b}
							SEM	NSD	± 0.35 (30df)	±0.53 (30df)	±0.25 (30df)

* Each observation is the mean of six values. Mean in the same column followed by different superscripts differ significantly ($P \leq 0.05$) according to Duncan's New Multiple Range Test. NSD = No significant difference

as observed by other workers (Oh et al. 1985; Mousa 1979; Burove and Medvedev 1981; Manser 1990) is thus confirmed.

Effect of water absorption levels : In case of vermicelli made from *maida*, at water absorption levels of 34-42 %, the final moisture content ranged between 8.1 and 8.9% and the cooking loss decreased from 30 to 13% for a dough moisture of 38%. Cooked weight increased by 4.04-fold and resulted in statistically significant better sensory quality, with respect to texture, flavour, taste and overall quality (Table 2). The moisture of the dried vermicelli was around 8.8%, when the vermicelli was made from *soji* dough containing 28 to 36% moisture (Table 2). The cooking test indicated that a dough with 34% moisture gave vermicelli with significantly better sensory qualities (Table 2) and with minimum (11%) cooking loss. It is apparent that semolina with coarser particles will naturally have lesser surface area and lower starch damage, and hence absorb lesser amount of water in the dough, as compared to *maida*.

Effect of drying conditions on the quality of vermicelli : The drying patterns 1 to 4 (Table 3) gave *maida* vermicelli of satisfactory to good sensory quality, with respect to appearance, texture and overall quality. The cooking loss was 8 to 9%. In contrast, drying patterns 5 and 6 gave *maida* vermicelli with higher cooking losses (11 to 13%) and poor overall quality. This may be attributed to the surface hardening of the vermicelli due to drying at higher temperatures. In case of *soji* vermicelli, the drying patterns 1 to 3 (Table 3) gave the product with lower cooking loss (8 to 9%), and significantly better overall sensory quality. The drying pattern 3, with the lowest cooking loss of 8%, and increase in cooked weight by 4.18-fold, was the best. For drying patterns 4 to 6, the cooking loss was slightly higher (11 to 14%) and the overall quality was poor. This again is believed to be due to exposure to higher temperature during drying. The results, thus, indicate that the drying of vermicelli is a very critical unit operation. They also reveal that the vermicelli should be exposed to gradual increase of temperature during drying for obtaining the best quality product, in terms of cooking and sensory qualities, as well as low solids loss.

Cooking quality of commercial vermicelli : The data indicated that the overall quality was not related to either the moisture content of vermicelli or the cooked weight (Table 4). Two of the samples

TABLE 4. COOKING QUALITY OF SOME COMMERCIAL SAMPLES AND THEIR COMPARISON WITH LABORATORY SAMPLE

Sample	Moisture, %	Cooking quality		Sensory quality*			
		Solids loss, %	Cooked weight, g	Appearance	Texture	Taste & flavour	Overall quality
1	5.7	20	378	6.83^{c}	13.80^{c}	15.83^{d}	5.50^{c}
2	10.4	7	423	7.20^{c}	15.17^{c}	16.20^{cd}	6.50^{d}
3	10.6	14	364	6.50^{c}	11.66^{d}	13.80^{e}	5.67^{c}
4	10.3	10	453	8.33^{ab}	17.70^{ab}	17.67^{ba}	8.16^{b}
5	11.3	7	443	9.00^{a}	18.30^{a}	18.00^{a}	9.00^{a}
Laboratory sample **	6.8	8	418	8.50^{ab}	18.00^{ab}	17.80^{ba}	8.50^{ab}
				SEM ± 0.30 (30df)	±0.54 (30df)	±0.50 (30df)	±0.24 (30df)

* Each observation is a mean of six values, and means in the same column followed by different superscripts differ significantly ($P<0.05$) according to Duncan's New Multiple Range Test.

** Laboratory made sample of vermicelli was prepared using commercial *maida* sample as per the optimised process.

(4 and 5), from medium to large scale units, showed the cooking loss of 7 and 10%, and were also significantly good with respect to appearance, texture, flavour and overall quality. The control vermicelli sample, prepared under the standardized method, was the best of the market samples. Samples 1 to 3, from cottage to small scale industries, were very poor to satisfactory in overall sensory qualities. These results suggest that there is a need for improvement in the quality of vermicelli produced commercially by the cottage and small scale sectors. The data from the present studies indicate that the drying strategy is the single major important factor which governs the overall quality.

It may be concluded that a water absorption of 38 and 34% and the total dough mixing time of 9.5 and 12 min (including 2 min of premixing), were optimum for the *maida* and *soji*-based vermicelli doughs, respectively. The dry heat technique involving stepwise drying can be used for making good quality vermicelli. The optimum step-wise drying schedule involves the pre-and final-drying at 30° and 95°C for 1 h each, whereas drying in the intermediate stages require 0.5 h each at 45° and 85°C.

References

AACC (1976) Approved Methods, 7th edn. American Association of Cereal Chemists, Minnesota

Anon (1991) Fasta pasta. Food Processing (UK) 60:27-29

Burove CA, Medvedev GM (1981) Effect of milling coarseness of hard wheat flour on pasta quality. Khlebopekarnaya i Konditerskaya Promyshlennost 7:38-39

Dante B (1988) Manufacture of pasta products: Pasta drying. In: Guiseppe F, Cludia L (eds) Durum Wheat: Chemistry and Technology. American Association of Cereal Chemists, Minnesota, pp 203-206

De Stefanis E, Sgrulletta D (1990) Effects of high temperature drying on technological properties of pasta. J Cereal Sci 12:97-104

Harter HL (1960) Critical values for Duncun's new multiple range test, Biometrics 16:671-685

Irvin GN, Bradley JW, Martin GC (1961) A farinograph technique for macaroni doughs. Cereal Chem 38:153-164

ISI (1976) Specification for Macaroni, Spaghetti and Vermicelli, 1S-1486. Indian Standards Institution, New Delhi

Lirici L (1990) Drying of pasta. Technica Molitoria 41:470-481, 492

Manser J (1990) Particle size of semolina in relation to quality of pasta. Technica Molitoria 14:1031-1034

Mousa ESI (1979) Influence of wheat classes and granular millstreams blends on pasta quality. Ph.D. Thesis, North Dakota State University, Fargo, ND

Oh NH, Scib PA, Deyoe CW (1985) Noodles, IV. Influence of flour protein, extraction rate, starch damage and granulation on the quality characteristics of dry noodles. Cereal Chem 62:441-446

Olliver JL (1986) Pasta drying at very high temperature - A fact. In: Mercier CH, Cantarelli C (eds) Pasta and Extrusion Cooked Foods, Elsevier Applied Science Publishers, Essex, pp 90-108

Pavan M (1988) Process and apparatus for desiccating food products such as pasta. European Patent No. 0253307 A1

Received 22 April 1993; revised 4 February 1994; accepted 8 February 1994

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 404-408

Effect of Salt and Its Blend with Polyphosphates on the Quality of Buffalo Meat and Patties Under Hot, Chilled and Frozen Conditions

A.S.N. ANJANEYULU*[1], N. SHARMA[1] AND N. KONDAIAH[2]

[1]Division of Livestock Products Technology,
Indian Veterinary Research Institute, Izatnagar-243 122, India.
[2]Ministry of Agriculture, Krishi Bhavan, New Delhi-110 001, India.

Effects of 2% salt alone and of 2% salt + 0.5% polyphosphates on quality of hot (unchilled meat, within 5 h of slaughter), chilled (stored at 2°C for 20-22 h) and frozen (stored at -10°C for 6 days) buffalo meat and palatability of patties were investigated. Hot, and salt-containing chilled meat were not significantly different for salt soluble proteins, emulsifying capacity, emulsion stability, yield, and acceptability of patties. Addition of salt + polyphosphates increased ($P<0.01$) pH, water-holding capacity, emulsion stability, yield, and sensory attributes of patties, but reduced cooking loss, irrespective of the method of meat handling. Chilling or freezing of ground buffalo meat, pre-blended with salt + polyphosphates, had no significant advantage in terms of emulsion stability, yield and palatability of patties, in comparison to incorporation of salt + polyphosphates, while processing.

Keywords : Salt, Polyphosphates, Pre-blending, Buffalo meat, Functional properties, Patties.

Potential benefits and possible disadvantages of hot processing of minced beef, pork and chicken have been well documented (Cuthbertson 1980; Smulders 1985). Hot processing improves binding ability of meat proteins, by increasing both the amount of salt extractable proteins, and the emulsifying capacity of the meat (West 1983). Addition of salt and polyphosphates to buffalo meat had significantly improved certain of its quality parameters (Kondaiah et al. 1985; Anjaneyulu et al. 1989). Pre-blending denotes mixing of minced meat with salt and other additives, and keeping it for a specific period of time under chilled, or under frozen storage. It improves the functional properties of meat, due to enhanced salt penetration and increased protein-salt interaction (Ockerman and Crespo 1982). Pre-blended meat is used in the sausage industry for maintaining uniformity in composition and quality (Pearson and Tauber 1984). A number of studies on storage stability of buffalo meat (Kulkarni et al. 1993) on the quality parameter of a variety of meats (Kondaiah et al. 1988) and skeletal and offal meats (Krishnan and Sharma 1991) and preparation of patties (Anjaneyulu and Sharma 1991) have also been carried out. Information on the effect of salt and polyphosphate on the functional properties of buffalo meat under different handling conditions is scanty. Further, no investigation has been done on pre-blending of buffalo meat, nor any on its suitability for product processing.

Therefore, the objectives of the present study were : (a) to determine the effect of pre-blending of buffalo meat with salt and polyphosphates on physico-chemical properties of the meat and the sensory quality of the patties made with it ; and (b) to compare the effects of polyphosphates on the functional properties of meat under different handling conditions.

Materials and Methods

Materials : A meat sample (10.5 kg), from the round portion (mainly biceps femoris, semi-membranosus, semi-tendinosus and quadriceps) of an adult female carcass, of good finish, was obtained within 5 h of slaughter. A meat sample of similar quality, from a single carcass was utilized for each trial of the experiment. Laboratory grade sodium chloride (salt) was used. Polyphosphates mixture consisted of 65% anhydrous sodium pyrophosphate, 17.5% sodium tri-polyphosphate and 17.5% sodium acid pyrophosphate (Anjaneyulu et al. 1989).

Meat processing : Visible fat and connective tissue sheath were removed, and the meat was cut into chunks of 5-6 cm size. Hot (i.e. unchilled) meat was fine-minced by passing through 8 mm and 4 mm plates. For each treatment, minced meat (600 g) or meat chunks (600 g) were immediately treated with additives as per experimental requirement. Salt alone (2%), or a mixture of salt (2%) + polyphosphates (0.5%), was blended with meat in a Hobart Food Mixer (N-50), using a flat beater at low speed, for 1 min in the case of a minced sample, and for 10 min in the case of chunks. Treated samples were packed in low density

* Corresponding Author

polyethylene bags.

In experiment I, six trials were conducted as follows : (1) hot (unchilled meat) : within 5 h of slaughter, meat was minced and mixed with salt; (2) chilled meat : hot meat was chilled at 2°C for 20-22 h, then minced, and mixed with salt; (3) hot meat was minced, and mixed with salt + polyphosphates; (4) chilled meat was minced, and mixed with salt + polyphosphates; (5) hot meat chunks, pre-blended with salt + polyphosphates, were chilled at 2°C for 20-22 h, and then minced; and (6) hot-minced meat, pre-blended with salt + polyphosphates, was chilled.

In experiment II, six trials were conducted as follows : (1) chilled meat was frozen at -10°C for 6 days, thawed at 4°C for 15 h, then minced and mixed with salt; (2) chilled meat was frozen, thawed, minced, and mixed with salt + polyphosphates; (3) hot meat was frozen, thawed, minced, mixed with salt + polyphosphates; (4) chilled minced meat, pre-blended with salt + polyphosphates, was frozen at -10°C for 6 days, and then thawed; and (5) hot minced meat, pre-blended with salt + polyphosphates, was frozen and thawed.

Meat emulsion and patties : For each treatment, the required quantity of emulsion (300 g) was made in a Hobart mixer (N-50), with finely minced meat/ pre-blended meat (85%) and refined soy oil (15%) using a wire whip at high speed. Treatments had either 2% salt alone or 2% salt + 0.5% polyphosphates on meat and oil basis. Ice-cold water (10%), spice mix (1%) and seasonings (4%) were also added. The emulsion was hand-moulded (using petridish, 77 x 17 mm) into 3 patties, each weighing 80 g. Patties were cooked at 180°C for 20 min in a pre-heated oven, to obtain an internal temperature of 75°C, as recorded by a probe thermometer. Cooked patties were weighed and their yield was expressed as a percentage.

Analysis : Meat pH was recorded using Elice pH meter with glass electrode, after homogenising a 10 g sample with 50 ml distilled water for 1 min. Water-holding capacity was determined as per the method of Wardlaw et al (1973) with slight modification (Anjaneyulu et al. 1989). Moisture, protein and fat (AOAC 1980), salt soluble protein (Knipe et al. 1985), emulsifying capacity (Swift et al. 1961) and cooking loss of meat and emulsion stability (Kondaiah et al. 1985) were determined by standard methods. The emulsion stability is inversely related to emulsion cooking loss. The samples were analysed, in duplicate, for water-holding capacity and salt-soluble protein, and in triplicate for cooking loss and emulsion stability.

Sensory evaluation : The sensory attributes of cooked patties were evaluated by experienced panel members, using an 8-point, structured scale, wherein 8 = extremely desirable appearance, flavour, juiciness, texture and overall palatability, while 1 = extremely undesirable attributes. Nine judges were employed for each trial in experiment I, and 10 judges for each trial in experiment II. Warm patties were cut across their centres to obtain 8 pieces of similar shape (triangular) and size from each patty, and served to the panelists for evaluation.

Statistical analysis : The data were subjected to analysis of variance, and critical differences (Snedecor and Cochran 1968) were calculated to determine any significant differences between treatment means.

Results and Discussion

The pH values of hot and chilled meat used in this study were 5.71 ± 0.04 and 5.54 ± 0.01, respectively. The lean meat contained 76.66 ± 0.35% moisture, 19.68 ± 0.11% proteins and 1.93 ± 0.13% fat. Hot meat mixed with salt had significantly higher ($P<0.01$) pH, as compared to chilled meat with salt (Table 1). Hot meat had significantly greater water-holding capacity, as compared to chilled meat, possibly due to higher pH of the former. Honikel et al (1981) have also reported greater increase in water-holding capacity (lower cooking loss) with the addition of salt to comminuted pre-rigor beef, than when the same amount of salt was added to rigor or post-rigor meat. Chilled meat had markedly higher cooking loss and lower product yield, as compared to hot meat. A similar increase in the cooking loss, during post-mortem storage of buffalo meat for 24 h, has been reported (Kondaiah et al. 1986). Hot and chilled meats were also not significantly different with respect to extractable salt-soluble protein, emulsifying capacity and emulsion stability (Table 1).

The superior functional properties of hot-boned meat, as reported by other workers (Cuthbertson 1980; West 1983), were not observed in this study. This is possibly due to delay of about 5 h in the processing of hot (unchilled) meat after slaughter, which resulted in the onset of rigor mortis. The onset of rigor mortis in bovine muscles occurs, when the ATP concentration in the tissue reaches a level of about 1 μ mol/g, which corresponds to

TABLE 1. EFFECT OF SALT AND ITS BLEND WITH POLYPHOSPHATES ON PHYSICO-CHEMICAL PROPERTIES OF MEAT UNDER DIFFERENT HANDLING CONDITIONS

Treatment	pH	WHC ml/ 100 g	EC, ml oil/ 2.5 g	Salt-soluble protein,%	Cooking loss, %	Emulsion stability, %	Patties yield, %
Hot meat, minced, salted	5.77[a] ±.04	33.8[a] ±6.0	117.5 ±4.4	8.5[a] ±.2	22.3[a] ±3.2	24.2[a] ±5.1	79.3[a] ±5.9
Chilled meat, minced, salted	5.64[b] ±.02	24.3[b] ±6.2	120.5 ±5.8	8.6[a] ±.3	26.4[a] ±3.6	24.7[a] ±4.2	76.9[a] ±4.4
Hot meat, minced, mixed with salt + polyphosphates	6.03[c] ±.04	43.6[c] ±4.4	120.5 ±4.5	9.7[b] ±.1	13.7[b] ±0.8	7.4[b] ±0.8	90.1[b] ±0.7
Chilled meat, minced, mixed with salt + polyphosphates	5.93[c] ±.02	36.5[c] ±5.4	123.5 ±5.8	10.0[b] ±.2	13.7[b] ±0.2	9.3[b] ±0.6	91.9[b] ±0.5
Chilling of hot meat chunks pre-blended with salt + polyphosphates, minced	5.99[c] ±.03	56.7[d] ±7.0	123.0 ±5.5	9.4[b] ±.7	10.2[b] ±0.8	8.8[b] ±0.5	93.2[b] ±0.4
Chilling of hot meat minced, pre-blended with salt + polyphosphates	5.99[c] ±.02	39.3[a] ±5.2	122.0 ±5.4	9.4[b] ±.3	10.8[b] ±1.1	8.9[b] ±1.2	92.8[b] ±0.4

WHC : Water holding capacity, EC : Emulsifying capacity ; n = 6.

Means with same superscripts in each column do not differ significantly (P>0.05)

about pH 5.9 of muscle in a normal animal (Honikel et al. 1981). Further, they have also reported a remarkable decrease in solubility of myofibrillar proteins and increase in the value of cooking loss at the onset of rigor.

Addition of salt + polyphosphates to hot and chilled meat mince has resulted in significantly (P<0.01) higher pH, salt-soluble protein, better emulsion stability, yield of patties and lower cooking loss, as compared to corresponding treatments 1 and 2 involving the use of salt alone (Table 1). These results confirm the findings of other workers (Knipe et al. 1985; Trout and Schmidt 1984; Bernthal et al. 1991).

Pre-blending of hot meat chunks with salt + polyphosphates (treatment 5) has resulted in a considerable increase in water-holding capacity, as compared to other treatments. In addition to action of salt and polyphosphates, mechanical disruption of surface fibres of hot meat chunks during blending, followed by chilling for about 20-22 h and mincing, possibly facilitated a better penetration of salt and polyphosphates, thereby leading to greater extraction of myofibrillar proteins, and consequent increase in hydration and swelling of meat, as compared to pre-blended meat mince (Treatment 6). Lamkey et al (1991) have reported that pre-blending of pork with 2% salt, prior to chilling, improved the water-holding capacity, when compared

TABLE 2. EFFECT OF SALT AND ITS BLEND WITH POLYPHOSPHATES UNDER DIFFERENT MEAT HANDLING CONDITIONS ON SENSORY ATTRIBUTES* OF *PATTIES*

Treatment	Appearance	Flavour	Juiciness	Texture	Overall acceptability
Hot (unchilled) meat, minced, salted	5.69[a] ±.17	5.71[a] ±.15	5.40[a] ±.17	5.35[a] ±.15	5.40[a] ±.15
Chilled meat, minced, salted	5.84[a] ±.16	5.69[a] ±.14	5.44[a] ±.16	5.22[a] ±.17	5.51[a] ±.16
Hot meat, minced, mixed with salt + polyphosphates	6.71[b] ±.09	6.71[b] ±.09	6.67[b] ±.09	6.71[b] ±.09	6.78[b] ±.08
Chilled meat, minced, mixed with salt + polyphosphates	6.78[b] ±.08	6.69[b] ±.08	6.75[b] ±.07	6.75[b] ±.08	6.89[b] ±.08
Chilled of hot meat, chunks pre-blended with salt + polyphosphates, minced	7.02[b] ±.06	6.82[b] ±.08	6.89[b] ±.09	6.95[b] ±.10	6.89[b] ±.10
Chilling of hot minced meat pre-blended with salt + polyphosphates	6.87[b] ±.07	6.67[b] ±.08	6.69[b] ±.10	6.73[b] ±.09	6.78[b] ±.09

* Sensory scores based on eight-point descriptive scale, 8 = extremely desirable, 1 = extremely undesirable.

Means with same superscript in each column do not differ significantly (P>0.05)

n = 45 sensory scores for 5 replications

TABLE 3. EFFECT OF SALT AND ITS BLEND WITH POLYPHOSPHATES ON PHYSICO-CHEMICAL PROPERTIES OF BUFFALO MEAT UNDER FROZEN MEAT HANDLING CONDITIONS

Treatment	pH	WHC ml/ 100 g	EC, ml oil/ 2.5 g	Salt-soluble protein,%	Cooking loss, %	Emulsion stability, %	Patties yield, %
Chilled meat, frozen, minced, salted	5.59[a] ±.03	19.7[a] ±3.2	106.7 ±3.5	7.9[a] ±.4	20.7[a] ±2.5	29.2[a] ±2.2	71.9[a] ±2.9
Chilled meat, frozen, minced, mixed with salt + polyphosphates	5.94[b] ±.04	35.4[b] ±3.7	112.2 ±3.7	10.2[b] ±.4	8.8[b] ±.8	7.2[b] ±.5	92.9[b] ±0.5
Hot meat, frozen, minced, mixed with salt + polyphosphates	5.94[b] ±.03	34.4[b] ±3.0	111.7 ±3.4	10.0[b] ±.3	8.8[b] ±.6	6.8[b] ±0.7	93.4[b] ±0.4
Chilled minced meat, pre-blended with salt + polyphosphates, frozen	6.08[c] ±.03	46.7[c] ±2.7	111.5 ±3.0	10.3[b] ±.7	8.9[b] ±.3	8.2[b] ±0.7	91.0[b] ±0.6
Hot minced meat, pre-blended with salt + polyphosphates, frozen	6.09[c] ±.04	50.4[c] ±1.2	113.5 ±2.8	8.7[a] ±.4	8.3[b] ±.4	8.3[b] ±.6	92.6[b] ±0.3

WHC : Water holding capacity, EC : Emulsifying capacity ; n = 6

Means with same superscripts in each column do not differ significantly (P>0.05)

to cold boned pork.

