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REVIEW

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Methods for Concentration of Fruit Juices : A Critical Evaluation

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Concentration of fruit juices, a major unit operation in fruit processing industry, is of critical importance as it determines the quality of the final product. Few commercially feasible methods include vacuum evaporation, freeze - concentration and membrane processes such as osmosis, reverse osmosis and ultrafiltration. Even though considerable developments have taken place in all these concentration methods, evaporation is still the most developed and widely followed method. With the numerous types of evaporators available today, the selection of suitable evaporator for individual fruit juice concentration is an important step. Different criteria such as heat sensitivity, fouling and viscosity, which aid in selection of evaporator, have been discussed. Aroma recovery has become an integral part of fruit juice concentration process. Various commercial aroma recovery equipments are described and the comparative evaluation of different concentration processes is delineated.

Keywords : Fruit juice concentration, Freeze-concentration, Reverse osmosis, Ultrafiltration, Evaporative concentration, Aroma recovery.

Fruit juice concentrates are valuable semi-finished products for use in the production of fruit juices, fruit juice beverages and fruit juice powders (Sulc 1984). The most common and convenient mode in which fruits are processed and preserved, is the form of fruit juices/pulps (*purees*). However, preservation of single strength juices is not economical, since the water content of fruit juices is very high (about 75 to 90%) (Young 1975). Concentration of fruit juices not only provides microbiological stability, but also permits economy in packaging, transportation and distribution of the finished product due to reduction in bulk by weight and volume (Labuza 1970).

Fruit juice concentration can be described as a separation process and forms one of the basic unit operations of fruit technology. In concentration processes, the solids content is increased upto 65 to 75% so that the final product is still in liquid form (Sulc 1984). During the last sixty years, several methods for concentration of liquid fluids have been developed. Among these, evaporative concentration, freeze-concentration and membrane concentration (reverse osmosis) have found commercial application for different fruit juices (Thijssen 1975; Bomben et al. 1973; Van Pelt 1984; Sulc 1984). The methods for concentration of fruit juices are critically evaluated in the present review.

Freeze-concentration

Freeze-concentration of fruit juices is a cold, gentle and selective concentration procedure, in which two distinctive steps, viz. ice crystallization and ice separation from concentrate phase are involved (Deshpande et al. 1984). In the first stage, fruit juice is super-cooled below its freezing point to allow water to separate as ice crystals. In the second stage, the ice crystals are separated from the concentrated fruit juices. Several factors affect the ice-crystal separation efficiency, the foremost being the viscosity of the slurry and the ice-crystal diam (Van Pelt 1981). A typical freeze-concentration system consists of two main components viz. a) crystallizer, b) separation device.

Crystallization in freeze-concentration

Direct contact crystallizer : It cools the incoming feed due to contact with the refrigerant and has advantages over indirect contact crystallizer. For example, it eliminates cooling wall, which reduces the rate of heat transfer and consequently the use of expensive scraped surface heat exchanger, and also lowers the power consumption (Thijssen 1975). This, however, requires operation of the crystallizer under high vacuum, and compressing large volumes of vapour at low pressures. Besides, the direct contact crystallizers are mostly used for non-food applications, since it is not desirable to allow mixing of the refrigerant with the food product.

Indirect contact crystallizers : These have found wide applications in food industry (Muller 1967: Thijssen 1975). These can be divided into two classes, based on the type of the indirect heat transfer method involved viz., internally and externally cooled crystallizers (Deshpande et al.

* *Corresponding Author*

1984). In the internally cooled crystallizers, the heat of crystallization is removed through the wall of crystallizer. The externally cooled crystallizers operate on the adiabatic principle, in which heat is removed from outside the crystal growth section.

Internally cooled crystallizers are further classified into (1) crystallizers producing a solidified or almost solidified suspension and (2) crystallizers producing pumpable slurries, i.e., suspension crystallizer (Muller 1967).

Externally cooled crystallizers can be subdivided into three types. The first type involves super-cooling of the feed stream to avoid heterogeneous crystallization within the crystallizer. To minimise the change of primary nucleation and crystallization in the heat exchange, which may cause a complete blockage of the liquid path, the wall of the heat exchanger contacting the process liquid must be highly polished (Deshpande et al. 1984). In the second type of crystallizer, the entire feed is recirculated from the crystallizer to the heat exchanger. The residence time of the crystals in the heat exchanger is generally short, as compared to that in the crystallizer. The longer residence time in the crystallizer allows proper crystal growth (Thijssen 1975). The third type of crystallizer, in which nucleation and crystal growth sections are separated, the heat flux through the wall of scraped heat exchanger is very high. This results in a very strong nucleation which, in turn, limits the residence time to only a few seconds (Van Pelt 1981). The slurry containing the small ice-crystals is then fed continuously to a ripening crystallizer. Ripening is based on the fact that the mean bulk temperature of the liquid settles to the values between the extreme values of the various melting temperatures of the crystals and nuclei, when the smaller iced crystals are mixed in the suspension (Van Pelt 1981). This results in a driving force for the growth of larger crystals and for the melting of smaller crystals. The ripening crystallizer has been developed to a commercial scale (Grenco 1972).

Ice-concentrate separation devices

The commerical applicability of freeze-concentration largely depends on the effectiveness of ice-concentrate separation. The separation can be performed either batch-wise or continuously in presses, filtering centrifuges, wash columns or combination of these devices (Thijssen 1974).

Filter presses have proved less effective for crystal separation. The loss of dissolved solids is primarily determined by the amount of liquid that remains occluded in the compressed ice cakes. At a pressure of upto 10 kg/cm², about 0.6 kg liquid remains occluded per kg ice (Kuivenhoven 1966). Dissolved solids cannot be easily removed by wash process even after grinding the cake.

Centrifuges can provide forces upto 1000 X **g**, by which the ice-crystals are separated from the concentrate due to difference in density between liquid and solid phases. Losses of concentrate depend on the content of dry solids and concentrate viscosity (Deshpande et al. 1984). A correlation between loss of concentrate and centrifuging acceleration has been studied by Pankovic and Gerl (1962). A serious disadvantage of centrifuges is the aroma loss, since they must be operated with a gas headspace into which the volatiles can escape (Bomben et al. 1973).

Wash columns provide a perfect separation of ice and liquid without any dilution. Because the wash columns are closed and operate without a headspace, aroma losses are virtually zero (Thijssen 1974). For ice-concentrate separation, the slurry is forced through one end of the column, where the ice crystals are separated from the concentrate by creating a counter-current motion between melting crystals and crystallizing liquid. Several wash columns tried for liquid foods have been described in the literature (Vostman and Thijssen 1972; Thijssen 1974, 1975).

The most economical method for ice separation could be the combination of a press and wash column (Thijssen 1975). The concentrated slurry leaving the crystallizer is partly separated in a press. The ice cake, still containing about 40% occluded concentrate, is thereupon dispersed in the feed to the system. The diluted ice is then completely separated in a wash column, and the liquid separated from the ice is fed back to the crystallizer.

Recent developments and present status

Most of the recent developments have been aimed at overcoming the drawbacks of single stage freeze-concentration method. The single stage freeze-concentration method consists of one crystallization and one separation step. Due to this, separation of ice crystals becomes difficult, as a result of increased viscosity of the end concentrate. On the other hand, in the multi-stage freeze-concentration process, the ice-crystals are separated out at the end of each cycle and the remaining concentrate is fed to the succeeding crystallizing compartments

(Deshpande et al. 1984). Thus, in a continuous operation, the ice-crystals are separated at different levels of concentration and viscosity. The major advantages of multi-stage freeze-concentration plant, over single stage concentration plant, include lower energy consumption (approx. 37% lower for co-current and 47% lower for counter-current systems), and approximately 50-70% lower operating cost (Van Pelt 1981).

Due to several advantages, freeze-concentration is widely investigated for concentrating various fruit juices (Daumas and Missirian 1986; Braddock and Marcy 1985). One of the obvious advantages of freeze-concentration over evaporative methods is that the energy needed to freeze a unit of water is much less. The low process temperature also prevents undesirable chemical and biochemical reactions, thus colour changes, non-enzymatic browning and vitamin losses would be minimum. Since the entire process is operated at or below the freezing temperature of water, and vacuum treatment is not required, the losses of low boiling flavour and aromatic esters are almost completely avoided (Deshpande et al. 1984). It has been shown that the flavour of freeze-concentrated fruit juices is better than those concentrated by evaporation (Askar et al. 1981; Braddock and Marcy 1985, 1987).

Although freeze-concentration has been shown to be a superior process, as compared to evaporation, it has been seldom used on commercial scale, because of certain drawbacks (Deshpande et al. 1984). One of the major problems is the loss of soluble solids of the juice in the separated ice (Muller 1967). This problem, however, has been significantly overcome by the development of wash column for the efficient separation of concentrate from the ice-crystals (Thijssen 1975). Another major problem remaining to be solved, is, that the final concentration of concentrated juice obtained by freeze-concentration is as low as 40-55% dry matter. This problem is due to the steep increase in viscosity of ice-concentrated mixture at the low operating temperature (Deshpande et al. 1984). Juice contents such as pectins, proteins and other colloidal substances also increase the viscosity and retard water crystallization. Because of this, the juice is required to be depectinized and filtered, prior to freeze-concentration. Development of multi-stage freeze-concentration systems can overcome this problem to a great extent (Deshpande et al. 1984).

Membrane concentration

Reverse osmosis (RO) and ultrafiltration (UF) are the most versatile separation processes in the food industry. RO is essentially a concentration process, in which water is separated from low molecular weight solutes. UF is a clarification or fractionation process, in which smaller solutes are transported across the membrane along with water and the membrane retains only large molecules (e.g., proteins and colloids), depending on the pore size of the membrane. Microfiltration (MF) is yet another membrane process, which is mainly used for clarification purposes due to large membrane pore size.

The mechanism of separation in RO is complex and cannot be explained by molecular size only. The preferential sorption-capillary flow (PSCF) mechanism is the most logical and probable explanation, in which the mechanism takes into account both capillary flow model and solution diffusion model mechanism (Pal and Cheryan 1987). The characteristics of various membrane processes are tabulated in Table 1.

TABLE 1. SALIENT FEATURES OF VARIOUS MEMBRANE PROCESSES (Cheryan 1991; Pal and Cheryan 1987; Ben et al. 1990)

Parameters	Ultrafiltration	Microfiltration	Reverse osmosis
Membrane pore size, mm	1-50	100-2000	0.5-2
Operating pressure, atmos	1-15	0.3-2.0	15-75
Permeate	Water and small molecules	Water and dissolved solutes	Water
Retentate	Most organic compounds over 1000 molecular weight including, pyrogen, viruses, bacteria and colloids.	Large suspended particles, some emulsions, most bacteria.	Ions and most organic compounds above 200 molecular weight
Application	Clarification and chill-proofing of clear fruit juices	Removal of yeast from wine, sterilization of liquids, removal of fat and casein from cheese whey.	Concentration of fruit juices, desalination of water

Membrane materials and types : The process of membrane technology became practical only with the development of suitable membranes. Most commercial RO membranes are usually made from cellulose acetate (CA) cast on asymmetric film (Sourirajan 1978). CA membranes give excellent performance with respect to high permeate flow and high rejection of small molecules or ions, though these membranes have limited temperature and pH tolerance. These are susceptible to microbial and enzymatic attack. However, these disadvantages have been overcome by developing new non-cellulosic membranes. These membranes are most resistant to heat and chemical attack (Marshall 1985) and hence are more widely applicable in industrial processing. A recent development in RO membranes is the thin-filmed composite (TFC) membranes, which are made of polyamide (PA) family (Pal and Cheryan 1987). This membrane consists of a very thin barrier layer (which affects separation) on top of a more porous membrane supporting layer (usually polysulphone or polyethylene). These membranes give better performance with regard to temperature and pH stability and cleanability, but have almost zero chlorine resistance (Cheryan 1991; Shew and Willey 1984). PA membranes are also known to have a longer useful life than CA membranes. The important membranes used in the separation processes and their operating capacity are listed in Table 2.

TABLE 2. COMMON MEMBRANES USED IN SEPARATION PROCESSES (Marshall 1985; Sourirajan 1978; Pal and Cheryan 1987; Cheryan 1991; Shew and Wiley 1984)

Membrane type	Application	pH range	Maximum temperature, °C tolerance
Acrylic copolymer	MF	NA	88
Cellulose acetate	MF,UF,RO	3.5 - 10.0	75
Ceramic	MF	1.0 - 13.0	140
Mixed cellulose esters	MF,UF,RO	4.0 - 8.5	120
Nylon	MF	NA	NA
Polyamide	MF,UF,RO	2.0 - 12.0	NA
Polycarbonate	MF,UF	NA	NA
Polyester	MF,UF	NA	150
Polyimide	UF	NA	NA
Polypropylene	MF	1.0 - 14.0	130
Polysulphone	MF,UF,RO	1.0 - 14.0	130
PTFE	MF	1.0 - 14.0	140

Note : Maximum temperature and pH may be limited by other materials of construction and varies with each device.

NA : Not available; MF : Microfiltration; UF : Ultrafiltration; RO : Reverse Osmosis.

MF membranes are available in natural and synthetic polymers (polypropylene, polycarbonates, polysulphone, polyvinyl chloride, cellulose esters) and inorganic materials (alumina, zirconia/carbon composites, carbon/carbon composites, stainless steel and silica). The ceramic membranes have increasingly found potential applications, particularly in biotechnology industry (Cheryan 1991).

Food industry is more concerned with the concentration without phase change or thermal damage as well as undue loss of solids, and with considerable amount of aroma retention at a cost competitiveness with evaporation. As RO meets these criteria, it has found increasing application for concentrating food liquids particularly milk and fruit juices (Matsuura et al. 1974).

UF in food industry is especially useful for various purposes such as clarification, fractionation, waste treatment and recovery of valuable products from plant effluents (Mackintosh 1983). The UF has found application in fruit juice clarification prior to the concentration (Berezovsky 1985; Bradford et al. 1986; Moslang 1984).

Application of RO in fruit juice concentration

Fruit juices are presently concentrated using multi-stage vacuum evaporators (Sulc 1984). This causes oxidation of compounds in the juice and loss of volatile components. Moreover, the process is high energy-intensive. The application of membrane processes like direct osmosis and reverse osmosis is the emerging methodology to concentrate fruit juices. Unlike concentration processes based on evaporation, freezing or sublimation, membrane concentration requires significantly less energy 20-30 Btu/lb of water removed (Robe 1983). Moreover, it provides gentle treatment for retaining flavour and aroma components (Koseoglu et al. 1990). The advantages of membrane concentration over the current multi-stage vaccum evaporator process for juice processing include lower energy consumption, increased aroma and flavour retention, reduction in capital equipment cost, lower thermal damage to product quality, reduced transport cost and simplicity of operation (Merson et al. 1980). Such membrane processing operations will become more and more attractive as membrane technology expands and the cost of energy increases (Deshpande et al. 1982). Table 3 gives some of the operating parameters for the pre-concentration of fruit juices by RO.

TABLE 3. CONCENTRATION OF FRUIT JUICES BY REVERSE OSMOSIS

Fruit Juice		Parameter					
		° Brix	Acidity, %	pH	Density, g cm^{-3}	Operating pressure, mPa	Reference
Orange	Feed	11.98	0.89	–	–	6.0	Braddock et al. (1988)
	Conc	25.26	1.86	–	–	–	
Lemon	Feed	7.70	4.60	–	–	6.0	Braddock et al. (1988)
	Conc	22.52	13.30	–	–	–	
Grape fruit	Feed	8.68	0.90	–	–	6.0	Braddock et al. (1988)
	Conc	25.06	2.66	–	–	–	
Peach	Feed	11.00	2.80	4.3	1.046	6.0	Demeczky et al. (1981)
	Conc	30.70	7.70	4.1	1.122	–	
Strawberry	Feed	7.00	9.10	3.5	1.059	6.0	Demeczky et al. (1981)
	Conc	28.70	33.90	3.3	1.133	–	
Apple	Feed	11.50	6.90	3.4	1.043	6.0	Demeczky et al. (1981)
	Conc	31.60	13.80	3.3	1.140	–	
Pine apple	Feed	11.45	–	3.7	1.046	7.0	Matsuura et al. (1975)
	Conc	21.65	–	–	1.089	–	
Grape	Feed	15.40	–	3.2	1.063	7.0	Matsuura et al. (1975)
	Conc	25.70	–	–	1.107	–	
Tomato	Feed	5.40	3.50	–	–	6.0	Demeczky et al. (1981)
	Conc	29.00	20.40	–	–	–	

RO technique can either be employed as a pre-treatment step to process a feed juice for evaporation, holding the resulting product in storage, or transporting it for further processing (Shew and Wiley 1983). RO-evaporation process has the advantage of reducing energy consumption and increasing production capacity. Use of reverse osmosis in pre-concentration of apple juice (Shew and Wiley 1984; Chua et al 1987; Chou et al. 1991), orange juice (Mohamed and Ahmed 1981; Cheryan 1991), pineapple juice (Bowden and Isaacs 1989), and grape fruit (Braddock et al. 1988), has been reported.

Recent developments and present status

The success of membrane technology in the fruit juice concentration depends on the development of suitable membranes and membrane modules that can retain flavour components. Among the membranes developed during the last decade, thin film composite (TFC) membranes of polyamide family have a higher flux rate, concentration range and retention of flavour components, than those with cellulose acetate (CA) membranes (Shew and Wiley 1983; Chua et al. 1987; Cheryan 1991). Fouling is a serious problem in membrane concentration of fruit juice, thereby requiring frequent cleaning. Different types of membrane cleaning methods have been developed (Ben et al. 1990). Cleaning time of pectin-fouled membrane could now be reduced to 2 min instead of 60 min by using 0.003% polyethylene oxide in 0.5% sodium hydroxide solution (Tzeng and Zall 1990). Low solids content achieved by conventional RO is the other drawback in membrane concentration of fruit juices (Shew and Wiley 1983). To overcome this limitation, a number of techniques/processes have been developed. The removal of suspended solids by UF prior to RO concentration allows for concentration of orange juice to levels above 42° Brix (Cross 1988). A new process called "Fresh note" process has also been developed by Septra system. This process can be used to concentrate fruit juices to 45-55° Brix on commercial scale and upto 70° Brix on pilot plant scale (Walker 1990).

Application of direct osmosis (DO) in fruit juice concentration is attracting interest in the recent years. Cloudy and pulpy fruit juices could be concentrated to 42° Brix, without the need for pre-filtering, need for using high temperature or high pressure and with a minimum membrane fouling (Beaudry and Lampi 1990). These developments have enabled the RO processes to emerge as a commercial reality for the concentration of fruit juices. Better product quality, less energy consumption, smaller installation, lower operating cost and environmental advantage are the key properties of membrane technology (Merson et al 1980). These support the penetration of this technology into the food processing area on a global scale.

ห้องสมุดกรมวิทยาศาสตร์บริการ

Evaporative concentration

The first fruit juice concentrate, produced through vacuum evaporation, dates from the beginning of the 1920's (Sulc 1984). Evaporation is probably the oldest method of concentration and even today, it is considered to be the best developed, economically the most favourable and widely used method for the concentration of liquid foods. The different aspects of evaporation methods used in the food industry are discussed by various workers (Armerding 1966; Mannheim and Passy 1974; Karel 1975). The essential features of some of the evaporators are given in Table 4.

TABLE 4. CHARACTERISTICS OF COMMERCIALLY AVAILABLE EVAPORATORS USED IN FRUIT JUICE INDUSTRY (Mannheim and Passy 1974; Khalil 1990; Ramteke 1987)

Evaporator type	No. of stages/ passes	Viscosity limits, C_p	Residence time
Vacuum pan	Single stage	-	one to several h
Tubular (climbing)	Recirculation	100	0.5 - 1 h
Tubular (climbing)	Single stage & one pass	100	About 1 min
Tubular (falling)	Single stage & one pass	200	About 1 min
Tubular (falling)	Five stages & single pass	200	About 4 min
Plate	Three stages & single pass	300-400	About 4 min
Agitated film	Single stage	20,000	20-30 sec
Centrifugal	One stage	40,000	1-10 sec

Selection of suitable evaporator : The choice of a proper evaporator for concentrating a given material is determined by many factors, which must be carefully weighed to ensure that the process requirements and capital costs are met. These factors include properties of feed material, quality requirements of the product, operating conditions and operating economy (Mehra 1986).

Fruit juices are produced as pulpy, cloudy and clear juices which have considerable differences in their physico-chemical characteristics, suspended solid content, pectin concentration, thermal properties and rheological properties are of primary importance in designing evaporator and optimizing the operating and processing components such as pumps, pipes, heaters, evaporators etc., (Khalil 1990).

Thermal properties of fruit juices include specific heat, enthalpy, thermal conductivity and boiling point which have been reviewed in the literature (Choi and Okas 1983; Ziegler and Rizvi 1985).

Heat sensitivity of the product is of particular importance in selecting the evaporator, as it affects the quality of the concentrate (Sulc 1984). Heat damage of the product is proportional to the residence time in the evaporator heating surface. Therefore, evaporator having short residence time is better suited for heat-sensitive juices. Examples of these evaporators are TASTE (Thermally accelerated short time evaporators) (Chen et al. 1979) and centrifugal evaporator (Mannheim and Passy 1974). Thijssen and Van Oyen (1977) have compared the severity of heat processing in different concentration processes and suggested that orange juice can be safely concentrated in falling film evaporator upto two effect. Ramteke and Eipeson (1991) showed that the aroma loss and intensity of browning were maximum in forced circulation evaporator, followed by plate evaporator and falling film evaporator in case of pineapple juice.

Rheological property of a food material is an important physical property, which is normally associated with the quality of the product. The relationship between the physico-chemical structure and the rheological behaviour of the fruit products have been reported (Costell and Duran 1983). Most of the clear fruit juices, which have been depectinised and filtered, behave as Newtonian fluids, while cloudy and pulpy juices exhibit non-Newtonian behaviour (Sarvacos 1970). The Newtonian behaviour of clarified apple, grape, pear and filtered lemon as well as orange juices have been reported (Rao et al. 1984; Rao 1986; Ibarz and Pagon 1987). Undepectinised concentrates of apple juice, passion fruit juice, orange juice and fruit purees have been reported to show non-Newtonian behaviour (Sarvacos 1970; Rao 1986).

Fouling, the deposition of burnt layer of organic matter on the hot surface of the evaporator, is a severe problem during concentration of fruit juices, particularly pulpy and cloudy juices (Mannheim and Passy 1974). Heat sensitive compounds in the feed material get destructed and cause fouling. Among the operating variables which affect the fouling rate, the temperature of heating surfaces is the major contributor (Carlson and Morgan 1962). Evaporation of cloudy apple juice at a temperature higher than 65.6°C causes considerable fouling. Flow direction of fluid was also found to affect the fouling (Sarvacos 1974). Rising film evaporator causes less fouling than falling film evaporator due to improper distribution

of the liquid in the latter, which results in local hot spot and scaling. Agitated thin film and rotary coil evaporators can also minimize fouling and scale formation.

Concentration of clarified and cloudy fruit juices

Depectinized, clarified and filtered juices contain only water soluble solids such as sugars, organic acids, vitamins, pigments, minerals and flavour volatiles. Concentration of such juices can be achieved without any major technological problems, since the increase in viscosity during evaporation is not great (Sulc 1984). The chemical composition of cloudy juices is almost similar to that of clear juices, but they also contain variable amounts of suspended particles comprising mainly of pectic substances, cellulose and hemicellulose. These exhibit much higher viscosities, in comparison to clear juices (Khalil 1990). Cloudy juices are, therefore, difficult to concentrate in falling film and plate evaporators, without the risk of thermal damage. For concentration of cloudy juices, centrifugal evaporators or agitated thin film evaporators are well suited. A two stage falling film or plate evaporator for pre-evaporation and a thin film evaporator for final concentration, could avoid these problems. Alternatively, expanding flow evaporator for pre-concentration and centrifugal evaporator for finishing could also be used (Sulc 1984).