Patties made from hot and chilled meat, with or without polyphosphates, were not significantly different with respect to the sensory attributes (Table 2). Hot-boned beef rolls (Pepper and Schmidt 1975) and steaks (Seman et al. 1987) have also been found to be comparable in sensory attributes to the conventionally processed products. Addition of salt + polyphosphates significantly (P<0.01) improved the sensory attributes of patties, as compared to those made with salt alone. This is in agreement with the findings obtained by many workers who worked with other meat products (Puolanne and Terrell 1983; Barbut et al. 1985). Meat handling conditions had no significant effect on sensory attributes of patties, when salt + polyphosphates were incorporated in the formulation. However, the sensory panel scores were slightly higher for patties from treatment 5, which may be due to higher water-holding capacity of meat and lower losses during cooking.

Freezing of hot and chilled meat had no significant effect on functional properties, when salt + polyphosphates were incorporated. Addition of salt + polyphosphates, either to frozen hot or chilled meat, significantly (P<0.01) increased pH, water-holding capacity, salt-soluble protein, emulsion stability, yield of patties and reduced cooking loss, as compared to frozen meat treated with salt alone (Table 3). Pre-blending of hot and chilled meats (treatments 4 and 5) with salt + polyphosphates has resulted in a significant increase in pH and

TABLE 4. EFFECT OF SALT AND ITS BLEND WITH POLYPHOSPHATES UNDER FROZEN MEAT HANDLING CONDITIONS OF SENSORY ATTRIBUTES* OF BUFFALO MEAT *PATTIES*

Treatment	Appearance	Flavour	Juiciness	Texture	Overall acceptability
Chilled meat, frozen, minced, salted	5.78[a] ±.14	5.74[a] ±.14	5.30[a] ±.12	5.10[a] ±.12	5.40[a] ±.11
Chilled meat, frozen, minced, mixed with salt + polyphosphates	7.04[b] ±.08	6.96[b] ±.06	6.90[b] ±.08	7.06[b] ±.09	7.06[b] ±.08
Hot meat, frozen, minced, mixed with salt + polyphosphates	7.14[b] ±.06	6.96[b] ±.06	6.94[b] ±.07	7.02[b] ±.09	7.06[b] ±.07
Chilled minced meat, pre-blended with salt + polyphosphates, frozen	6.84[c] ±.08	6.84[b] ±.07	6.68[b] ±.09	6.76[c] ±.11	6.74[c] ±.10
Hot minced meat, pre-blended with salt + polyphosphates, frozen	6.84[c] ±.09	6.80[b] ±.07	6.70[b] ±.07	6.60[c] ±.11	6.62[c] ±.10

n = 50 sensory scores for 5 replications.

* Sensory scores based on eight-point descriptive scale, 8 = extremely desirable, 1 = extremely undesirable.

Means with same superscript in each column do not differ significantly (P>0.05)

a consequent increase ($P<0.05$) in water-holding capacity, when compared to frozen hot and chilled meat treated with salt + polyphosphates (treatments 2 and 3). Hamm (1981) reported that maintenance of superior functional properties of pre-rigor meat during storage required salting, rapid freezing and the use without thawing. Kondaiah et al (1986) found that frozen buffalo meat appeared to be better for use in comminuted products. Pre-blending of hot meat with salt + polyphosphates (treatment 5) resulted in a significant decrease in extractability of salts soluble proteins, as compared to meat from treatments 2, 3 and 4. Increase in water-holding capacity, in turn, reduced the extractability of salt-soluble proteins (Macfarlane 1974), possibly due to gelation of proteins and consequent enhancement of hydration.

The emulsifying capacity did not significantly vary among different frozen meat conditions. This is in contrast to the findings of Acton and Saffle (1969), who have reported that the pre-blending of post-rigor frozen meat emulsified 30% more fat in frankfurters than that of either fresh post-rigor or frozen post-rigor meat. Salt + polyphosphates incorporation significantly ($P<0.01$) improved sensory attributes of patties (Table 4). Patties made from frozen hot or chilled meat formulations, with salt + polyphosphates, were not significantly different in their sensory attributes. These were also rated markedly better for appearance, texture and overall palatability in comparison to the products made from the frozen pre-blended meat.

References

Acton JC, Saffle RL (1969) Pre-blend and pre-rigor meat sausage emulsions. Food Technol 23:367-371

Anjaneyulu ASR, Sharma N, Kondaiah N (1989) Evaluation of salt, polyphosphates and their blends at different levels on physico-chemical properties of buffalo meat and patties. Meat Sci 25:293-306

Anjaneyulu ASR, Sharma N (1991) Effect of fat and phosphate on the quality of raw and pre-cooked buffalo meat patties. J Food Sci Technol 28:157-160

AOAC (1980) Official Methods of Analysis, 13th ed. Association of Official Analytical Chemists, Washington, DC

Barbut S, Maurer AJ, Lindsay RC (1985) Effects of reduced sodium chloride and added phosphates on physical and sensory attributes of turkey frankfurters. J Food Sci 53:62-66

Bernthal PH, Booren AM, Gray JI (1991) Effect of reduced sodium chloride concentration and tetrasodium pyrophosphate on pH, water-holding capacity and extractability of protein of pre-rigor and post-rigor ground beef. Meat Sci 29:69-82

Cuthbertson A (1980) Hot processing of meat : A review of the rationale and economic implications. In: Lawrie R (ed) Developments in Meat Science - 1. Applied Science Publishers Ltd., London, pp 61-68

Hamm R (1981) Post-mortem changes in muscle affecting the quality of comminuted meat products. In: Lawrie R (ed) Developments in Meat Science - 2, Applied Science Publishers Ltd., London, pp 93-124

Honikel KO, Fisher C, Hamid A, Hamm R (1981) Influence of post-mortem changes in bovine muscle on the WHC of beef: Post-mortem storage at 20°C. J Food Sci 46:1-6

Knipe CL, Olson DG, Rust (1985) Effect of selected inorganic phosphates, phosphate levels and reduced sodium chloride levels on protein solubility, stability and pH of meat emulsion. J Food Sci 50:1010-1013

Kondaiah N, Kesava Rao V, Anjaneyulu ASR, Sharma N, Lakshmanan V (1986) Evaluation of variety meats from buffaloes for some quality parameters. J Food Sci Technol 23:113-115

Kondaiah N, Anjaneyulu ASR, Rao VK, Sharma N, Joshi HB (1985) Effect of salt and phosphate on the quality of buffalo and goat meat. Meat Sci 15:183-192

Kondaiah N, Anjaneyulu ASR, Rao VK, Sharma N (1986) Effect of different handling conditions on minced buffalo meat quality. Indian Anim Sci 56:677-679

Kulkarni VV, Kowale BN, Kesava Rao V, Murthy TRK (1993) Storage stability and sensory quality of washed ground buffalo meat and meat patties during refrigerated storage. J Food Sci Technol 30:169-171

Krishnan KR, Sharma N (1991) Studies on the quality characteristics of buffalo skeletal, offal meats and their combinations. J Food Sci Technol 28:304-307

Lamkey JW, Mandigo RW, Calkins CR (1991) Pre-blending hot and cold boned pork at different particle sizes. J Food Sci 56:1511-1513

Macfarlane JJ (1974) Pressure-induced solubilization of meat proteins in saline solution. J Food Sci 39:542-547

Ockerman HW, Crespo FL (1982) Physico-chemical changes occurring during storage of pre-cured beef pre-blends at different temperatures and two levels of salt. J Food Sci 47:849-851,857

Pearson AM, Tauber FW (1984) Processed Meats 2nd ed. AVI Publishing Co., Westport

Pepper FH, Schmidt GR (1975) Effect of blending time, salt, phosphate and hot boned beef on binding strength and cooked yield of beef rolls. J Food Sci 40:227-230

Puolanne EJ, Terrel RN (1983) Effect of rigor state, levels of salt and sodium tripolyphosphate on physical, chemical and sensory properties of frankfurter type sausages. J Food Sci 48:1036-1038

Seman DL, Moody WG, Fox JD, Gay N (1987) Influence of hot and cold boning on the palatability, textural and economic traits of restructured beef steaks. J Food Sci 52:879-882

Smulders FJM (1985) Modern processing techniques to improve meat quality. In: Krol B, van Roon PS, Houben JH (eds) Trends in Modern Meat Technology. Pudoc, Wageningen, Netherlands, pp 40-45

Snedecor GW, Cochran WG (1968) Statistical Methods, 6th ed. Oxford and IBH Publishing Co., Calcutta

Swift CE, Locker C, Fryar AJ (1961) Comminuted meat emulsions - the capacity of meats for emulsifying fat. Food Technol 15:468-473

Trout GR, Schmidt GR (1984) Effect of phosphate type and concentration, salt level and method of preparation on binding in restructured beef rolls. J Food Sci 49:687-694

Wardlaw FR, McCaskill LH, Acton JC (1973) Effects of post-mortem changes on poultry meat loaf properties. J Food Sci 38:421-423

West RL (1983) Functional properties of hot boned meat. Food Technol 37(5):47-66

Received 7 May 1993; revised 10 February 1994; accepted 3 March 1994

J. Food Sci. Technol., 1994, Vol. 31, No. 5 409-412

Biological Evaluation of the Effects of Traditional Processing Methods on Protein Quality of Fishes (*Heterotis niloticus* and *Chrysichthys nigrodigitatus*)

ONIMAWO AKHAKHIA IGNATIUS

Science Technology Department, Federal Polytechnic, Idah, Kogi State, Nigeria.

Fresh samples of *Heterotis niloticus* and *Chrysichthys nigrodigitatus* were processed by dry and wet curing methods, before sun-drying and smoking. Control samples were oven-dried at 60°C. These were compared for the protein quality by providing 10% protein in the test diets fed to weaning albino rats for 14 days. Apparent and true digestibility values of *H. niloticus* were in the ranges of 84.37 - 86.26% and 94.60 - 96.37%, respectively. Corresponding values for C. *nigrodigitatus* were 83.33 - 88.97% and 93.77 - 96.83%, respectively. Weight gain, protein efficiency ratio, net protein ratio, protein retention efficiency, biological value and net protein utilization were not significantly different among the various diets (P>0.05). The results showed that the processing methods did not adversely affect the protein quality of the fish species.

Keywords : *Fishes, Heterotis niloticus, Chrysichthys nigrodigitatus*, Traditional processing methods, Protein quality, Animal feeding.

The dietary intake of good quality proteins is of significant nutritional importance, because of its role in furnishing a mixture of amino acids of the proper pattern for the synthesis of tissue proteins and maintenance of body functions (Osborne and Mendel 1919; Rose and Witch 1979; King et al. 1976). Fish, a potential source of protein with high digestibility, contain amino acids in proportions, which vary from species to species (Nasedkina and Pakbomova 1972, Kizevetter and Nasedkina 1975). In developing countries, preservation of fishes is done by salting and drying. (Suryanarayana Rao and Khabade 1968). Some workers in India have observed significant changes during storage of fish (Reddy and Srikar 1991; Warrier et al. 1988). These traditional salting and drying methods are used in the majority of processed fish in Nigeria today and may affect the protein quality of the processed fish.

The objective of this study was to elucidate information on the effects of these processing methods on the protein quality of two, West African, fresh-water fishes, *H. niloticus* and *C. nigrodigitatus*, before and after processing.

Materials and Methods

H. niloticus and *C. nigrodigitatus* were purchased in the open market and stored in a deep freezer, before processing. In all, 12 kg of each species were bought and divided into three groups of 4 kg each. One group was processed and sun-dried, while the second group was processed in the same way, and smoked; the third group served as control. The processing methods employed were dry-curing, or salting, followed by sun-drying (DCSD), wet curing, or salting, followed by sun-drying (WCSD); dry curing or salting followed by smoking (DCSM) and wet curing or salting followed by smoking (WCSM). Common salt (NaCl) was used for curing. The sun-drying was carried out for nine days. Drying was aided by the hamattan (dry wind) weather. On the other hand, smoking was done continuously for three days over charcoal. The control was oven-dried at 60°C for 48 h. The fishes were milled after drying, and made into meals. The crude protein of the processed fish was determined by AOAC (1980) method. The meals were incorporated into diets to provide 10% proteins as the only source. In all, there were eleven diets. These were diets I-V for *H. niloticus*, diets VI-X for *C. nigrodigitatus* and a basal diet BO. The basal diet consisted of (%) 65 corn starch, 5 glucose, 10 sucrose, 5 non-nutritive cellulose, 10 groundnut oil, 4 mineral mix (Halver 1957) and 1 vitamin mix (Halver and Shanks 1960). The variously processed fishes were incorporated into the basal diet, at the expense of corn starch to provide 10% proteins. Diets I and VI contained fish meals of DCSD, II and VII contained fish meals of WCSD, III and VIII contained fish meals of DCSM, IV and IX contained fish meals of WCSM, while V and X contained fish meals of oven-dried sample of *H. niloticus* and *C. nigrodigitatus*, respectively.

Animal feeding : Thirtythree weanling male albino rats of the 'Wistar' strain were used. The rats were obtained from the rat colony of the department of Veterinary Medicine, University of Ibadan. The weights of the rats averaged 48.5 g. Three rats were randomly assigned on basis of body weight to each diet. Feeding was *ad libitum* and water was provided at all times. They were weighed

TABLE 1. PROXIMATE COMPOSITION OF DIFFERENTLY PROCESSED *HETEROTIS* AND *CHRYSICHTHYS* SPECIES

Processing methods	*Heterotis* species						*Chrysichthys* species					
	Moisture %	Crude protein, %	Crude fibre, %	Fat, %	Ash, %	Nitrogen free extracts %	Moisture %	Crude protein, %	Crude fibre, %	Fat, %	Ash, %	Nitrogen free extracts %
Dry-curing and sun-drying	5.1	57.4	0.5	9.6	20.9	1.4	10.9	55.0	1.3	24.1	20.1	0.5
Wet-curing and sun-drying	10.1	64.6	0.5	12.7	22.2	0.6	9.2	56.5	1.5	24.6	16.9	0.4
Dry-curring and smoking	5.2	71.4	0.5	8.8	18.0	0.8	6.3	63.3	1.5	20.6	14.3	0.6
Wet-curing and smoking	11.9	60.0	0.6	14.0	12.6	1.9	10.7	56.4	1.0	22.7	19.2	0.7
Control (Oven-dried at 60°C)	3.2	82.5	0.4	6.8	10.1	0.2	3.0	71.9	1.1	16.9	10.0	0.1

at the beginning and at the end of the experimental period (14 days). Total protein was calculated from the protein content of diets and the amount of food consumed.

Analytical methods : A period of seven days was allowed for the rats to adjust to the new conditions, before faecal and urinary samples were collected. The urine samples were collected and stored in sample bottles in a deep freezer, pending analysis. Faecal samples were similarly collected and dried in the oven at 85°C for 24 h. These were ground mechanically, with a laboratory mortar and pestle, and stored in polythene bags at room temperature. After the experimental period of 14 days, the rats were weighed, and killed, using chloroform. Incisions were made on the head and from the lower jaw to the abdomen to fecilitate uniform drying. The carcasses were dried at 85°C for 48 h to constant weight. For the determination of nitrogen, each carcass was thoroughly milled using a mechanical blender. Representative samples of these were used for the determination of nitrogen content by AOAC (1980) method. The carcass nitrogen values and the nitrogen intake values for 14 days feeding period were used to compute net protein utilization (NPU), biological value (BV), and true digestibility (TD). Other parameters determined included protein efficiency ratio (PER), feed conversion efficiency (FCE), net protein retention (NPR), protein retention efficiency (PRE), apparent digestibility (AD), weight gain, total feed intake and total protein intake. Standard methods were adopted for calculating the above parameters. These included those of Osborne and Mendel (1919) for PER, Bender and Doell (1957) for PRE, and Mitchel (1923, 1924) for NPU and BV.

Results and Discussion

Results of the proximate analysis of the processed fish samples are shown in Table 1, while those of the diets are given in Table 2.

Protein quality indices : Average values for feed intake, average weigh gain, FCE, PER, NPR and PRE are presented in Table 3. The values for these indices were not significantly different ($P>0.05$) from those of the control diets V and X in both fish species. This means that, with the exception of the basal diet, all the diets were equally effective in promoting growth in rats. Values relating to BV, NPU, AD and TD are presented in Table 4. The BV of *Heterotis* ranged from 60.0 to 65.7%, while those for *Chrysichthys* were in the range of 63.1 to 75.4%. This indicated that both the fish proteins are of high quality. When compared with the control, these values showed no significant differences. The values for NPU were also high, ranging from 56.8 to 63.6% for *Heterotis*, and from 60.9 to 70.7% for *Chrysichthys*. Values for AD and

TABLE 2. PROXIMATE COMPOSITION OF DIETS

Attribute, %	Diets involving *Heterotis* species					Diets involving *Chrysichthys* species					
	I	II	III	IV	V	VI	VII	VIII	IX	X	Basal diet
Crude protein	9.9	10.4	10.1	10.2	10.1	10.6	10.4	10.7	10.1	11.00	0.7
Crude fibre	1.0	1.3	1.8	1.0	1.1	1.1	0.1	1.3	1.2	1.2	1.8
Fat	13.9	13.4	15.4	15.1	14.0	21.0	22.3	22.2	21.4	20.5	11.4
Total ash	3.2	2.1	2.9	3.1	2.7	2.1	2.4	2.0	2.1	2.1	2.0
Nitrogen-free extracts	71.9	72.9	69.4	70.0	72.1	65.2	63.6	64.8	64.1	65.2	84.3

TABLE 3. PROTEIN QUALITY INDICES BASED ON WEIGHT GAIN BY THE RATS

Attribute	Diets involving *Heterotis* species						Diets involving *Chrysichthys* species					
	I	II	III	IV	V	Mean	VI	VII	VIII	IX	X	Mean
Total food intake, g	81.6	86.6	106.5	93.1	99.0	92.0	113.2	107.9	99.9	93.4	98.8	103.8
Total protein intake, g	8.1	9.0	11.3	9.5	10.1	9.2	12.0	11.2	10.7	9.4	10.8	10.4
Total weight gain, g	28.3	37.2	41.7	35.0	47.0	47.0	48.0	48.0	42.8	39.5	42.9	44.3
Food conversion efficiency	2.9	2.3	2.6	2.7	2.7	2.6	2.4	2.3	2.3	2.4	2.3	2.3
Protein efficiency ratio	3.5	3.9	3.7	3.7	3.7	3.7	4.0	4.3	4.0	4.2	4.0	4.1
Net protein ratio	4.2	4.7	4.2	4.3	4.3	4.3	4.4	4.8	4.5	4.8	4.5	4.6
Protein retention efficiency	67.0	75.9	66.6	68.0	70.1	69.4	76.3	72.3	72.3	76.6	71.6	73.8

All values are not statistically significant (P>0.05)

TD indicate that the protein quality of both the fish species is high.

Apparent digestibility values ranged from 84.0 to 88.3% for *Heterotis* and from 83.3 to 87.0% for *Chrysichthys*. True digestibility varied from 94.6 to 96.4% in *Heterotis* and 93.8 to 96.8 in *Chrysichthys*. This observation is in agreement with that made by Henry and Kon (1957), who stated that the changes in levels of intake do not always appear to affect their true digestibilities for good quality protein.

In general, results of the parameters used in this experiment showed that processing methods employed did not adversely affect the protein quality of the two fish species significantly. The results also indicate that the two fish species have high nutritional value. Any protein with a PER value of 2.0 or more, when fed at 10% in the diet, is considered to be a protein of good quality (Friedman 1974). In all the diets, PER values were higher than 3.0, indicating that both the fish species contain high quality proteins. These results also agree with those of Vervack et al (1977), who found no significant differences in the protein quality of cod, herring, plaice, shrimp, anchovy and sardine, when differently processed. However, the big-eye fish was inferior to white fish and herring in food intake and AD, while other parameters did not differ significantly (Talabi et al. 1980).

The mean values for NPU, in the present study, were also above 40%, the least being 56.8% (Table 4). The relationship between NPU and PER, as reported by Bender and Harelden (1956), indicates that when NPU is below 40, rats are unable to grow on the experimental diets; consequently, the PER values are also low. The degree to which the PER is lowered depends on the amount and quality of proteins. The results of the present study are in agreement with the findings of Bender and Harelden (1956). Biological value of proteins is affected by many factors, one of which is amino acid imbalance (Deshpande et al. 1958). The high BV observed in the present study indicates that the two fish species are of good quality, and that their proteins are not

TABLE 4. BIOLOGICAL EVALUATION OF PROCESSED FISH SPECIES : PROTEIN QUALITY INDICES BASED ON CARCASS NITROGEN

Attributes	Diets involving *Heterotis* species						Diets involving *Chrysichthys* species					
	I	II	III	IV	V	Mean	VI	VII	VIII	IX	X	Mean
Carcass nitrogen matter, %	10.4	10.4	10.8	10.6	10.6	10.6	10.8	10.7	10.9	10.7	10.8	10.8
Apparent digestibility,%	86.2	84.4	88.4	84.0	85.3	85.7	85.7	83.3	83.9	89.0	87.0	85.8
True digestibility, %	96.4	94.6	96.2	95.2	95.5	95.6	85.6	94.0	93.8	96.7	96.8	95.4
Net protein utilization,%	63.6	57.2	60.1	56.8	60.9	59.7	67.1	66.6	70.7	65.3	60.9	66.1
Biological value	65.7	60.7	62.7	60.0	63.8	62.6	71.1	74.1	75.4	67.3	63.1	70.2

All values in the horizontal column for each attribute are not statistically significant (P>0.05)

adversely affected by processing. However, there is still a need to carry out an analysis of the amino acid profile, before final conclusions can be reached.

References

AOAC (1980) Official Methods of Analysis, 10th ed. Association of Official Analytical Chemists, Washington DC

Bender AE, Doell BN (1957) Biological evaluation of proteins, a new aspect. Br J Nutr 11:40-47

Bender AE, Harelden S (1956) Biological value of proteins of a variety of fish meals. Br J Nutr 11:42-52

Deshpande PD, Harper AC, Elvehjem CA (1958) Amino acid imbalance and nitrogen retention. J Biol Chem 230:335-343

Friedman MC (1974) Assay Methods: Biological, Biochemical and Chemical-Protein Nutritional Quality of Foods and Feeds. Marcel Dekker Inc., New York

Halver JE (1957) Nutrition of salmonoid fishes: Water soluble vitamin requirements of chinook salmon. J Nutr 62:225-243

Halver JE, Shanks W (1960) Nutrition of salmonoid fishes VIII: Indispensable amino acids for sockeye salmon. J Nutr 72:340-346

Henry KM, Kon SK (1957) Effect of level of protein intake and age of rats on biological value of proteins. Br J Nutr 11:305-310

King MH, King FM, Monday DC, Burgess HTL, Burgess AP (1976) Nutrition for Developing Countries. Oxford University Press, Ibadan, Nigeria

Kizevetter IV, Nasedkina SA (1975) Characteristics of nitrogen compounds of the meal of sharks and rays as a food protein source. Voprosy Pitania 1:36-40

Mitchell HH (1923) The nutritive value of proteins. Physiol Rev 4:424-436

Mitchell HH (1924) A method of determining the biological value of protein. J Biol Chem 58:873-876

Nasedkina EA, Pakbomova TV (1972) Hydroxyproline and tryptophan contents of meat of some fish. Rybee Khozyaistvo 10:69-70

Osborne TB, Mendel LBA (1919) A method of expressing numerically the growth promoting value of proteins. J Biol Chem 37:557-561

Reddy GV and Srikar LN (1991) Effect of ice storage on protein and related changes in pink perch *(Nemiplorus japonicus)* J Food Sci Technol 28:101-104

Ross C, Witch E (1979) Nutrition, Houghton Miflin Co., Boston

Suryanarayana Rao SV and Khabade VS (1960) Studies on artificial drying of salted mackerel. J Food Sci Tech 5:123-126

Talabi SO, Fctuga BL, Ologhiobo A (1980) Utilization of 'big-eye' fish *(Brachydenterus auritus)* for fish meat and fish protein concentrate production. In: Connell JJ (ed) Advances in Fishery Sciences. Cambridge University Press, Cambridge, pp 46-50

Vervack WM, Vombelle M, Foulon M (1977) The amino acid composition of some fish products. Fermentations et les Industries Alimentaires 32(6):171-177

Warrier SB, Ghadi SV, Ningoor V (1988) Effect of cold storage on the proteolytic enzymes of fish muscle. J Food Sci Technol 25:313-314

Received 27 July 1992; revised 8 February 1994; accepted 4 March 1994

Characteristics of Yoghurt-like Cultured Milks

GEETHA C. JAYAN*[1] AND MOHAMMED HABIBULLA KHAN
Department of Dairy Science,
Madras Veterinary College, Madras-600 007, India.

With the objective of producing yoghurt-like products, having improved therapeutic value and altered flavour characteristics, *Lactobacillus acidophilus* and *Lactococcus lactis* ssp. *lactis* biovar. *diacetylactis* were added separately, along with yoghurt cultures such as *Streptococcus salivarius* ssp. *thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*, in the preparation of the products. Use of *L. acidophilus* at 2% level and *L. lactis* ssp. *lactis* biovar. *diacetylactis* at 3% level was found to give a product with higher organoleptic properties and improved antibacterial effect against a number of undesirable microorganisms. When lactococcus was used as a supplementary culture, it had to be incubated at 37°C, so as to get the beneficial effects.

Keywords : Yoghurt-like cultured milk, Supplementary cultures, Antibacterial effects, Organoleptic properties, Temperature of incubation, Yoghurt bacteria.

Yoghurt is the best known fermented milk product, which has enjoyed wide popularity all over the world within the last three decades (Puhan 1990) and is often made even with fruit pulp and oilseed proteins (Bilani et al. 1989; Balasubramaniam and Kulkarni 1971). Of late, the market for low-fat yoghurt has expanded rapidly (White 1991). *Streptococcus salivarius* ssp. *thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus* are the conventional yoghurt bacteria. The present study was undertaken to prepare and evaluate samples of skim milk yoghurt (SMY), supplemented with cultures of *Lactobacillus acidophilus* or *Lactococcus lactis* ssp. *lactis* biovar. *diacetylactis*. The sensory characteristics, the *in vitro* antibacterial activity and the important biochemical characteristics of the product were also studied.

All the lactic cultures were obtained from the National Dairy Research Institute, Karnal. *Lactobacillus delbrueckii* ssp. *bulgaricus* (1373), *Streptococcus salivarius* ssp. *thermophilus* (489), *Lactobacillus acidophilus* (R) and *Lactococcus lactis* ssp. *lactis* biovar. *diacetylactis* (DRC1) were the lactic cultures used in the study. *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis*, *Bacillus cereus*, *Pseudomonas aeruginosa* and *Pseudomonas fluorescens* were the test organisms used to study the *in vitro* antibacterial activity.

Preliminary trials in yoghurt preparation were conducted to study the optimum level of addition of skim milk powder (SMP) and sugar to the skim milk, so as to get a curd of good acceptability. These trials indicated that the yoghurt prepared from skim milk having fat content < 0.2%, fortified using 4% (w/v) SMP and sweetened with 3% (w/v) cane sugar gave very good results. The level of addition of sugar was kept as low as possible, at an acceptable level, so as to minimise the cost of production. In subsequent trials, control yoghurt (YC) was prepared using 1% (v/v) each of *L. delbrueckii* ssp. *bulgaricus* and *S. salivarius* ssp. *thermophilus*. The levels at which the different supplementary cultures were used are as follows: Over and above the cultures used in YC, 1%, 2% and 3% of *L. acidophilus* were added in samples YA1, YA2 and YA3, respectively. In another set, 1%, 2% and 3% of *L. lactis* ssp. *lactis* biovar. *diacetylactis* were added in samples YD1, YD2 and YD3, respectively. The yoghurt mix was heat-treated at 85°C for 30 min, cooled to the incubation temperature and inoculated with the desired lactic cultures. All the samples were incubated at two different temperatures viz., 37 and 42°C. The time taken for setting of the yoghurt curd was noted. Once a firm curd was obtained, the samples were transferred to 5°C.

Organoleptic evaluation of the samples was carried out at the time of setting and after 24 h cold storage, by a panel of five selected judges, using the score card suggested by Pearce and Heape (1974). The pH, titratable acidity (TA), proteolysis and diacetyl content in the samples were estimated at different time intervals after culture inoculation. The *in vitro* antibacterial activity of the cell-free-culture-filtrates (CFCF) from the samples was measured at different levels of pH, by the agar well assay technique (Reinheimer et al. 1990). The titratable acidity (TA) and pH of the samples were measured as per the standard procedure (BIS 1981). Proteolysis was measured by estimating the amount of tyrosine released, following the procedure of Lowry et al (1951). The colorimetric

* *Corresponding Author.* [1] *Present address : K.A.U. Dairy Plant, Veterinary College, Mannuthy P.O., Thrissur-680 651, India.*

method of Walsh and Cognan (1974) was followed for the estimation of diacetyl.

At the incubation temperature of 37°C, samples took longer time for setting, than at 42°C (Table1) and this is because of the low incubation temperature, which prolongs the incubation period for curd formation. Rasic and Kurmann (1978) reported that yoghurt samples incubated at 30 to 37°C required longer incubation period than those incubated at 41 to 42°C. Comparing the setting time of the samples, all samples, except those supplemented with lactococci and incubated at 42°C, showed a decrease in setting time with increase in the amount of inoculum used. This is because of the accelerated rate of acid development with an increase in the inoculum and the consequent faster coagulation and setting. But lactococci showed poor growth at temperatures above 37°C, and hence there was no decrease in incubation time with increase in the amount of lactococcal inoculum, when the incubation temperature was 42°C. Due to the same reason, the biochemical characteristics of these samples at 42°C did not differ significantly from that of the control (Table 1).

All the samples, at both the temperatures of incubation, showed a rapid and significant decrease in pH upto the time of setting (Table 1). The pH values of the different samples at setting ranged from 4.6 to 4.7. Tamime and Robinson (1985) reported that the pH of yoghurt, at the time of setting, ranged from 4.6 to 4.7. At both the temperatures, the titratable acidity, tyrosine values and diacetyl contents of all samples showed a rapid and significant increase upto the time of setting. The acidity values at setting ranged from 0.7 to 0.9% lactic acid among the various samples. The tyrosine values at this stage ranged from 52.7 to 70.1 µg/g. Acidity of all samples, except that of YA3, were in agreement with the BIS (1973) specifications, according to which the titratable acidity of yoghurt should not exceed 0.7%. Asperger (1973) observed that good quality yoghurt samples had tyrosine contents ranging from 50 to 100 µg/g. Diacetyl content in the different samples ranged from 1.8 to 5.7 ppm. Samples supplemented with lactococci contained significantly higher amounts of diacetyl than the control, only when incubated at 37°C. No significant change was noticed in any of the biochemical characteristics of the samples, upto 24 h storage at 5°C.

Results of organoleptic evaluation (Table 1) showed that, incubation at 37°C favoured better development of body and texture. Angevine (1972) stated that a lower temperature favoured better curd formation, even though 41 to 42°C is the commonly employed incubation temperature for yoghurt. Cold storage improved the body and texture of the product. Flavour scores for samples supplemented with lactococci and incubated at 37°C were significantly higher than those of the control, due to diacetyl production by the lactococci. Samples YA3 scored significantly lower points for flavour than YC, and these samples had a high-acid taste. This may be due to the excess acid

TABLE 1. CHARACTERISTICS OF YOGHURT-LIKE CULTURED MILKS PRODUCED AT TWO DIFFERENT TEMPERATURES OF INCUBATION

Culture used	Incubation temperature, °C	Setting time, h	Values at the time of setting					Inhibitory zone (diam in mm) with test organisms					
			pH	Lactic acid,%	Tyrosine, µg/g	Diacetyl, ppm	Organoleptic scores*	*S. aureus*	*E. coli*	*B. subtilis*	*B. cereus*	*P. aeruginosa*	*P. fluorescens*
YC	37	4.5	4.6	0.7	53.0	1.9	12.4(14.9)	13.7	8.6	8.4	8.9	4.4	5.1
	42	3.5	4.7	0.7	52.7	1.9	12.1(14.8)	13.9	8.8	8.5	9.1	4.7	5.2
YA1	37	4.2	4.7	0.7	61.7	1.9	11.5(14.7)	15.8	12.5	9.9	9.9	5.2	5.7
	42	3.0	4.7	0.7	61.3	1.8	10.9(14.6)	16.1	12.8	10.0	10.2	5.5	6.0
YA2	37	3.8	4.6	0.8	66.5	1.8	11.6(15.9)	16.9	13.3	10.4	10.8	5.7	6.0
	42	2.7	4.6	0.8	66.0	1.8	10.9(15.4)	17.2	13.6	10.7	11.4	6.0	6.2
YA3	37	3.5	4.6	0.9	70.1	1.8	11.4(14.8)	17.8	14.1	11.2	11.3	6.3	7.1
	42	2.3	4.6	0.8	67.8	1.8	10.7(14.8)	18.3	14.4	11.4	11.6	6.6	7.5
YD1	37	4.1	4.6	0.7	60.2	4.3	13.1(16.4)	14.5	10.2	9.1	9.4	6.2	7.3
	42	3.4	4.6	0.7	53.0	2.0	11.7(14.8)	14.1	9.1	8.6	9.2	4.7	5.3
YD2	37	3.7	4.6	0.7	63.6	4.8	13.2(17.5)	15.3	10.7	9.5	9.9	7.3	7.7
	42	3.3	4.6	0.7	53.1	2.0	11.9(15.8)	14.2	9.2	8.8	9.3	4.8	5.3
YD3	37	3.5	4.6	08	67.0	5.7	13.8(19.3)	16.4	11.4	10.0	10.3	8.0	8.5
	42	3.3	4.7	0.7	53.2	2.1	12.5(16.2)	14.3	9.2	8.8	9.3	4.9	5.4

YC : *S. salivarius* spp. *thermophilus* + *L. delbrueckii* spp. *bulgaricus* : 1% each, YA1, YA2, YA3 : same as YC but with 3 levels (1%, 2% and 3%) of *L. acidophilus*, respectively, YD1, YD2, YD3 : same as YC but with 3 levels (1%, 2% and 3%) of *L. lactis* ssp. *lactis* biovar. *diacetylactis*, respectively. *Figures in parantheses were obtained after storing the samples for 24 h at 5°C. Values reported are the average of six trials, Initial pH 6.67± 0.012.

TABLE 2. F-VALUES. STANDARD ERROR, CRITICAL DIFFERENCE AND STATISTICAL SIGNIFICANCES FOR VARIOUS ATTRIBUTES

Attribute	Relationships			
	Between treatments	Between periods Upto setting	After setting	Between temperatures
Setting time, h				
F-value	4.01**	-	-	4.01**
Standard error	0.03	-	-	0.03
Critical difference	0.15	-	-	0.15
pH of the product				
F-value	4.39**	4.45**	0.41NS	4.11**
Standard error	0.05	0.02	-	0.10
Critical difference	0.19	0.10	-	0.27
Titratable acidity of the product, % lactic acid				
F-value	11.13**	9.72**	0.53NS	10.00
Standard error	0.02	0.03	-	0.03
Critical difference	0.08	0.12	-	0.10
µg tyrosine/g product				
F-value	5.89**	6.99**	0.31NS	7.98**
Standard error	0.81	0.62	-	0.22
Critical difference	1.98	1.54	-	1.04
Diacetyl content of the product				
F-value	36.58**	33.51**	0.29NS	34.11**
Standard error	0.07	0.08	-	0.18
Critical difference	0.26	0.38	-	0.99
Organoleptic score				
F-value	27.98**	29.11**		29.78**
Standard error	0.28	0.21		0.19
Critical difference	1.00	0.99		0.88

** : F-value highly significant ($P<0.01$), NS : F-value not significant ($P\geq0.05$)

production by the lactobacilli.

Data on the relationship between different attributes and statistical significances are given in Table 2.

Study of the *in vitro* antibacterial activity, using *S. aureus*, *E. coli*, *B. subtilis*, *B. cereus*, *P. aeruginosa* and *P. fluorescens* as test organisms, showed that addition of supplementary cultures increased the antagonistic properties of the product (Table 1).

From the results of this study, it can be concluded that, *L. acidophilus* can be used as a supplementary culture in the preparation of skim yoghurt upto a level of 2%, and *L. lactis* ssp. *lactis* biovar. *diacetylactis* can be used upto 3% level, so as to get a product having better organoleptic properties and improved antibacterial effect against undesirable microorganisms. When lactococci is used as the supplementary culture, it has to be incubated at 37°C, in order to get the beneficial effects.

Acknowledgement

The authors are thankful to the Dean, Madras Veterinary College, and to The Tamil Nadu Veterinary and Animal Sciences University, for providing facilities. Grant of Junior Research Fellowship to Geetha C. Jayan by the Indian Council of Agricultural Research, New Delhi, is gratefully acknowledged.

References

Angevine NC (1972) Making yoghurt via vat-method. Dairy and Icecream Field 155:42-56

Asperger H (1973) Acceptability of analytical methods for the assessment of yoghurt quality. Osterreichische Milch Wirtschaft 28:125-129

Balasubramanyam BV, Kulkarni S (1991) Standardisation of manufacture of high fat yoghurt with natural fruit pulp. J. Food Sci Technol 28: 389-390

Bilani N, Hayashi K, Haragachi K, Kasumi T (1989) Utilisation of sunflower proteins in yoghurt. J Food Sci Technol 26: 205-209

BIS (1973) Specifications for Fermented Milk Products. 7035. Bureau of Indian Standards, New Delhi

BIS (1981) Handbook of Food Analysis, Part XI SP:18. Bureau of Indian Standards, New Delhi

Lowry DH, Rosenbrough NJ, Farr AJ, Randall RF (1951) Protein measurements with the Folin phenol reagent. J Biol Chem 193: 265-275

Pearce LE. Heape HA (1974) Town milk. J New Zealand Milk Board 22:18

Puhan Z (1990) Developments in the technology of fermented milk products. Cult Dairy Prod J 25:4-9

Rasic LJ, Kurmann JA (1978) Fresh Fermented Milk Products, Vol I. Technical Dairy Publishing House, Copenhagen

Reinheimer JA, Demkow MR, Candioti MC (1990) Inhibition of coliform bacteria by lactic cultures. Australian J Dairy Technol 45:15-18

Tamime AY, Robinson RK (1985) Yoghurt-Science and Technology. Pergamon Press, Toronto

Walsh B, Cognan TM (1974) Further studies on the estimation of diacetyl by the methods of Prill and Hammer and Owades and Jakovac. J Dairy Res 41:31-35

White C (1991) 'Light' yoghurts with heavy consumer appeal. Dairy Field 174:52-53

Received 30 July 1993: revised 15 December 1993; accepted 15 December 1993

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 416-417

Relationship of Husk Content of Paddy with Grain Dimension and Weight

SULOCHANA SURIYAMOORTHY AND P. PILLAIYAR*
Paddy Processing Research Centre, Thanjavur-613 005, India.

The husk content in 151 samples of paddy ranged from 18.1 to 26.3%, the length (L) from 5.75 to 10.33 mm, breadth (B) from 2.10 to 3.52 mm, L:B from 1.81 to 4.10 and 1000-grain weight from 10.24 to 30.33g. The husk content was less in coarse (20.8%), when compared to that in fine (21.9%) and super fine (22.1%) varieties. The breadth and weight were found to be negatively related to husk content.

Keywords : Rice, Paddy, Husk content, Dimension, Weight, Relation of dimension with husk.

Husk content is one of the factors that decides the rice yield from a cultivar, the other factors being degree of bran removal and kernel breakage during milling (Bhattacharya 1979). On global basis, the husk content in paddy is reported to range from 14% (Baldi et al. 1974) to 28% (Cagampang et al. 1966), thereby showing a difference in potential yield of rice of as much as 14% due to this factor alone. In Indian varieties, the husk content varies from 19-23% (Bhattacharya 1979). If a low husk strain, with desirable technological and cooking characteristics is developed, the potential yield of rice can be substantially increased. It is well known that husk-sealed grain facilitated quick drying besides improving the appearance of milled rice and preventing fungal growth in parboiled rice (Anthony raj et al. 1981). With the above in view, 151 varieties/cultures of paddy, collected from the Tamil Nadu Rice Research Institute, Aduthurai, and School of Genetics, Tamil Nadu Agricultural University, Coimbatore, were studied.

The samples were thoroughly cleaned by aspirating in the Satake laboratory dehusker (type THU) by disengaging the rubber rolls. The length (L) and breadth (B) of paddy and brown rice were determined with the aid of a graduated grooved card by placing 10 grains end to end (Pillaiyar and Mohandoss 1981). One thousand grains picked at random from the above sample were weighed in a Sartorius balance. To avoid possible bruising or scouring on brown rice during dehusking, husk was peeled off carefully by hand in 100-grain lots and the weights of husk and brown rice were determined separately. All these tests were carried out in triplicate. Based on the L and L:B of brown rice, the samples were classified as super fine, fine and coarse (Department of Food 1980). Bhattacharya et al (1982) suggested the use of surface area per unit weight for classifying rice.

The range and mean values of the properties determined are indicated in Table 1. The samples represented all the classes viz., super fine (21 samples), fine (52) and coarse (78). The husk content in superfine (22.1%) and fine (21.9%) varieties was more, than that in coarse (20.8%). Juliano et al (1964) also noticed greater proportion of husk in longer and thinner paddy. The mean brown rice weight was found to be less in super fine and fine varieties, but more in coarse varieties. The length of paddy or brown rice did not reflect any relation with the husk content (Table 2).

In their studies on the physical properties of paddy and rice and their interrelations, Bhattacharya et al (1972) noticed that the grain length was an

TABLE 1. RANGE AND MEAN OF PHYSICAL CHARACTERISTICS

Characteristics	Paddy		Brown rice	
	Range	Mean	Range	Mean
Husk content, %				
SF (21)	19.4-26.2	22.1	-	-
F (52)	18.4-26.3	21.9	-	-
C (78)	18.1-25.4	20.8	-	-
Length (L), mm				
SF	7.90-10.33	9.25	5.83-7.90	6.84
F	6.03-9.50	8.06	4.30-7.00	6.01
C	5.75-8.75	7.80	4.13-6.43	5.75
Breadth (B), mm				
SF	2.10-3.10	2.58	1.80-2.50	2.16
F	2.37-3.08	2.87	1.98-2.50	2.28
C	2.60-3.52	3.01	2.20-3.05	2.56
L:B				
SF	3.16-4.10	3.41	3.00-3.60	3.17
F	2.40-3.40	2.95	2.00-2.99	2.63
C	1.81-3.01	2.59	1.48-2.49	2.22
1000-grain weight, g				
SF	12.94-30.33	21.82	10.81-24.59	17.09
F	10.24-26.07	19.65	8.18-20.80	15.39
C	12.63-27.39	21.73	9.65-21.46	17.23

SF : Super fine, F: Fine, C: Coarse. Figures in parentheses indicate number of varieties under each class

* Corresponding Author

TABLE 2. RELATIONSHIP BETWEEN GRAIN DIMENSION, WEIGHT AND HUSK CONTENT (n=151)

Characteristics	Paddy					Brown rice		
	Husk content, %	L	B	L:B	1000-grain weight	L	B	L:B
Paddy								
Length (L), mm	-0.061							
Breadth (B), mm	-0.271**	-0.037						
L:B	0.114	0.778**	-0.645**					
1000- grain weight, g	-0.258**	0.658**	0.626**	0.107				
Brown rice								
Length (L), mm	0.018	0.947**	-0.094	0.768**	0.632**			
Breadth (B), mm	-0.232**	0.059	0.783**	-0.451**	0.574**	0.005		
L:B	0.225**	0.718**	-0.646**	0.942**	0.049	0.779**	-0.501**	
1000- grain weight, g	-0.369**	0.635**	0.635**	0.084	0.988**	0.605**	0.570**	0.027

** Significant at 1% level

independent variable not related to any other parameter, and so also was the grain weight. However, in this study, it was found that the length as well as the breadth influenced the 1000-grain weight. The breadth as well as 1000-grain weight of paddy and brown rice exhibited significant negative correlations with husk content. On the other hand, the L:B of brown rice alone exhibited a significant positive influence on the husk content (r=0.225**, n=151).