Concentration of pulpy juices

Due to their high contents of suspended pulp particles, pulpy fruit juices form a very viscous and sticky fruit mass during concentration, thereby resulting in fouling and reduced evaporation rate. The concentrated product may, therefore, undergo thermal damage resulting in changes in quality characteristics, particularly colour and flavour. Pulpy fruit juices almost behave as non-Newtonian pseudoplastic fluids and the apparent viscosity of these fluids decreases with increasing shear rate (Sarvacos 1974). Therefore, evaporators having proper agitation are suited for concentration of pulpy juices (Carlson et al. 1967).

Serum concentration process

It is an alternate method for concentration of pulpy fruit juices. In this method, the fruit juice is centrifuged to separate the solid phase (pulp) and the liquid phase (serum) is then concentrated in an evaporator before mixing with the pulp (Sulc 1984). It has been reported that the quality of higher °Brix mango concentrate, obtained by serum concentration procedure, was much better than that obtained by conventional methods (Askar et al. 1981; El-Samahy et al. 1982).

Evaporation economy

Economic aspects are the important factors which need to be considered in selecting an evaporator for juice concentration. In addition to the capital cost, operating cost is the major factor in overall economy of evaporative concentration. Energy consumption in different types of evaporators for the concentration of fruit juices have been reported (Chen et al. 1979; Filho et al. 1984). Heating steam and cooling water requirements in fruit juice evaporation are the major factors determining operating cost (Sulc 1984). Consumption of steam and water can be reduced in fruit juice concentration by using multi-effect evaporator. Theoretically, heating steam requirement is reduced in direct proportion to the number of evaporation bodies. Several evaporators with 2-9 effects have been employed in food industry (Hallstorm 1983; Rao 1989). However, the optimum number of effects is limited by the higher construction and operating costs. While the costs of steam and water consumption decrease with increasing number of effects, capital costs increase continuously. As a consequence of that, four effects were found to be optimum (Sulc 1984).

Steam consumption can be further reduced by vapour compression (Pennik 1986). Vapour compression can be achieved either thermally through steam ejector or mechanically through electric motor, combustion engine or steam turbine. Table 5 gives the specific consumption of steam and cooling water in multi-stage evaporators with and without vapour compression (Sulc 1984).

TABLE 5. STEAM AND COOLING WATER CONSUMPTION IN EVAPORATORS (Sulc 1984; Khalil 1990)

No. of stages	Steam/cooling water (kg/kg water evaporated)			
	Steam		Water	
	−vc	+vc	−vc	+vc
1	1.10	0.55	18	10
2	0.65	0.40	10	7
3	0.45	0.32	7	5
4	0.35	0.27	5	4

+vc = With vapour compression
−vc = Without vapour compression

Aroma loss and restoration

During evaporative concentration of fruit juices, the volatile aroma of the fruit juices are partially or completely lost along with water vapour, thereby impairing the flavour quality of the concentrate (Bomben et al. 1973).

For flavour enhancement, the fruit juice concentrates are mixed with fresh juices to compensate the loss of flavour during concentration. This principle has been used in cut-back technique. In this method, which is widely used in citrus industry, the juice is concentrated to 62° Brix and then it is diluted to 42° Brix with fresh juice (Mannheim and Passy 1974). However, this method is not suitable, when highly concentrated juices are required. In order to overcome the drawback of aroma loss, particularly in evaporative concentration of fruit juices, a technique called aroma recovery is widely practised today. (Bomben et al. 1973).

Fruit aromas are found to be a complex mixture of organic compounds having diverse molecular structures, boiling points and solubilities (Bomben et al 1973). Esters, aldehydes, ketones, hydrocarbons and acids are the examples of fruit aroma. Over the last three decades, several methods and techniques have been developed for isolation and identification of fruit aroma compounds (Idstein and Schreier 1985; Engel and Tressel 1983). Several authors have reviewed the aroma composition of fruits (Ramteke et al. 1981; Morton and MacLeod 1990).

Dynamics of aroma separation

Because of the complexity of fruit aroma volatiles, they behave differently during evaporation (Bomben et al. 1973). For each type of fruit juice, a specific degree of fruit juice evaporation is required in order to recover almost all the aroma (Sulc 1984). The amount of water that must be evaporated, in order to recover the desired degree of aroma separation, is the first and basic information required for a successful aroma recovery plant. Such studies have been carried out for many temperate fruit juices (Sulc 1970, 1980) and tropical fruit juices like banana, pineapple, guava and mango (Ramteke 1987; Ramteke et al. 1990a; Khalil 1990). Fig.1 shows the dynamics of aroma separation from some tropical fruit juices. Table 6 gives the variation in the effective relative volatilities and % evaporation required to recover 90% of total aroma of fruit juices/pulps.

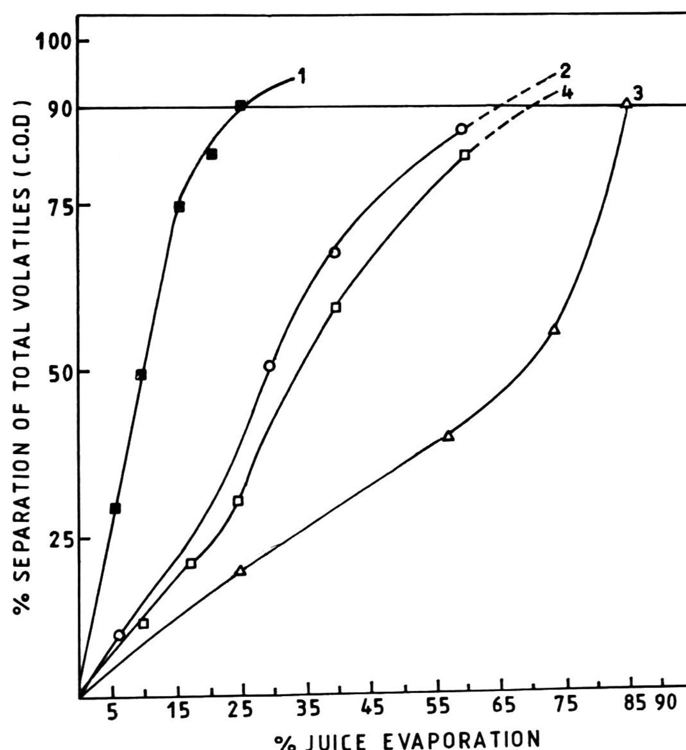

Fig. 1. Dynamics of total aroma separation from some tropical fruits 1. Banana juice 2. Mango *(Totapuri)* pulp 3. Pine apple juice 4. guava juice (Ramteke 1987; Khalil 1990).

TABLE 6. RELATIVE EFFECTIVE VOLATILITY (e) AND % EVAPORATION FOR SOME FRUIT JUICES

Fruit juices/ pulps	% Evaporation*	e	Reference
Apple	10	81.00	Bomben et al. (1973)
Plum	32	5.97	Sulc (1984)
Grape (*Concord*)	73	3.33	Bomben et al. (1973)
Strawberry	82	1.34	Sulc (1984)
Banana	20	10.32	Khalil (1990)
Mango (*Alphonso, Totapuri*)	67	4.43	Ramteke et al. (1987)
Guava	68	4.24	Ramteke et al. (1987)
Pine apple	85	1.59	Ramteke et al. (1987)

* For 90% aroma separation

Aroma recovery process

In the aroma recovery process, the volatile aroma compounds are transferred from fruit juice to another phase. This second phase can be a gas (evaporative, gas stripping), a liquid (solvent extraction) or a solid (adsorption) (Bomben et al. 1973). In the second step of the process, the separated aroma is concentrated to aroma-rich solution, which can be added back to the concentrated juice. Most of the aroma recovery systems work on evaporation-distillation principle (Bomben et al 1973). Fig.2 shows the general flow diagram of aroma recovery process.

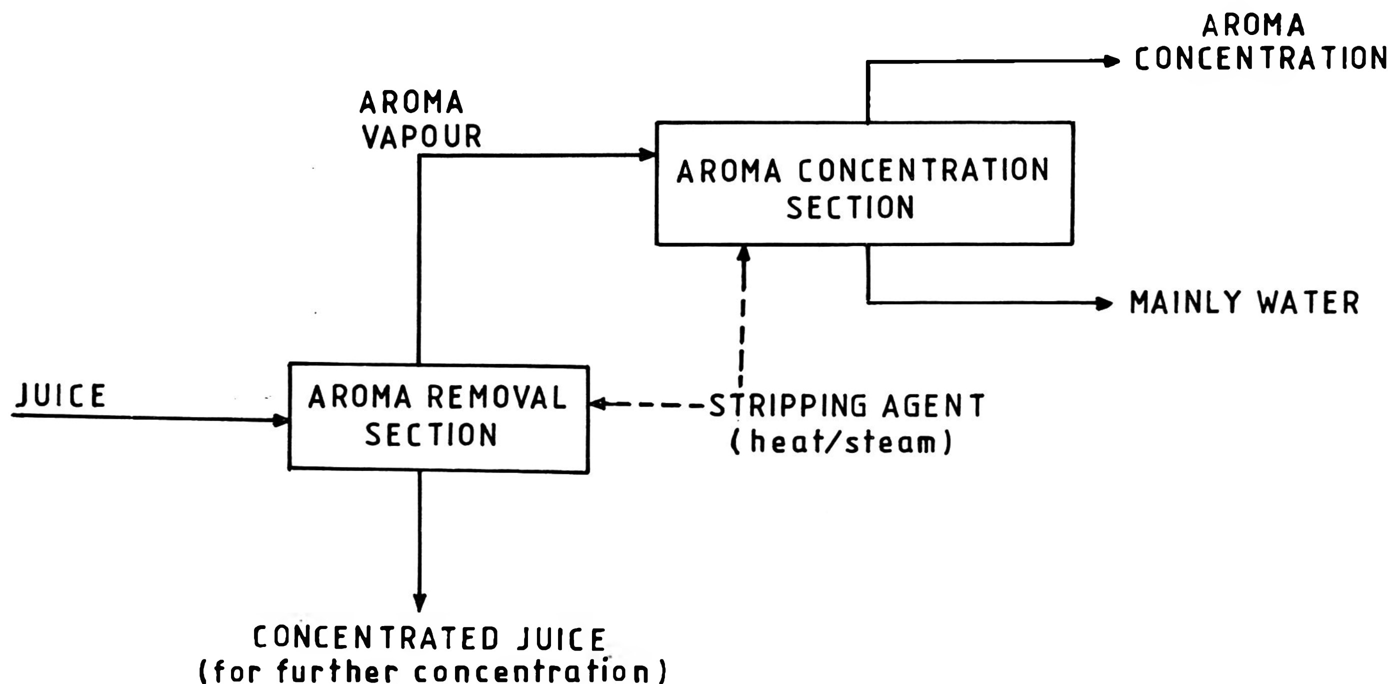

Fig. 2. Flow diagram of aroma recovery by evaporation-distillation process.

At present, three systems of aroma recovery process are available, which differ in operating pressure viz., systems operating at atmospheric pressure or under vacuum and combination of both. Aroma recovery systems operating under atmospheric pressure are largely restricted to apple juice and fruit juices, which require low degree of juice evaporation (15-20%) for aroma stripping (Sulc 1984). Aroma recovery under vacuum is particularly suitable for fruit juices containing poorly volatile aroma compounds, since they need more percentage of water evapcration for complete aroma separation, which under atmospheric conditions leads to thermal damage. Moreover, the azeotropic behaviours of some aroma compounds are changed under low pressures so that they could be recovered at the top of the rectification column (Sulc 1984). Several aroma recovery systems operating under reduced pressure have been developed. The Western Utilization Research Vacuum Aroma Column (WURVAC) process (Wolford et al. 1968), Yugoslavian design by Jedinstovo (Sulc 1984) and vacuum stripping systems are some of the examples.

However, at low pressures, highly volatile aroma compounds are lost through vacuum pump. To overcome this problem, expensive gas washing and condensation systems have to be included in the system. Further, such systems required large rectification columns having 18 to 20 theoretical plates of sieve or bubble plates (Sulc 1984).

In order to compromise between aroma yield and quality on one hand, and economy on the other, many present day aroma recovery systems are designed having a combination of vacuum evaporation and atmospheric or near atmospheric rectification. Combined aroma recovery plants are mainly used for the treatment of berry, citrus and pineapple fruits, where a relatively high degree of juice evaporation is required for the recovery of poorly volatile aroma components (Sulc 1984).

Properties of aroma concentrates

Commercially, aroma concentrates of 200-fold strength are prepared for blending with the fruit juice concentrates. The quality of aroma concentrates is affected by the process parameters such as pressure, reflux ratio and condenser temperature (Ramteke et al 1990b, 1993; Peleg and Mannheim 1973). Aroma concentrates have been found to be unstable under ambient conditions and hence have to be cold-stored. The storage stability of aroma concentrates from apple, orange, banana, guava, mango and cashew apple have been reported (Ramteke 1987; Khalil 1990). In certain cases, aroma concentrate mixed with fruit juice concentrate showed better stability than when the aroma concentrate was stored separately (Ramteke et al 1991).

Comparative evaluation of concentration processes

Economic aspects of concentration process play an important role in the selection of proper method of concentration i.e., freeze concentration, reverse osmosis or evaporation (Renshaw et al 1982; Sapakie and Renshaw 1984).

Concentration costs include labour, capital, maintenance, utilities, non-selective product loss and other cost aspects. Labour costs vary depending on the degree of automation and capacity of processing unit (Thijssen and Van Oyen 1977). Capital costs are directly related to the installed cost of concentration process and are inversely proportional to the number of production hours per year and to the capacity of concentration process.

Different workers (Thijssen and Van Oyen 1977; Renshaw et al. 1982; Robe 1983; Marshall 1985) have compared the cost of water removal in various concentration processes. According to Thijssen and Van Oyen (1977), even though the cost of water removal can be reduced to 0.16 (steam equivalent), it is much higher than those for freeze concentration and reverse osmosis (Table 7). However, with aroma recovery and multi-effect evaporation, the cost becomes comparable to either freeze-concentration or reverse osmosis.

TABLE 7. ENERGY CONSUMPTION OF VARIOUS CONCENTRATION PROCESSES (Thijssen and Van Oyen 1977; Renshaw et al. 1982; Marshall 1985)

Process	Steam equivalents	
	without aroma recovery	With aroma recovery
Evaporator		
One effect evaporator	1.20 - 1.28	1.25 - 1.32
Two effects falling film evaporator with thermal compression	0.36	0.53
Three effects falling film evaporator with thermal compression	0.29	0.50
Four effects falling film evaporator with thermal compression	0.18	0.45
Freeze-concentration	-	0.25 - 0.50
Reverse osmosis	0.01 - 0.02	0.48
Ultrafiltration	0.01 - 0.02	-

Applicability to concentration of vegetable juices

In the recent years, vegetable juices such as carrot and beet-root, have attained commercial importance. These juices can be successfully concentrated in any type of evaporators, since they do not contain high levels of pectin or suspended particles. These juices have also been investigated for concentration by reverse osmosis method (Demeozky et al. 1981).

Overviews

Concentration by vacuum evaporation still remains the best option for concentrating most of the fruit juices. Freeze-concentration has the advantage of being the method causing least thermal damage to the product as well as retention of aroma constituents. With the development of improved wash columns as well as multi-effect freeze-concentration system, freeze-concentration is emerging as a low energy intensive process for heat sensitive juices. Reverse osmosis is the least energy consuming process available. With the development of versatile membrane systems, this method is emerging fast as a commercial method for pre-concentration of fruit juices and in some cases for preparing concentrates of high degree Brix.

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Microbiological Studies on the Production of Dehydrated Convenience Foods : A Case Study on Multiprocess, Multicomponent Assembled Product : *Avial* Mix

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Dehydrated *Avial* Mix, assembled with 14 individually and differently processed ingredients, had upto 10^6, 10^5 and 10^4/g SPC coliforms, yeasts and moulds, respectively. No *E. coli*, *Salmonella* or *Staphylococcus aureus* were present, but *Citrobacter*, *Proteus* and *Klebsiella* were encountered in all samples tested. The nature and source of contamination were traced to 7 ingredients. To facilitate ready identification of such important ingredients, a quality grid was constructed. The causes of high levels of survivors in dried ingredients were found to be the absence of pasteurization of *dahi* and coconut homogenate, the long soaking of blanched beans and cauliflower in sugar solution, improper handling of blanched green chillies and insufficient treatment of spices. After effecting the remedial measures, the overall microbial load on the assembled *avial* mix was reduced by 2-3, 2-5, 3-5 and 2-4 log numbers for SPC, coliforms, faecal coliforms and yeasts plus moulds, respectively.

Keywords : *Avial* mix, Dehydrated vegetable curry, Microbiological quality, Production microbiology, HACCP, Multiprocess product

The presence of viable microorganisms in dried foods is the net result of microbial contamination of the raw materials, the effect of processing parameters on these microorganisms, the type of handling, and hygiene exercised in manufacture (Bryan 1974). Foods containing vegetables, cereals and spices are naturally contaminated with a variety of microorganisms, while other components such as milk and milk products contain both spoilage and pathogenic microorganisms (Hobbs and Gilbert 1978). When these materials are dried in the processing of convenience foods, the time and temperature of drying are kept as short, and as low as feasible in order to minimize alterations in the organoleptic properties. Such treatments are, therefore, not lethal to all microbial forms (Gibbs 1986), and bacterial spores as well as vegetative cells survive. Further contamination is introduced into these dried foods during manufacture, storage and distribution. Dried vegetables and spices have been reported to contain variable numbers of vegetative and spore forming organisms, including pathogens and toxigenic moulds (Vaughan 1951; Flannigan and Hui 1976; Krishnaswamy et al. 1971; Pafumi 1986; Geetha and Kulkarni 1987; Antar 1988; Stehli et al. 1988). Perishability of dehydrated foods, in spite of the presence of a large number of spoilage organisms, is prevented naturally, because of their low moisture content (Frazier and Westhoff 1978).

During the development of a quick cooking dehydrated vegetable curry type dish known as '*avial* mix' in South India, high temperature short time pneumatic drying, spray-drying, and hot air cabinet drying were used. Microbiological analyses of some early batches revealed the presence of rather high concentrations of aerobic bacteria, coliforms, faecal coliforms and yeasts plus moulds. Studies were carried out to identify the source and reasons of such contamination in the final product. In this paper, the results of the microbiological investigations on *avial* mix, before and after taking remedial measures, are reported.

Materials and Methods

Ingredients - processing and preparation : Avial mix was made from 14 dehydrated ingredients (vegetables, coconut, *dahi* (curds) and spices and condiments), which were variously processed (Jayarman et al. 1982, 1991). The general sequence of operations involved in the preparation of *avial* mix is represented diagrammatically in Fig.1. The *avial* mix contains vegetable portion and gravy mix, packed separately in the proportion 45:55. For reconstitution, the vegetables were first simmered in boiling water for 10 min in 1:3-4 proportion, then the gravy powder was added and further simmered for 5 min.

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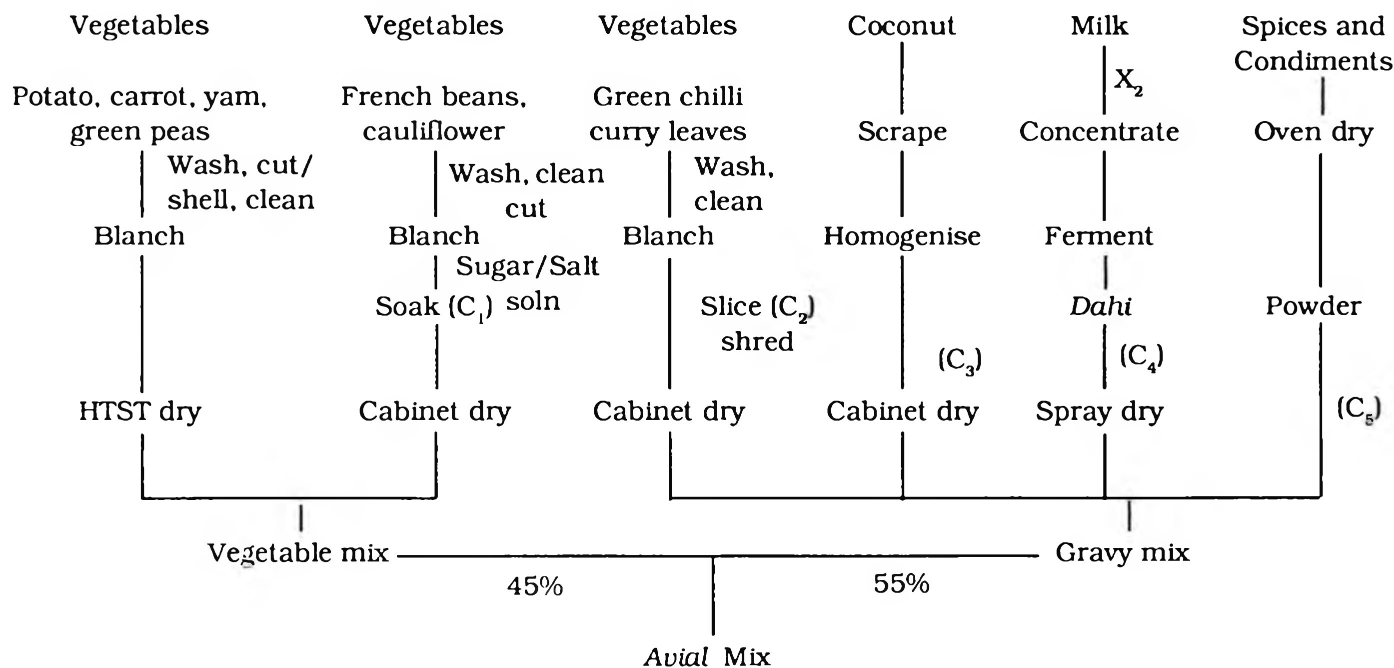

Fig. 1. Flow diagram of the manufacture of *Avial* mix : A multicomponent, multiprocess preparation and assembly operation.

Sample treatment for microbiological analysis : Ten g of each food sample were aseptically macerated for 5 min with a glass mortar and pestle using 90 ml of 0.1% peptone water. The suspension was kept at room temperature for 1 h and decimal dilutions were made using the same diluent. All analyses were performed using media and methods described by Harrigan and McCance (1976). Bacteriological media components were the products of HiMedia, India.

Enumeration of mesophilic aerobic and anaerobic bacteria : Colony forming units (CFU) were estimated by plating serial dilutions on plate count agar, and incubating at 30°C for 48 h. Coliforms were estimated by plating on violet red-bile-agar plates, and incubating at 37°C for 18 h. Faecal coliforms were estimated by using a three tube replication of EC broth in a most probable number (MPN) series (Speck 1976). Aliquots (1 ml) from each dilution were inoculated into tubes of EC broth, and incubated at 44.5 ± 0.2°C for 24 h. Presumptive positive tubes were tested by streaking on eosine-methylene blue-agar (EMB), and incubating at 37°C for 24 h. A minimum of five colonies appearing on EMB agar were examined by the IMViC tests (Harrigan and McCance 1976), followed by the API-20E gallery test (API System, France), to determine the constituent genera. The MPN of faecal coliforms was computed from the tables (Harrigan and McCance 1976).

Aliquots from serial dilutions were plated on acidifed potato-dextrose-agar, which was incubated at 25°C for 3-5 days. All colonies appearing on countable plates were counted for yeasts and moulds. Sample dilutions were surface-plated on Baird Parker agar for enumeration of *S.aureus* incubated at 37°C for 48 h. Typical colonies were counted, and tested for coagulase reaction (Harrigan and McCance 1976). Sample dilutions were plated on egg-yolk free tryptose-sulphite-cycloserine agar (Speck 1976), and incubated anaerobically at 37°C for 18-24 h under H_2 gas for enumeration of *Clostridium perfringens.*

Samples (25 g) were transferred to 225 ml lactose broth, and incubated at 37°C for 24 h for isolation and identification of *Salmonella.* One ml of the pre-enrichment cultures was transferred into each tube containing 10 ml tetra-thionate, and selenite broths and incubated at 37°C for 24 h. Growth, from both the broths, was streaked into brilliant green-agar as well as bismuth sulphite - agar for incubation at 37°C for 18-24 h. Five colonies from these plates were further tested on triple sugar-iron medium and Kohn's 2-tube medium. Colonies testing positive at this stage were designated as presumptive positive *Salmonella.* Since none of the colonies tested gave typical *Salmonella* reactions, no further serological tests were carried out.