Considering the low husk content, the coarse varieties would undoubtedly yield more rice, than the other two classes of paddy, but the yield of rice is not determined by husk content alone. The associated technological characteristics, as pointed out by Murugesan and Bhattacharya (1993), also decide the yield of rice. These workers found that the grains possessing greater breadth were associated with technologically poor characteristics. However, considering the existence of wide variation in husk content, there does exist the possibility of developing technologically superior varieties with low husk content.

References

Anthony Raj S, Venkatesan V, Singaravadivel K, Vasan BS (1981) Improvement in the conventional parboiling of rice through prevention of husk opening. J Food Sci Technol 18:252-254

Baldi B, Malagoni R, Pela E, Ranghino F (1974) Chemical composition and quality of Italian rice varieties. Riso 23 (Spec. issue): 3-20

Bhattacharya KR (1979) Rice, in: Venkateswarlu D (ed) Food Industries. Indian Institute of Technology, Madras, pp1.0-1.28

Bhattacharya KR, Ramesh BS, Sowbhagya CM (1982) Dimensional classification of rice for marketing. J Agri Engg 19(4):69-76

Bhattacharya KR, Sowbhagya CM, Indudhara Swamy YM (1972) Some physical properties of paddy and rice and their interrelations. J Sci Food Agric 23:171-186

Cagampang GB, Cruz LJ, Espiritu SG, Santiago RG, Juliano BO (1966) Studies on the extraction and composition of rice proteins. Cereal Chem 43:145-155

Department of Food (1980) Report of Balasubramanian Committee-Classification of Rice/Paddy. Department of Food, Ministry of Agriculture and Irrigation, Government of India, New Delhi

Juliano, BO, Cagampang GB, Cruz LJ, Santiago RG (1964) Some physicochemical properties of rice in South east Asia. Cereal Chem 41:275-286

Murugesan G, Bhattacharya KR (1994) Interrelationship between structural features of paddy, and indices of the technological quality of rice. J Food Sci Technol 31:104-109

Pillaiyar P, Mohandoss R (1981) Cooking qualities of parboiled rices produced at low and high temperatures. J Sci Food Agric 32:475-480

Received 19 June 1993: revised 13 December 1993; accepted 15 December 1993

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 418-419

Use of Globin Protein in Microbiological Media for Enumeration of Aerobic Viable Cell Counts

M. HAZARIKA[1]
Department of Food Hygiene,
University of Veterinary Science, Budapest-VII, Hungary.

Globin, the decolorized protein portion of haemoglobin, is a slaughter house or animal by-product and contains almost all essential amino acids. An agar medium was developed, replacing the usual protein source like tryptone by globin protein, for enumeration of viable mesophilic and psychrophilic bacteria. The new agar medium, termed as globin-agar, gave identical or slightly better results than control tryptone-glucose-yeast extract-agar medium. The sensitivity, reproducibility and coloidal morphology were comparable to control medium. The study has indicated that globin is suitable for use as a protein ingredient in bacteriological media.

Keywords : Globin protein, Globin-agar, Microbial media, Aerobic viable count, Comparison with standard media, Mesophilic bacteria, Psychrophilic bacteria.

Animal blood contains a large quantity of high quality proteins. On separation, blood yields 60-70% by weight of plasma and 30-40% red blood corpuscle. Globin, the protein portion of haemoglobin of red blood cells can be easily separated and used in a variety of products, including microbial media preparation (Hald-Christensen 1978; Piot et al. 1988; Tybor et al. 1973; Wismer-Pedersen 1980). However, the use of globin-agar for bacterial enumeration has not yet been attempted. Invariably, the ingredients used in composing a culture medium are very expensive. With this background, an attempt has been made in the present study to prepare globin-agar for the enumeration of mesophilic and psychrophilic bacteria in foods.

The globin protein isolate (GPI) was collected from Zala Megyei Livestock Trade and Meat Industry, Zalaegerszeg, Hungary. The isolate was prepared according to the methods described by Hald-Christensen (1978) and Wismer-Pedersen (1980). The gross composition of GPI, in terms of proteins, moisture, fat and ash, were determined using the methods described by AOAC (1984). Calcium, phosphorus, sodium, potassium, zinc, copper, manganese, iron and magnesium were determined by atomic absorption spectrophotometry (Model 5000, Perkin Elmer, Germany), using the methodology as described by Varju (1971). Amino acid analysis was done after acid hydrolysis (6 N HCl, 105°C, 20 h) of the samples, using an automatic amino acid analyser (Labor MIM Aminochrom II, OE 914, Hungary) as per the basic procedure of Moore and Stein (1954). The presence of any anti-microbial residues was determined by quantitest, a standard microbial agar diffusion plate assay method (Phylaxia 1984), using the spores of *Bacillus stearothermophilus* var *calidolactis* C 953 as test organism. Nouws nutrient-broth (Lombai et al. 1982) and Muller-Hinton nutrient-agar (Lombai et al. 1982) were used as the growth and test agar media, respectively.

Tryptone-glucose-yeast extract-agar (TGYA), an agar medium accepted for aerobic plate count (ICMSF 1978), and globin-agar (GA) were prepared as per the standard composition (g/l) i.e., glucose (Oxoid) 1, yeast extract (Oxoid) 2.5, bacto agar (Merck) 15, and bacto tryptone (Oxoid) or globin protein isolate 5, and distilled water 1000. The pH of the medium was adjusted to 7.0 ±0.1. The cost of production of the media worked out to be US $ 1.10 and 0.86/1 for TGYA and GA, respectively, based on the cost of ingredients only. These media were used in the enumeration of mesophilic aerobes and psychrophiles from samples of milk, Italian *salami* and chicken thigh muscle. For the enumeration of mesophilic aerobes, appropriate dilutions of the samples were surface-plated and incubated at 30±1°C for 48 h, while in case of psychrophiles, dilutions were surface-plated and incubated at 4±1°C for 7 days (Jay 1970). Besides, pure cultures of *Micrococcus luteus*, *Bacillus subtilis* and *Flavobacterium* sp., received from the Central Bacteriological Laboratory, Ministry of Hungarian Food Industry, Budapest-IX, Hungary were also used. Mean values and standard errors were expressed in $\log_{10}$cfu/g. Results were analyzed using standard paired t-test.

The proximate chemical composition and amino acid profile of the GPI are presented in Table 1.

[1] *Present address : Department of Animal Production and Management, Lakhimpur College of Veterinary Science, Assam Agricultural University, Azad campus, North Lakhimpur-787 001, Assam: India*

TABLE 1. CHEMICAL COMPOSITION AND AMINO ACID PROFILE OF GLOBIN PROTEIN ISOLATE

Chemical composition,DM basis[a]		Amino acid composition mg/100 mg protein[b]	
Moisture %	7.9	Aspartic acid	11.1
Crude protein %	81.0	Threonine	32.2
Fat	N D	Serine	4.9
Ash%	11.4	Glutamic acid	9.1
Calcium mg/100g	63	Proline	1.9
Phosphorus mg/100g	357	Glycine	6.0
Magnesium mg/100g	62	Alanine	11.1
Iron mg/100g	13	Cysteine	0.4
Manganese mg/100g	0.15	Valine	9.1
Sodium g/100g	1.425	Methionine	-
Potassium mg/100g	189	Isoleucine	0.6
Copper mg/100g	669	Leucine	13.4
Zinc mg/100g	2.11	Tyrosine	2.1
		Phenylalanine	6.7
		Lysine	10.2
		Histidine	7.4
		Arginine	4.5

A= Average of five samples, ND= Not detectable,
b= Average of two samples.

The proteinaceous material was approximately 81.0% and fat was undetectable. Among the inorganic elements, sodium was found to be at much higher concentration. Almost all amino acids which are essential for microbial nutrition, were present in GPI, except methionine, indicating that methionine was the most limiting essential amino acid, followed by isoleucine and cysteine. Anti-bacterial residues were not detected in GPI.

The average mesophilic and psychrophilic bacterial counts of pure culture and other food samples are presented in Table 2. From the results, it was observed that GA was almost equal or slightly better than TGYA. In all food samples and in case of pure cultures, the differences in the counts were statistically insignificant. The shapes and sizes of the mesophilic bacterial colonies as appearing on TGYA and GA are shown in Fig. 1. GA proved to be as good as TGYA. A similar trend was observed in case of psychrophilic bacterial colonies appearing on both the media.

TABLE 2. COUNTS OF MESOPHILIC AND PSYCHROPHILIC BACTERIA ON TRYPTONE-GLUCOSE-YEAST EXTRACT-AGAR AND GLOBIN-AGAR BY SURFACE PLATING*

Sample	Bacterial counts (log10 cfu/g)			
	Mesophilic 30±1°C, 48 h		Psychrophilic 4± 1°C, 7 days	
	TGYA	GA	TGYA	GA
Chicken thigh muscle	5.16±0.33	5.18±0.33	4.92±0.83	4.99±0.91
Italian *salami*	4.73±0.67	4.72±0.60	5.17±0.94	5.16±0.75
Milk, pasteurized	3.30±0.51	3.44±0.55	5.95±0.99	5.96±0.95
M. luteus	5.68±0.48	5.67±0.05	- -	- -
B. subtilis	5.24±0.32	5.26±0.46	- -	- -
Flavobacterium sp.	- -	- -	5.46±0.83	5.50±0.70

* Average of ten observations : Nil.

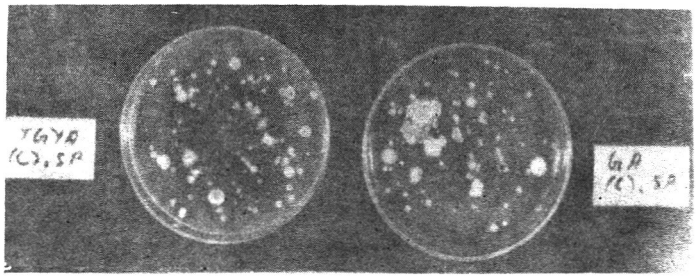

Fig 1. Apprearance of mesophilic bacterial colonies on TGYA and GA from chicken thigh muscle sample

It may be concluded that GA compared well with TGYA with respect to the enumeration of mesophilic and psychrophilic bacteria. GA was as clear and transparent as TGYA and also economical. The study also indicated the possible suitability of using GPI as an ingredient in other bacteriological media.

The author is grateful to the authority of Zala Megyei Livestock Trade and Meat Industry Enterprise,. Zalaegerszeg. Hungary, for the supply of the globin protein isolate. Thanks are also due to Dr. Boldizsar Harrison, Department of Veterinary Physiology, University of Veterinary Science, Budapest, Hungary, for help in amino acid analysis of the globin samples.

References

AOAC (1984) Official Methods of Analysis, 11th ed. Association of Official Analytical Chemists, Washington, DC

Hald-Christensen V (1978) Decolorisation of slaughter blood by partial enzymatic hydrolysis. In: Proceedings of the European Meeting of Meat Research Workers, No. 24, Copenhegen, Denmark, pp. 1-6

ICMSF (1978) Microorganisms in Foods, 2nd ed. International Commission on Microbial Specification for Foods, University of Toronto, Toronto

Jay JM (1970) Modern Food Microbiology. Van Nostrand Reinhold Co., New York

Lombai G, Lendvai I, Biro G (1982) A procedure for demonstration of the residues of antibiotics in the milk. Magyar Allotorvosok Lapja 37 (2):75-79

Moore S, Stein WH (1954) Procedures for the chromatographic determination of amino acids on four per cent cross-linked sulfonated resins. J Biol Chem 211:893-896

Phylaxia (1984) Quantitest-Determination of antibiotics in milk. In:Veterinary Pocket Book, Phylaxia Pharmaceutical Co., Budapest, pp 38-49

Piot JM, Guilloshon D, Leconte D, Thomas D (1988) Application of ultra-filtration to the preparation of refined hydrolysate of bovine haemoglobin. J Chem Tech Biotechnol 42:147-156

Tybor PT, Dill CW, Landmann WA (1973) Effect of decolorization and lactose incorporation on the emulsification capacity of spray-dried blood protein concentrate. J Food Sci 38: 4-6

Varju M (1971) Atomic absorption spectrophotometry and its application in investigations in food chemistry. Elelmiszer vizsgalati kozlemenyek 17 (1-2):64-71

Wismer-Pedersen J (1980) Decoloration of haemoglobin. Fleischwirtschart 60:987-990

Received 13 April 1993: revised 22 December 1993; accepted 27 December 1993

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 420-422

Microflora of Some Dried Spices and Condiments Sold in Maiduguri Market, Nigeria

IRO NKAMA*[1], M.H. BADAU[1], E.K. COLLISON[1],
W. MIAN[2], J.O. IGENE[1] AND C.A. NEGBENEBOR[1]
[1]Department of Food Science and Technology, [2]Department of Crop Science,
University of Maiduguri, P.M.B. 1069, Maiduguri, Nigeria.

Study of microflora associated with dried market spices and condiments, sold in Maiduguri market, showed predominance of *Aspergillus flavus* and *Penicillium* spp. *Aspergillus fumigatus* at a higher frequency in *tattashe* - sweet pepper (50%), *borkono*- hot pepper (66.7%), *gedar miyar* (66.7%), and *kulikult*-groundnut cake, while *Penicillium funiculosum* occurred at 61.5% frequency in *pasakori*. *Kanunfari* (clove) did not support the growth of moulds. Among the bacterial types, *Bacillus laterosporus*, *B. subtilis* and *B. brevis* were predominant.

Keywords : Moulds, Bacteria, Spices, Condiments, Nigerian market, Water activity.

Spices have been used for flavouring foods and beverages as well as for medication and are highly valued because of their preservative and antioxidant properties (Anon 1969; Purseglove et al. 1981; Madhyastha and Bhat 1985; Conner and Beuchat 1985; Pearson and Tauber 1984). In Nigeria, especially in the Northern States, spices are extensively used (Igene and Ekanem 1985; Igene 1988; Nkama 1991a) to season locally roasted meat products such as *tsire* (staked barbecued meat), *balangu* (meat cuts roasted over glowing fire), *denderu* (clay pot baked meat) as well as in processed foods from cereal grains and grain legumes such as *kunu* (non-alcoholic beverage), *masa* (fermented puff batter), *sinasin* (fermented pancake), *akara* (fried bean balls), *moin-moin* (steamed bean cake).

The microbial quality of spices and condiments has a role in affecting the overall quality of foods. Earlier studies carried out elsewhere have documented the microflora of spices (Raymond 1966; Gwoto et al. 1971; Shank et al. 1972; Coker et al. 1984; Lee and Lim 1985; Patel et al. 1976; Krishnaswamy et al. 1971; Srivastava and Jain 1992). However, such data are lacking for these food ingredients in Nigeria, where climatic conditions and sub-standard storage practices can lead to rapid microbial growth in these food ingredients (Nkama 1991b). Therefore, an attempt has been made, in the present study, to determine the microbial status of few dried market spices and condiments used in food preparations. The study would provide useful information in reducing public health hazards and economic losses.

Spices and condiments used in this study were purchased from spice stalls in Maiduguri market, Borno State, Nigeria. These are *masoro* (*Piper guineense*), *kanunfari*- clove (*Eugenia caryophyllata*), *gedar miyar*, *borkono* - hot pepper (*Capsicum frustescens*); *albasa*- onion (*Allium cepa*); *chitta*-ginger (*Zingiber officinale*); *pasakori* (*Fagara xanthoxyloides*) and *kulikuli*- groundnut cake. Ten samples of each of the spices/condiments were collected from different stalls in the market once a month, over a period of one year. The temperature and relative humidity of the storage conditions ranged from 24-29°C and 20-72%, respectively. Each sample was separately packed in a sterile container and examined within 3-4 h after collection.

Spice samples were analyzed for moisture content (AOAC 1984). Water activity (a_w) was measured by using an electric hygrometer (Hygroskop DT. Rotronic AG, Zurich, Switzerland), which was calibrated with salt solutions of known a_w (Labuza et al. 1976; Lerici et al. 1984).

Appropriate dilutions of milled samples, in triplicate, were enumerated for counts of bacteria, yeasts and moulds, using nutrient-agar, potato-dextrose-agar and Czapek-Dox-agar (Lee and Lim 1985). Inoculated plates were incubated at appropriate time-temperature combinations. Colonies of respective microbial types, appearing in incubated plates, were counted and expressed as colony forming units/g (cfu/g). Colonies of bacteria, yeasts and moulds were isolated and sub-cultured to obtain pure cultures. Mould cultures were identified according to the method of Gilman (1957). Bacterial cultures were identified by morphological, cultural and biochemical characteristics (Cowan and Steel 1961; Collins and Lyne 1970; Harrigan and McCance 1976).

* Corresponding Author

TABLE 1. MOISTURE CONTENT, WATER ACTIVITY AND MICROBIAL COUNTS OF SPICES

Spices	Moisture content[a,b], %	Water activity[a,b], a_w	Mould counts[c], Cfu/g	Total bacterial counts[d], Cfu/g
Masoro Piper-guineense)	7.9±0.3	0.235±0.002	$2.0x10^2$	$4.2x10^3$
Kanunfari (Eugenia caryophyllata)	13.5±0.4	0.247±0.001	ND	3.7x102
Chitta Gingiber efficinale	7.1±0.3	0.27±0.004	$2.2x10^2$	$3.2x10^3$
Pasakori, ginger Fagara xantho xyloides	5.0±0.3	0.240—0.004	$3.9x10^2$	$4.3x10^2$
Tattashe (Capsicum annum) sweet pepper	5.2±0.3	0.231±0.001	$1.3x10^2$	$4.7x10^3$
Borkono (Capsicum frustescens), hot pepper	3.8±0.5	0.231±0.001	$1.7x10^2$	$2.4x10^3$
Gedar miyar	16.2±0.3	0.193±0.003	$1.6x10^2$	$4.4x10^3$
Kulikuli, groundnut cake	12.0±0.4	0.822±0.001	$1.5x10^2$	$4.4x10^3$
Albasa, Onion *(Allium cepa)*	4.9±0.1	0.211±0.002	$3.0x10^1$	$1.5x10^2$

a : Moisture contents and water activities of spices as determined soon after they were purchased.
b : Mean of 10 determination ± standard deviation
c : Mould colony forming units (Cfu/g) after 5-7 days incubation.
d : Bacteria colony forming units (Cfu/g) after 24 h incubation.
ND : Not detected.

The moisture content, water activity and microbial counts of spices and condiments are presented in Table 1. *Tattashe* (sweet pepper) had the lowest mould count, while *pasakori* had the highest. *Kanunfari* (clove) showed no evidence of moulds. The absence of moulds may be due to the antimicrobial properties, which have been established in the extracts of spices (Conner and Beuchat 1985). The total bacterial counts ranged from 1.5 x 10^2 to 4.7 x 10^2 cfu/g in *albasa* and *tattashe*, respectively (Table 1). Although most of the spices have a_w values within the safe range for storage (Jay 1978), spores of moulds and bacteria exist on these ingredients, which could germinate and cause spoilage, if conditions are favourable.

The mould counts observed in all the spices were comparatively low, which seems to correlate with the low moisture content and a_w of samples. The different mould and bacterial types isolated from various spices and their average % frequency of occurrence are presented in Table 2. The mould isolates comprised mainly of *Aspergillus* and *Pencillium. Aspergillus fumigatus* occurred more frequently in *kulikuli* (85%), *albasa* (50%), while *A. niger* occurred more frequently in *masoro* (45%) and *pasakori* (38.5%). *A. flavus* occurred at low frequency (16-19%) in *masoro* and *chitta. Penicillium funiculosum* occurred more frequently in *pasakori* (61.5%). Other moulds isolated were *Phoma* sp., *Arachniotus* Sp. and *Rhizopus arrhizus.* These moulds have also been reported in stored dried spices (Lee and Lim 1985). Among the bacterial types, only spore forming bacteria (*Bacillus* spp.) were isolated, which may be due to the dry nature of spices. Isolates of *Bacillus subtilis, B. laterosporus* and *B.*

TABLE 2. DISTRIBUTION OF MOULDS AND BACTERIA AND THEIR FREQUENCY OF OCCURRENCE IN DRIED MARKET SPICES AND CONDIMENTS[a]

	Masoro	*Kanunfari*	*Chitta*	*Passkori*	*Tattashe*	*Gedar miyar*	*Borkono*	*Kulikuli*	*Albasa*
Moulds									
Aspergillus spp									
A. flavus	18.5	–	16.1	–	–	–	–	–	–
A. nidulans	11.1	–	–	–	–	–	–	–	–
A. fumigatus	–	–	12.9	–	50.7	+66.7	+66.7	85	79
A. versicolor	–	–	–	–	–	33	–	–	–
A. niger	44.5	–	9.7	38.5	–	–	16.7	–	21
Penicillum spp									
P. rubrum	22.2	–	22.6	–	–	–	16.6	15	–
P. funiculosum	–	–	–	61.5	–	–	–	–	–
Phoma sp.	3.7	–	–	–	–	–	–	–	–
Arachniotus sp.	–	–	38.7	–	–	–	–	–	–
Rhizopus arrhizus	–	–	–	–	50	–	–	–	–
Bacteria									
Bacillus spp.									
B. polymyxa	–	–	37.5	–	–	–	20	–	–
B. subtilis	–	50	–	59	–	55.6	–	–	33.3
B. pumilis	–	50	–	–	–	–	–	–	–
B. coagulans	40	–	–	20	–	–	–	–	66.7
B. laterosporus	40	–	33.5	–	–	–	40	66.7	–
B. brevis	20	–	25	21	40	–	–	33.3	–
B. alvei	–	–	–	–	60	44.4	40	–	–

a : Values indicate frequency of occurrence.; – : Nil

brevis were more predominant. Other *Bacillus* spp. isolated included *B. polymyxa*, *B. pumilis*, *B. coagulans* and *B. alvei*.

In conclusion, it should be noted that dried market spices may become contaminated with moulds and bacteria under favourable conditions. Although this may have serious implications in terms of safety and health of those who handle and consume spices, it has been emphasized that mycotoxins in spices are unlikely to pose serious health hazards (Madhyastha and Bhat 1985; Nkama and Muller 1989). Among the spices, ginger and red pepper are regarded as high risk commodities requiring routine screening for mycotoxins. There is a need to handle these adequately to avoid contamination by moulds and bacteria.

Support in form of a grant from the University of Maiduguri Research Grant Committee is gratefully acknowledged.

References

AOAC (1984) Official Methods of Analysis, 14th ed. Association of Official Analytical Chemists, Washington, DC

Anon (1969) Know your spices. Food Eng 41(5):88-91

Collins CH, Lyne, PM (1970) Microbiological Methods : Laboratory Technique Series. University Park Press

Coker RD, Jones BD, Negler MJ, Gilman GA, Walibridge AJ, Panigrahi AJ (1984) Mycotoxin Training Manual. Tropical Product Development and Research Institute, London

Cowan ST, Steel KY (1961) Diagnostic tables for the common medical bacteria. J Hyg Camb 59:357

Conner DE, Beuchat LR (1985) Effects of essential oils from plants on growth of food spoilage yeasts. 3. Food Sci 49)2): 429-434

Gilman JC (1957) A Manual of Soil Fungi, Revised 2nd ed. The Iowa State University Press, Ames, Iowa, USA

Gwoto A, Yamazaki K, Oka M (1977) Bacteriology of food radiation sterilization of spices. Food Irradiation 6(1):35-42

Harrigan WF, McCance ME (1976) Laboratory Methods in Food and Microbiology, Revised ed. Academic Press, London

Igene JO, Ekanem EO (1985) Effect of processing methods on the nutritional and sensory characteristics of *tsire*-type *suya* meat products. Nigerian J App Sci 3:1

Igene JO (1988) Lipid, fatty acid composition and storage stability of *Kilishi*, a sun-dried meat product. Trop. 28:153

Jay JM (1978) Modern Food Microbiology, 2nd ed. D. Van Nostrand Co., New York

Krishnaswamy, MA, Patel, JD, Nair, KKS, and Parthasarathy, N. (1971) Estimation of micro-organisms in spices and spice mixtures J Food Sci Technol 8:191-194

Labuza TP, Acott K, Tatini SR, Lee RY, Flink J, McCall W(1976) Water activity determination : A collaborative study of different methods. J Food Sci 41:910

Lerici CR, Piva M. Dalla Rosa M (1984) Water activities and freezing point depression of aqueous solutions and liquid foods. J Food Sci 48:1667

Lee K, Lim G (1985) Fungi associated with stored dried food products in Singapore. ASEAN Food J 1(12):85

Madhyastha MS, Bhat RV (1985) Evaluation of substrate potentiality and inhibitory effects to identify high risk spices for aflatoxin contamination. J Food Sci 50:376

Nkama I (1991a) Traditional methods of production of high protein energy foods from grain legumes in the North-eastern States of Nigeria. In:Sefa-Dadeh S(ed), Proceedings of the International Seminar on the Development of High Protein Energy Foods from Grain Legumes, Association of African Universities, Legon, Accra, Ghana pp 124-133

Nkama I (1991b) *Aspergillus flavus* infection and aflatoxin contamination of some Nigerian rice varieties. Nigerian Food J 9:78-84

Nkama I, Muller HG (1989) Studies on aflatoxin in rice: Description and evaluation of a new apparatus for the separation of husk from dehulled rice contaminated with aflatoxin. J Sci Food Agric 46:311

Patel JD, Krishnaswamy MA, and Nair KKS (1976) Biochemical characteristics of coliforms isolated from spices J Food Sci Technol 13:37-40

Pearson AM, Tauber FN (1984) Processed Meats, 2nd ed. AVI Publishing Co., Westport, Conn

Purseglove JW, Brown EC, Green CL. Robbins SK (1981) Spices, Vol. 1. Longman, London

Raymond WD (1966) The importance of mould in the deterioration of tropical foods and feeding stuffs. Monogr Soc Chem Ind London 23:21

Shrivastava, A, Jain, PC (1992) Seed mycoflora of some spices J Food Sci Technol 29: 228-230

Shank RC, Wong GN, Gibson JB (1972) Dietary of aflatoxins and human liver cancer. Toxigenic moulds in foods and foodstuffs of tropical South-East Asia. Ed. Cosmet. Toxicol. 10:51

Received 24 April 1993; revised 28 January 1994; accepted 30 January 1994

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 423-425

Processing of Soybean for Use as *Dhal*

V.M. PRATAPE AND H.V. NARASIMHA*
Department of Grain Science and Technology,
Central Food Technological Research Institute, Mysore-570 013, India.

Possibility of rendering soybean to cook like conventional *toor dhal* has been studied by employing a technique of wet toasting at 160±5°C, followed by deoiling. The results revealed that toasting of moistened (32% moisture) *soya dhals* increased the extractability of oil, without loss of *dhal* shape. Removal of about 60% oil rendered it to cook somewhat like *tur dhal* in about 40 to 50 min. Reduced dispersion of solids in soya *dhals* during cooking has been attributed to reduced cell separation. Occurrence of rounding-off of cells caused the basic difference in the cooking behaviour of *tur* and soya *dhals*.

Keywords : Soybean, Soya *dhal*, *Tur dhal*, Deoiling, toasting, Moistening, Cooking quality.

Soyabean (*Glycine max*) is an important crop in Madhya Pradesh and a few other states of India, the annual production being about 2 to 2.4 million tonnes (Anon 1992). It has about 20% oil, 40% proteins (twice the protein content of common pulses), and very little starch (CFTRI 1992). In spite of its potential as a source of oil and proteins, use of soybean as a substitute for conventional *dhals* or extender of pulses, is not yet achieved. There have been efforts in recent years to prepare solvent extracted *dhals*, which showed a reduction in cooking time (Chakraborthy et al. 1985; Jain et al. 1986; Das et al. 1987). However, there is no work on the evaluation of the deoiled soya *dhal* as a *tur dhal* substitute. This has been attempted in the present study, along with a comparison of different approaches like salt coating (Narasimha and Desikachar 1978 b) and flaking (Desikachar and Subrahmanyan 1961). A possible explanation has also been given for the observed differences in cooking behaviour of soya *dhal*, from that of commonly used *tur dhal*.

Black and white seed coat varieties of soybeans (moisture 10%) as well as *tur dhal* were procured from the local market, cleaned and size-graded. *Dhals* were prepared from soybeans according to the method described by Ramakrishnaiah and Kurien (1983).

Dhals were equilibrated with 25% water for 3 h (32% moisture) and toasted in hot sand at 160±5°C for 1.5 min (12.5% moisture). Toasted *dhals* were also flaked, after raising the moisture to about 22% by addition of 10% water and equilibrating for 3 h, followed by steaming at atmospheric pressure, for 30 min, in a roller flaker (Type J, Aktiebolaget, Kvarnmaskiner, Malmo, Sweden) to a thickness of 0.2 mm. All samples (*dhals* and flakes) were individually deoiled by immersing in 10 volumes of hexane at room temperature (28 to 30°C) for about 20 h, followed by filtration and drying (8 h, 80°C) in a current of air, till the residual solvent was not organoleptically perceptible. Oil contents of these samples and the original *dhal* were determined by the standard AOAC (1980) method. Soya *dhals* were coated with sodium bicarbonate (1%) and ammonium carbonate (0.5%), as described by Narasimha and Desikachar (1978b). *Dhal*/flakes (10 g) were cooked in 100 ml water over a hot plate, with replenishment of the evaporated water. Completion of cooking was judged by pressing the sample between two glass plates and attainment of uniform translucency. This was noted as the subjective cooking time (SCT). Solids dispersed during cooking were determined as per Narasimha and Desikachar (1978 a).

Firmness of cooked *dhals* was determined in a Chopin-INRA viscoelastogram (Laignelet and Feillet 1979) using a load of 1000 g for soya *dhals* and 500 g for cooked *tur dhal*. Three grains of cooked *dhal* were placed in the instrument to form a triangle. In each case, initial thickness (a) and thickness after compression (b) were measured. At least six measurements were made for each cooking time, and % firmness (F) value was calculated by dividing 100 x b by a. Cooked *dhals* were sectioned in a freezing microtome to a thickness of 15μ and photographed in a Carl Ziess light microscope to highlight the cellular differences and cooking pattern.

Data indicated that partial deoiling of toasted *dhals* reduces the cooking time and imparts textural softness on cooking (Table 1). Simple solvent soaking removed only about 30 to 40% oil from *dhals* and this increased to about 50 to 60%, when previously wet-toasted *dhals* were used. This could be due to some swelling and fissures created in

* *Corresponding Author*

TABLE 1. COOKING CHARACTERISTICS OF *TUR* AND SOYA *DHALS*

Sample	Oil content, %	Subjective cooking time, min	Dispersed solids,% (at SCT)	Firmness, % (at SCT)
Tur dhal	- -	35	70	68
Soya *dhal* (white seed coat)				
As such	21.0	120	28	74
Partially deoiled	12.6	60	30	70
Toasted and deoiled	7.3	40	32	68
Toasted, flaked and deoiled	1.6	10	75	- -
Salt coated	21.0	90	35	70
Soya *dhal* (black seed coat)				
As such	20.0	150	25	72
Partially deoiled	12.1	90	30	68
Toasted and deoiled	8.2	55	32	70
Toasted, flaked and deoiled	1.8	12	70	- -
Salt coated	20.0	120	30	70

dhals during wetting and toasting steps. Oil removal was over 90%, when the toasted *dhals* were flaked and then deoiled as above. It is seen that the cooking time and F values of toasted and deoiled soya *dhals* were almost in the range of conventional *dhals*. However, soya *dhals* lacked the desired solids dispersibility (Subba Rao et al. 1964) of conventional *dhal* during cooking. Coating with alkaline salts has been shown to reduce the cooking times by about 50% for *tur* (Narasimha and Desikachar 1978b) and kidney bean *dhal* (Eduardo et al. 1980). In the present study, salt coating, however, had little

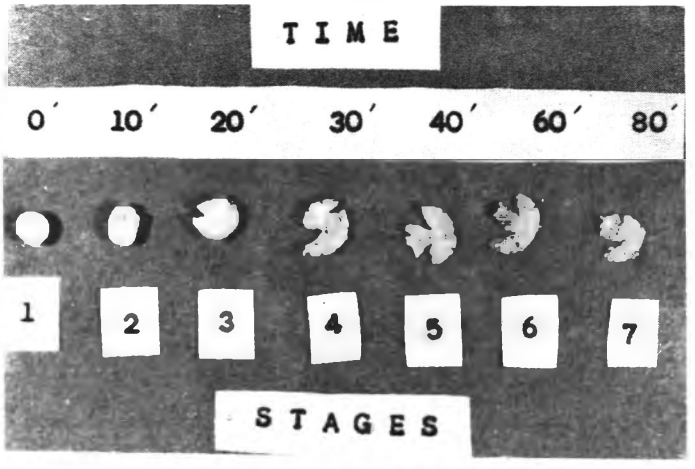

Fig. 1. Pattern of changes in *Tur Dhal* during cooking. Stages - (1) just soaked; (2 to 7) Cooked for 10,20,30,40,60 and 80 min, respectively

effect on the cookability of soya *dhals* (reduction only 30%), with the consequent lower level of dispersion during cooking. This behaviour could be ascribed to the fact that the cooking pattern for *tur dhal* goes upto stage 7 (Fig.1), in contrast to the stoppage at stage 2 in case of soya *dhal*. This implies that both tur and soya *dhals* absorb water during cooking and swell in size, but *tur dhal* disintegrates after a certain period of cooking, while

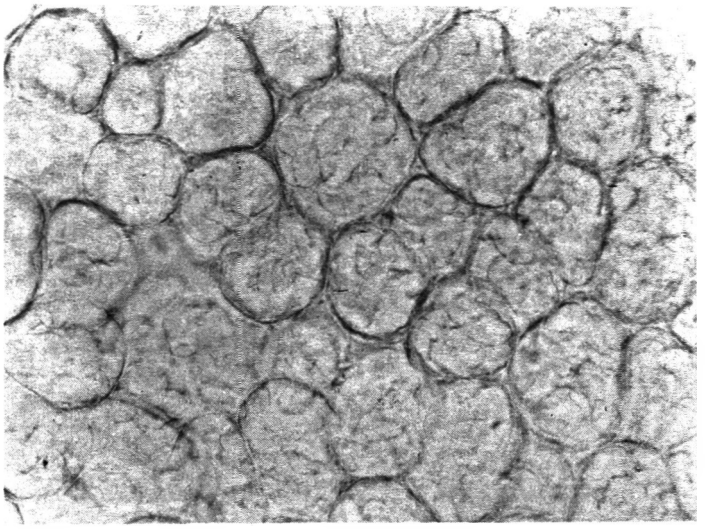

Fig. 2. Light micrograph of cooked *tur dhal*

soya *dhal* does not. Such a behaviour is perhaps due to the lack of starch in the latter. It has been shown (Narasimha et al. 1989) that the cells in *tur dhal* (as in most other pulses) tend to become round during cooking (Fig.2) and get separated out. This is due to the reduced inter-cellular contact and loss of middle lamella (Rockland and Jones 1974). This rounding-off of cell does not appear to occur in soya *dhals* (Figs. 3 and 4), thereby resulting

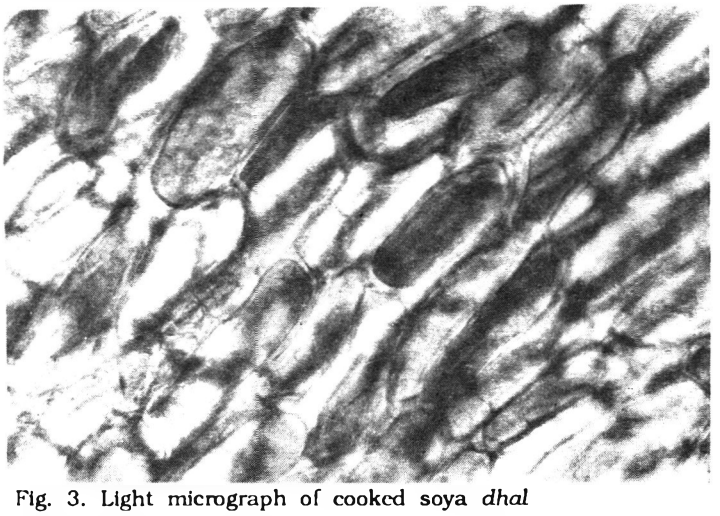

Fig. 3. Light micrograph of cooked soya *dhal*

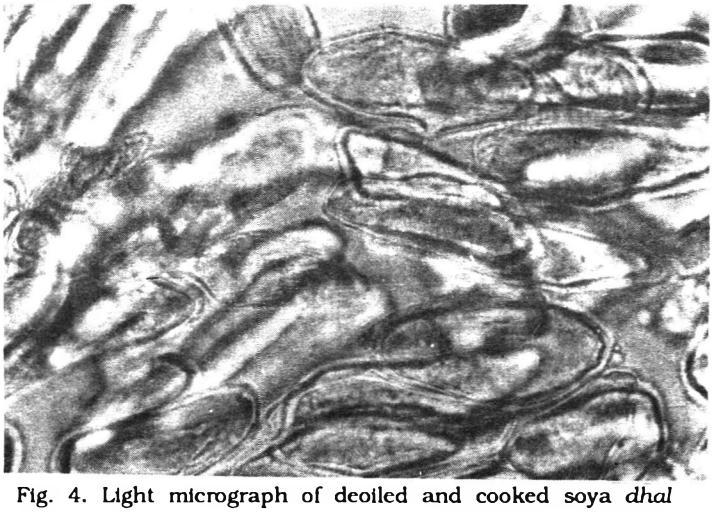

Fig. 4. Light micrograph of deoiled and cooked soya *dhal*

in lesser cell separation. This also accounts for lower dispersion of solids during cooking, which perhaps is a limiting factor for its use as *tur dhal* substitute.

Data on the texture of cooked *dhals* (Fig.5) show that all samples attain an F value of around

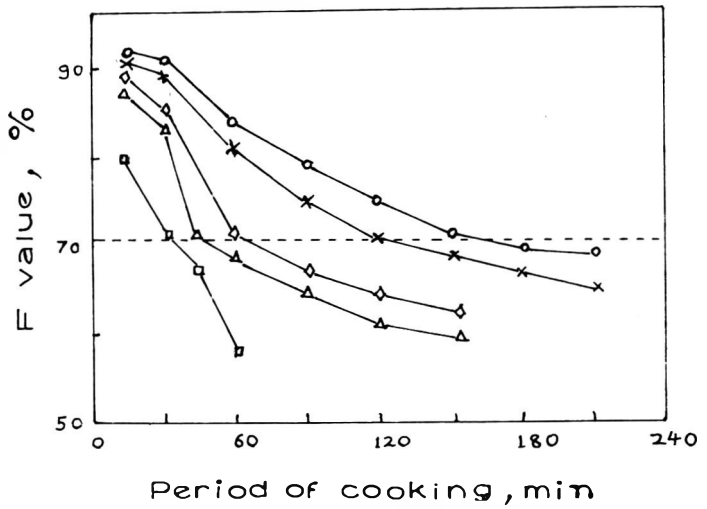

Fig.5. Firmness values of cooked *dhal* samples during progressive cooking
□—□ *Tur dhal* , 0—0 : Soya *dhal* (black seed coat) x----x : Soya *dhal* (white seed coat) ◊----◊ : Toasted and deoiled soya *dhal* (black seed coat) Δ----Δ : Toasted and deoiled soya *dhal* (white seed coat) --------- : Soft eating texture (F= ~70)

70%, which corresponds to the soft eating texture, at the corresponding subjective cooking times (SCT) of *dhals*. For instance, F value of 70% is attained for *tur* at 40 min, in contrast to 150 min for black soya *dhal* and 120 min for white soya *dhal*. Further, it is seen that toasted and deoiled soya *dhals* attain this F value much faster, at around 45 and 55 min for white and black soya *dhals*, respectively. However, the reduction in F value below this level is very gradual, thereby indicating a much slower softening rate after this stage. Taking advantage of the dispersible qualities of *dhals* like *tur* and combining the closeness in F value, it is possible that soya *dhal* (toasted, partially deoiled and specially from the white variety) could be used in the traditional preparations to an extent of about 50%, in place of conventional *tur dhal*. However, flaked soya *dhal* can replace *tur dhal* to a greater extent (upto about 80%).

The present studies have shown the possibility of treating different varieties of soya *dhals*, by a combination of wet-toasting and partial deoiling, so that they can be cooked in a reasonably short time of 40-55 min. Such a process could easily be scaled up for toasting in the gram frying machine and adopting the usual solvent extraction procedure. Recovery of oil from soya beans in such a process would be over 60 to 70%, without loss of shape of the *dhal*. Hence, the process offers a potential for rendering soybean for use as *dhal*, by a partial substitution of the expensive *tur dhal*.

References

Anon (1992) All India Final Estimates of Principle Crops, Agricultural Situation in India, XLVII (9): pp 750-751

AOAC (1980) Official Methods of Analysis, 13th ed. Association of Official Analytical Chemists, Washington, DC

CFTRI (1992) Food and Allied Industries News (Jan-Mar), Central Food Technological Research Institute, Mysore, India

Chakraborthy BK, Murthy TN, Devdhara VD (1985) Partially deoiled soyabean *dhal*. Indian Food Industry 4:59-61

Das HK, Tiwari HK, Bandopadhyay SK, Dhote VH (1987) Parameters in the preparation of a *dhal* from soybeans. Indian Food Industry 6:62-65

Desikachar HSR, Subrahmanyan V (1961) Effect of flaking on the culinary quality of the pulses. J Sci Industr Res 20(D):413-415

Eduardo CB, Narasimha HV, Desikachar HSR (1980) Studies on the improvement of cooking quality of kidney beans (*Phaseolus vulgaris*), J Food Sci Technol 17:235-237

Jain SK, Khanna RK, Maheshwari PN (1986) Studies on Production of Soya *dhal*. In: Proceedings of the OTAI-AFST National Seminar on Oilseed Products for Edible Purposes, Harcourt Butler Technological Institute, Kanpur, March 1-2, pp 95-96

Laignelet B, Feillet P (1979) Use of viscoelastograph for measuring the texture of cooked rice. In: Proceedings of Chemical Aspects of Rice Grain Quality. International Rice Research Institute, Los Banos, Laguna, Philippines, pp 355-361

Narasimha HV, Desikachar HSR (1978a) Objective methods for studying cookability of *tur* pulse (*Cajanus cajan*) and factors affecting varietal differences in cooking. J Food Sci Technol 15:47-50

Narasimha HV, Desikachar HSR (1979 b) Simple procedures for reducing the cooking time of split red gram (*Cajanus cajan*). J Food Sci Technol 15:149-151

Narasimha HV, Srinivas T, Desikachar HSR (1989) A histological basis for hard-to-cook phenomenon in red gram (*Cajanus cajan*) cultivars. J Food Sci 54:125-127

Ramakrishnaiah N, Kurien PP (1983) Variabilities in dehulling characteristics of pigeon pea (*Cajanus cajan*) cultivars. J Food Sci Technol 20:287-291

Rockland LB and Jones FT (1974) Scanning electron microscope study on dry beans- Effect of cooking on cellular structure of cotyledons in rehydrated lima beans. J Food Sci 39:342-346

Subba Rao PV, Ananthachar TK, Desikachar HSR (1964) Effect of certain chemicals and pressure on cookability of pulses. Indian J Technol 2(12):417-418

Received 12 May 1993; revised 10 January 1994; accepted 15 January 1994

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 426-427

Quality Characteristics of Some Marketed Indigenous Milk Products : Major Constituents and Mineral Composition of *Rabri*

T.K. CHATTERJEE, S. SARKAR AND G. BISWAS*
Central Food Laboratory, Calcutta, 700 016, India.