Results and Discussion

The results pertaining to indicator organisms and pathogens in five pilot scale (25 kg) production batches indicated the range of 1.3×10^5 to 7.9×10^6, 4.4×10^3 to 6×10^5, 3.8×10^3 to 1.2×10^5 and 1.1×10^3 to 2.8×10^4 for SPC, coliforms, faecal coliforms and yeasts and moulds, respectively. *Clostridia* were present in low numbers (upto 15/g), while *S. aureus* and *Salmonella* were not detected. Analysis of the faecal coliforms revealed that *E.coli* was present in only one sample, the rest were *Klebsiella* spp. and *Enterobacter* spp. In a dehydrated product, the presence of high numbers of aerobic mesophilic bacteria and faecal coliforms reflects process failure, poor hygiene or both. To investigate this, the vegetable part and the gravy mix were separately analysed in the dry, and reconstituted form. It was found that coliforms and faecal coliforms and yeasts and moulds were higher in the gravy mix by 1-2 log cycles than in the vegetable mix (Table 1). Heat applied during reconstitution apparently was able to reduce the microflora in the latter to negligible levels, but not that of gravy mix. The reduction in viable counts in the gravy occurred upto 2 log cycles, thereby leaving considerable residual flora. The high counts in the dried gravy mix could also have been derived from spices and the general microbial quality of these products has been found to be poor. Earlier studies by other workers indicate that the spices have a good load of microorganisms. (Geetha and Kulkarni 1987; Thangamani et al 1975; Subbulakshmi et al. 1991)

TABLE 1. RESIDUAL MICROFLORA AFTER RECONSTITUTION COOKING OF THE TWO MAJOR COMPONENTS OF *AVIAL* MIX

Product	Sample	Viable counts, g^{-1}			
		SPC	Coliforms	Faecal coliforms	Yeasts and moulds
Vegetable mix	Dry	1.6×10^5	2.4×10^3	6.1×10^3	2.0×10^3
	Reconstituted	20	0	0	0
Gravy mix	Dry	2.0×10^5	5.1×10^5	4.6×10^5	3.1×10^4
	Reconstituted	8.9×10^3	2.5×10^3	6.3×10^3	2.4×10^2

To further localize the source of contamination in the two major components, each ingredient was analyzed before assembling. The data are summarized in Table 2. Beans, cauliflower, green chilli, *dahi* and spices contained 10^5/g and more of SPC. Beans and green chilli carried the highest number of coliforms, followed by coconut, cauliflower and peas. Faecal coliforms were found in four vegetables and coconut, while moulds were encountered in cumin, green chilli, coconut and salt. HTST pneumatic dried vegetables had lower SPC and no coliforms (except for peas), when compared to other components. The limit for SPC for certain dehydrated vegetables is 1×10^5/g (Australian Defence Force Food Specification 1979), but these do not include the vegetables used in *avial* mix. High incidence of moulds in retail samples of different dried vegetable products were reported by Udagawa et al. (1984).

TABLE 2. MICROBIAL QUALITY OF INDIVIDUAL DRIED VEGETABLES AND SOME OF THE COMPONENTS OF GRAVY MIX USED IN THE ASSEMBLY OF *AVIAL* MIX

Component	Dehydration/ process	Microorganisms, g^{-1}			
		SPC	Coliforms	Faecal coliforms	Yeasts and moulds
Dried vegetables					
Potato	HTST	4.5×10^2	0	0	20
Yam	"	2.6×10^2	0	0	5
Peas	"	2.3×10^3	1.3×10^2	0	50
Carrot	"	3.0×10^3	0	0	55
French beans	Cabinet	2.8×10^6	2.1×10^4	4.0×10^3	25
Cauliflower	"	5.7×10^5	8.2×10^2	4.0×10^1	10
Green chilli	"	4.8×10^6	1.6×10^4	6.2×10^3	4.1×10^3
Curry leaves	"	2.2×10^4	2.6×10^1	1.1×10^1	5
Gravy mix components					
Dahi	Spray drying	8.2×10^7	0	0	80
Coconut	Cabinet	5.6×10^4	7.2×10^3	6.4×10^3	6.6×10^3
Turmeric	Powder	8.4×10^5	0	0	80
Cumin	Powder	6.3×10^5	0	0	1.1×10^4
Salt	Commercial	2.5×10^5	0	0	2.0×10^4
Corn flour	"	2.1×10^2	0	0	50

Both coliforms and faecal coliforms as well as moulds survived both blanching and dehydration. However, neither *E. coli* nor *Salmonella* were detected in the samples, though *Citrobacter*, *Proteus* and *Klebsiella* were found in all faecal coliform positive samples. These organisms are known to be opportunistic pathogens (Doyle 1986), and were observed to survive after rehydration of the gravy mix.

To identify ingredients involved in elevating the microbial load of the final mix, a ready reference grid for quality check was constructed (Table 3).

TABLE 3. A REFERENCE GRID TO IDENTIFY THE ROLE OF EACH COMPONENT IN THE FINAL MIX

Grade	Category A	Category B	Category C
1	Cumin	Carrot, yam, corn flour	Potato
2	Turmeric, green chillies	Cauliflower, salt	Peas, coconut powder
3	Curry leaves	Beans	Curry powder

Category : Quantity, g% of each component in final mix A : ≤ 1 (low); B : 2-9 (medium) C : > 10 (Large)

Grade : Microbial contamination contributed by each component towards microbial load per g of final mix
1 : SPC 10^2 and coliforms 0-10 (low);
2 : SPC 10^3 - 10^4 and coliforms < 10^3 (medium);
3 : SPC > 10^4 and coliforms > 10^3 (high)

Those graded 1, irrespective of the quantities in which they were added to the mix, were potato, carrot, yam and cumin, because of low contribution to microbial load. Those graded 3 contributed the maximum number of organisms to the final mix.

Data presented in Table 4 show that washing of French beans did not eliminate the inherent surface microflora, but blanching did perform this task. However, after a long soaking treatment (16 h at 4°C), an increase in 5-6 log cycles occurred in the residual flora. As a result, the spent solution also contained very large numbers of both SPC and coliforms. It may be possible that sucrose in this solution served not only as a rich resuscitation medium for those organisms sublethally injured after blanching, but also promoted growth and multiplication as reported by van Schothorst et al. (1979).

TABLE 4. MICROBIAL CONCENTRATION IN 'ON LINE SAMPLES' TAKEN DURING PROCESSING OF FRENCH BEANS AND CAULIFLOWER

Type of sample	Microorganisms, g^{-1} SPC	Coliforms	Faecal coliforms	Yeasts and moulds
Fresh, cut beans	8.2×10^4	5.4×10^3	2.0×10^1	75
Blanched	55	0	0	0
Fresh soak solution	65	0	0	15
Beans, soaked 16 h/4°C	5.9×10^6	2.6×10^5	2.1×10^4	15
Beans, dried	6.6×10^6	6.2×10^4	4.0×10^2	70
Spent soak solution	4.1×10^7	1.6×10^6	3.1×10^5	15
Cauliflower blanched	95	0	0	0
soaked (16 h/4°C)	4.4×10^6	3.7×10^4	3.0×10^4	10
dried	7.8×10^4	9.1×10^3	5.2×10^1	5

Data in Table 5 show that dehydration affected the SPC in a much less dramatic way than it did the coliforms, and faecal coliforms present in *dahi*. Coliforms became more susceptible to drying at the acidic pH (4.2) of *dahi*. After the homogenization of fresh coconut, one log increase in SPC and coliforms was seen. After dehydration, only upto 2 and 3 log reduction occurred in these bacteria, thus leaving substantial numbers of mixed flora as well as coliforms. The blanched green chillies have low SPC and coliforms as acquired microorganisms in large numbers (10^7/g) afresh after being sliced. Coconut and green chillies are two examples, where handling could introduce additional contamination, and where hygiene and sanitary control would be necessary as critical controls. Curry leaves appeared to retain all their post-blanching flora after dehydration, with reductions seen in both coliforms and faecal coliforms.

TABLE 5. MICROBIOLOGICAL EXAMINATION OF *DAHI*, COCONUT, CHILLI AND SPICES AT THE PREPARATORY STAGES

Product	Preparation	Microorganisms, g^{-1} SPC	Coliforms	Faecal coliforms	Yeasts and moulds
Dahi	Fresh	8.2×10^7	7.2×10^6	9.6×10^6	5.2×10^3
	Dried	7.4×10^6	0	0	70
Coconut	Fresh	4.2×10^5	1.2×10^5	4.1×10^3	1.1×10^2
	Homo-genised	5.1×10^6	1.2×10^6	5.0×10^3	2.0×10^2
	Dried	6.2×10^4	4.5×10^3	2.1×10^3	80
Green chilli	Blanched	4.1×10^2	4.3×10^2	1.1×10^2	15
	Sliced	4.8×10^7	1.6×10^4	1.3×10^3	4.1×10^3
	Dried	6.1×10^6	3.0×10^4	5.0×10^3	2.1×10^3
Curry leaves	Steam blanched	3.2×10^5	4.3×10^3	2.1×10^2	10
	Dried	8.2×10^5	1.0×10^1	1.0×10^1	5

Remedial measures at important points (Fig. 1: C_1 to C_5) were incorporated during processing in an effort to bring an overall improvement in the microbial quality of *avial* mix. *Dahi* and coconut homogenate were pasteurized before dehydration. Blanched beans and cauliflower received a shorter soak period in a higher strength solution. Green chillies were sliced before blanching and spice powder was dry-roasted. That these measures were essential and useful was proven by the microbiological examination of subsequent batches showing a reduction of 2 to 3, 2 to 5, 3 to 5 and 2 to 4 log numbers in the levels of SPC, coliforms, faecal coliforms and yeasts plus moulds in the final assembled mix. The maximum counts in respect of these groups of organisms now were 7.1 x 10^3, 20, 1 and 20 per g, respectively.

This investigation has demonstrated that the HACCP concept as outlined by Bauman (1974)

could be applied informally to evolve a preventive system of control with regard to microbiological hazards, and minimize quality defects in the production of food. The method of assigning ingredients specific positions in the quality grid helps to identify problem causing materials for which specific controls may be successfully adopted in a practical and economic way.

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Development of a Process for Coconut Cream on Commercial Scale

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A demonstration plant for production of coconut cream, envisaging utilisation of coconut residue and shell, has been developed to process 1000 nuts per 8 h. Its operation and machinery are described. The canned coconut cream is superior in terms of quality parameters of comparable products marketed abroad.

Keywords : Demonstration plant, Coconut cream, Pasteurization, Milk extraction, Heat penetration, Product composition.

With a total production of 9200 million nuts during 1989-90, India is the third largest producer of coconut in the world (George et al. 1991). Coconut culture and processing play a dominant role in the agricultural economy of the Southern States. More than 50% of the nuts are consumed as raw in the household sector and some in the form of ready - to-eat sweet meats using sugar or jaggery (Satyanarayana Rao et al. 1990 a,b). Newer products such as processed coconut milk, coconut water and many other food products including infant foods have been developed and marketed abroad (Timmins and Kramer 1977; Lupke 1979; Husin and Hassan 1978; Goncalves and Teixeira Neto 1982; Hagenmaier 1977; Prasanna et al. 1969). However, no serious R & D efforts are made in India and, therefore, coconut economy depends mainly on a single commercial product, i. e. coconut oil. Processed coconut cream is one of the products that has good market potential. An improved process for shelf stable coconut cream has been developed and a demonstration plant was established at Kochi. This paper relates to the details of the equipments, optimised unit operations etc., of the demonstration plant of a capacity to process 1000 coconuts/8 h.

Materials and Methods

Well ripened fresh nuts, husked and aged for a week, were split manually. Specially made scooping knives were employed for manual deshelling. The kernel was washed with water containing 100 ppm H_2O_2 in S.S. tank of 500 l capacity. For blanching, these were immersed in hot water at 80°C for 10 min in a S.S. tank of 500 l capacity, fitted with open steam coils for steam sparging to heat water to boiling temperature. Prior to milk extraction, the wet kernel was subjected to size reduction using hammer mill (Batliboi Engineers, Bangalore). The optimum particle size obtained by using 6 mm sieve in a hammer mill was arrived at, as a result of laboratory, and pilot plant trials. It has a through-put of 500 kg kernel/h and was provided with a chamber to collect wet gratings.

The wet grating was fed into a S.S. screw press specially designed and fabricated for maximum milk extraction on commercial scale, based on the data with respect to size of the gratings, performance of other extraction equipments, pressure, and other physical requirements. It has a progressively tapering worm screw, housed in a perforated cage, lined with 2 mm S.S. sieve. The drive consisted of 7.5 HP motor and a reduction gear. The compression ratio was 12 and the back pressure was adjusted by controlling the exit slit. The milk is expelled through the perforation on the cage and collected in the reception chamber at the bottom. The residue from the screw press was mixed with hot water for the final milk extraction, using a hand driven geared residue mixer. It is a S.S. vessel of 300 l capacity, provided with baffles and scraper. The cycle of extraction optimised here, was first two passes without water and the third with water equal to half the weight of the residue. Under these conditions, about 70% of the soluble solids of the coconut gratings can be extracted.

Filtration : The milk obtained was filtered using a vibratory sieve (J. T. Jagtiani, Bombay). The sieve (60 mesh, 24" dia) is subjected to gyratory motion by an electric motor of 2 HP.

Additive mixing : Additives which consisted of Tween-80, casein, guar gum, CMC sodium salt of high viscosity and sugar were dispersed in hot water in a 100 l capacity steam jacketted S.S. kettle, the pooled milk was added, heated to 80°C

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and emulsified in a portable industrial mixer (Remi Engineering, Bangalore). The cream was pasteurized, using a plate heat exchanger system, specially designed for the pasteurization of coconut cream (92°C for 20 min). This system has a plate and frame heat exchanger made of S.S. holding tank of 200 l and hot water tank. The cream is charged into the holding tank, and circulated through the product channel of the heat exchanger and hot water at 95°C is circulated through the heating medium channel with the aid of 2 HP pumps. The cream was hot-filled in plain tin cans using a volumetric filling machine (J. T. Jagtiani, Bombay). The cans with loosely placed lids were passed through a continuous exhaust box (Gardner's Corp., New Delhi). The exhausted cans were sealed using a standard industrial sealer of the capacity 300-400 cans/h. A rotary retort (Fabricated by Plants (India) Ltd., Cochin - as per our design) consisting of a horizontal cylindrical vessel with rotating inner drum and a stationary outer shell was used for can retorting. The inner drum is provided with 660 slots to hold the standard 301 x 204 size cans. The central shaft to the inner drum is connected to a geared motor to rotate at 1 rpm. Steam is passed into the retort to maintain a pressure of 15-30 psi. While the inner drum is in rotation, holding the cream filled cans, a continuous mixing of the cream is achieved, facilitating faster heat penetration, and uniform heating. The rotary retort was designed, and fabricated specially for coconut cream sterilization.

Residue drying : The residue was dried to a moisture content of 3% by using a through flow electrical dryer (Premier Engineering Co., Cochin). Fifty kg of the residue could be dried in 1 h. A boiler (Laxmi Boilers, Bombay), with an evaporation capacity of 300 kg/h and fuelled by coconut shell supplemented with firewood, was used. Total connected load for the plant is 65 KW, while the estimated water requirement for 8 h shift is about 10,000 l. The demonstration plant has a total area of 2,500 sq. ft., divided into boiler house, work area and processing area. It processes 1000 coconuts in 8-10 h to yield about 250 kg coconut cream, and 50 kg coconut powder.

Analytical methods : Microbiological analysis of samples was carried out as per standard procedure (Ranganna 1986). Total solids, fat, protein, sugars, minerals and gums were estimated as per BIS (1961) methods.

Results and Discussion

Yield of kernel : About 50 trials (200-400 coconut batch size) were conducted. Normally, the weights of coconuts of the commercial varieties in India, range from 400-600 g with a mean value of 500 g. The average yields recorded were 50 kg fresh meat, 20 kg water and 30 kg shell from 100 kg dehusked coconut, consistently with narrow limits of variation. The overall average ±SD value for dehusked coconut, shell, water and kernel for the selected trials (6 trials comprising 1890 nuts) were 173 ± 20, 52 ± 6.2, 35 ± 4.2 and 87 ± 9.6, respectively. The average weight (800 g) reported for major coconut growing countries like Philippines, Indonesia and Sri Lanka is much higher than that of Indian varieties, probably due to varietal variations (Woodroof 1979).

Milk extraction : The sequential operations for the coconut cream process is presented in the flow chart (Fig. 1). Attempts to mechanise breaking and deshelling did not yield desirable results. The process of removal of brown testa (called paring) is a labour intensive operation, which also reduces the weight of the kernel by 10-15% (Child 1974). Earlier processes for coconut cream include paring as an important step to obtain white milk (Woodroof 1979). The colour of the milk was not affected with or without paring (Arumughan et al. 1984). Therefore, the step of paring has been avoided to not only save labour but also increase the milk yield. The washing of kernel in water with 100 ppm H_2O_2, followed by blanching for 10 min at 80°C, was intended to reduce the initial load of microflora. The blanching step is reported to reduce enzymes like lipases (Krishnamurthy and Chandrasekhara 1979) that may cause undesirable flavour. Size reduction of the kernel into small particles is an essential step for subsequent milk extraction.

Stabilization of emulsion : Extensive studies incorporating permitted emulsifiers and stabilizers, followed by emulsification, were conducted to arrive at optimum levels (Arumughan et al. 1987). The pH of the additive mixture which consisted of Tween-80, casein, guar gum, CMC and sugar was adjusted for complete dissolution of various ingredients and then only this was added to the pooled milk prior to emulsification.

Preservation : A pre-heat treatment using plate heat exchanger for 20 min at 92°C was found to reduce the population of spoilage organisms to a

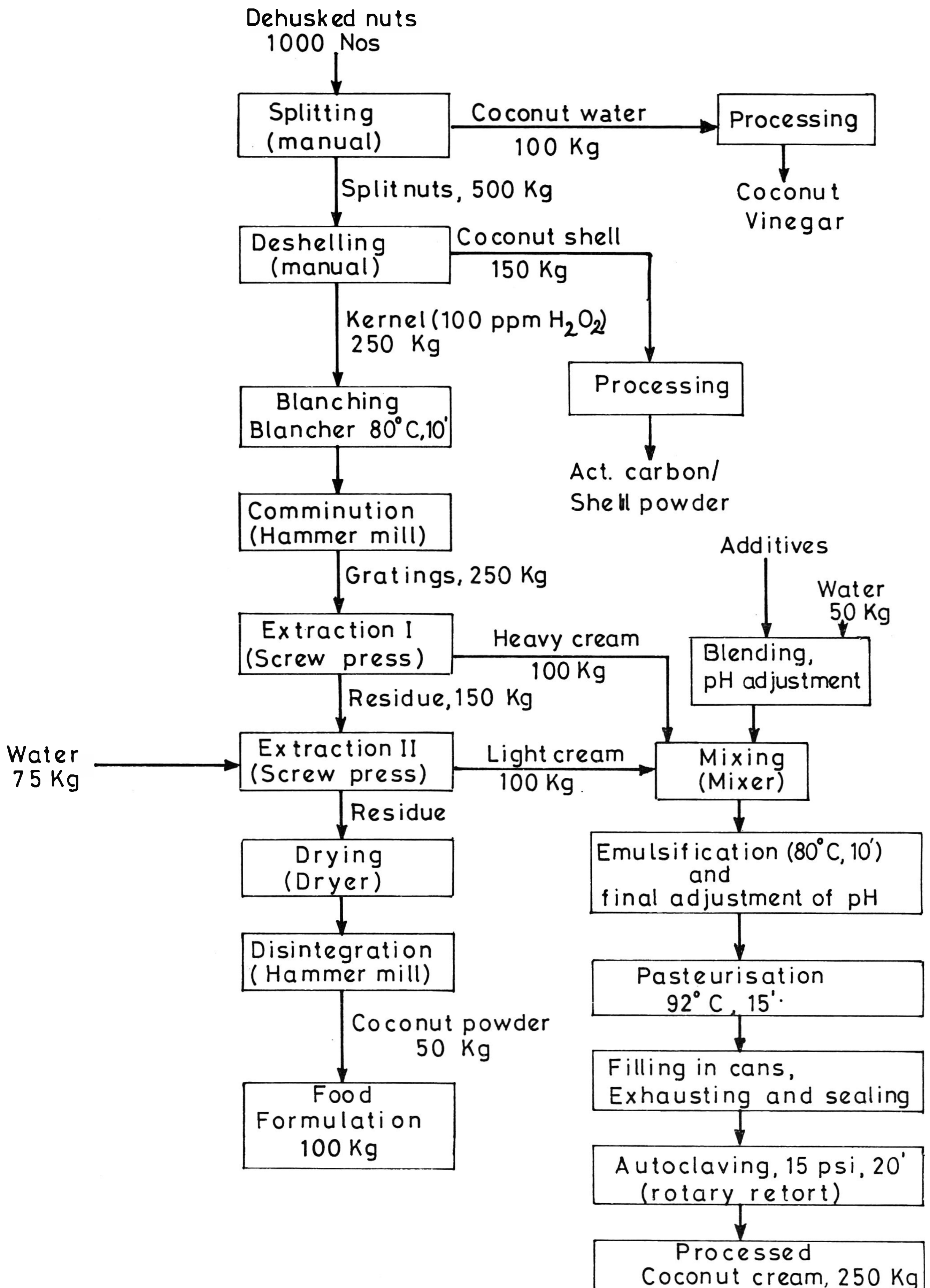

Fig. 1. Flow sheet showing the various steps involved in the production of processed coconut cream.

TABLE 1. MICROBIOLOGICAL ANALYSIS OF SAMPLES DURING VARIOUS STAGES OF PROCESSING*

Sample collected	Total count/ml
Coconut-kernel wash water	10^2 - 10^3
Water after blanching	10^3 - 10^4
Crushed gratings	10^4
Milk extract (First)	10^4 - 10^5
Additives	0 - 10
Milk + additives	10^5
Milk after stirring and homogenization	10^5 - 10^6
During pasteurization	10^2 - 10^3
Pasteurized sample in bottle (which showed spoilage in 7-10 days) collected on the day of preparation	10^3

* *Bacillus* were present in all the samples. *Micrococcus* and *Proteus* were encountered in coconut-kernel wash water (before and after blanching) and crushed gratings, respectively.

great extent (Table 1). As pasteurization alone was found to be inadequate, the coconut cream was subjected to further treatments such as exhausting and retorting. Based on heat penetration studies, a time-temperature profile of 35 min at 15 psi was arrived at for sterilization in a stationary retort. Though this heat treatment was found to give a sterile product, the product quality suffered from browning, curdling and off-flavour. Coconut proteins have been shown to be highly sensitive to temperature (Samson 1971) and pH (Balachandran and Arumughan 1992). Exposure to high temperature for long time resulted in denaturation and precipitation of proteins. The process of denaturation was accelerated in the acidic and basic regions. In the process for coconut cream, these problems have been overcome by the incorporation of additives and adoption of rotary retort. While the additives minimized the impact of heat treatment, mixing of the cream during sterilization facilitated faster and uniform heat penetration, and reduction in the time of heat treatment. Under these conditions, sterilization at 15 psi for 20 min was found to give a product free from curdling and browning. The effectiveness of sterilization was further confirmed by microbiological analysis for mesophilic aerobes, mesophilic spore formers, *Bacillus stearothermophillus*, total anaerobes and presumptive coliforms. These organisms were found to be absent in the product.