Rabri (an indigenous milk-based sweet, thick slurry-like product, which is rich in cream and is a popular delicacy), collected from shops in Calcutta city, showed wide variations in total solids, fat, protein, lactose, sucrose, ash, minerals and acidity values. Among these, fat and sucrose levels showed higher variations. Data obtained may be useful in specifying standards for *rabri* by various regulatory agencies.

Keywords : *Rabri*, Market samples, Calcutta market, Chemical constituents, Mineral content.

Rabri, an indigenous milk-based sweet, thick slurry-like product, is prepared by boiling milk and adding cane sugar when cooled. Despite regional preference, this product, in recent years, is becoming more and more popular throughout the country. The chemical quality of *rabri* will largely depend on the type of milk, moisture retention and level of sugar addition. There are no mandatory or prescribed standards as yet formulated. Information on major constituents of Delhi and Karnal market samples of *rabri* has been reported (Gayen and Pal 1991). However, information on minerals in the product from Calicutta market or laboratory product is not available.

Data on major constituents and minerals in *rabri* from Calcutta market as well as laboratory samples are reported in present communication, as these will be useful for prescribing standards under the Prevention of Food Adulteration Act and Rules.

A total of 60 market samples (250 g each) were collected on 3 occasions from five different shops (4 from each) and stored at 5°C until analyzed. The entire sample was mixed thoroughly before using for analysis.

The laboratory samples (10 numbers) were prepared, following the common practice of preparation of *rabri* in trade. The process involved heating of milk at 90 to 95°C, repeated removal of clotted cream (*malai*) in a total quantity equal to approximately one-tenth of the initial volume of milk, 3-fold concentration of the remaining portion, addition of sugar at a level equal to 6% of the initial quantity of milk and adding back the *malai*.

The moisture and total solids were determined by standard gravimetric method (ISI 1981) with minor modification, which involved addition of 5 ml of hot distilled water to disperse the matter uniformly. Fat and protein contents were determined by Rose-Gottlieb method and micro Kjeldahl method, respectively (ISI 1981). Lactose and sucrose were determined by the method of Lane and Eynon (ISI 1981). Ash content and acidity were determined by the standard method (ISI 1981). Sodium and potassium concentrations in the ash were determined in a Systronic digital flame photometer (Model 121, with sodium and potassium filter) at constant air pressure of 0.5 kg/cm^2, using regulated liquefied petroleum gas as a source of fuel (Osborne and Voget 1978). Magnesium, copper, iron and zinc in the ash were estimated using atomic absorption spectro-photometer, Perkin Elmer, model 380 (Antila and Anitla 1974).

The average values of the major constituents of market and laboratory samples of *rabri* are shown in Table 1. The moisture retention varied in samples from shop to shop, but was always below 50%. Consequently, the total solids in all cases were minimum 50% or above. The average fat contents of the market samples varied and these were lower in the market samples than those in laboratory samples. This could be attributed to the differences in the fat content of the milk used.

The protein contents of laboratory samples varied from those of market samples, the latter having higher levels. The carbohydrates, ash and acidity levels in market samples were higher than those in the laboratory samples. The common practice to prepare *rabri* with milks attaining higher acidity values permits high levels of addition of sugar in market *rabri*. The high ash values in market samples possibly indicate the use of neutralizers. A few samples from the unorganised sector showed presence of cellulose also (not shown in table).

* *Corresponding Author*

TABLE 1. MAJOR MILK CONSTITUENTS AND ACIDITY LEVELS OF *RABRI* SAMPLES

Constituents	Market samples						Laboratory samples		
	1	2	3	4	5	Average of 60 samples	1	2	Average of 60 samples
Moisture, %	43.7 ±1.0	49.2 ±0.9	34.3 ±1.4	41.7 ±1.0	46.5 ±0.8	43.1 ±1.0	48.2 ±0.2	46.9 ±0.3	47.5 ±0.2
Total solids, %	55.3 ±1.0	49.8 ±0.9	64.7 ±1.4	57.3 ±1.0	52.5 ±0.8	55.9 ±1.0	50.8 ±0.2	52.1 ±0.3	51.4 ±0.2
Fat as such basis, %	16.4 ±1.2	12.9 ±1.1	16.7 ±0.7	12.6 ±0.9	10.2 ±1.3	13.8 ±1.0	16.1 ±0.1	15.6 ±0.1	15.8 ±0.1
Fat on dry weight basis, %	30.1 ±2.9	25.9 ±3.7	25.8 ±2.1	25.4 ±1.1	26.9 ±1.9	26.8 ±2.3	31.7 ±.3	30.8 ±.3	31.2 ±0.3
Proteins, %	12.5 ±0.5	10.8 ±0.8	13.1 ±0.9	12,8 ±0.7	13.0 ±1.1	12.4 ±0.8	10.1 ±0.1	10.7 ±0.2	10.4 ±0.1
Sucrose, %	13.8 ±1.3	12.3 ±1.4	19.6 ±1.4	18.7 ±1.3	17.2 ±1.4	16.3 ±1.4	11.9 ±0.2	15.1 ±0.1	13.5 ±0.1
Lactose %	12.2 ±1.4	13.5 ±1.3	14.5 ±1.1	13.8 ±1.3	12.3 ±1.5	13.3 ±1.4	11.8 ±0.3	12.1 ±0.2	11.9 ±0.2
Ash, %	2.3 ±0.2	2.2 ±0.1	2.8 ±0.6	2.5 ±0.6	2.6 ±0.5	2.5 ±0.4	2.0 ±0.2	2.1 ±0.1	2.0 ±0.1
Acidity, %	0.4 ±0.2	0.4 ±0.2	0.4 ±0.1	0.4 ±0.2	0.4 ± 0	0.4 ±0.1	0.3 ± 0	0.3 ± 0	0.3 ± 0
Sodium, mg/100g	62.6 ±4.5	66.1 ±2.1	76.3 ±3.1	63.3 ±3.4	55.6 ±3.8	64.8 ±3.4	68.5 ±0.5	72.1 ±0.6	70.3 ±0.5
Potassium, mg/100g	59.1 ±0.8	60.5 ±1.8	66.3 ±1.6	59.8 ±2.1	48.9 ±3.1	58.9 ±3.4	60.8 ±0.3	66.3 ±0.2	63.5 ±0.2
Magnesium, mg/100g	11.8 ±0.8	12.1 ±1.1	14.5 ±0.9	13.1 ±1.3	10.9 ±0.7	12.6 ±1.0	16.1 ±0.4	16.8 ±0.6	16.4 ±0.5
Copper, mg/100g	0.6 ±0.1	0.4 ±0.1	0.5 ±0.5	0.5 ±0.2	0.2 ± 0	0.4 ±0.2	0.5 ±0.1	0.5 ±0.1	0.5 ±0.1
Iron, mg/100g	0.6 ±0.2	2.0 ±0.2	3.2 ±0.4	1.4 ±0.2	0.3 ± 0	1.7 ±0.2	4.1 ±0.1	3.9 ±0.2	4.0 ±0.1
Zinc, mg/100g	0.7 ±0.1	0.7 ±0.1	0.7 ±0.1	0.7 ±0.1	0.6 ± 0	0.7 ±0.1	0.7 ± 0	0.7 ±0.1	0.7 ± 0

Man ± S.E. of 12 and 5 samples from market and those made in laboratory, respectively.

Data on mineral composition of *rabri* samples are given in Table 1. Among major minerals, the concentration of sodium was maximum in all the samples. Among the trace elements, iron was found to be the highest. Among minerals, concentration of magnesium was the lowest (10.9 to 14.5 mg/100g.) in the samples. Reports by Gayen and Pal (1991) on *rabri* and also those by Narain and Singh (1981) as well as Boghra and Mathur (1991) on *khoa* have shown some variations in respect of minerals in comparison to the present data.

The values obtained in the present study may be useful in specifying standards for *rabri* by different regulatory agencies in the country.

References

Antila P, Antila V (1974) Determination of trace elements in milk products by atomic absorption spectrophotometry. Paper IE-526, XIX International Dairy Congress, New Delhi

Boghra VR, Mathur DN (1991) Chemical quality of some marketed indigenous milk products : Mineral composition of *Khoa*. J Food Sci Technol 28(1):59-60

Gayen D, Pal D (1991) Sensory, chemical and microbiological qualities of Delhi and Karnal market samples of *rabri*. Indian J Dairy Sci 44(1):80-83

ISI (1981) Hand book of Food Analysis, Part XI, Dairy products. Bureau of Indian Standards, New Delhi

Narain N, Singh GS (1981) The qualities of *khoa* marketed in Varanasi City. Indian J Dairy Sci 34:91-93

Osborne DR, Voget P (1978). The Analysis of Nutrients in Food, Food Science and Technology. Academic Press, Inc., London

Received 3 May 1993; revised 10 January 1994; accepted 15 January 1994

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 428-429

Frying Quality of Six Varieties of Potato

SUNEETA PANT AND K. KULSHRESTHA*
G.B. Pant University of Agriculture and Technology, Pantnagar - 263 145, India

Six potato varieties, namely 'K. Badshah', 'K. Bahar', 'K. Jyoti', 'K. Chandramukhi', 'JH 222' and 'JI 4486' were evaluated for biochemical composition and their fried product characteristics 'K. Chandramukhi' having the lowest reducing sugar (0.94%) and total phenols (30.30 mg/100 g) and 'K. Badshah' having the highest starch content (15.12%) were rated superior for making chips. 'JH 222' having the highest total phenols and 'JI 4486' having the highest reducing sugar rated inferior for making chips. The variety 'K. Bahar' and 'K. Jyoti' were rated intermediate in suitability for the purpose of making chips.

Keywords : Potato varieties, Composition, Potato chips, Organoleptic evaluation. Fried product characteristics.

The composition of potato is an important factor for its processing, and all potato varieties are not equally suitable for diverse form of processing (Marwaha 1988). The processing quality of potato depends on biochemical composition of its variety, particularly its content of dry matter, reducing sugars, protein, nitrogenous compound and phenolics (Marwaha 1988; Misra and Premchand 1988). The present investigation was undertaken to screen the suitability of six varieties of potato for chips making.

Six commercially released potato varieties, viz., 'K. Badshah', 'K. Bahar', 'K. Jyoti', 'K. Chandramukhi', 'JH 222' and 'JI 4486' were obtained from the Horticulture Research Centre of the University. Dry matter content of potato tubers was determined by loss in weight of the sample upon drying at 65°C for 12 h (Woodbury and Weinheimer 1964). For the rest of the estimations, the sample was prepared according to the methods described by Ranganna (1986). Potatoes were washed, peeled and cut into 2-3 mm thick slices. Within 2 min, the slices were steamed for 10 min. The steamed slices were dried in a cabinet dryer at 55°C for 8.5 h, and thereafter pulverized to flour (60 mesh). The reducing sugars of the samples were determined by the method of Somogyi (1945). Free amino acid contents were determined by the method of Mertz et al (1974), with slight modification as given by Sung and Lambert (1983). Starch content was determined by first extracting the sample with 50% ethanol to eliminate sugars. Thereafter, its starch was solubilized with perchloric acid. The resultant maltose was determined colorimetrically using anthrone reagent (McCready et al. 1950) and starch content was calculated by multiplying maltose content with a factor 0.9. Total phenol content was determined by the method of AOAC (1975).

The washed potatoes were dipped in 10% boiling NaOH solution for 1 min and the adherent alkali was neutralized with 1% HCl. These treated potatoes were washed, rubbed with hands to remove peels and sliced with stainless steel chip cutter into 1-2 mm thick slices. After blanching for 3 min in boiling water, the slices were cooled and dipped in 2000 ppm potassium metabisulphite for 10 min. The drained slices were fried in refined soybean oil at 180°C for 1.5 min (Sandhu et al. 1987). The chips were evaluated organoleptically by a semi-trained panel, consisting of 6 members for crunchiness and colour by descriptive analysis with scaling, and overall acceptability was evaluated on a 9-point Hedonic scale (Larmond 1977).

The biochemical composition of potato varieties (Table 1) revealed that variety 'JH222' had the highest content of dry matter (21.45%) and total phenols (47.30 mg/100 g). Lowest free amino acid content (325.08 mg/100 g) was observed in variety 'K. Badshah'. Starch content was maximum in 'K. Badshah'. 'K. Chandramukhi' had the lowest contents of reducing sugar (0.94%) and total phenols (30.30 mg/100 g). Thus, significant varietal variations (p=0.05) in the content of dry matter, starch, sugar, free amino acid and total phenols

TABLE 1. BIOCHEMICAL COMPOSITION OF POTATO VARIETIES.

Variety	Dry matter, %	Starch, %	Reducing sugars, %	Free amino acids, mg/100g	Total phenols mg/100g
'K. Badshah'	19.70	15.12	1.12	325.08	36.69
'K. Bahar'	18.05	11.60	1.26	512.56	31.33
'K. Jyoti'	17.30	9.27	1.33	481.40	44.67
'K. Chandramukhi'	18.63	11.03	0.94	505.68	30.30
'JH 222'	21.45	13.27	1.32	481.60	47.50
'JI 4486'	18.25	9.92	1.44	368.08	43.80
Mean	18.89	11.71	1.24	440.82	38.97
SEM	0.19	0.71	0.02	11.29	0.75
CD at 5 %	0.57	0.53	0.06	34.79	2.30

*Corresponding Author

TABLE 2. SENSORY CHARACTERISTICS OF POTATO VARIETIES.

Variety	Texture	Colour	Overall acceptability
'K. Badshah'	3.27	0.77	2.10
'K. Bahar'	3.33	2.69	3.73
'K. Jyoti'	3.70	2.20	3.15
'K. Chandramukhi'	4.13	2.35	2.28
'JH 222'	3.93	2.85	4.93
'JI 4486'	3.80	3.50	4.61
Mean	3.73	2.29	3.48
SEM	0.12	0.12	0.12
CD at 5 %	0.34	0.33	0.33

were observed.

The sensory characteristics of fried potato are presented in Table 2. The chips of 'K. Badshah' were pale golden yellow and those of 'JI 4486' were darkish brown. The varietal differences in colour of the chips were due to the differences in contents of reducing sugars and free amino acids influencing the degree of Maillard reaction, as suggested by Nagaich (1977). The chips of 'K. Chandramukhi' had a texture preference, for being the highest in crunchiness. The chips of varieties 'K. Badshah' and 'K. Bahar' were low in crunchiness. Overall acceptability scores were significantly correlated (r=0.847) with reducing sugar contents. This should be due to the excessive caramelization of sugar on frying, thereby resulting in the developments of undesirable dark colour, bitter taste and flavour (Roe et al. 1990). Recent studies indicate that chips made from potato tubers can even be stored upto 1 year without affecting the colour and taste (Anand et al. 1982).

The varieties 'K. Badshah' and 'K. Chandramukhi' were ranked first and rated almost equally for the purpose of chips making. These were followed by 'K. Jyoti' and 'K. Bahar', while 'JI 4486' and 'JH 222' were rated the lowest on the basis of organoleptic evaluation.

References

AOAC (1975) Official Methods of Analysis, 12th ed. Association of Official Analytical Chemists, Washington, DC

Anand JC, Maini SB, Diwan, B (1982) A simple way to preserve potato for chips making. J Food Sci. Technol 19: 267

Larmond E (1977) Laboratory Methods for Sensory Evaluation. Food Research Institute, Ottawa, Ontario

Marwaha RS (1988) Nutritional composition of commonly cultivated potato varieties. Indian J Nutri Diet 25:26-31

Misra, JB, Premchand (1988) Improvement of chip colour by removal of colour reactants from potato tuber slices by water washing. J Food Sci Technol 25:99-100

McCready RM, Guggolz S, Silvirra V, Owens HS (1950) Determination of starch and amylose in vegetables. Anal Chem 22:1156-1158

Mertz ET, Misra PS, Jambunathan P (1974) Rapid ninhydrin colour test for screening high lysine mutants of maize, sorghum, barley and other cereal grains. Cereal Chem 51:304-307

Nagaich BB (1977) Recent Technology in Potato Improvement and Production, Potato Research Technology, Shimla

Ranganna S (1986) Handbook of Analysis and Quality Control for Fruit and Vegetable Products, 2nd ed. Tata McGraw Hill Publishing Co. New Delhi

Roe MA, Faulks RM, Belsten JL (1990) Role of reducing sugars and amino acids in colour of chips from potatoes under different nitrogen regimes. J Sci Food Agric 52:207-214

Sandhu KS, Bawa AS, Thind SS, Sekhon KS (1987) Evaluation of potato cultivars for processing. Indian Food Packer 41:18-25

Sung TM, Lambert RJ (1983) Ninhydrin colour test for screening modified endosperm in opaque-2 maize. Cereal Chem 601:84-85

Somogyi M (1945) A new reagent for the determination of sugars. J Biochem 160:61-68

Woodbury GW, Weinheimer WH (1964) Specific gravity - solids correlations in Russel Burbank with respect to point of origin and storage history. Amer Potato J 42:98-102

Received 26 May 1993; revised 25 January 1994; accepted 1 February 1994

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 430-432

Spirulina platensis as Retinol Supplement for Protection Against Hexachlorocyclohexane Toxicity in Rats

L.V. VENKATARAMAN*, G. SUVARNALATHA, M.K. KRISHNAKUMARI AND PIUS JOSEPH[1]
Central Food Technological Research Institute, Mysore, 570 013, India

Spirulina platensis, a cyanobacterium, was evaluated as a possible ameliorant of hexachlorocyclohexane (HCH)-induced dietary toxicity in retinol deficient male albino rats by feeding 1000 ppm hexachlorocyclohexane mixed with diets free of vitamin A or supplemented with *Spirulina* at 0.0628 and 3.18% (2000 and 1,00,000 I.U. of vitamin A/kg diet, respectively) for seven weeks. Growth rate was considerably reduced in rats fed with vitamin A-free diets with and without HCH, while the body weight gain increased at the end of the seven weeks in rats fed with alga supplemented diets, with or without HCH. Hepatic vitamin A stores of rats showed diet-related difference. Significant ($p<0.05$ and $p<0.001$) alterations were discernible in serum and liver enzymes, like glutamate oxaloacetate transaminase, glutamate pyruvate transaminase and alkaline phosphatase of rats fed with diets containing HCH, but without the alga. Such changes were not observed in rats fed with HCH diets supplemented with alga. The results are suggestive of the ameliorating effects of alga on the dietary toxicity of HCH in retinol deficient albino rats.

Keywords : Dietary toxicity, Hexachlorocyclohexane, Amelioration, *Spirulina platensis*, Retinol-deficient rats

Spirulina platensis, the blue-green alga, has been a success in health food market of the Western countries in recent years (Benemann 1988), as it is an excellent source of proteins, vitamins and minerals (Venkataraman and Becker 1986). Gamma-linolenic acid contained in this alga has been reported to stimulate prostaglandin synthesis and induction of the regulation of blood pressure, cholesterol synthesis, inflammation and cell proliferation (Borowitzka and Borowitzka 1987; Venkataraman 1993). Hexachlorocyclohexane (HCH), the organochlorine compound, has been widely used in India as a broad spectrum insecticide (Ahuja and Awasthi 1993). Being recalcitrant, its repeated usage and lower rate of biodegradability have led to its accumulation in substantial levels in soil, tissues of human and livestock, thereby causing considerable health hazards (Lindane 1972). Both macro-and micro-nutrients have tremendous influence on the pesticide toxicity (Ferrando et al. 1973; Shakman 1974). It has also been reported that rats were highly susceptible to HCH intoxication under vitamin A deficiency, while the diets supplemented at 2000 and 1,00,000 I.U./kg diet (but not hyper-vitaminotic) offered protection to rats fed HCH at 1000 ppm (Pius Joseph 1988).

Feeding *Spirulina* to humans and rats as major dietary ameliorant, or a prophylactant against the pesticide-associated health risks is a new concept, which is being explored at CFTRI Mysore. The present study aims to investigate *Spirulina* as retinol supplement for protection against HCH toxicity in albino rats.

*Corresponding Author. [1]Present address : Department of Pharmacology, Fox Chase Cancer Centre, Philadelphia, USA.

Algal material : High quality food grade algal powder (spray-dried) was produced at this institute by cultivating the alga in clean water in culture basins under optimized conditions (Venkataraman and Becker 1984).

Animals and diets : Male (21 days old) weaning albino rats (*Rattus norvegicus* 'CFT-Wistar' strain) were divided at random into six diet groups: a) synthetic diet which contained (g/kg) devitaminized casein 200, vitaminized starch 10, salt mixture 20, groundnut oil 50, corn starch 717, choline chloride 2 and vitamin oil 1; b) synthetic diet with HCH at 1000 ppm, c) synthetic diet supplemented with alga at 0.062% (2000 I.U. vitamin A/kg); d) synthetic diet supplemented with alga at 0.062% + HCH at 1000 ppm; e) synthetic diet supplemented with alga at 3.1% (1,00,000 I.U. vitamin A/kg diet) and f) synthetic diet supplemented with alga at 3.1% + HCH at 1000 ppm. Synthetic diet was prepared by mixing fat-free casein with corn starch, all essential minerals and vitamins, with the exception of vitamin A. *Spirulina* powder was suspended in unrefined groundnut oil and mixed well with the respective diets so as to get the desired concentrations. Technical grade HCH consisting of α 72–74%, β 8-10%, γ 14-16 %, σ 6-8 %, ε <1% and ω <1%, obtained from Hindustan Insecticides Ltd., Udyogamandal, India, was suspended in groundnut oil and mixed thoroughly with the respective diets to get the concentration of 1000 ppm. All rats had free access to the diet and water. Daily food intake and weekly body weights were recorded.

Analytical aspects : At the end of the seven week feeding experiments, the rats were

anaesthetized by ether and blood, collected directly from the heart was allowed to clot at room temperature. Liver was removed, cleaned, weighed and frozen till analyzed. Central lobe portion of the liver was homogenized in 0.25 M ice-cold sucrose, using a tissue homogenizer (3431-D 70, Thomas Scientific). The homogenates (10%) were centrifuged at 4000 rpm for 20 min at 4°C. The sera were obtained by centrifuging the clotted blood samples. The sera and the supernatant from liver homogenates were assayed for glutamate oxaloacetate transaminase, glutamate pyruvate transaminase and alkaline phosphatase, as per the methodology described by Whitaker (1969) and Bergmeyer and Brunt (1974). Vitamin A estimation was carried out by the method of Bayfield (1975).

Body weight gain : Rats of all the six diet groups consumed food uniformly and gained body weight till the end of the sixth week (Table 1). However, during the seventh week, a slight reduction in the body weight gain among the rats fed with synthetic diet alone and containing HCH was observed. Retardation of growth in rats fed with beta-HCH has been demonstrated by Srinivasan and Radhakrishnamurthy (1983) and Barrows and Saliba (1978). Rats fed with *Spirulina* diets gained statistically non-significant body weights at the end of the seventh week, irrespective of the presence of HCH, but the different treatments were not statistically significant.

Liver weights and hepatic vitamin A stores : The absolute weights of liver of rats treated with HCH were significantly increased (Table 1), compared to their respective controls. Similar results were reported by Shivanandappa and Krishnakumari (1981) and Muralidhara et al (1986). The relative weights of rats fed with *Spirulina* at 0.062% with HCH were significantly higher, compared to the other two groups. Liver stores of vitamin A were significantly depleted in synthetic diet and these were further reduced (80%) in rats fed dietary HCH. Vitamin A levels were increased by 4-fold in rats supplemented with *Spirulina* at 0.062%, while HCH brought down the levels slightly. *Spirulina* supplementation at 3.1% significantly increased the vitamin A content by 60 times as compared to unsupplemented diets, while HCH depleted (76%) the same significantly. The exact mechanism by which vitamin A is being depleted by HCH is not known. Perhaps, both HCH and vitamin A, being lipophilic, could be competing at a common site for absorption, storage and metabolism.

Serum and liver enzymes: All the enzymes of serum exhibited significantly enhanced activities (Table 2) in the rats fed with synthetic diets containing HCH. Glutamate pyruvate transaminase and glutamate oxaloacetate transaminase levels were elevated by 3.55 and 2.07-folds, respectively, while alkaline phosphatase level was increased by 1.47-fold in rats fed with HCH. Such alteration in serum and hepatic enzymes have been reported both in acute and chronic HCH exposure in animals (Muralidhara et al. 1986; Kashyap et al. 1976). There were no significant alterations in the enzyme activities between *Spirulina* supplemented diets with and without HCH. Liver enzymes were less markedly affected (Table 2) compared to serum enzymes. Glutamate pyruvate transaminase, glutamate oxaloacetate transaminase and alkaline phosphatase activities were significantly reduced in HCH-treated unsupplemented diets. No such significant alterations were observed in rats fed

TABLE 1. BODY WEIGHT (g) OF RATS FED *SPIRULINA*-FREE AND SUPPLEMENTED DIETS CONTAINING 1000 PPM HCH FOR SEVEN WEEKS

Diet group	Body weight g* at the week				Liver weight, g	Vitamin A content in liver, mg/g
	Initial	1	5	7		
Synthetic diet	46.37±2.00	66.34±2.32	151.36±5.17	155.75±4.34	6.51±0.47	14.64±1.51
Synthetic diet + 1000 ppm HCH	44.71±1.71	67.41±2.08	146.47±6.54	159.28±6.37	9.67±0.72[b]	2.45±0.35[b]
Synthetic diet + 0.062% *Spirulina*	48.45±1.45	66.89±1.98	156.74±4.53	187.60±5.41	7.41±1.15	56.14±2.42
Synthetic diet + 0.062% *Spirulina* + 1000 ppm HCH	45.01±1.49	68.31±2.50	152.69±4.35	182.70±4.89	10.88±0.96[b]	43.72±1.63[a]
Synthetic diet + 3.1% *Spirulina*	46.31±2.18	64.75±3.01	161.46±4.06	193.28±4.85	7.38±0.91	301.82±11.56
Synthetic diet + 3.1% *Spirulina* + 1000 ppm HCH	44.51±2.15	87.39±2.89	163.95±5.08	188.92±8.11	10.58±0.38[b]	72.56±4.57[b]

Values are mean ± SE of four rats each

* Student's 't' test : No significant differences between treatment and control.

a : Significantly different from control, $P < 0.05$.

b : Significantly different from control, $P < 0.001$.

TABLE 2. SERUM AND LIVER ENZYMES OF MALE ALBINO RATS FED *SPIRULINA*-FREE AND SUPPLEMENTED DIETS CONTAINING 1000 PPM HCH FOR SEVEN WEEKS

Diet Group	Glutamate oxaloacetate transaminase[1]		Glutamate pyruvate transaminase[2]		Alkaline phosphatase[3]	
	Serum	Liver	Serum	Liver	Serum	Liver
Synthetic diet	5.67±0.51	0.350±0.025	3.42±0.46	2.01±0.11	11.51±1.25	4.95±0.25
Synthetic diet + 1000 ppm HCH	11.75±0.98[b]	0.202±0.016[a]	12.15±1.09[b]	1.36±0.9[b]	16.96±1.62[b]	3.65±0.27[a]
Synthetic diet + 0.062% *Spirulina*	7.95±0.64	0.315±0.036	4.01±0.26	2.61±0.17	9.56±2.01	3.94±0.16
Synthetic diet + 0.062% *Spirulina* + 1000 ppm HCH	8.62±0.86	0.292±0.151	5.95±0.31	2.15±0.25	10.07±1.97	3.72±0.21
Synthetic diet + 3.1% *Spirulina*	6.97±1.05	0.285±0.062	4.51±0.41	2.74±0.09	10.36±1.56	4.52±0.24
Synthetic diet + 3.1% *Spirulina* + 1000 ppm HCH	7.43±0.97	0.285±0.051	4.76±0.46	3.01±0.15	10.75±2.03	4.67±0.19

Values are mean ± SE of four rats each; P values : a. $P < 0.05$; b. $P < 0.001$.;
[1]μ mole of oxaloacetate/ml/min; [2]μ mole of pyruvate/ml/min; [3]μ mole of p - nitrophenol/ml/min.

Spirulina supplemented diets.

The results are in concurrence with previous studies (Pius Joseph 1988) establishing that the supplementation of diets with synthetic vitamin A acetate at 2000 and 1,00,000 I.U./kg diet offered protection to rats fed with 1000 ppm of HCH. The present study indicates the beneficial effects of *Spirulina platensis* for the first time as retinol supplement for protection against HCH toxicity in rats. The exact role of *Spirulina platensis* in detoxifying HCH needs further investigation.

References

Ahuja AK, Awasthi MD (1993) Contamination of rice and wheat grains with the residues of HCH and DDT. Pes Res J 5:83-86

Barrows SD, Saliba AM (1978) Toxicity of hexachlorocyclohexane in rats. Toxicol 10:271-279

Bayfield RF (1975) Simplified methods for the examination of liver lipids 1. Determinations of vitamin A using a direct solvent extraction technique. Anal Biochem 66:403-413

Benemann JR (1988) Microalgae Biotechnology, Products Processes and Opportunities, Vol 1. OMFC International Inc, Washington

Bergmeyer HU, Brunt E (1974) Enzymes 1: Bergmeyer Hu (ed) Oxidoreductases, Transferases. In: Methods in Enzymatic Analysis. Academic Press, New York, pp 760-785

Borowitzka MA, Borowitzka LJ (1987) Microalgae Biotechnology. Cambridge University Press, New York

Ferrando R, Fourion C, Gutel B (1973) Vitamin A and DDT. Int J Vitam Nutr Res 43:504-510

Kashyap SK, Gupta SK, Bhatt HV, Shan MP (1976) Acute oral toxicity of hexachlorocyclohexane. Ind J Med Res 64:768-772

Lindane UE (1972) Monograph of an Insecticide. Verlag K Schillinger, Freiburg

Muralidhara, Krishnakumari MK, Majumdar SK (1986) Effect of low dietary protein on the mammalian toxicity of x-factor in rats. J Food Sci Tech 23:281-286

Pius Joseph (1988) Role of dietary protein and vitamin A in the toxicity of hexachlorocyclohexane (HCH) to the rat. Ph.D. thesis, University of Mysore, Mysore

Shakman RA (1974) Nutritional influence on the toxicity of environmental pollutants. Arch Environ Health 28:105-113

Shivanandappa T, Krishnakumari MK (1981) Histochemical and biochemical changes in rats fed dietary benzene hexachloride. Ind J Exp Biol 19:1163-1168

Srinivasan K, Radhakrishnamurthy R (1983) Induction of liver mixed function oxygenase system by β and γ hexachlorocyclohexane. Ind J Biochem and Biophys 20:84-91

Venkataraman LV (1993) *Spirulina* in India . In: G. Subramaniam (ed), Proceedings of the National Seminar on 'Cyanobacterial Research-Indian Scene' National Facility for Marine Cyanobacteria, Tiruchirapalli, India, pp 92-116

Venkataraman LV, Becker EW (1984) Production and utilization of blue green algae *Spirulina* in India. Biomass 4:106-125

Venkataraman LV, Becker EW (1986) Biotechnology and Utilization of Algae. The Indian Experience. Department of Science and Technology, New Delhi

Whitaker JE (1969) A general colorimetric procedure for the estimation of enzymes which are linked to the NADH/NAD system. Clin Chim Acta 24:23-32

Received 23 July 1993; revised 29 January 1994 ; accepted 1 February 1994

J. Food Sci. Technol., 1994, Vol. 31, No. 5, 433-434

Quantification of Qualitative Baudouin Test for the Detection of Sesame Oil

R.K. CHAVAN[1]*, V.S. GHOLE[2] AND M. DIKSHIT[2]

[1]State Public Health Laboratory, Pune-411 001, India.
[2]Department of Chemistry, Poona University, Pune-411 007, India.

For quantification of the qualitative Baudouin test, a simple spectrophotometric method was standardized for the estimation of sesamol, a phenolic substance found in sesame oil. Different admixtures of conventional oils containing 1.0 to 5.0% sesame oil were prepared, examined for total sesamol concentration, and the corresponding red units measured in a 1-cm cell, on Lovibond scale are reported. The data indicated good correlation among these tests.

Keywords : Baudouin test, Sesame oil, Sesamol, Red units, Admixtures, Spectrophotometry.

A maximum permissible limit of 15 red units on the Lovibond scale, in a 1-cm cell, is permitted under Rule 44 of the Prevention of Food Adulteration Rules (PFA 1991), when the oil is tested for the Boudouin reaction. This qualitative test involves a visual comparison of the red colour produced in the reaction by sesame oil, with the standard colour on the Lovibond scale. It has a limitation of personal error, while observing red units on the scale. Moreover, the intensity of the natural yellow colour of the oil under examination also interferes with visual comparison. Nevertheless, the use of concentrated hydrochloric acid in the qualitative test creates a persistent turbidity in the acid layer, and also causes a considerable destruction of sesamol (Budowski et al. 1950). Some methods have been developed for the detection of sesame oil in coloured fatty foods (Bandyopadhyay et al. 1983).

To overcome the difficulties in the qualitative Baudouin test, a simple and rapid quantitative spectrophotometric method has been developed, based on the use of aqueous sulphuric acid to estimate the concentration of sesamol in the Baudouin test positive oil samples (Ambros et al. 1958; Beroza 1954, 1956; Bishoff 1957; Fukuda and Namiki 1988). The results are reported in the present communication.

Edible oils, in crude and refined forms, were procured from the local market. In addition, sesame oil was extracted from white and brown seeds of *Sesamum indicum*, using the solvent extraction method (Bailey 1946). Two sets of admixtures of conventional oils, containing 1.0 to 5.0% sesame oil (extracted from white and brown seeds), were prepared and examined for sesamol concentration, as well as the corresponding red units in 1 cm cell on Lovibond scale. Overall, two types of sesame oil (extracted from white and brown seeds) and ten sesame oil samples, procured from the local market, were examined for sesamol concentration. In addition, the edible oil samples procured from the market were spiked with synthetic sesamol and examined for recovery of the sesamol added (Carlos 1952). The recovery of sesamol added was found to be 97 to 98% by this method. The edible oils and their admixtures were also examined for other parameters, like butyrorefractometer reading at 40°C, Bellier's turbidity temperature, and iodine value as per standard methods (DGHS 1978). All the chemicals used were of analytical grade.

For the estimation of total sesamol, a suitable quantity of the oil (depending upon the intensity of red colour produced in the qualitative test) was dissolved in 10-20 ml iso-octane in a 250-ml, stoppered conical flask. Then, 50 ml of aqueous sulphuric acid (sp. gr. 1.84, 1:2 v/v) and 1 ml alcoholic solution of furfural (2%) were added. The flask was then tightly stoppered, and shaken on the mechanical shaker for 30 min, before pouring the contents into a 125-ml separating funnel, and the layers were allowed to separate for 20 min. Then, the red colour produced in the acid layer was measured at 518 nm in spectrophotometer, in the time range of 50 to 75 min from the start of the reaction. A blank was prepared under the same conditions, using 1 ml of absolute alcohol instead of furfural (Budowski et al. 1950). The calibration curve was obtained by dissolving synthetic sesamol (1 mg/10 ml of absolute alcohol) and taking 1.0 to 5.0 ml of this solution. From the calibration curve, the concentration of total sesamol in the sesame oil samples and the admixtures were determined.

* *Corresponding Author*

TABLE 1. SESAMOL CONCENTRATION AND RED UNITS FOR DIFFERENT ADMIXTURES OF REFINED AND CRUDE OILS

Sesame oil, %	Admixtures with refined oils		Admixtures with crude oils	
	Sesamol estimated, mg/100 g	Red units	Sesamol estimated, mg/100 g	Red units
	White seed sesame oil			
1.0	0.75-0.80	10-11	0.75-0.85	13-20
1.5	1.15-1.20	15-16	1.20-1.25	17-28
2.0	1.35-1.50	20-21	1.35-1.50	25-40
3.0	2.15-2.45	31-32	2.20-2.50	37-60
4.0	2.75-2.95	42-45	2.80-3.00	48-70
5.0	3.35-3.50	50-51	3.40-3.55	51-*
	Brown seed sesame oil			
1.0	0.70-0.80	11-12	0.70-0.80	12-22
1.5	1.15-1.25	16-17	1.10-1.25	18-28
2.0	1.35-1.50	21-23	1.30-1.50	25-45
3.0	2.00-2.50	32-33	2.10-2.50	36-67
4.0	2.80-3.00	44-49	2.75-3.00	47-72
5.0	3.35-3.50	51-53	3.30-3.50	52-*

* Beyond the scale

Total sesamol concentrations in the extracted sesame oil samples and the sesame oil samples procured from the local market were found to be 0.095 to 0.1%. The sesamol concentrations, along with the corresponding red units for different admixtures are shown in Table 1. Data indicate that the red units depend upon the concentration of sesamol, and the intensity of the yellow colour of the oil. In spite of the same addition of sesame oil in both refined and crude admixtures, the higher red units have been observed for the crude admixtures, thereby indicating the interference of yellow colour of the oil in the measurement of red units. This may be due to extraction of the yellow colour of the oil in the acid layer. The parameters like butyrorefractometer readings, iodine values, and Bellier's turbidity temperatures of these admixtures, as compared to the values for the conventional oil samples, are given in Table 2. Data indicate that there is a very little variation in the values of these parameters. By taking into consideration the permissible limit of 15 red units and the corresponding sesamol concentration for the mixture containing 1.5% sesame oil, a maximum permissible limit for sesamol concentration as 1.15 to 1.25 mg/100 oil can be fixed for the oil samples showing positive Baudouin test.

With the help of this method, the admixtures of conventional oils containing different varieties of sesame oil and with different concentrations of seasmol, can be studied for the fixation of a more appropriate and precise permissible limit for the sesamol concentration under Rule 44 of the PFA Rules 1955, in place of 15 red units, for more reliable quantification purposes.

TABLE 2. BUTYROREFRACTOMETER READINGS AT 40∞C, IODINE VALUES AND BELLIER'S TURBIDITY TEMPERATURES OF CONVENTIONAL OILS AND THEIR ADMIXTURES

	Groundnut oil			Safflower oil		
	BR reading at 40°C	Iodine value	BT Temp °C	BR reading at 40°C	Iodine value	BT Temp °C
Conventional oil, no admixing	55.7	95.96	40.0	64.5	145.4	14.5
	White seed sesame oil					
Sesame oil, %						
1.0	55.7	96.03	40.0	64.5	145.30	14.5
2.0	55.7	96.20	40.0	64.5	145.10	14.5
3.0	55.8	96.34	39.8	64.4	144.84	14.6
4.0	55.9	96.50	39.7	64.3	144.70	14.7
5.0	56.1	96.68	39.6	64.2	144.40	14.8
	Brown seed sesame oil					
1.0	55.7	96.12	39.9	64.5	145.10	14.6
2.0	55.7	96.24	39.9	64.5	144.80	14.6
3.0	55.8	96.40	39.8	64.4	144.50	14.7
4.0	56.0	96.62	39.7	64.3	144.20	14.8
5.0	56.1	96.70	39.6	64.2	143.80	15.0

BR : Butyrorefractometer reading,
BT : Bellier's turbidity temperature

References

Ambros AM, Cox AJ, DeEds F (1958) Toxicological studies on sesame oil. J Agric Food Chem 6:800-802

Bailey A (1946) Industrial Oil and Fat Products, 2nd ed. Interscience Publishers, Inc, New York

Bandyopadhyay TS, Chakrabarti J, Guha KC, Roy BR (1983) Rapid detection of sesame oil in coloured fatty foods. J Food Sci Technol 20:175-176

Beroza M (1954) Pyrethrum synergists in sesame oil - Sesamolin, a potent synergist. J Am Oil Chem Soc 31:302-304

Beroza M (1956) 3, 4-Methylenedioxyphyenoxy compounds as synergists for natural and synthetic pyrethrins. J Agric Food Chem 4:49-53-53

Bishoff F (1957) A co-carcinogenic fraction from sesame oil. Fed Proc 16:155-157

Budowski P, O'Connor RT, Field ET (1950) Determination of free and bound sesamol. J Am Oil Chem Soc 27:307-310

Carlos SC (1952) Determination of sesamol, sesamolin and sesamin in sesamin concentrates and oils. Anal Chem 24:668-671

DGHS (1978) Manual of Methods of Tests and Analysis for Food (Oil and Fats). Director-General of Health Services, Ministry of Health and Family Welfare, Govt. of India, New Delhi

Fukuda Y, Namiki J (1988) Recent studies on sesame seed and oil. J Japanese Soc Food Sci Technol 33(8):52-55

PFA (1991) The Prevention of Food Adulteration Act 1954 and Rules 1955, 14th ed. Eastern Book Company, Lucknow

Received 8 May 1993; revised 30 December 1993; accepted 27 January 1994

Evaluation of Certain Food Additives and Contaminants. WHO Tech Report Series No. 837, WHO, 1211, Geneva, 27, Switzerland 1993, pp 56, Price SW Fr 10/: For developing countries SW Fr 7/-

This is the 41st report of a Joint FAO/WHO Expert Committee on Food Additives that met in Geneva in February 1993. This report addresses chiefly two major issues (1) toxicological evaluation of several food additives and contaminants; and (2) specifications in foods for the same.

The report provides valuable information on several food additives and contaminants for the first time and has also re-evaluated many that were considered in the previous meetings. The following are the food additives considered in this report : (1) Antioxidants (gallates); (2) flavouring agents (benzyl acetate, ethyl hexanol, limonene, α-methyl benzyl alcohol, and quinine; (3) flavour enhancers (disodium 5'-guanylate, disodium 5'-inosinate; (4) food colours (carotenes from algal and vegetable sources); (5) sweetening agents (maltitol and maltitol syrup, saccharin); (6) thickening agents (Konjac flour, processed Eucheuma seaweed, propylene glycol alginate); and (7) miscellaneous substances (β-Cyclodextrin, sodium iron EDTA, sucrose acetate isobutyrate, and urea. The contaminants for which toxicological and specification data are reviewed are (1) cadmium, (2) chloropropanols, (3) lead. A noteworthy feature is the information on the acceptable daily intakes (ADI) for many of the food additives and contaminants, based on either no observed effects level, or minimum effects level. However, it may be noted that, in the case of some additions, adequate information is not available for the calculation of an ADI.

The Appendices on other available FAO/WHO Expert Committee Reports on food additives, toxicological information already available on the food additives and contaminants reviewed in the report, and the information that needs to be generated, will be found especially useful by those who are planning research studies on food additives and contaminants.

This report is a valuable updated resource on food additives and contaminants for professionals in the area of food industry and researchers/ teachers in the area of toxicological evaluation of food additives and contaminants.

SUBADRA SESHADRI
MS UNIVERSITY OF BARODA, BARODA-390 002

Fractionation by Packed-Column SFC and SFE - Principles and Applications, Edited by Muneo Saito, Yoshio Yamauchi and Tauneo Okuyama, published by VCH Publishers Inc., (UK), 8 Wellington Court, Cambridge CB1 1HZ United Kingdom, 1994, pp. 276, Price DM 198/- or £ 80/-

This book presents a birds' eye view of the art and status of Supercritical Fluid Chromatography (SFC) and Supercritical Fluid Extraction (SFE). It is divided into two sections: Section I, dealing with basic principles and instrumentation, consists of 4 chapters viz., Introduction, Fundamental Properties of Supercritical Fluids relevant to Chromatography and Extraction, Fundamentals of Packed Column SFC and SFE, and Instrumentation - contributed by professionals; Section II contains 9 chapters on applications of SCF and SFE; the first and fifth chapters which review applications of SFE and SCF in industry, are by no means exhaustive, but could still serve as useful guides to the researchers. The remaining eight chapters are research articles on SFE and SFC dealing with applications, programmed elution/extraction of lemon peel oil using SFC, SFC of polyunsaturated fatty acids from vegetable oils, fractionation of eicosapentaenoic acid and docosahexaenoic acid esters from esterified fish oils, chiral separations in SFC using chiral stationary phases, oligomer separation in polymers, and separation of fullerenes.