The available reports for the coconut cream process from the Philippines (Timmins and Kramer 1977), Malaysia and Thailand (Hagenmaier 1977) involved severe heat treatment to impart product sterility. For example, the Philippine process has adopted autoclaving of the cans for 45-70 min. In the case of Malaysian and Thailand processes, the milk is subjected to heat treatment in open steam kettles at 80°C for 4 h, followed by addition of sodium metabisulphite before packing. These resulted in the browning, curdling and phase separation of the product. The analytical data of coconut cream processed at RRL(T) and two commercial brands from Malaysia and Singapore are presented in Table 2. The process reported here has overcome these quality defects by adopting suitable additives coupled with sterilization conditions, as already described. Further, this process also avoided preservative, which usually imparted undesirable flavour and taste.

TABLE 2. ANALYTICAL DATA OF COCONUT CREAM PROCESSED AT RRL (T) AND OF TWO COMMERCIAL BRANDS FROM MALAYSIA AND SINGAPORE*

	RRL (T)	From Malaysia 155 g	From Singapore 170 g
Colour	White	Dirty white	Dirty white
Texture	Smooth	Curdled	Curdled
Flavour	Coconut like	Slight burnt flavour	Synthetic coconut flavour
Appearance	Homogeneous	Two phases	Two phases
Consistency	Creamy	Watery	Watery
Total solids %	37	21.2	15.6
Solids non-fat, % (SNF)	12	7.2	4.1
Fat, %	25	14.0	11.0
Protein, %	4.5	0.3	0.5
Sugars, %	5.5	2.9	2.0
Minerals, %	1.8	0.7	0.6
Added gums, %	0.4	2.5	1.5

* Procured from the Middle East

Composition and material balance : The composition of the canned coconut cream and coconut powder by this process and the material balance data are shown in Table 3 and Fig.1. The coconut powder was converted into ready-to-use food formulations such as curry or *chutney* powder with acceptable quality attributes. This further

TABLE 3. COMPOSITION OF THE COCONUT CREAM, COCONUT RESIDUE AFTER MILK EXTRACTION AND DESICCATED COCONUT

	Coconut cream (wt %)	Residue (wt %)
Moisture	65.0	3.0
Fat	23.0	45.0
Protein	4.5	8.0
Sugars	5.5	9.0
Fibre	-	15.0
Minerals	1.0	1.5

adds to the economic viability of this process. The coconut water is yet another byproduct that can be converted into coconut vinegar, thereby adding value to a waste product. Further formulation of the coconut powder could give 100 kg ready-to-use chutney or curry powder. The shell (150 kg) is used as a boiler fuel at present. However, it can be profitably used for making shell powder or activated carbon.

The demonstration plant was established at a cost of Rs. 25 lakhs, and the canned product was test marketed at metropolitan and other cities. The feedback obtained from this programme suggested that the product was acceptable in all household dietaries and catering establishments, where coconut is used.

Technology transfer for commercialisation : The process has been transferred for commercial production to a private company. The proposed commercial plant will have a capacity to process 10,000 fresh coconuts per day, which would yield 2500 kg coconut cream and 500 kg dry coconut powder. Economic viability for the commercial plant has also been worked out for the detailed project report. The total cost of this project is Rs. 150 lakhs of which Rs. 90 lakhs account for capital cost. The project breaks even at 40% capacity with a pay back period of 4 years for the term loan. The commercial plant is proposed to be located in Trichur district of Kerala State.

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Effect of Various Treatments on Nutritional Quality of Faba Beans (*Vicia faba*)

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Pressure-cooked, roasted, sprouted, dehusked and raw faba beans were analysed for protein, amino acids, minerals and anti-nutritional factors. The results indicated that pressure-cooking resulted in maximum loss of methionine, cystine and tryptophan ($P < 0.01$). Faba beans were found to be good source of minerals, namely, calcium, phosphorus and zinc. Pressure-cooked beans had the least amounts of phenols (2.6 g%), phytin-phosphorus (0.15 g%) and trypsin inhibitor activity (28.2 TIU/mg protein), while dehusked beans had the lowest tannin content (0.63 g%). Protein quality, in terms of net protein ratio, protein efficiency ratio and apparent digestibility, was maximum for dehusked beans, followed by pressure-cooking.

Keywords : Faba beans, Protein quality, Minerals, Phytate, Trypsin inhibitor activity, Tannins.

Faba beans (*Vicia faba*) are good sources of proteins (Uhlig et al. 1980) and excellent sources of calcium, phosphorus and other essential minerals (Eden 1969). The temperature dependence of the soaking and cooking rates of faba beans has been studied (Bera et al 1990). The biological value (BV) of faba beans is, however, limited by anti-nutritional factors, including proteolytic enzyme inhibitors, tannins, phytic acid and its derivatives (Ruml et al 1982) Various treatments are known to destroy the anti-nutritional factors in different legumes (Sosulski and Youngs 1979). The present study was undertaken to determine the nutritional quality in terms of proteins, amino acids, minerals, anti-nutritional factors and protein quality parameters of faba beans, after various treatments.

Materials and Methods

Faba beans ('dark seed' variety) were procured from the Department of Agronomy of the University. Faba beans were grown in 1987 at the University Farms at Ludhiana. The samples for analysis and feeding purposes were withdrawn from the same stock. The beans were cleaned, freed of extraneous substances, and divided into 5 parts for different treatments. Four parts were treated, i.e. pressure-cooked, roasted, sprouted and dehusked, whereas the fifth part was used as raw sample.

Pressure-cooking : The beans were soaked in tap water for 12 h and pressure-cooked for 40 min at 15 lbs psi. After cooking, the excess water was strained, the grains were spread on a filter paper for soaking excess water, and sun-dried. Final drying was done in hot air oven at 60 ± 2°C.

Roasting : The sample was roasted in sand in an iron pan at about 250°C for approximately 2 min.

Sprouting : The beans were soaked in water overnight, then tied in a wet muslin cloth, kept in a dark place, allowed to germinate for 36 h at 40°C and then, dried at 60 ± 2°C in an hot air oven.

Dehusking : Dehusking was done using traditional method. The beans were soaked in water overnight and then, dried at 60°C.

These were coarse ground, using hand-grinder, to split the grains. The husk and grains were separated by winnowing.

In all the cases, the raw and treated beans were ground to a fine powder in an electric grinder, and stored in air-tight containers.

Chemical analysis : The proximate analyses, i.e. moisture, ash, ether extract and crude fibre, were carried out, as per AOAC (1985) methods. Available lysine was determined by the method of Carpenter (1960), as modified by Booth (1971). For the determination of tryptophan, the method of Concon (1975) was followed.

Methionine was estimated, using colorimetric method of Horn et al (1946), while cystine was estimated from acid hydrolysate by the method of Liddell and Saville (1959). Calcium was estimated by AOAC (1985) method and phosphorus was determined by the micro-method of Fisher (1971). Trace elements, namely iron, copper, zinc and manganese, were estimated, using atomic absorption spectrometer (GBC Scientific Equipment Pvt. Ltd., Victoria, Australia). Ionisable iron was estimated by the method of Prabhavati and Rao (1979).

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Anti-nutritional factors viz., tannins and total phenols, were estimated using the standard methods (AOAC 1985). The modified method of Snook (1938), as described by Tara and Bains (1971), was followed for the estimation of phytin-phosphorus. Trypsin inhibitor activity was determined by the method of Roy and Rao (1971).

Animal experiments : The animal experiment was carried out to evaluate the protein quality of both raw and treated beans. The diets were prepared at 10% protein level. Crude fibre and fat were adjusted to 5 and 10%, respectively, by adding non-nutritive cellulose and refined groundnut oil. All the diets were adequately supplied with vitamins and minerals, thoroughly mixed and sieved for uniform distribution of ingredients. Skimmed milk powder was used as a reference protein, and a protein-free group was also run. The diets were fed *ad libitum* to 24 days old male albino rats, caged individually. The average weight of each group (eight rats/group), at the beginning of experiment, was 28.9 g. Daily records of food intake were maintained and animals were weighed at weekly intervals, over a period of 4 weeks. The protein quality parameters were studied by the methods as described by Evans and Witty (1978).

Net protein ratio (NPR) was calculated from the weight gain of the test group, weight loss of the non-protein group and protein consumed by the test group. Protein efficiency ratio (PER) was calculated from the total weight gain of the rats and total protein consumed. Apparent protein digestibility was calculated from food nitrogen and faecal nitrogen. Similarly, relative nitrogen utilization (RNU) was calculated from the weight gain of the test group and initial as well as final weight of protein-free group and total nitrogen intake. The results were statistically analysed by the analysis of variance (Walter 1955), for testing the significance.

Results and Discussion

The crude protein content in raw faba beans was found to be 25.8% (Table 1), and was in agreement with the value of 25-31% (Daniel 1982). The results indicated that various treatments, i.e., sprouting, roasting, pressure-cooking and dehusking, had no significant effect on the protein content of the faba beans.

Various treatments resulted in a different effect on each amino acid (Table 1). Pressure-cooking resulted in maximum loss of methionine, cystine and tryptophan ($P < 0.01$). Such loss of methionine during rye bread making has been reported by Eggum and Duggal (1977), and also during *chapati* making by Kaur and Hira (1988). In the present study, the loss of methionine could be attributed to longer cooking time and the leaching effects. Maximum loss of available lysine was observed on roasting and pressure-cooking ($P < 0.01$), followed by sprouting and dehusking, respectively. Geervani and Theophilus (1980) have shown that the available lysine of roasted legumes was less than that of boiled and pressure-cooked legumes.

TABLE 1. PROTEIN, AMINO ACID AND MINERAL CONTENTS OF RAW AND TREATED FABA BEANS

Constituent	Treatments						
	Raw	Roasted	Sprouted	Pressure-cooked	Dehusked	F-ratio	C.D. 1%
			Proteins, g/100 g				
Crude protein	25.8 ± 1.05	25.8 ± 0.87	25.5 ± 0.36	24.4 ± 1.03	24.5 ± 0.44	1.51	2.55
			Amino acids, g/16g N				
Methionine	0.5 ± 0.02	0.4 ± 0.02	0.4 ± 0.03	0.3 ± 0.02	0.4 ± 0.02	18**	0.082
Cystine	1.3 ± 0.02	1.2 ± 0.03	1.3 ± 0.02	1.2 ± 0.03	1.3 ± 0.03	9.88**	0.081
Tryptophan	1.1 ± 0.03	0.8 ± 0.02	0.9 ± 0.02	0.6 ± 0.04	0.9 ± 0.03	80.48**	0.100
Available lysine	6.0 ± 0.40	4.6 ± 0.03	5.3 ± 0.01	4.8 ± 0.01	5.6 ± 0.02	19.58**	0.580
			Minerals, mg/100 g				
Calcium	180 ± 19.60	176 ± 12.20	163 ± 18.00	175 ± 8.20	160 ± 6.50	1.25	44.00
Phosphorus	424 ± 19.60	417 ± 12.30	401 ± 15.50	325 ± 20.40	423 ± 20.40	10.88**	56.85
Iron	4.0 ± 0.73	3.9 ± 0.03	2.9 ± 0.65	2.6 ± 0.48	3.7 ± 0.57	2.53	1.76
Ionisable Iron	1.7 ± 0.41	1.6 ± 0.50	1.8 ± 0.37	1.1 ± 0.12	1.5 ± 0.35	0.99	1.17
Copper	0.7 ± 0.01	0.7 ± 0.26	0.6 ± 0.33	0.6 ± 0.15	0.7 ± 0.04	24.40**	0.64
Manganese	1.1 ± 0.08	1.1 ± 0.09	1.0 ± 0.02	1.1 ± 0.03	0.9 ± 0.01	27.27**	0.06
Zinc	5.7 ± 1.22	5.6 ± 0.98	5.4 ± 1.55	5.0 ± 1.30	5.7 ± 1.37	9.11**	4.13

** $P < 0.01$, Values are mean ± S.D of quintuplicate samples on dry weight basis

The mineral composition of beans is shown in Table 1. Calcium and phosphorus contents of raw faba beans were found to be 180 and 424 mg/ 100 g dry matter, respectively. Sprouting and dehusking resulted in significant ($P < 0.01$) loss of calcium, while roasting and pressure-cooking ($P < 0.01$) resulted in a significant loss of phosphorus. Reduction in phosphorus content might be due to leaching of minerals in cooking water. Similar results on pressure-cooking of three pulses have been reported by Meiners et al (1976).

A significant reduction ($P < 0.05$) in iron content of the beans was observed on pressure-cooking. The ionisable iron of raw, roasted, sprouted, pressure-cooked and dehusked beans constituted 42, 41, 62, 42 and 41% of the total iron, respectively. An increase in ionisable iron was observed on sprouting, which might be due to release of iron from protein-bound combinations (Singh and Banerjee 1953). Statistically significant ($P < 0.01$) decreases in copper, manganese and zinc were found upon different treatments and might be due to leaching effect during cooking. Similarly, Rao and Deosthale (1983) had reported significant decreases in iron, copper and zinc contents during cooking.

Various treatments resulted in a loss of the phenolic compounds (Table 2). Earlier studies also indicated that nitrogen solubility increased both below and above the isoelectric pH of 4.4 and higher salt concentration reduced the nitrogen solubility (Shashi Gaur et al. 1992). Pressure-cooking resulted in a maximum loss (66%), followed by sprouting (38%), dehulling (29%) and roasting (27%) (Table 2). A drastic reduction ($P < 0.05$) on pressure-cooking might be due to destruction of phenols at high temperature and some leaching of the component in cooking water. All the treatments resulted in a significant loss of tannins ($P < 0.05$). Maximum reduction ($P < 0.01$) was observed on dehulling (47%), followed by pressure-cooking (30%), roasting (22%) and sprouting (15%), respectively. The phytin-phosphorus content of raw, roasted, sprouted, pressure-cooked and dehusked beans constituted about 56, 52, 51, 46 and 54 % of total phosphorus, respectively. Reduction ($P < 0.01$) in phytin phosphorus on pressure-cooking might be due to increase in phytase activity (Belavady and Banerjee 1953).

A statistically non-significant difference in trypsin inhibitor activity (TIA) of faba beans, due to different treatments, was observed. But pressure-cooking resulted in a significant ($P < 0.05$) and maximum destruction (29%) in trypsin inhibitor activity, which might be due to inactivation of trypsin inhibitor by long time heat treatment. Wilson et al. (1972) had reported the destruction of trypsin inhibitor activity of the faba beans by cooking at 110°C for 40 min.

As indicated in Table 2, NPR and RNU of various diets ranged from 1.43 to 2.40 and 8.69 to 12.18 for raw and dehusked beans diets, respectively. The values were, however, lower than the respective values of 4.54 and 21.13 for standard skim milk diet. The maximum values of NPR and RNU of dehusked beans diet might be due to loss of anti-nutritional factors in the removed husk. The increase in both these parameters on roasting and pressure-cooking might be due to destruction of anti-nutritional factors on heat treatment. All the

TABLE 2. ANTI-NUTRITIONAL FACTORS AND PROTEIN QUALITY PARAMETERS OF RAW AND TREATED FABA BEANS

Parameter	Treatments							
	Raw	Roasted	Sprouted	Pressure-cooked	Dehusked	F-ratio	C.D.	
							5%	1%
Phenols, g/100 g	6.8 ± 1.50	4.9 ± 1.80	4.1 ± 1.28	2.6 ± 1.06	4.8 ± 1.72	3.24	–	–
Tannins, g/100 g	1.2 ± 0.25	0.9 ± 0.21	1.0 ± 0.06	0.8 ± 0.04	0.6 ± 0.20	4.15*	0.32	0.45
Phytin P, mg/100 g	238 ± 20.13	216 ± 13.81	210 ± 23.12	151 ± 18.75	229 ± 20.21	1.66	–	–
Trypsin inhibitor activity, TIU/mg protein	39.5 ± 8.05	361 ± 5.20	35.1 ± 4.80	28.2 ± 3.50	32.3 ± 4.67	1.80	–	–
NPR	1.4 ± 0.78	2.0 ± 0.34	1.6 ± 0.82	1.9 ± 0.77	2.4 ± 0.62	0.97	–	–
RNU[1]	8.7 ± 1.14	11.7 ± 1.79	9.3 ± 1.57	11.1 ± 1.26	12.2 ± 1.22	5.07**	3.16	4.27
PER	0.5 ± 0.16	1.2 ± 0.34	0.7 ± 0.26	1.2 ± 0.19	1.3 ± 0.23	4.44**	0.39	0.53
Apparent digestibility, %	73.6 + 8.47	79.2 + 4.63	76.5 + 4.56	75.7 + 9.16	82.5 + 6.72	1.23	–	–

[1] RNU was calculated from initial (28.9 g) and final wt (25.6 g) of protein-free group.

* $P < 0.05$, ** $P < 0.01$

treatments (Table 2), except for sprouting, significantly ($P < 0.01$) improved the PER of the faba beans. PER (1.16) of pressure-cooked beans was significantly higher as compared to that of the raw beans (0.50). The beneficial effect of heat processing might be due to destruction of the tryptic activity and the growth inhibitors present in legumes. Maximum PER of 1.29 was observed in group on dehusked beans diet, which might be due to the removal of anti-nutritional factors in the husk. Protein efficiency ratio of all diets, however, was lower ($P < 0.01$) than that of the reference diet (3.00).

The apparent protein digestibility of the raw faba beans (73.6%) was comparable to the literature value of 76%, as reported by Griffithe (1979) and Moseley and Griffithe (1979). Various treatments did not result in any significant change in % digestibility. However, it was the highest (82.5%) for the dehusked beans diet. The digestibility of roasted, sprouted and pressure-cooked beans might have increased, due to loss of anti-tryptic activity during these treatments.

Conclusions

Faba beans are a good source of proteins, amino acids (namely, cystine, tryptophan and available lysine) and also of minerals (namely, calcium, phosphorus and zinc). Among various treatments, dehusking and pressure-cooking resulted in maximum destruction of anti-nutritional factors and also in the highest values for NPR, RNU and PER. So, these treatments, among those studied in the present case, can be considered as the best treatments for the faba beans.

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Optimization of Process Parameters for Production of *Chhana* from Low Fat Cow Milk

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Heat treatment of milk prior to acidification, coagulation temperature, acidity of milk-acid mixture and residence time of the coagulum before separation, were studied for obtaining an optimum combination of these parameters for maximum recovery of milk solids and yield of *chhana* from low fat cow milk. The *chhana* with good texture and the maximum recovery of 48.2% milk solids could be obtained at 70°C coagulation temperature, 0.522% acidity (expressed as lactic acid) and 8 min residence time. The yield was 11.5% of the milk and this amounted to about 90% of the maximum yield. The combination of parameters that resulted in maximum yield gave *chhana* with granular body, which is not suitable for making sweetmeats. The degree of heat treatment required for the maximum recovery of milk solids could result in 99.95% denaturation of whey proteins.

Keywords : *Chhana*, Heat treatment prior to acidification, Whey protein denaturation, Milk solid recovery, Yield, Optimization, Low fat cow milk.

Chhana, an indigenous milk product, obtained by acid coagulation of hot milk and drainage of whey, is used as a base in the preparation of a variety of sweets like *rasogolla, rasmalai, sandesh*, etc. Cow milk is generally preferred, since it yields a soft-bodied and smooth-textured product, which is highly desirable in the preparation of good quality sweets and kneading plays an important role in the preparation of sweets (Tarafdar et al. 1988; De and Ray 1954; Soni et al. 1980). It has been estimated that about 4% of the total milk production in India in 1990 was converted into approximately 30,900 million kg of *chhana* (Mathur 1991). The popularity of *chhana* - based sweets is increasing day by day. To meet the growing demand, a need exists for standardizing and optimizing the process for large scale production of *chhana*.

The process for recovery of milk solids in the preparation of *chhana* was shown to be influenced by a number of factors, such as heat treatment of milk prior to acidification (x_1), coagulation temperature (x_2), acidity of the milk-acid mixture (x_3) and the residence time (x_4) of the coagulum prior to separation, besides homogenization and levels of fat (Jagtap and Shukla 1973). These studies (De and Ray 1954; Soni et al. 1980; Sen 1985, 1986; Iyer 1978; Singh and Ray 1977; Sen and Rajorhia 1986), however, involved the influence of only one or two factors at one time. Therefore, the present study was undertaken to obtain the optimum combination of the four variables for the maximum recovery of milk solids and yield of *chhana*. A low fat milk has been used as raw material so as to provide avenues for utilization and processing of such milk.

Materials and Methods

Type and composition of milk : Daily in the evening, milk from one particular cross-bred ('Jersey' x 'Haryana') cow was collected from a local farm. It was stored in refrigerator during the night for its use on the next day.

Preparation of chhana: At a time, 200 g milk was heated to 95°C in a microwave oven and cooled to three coagulation temperatures, viz., 70, 80 and 90°C. Time of heating and the temperatures of the milk during cooling, at an interval of 45 sec. were recorded. Citric acid (50 g) of three strengths (1, 1.5 and 2%) was heated to the coagulation temperature, before adding to the milk. The mixture was stirred, till the appearance of clear whey and held at the coagulation temperature (± 2°C) for three residence times, viz., 2, 5 and 8 min. The *chhana* was strained through a muslin cloth, tied up in a bundle and hung up for 20 min to drain out the whey and to cool it to room temperature.

Chemical analysis : The total solids in milk and whey were determined by oven drying at 100 ± 5°C for 4.5 h. The fat content in milk was determined by Gerber method (ISI 1970). The titratable acidity of milk was measured by the method recommended by AOAC (1975). The % moisture content of *chhana* was determined by means of an infrared moisture balance.

The recovery of milk solids (y_1) was calculated from the following equation :

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$$y_1 = \frac{S_c W_c - (100 - S_c)\, W_c\, [bW_a/\{(100 - b)\, W_a + (100 - S_m)\, W_m\}]}{W_m S_m} \quad \ldots (1)$$

Where, S_c is the solids content in *chhana* (%); W_c is the weight of *chhana* (kg); W_m is the weight of milk (kg); b is the strength of citric acid solution (%) and S_m is the solid contents in milk (%).

The yield of *chhana* was calculated from

$$y_2 = W_c/W_m \quad \ldots (2)$$

Analysis of data: Regression equations relating to the recovery of milk solids (y_1) and yield of *chhana* (y_2) with the four factors, viz. the heat treatment prior to acidification (x_1), the coagulation temperature (x_2), the acidity of the milk-acid mixture (x_3) and the residence time of the milk-acid coagulum prior to separation (x_4), were developed. The equations were simplified by eliminating few of the coefficients through statistical tests of significance (Myers 1971).

Results and Discussion

The data on milk analysis indicated that the total solid content in milk ranged from 9.94 to 10.76% (average 10.27%), while the average fat content was 2.65%. The titratable acidity of the milk was 0.13 % lactic acid, and it showed negligible (± 0.005 %) variation.

Some of the important facts, which have governed the levels of various factors selected and the process methodology adopted, are of vital nature in understanding the data and their analysis, as reported in the present paper. These are briefly described below :

Heat treatment of milk : The heat treatment of milk, prior to acidification, causes denaturation of whey proteins and reduction in colloidal calcium phosphate solubility (Walstra and Jennes 1983). Studies have shown that a maximum of 90°C temperature is sufficient for complete denaturation of whey proteins (Burton 1988). By acidification, denatured whey proteins and insoluble calcium phosphate get precipitated, along with the casein micelles. A high acidity of the milk acid mixture is undesirable, because the acid solubilizes a part of the colloidal calcium phosphate, and reduces the yield of *chhana*, thereby leading to low recovery of milk solids. It also results in granular texture, making the *chhana* unfit for preparation of *rasogolla*. A low acidification temperature of 70 - 85°C has been found to increase moisture retention and thereby the yield of *chhana* (De and Ray 1954; Sen 1986; Iyer 1978). These studies suggest that milk is required to be heated and then cooled before acidification. Hence, the milk was heated to 95°C, and the acidification was done after cooling it to (i.e., x_2) 70, 80 and 90°C.

The extent of the heat treatment of milk, prior to acidification, was represented in two ways. The first involved the use of the area (x_{1a}) under the temperature, T versus time t plot. As the denaturation of whey proteins becomes noticeable above 60°C (Walstra and Jennes 1983), the area under the plot above T = 60°C only was calculated. Thus :

$$x_{1a} = 1/3600 \int_{t_1}^{t_2} T dt \quad \ldots (3)$$

where, x_{1a} is the heat treatment parameter of milk (°C . h); t_1 is the time (sec), when milk has attained 60°C, and t_2 is the time, when milk is allowed to reach coagulation temperature.

The second way was based on the degree of whey protein denaturation (x_{1b}). If c_0 and c are the initial and final values of whey protein concentrations, and since the whey protein denaturation follows first order reaction kinetics, it can be shown that

$$x_{1b} = \log (c_0/c) = k^* t/2.303 \quad \ldots (4)$$

where, k^* is the whey protein denaturation rate constant (sec^{-1}) and t is the time of heat treatment (sec) (Walstra and Jennes 1983; Burton 1988).

Many factors affect the value of k^*, notably the temperature, T. Within a small temperature range, a plot of k^* versus 1/(T+273) gives a straight line. The reaction kinetics of whey proteins have shown marked changes at temperatures 90-100°C, as the reaction rates are much less dependent on temperatures in the range above 100°C, than on those below 90°C. From decimal reduction time, data of Burton (1988) for α - lactoglobulin, the largest fraction of whey protein in milk, the following equations were obtained :

$$\log k^* = 39.22 - 14754/(T + 273) \quad 60 < T < 90°C \quad \ldots (5)$$

$$\log k^* = 3.43 - 1760/(T + 273) \quad 90 < T < 30°C \quad \ldots (6)$$

By means of these equations, a plot of k^* versus t was made from the T versus t plot. From eqn. (2), it can be seen that the area under the k^* versus t plot represents 2.303 $\log(c_0/c)$.

Acidity of milk-acid mixture : The acidity of the milk-acid mixture, x_3 was calculated from

$$x_3 = \frac{C_m + b(M_1/M_a)W_a/W_m}{1 + W_a/W_m} \quad \ldots (7)$$

where x_3 is the acidity of milk-acid mixture, expressed as equivalent % lactic acid; C_m is the acidity of milk (% lactic acid); W_m is the weight of milk (kg); b is the strength of citric acid solution (%); M_l is the molecular weight of lactic acid (90 g/mole); M_a is the equivalent weight of citric acid (64 g/mole) and W_a is the weight of acid solution (kg).

De (1980) reported that 2-2.5g of citric acid/kg milk (bW_a/W_m = 0.2-0.25) was needed for coagulation. He also mentioned that optimum strength of the acid solution, b should be between 1 and 2%. From these data, we find the maximum value of W_a/W_m as 0.25. The cow milk had an acidity of 0.13% lactic acid (C_m = 0.13). In the present experiment, three levels of citric acid strength (b = 1, 1.5 and 2) were used and these resulted in the computed values of x_3 from eqn. (5) as 0.381 (b = 1), 0.522 (b = 1.5) and 0.663 (b = 2)

Residence time of milk-acid mixture : Studies have been carried out on immediate and delayed straining (Rajorhia and Sen 1988; Chandan 1992). For a large scale manufacture of *chhana*, a continuous process is essential. In continuous process, delayed straining, however, is not desirable. In this study, the values for the residence time x_4 were 2, 5 and 8 min.

Yield and recovery of milk solids : Table 1 shows the values of y_1, y_2 and $(100 - S_c)$, as affected by the values of x_{1a}, x_{1b}, x_2, x_3 and x_4. During the experiment, the value of x_{1a} was found to vary from 1.370 to 5.779°C.h and the value of x_{1b} from 1.808 to 6.319. The recovery of milk solids varied from 0.4180 to 0.4819 kg solids in *chhana*/kg solids in milk. The yield of *chhana* varied from 0.0900 to 0.1274 and its moisture content from 48.31 to 62.35%.

TABLE 1. VALUES OF y_1, y_1', y_2, y_2' AND $(100 - S_c)$ AS AFFECTED BY VALUES OF x_{1a}, x_{1b}, x_2, x_3 AND x_4.

Degree of heat treatment: area T- t plot, x_{1a} (°C-h)	Degree of heat treatment: log (c_0/c) of whey protein, x_{1b}	Coag. temp, x_2 (°C)	Acididity of milk-acid mixture, x_3 (% lactic acid)	Res. time, x_4 (min)	Recovery of milk solids: actual y_1 (kg/kg)	Recovery of milk solids: predicted, y_1' (kg/kg)	Yield of *chhana*: actual y_2 (kg/kg)	Yield of *chhana*: predicted y_2' (kg/kg)	Moisture content of *chhanna* $100 - S_c$ (%)
5.779	4.462	70	0.381	2	0.433	0.442	0.105	0.102	57.73
5.117	3.713	70	0.381	5	0.448	0.454	0.111	0.109	58.71
5.050	4.430	70	0.381	8	0.454	0.459	0.107	0.109	56.67
2.821	3.029	80	0.381	2	0.454	0.446	0.105	0.110	55.33
3.748	4.430	80	0.381	5	0.448	0.448	0.107	0.107	55.65
3.756	4.642	80	0.381	8	0.464	0.459	0.106	0.110	54.70
1.817	2.817	90	0.381	2	0.443	0.438	0.102	0.101	54.12
1.929	2.913	90	0.381	5	0.453	0.444	0.106	0.101	54.74
1.972	3.062	90	0.381	8	0.451	0.455	0.104	0.102	54.31
5.188	4.853	70	0.522	2	0.464	0.450	0.105	0.101	54.51
5.206	4.430	70	0.522	5	0.467	0.459	0.112	0.109	56.99
4.260	3.290	70	0.522	8	0.482	0.480	0.115	0.114	54.76
3.496	4.823	80	0.522	2	0.436	0.445	0.094	0.103	52.71
3.896	4.832	80	0.522	5	0.447	0.449	0.107	0.105	57.49
4.941	6.319	80	0.522	8	0.455	0.456	0.105	0.105	55.94
1.585	2.475	90	0.522	2	0.418	0.428	0.093	0.093	51.70
1.370	1.808	90	0.522	5	0.432	0.432	0.090	0.091	48.31
1.564	2.215	90	0.522	8	0.437	0.444	0.090	0.094	51.70
5.165	4.365	70	0.663	2	0.473	0.465	0.111	0.111	57.33
4.983	4.300	70	0.663	5	0.462	0.471	0.107	0.119	56.92
5.100	4.430	70	0.663	8	0.482	0.481	0.127	0.127	61.84
3.064	3.420	80	0.663	2	0.438	0.448	0.114	0.107	61.04
3.825	4.169	80	0.663	5	0.444	0.452	0.111	0.112	59.73
3.183	3.436	80	0.663	8	0.471	0.465	0.127	0.118	62.65
2.180	2.671	90	0.663	2	0.431	0.421	0.090	0.089	52.64
1.671	2.264	90	0.663	5	0.424	0.425	0.091	0.091	53.85
1.725	2.443	90	0.663	8	0.445	0.437	0.092	0.095	51.95

Since 99.9% whey protein denaturation corresponds to x_{1b}= 3, for all values of x_{1b} < 3, the y_1 was low (0.4180 to 0.4528), and the value of y_2 was also low (0.0900 to 0.1056).

The recovery of milk solids and the yield in this study were low compared to those reported by

Sen and Rajorhia (1986). They stated that the yield (y_2) varied from 0.16 to 0.18 for *chhana* containing 49 to 58% moisture. They obtained the recovery of milk solids y_1 from 0.58 to 0.59. The low values of y_1 (from 0.448 to 0.482) and y_2 (from 0.090 to 0.127), reported in the present study, were due to the low fat content of the milk. Tambat et al (1992) found that the recovery of milk solids as well as the yield decreased with decrease in the fat level of milk. For milk with 3.0% fat, they obtained a recovery of milk solids of 0.126 and a yield of 0.504 . These data compare well with those of the present studies, since the milk which was used in the present case had 2.7% fat.

The reason for the low yield and recovery of milk solids might be due to less number of fat globules in the milk, which could not trap sufficient amount of milk protein through their association with the fat globule membrane. Since the size of the coagulated protein associated with the fat globules is normally larger than those of coagulated casein micelles, higher recovery of protein from milk is possible, only when the fat content of the milk is large. The small size of the coagulated casein micelles, in the absence of the fat globules, could pass through the strainer, which was used for the recovery of *chhana*. A part of the proteins, therefore, could not be separated from the whey, which led to a low yield and low recovery of milk solids.

Second order regression equations, for prediction of the recovery of milk solids y'_1 and yield y'_2, were fitted with the values of x_{1b}, x_2, x_3 and x_4. The equations are :

$$y'_1 = 0.4492 - 0.0502\, x_{1b} + 0.5553\, x_3 + 0.5942 \cdot 10^{-3}\, x_{1b}\, x_2 - 0.6808 \cdot 10^{-2}\, x_2 x_3 + 0.2831 \cdot 10^{-3}\, x_4^2 \quad \ldots (8)$$

Correlation coefficient $R = 0.897$

$$y'_2 = -0.2048 + 0.8785 \cdot 10^{-2} x_2 - 0.4138 \cdot 10^{-2} x_4 - 0.1591 \cdot 10^{-2}\, x_{1b}^2 + 0.0130\, x_{1b}\, x_3 + 0.7813 \cdot 10^{-3}\, x_{1b}\, x_4 - 0.5140 \cdot 10^{-1}\, x_2^2 - 0.2615 \cdot 10^{-2}\, x_2\, x_3 + 0.4981 \cdot 10^{-2}\, x_3\, x_4 + 0.1402\, x_3^2 \quad \ldots (9)$$

Correlation coefficient $R = 0.900$

The predicted values for y'_1 and y'_2 are shown in Table 1. It can be seen that the recovery of milk solids and the yield increased with increase in the residence time (x_4).

At 0.522 acidity, 70°C coagulation temperature and 8 min residence time, the recovery of milk solids was highest (0.4819). At this acidity, the *chhana* coagulated at 70 and 80°C was found to have good texture. Coagulating at 70°C and 0.663 acidity resulted in highest yield (0.1274), but the *chhana* was having granular texture. The texture of the *chhana* at the acidity of 0.381, was good, but the recovery of milk solids (0.4329 to 0.4648) and the yield (0.1020 to 0.1129) were low.

From the economical point of view, the heat treatment of milk, prior to acidification, and the residence time of milk-acid coagulum, prior to separation, should be as short as possible, while the coagulation temperature should be as high as possible, and the amount of acid used should be as low as possible.

Based on these considerations, it may be concluded that the coagulation temperature should be 70°C, the acidity 0.522 and the residence time 8 min for *chhana* of good quality and the maximum recovery of milk solids. At these conditions, the yield (0.1151) of *chhana* was about 90% of the maximum yield (0.1274). The degree of heat treatment of milk for this optimum point was 4.26°C.h and the log cycle change in the denaturation of whey protein was 3.29. The moisture content of the *chhana* was 54.76%, which lies within the limits of Prevention of Food Adulteration Rules (PFAR 1955) specified for *chhana*.

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Thermal Processing of Acidified Vegetables

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Effect of lowering the pH, either by adding acid or lactic fermentation, on thermal process requirements for canned vegetables was investigated. Malic acid was preferred for acidification of canned vegetables. Addition of acid to covering brine was preferable to the blanching in acid solution, as the acidification was uniform, and it reduced the extent of discolouration. Acidification by lactic fermentation, using 2% boiling hot brine to cover the prepared vegetable, reduced the pH to 3.8 in 3 days. Fermentation is initiated by the species of *Leuconostoc* and *Lactobacillus* followed by *Pediococcus* and *Streptococcus*, Process time, based on a sterilisation value of $F^{8.3}_{100}$ = 3.5 min, was adequate to render the canned acidified vegetables (pH ≤ 4.0) microbiologically safe. The process time required for 77.8 x 119.1 mm and 103 .2 x 119.1 mm cans, having initial temperature of `65°C, was 15 min or less in boiling water. Colour of the lactic fermented canned products was superior to canned vegetables acidified with malic acid. Both had texture similar to that of the freshly cooked vegetables. Products acidified by fermentation had minimal sour taste.

Keywords : Acidified vegetables, Fermented vegetables, Canning, Thermal processing, Microbial changes, Storage studies.

Thermal process requirements for low-acid foods (pH > 4.6), especially vegetables, are severe due to the possibility of growth of toxigenic *Clostridium botulinum* and other heat resistant spore - forming bacteria. In earlier studies, the thermal process schedules for okra, potato, yam and drumstick are reported (Saikia and Ranganna, 1992). Acidification, either by addition of acid or by fermentation, to lower the pH as well as process requirements, modifies flavour and chelates trace metals (Anon 1980, 1990; Kozup and Sistrunk 1982).

Blanching in acid solution of pH < 2.0, immersing of blanched vegetable in acid solution or addition of acid to individual containers, are some of the direct acid addition methods for lowering the pH of the vegetables (Anon 1980). In the case of cowpea, blanching is done in hot water in order to get a good quality product by destroying certain enzymes(Ramesh and Nath 1990). Citric, malic, tartaric, lactic and acetic acids are generally used, while phosphoric, adipic, fumaric acids and glucono-delta-lactose (GDL) also find specific uses in the acidification of foods (Anon 1990). 'Salad Bar Fresh' process, developed recently, involves the addition of an ingredient having trade mark 'PHM-1' to the cans. This has been reported to reduce time as well as temperature of processing, and yield products which are similar to freshly cooked vegetables, with respect to colour, texture and flavour (Anon 1986).

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Lactic acid fermentation also lowers the pH and, consequently renders the food resistant to pathogenic and spoilage microorganisms as well as inhibits the growth of spores (Anon 1980; Anderson et al. 1990). A number of vegetables are preserved by brining and fermentation. Cabbage and cucumber fermentation are, by far, the most extensively studied. Okra becomes soft and mushy on thermal processing and hence, is acidified, either by addition of acid or by lactic fermentation before canning. *Lactobacillus cellobiosus*, isolated from okra and when used as inoculum, reduces the pH to less than 4.5 after 24 h, and renders the surface of canned okra less mucilagenous and less sloughing (Kotzekido and Roukas 1987a). *L. plantarum*, *L. brevis* and *Pediococcus cerevisiae* have also been used as start cultures in the fermentation of different vegetables (Fleming and McFeeters 1981). Toxigenic amines (1 to 5 mg/kg), formed during fermentation, were considerably lower than the poisonous level (Anderson 1988).

In recent years, there is a renewed interest to reduce the thermal process requirements of low-acid (pH > 4.6) vegetables during canning, either by addition of acid (Kozup and Sistrunk 1982; Kotzekidou and Roukas 1987a) or by lactic fermentation (Kozup and Sistrunk 1982; Kotzekidou and Roukas 1987a, b; Edeza and Sanchez 1989; Anderson et al. 1990). Time and temperature conditions, which were made use of in thermal preservation by the authors, were found to vary considerably, and the basis for this has not been investigated. Studies on evolving thermal schedules for canned vegetables, acidified with

acids or by fermentation, form the subject matter of this paper.

Materials and Methods

Acidification using acids : Fresh vegetables, purchased from the local market, were washed and used. The outer green leaves of cabbage were removed, cored, and shredded. Carrots were peeled and sliced to 1 cm thickness size. The stem of cauliflower was removed and the curds broken into pieces. The green beans were snipped and cut into small pieces of 5 cm length. Green peas were shelled. The two edges of the ivy gourd (*Kundri, Tindora*) were trimmed. Potatoes were peeled, eyes trimmed and cut into halves.

Prepared vegetables and brine (1%) were blended in the ratio of 2:1 in a blender, and the blend was acidified with 10% solution of the acid, to determine the quantity of acid required to get the desired pH.

For acidification, the prepared vegetables were blanched in 3% solutions of lactic, malic, succinic, citric and fumaric acids as also glucono-delta-lactone (GDL), either for 15 min at 70°C as recommended in the canning of cauliflower (Hoogzand and Doesburg 1961) or in boiling solution for 3 min, filled (500 g) into A $2\,^1/_2$ (103.2 x 119.1 mm) plain cans, covered with 2% salt solution, exhausted, sealed and processed in boiling water for 15 min.

Acidification by fermentation : The prepared green beans, cauliflower, peas, carrot and ivy gourd in equal proportions or individually were filled (1.5 kg) into 5 litre jars and covered with hot (97°C), boiled and cooled (45°C), or cold (25°C) brine of 2 to 6% concentrations, containing 0.4 to 0.8% acetic acid or without the acid. The containers were covered with nylon (200 gauge) film and tied with thread. Use of hot brine with acetic acid is somewhat akin to the method followed in Iran to preserve vegetables in the autumn for use in the winter.

Lactic acid bacteria were isolated from the fermenting vegetables at 12, 24 and 48 h intervals, using MRS broth and agar, (NCA 1968), as well as *Lactobacillus-Streptococcus* differential medium (LSDM) (HiMedia 1989). Isolation of pure cultures was done by serial dilution, plating and repeated streaking of single colonies. For biochemical studies, 12 h old cultures of individual isolates were purified by centrifugation. Identification procedure followed was according to Sharpe (1979) and Kandler and Weiss (1986).

After fermentation, the brine was drained, the fermented vegetable rinsed in water, filled (250 g) into 77.8 x 119.1 m or (500 g) into 103.2 x 119.1 mm cans, covered with boiling 1% brine, and the cans were exhausted, sealed and processed as before.

Thermal process evaluation : Heat penetration studies, using Ecklund plug in needle type thermocouples and manually operated Leeds and Northrup potentiometer, indicated that the heating was by convection and the cold point was at about 1/10th the height of the can. Heat penetration data, collected at intervals of 1 min with 6 cans for each run, was used for calculating the process time required by equal time interval method (Patashnik 1953) to inactivate the *Cl. pasteurianum* or heat resistant enzymes.

Inoculated pack studies : Cans filled with vegetables were inoculated with spores of *Bacillus licheniformis* (7,50,000 spores/can) and/or *Cl. sporogenes* (2,40,000 spores/can). These cultures were isolated from canned mango pulp of pH 4.3 (Azizi and Ranganna 1993). The vegetables were then covered with brine, cans sealed and contents mixed. The inoculated cans were processed as described above and incubated at 37°C. Uninoculated cans were used as control.

Storage study : The canned products were stored at room temperature and examined at intervals of 3 months. Texture was measured in Instron texturometer, using Kramer shear cell (2830 - 018) and plunger assembly (2830 - 010).

Results and Discussion

Vegetables blanched in acid solution for 15 min at 70°C, as recommended for cauliflower (Hoogzand and Doesburg 1961), or in boiling solution for 3 min, did not ensure acidification of the interior parts, but caused discolouration. The brown colour was nearer to the cut surface. Hence, acidification by addition of acid to the covering brine was examined. Concentration of acid required to reduce the pH of the vegetable to 4.0 or less ranged from 0.06 to 0.55%, depending on the acid and the vegetable (Table 1). Sensory evaluation by ranking test (Ranganna 1986) indicated that, among the acids studied, malic acid was the best acidulant for canned vegetables in brine, while malic acid or GDL made no difference for curried vegetables.

The exploratory studies carried out using 2 to 6% brine, with added acetic acid (0.39 to 0.78%) or without acid at different temperatures, indicated

TABLE 1. AMOUNT OF ACID REQUIRED TO REDUCE THE pH OF VEGETABLE BRINE BLEND (2:1)

	Lactic acid		Glucono-delta-lactone		Malic acid		Succinic acid		Citric acid		Fumaric acid	
	%	pH	%	pH	%	pH	%	pH	%	pH	%	pH
Carrot	0.15	3.8	0.22	3.8	0.10	3.9	0.22	3.7	0.13	3.8	0.28	4.1
Cauliflower	0.03	3.5	0.42	3.5	0.17	3.7	0.19	3.9	0.18	3.8	0.31	4.0
Green beans	0.22	4.0	0.16	3.6	0.12	3.8	0.27	3.9	0.01	3.7	0.32	3.7
Ivy gourd	0.19	3.5	0.16	3.7	0.06	3.8	0.12	3.7	0.07	3.7	0.22	3.8
Peas	0.28	4.1	0.55	3.9	0.25	3.8	0.40	3.7	0.27	3.9	0.29	4.0
Potato	0.30	3.7	0.43	3.5	0.17	3.5	0.19	3.6	0.18	3.7	0.31	3.8

that fermentation occurred, when 2% brine at 97°C was used for covering the vegetables. The temperature had decreased to 55 – 58°C on contact with vegetables within about 30 min. The use of hot brine probably destroyed some of the heat sensitive undesirable microorganisms and expelled cellular gases from vegetables. This favoured anaerobic fermentation, enhanced the stability of ascorbic acid as well as natural colour of the vegetables (Steinkraus 1983), and inhibited the activity of enzymes. In the presence of hot brine, the waxy layer on the outer surface of the fresh vegetables got dissolved, thereby causing the natural colour to become bright. The fermentation rendered the vegetables translucent, texture remained firm, and the vegetables as well as brine acquired the typical lactic fermented taste, but the brine was opaque in appearance. The fermented vegetables, produced using hot brine, were better than those involving the use of cold brine.

Vigorous fermentation was found to set in within 16 h of brining, the pH reduced at the end of 24 h to 4.1 – 4.2, and at the end of 90 h to 3.6 – 3.8. There was no change in the pH between 48 and 72 h. Consequently, this period could be considered more as a period of equilibration. After 24 h, the pH was lower, when boiling brine was used as compared to cold brine, but the brine had not penetrated into the interior of vegetables, particularly in those with a hard texture, such as carrot and cauliflower. Hence, fermentation for a minimum of 3 days was considered necessary.

Microbial changes during fermentation : The microbial flora of fermenting vegetables consisted of cocci and rods. The cocci in the first 12 h consisted of *Leuconostoc mesenteroides*. *L. cremoris* and *L. oenos*, which have the ability to withstand 60°C for 30 min. These produced gas and acid, thereby contributing to anaerobic conditions, besides lowering the pH. Another species, the homofermentative *Lactobacillus delbrueckii* sub sp. *lactis*, produced lactic acid during this period. Besides these microorganisms, during the first 24 h, the flora consisted of *Pediococcus acidilactia*, *P. damnosus* and *Lactobacillus plantarum*. At the end of 48 h, *Streptococcus lactis* and *S. rabbinolactis*, which produced only acid, dominated. The results show that, when hot brine was used, fermentation was initiated by *Leuconostoc*, which produced CO_2 and created anaerobic conditions. This organism, as well as acid producing lactobacilli, were followed by pediococci between 12 and 24 h. Streptococci come into the picture only after this period. All these microorganisms contributed to the lowering of the pH to about 3.8 at the end of 3 days of fermentation.

pH of canned product : The vegetables fermented for 24, 48, 72 and 96 h, on rinsing and canning in fresh 1% brine, had pH of 4.5, 4.3, 4.0 and 3.6 to 3.8, respectively. The pH of the vegetables, canned after 24h of fermentation, was close to 4.5, and even after 48 h of fermentation, it was just 4.3. As these pH levels are favourable for the growth *B. coagulans* and *B. licheniformis* (Azizi and Ranganna 1993) a fermentation period of 72 or 96 h is recommended, as it will lead to a pH of 4.0 or less in the canned products.

Thermal process requirements for canned products : National Canners Association (NCA 1986) recommended sterilisation $F^{8.9}_{93.3}$ value equivalent to 0.1 min at pH 3.9 or less to 20 min at pH 4.4-4.5. $F^{8.9}_{93.3}$ of 20 min is equivalent to 3.5 min at 100°C. Though the acidified vegetables had pH < 4.0, $F^{8.9}_{100}$ of 3.5 min formed the basis for process evaluation in this study, to accommodate for variations in fill weight of vegetable, net weight, pH and also to impart cooked taste to the canned product. This F value is adequate to destroy *Cl. pasteurianum* (D_{100} = 0.1 to 0.5 min at pH 4.2 to 4.5) and non-spore forming yeasts and moulds (D_{65} = 0.5 to 1.0 min) (Stumbo 1973).

The graphical interpolation curves are given in Figs. 1 and 2. The time required in boiling water ranged from 12 to 15 min, except when the initial temperature was high (Table 2).