Chapter 1 describes the development of SFE and SFC that includes its historical development, basic theory on SFE and SFC, various stages of SFC, trends in applications, ending with the objectives of the book. Chapter 2 deals briefly with phase equilibria and certain groups of phase equilibria, as also with basic preliminary theory on estimation and prediction of critical components. The chapter ends with a computer programme listing for determination of phase equilibria in a binary component mixture that can be run on any IBM compatible computer. Chapter 3 on "Fundamentals of Packed Column SFC and Extraction" lucidly brings out theory on distribution coefficient, capacity factor, migration velocity, theoretical plate number and plate height; and their

relationship with linear velocity, retention behaviour and fundamental factors in designing and operating an SFC system. Chapter 4 describes the various components, their functionalities as well as critical points of design with an emphasis in safety practices in high pressure technology.

Chapter 6, entitled "Application of microsupercritical fluid extraction on investigation of lemon peel oil extraction with supercritical fluid carbon dioxide" describes the apparatus used, and concludes that fractionation of the extract is done and quality variation occurs with extraction conditions. A comparison with the cold-pressed oil indicated higher recovery, and more oxygenated in SFE. Chapter 7, on "Fractionation of lemon peel oil by supercritical fluid chromatography with programmed extraction/elution" proves that the fractionation of lemon peel oil can be performed using supercritical fluid chromatography with higher column loads. The programmed extraction/elution method is more suitable for individual compound fractionation than high resolution separation to a single compound. It is pointed out that the techniques may be useful for remixing the fractions to produce tailor-made flavours. Chapter 8 is on "Separation of polyunsaturated fatty acids from vegetable oil, supercritical fluid extraction and chromatography". Attempts have been made to separate triolein from other triglycerides. In SFC, better separation is achieved by non-modifier solvent and increase of stationary phase. Chapter 9 is on "Fractionation of eicosapentaenoic acid and docosahexaenoic acid esters from esterified fish oiled by coupled supercritical fluid extraction chromatography". An equipment manufactured by JASCO-Model Super 200 System 3 was successfully used for separation of purified fractions with carbon dioxide at differential pressures using ethanol as a modifier. Chapter 10 is on "Application of supercritical fluid extraction to mutagenicity test of essential oils from irradiated spices". Established essential oils, obtained by SCF or solvent extraction from irradiated spices, have no difference in their growth inhibition doses. The irradiation of spices at doses upto 10 KGy does not induce any mutagenicity. Chapter 11 is on "Chiral separation by supercritical fluid chromatography/chiral stationary phases" describes the use of CSP polymers as stationary phase with ethanol/isopropanol modifiers to achieve separation as good as in HPLC. Chapter 12 is on "Applications of preparative SFC to oligomer analysis and characterization". It describes the separation of st and it-oligomers of methyl.pa methacrylate, PPMA, to obtain highly pure crystals of Oligo (oxymethylene) diacetate. Chapter 13 describes the separation of fullerenes of C60 and C70 using SCFE using toluene and carbon dioxide at a pressure of 250 bar and 100°C.

Supercritical Fluid Chromatography, which was talked of as a probable analytical tool a decade ago, has come of age, as an effective and viable analytical procedure. This book provides the normal reader the understanding of the basic principles and vividly describes instrumentation, sample preparation, and applications of SCF and SFE with some practical examples. It is a useful collection of separation methods for analytical chemists, and also for environmental chemists, as it describes environmentally clean separations. The book is rightly dedicated to Jentoff and Gouw, who are pioneers in the development of SFC.

K. UDAYA SANKAR
CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE, MYSORE-570 013

Dehydrated Vegetables - A survey of major markets. Published by International Trade Centre. UNCTAD/GATT, Palais des Nations, 1211, Geneva 10, Switzerland : 1993, 113, Price not mentioned.

Dehydrated Vegetables - A survey of major markets is an update of the earlier publication in 1981 entitled "The market for dehydrated vegetables in select European countries, the United States of America, and Japan. The present survey provides up-to-date information on the four major markets - Germany, Netherlands, United Kingdom and United States of America. The first chapter reviews the world market situation giving comments and data on supply and demand, production and export, imports, market characteristics, market requirements, packaging, distribution channels and market access, thereby presenting a quantitative and qualitative overview of world trade in dehydrated vegetables. These are further highlighted by Tables depicting import and export of dehydrated vegetables by different countries. This would enable developing countries to identify new export opportunities. Onion, tomatoes, mushrooms, garlic, carrots, olives and other herbs constitute some of the major import-export products.

Each of the following four chapters is devoted to the four countries under survey. Other than the topics common to chapter 1, reference to regulation on imports like customs duties, food laws and regulations and prospects are also dealt with,

aiming to help exporters to adapt their products for sale abroad, and promote these goods on the international market. It further provides information on materials with special reference to type of vegetable required, product form and presentation, distribution channels, as well as on major agents and organisations and associations in the industry.

Each chapter is followed by an 'Annexure' giving selected addresses of importers, importers/ reprocessors, selected end-users, suppliers to the catering and institutional sectors and government offices and association, product list etc. which would come in handy to prospective traders.

This book is highly informative and useful for Government agencies involved in processed vegetable development programmes. It also helps individual enterprises, individuals and organisations such as producers and exporters of dehydrated vegetables. It would equally help international organisations, development banks, and trade associations in exporting and importing countries, and export promoting bodies.

W.E. EIPESON
CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE, MYSORE-570 013

Dietetics : by B. Srilakshmi, Wiley Eastern Ltd., New Delhi 110 002, 1993, pp. 323, Price Rs. 120/-

The importance of nutrition in health and disease is unquestionable. A good knowledge of principles of nutrition is essential to translate foods into diets for individuals and communities. This book has been written as a text-book, compiling information from other sources, for the students of different disciplines studying food and nutritional sciences. Though books are available on 'Dietetics', an attempt made by the author to write a text-book covering Indian meal pattern, wherever possible, is a welcome step. The book is divided into several chapters. The subjects covered under these chapters can be broadly classified into three divisions.

The first ten chapters of the book cover the aspects of planning meals for families and individuals in different age groups and physiological conditions. The chapters on childhood, pregnancy and lactation also give the information on the common nutritional problems like anaemia, PEM, diarrhoea, etc., and also nutrition programmes in India. Information on nutritional anaemia is presented in chapter 9, though it is covered in the previous chapters.

Chapters 11 to 20 concentrate on the therapeutic aspects of nutrition covering principles of diet therapy for different disease conditions, like diabetes mellitus, coronary heart disease, cirrhosis of liver, kidney failure, peptic ulcer, etc. Information on allergy is given in chapter 19 along with the suggested treatment. The summary of therapeutic diets is presented in chapter 20.

The last two chapters 21 and 22 cover the information on responsibilities of dietetian along with present status of dietetics training in India.

At the end of each chapter, a series of questions is given to help the student to understand the importance of aspects covered in the respective chapter. The book is profusely illustrated with figures and tables. However, a thorough reading of the text leaves one with the feeling that it is a compilation of information based on Western text books with very little information based on Indian lifestyle. Though general guidance is given on planning meals for a family, the exact procedure of translating Recommended Dietary Allowances (RDA) to family meals is not given. Also, certain terms like 'menu' has been used loosely without relating to meals in the Indian context. In chapters 2 to 9 again, no attempt has been made to adopt the 'RDA' to evolve 'RDI' (Recommended Dietary Intake) for individuals. General notes and RDA given by ICMR have been used throughout the text without attempting to interpret or apply to individuals both in normal and disease conditions. Certain aspects, viz., anaemia, under weight/over weight are repeated in different chapters. It certainly needs revision to make it applicable for the Indian students of nutrition and dietetics to practise dietetics as a profession. In the present form, it serves as a compiled source book only, for the students in the field of Nutrition and Medicine.

SHASHIKALA PUTTARAJ
UNIVERSITY OF MYSORE, MANASAGANGOTHRI, MYSORE-570 006

 J. Food Sci. Technol., 1994, Vol. 31, No. 5, 438--440

ICFoST - 94 AND ANNUAL CENTRAL BODY MEETING

The Association of Food Scientists and Technologists (India), Delhi Chapter, coinciding with its Silver Jubilee year, organised the Indian Convention of Food Scientists and Technologists (ICFoST-94) from September 2-3, 1994 at India International Centre, New Delhi. It was co-sponsored by the Ministry of Food Processing Industries, National Horticulture Board, Agricultural and Processed Food Products Export Development Authority, National Cooperative Development Corporation, Council of Scientific and Industrial Research, All India Food Preservers' Association, National Agricultural Cooperative Marketing Federation of India Limited, and Modern Food Industries Ltd. The focal theme for the Convention was "Strategies for Packaging and Storage of Fresh and Processed Fruits and Vegetables in 21st Century".

INAUGURAL SESSION

It was held at India International Centre, New Delhi. Around 300 delegates participated in the Convention. Prof. B.S. Bhatia, President, AFST(I) Delhi Chapter, welcomed the delegates, Dr. Susanta K. Roy, President, AFST(I) Headquarters, briefed on the theme of the ICFoST-94.

The function was inaugurated by the Hon'ble Minister for Tourism (Delhi), Sri Ratawal. The Minister commended work carried out by the Food Scientists and Technologists in the country, especially in the area of preservation of fruits and vegetables.

The other distinguished members who spoke during the inaugural session included Dr. K.L. Chadha, Dy. Director-General (Hort.), Indian Council of Agricultural Research; Sri Gokul Patnaik, Chairman, Agricultural and Processed Food Products Export Development Authority; and Sri C.K. Basu, Joint Secretary, Ministry of Food Processing Industries.

Release of Souvenir : A souvenir brought out by the AFST(I) Delhi Chapter was released by the Hon'ble Minister for Tourism (Delhi), Sri Ratawal.

Release of IFCON-93 Proceedings : The Hon'ble Minister for Tourism (Delhi), Sri Ratawal, also released the Proceedings of International Food Convention (IFCON-93) held at Mysore between 7-12 September 1993. The volume consisting of about 1200 pages, covers 24 areas, and 152 technical papers, presented during the Convention by eminent scientists/experts from India and abroad.

Release of IFCON-93 Proceedings in Floppy Diskettes : The proceedings of the Convention were brought out in the form of floppy diskettes for the first time by AFST(I). The entire proceedings have been accommodated in 3 High Density Floppy Diskettes. The user can operate it, using Word Star 4 to take the print-out of the desired papers. The floppy diskettes were released by Shri Gokul Patnaik, Chairman, APEDA, New Delhi.

Release of AFST(I) Membership Directory: The computerized AFST(I) membership has been brought out by AFST(I) recently. This useful document contains the addresses, fields of specialization, professional affiliation and type of membership of over 2500 members of the Association. The directory was a long felt need and it was released on this occasion by Dr. Susanta K. Roy, President, AFST(I).

Release of Booklet on 'Pesticide Residues in Foods": With rising awareness of the problem of toxic pesticides in food all over the world, this subject has become a major concern for the exporters. A popular article has been recently published by AFST(I) Education & Publication Trust, Mysore. The booklet, first series of its kind, was released by Dr. K.L. Chadda, Dy. Director-General (Hort.), ICAR, New Delhi.

AFST (I) AWARDS

The other highlight of the inaugural session was the presentation of AFST(I) Annual Awards by the Hon'ble Minister. Sri G.A. Krishna, Hony.. Secretary, AFST(I), briefed the distinguished gathering about the various awards instituted by AFST(I), and read the citation of the award recipients.

The following persons received the Awards of AFST(I) for the year 1993:

I. AFST (I) Fellow Award

1. Dr. V. Prakash, Director, Central Food Technological Research Institute, Mysore.
2. Dr. S.S. Arya, Additional Director, Defence Food Research Laboratory, Mysore.

II. Laljee Godhoo Smarak Nidhi Award

Dr. M.K. Rama Murthy, Dr. Satish Kulkarni

and Dr. B. Surendra Nath, National Dairy Research Institute, Southern Regional Station, Bangalore.

III. Young Scientist Award

Dr. R. Nagendra, Central Food Technological Research Institute, Mysore.

IV. Best Student Award

Sri M.P. Pimputkar, Central Food Technological Research Institute, Mysore.

V. Best Paper Award

It has been awarded to Sri Y.M. Indudharaswamy, Dr. K.R. Unnikrishnan and Dr. K.S. Narasimhan for their paper on "Changes in Free Fatty Acids and Insect Infestation during Storage of Brown Rice Obtained by Shelling Paddy in Rubber Roll and Disc Shellers", published in Vol. 30, No. 5 of the *Journal of Food Science and Technology* in the year 1993.

Dr. D.S. Khurdiya, Hony. Secretary, AFST(I) Delhi Chapter, proposed the vote of thanks.

TECHNICAL SESSIONS

The Technical Session I on 'Packaging of Fresh and Processed Fruits and Vegetables' was conducted under the chairmanship of Dr. D.K. Uppal, followed by the inaugural session. Eight scientists presented their work during this session.

The Technical Session II on 'Storage of Fresh and Processed Fruits and Vegetables' was conducted in two sections. Six scientists presented their papers. The Chairmen for these sections were Dr. G.L. Kaul and Dr. Paul Thomas.

The Technical Session III was on "Export Marketing of Fresh and Processed Fruits and Vegetables" and was chaired by Shri Gokul Patnaik.

POSTER SESSION

It was held on 3rd September, 1994 at Nuclear Research Laboratory Auditorium, Indian Agricultural Research Institute, New Delhi.

The Poster Session was classified into three categories, viz.,

1. Packaging of Fresh and Processed Fruits and Vegetables.
2. Storage of Fresh and Processed Fruits and Vegetables.
3. General.

There were about 66 posters displayed in the two hour poster session and awards were given to the Best Poster Presentation.

The awards were as follows :

1. Reduction of post-harvest losses of banana during rail transport - R.K. Pal, Susanta K. Roy, D.P. Waskar and Sanjay Srivastava, IARI, New Delhi.
2. White onion varieties for dehydration - Netra Pal and Narendra Singh, IARI, New Delhi.
3. Mushroom dehydration using solar cabinet dryer - M. Usha, R. Raghupathy and L. Gothandapani, Tamil Nadu Agricultural University, Coimbatore.

Prof. S.K. Sinha, gave away the prizes to the winners of the Poster Session.

PLENARY SESSION

It was chaired by Shri C.K. Basu, Joint Secretary, Ministry of Food Processing Industries. He emphasised on the active participation of AFST(I) in formulating the policy matters related to food and allied areas.

SPECIAL GENERAL BODY MEETING

It was convened to discuss the amendments to the existing clauses 3.7.1 and 3.7.2 of the Constitution of AFST(I). The Hon. Exec. Secretary, Mr. G.A. Krishna, read the existing clauses and the proposed amendment. He said that these amendments to the existing rules and regulations under clauses 3.7.1 and 3.7.2 were necessitated to provide an opportunity to the chapters for the active participation in the activities of the AFST(I).

The amendments were passed unanimously.

ANNUAL GENERAL BODY MEETING

The Annual General Body Meeting of AFST(I) was held on 3rd September 1994 at 5-45 p.m. in NRL auditorium, IARI, New Delhi. The President Dr. S.K. Roy welcomed the members.

Mr. G.A. Krishna, in his Secretary's report presented the various activities and achievements such as the computerization of accounting system of AFST(I), amendments to the bye-laws, information brochure, new application form, life membership folder and annual report. The secretary also reported the other publications brought out during the period, viz.,

1. IFCON-93 Proceedings.
2. Views on GATT - the Report on one day

colloquium organised at the headquarters, Mysore on 10th June, 1994.

3. Pesticide Residues in Foods and their Safe Limits.
4. AFST(I) membership directory.

Activities of various chapters were also highlighted by the Secretary.

The audited statement of accounts for the year 1993-94 was presented by Shri R.S.Matche, Hony. Treasurer, AFST(I). He also presented the audited accounts of IFCON-93 and budget proposal of AFST(I) and AFST(I) Education and Publication Trust for the year 1994-95. The general body approved both the reports and budgetary proposals and appreciated the work.

ANNOUNCEMENT OF ELECTION RESULTS

The Secretary Mr. G.A. Krishna announced the results of the election for the year 1994-95.

1. President - Designate	Dr.(Mrs.) Rugmini Sankaran
2. Vice-Prsident (HQ)	Mr. A. Ramesh
3. Vice-President (Chapters)	Dr. G.S. Chauhan (Pantnagar) Dr. A.S. Gholap (Bombay) Mr. G.V. Krishnamurthy (Hyderabad).
4. Joint Secretary	Mr. P.C.S. Nambiar
5. Hon. Treasurer	Dr. M.S. Krishna Prakash

In addition to the above elected office bearers, the President : Dr. P. Narasimham; Immediate Past President : Dr. Susanta K. Roy; Honorary Executive Secretary : Dr. K. Udaya Sankar; Immediate Past Secretary : Mr. G.A. Krishna; Editor, JFST : Dr. B.K. Lonsane; and Chief Editor, IFI : Mr. S.P. Pillai will form the members of the Central Executive Committee for the year 1994-95.

The outgoing President, Dr. Roy, welcomed the members of new CEC and inducted Dr. P. Narasimham to the Chair of Presidentship of AFST(I). Dr. Narasimham acknowledged with gratitude the confidence reposed in him by the members of the Association, and said he would do his best to enhance the reputation of the Association during his tenure.

Dr. K. Udaya Sankar, Hony. Jt. Secretary was also inducted as Hony. Secretary during this function. While thanking the members of AFST(I) for the support, he requested them to further strengthen his hands for taking AFST(I) to its optimum glory and unique distinction in whole of the world.

The meeting ended with the vote of thanks.

BOMBAY CHAPTER

The Annual General Body Meeting(AGBM) of AFST(I) Bombay Chapter was held on June 24, 1994. The following office-bearers and executive committee members were elected for the year 1994-95.

President : Prof. J.S. Pai

Vice-President : Dr. A.S. Gholap, Dr. K.A. Savagaon

Hon. Secretary : Dr. V. Ninjoor

Hon. Jt. Secretary : Dr. N.D. Kamat

Hon. Treasurer : Dr. S.V. Padgaonkar

Executive Committee Members : H.R. Adhikari, Dr. S.R. Agarwal, Dr. A.C. Behere, Dr. S.V. Bhalkar, Mr. M.M. Chitale, Dr. J.V. Parekh, S.B.K. Warrier, J.P. Upadhyay.

BANGALORE CHAPTER

AFST(I) Bangalore chapter held its Annual General Body Meeting on 16th June 1994 at Bangalore. The following were elected as the office-bearers for the year 1994-95.

President	: Mr. V. Seshamani
Vice-President	: Mrs. D.G. Gideon
Treasurer	: Dr. P.A. Shankar
Hon. Secretary	: Dr. R.R. Mohite

HYDERABAD CHAPTER

World Food Day was celebrated on 16-10-94 by AFST (I) Hyderabad Chapter in collaboration with Oil Technologists Association of India, Southern Zone at IICT auditorium. Dr. M.V. Rao, Vice Chancellor, A.P. Agricultural University, Hyderabad delivered the key note lecture. The functions was presided over by Dr. G.S. Siddhu, former Director-General, CSIR. Dr. A.V. Rama Rao, Director, IICT, Hyderabad, also graced the function. More than 100 members participated in the function. Dr. Narayana Rao, Former FAO Consultant (retired) delivered a lecture on "Water for Agriculture". Dr. Krishnamurthy, retired Jt. Commissioner, Ministry of Food, Govt. of India spoke on "National food policy". Dr. T.N.B. Kaimer, Head, Oils & Fats Division, IICT, Hyderabad, spoke on "Processing of oilseeds". The technical session was chaired by Dr. Narasinga Rao, Retired Director of NIN, Hyderabad.

BOOK YOUR ORDERS TODAY

FOR

IFCON'93 PROCEEDINGS

AVAILABLE IN

BOTH HARD BOUND COPY AND FLOPPY DISKETTES

Pre-publication cost : Rs. 450/- at a savings of Rs. 100/-
Floppy Diskettes (2 Nos.) : Rs. 400/-
Approximate No. of pages : 1200

Send the DD/MO to the Hon. Exec. Secretary, AFST (I), CFTRI Campus, Mysore - 570 013 (Ph. 521747 Fax : 821-521747)

Announcement

The Second Agricultural Science Congress is being organised by the National Academy of Agricultural Sciences at the Andhra Pradesh Agricultural University Campus at Rajendra Nagar, Hyderabad -500 030 from the **19th to 21st January, 1995.** As part of the Congress, three symposia will also be organised on (i) National Water Policy (ii) Vector Biology and (iii) Integrated on-farm and off-farm Employment. Registration fee for participation is Rs. 250/-. Those wishing to participate may ask for details from :

Dr. M.V. Rao,
Vice Chancellor,
APAU and Chairman,
Organising Committee
Rajendra Nagar,
Hyderabad - 500 030
Tel. No. (80-245035)

Dr. Anupam Verma, Head,
Division of Mycology
Plant Pathology,
IARI and Secretary,
National Academy of
Agricultural Sciences,
IARI Campus, New Delhi - 110 008
Tel. (011-5781474, 5753677,
5753713)

Announcements

NATIONAL CONFERENCE
on
Total Quality Management in Food, Fermentation and Allied Industries

January 20-21, 1995

Jointly organised by :

Association of Food Scientists and Technologists (India)
Calcutta Chapter

&

Food Technology & Biological Engineering Department
Jadavpur University, Calcutta 700 032

For details please contact : Amit Ghosh, Convenor (Administration), Food Technology & Biochemical Engineering Department, Jadavpur University, Calcutta 700 032, Tel : 473-4044 or 473-0399, Extn. 50 FAX : 473-4266

Last date for submission of abstracts : December 20, 1994

FOOD NUTRITION DIVISION
of
Dr. Subhas Mukherjee Memorial
Reproductive Biology Research Centre
WBSIC Industrial Estate, Building 1, 620, Diamond Harbour Road, Calcutta - 700 034

has been set up with the support of the
Ministry of Food Processing Industries, Govt. of West Bengal
to provide the following services :

a. Assisting food processing industries to solve specific technical problems.
b. Preparing project reports for small scale industries.
c. Manpower development for food processing industries through training of entrepreneurs and operators.
d. Development of appropriate and novel products & processes in the context of present economic liberalisation policy.
e. Testing of processed food products.
f. Pillot plant trials for a process.
g. Organisation of meetings, seminars & exhibitions.
h. Providing nutrition guidance.