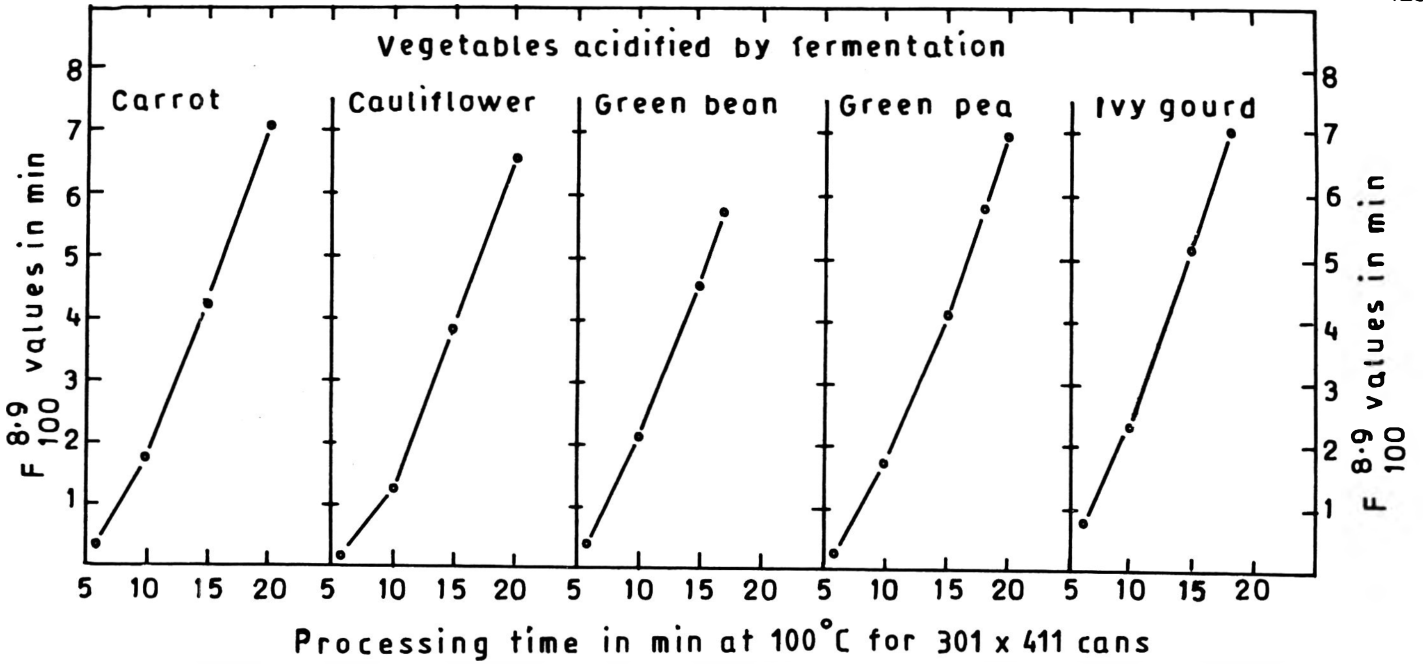

Fig. 1. Graphical interpolation of curves of sterilization values (i.e. $F^{8.9}_{100}$) vs process time for vegetables acidified by fermentation and canned in brine in 77.8 x 119.1 mm cans.

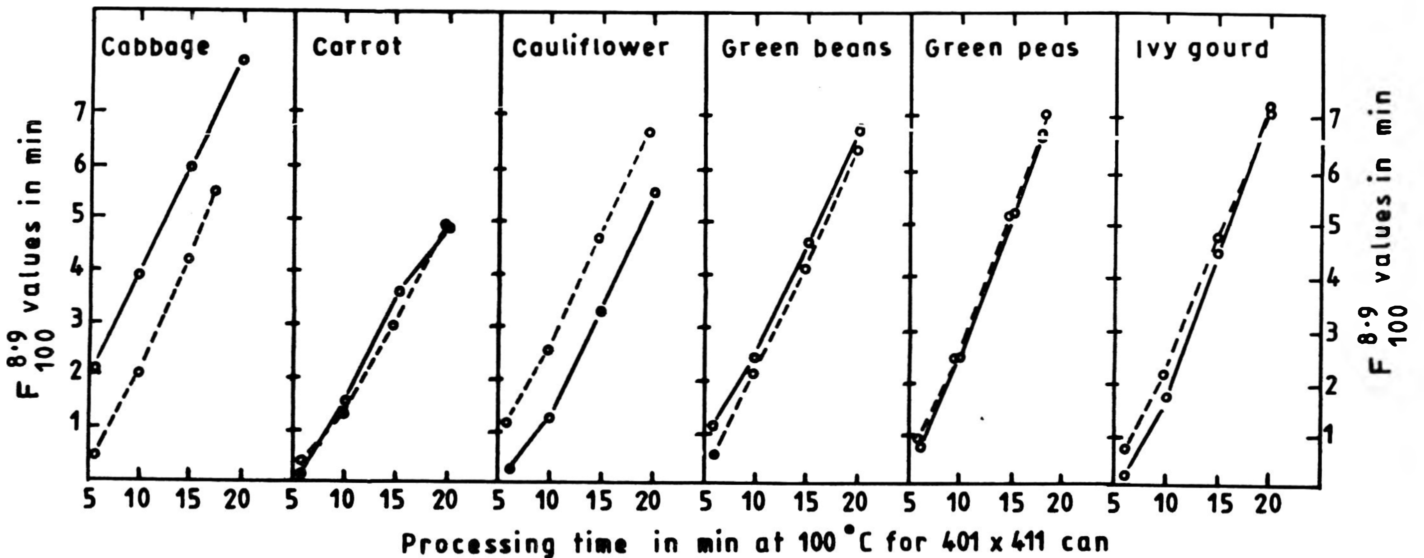

Fig. 2. Graphical interpolation curves of sterilization values vs processing time for fermented vegetables (O——O)) and vegetables acidified with added acid (O------O) and canned in brine in 401 x 411 (103.2 x 119.1 mm) cans.

Peas, French beans, ivy gourd, cauliflower and carrot were found to support the growth of *B. licheniformis*, which elevates the pH, thereby resulting in conditions favourable for the growth of heat resistant *Clostridia* (Azizi and Ranganna 1993). The D_{100} ranged from 2.1 to 2.8 in the vegetables investigated (Table 3). Process time to achieve sterilisation value, corresponding to 5D of *B. licheniformis*, would be considerably higher than the sterilisation value of $F^{8.9}_{100}$ = 3.5 min. The redeeming feature is that the organism grows only at pH 4.2 and above. Hence, if the canned product is acidifed to pH 4.0, with a safety margin of 0.2 units or even lower pH, the possibility of spoilage by this organism is forestalled.

Inoculated pack studies : No spoilage occurred in cans acidified to pH < 4.0, inoculated with spores of *B. licheniformis* and/or *Cl. sporogenes* and processed $F^{8.9}_{100}$ = 3.0 or 3.5 min, but this was not adequate for unacidified canned vegetables, and all such cans spoiled.

Changes during storage of the vegetables acidified using acid : When examined, soon after

TABLE 2 . THERMAL PROCESS REQUIREMENTS AT 97°C FOR CANNED ACIDIFIED VEGETABLES IN BRINE

Acidification	pH	IT °C	77.8 x 119.1 mm cans Processing time (min) corresponding to $F_{100}^{8.9}$ of 3.5 min	5 min	IT °C	103.2 x 119.1 mm cans Processing time (min) corresponding $F_{100}^{8.9}$ of 3.5 min	5.0 min
Acidification using malic acid							
Cabbage	3.7		ND	ND	93	9	13
Carrot	3.9		ND	ND	64	15	18
Cauliflower	4.0		ND	ND	65	15	18
French beans	4.1		ND	ND	65	12	16
Peas	4.0		ND	ND	80	12	15
Ivy gourd	3.8		ND	ND	67	13	16
Acidification by fermentation							
Cabbage	3.6		ND	ND	63	13	15
Carrot	3.8	60	14.0	16.5	66	16	20
Cauliflower	3.8	64	15.0	17.5	66	13	16
French beans	3.8	65	12.5	16.0	66	14	17
Green peas	3.9	65	13.5	17.0	73	12	15
Ivy gourd	3.6	88	12.0	14.8	66	13	16

IT : Initial temperature at cold point of the can at the start of processing time
ND : Not determined. Acidity in the finished product ranged from 0.4 to 0.6%.

TABLE 3. THERMAL RESISTANCE (D) OF *B. LICHENIFORMIS* IN NEUTRAL PHOSPHATE BUFFER AND VEGETABLES

Product	pH	D_{100} value (min)
Natural phosphate buffer	7.0	3.1 ± 0.20
	4.2	2.5 ± 0.08
Peas	4.5	2.5 ± 0.10
French beans	4.2	2.2 ± 0.20
		2.6 ± 0.20
Ivy gourd	4.2	2.2 ± 0.20
	4.5	2.3 ± 0.30
Cauliflower	4.2	2.1 ± 0.90
	4.5	2.8 ± 0.40
Carrot	4.2	2.2 ± 0.20
	4.5	2.5 ± 0.20

canning or after storage for 9 months, the vegetables were negative to heat resistant enzymes like catalase, peroxidase and polyphenoloxidase (Ranganna 1986)

Among the vegetables studied, the green colour of beans, ivy gourd and peas turned yellowish brown during processing mainly due to chlorophyll destruction. This change was further intensified during storage. The natural creamy colour of acidified, canned cauliflower turned to light pink at the end of 3 months of storage and then to brown on further storage. The pink discolouration in cauliflower has been attributed to polymerisation of leucoanthoyanins present in a pseudo-base form (flavorn-4-ol), which is intensified further by the acid (Setty and Ranganna 1972). However, carrot retained the natural colour over the prolonged storage.

The texture of canned acidified vegetables was superior to canned unacidified vegetables processed under pressure, and resembled more closely to fresh cooked product, when examined at the end of 9 months storage (Table 4). Mere blanching of the fresh vegetables, a step in the conventional canning and in the canning of vegetables acidified using acid, considerably reduced the firmness, as seen from the minimum force required to begin extrusion (KN/kg) and the total work done (KJ/kg). Processing of the acidified vegetables in boiling water did not affect the texture further, whereas processing under 10 psig pressure (control) considerably affected the texture.

Acidifed vegetables had perceptible sour taste. In the preparation of curried vegetables in India, acidulants like tomatoes, lime juice, tamarind extract or unripe mango powder (called *amchur*) are added. Hence, slight sour taste should not alter the acceptability much.

Storage changes of canned vegetables acidified by fermentation : Irrespective of the colour of fresh vegetables, the fermented product, on canning, appeared bright and retained the natural colour better. The change in colour during storage even upto 2 years was minimal. Since lactic acid was formed *in situ* from sugar by fermentation, the degradation of chlorophyll in green vegetables was minimal. Hence the colour of the canned product was dull green, but not brown, as in the case of vegetables acidified by acid. Cauliflower did not turn pink and the carrot was bright yellow.

The values of texture properties of the canned fermented vegetables, after storage for 9 months, were lower than those of the fresh vegetable, but

TABLE 4. VALUES OF pH AND TEXTURE OF FRESH, BLANCHED AND CANNED VEGETABLES AFTER STORAGE AT 37°C FOR 9 MONTHS

Attribute	pH	Texture values: Peak force kN/kg	Work done kJ/kg
Carrot			
1. Fresh	5.20	96.86	12.00
2. Blanched	ND	12.16	2.36
3. Acidified	4.00	11.69	2.28
4. Fermented	3.50	30.11	5.98
5. Control	4.85	1.52	0.42
F ratio		312.98	181.14
S.E.		1.81	0.29
Cauliflower			
1. Fresh	6.20	47.25	8.74
2. Blanched	ND	23.52	4.13
3. Acidified	4.50	15.96	2.70
4. Fermented	3.60	30.44	5.12
5. Control	5.00	1.04	0.34
F ratio		81.39	53.09
S.E.		1.60	0.36
French beans			
1. Fresh	5.70	53.46	10.08
2. Blanched	ND	36.24	6.43
3. Acidified	4.30	27.50	5.15
4. Fermented	3.50	46.56	7.20
5. Control	5.00	7.31	2.34
Ivy gourd			
1. Fresh	4.60	53.29	10.28
2. Blanched	ND	39.17	7.20
3. Acidified	3.80	22.20	3.70
4. Fermented	3.60	31.31	4.64
5. Control	4.50	2.38	0.43
F ratio		184.00	168.84
S.E.		1.26	0.26
Green peas			
1 Acidified	3.90	20.60	4.54
2. Control	5.00	7.16	1.28

Blanched : Blanched before canning, Acidified : Canned product acidified with malic acid, Fermented : Fermented vegetable canned, Control : Processed at 116°C for 25 min, F ratio : $P < 0.001$, df : 14 in the case of carrot and cauliflower, and 12 in ivy gourd, ND : Not determined.

higher than those of blanched vegetable. This probably is due to exclusion of blanching in the canning of fermented vegetables (Table 4). The overall quality of the canned fermented vegetable was far superior to the product canned using malic acid or by conventional method without acid, either immediately after canning or after prolonged storage. When made into curry, the lactic fermented note or sour taste was not distinguishable, as reported by the panel members to whom the canned fermented vegetables had been given for preparing the curried product, in their homes for evaluation purposes.

Conclusion

Vegetables acidifed with malic acid, or by lactic fermentation, using 2% boiling brine (the temperature decreasing to 55°C on contact with prepared material) for 3-4 days, to lower the pH to 3.6-3.8, reduced the processing temperature by 15-20°C and also the time. The resulting canned product is microbiologically safe, and similar in texture to fresh cooked vegetable. The sour tinge in taste is not discernible, when made into curry.

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Suitability of Indigenously Fabricated Aluminium Cans for Canning of Indian Foods

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Two piece aluminium cans were fabricated in three different sizes, using indigenous 3004 alloy (Mg, Mn and Al), in cooperation with a convertor, and evaluated for suitability to the canning of different Indian foods. The studies indicated the viability of aluminium alloy, as an alternative for tin containers, for eight different types of Indian foods.

Keywords : Rigid container, Aluminium cans, Suitability, Canning of Indian foods, Thermal processing, Lacquering, Storage studies.

Rigid containers have played a very significant role over several years in food processing and build up of consumer acceptance as well as confidence in preserved foods. In India, manufacturing units depend heavily on imported raw materials for fabrication of food cans, thereby necessitating the import of 300,000 tons of tin plate per annum, valued at Rs. 300 crores (TIFAC 1991). This has resulted in constraints with regard to the growth of the can manufacturing and food processing industries. Alternate materials for manufacturing rigid containers, in lieu of tin containers, have long been explored in various parts of the world (Leymarie 1972). The most attractive and viable alternate material in India is aluminium and its alloys. Aluminium is abundantly available in the country, as India possesses 8% of the world's bauxite reserves (Kothari 1986). In addition, aluminium is very light, as it weighs 1/3 that of steel. The corrosion resistance of aluminium is excellent, as compared to that of the conventional low carbon steel, and it also possesses good mechanical properties. Aluminium, when pure, is soft as well as ductile and is capable of attaining high tensile strength by cold working, heat treating and alloying.

Aluminium, in the form of foil, is already being used extensively as an excellent packaging material for processed and fast foods in large catering institutions (Satyanarayana Rao et al. 1990; Padmanabha Reddy and Khan 1993). In the form of collapsible tubes and rigid containers, it finds use in various sectors like pharmaceuticals, beverages, dairy and cosmetic industries (Neider 1986). However, its use in the form of rigid containers for canning processed foods, other than the beverages, is highly limited. Though the energy consumption for extracting the aluminium is high, its excellent recyclability makes it not only environment friendly, but also economically viable. Since armed forces in India is the single largest consumer of processed foods, research and development of two piece aluminium cans, using indigenous materials was undertaken (Jayaraman et al. 1988). Earlier work carried out with cans, fabricated out of 99.5% pure aluminium, has shown that the metal was too soft, and did not possess adequate mechanical strength for thermal processing (Srivatsa et al. 1990). Therefore, an alloy of aluminium (3004) was selected in the present studies. Cans and lids were fabricated out of the same alloy. This paper reports the data on the fabrication of aluminium cans using AA 3304 sheets and their efficacy for canning of eight different Indian processed foods.

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Materials and Methods

Aluminium cans : Two piece round aluminium cans were fabricated using aluminium sheets of AA 3004 alloy, equivalent to 4S, (Mn 1.25%, Mg 0.95% and rest aluminium) by drawn, redrawn and ironed (D&I) process, at the premises of a converting firm. The finished cans had an ultimate wall thickness of 0.33 mm. The lids were also of the same thickness and made out of the same alloy. Cans of three different dimensions, fabricated and used in the present studies, are as per the following details :

Dimension (mm)	Capacity (ml)
83 x 50	210
83 x 80	400
130 x 50	450

Lacquering of the cans : Lacquering of the cans and the lids was carried out at the place of the

converting firm, using epoxy-phenolic resins, by spraying it with an automatic gun, immediately after fabrication. The resins used were the conventional types already in use for tin containers. The quantity of lacquer was adjusted to provide nine concentrations, ranging from 0.014 to 0.255 g/ 25 sq.cm.

Preparation of foods : Upma, the savoury semolina pudding, contains wheat semolina, salt, hydrogenated oil and spices. For its preparation, roasted semolina was cooked in water containing hydrogenated oil and spices. *Sooji halwa*, the sweet semolina pudding, contains wheat semolina, sugar, hydrogenated oil and cardamom. For its preparation, roasted wheat semolina was cooked in sugar syrup containing cardamom. *Alu cholay*, the chickpea and other vegetables gravy, contain chickpea, potato, tomato, hydrogenated oil, salt and spices. Soaked chickpea and fried potato were cooked in water containing other ingredients for its preparation. *Avial*, the vegetable stew in curd gravy, contains vegetables (ash gourd, yam, beans, carrot, potato), coconut, curd and spices. Mixed vegetables were cooked in coconut and curd mixture for its preparation. Beans in sauce consists of beans in tomato puree. For its preparation, soaked beans were cooked in tomato *puree*. *Kheer*, the semi solid sweet blend of cooked rice and milk, contains rice, milk, sugar and cardamom. For its preparation, rice was cooked in milk containing sugar and cardamom. Fish curry (fish gravy) contains fresh water fish, tomato, onion, salt and hydrogenated oil. Fish was cooked in water containing hydrogenated oil, tomato, onion and spices for its preparation. Vegetable *pulav* (savoury cooked rice and vegetables) consists of rice, vegetables (potato, greenpeas), hydrogenated oil, salt and spices. For its preparation, rice was cooked in water containing vegetables, hydrogenated oil, salt and spices. All these Indian foods were prepared in the laboratory as per conventional methods. Some of the ingredients required trimming, cleaning, blanching, blending and pre-cooking.

Canning : The required quantities of foods were filled in different sizes of cans, the cans exhausted and double seamed, using specially designed rollers and base plates (Hersom and Hulland 1980). The conventional can seamers were fitted with the attachments and used for hermetic sealing.

Thermal processing of foods : Heat processing of the foods was carried out in steam retorts. The retorts were equipped with facility for using compressed air for over-head pressure and a high pressure water circulating pump for cooling under pressure (Ghosh et al. 1980). The temperature of the product was continuously recorded during heat processing, through the copper-constant thermo-couples, which were placed in the geometric centres of the cans. The cans were placed at different locations in the retort. The temperatures were calculated from the thermo-electro-motive-force at regular time intervals. The F_0 value was calculated from the data on temperatures and time. The cans were heated initially, till their inside temperature reached that of the retort. Subsequently, the pressure of the steam was raised, in stages, from 5 lbs to 15 lbs/sq.in. gauge pressure. The processing was carried out to achieve a F^{18}_{250} in the range of 6.0 to 7.0, to achieve commercial sterility (Ghosh et al. 1980). The cooling was performed under pressure with the help of compressed air and water. The cooled cans were wiped dry and examined for any visual defect. In addition, cut-out examination was carried out.

Storage studies : The cans were stored at room temperature (19° – 30°C) and 5°C for 9 months. The cans stored at 5°C served as control. The foods were analysed at an interval of 0, 3, 6 and 9 months for moisture, total fat, acidity, peroxide value (PV) and free fatty acids (FFA) as per standard methods (AOAC 1990). Microbiological analyses were also carried out for different types of organisms (Harrigan and McCance 1976). The cans were incubated at 37°C and 55°C for 7 days. Standard Plate Count (SPC) was determined using dextrose tryptone-agar after incubation for 48 h at 30°C. Yeast and moulds were estimated with the help of acidified potato-dextrose-agar, after incubation at 30°C for 4-5 days. *Salmonella* and *Shigella* were tested by streaking the enriched sample with selenite-cystine broth at 37°C for 24 h, 48 h and 72 h. Spore formers were determined after killing the vegetative cells by keeping the sample in boiling water bath for 15 to 20 min and subsequently inoculating and incubating at 37°C and 55°C for 48 h (Harrigan and McCance 1976). Sensory evaluation of the product was carried out by a test panel of 10 trained subjects, based on a nine point Hedonic scale.

Transportation : Transportation studies were carried out by packing the cans in 5 ply-corrugated cartons, made out of 110/130 gsm virgin kraft paper. The cartons were closed with the help of

cloth, bound with 5.0 cm wide gum tape, and were mounted on a horizontal surface. A frequency sweep of 3 Hz was used from 0 to 100 Hz at intervals of one min.

Data analyses : All the analyses were carried out in duplicate. The data were analysed statistically to find out standard deviations.

Results and Discussion

The basis for selection of the alloy and the lacquering compound is worth mentioning. The alloy used, namely aluminium-manganese-magnesium (AA 3004 series), was the best compromise in terms of cost, heat resistance and mechanical strength, as compared to aluminium-silican-magnesium (AA 6000) or aluminium-zinc-magnesium (AA 7000). It was also found that 3004 alloy was easily available within the country. The alloy obtained in the sheet form, can be easily drawn and redrawn and the cans of the required sizes obtained. Epoxy phenolic lacquer, also known as gold lacquer, was chosen because of its extensive use in autoclaved cans and excellent corrosion resistance. White vinyl resins were not selected in these studies, because of the difficulty in procuring them from indigenous sources. Repetitive spraying of the lacquer, with the help of a moving spray gun was found to be simple and could be readily adopted, with slight modifications to the spraying head.

Data on the efficacy of lacquering gave useful results when the cans with coatings varying from 0.0140 to 0.0555 g/25 sq.cm were evaluated. It was found that a minimum of 0.0438 g/25 sq.cm was essential for effective corrosion resistance and adequate protection to the various products. At lower levels, there was peeling, and the lacquering was inadequate. Lacquering higher than 0.0438 g/ 25 sq. cm did not offer any additional advantage.

In order to study the suitability of the can and the lacquering, eight different foods were investigated. These foods were chosen, as these represent acid, semi-acid and non-acid foods, and also for their variation in homogeneity like solid, semi-solid and solid in gravy (Table 1). Consequently, the periods of heating to achieve commercial sterility also varied. Since aluminium cans required special precautions, the processing was carried out in a modified retort, using compressed air for pressure compensation. This ensured the seam integrity, and also protected the walls from any damage, during thermal processing. The physical examinations of the cans immediately after processing did not exhibit any mechanical damage. The wall thickness of 0.33 mm was, thus, adequate and was able to withstand the processing cycles. The cut out examinations revealed good seaming integrity and satisfactory hooking of the lids to the body of the cans. The lacquer did not impart any foreign odour, which was confirmed by using *sooji halwa*, without any strong flavouring agent. Thus, the AA 3004 alloy met all the requirements successfully.

Storage studies were carried out, by storing the product at room temperature (19°C – 30°C) and

TABLE 1. TYPES OF FOODS STUDIED, THEIR CHARACTERISTICS AND THERMAL PROCESSING

Indian food products	Ingredients	pH	Acid type	Homogeneity	* Heat processing Temp (°C)	Time (min)	F_0 Value	Can size used (mm)
Upma	Semolina, hydrogenated oil, salt, peas and spices	4.70	Semi-acid	Cooked moist solid	120	7 10	6.10 6.34	83 x 50 83 x 80
Sooji halwa	Semolina, sugar, hydrogenated oil and cardamom	6.25	Non-acid	Cooked moist solid	119	8 10	6.14 6.37	83 x 50 83 x 80
Alu cholay	Chickpea, potato, onion, tomato, hydrogenated oil and spices	5.70	Semi-acid	Cooked solid in liquid gravy	119	6 10	6.14 6.58	83 x 50 83 x 80
Avial	Vegetables, coconut, curd and spices	3.80	Acid	Cooked solid in liquid gravy	119	6 10	6.11 6.30	83 x 50 83 x 80
Beans in sauce	*Rajma* (beans), tomato sauce and spices	3.80	Acid	Cooked solid in solid gravy	118	10	6.47	83 x 80
Kheer	Rice, milk, sugar and cardamom	7.00	Non-acid	Semi-solid	120	5	6.16	83 x 80
Fish curry	Fish, tomato, hydrogenated oil and spices	5.40	Semi-acid	Cooked solid in gravy	120	10	6.89	83 x 80
Vegetable *pulav*	Rice, vegetables, hydrogenated oil, salt and spices	6.20	Non-acid	Cooked moist solid	120	10	6.69	83 x 80

* Heat processing was carried out at 15 lbs/sq. in gauge pressure

TABLE 2. STORAGE STUDIES ON THE CANNED PRODUCTS STORED AT RT (19° – 30°C)

Product	Storage period, months	Moisture, %	Total fat, %	Acidity, %	FFA, % oleic acid
Upma	0	53.9 ± 0.1	13.8 ± 0.6	0.21 ± 0.01	0.96 ± 0.04
	3	53.6 ± 0.4	14.9 ± 0.0	0.24 ± 0.01	1.29 ± 0.03
	6	54.0 ± 0.1	14.9 ± 0.1	0.23 ± 0.01	1.29 ± 0.02
	9	53.9 ± 0.1	15.0 ± 0.0	0.24 ± 0.01	1.55 ± 0.02
Sooji halwa	0	34.5 ± 0.2	10.8 ± 0.2	ND	0.24 ± 0.01
	3	34.5 ± 0.2	10.5 ± 0.1	ND	0.38 ± 0.04
	6	35.1 ± 0.1	10.2 ± 0.2	ND	1.18 ± 0.02
	9	35.0 ± 0.0	10.5 ± 0.1	ND	1.42 ± 0.02
Alu cholay	0	71.3 ± 0.6	11.5 ± 0.2	ND	1.38 ± 0.02
	3	73.4 ± 0.8	10.9 ± 0.1	ND	1.41 ± 0.01
	6	73.8 ± 0.4	10.6 ± 0.2	ND	1.61 ± 0.02
	9	74.5 ± 0.5	10.9 ± 0.1	ND	1.90 ± 0.02
Avial	0	86.5 ± 0.0	ND	0.38 ± 0.01	ND
	3	85.6 ± 0.6	ND	0.58 ± 0.02	1.41 ± 0.01
	6	85.0 ± 0.1	ND	0.61 ± 0.01	1.42 ± 0.02
	9	85.0 ± 0.0	ND	0.56 ± 0.02	1.61 ± 0.01
Beans in sauce	0	79.5 ± 0.2	ND	0.82 ± 0.02	ND
	3	79.1 ± 0.4	ND	0.96 ± 0.02	ND
	6	80.1 ± 0.6	ND	1.15 ± 0.01	ND
	9	80.0 ± 0.1	ND	1.20 ± 0.02	ND
Kheer	0	64.8 ± 0.4	ND	ND	1.12 ± 0.01
	3	64.5 ± 0.3	ND	ND	1.80 ± 0.02
	6	64.4 ± 0.2	ND	ND	1.90 ± 0.02
	9	64.4 ± 0.2	ND	ND	4.40 ± 0.02
Fish curry	0	72.8 ± 0.4	20.2 ± 0.4	0.44 ± 0.01	ND
	3	73.5 ± 0.3	20.0 ± 0.2	0.65 ± 0.01	ND
	6	74.0 ± 0.4	19.0 ± 0.4	0.78 ± 0.02	ND
	9	74.0 ± 0.2	19.0 ± 0.4	0.78 ± 0.02	ND
Vegetable *pulav*	0	66.2 ± 0.2	7.4 ± 0.4	ND	ND
	3	66.0 ± 0.4	7.0 ± 0.2	ND	0.82 ± 0.04
	6	65.2 ± 0.2	6.9 ± 0.2	ND	2.40 ± 0.02
	9	65.0 ± 0.0	6.8 ± 0.1	ND	2.60 ± 0.02

Mean ± SD. ND = Not detected
Peroxide values were nil for all the samples

compared to those stored at 5°C. Results of chemical analysis of the stored products (Tables 2 and 3) did not show any significant change. Since fat used in the preparation was hydrogenated oil, no oxidative rancidity, in terms of peroxide value, could be detected. However, the results did not follow any definite patterns, probably due to the heterogeneous nature of the products and difficulty in uniform filling especially in case of *alu cholay* and *avial*.

The microbiological analysis revealed that the products remained sterile during the entire period of storage. For example, the counts of SPC, yeasts and moulds, coliforms, *Salmonella*, *Shigella* and other spores as well as anaerobes were negative for all the samples, when examined at the end of 0, 3, 6 and 9 months of storage at RT (19° – 30°C) and 5°C. The products were found to be acceptable by a taste panel on a nine point Hedonic scale.

TABLE 3. STORAGE STUDIES ON THE CANNED PRODUCTS STORED AT 5°C

Product	Storage period, months	Moisture, %	Total fat, %	Acidity, %	FFA, % oleic acid
Upma	0	53.9 ± 0.08	13.8 ± 0.18	0.21 ± 0.18	0.96 ± 0.04
	3	54.0 ± 0.00	13.7 ± 0.26	0.22 ± 0.00	0.98 ± 0.02
	6	54.0 ± 0.00	14.0 ± 0.00	0.22 ± 0.00	1.00 ± 0.00
	9	53.8 ± 0.18	13.9 ± 0.08	0.21 ± 0.18	0.99 ± 0.01
Sooji halwa	0	34.5 ± 0.44	10.8 ± 0.26	ND	0.24 ± 0.01
	3	34.0 ± 0.00	10.9 ± 0.35	ND	0.26 ± 0.01
	6	33.5 ± 0.44	10.5 ± 0.00	ND	0.25 ± 0.00
	9	34.6 ± 0.53	10.8 ± 0.26	ND	0.24 ± 0.01
Alu cholay	0	71.3 ± 0.18	11.5 ± 0.44	ND	1.38 ± 0.02
	3	72.0 ± 0.44	11.0 ± 0.00	ND	1.37 ± 0.01
	6	72.0 ± 0.44	11.4 ± 0.35	ND	1.38 ± 0.02
	9	71.8 ± 0.26	10.9 ± 0.08	ND	1.38 ± 0.02
Avial	0	86.5 ± 0.44	ND	0.38 ± 0.02	ND
	3	86.0 ± 0.00	ND	0.40 ± 0.00	ND
	6	86.0 ± 0.00	ND	0.50 ± 0.36	ND
	9	86.0 ± 0.00	ND	0.39 ± 0.01	ND
Beans in sauce	0	79.5 ± 0.44	ND	0.82 ± 0.26	ND
	3	79.9 ± 0.09	ND	1.10 ± 0.02	ND
	6	80.0 ± 0.00	ND	0.96 ± 0.02	1.10 ± 0.02
	9	80.0 ± 0.00	ND	1.15 ± 0.09	1.10 ± 0.02
Kheer	0	64.8 ± 0.18	ND	ND	1.12 ± 0.02
	3	65.0 ± 0.00	ND	ND	1.10 ± 0.00
	6	64.4 ± 0.44	ND	ND	1.30 ± 0.18
	9	65.0 ± 0.00	ND	ND	1.20 ± 0.18
Fish curry	0	72.8 ± 0.18	20.2 ± 0.18	0.44 ± 0.01	ND
	3	73.0 ± 0.00	20.0 ± 0.00	0.45 ± 0.00	ND
	6	72.5 ± 0.44	21.0 ± 0.88	0.39 ± 0.05	ND
	9	73.0 ± 0.00	20.5 ± 0.44	0.42 ± 0.03	ND
Vegetable *pulav*	0	66.2 ± 0.18	7.4 ± 0.00	ND	ND
	3	66.0 ± 0.00	7.4 ± 0.00	ND	ND
	6	65.8 ± 0.18	7.0 ± 0.35	ND	ND
	9	66.0 ± 0.00	7.5 ± 0.44	ND	ND

Mean ± SD. ND = Not detected
Peroxide values were nil for all the samples

With a view to establish the transport worthiness of the cans, with respect to the mechanical strength, simulated transportation studies were conducted. The cans did not suffer any visible damage, thus establishing the strength of the alloy. Thus, the aluminium cans, drawn out of Al-Mg-Mn alloy can easily meet the transport requirements,under normal conditions.

Therefore, it may be seen that two piece aluminium cans, with the inherent advantages of recyclability, absence of lead soldering and easy availability of raw materials for fabrication, offer vast potential for canning of a variety of Indian foods.

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Preparation and Evaluation of Sand Pear Vermouth

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Dry and sweet vermouths with variable alcohol levels were prepared from sand pear base wine. Higher levels of total phenols, aldehydes and esters were observed in the vermouths due to the addition of extracts of herbs/spices to the base wine and these improved the sensory attributes of the final product. Sweet vermouth having 15% alcohol was considered as the most acceptable product.

Keywords : Vermouth, Sand pear, Proximate composition, Wine, Sensory evaluation.

Vermouth, a wine to which extract of spices and herbs is added to enhance the flavour, is traditionally prepared from the grapes (Pilone 1954; Amerine et al. 1980). Further, techniques for the preparation of mango and plum vermouths of commercially acceptable quality have been standardized (Onkarayya 1985; Joshi et al. 1991). Several varieties of mangoes were also screened for wine making (Kulkarni et al. 1980). Sand pear (*Pyrus pyrifolia* L.), which is in abundance in Himachal Pradesh, was used in the preparation of perry - a low alcoholic drink (Azad et al. 1985). Due to the bland flavour of sand pear juice, in the present study, an attempt was made to prepare and evaluate sand pear vermouth.

The must was prepared by subjecting sand pear fruits to washing, grading, juice extraction by basket press, followed by filtering, heating to 85°C for 10 min. and subsequent cooling. This was ameliorated to total soluble solids (TSS) of 24°B, to which were added 0.5% of pectinol enzyme, 0.1% of diammonium hydrogen phosphate (DAHP) and potassium metabisulphite (KMS) at 100 ppm sulphur dioxide level. Fermentation of the must was carried out at 22 ± 1°C using an active culture of *Saccharomyces cerevisiae* var. *ellipsoideus* at 5% level. Once the value of TSS became stable, it was siphoned/racked, filtered and subsequently, allowed for maturation for a period of 6 months at room temperature. From the base wine, a portion was distilled for brandy preparation according to the standard method (Amerine et al. 1980).

Extract of selected spices and herbs was prepared according to the method of Amerine et al (1980) and was used in vermouth preparation by different treatments at 10% level, on the basis of earlier trials carried out to find the optimum levels of spice/herbal extract to be used. These comprised of black pepper (*Piper nigrum* L.) 0.75 g; coriander (*Coriander sativum* L.) 0.70 g; cumin (*Cuminum cyminum* L.) 0.50 g; clove (*Syzygium aromaticum* L.) 0.25 g; large cardamom (*Amomum subulatim* Roxb.) 0.50 g; saffron (*Crocus sativus* L.) 0.01 g; fenugreek (*Trigonella foenumgreccum* L.) 0.50 g; nutmeg (*Myristica fragrans* Houtt.) 0.25 g; cinnamon (*Cinnamomum zeylanicum* Beryn.) 0.50 g; poppy seed (*Papaver somniferum* L.) 1.00 g; ginger (*Zingiber officinale* Rosc.) 1.00 g; woodfordia (*Woodfordia floribunda*) 0.25 g; asparagus (*Asparagus* sp.) 0.10 g; withania (*Withania somnifera*) 0.20 g; adhatoda (*Adhatoda* sp) 0.25 g; rosemary (*Rosmarinus officinalis*) 0.10 g; per litre. In the preparation of vermouth, alcohol level of the base wine was raised to 15-19% with sand pear brandy (65% alcohol; v/v) followed by addition of herbal/spice extract. The TSS was raised by 5% with addition of sugar syrup (70°B) in case of sweet vermouth only. Sulphur dioxide at 50 ppm was also added prior to bottling, and later kept for maturation for a period of 3 months at room temperature.

The products were analysed for the following: TSS using hand refractometer; colour with a Lovibond tintometer (Ranganna 1986); pH in a digital pH meter; acidity by titration; volatile acidity, alcohol, total phenols, aldehydes, esters, sugars and ascorbic acid according to the standard methods (Pilone et al. 1972; Caputi et al. 1968; Amerine and Ough 1974; Singleton and Rossi 1965; Libraty 1961; AOAC 1980). The samples were also enumerated for standard plate counts (SPC) (Harrigan and McCance 1966).

Sensory analysis of the products was carried out by getting scores for individual attributes with the help of trained panel of judges. The data obtained for the physico-chemical characteristics were analysed by completely randomised block

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design (CRD) and that of sensory evaluation by randomised block design (RBD) (Cochran and Cox 1963; Mahony 1985).

The physico-chemical characteristics of sand pear base wine (Table 1) were comparable to those of other similar wines (Amerine et al. 1980) and possessed the requirements as a base wine for the preparation of vermouth. The results presented in Table 1, shows that sand pear vermouth having 11, 15 and 19% alcohol levels, did not exhibit any marked differences when analysed for various parameters as described earlier. Sweet vermouth had a higher TSS of 13-15°B as against dry vermouth (8.5 – 10.4°B). A slight decrease in the titratable acidity was observed in vermouth (0.431 – 0.448%) from that of base wine, which may be due to the process of maturation and/or addition of brandy. Sediment was found to increase with increase in alcohol level and sweet products showed comparatively more sediment than that by the dry ones, indicating occurrence of precipitation during maturation process. The colour values remained the same, thereby indicating no interference from the addition of herbal extract.

With reference to biochemical characteristics (Table 1), reducing and total sugars were not detected in sand pear wine and dry vermouth. The volatile acidity (%AA), recorded in the range of 0.034 to 0.045, were within the legal limits specified for wine (Amerine et al. 1980). There was an increase in the content of aldehydes (126 – 137 mg/l), total phenols (244 – 277 mg/l) and esters (215 – 286 mg/l) in vermouth over that of base wine and it was invariably more in sweeter products. These higher values in vermouth may be attributed to the addition of extract of herbs/ spices and partly to maturation process, an observation made in an earlier study (Amerine et al. 1954).

The different products, when analysed for SPC, showed no microbial counts. This may be attributed to the low pH and presence of KMS in the products.

Considering the sensory parameters like aroma, taste and overall quality, the sweet vermouths were

TABLE 1. PHYSICO-CHEMICAL CHARACTERISTICS OF SAND PEAR VERMOUTH WITH DIFFERENT ETHANOL LEVELS.

Characteristics	Dry vermouth Ethanol levels (%)			Sweet vermouth Ethanol levels (%)			Sand pear base wine	C. D. (p = 0.05)
	11	15	19	11	15	19		
Total soluble solids, °B	8.50	9.50	10.40	13.00	13.00	15.00	8.10	0.17
Titratable acidity, % MA	0.44	0.43	0.45	0.44	0.44	0.47	0.48	0.01
Sediment, %	0.30	0.92	1.38	0.60	1.22	1.53	-	0.01
pH	3.89	3.97	3.72	3.95	3.95	3.68	3.99	0.05
Optical density, 440 nm	0.70	0.64	0.52	0.60	0.58	0.49	0.64	0.02
Colour units								
Red	3.00	3.0	2.0	3.0	3.0	2.0	3.0	NS
Yellow	10.00	10.0	10.0	10.0	10.0	10.0	10.0	NS
Blue	0.01	0.1	0.0	0.0	0.1	0.0	0.01	NS
Reducing sugars, %		Not detected		3.90	4.17	4.58	ND	0.09
Total sugars, %		Not detected		4.14	4.35	4.68	ND	0.08
Volatile acidity, %AA	0.04	0.04	0.03	0.05	0.04	0.04	0.04	0.003
Ascorbic acid, mg/100 ml	5.50	5.40	5.60	5.50	5.50	5.60	6.60	0.28
Total phenols, mg/l	277	274	260	266	264	244	226	3.4
Aldehydes, mg/l	126	130	135	129	133	137	104	1.04
Esters, mg/l	201	215	248	235	268	286	198	0.92

ND = Not Detected NS = Not significant

TABLE 2. SENSORY ANALYSIS OF SAND PEAR VERMOUTH OF DIFFERENT TREATMENTS

Treatments	Colour	Body & appearance	Aroma	Taste	Astringency	Overall quality
Sand pear vermouth (ethanol 11%)						
Dry vermouth	12.8	15.3	12.3	12.3	12.8	11.5
Sweet vermouth	14.1	14.0	14.8	16.0	15.3	15.0
Sand pear vermouth (ethanol 15%)						
Dry vermouth	15.8	15.5	14.6	12.0	13.8	12.3
Sweet vermouth	13.9	12.8	15.1	16.6	14.6	16.5
Sand pear vermouth (ethanol 19%)						
Dry vermouth	14.5	15.8	12.3	10.6	11.8	11.0
Sweet vermouth	16.0	12.8	16.3	15.3	15.6	15.4
Sand pear base wine						
Sand pear wine	15.8	11.6	13.1	15.3	14.1	14.0
C. D. (P = 0.05)	3.2	3.2	3.2	3.2	NS	3.2

Sensory attributes: Colour, Body & appearance, Aroma, Taste, Astringency, Overall quality.

preferred (Table 2). The sweet vermouth with 15% alcohol was scored as the most acceptable product. The present study suggests the possibility of preparing vermouth with good colour, aroma and taste from sand pear base wine.

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Occurrence of Enterotoxigenic *Salmonella* Serotypes in Seafoods

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Nine samples, comprising 2 prawns and 7 fishes collected from Calcutta market, were positive for the presence of *Salmonella*. A total of 17 isolates belonging to five serotypes namely *S.I* 4,12:b:- (monophasic) (7); *S. paratyphi* B var *java* (7); *S. javiana* (1); *S. typhimurium* (1); and *S.I* 9,12:r:1, 5 (1) were isolated. Serotypes *S.I* 4,12:b:- (monophasic) and *S.I.* 9,12:r:1, 5 were isolated from fish and seafoods. Sodium desoxycholate (0.3%) treatment of *Salmonella* cultures was found effective to release enterotoxin from all the 17 isolates, as determined by mouse foot pad test (MFPT) and vasopermeability factor test (VPFT).

Keywords : *Salmonella*, Serotypes, Enterotoxigenicity, Seafoods, Sodium desoxycholate.

Foodborne salmonellosis has been widely reported (Sayler et al. 1976; Majorri et al. 1977; Roumani et al. 1981; Bachhil and Jaiswal 1988; Rao 1983). A number of *Salmonella* serotypes responsible for foodborne infection have also been isolated (Fraiser and Koburger 1984; Gerigk, 1985; Iyer et al. 1986; Singh et al. 1992). Diarrhoea has been the common symptom in a majority of salmonellosis outbreaks. Due to cell-wall bound nature of enterotoxins (Parker 1984) and the speical techniques needed to release enterotoxin (Houston et al. 1981; Harne et al. 1990), only a few *Salmonella* isolates have been proved to be enterotoxigenic. Considering the importance of foodborne salmonellosis, an attempt was made in the present study to find out the occurrence of *Salmonella* serotypes in a few selected seafoods and test for their enterotoxigenicity.

Swabs were prepared from the slime of skin/ gills of samples comprising of 13 seafish and 6 sea prawns, collected from the markets of Calcutta. Swabs were immediately transferred into Cary and Blair (Difco) transport media vials and brought to laboratory under ice. The samples were processed for isolation of *Salmonella* as per the procedure recommended by the International Commission on Microbiological Specifications for Foods (ICMSF 1978). Serotyping of *Salmonella* isolates was done as described by Edwards and Ewing (1972).

Cell-free culture filtrates (CFCF) of *Salmonella* isolates were prepared as described by Singh et al. (1992) for testing of enterotoxigenicity by growing the cultures in brain heart infusion (BHI) broth for 18 h at 37°C. Half of the incubated culture was, then treated with 0.3% sodium desoxycholate for 30 min. The BHI broth cultures, both treated and untreated, were centrifuged at 5000 rpm for 30 min at 4°C and supernatants were sterilized through membrane filters (0.45 µm). Filtrates were stored at 4°C until further use. Enterotoxigenicity of the *Salmonella* CFCFs was determined by vasopermeability factor test (VPFT) (Sanderfur and Peterson 1976) and mouse foot pad test (MFPT) (Singh et al. 1992).

Salmonella serotypes, isolated from samples of marine prawn and fish, are presented in Table 1. Most of the seafood samples were contaminated

TABLE 1. SEROTYPES OF *SALMONELLA* ISOLATED FROM SEAFOODS

Type of seafood	Number of samples (Examined)	(Positive for *Salmonella*)	Serotypes
Marine prawn	6	2	*S. paratyphi* B var *java* (1)
			S.I. 4,12,b:-(2)
Marine fish	13	7	*S. paratyphi* B var *java* (6)
			S. javiana (1)
			S.I. 4,12,b:-(5)
			S.I. 9,12,r:1,5 (1)
			S. typhimurium (1)

Figures in parenthesis indicate the number of seafood samples contaminated with the serotype of *Salmonella*.

with more than one serotype, except a prawn and a fish which were contaminated only with *SI* 4, 12:b:- and *S. javiana*, respectively.

Results of enterotoxigenicity tests (Table 2) show that *S. javiana* and *S.I* 9,12, r:1,5 were non-enterotoxigenic, while four *S. paratyphi* B var *java*, three *S.I* 4,12, b:- and one *S. typhimurium* isolates were enterotoxigenic in the absence of treatment with 0.3% sodium desoxycholate. After the treatment of *Salmonella* cultures with 0.3% sodium desoxycholate for 30 min, all the isolates gave

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TABLE 2. ENTEROTOXICITY OF *SALMONELLA* ISOLATES

Serotypes	Cell-free culture filtrates			
	Untreated		Treated*	
	MFPT	VPFT	MFPT	VPFT
	(Isolates positive)			
S. paratyphi B var. *java* (7)	4	4	7	7
S. I. 4,12,b:-(7)	3	2	7	7
S. javiana (1)	Nil	Nil	1	1
S. typhimurium (1)	1	1	1	1
S. I. 9,12,r:1,5	1	Nil	1	1

* Treatment of cultures with 0.3% sodium desoxycholate.
Figures in parenthesis are the number of isolates tested.
MFPT = Mouse foot pad test.
VPFT = Vasopermeability factor test.

positive reaction for enterotoxicity tests with VPFT and MFPT.

Salmonellosis is considered as one of the most significant diseases because of its persistent prevalence even in developed countries. The causative agent has been isolated from various countries including India (Fraiser and Koburger 1984; Parker 1984; Singh et al. 1992). Isolation of *Salmonellae* from seafoods are of public health significance as *S. paratyphi* B, an important human pathogen, has been isolated from 7 samples out of 19 tested. Further, 7 isolates of *S. I.* 4,12:b:- (monophasic) and one *S. I.* 9,12,r:1, 5 have been reported from seafoods in India. It poses a serious threat to fish consumers. *Salmonella javiana* has also been reported in India from fish in Calcutta area. *Salmonella typhimurium*, a well known zoonotic enterotoxigenic and foodborne *Salmonella* (Parker 1984) has also been recorded in this study. Further, the treatment of *Salmonella* cultures with 0.3% sodium desoxycholate produced reproducible results with regard to release of enterotoxin, an observation of significance from the point of public health aspects.

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Preparation and Storage Stability of Pickled Poultry Eggs

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Poultry eggs, pickled in vinegar and stored upto 3 months at ambient and refrigeration temperatures, were rated moderately acceptable to very acceptable during the entire storage. Standard bacterial plate counts were below 10^5 in samples stored at ambient temperature and negligible in refrigerated samples. Yeast and mould counts were absent in both samples, while pH remained unchanged. The cost of production of pickled eggs packed in HDPE bags was approximately Rs. 25/20 eggs.

Keywords : Poultry eggs, Pickling, Vinegar, Storage, Microbial changes, Sensory evaluation.

Pickling of food items has been a practice since long, as a means of preservation and imparting desirable taste and flavour to the food. Several recipes of vegetable pickle in oil or in vinegar are in practice in different parts of the country (Singh and Bano 1977; Raikhy and Bawa 1992). Processes have been developed for pickling chicken eggs, using organic acidulants with or without common salt, sugar and spices (Acton and Johnson 1973; Ball and Saffores 1973; Essary and Georgiades 1982; Stadelman et al. 1982). In India, most of the work has been done on pickling of quail eggs and their keeping quality in various packaging materials (Panda et al. 1979; Singh and Panda 1989; Singh et al. 1989, Srivastava and Panda 1976). Increased production of poultry eggs in the country offers a good scope for utilization of pickled poultry eggs. The present study was undertaken to standardize the procedure for preparation of pickled poultry eggs in vinegar, together with other additives and assessment of its storage stability under ambient and refrigerated conditions.

Fresh poultry eggs were held for 24 h at ambient temperature and then cooked in simmering water containing 2% (w/v) common salt for 10 min. The eggs were cooled in cold water, peeled and washed. The ingredients used for pickling 30 eggs consisted of white vinegar 500 ml, water 500 ml, common salt 80 g spice mixture 25 g ginger and garlic 45 g. The formulation of spice mixture consisted of anise 10, red chilli 20, cardamom 10, caraway 10, cinnamon 10, clove 2.5, cumin 20, black pepper 7.5 and turmeric 10 parts. Vinegar and water were boiled first and then salt, spices and ginger - garlic mixture were added one after another. Pickle solution was boiled for 10 min with continuous agitation and poured hot (75°C) over the peeled eggs in high density plastic jars, capped and seasoned at ambient (25°C) temperature for 48 h. For storage studies, 4 pickled eggs were packed in high density polyethylene (HDPE) bags and stored at ambient (25°C, RH 60%) and refrigeration (6°C, RH 80%) temperatures.

The samples were analysed for pH, standard plate counts, yeast and mould, while organoleptic evaluation was carried out at fortnightly intervals upto three months. Microbial analysis was done as per Nordic Methodisk (1970) and Cowan and Steel (1970). Organoleptic evaluation was conducted by a group of six semi-trained panelists drawn from the professional staff of the Institute. The panel rated each sample at random using eight point Hedonic scale for colour, appearance, flavour, texture and overall acceptablility (8 = extremely acceptable, 1 = extremely unacceptable). Saltiness and sourness (acidic taste) were rated on four point scale, with a score of 4 being liked very much and 1 being disliked very much. Refrigerated samples were allowed to attain room temperature prior to organoleptic evaluation.

The pH of freshly boiled egg was 5.8 and it reduced to 4.1 after 48 h of seasoning at ambient temperature, and then remained more or less constant for 3 months at ambient or refrigeration temperatures, agreeing with earlier findings in pickled quail eggs (Singh et al. 1989). Standard plate counts in samples stored at ambient temperature were below 10^5, but almost negligible in refrigerated samples. Yeast and mould were absent in both the cases. Similar lower aerobic plate counts were observed in quail eggs by Singh and Panda (1989) and Singh et al (1998), due to the inhibitory effect of low pH of the product on multiplication of bacteria (Acton and Johnson 1973; Levine and Fellers 1940). Microbial quality

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TABLE 1. ORGANOLEPTIC EVALUATION SCORES OF THE PICKLED EGGS

Storage period, Days	Appearance A	Appearance B	Flavour A	Flavour B	Texture A	Texture B	Sourness/saltiness A	Sourness/saltiness B	Overall acceptablility A	Overall acceptablility B
0	6.2 ± 0.3	–	6.4 ± 0.2	–	6.8 ± 0.3	-	3.7 ± 0.4	–	6.3 ± 0.2	–
15	6.2 ± 0.2	6.2 ± 0.2	6.0 ± 0.0	5.8 ± 0.2	6.2 ± 0.2	6.2 ± 0.2	3.0 ± 0.0	3.8 ± 0.2	6.2 ± 0.2	6.6 ± 0.2
30	6.0 ± 0.0	6.0 ± 0.0	6.2 ± 0.2	6.0 ± 0.4	6.4 ± 0.2	6.2 ± 0.2	3.2 ± 0.2	3.0 ± 0.0	6.4 ± 0.2	6.2 ± 0.2
45	6.1 ± 0.3	6.5 ± 0.3	6.0 ± 0.2	6.0 ± 0.0	6.4 ± 0.2	6.0 ± 0.0	3.1 ± 0.1	3.2 ± 0.2	5.9 ± 0.1	6.5 ± 0.2
60	6.5 ± 0.3	6.0 ± 0.2	6.2 ± 0.4	7.0 ± 0.0	6.2 ± 0.4	6.6 ± 0.2	3.4 ± 0.2	3.4 ± 0.2	6.2 ± 0.4	6.8 ± 0.0
75	6.5 ± 0.2	6.7 ± 0.2	6.3 ± 0.1	6.4 ± 0.1	6.5 ± 0.2	6.6 ± 0.2	3.5 ± 0.2	3.5 ± 0.2	6.5 ± 0.3	6.8 ± 0.0
90	6.1 ± 0.1	6.7 ± 0.2	6.0 ± 0.2	6.2 ± 0.5	6.3 ± 0.2	6.5 ± 0.2	3.1 ± 0.1	3.3 ± 0.2	6.1 ± 0.1	6.7 ± 0.2

A : Ambient condition (25°C, 60% RH), B : Refrigeration (6°C, 80% RH)
Each value is a mean of 6 observations. The standard error ranged between 0–0.5 in all the cases.

of pickled eggs was more dependent on the acid strength of pickling medium than the storage temperature.

Sensory scores of pickled eggs stored at ambient and refrigerated temperatures did not differ significantly during the entire storage period. Samples were moderately acceptable to very acceptable (Table 1). However, refrigerated samples were more preferred by the panelists than the other samples. These results suggest that pickled poultry eggs can be safely preserved for 3 months in HDPE film pouches at ambient and refrigeration temperatures. Cost of production of pickled poultry eggs, packed in HDPE bags, was around Rs. 25/ 20 eggs. This total cost includes cost of eggs, Rs. 20; HDPE bags, Rs. 0.15; spices, Re. 1.00; vinegar, Rs. 2.60; and fuel, Rs. 1.25.

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Total Soluble Solids, Acidity, pH and Standard Plate Counts in the Indian Honey as Affected by Different Treatments and Storage Conditions

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During storage of honey for 4 months, the total soluble solids increased from 81.5% to 82.26 %, whereas acidity increased from 2.47 to 3.05 m.e./100 g, and pH declined from 4.1 to 3.7 after storage of 6 months. Heating at 60°C, addition of potassium metabisulphite (80 ppm) and temperature of storage (room temperature, 5°C and 40°C) did not affect the total soluble solids, pH and acidity of honey. The standard plate counts were the highest (6.5 x 10^2 CFU/g) in unheated fresh honey and lowest (4.45 x 10^2 CFU/g) in honey subjected to heating and stored at 5°C. The standard plate counts of the honey samples declined with storage.

Keywords : Honey, Storage temperature, Total soluble solids, Acidity, pH, Standard plate counts.

Honey, a delicious and viscous food, is prepared by bees from the nectar of flowers. India produces about 7759 metric tonnes of apiary honey annually, valued at Rs. 233 millions (Rs. 30/kg). The output of honey from Himachal Pradesh is about 150 metric tonnes (Goyal and Gupta 1992). The honey remains on the market shelf for about a year. In order to ensure lucrative prices, the honey should retain its liquid form and attractive appearance, besides being free from fermentation. Heating is used to control the deteriorative changes, but it may impair the sensory qualities of the product. Fermentation is a major drawback, which adversely affects the sale value of honey. A knowledge of the types of microorganisms found in honey is desirable from the view point of minimising chances of fermentation. Some studies have been done earlier on the composition of *Apis dorasta* honey collected from different localities (Mann et al. 1970). In our earlier work (Gupta et al. 1992), it was observed that the storage of honey at 40°C resulted in deterioration of colour, though granulation was prevented. Similarly, the addition of potassium metabisulphite reduced the extent of colour darkening, while the honey stored at 5°C was found to be the best in terms of sensory qualities. The effects of different treatments and storage periods on the total soluble solids (TSS), acidity, pH and standard plate counts are described in this communication.

The preparation of honey samples for the experiments and the details of treatments were the same as described in an earlier paper (Gupta et al. 1992). The TSS of honey was determined by refractometer, while acidity was measured by titrating honey solution against standard sodium hydroxide (Deans 1963). The pH was measured using pH meter. The standard plate counts (SPC) were determined by pour plate technique using plate count agar (Harrigan and McCance 1966). The data were analysed statistically.

The initial TSS of honey (81.5%) increased significantly ($P \leq 0.05$) to 82.26% after storage of 4 months, and the subsequent storage for next 2; months showed no significant change. Heating or addition of potassium metabisulphite also did not significantly affect the TSS of honey. The acidity of honey increased significantly ($P \leq 0.05$) from 2.47 to 2.72, 2.92 and 3.95 m.e./100 g after 2, 4 and 6 months of storage, respectively. The increase in acidity during storage might be due to the microbial action on sugars and consequent production of acids. White et al (1962) also observed a significant increase in acidity during storage of 10 types of honey for 2 years at room temperature. Interestingly, Wootton et al. (1976) found an increase in acidity of four types of honey, but decrease in two types of honey, when stored at 50°C for 44 days. It, thus, seems that the changes in acidity of honey during storage are dependent on the type of honey, especially under different storage conditions. The pH of the honey decreased from 4.1 to 3.7 during storage, and is consistent with the increase in acidity.

The standard plate counts (SPC) were 6.5 x 10^2 CFU/g of the unheated honey at the start of experiment (Table 1). According to White (1975), the yeast count of honey may range from 10 to 10,000/ g, the greatest number usually being associated

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TABLE 1. EFFECT OF DIFFERENT TREATMENTS AND STORAGE PERIODS ON THE STANDARD PLATE COUNT (CFU X 10^2/g) OF HONEY

Treatments	Storage period, months: 2	4	6
		Room temp. (7 - 30°C)	
Unheated	6.10	6.02	6.00
Unheated, KMS treated	5.97	5.85	5.80
Heated	4.80	4.70	4.65
		5°C	
Unheated	5.95	6.00	5.60
Unheated, KMS treated	5.84	5.70	5.45
Heated	4.75	4.60	4.45
		40°C	
Unheated	6.00	5.90	5.70
Unheated, KMS treated	6.00	5.80	5.65
Heated	4.90	4.85	4.70

The initial standard plate counts were 6.50, 5.95 and 4.95 CFU x 10^2/g in unheated; unheated, KMS treated; and heated honey samples

with highest moisture content. It is well known that, in addition to osmophilic yeasts, a number of bacteria can also survive in honey for variable periods (Mitamura et al. 1979; Butta et al. 1983). Heating of honey at 60°C for 30 min resulted in reduction of standard plate counts as compared to those in unheated and the honey with potassium metabisulphite. Unheated honey with potassium metabisulphite showed lower standard plate counts. The number of CFU in different treatments ranged between 4.45 and 6.5 X 10^2. The highest standard plate counts were in the unheated honey and the least in the heated honey stored for 6 months at 5°C. There was a decrease in the standard plate counts of honey during storage. The presence of microbes in honey apparently was due to contamination during its extraction, but high soluble solids might have prevented their multiplication. Despite the presence of microbes in honey of various treatments, there was no apparent spoilage manifestations in any of the honey samples, thereby suggesting that the honey could be stored for a period of 6 months without spoilage, in spite of high initial standard plate counts.

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Cultivation of *Pleurotus platypus* and *Pleurotus sajor-caju* in Imphal

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Cultivation of *Pleurotus platypus* and *P. sajor-caju* was studied using three different agricultural and forest residues in Imphal, Manipur, along with the characterization of the fungal aerospora of the growing room. Both the mushrooms gave maximum yield on hot water treated paddy straw with a biological efficiency of 70 and 60%, respectively. It was followed by cold water treated paddy straw, saw-dust and pine needles in the descending order. The concentration of the fungal spores inside the growing room was maximum (15×10^5 and 12×10^5 spores/m^3 of air during the fruiting and post-harvest period of the mushroom, respectively).

Keywords : *Pleurotus*, Cultivation, Agricultural and forest residues, Aerospora of growing room, Treatment of substrate.

Manipur, being an agrarian State, depends largely on agriculture for its socio-economic development. Large quantities of different agro-wastes and forest byproducts are available in the State. However, only small amounts of these are used as cattle feed and at times, create disposal problems. In many cases, these are either burnt or allowed to rot, thereby resulting in environmental pollution. Higher fungi, including mushrooms, utilize lignocelluloses as food for their growth through enzymatic degradation (Lu et al. 1988). The yield of cultivated mushrooms was found to be closely related to the type of the substrate, substrate treatment, environmental conditions and degree of diseases of mushrooms (Bahukhandi and Munjal 1989; Bano et al. 1987; Block et al 1958; Rajarathnam et al. 1983). Weed fungi and other microorganisms also play an important role in attacking either the crop itself or compete for space and nutrition (Bahukhandi and Munjal 1989; Bano et al. 1987; Block et al. 1958). This has been overcome by treating the substrates with hot water or chemicals (Pandey and Tewari 1989; Rajarathnam et al. 1983). Species of *Pleurotus* and other cultivated mushrooms are reported to release thousands of spores in the growing room (Lacey 1974), which have a profound effect on the health of workers causing allergy and other respiratory ailments (Gandy 1955; Kondo 1969; Lacey 1974. Symington et al. 1981).

Nutritional and toxicological aspects of *pleurotus* spp have also been studied by various workers (Mukta Singh et al. 1991; Gupta and Majumdar 1991). The present investigation was undertaken to study the effect of substrate like paddy straw, pine needles and broad leaved sawdust on yield of *Pleurotus platypus* (Cooke and Masses) Sacc. and *P. sajor-caju* (Fr.) Sing. The aerospora of the growing room was also characterized. Besides, microbial pollutants of paddy straw are also known to have an adverse effect on growth (Sathe and Dighe 1991)

Pure cultures of *Pleurotus platypus* and *P. sajor-caju* were obtained from Indian Council of Agricultural Research Complex for North Eastern Region, Barapani, Meghalaya and were maintained on potato-dextrose-agar. Wheat grain spawn was prepared for inoculation of the different substrates (Martinez and Guzman 1987). Three different substrates, such as paddy straw, pine needles and broad leaved sawdust were used. The paddy straw and pine needles were chopped into 3-5 cm length size, and steeped either in cold water overnight or hot water (80-90°C) for 20 min. After cooling and removal of excess water, the substrate (500 g on dry weight basis) and 100 g grain spawn were mixed thoroughly, and filled in transparent polythene bags of 35 x 50 cm size. The open ends of the bags were closed securely with rubber bands and incubated in a warm room (20 - 25°C). However, the sawdust was mixed with rice bran (10%). $CaCO_3$ (0.2%) and water (65-70%) before pasteurization by steaming for 30 min on three consecutive days. After cooling, holes were made with sterile glass rod for inoculation with spawn grain and incubated as in the first case. Three replications were taken for each treatment. The mycelial run was completed within 12-15 days in the case of paddy straw and pine-needle substrate. However, it took 18 - 20 days for sawdust substrate. All the bags were cut open, when the mycelial run was completed and

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all the optimum cultural practices for fruiting were followed (Goswami et al. 1987). The fresh weight of mushrooms was recorded upto third flushes, and the biological efficiency of each treatment was calculated.

The air spora of the growing room (3 m x 2.7 m x 4.8 m) having a door and window was studied using a rotorod air sampler (Tilak 1982). The sampler was located at 60 cm above the ground level and operated for 5 min to avoid overcrowding of the spores in the sampler during spawn running stage, fruiting stage and post-harvesting period. The trapped fungal spores were identified depending on their morphological characters and visual identification by comparing with reference slides (Gregory 1961). The sampler being volumetric, the number of spores/m³ of air was calculated by multiplying the total number of spores by a constant factor of 5 in all the cases.

The data on the yield of *P. platypus* and P. *sajor-caju* on paddy straw, pine needles and saw-dust (Table 1) showed that *P. sajor-caju* performed better than *P. platypus* in all the treatments. Highest yield of 70% was obtained in case of *P.sajor-caju* cultivated on paddy straw treated with hot water. Thus, the present findings are in conformity with the findings of previous workers (Bahukhandi and Munjal 1989; Bano et al. 1987; Block et al. 1958; Rajarathnam et al. 1983). These workers recorded the highest yield of *P. sajor-caju* and *P. flabellatus* on hot water treated paddy straw.

TABLE 1. YIELD OF *PLEUROTUS PLATYPUS* AND *P. SAJOR-CAJU* ON DIFFERENT SUBSTRATES.

Substrate	Treatment	Mean yield of fresh mushroom, g/500 g dry substrate	
		P. platypus	*P. sajor-caju*
Paddy straw	Hot water	330 (66.0)	350 (70.0)
	Cold water	250 (50.0)	290 (58.0)
Pine needles	Hot water	144 (28.8)	150 (30.0)
	Cold water	194 (45.0)	106 (21.2)
Sawdust	Steaming	140 (48.0)	250 (50.0)

Figures in parenthesis indicate biological efficiency of each treatment.

Table 2 shows the indoor air spora of *Pleurotus* growing room during spawn running, fruiting and post-harvest stages. During the spawn running stage, the most dominant fungal spores were those of penicilli and aspergilli. The drastic increase in the microbial population during fruiting and post harvesting stages may be due to liberation of thousands of spores by *Pleurotus* species (Lacey 1974). The spores of *Pleurotus* species were reported to have high penetrating power deep inside the human system, thereby encouraging many respiratory diseases (Lacey 1974). It is, therefore, suggested to make efforts to develop sporeless strains of these cultivated fungi so that the hazards caused by their spores may be reduced.

TABLE 2. AIR SPORA OF *PLEUROTUS* GROWING ROOM (SPORES/M³ AIR)

Spore type	Spawn running	Fruiting	After harvest
Aspergilli/Penicilli	195	215	230
Bispora sp.	5	000	000
Chaetomium sp.	000	15	5
Cladosporium	20	10	5
Cunninghamella sp.	20	30	15
Curvularia sp.	45	40	50
Didymosphaeria sp.	10	000	5
Exosporium sp.	15	5	5
Fusiform types	45	40	40
Hysterium sp.	5	000	000
Lophiostoma sp.	15	5	5
Myrothecium sp.	5	000	000
Memnoniella sp.	5	000	000
Pestalotiopsis sp.	15	5	5
Pleurotus sp.	000	15×10^5	12×10^5
Phaeotrichonis sp.	15	5	000
Pringsheimia sp.	5	000	000
Sporidesmium sp.	5	000	000
Smut spores	5	000	000
Theilaviopsis sp.	25	15	5
Torula sp.	20	5	000
Triploa sp.	15	000	000
Tichocladium sp.	15	5	000
Algal mycelium	20	5	10
Mycelium fragments	5	15	25
Mites	5	5	5
Unidentified types	20	10	5
Total	555	1500430	1200420

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Occurrence of *Salmonella* in Eggs and Meat

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Samples of poultry meat (9%), egg shell (4.9%) and egg yolk (0.9%) were found to contain *Salmonella* serotypes viz., *Salmonella typhimurium, S. infantis, S. newport, S. tennessee, S. bareilly* and *S. gallinarum*. Samples of sheep meat and edible organs of sheep and poultry were free from *Salmonella*. Gentamicin was most effective against *Salmonella* cultures.

Keywords : *Salmonella* serotypes, Egg shell, Egg yolk, Antibiotics, Poultry and sheep meat.

The wide distribution of *Salmonella* in livestock and poultry makes the meat and eggs as one of the major vehicles of transmission of these organisms to man (Paturkar et al. 1992; Rao 1983; Bachhil and Jaiswal 1988). In a study of 61 outbreaks of *Salmonella* food poisoning, eggs and egg products accounted for 23, chicken and turkey for 16, beef and pork for 8 and other foods for 14 outbreaks (Steele and Galton 1967). Status of *Salmonella* infection, as transmitted through food, is obscure in India, but their presence is certain in outbreaks of gastroenteritis due to consumption of milk and milk products (Mathur 1959; Agarwal et al. 1970). In the present study, an attempt was made to determine the extent of involvement of *Salmonella* in poultry eggs, meat of poultry as well as sheep and the antibiotic sensitivity test on isolated serotypes of *Salmonella*. Such data can identify the antibiotics suitable for the control of meat/egg borne salmonellosis.

Six hundred and nine samples, comprising 100 of poultry meat, 101 of edible organs (liver and heart) of poultry as well as 102 each of sheep meat, edible organs (liver and kidney) of sheep and poultry eggs, were collected from local markets, slaughterhouses and various poultry farms. Outer surfaces of shell and yolk of each egg were tested as two different samples. The samples of edible organs were constituted by mincing equal quantities of organs. The samples of eggs and meat were processed as per the procedures of AAVLD (1976) and Leusden et al (1982), respectively, using tetrathionate broth as enrichment and brilliant green-agar (BGA) as selective media. Suspected colonies of *Salmonella* on BGA were purified and identified (Cowan 1977). Biochemically identified isolates of *Salmonella* were serotyped at National *Salmonella* and *Escherichia* Centre, Kasauli. Antibiotic sensitivity patterns of isolates were determined by the *in vitro* single disc diffusion technique (Bauer et al. 1966) using nutrient agar. The antibiotics tested were, penicillin (10 units), ampicillin (10 μg), cloxacillin (1 μg), streptomycin (10 μg). neomycin (30 μg), gentamicin (10 μg), oxytetracycline (30 μg), chloramphenicol (30 μg), erythromycin (15 μg), lincomycin (2 μg), polymyxin-B (300 units), nalidixic acid (30 μg), nitrofurantoin (300 μg), furazolidone (300 μg), cephaloridine (30 μg) and cotrimoxazole (25 μg). Results were interpreted as per zone size standards given by manufacturers (HiMedia Laboratories).

Five of the 102 (4.9%) samples of egg shell, one of the 102 (0.98%) of egg yolk and 9 of the 100 (9%) of poultry meat were found positive for *Salmonella*, while all the samples of sheep meat (102), edible organs of sheep (102) as well as poultry (101) were free from *Salmonella*. These isolates of *Salmonella* belonged to six serotypes (Table 1). Antibiotic susceptibility test on 11 isolates of *Salmonella [S. infantis (4), S. bareilly (3) and S. newport (4)]* revealed that all were sensitive to gentamicin, chloramphenicol, streptomycin and cotrimoxazole, but were resistant to erythromycin, cephaloridine, penicillin and ampicillin. However,

TABLE 1. *SALMONELLA* SEROTYPES ISOLATED FROM EGGS AND POULTRY MEAT

Sample type	Serotypes isolated	Antigenic structure
Egg shell	*S. infantis* (3)	6,7:r:1,5
	S. newport (1)	6,8:e,h:1,2
	S. tennessee (1)	6,7:z_{29}:-
Egg yolk	*S. infantis* (1)	6,7:r:1,5
Poultry meat	*S. newport* (3)	6,8:e,h:1,2
	S. bareilly (3)	6,7:y:1,5
	S. typhimurium (2)	4,5,12:i:1,2
	S. gallinarum (1)	9,12 :- : -

Figures in parenthesis indicate the number of isolates.

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the sensitivity to oxytetracycline, nitrofurantoin, nalidixic acid, polymyxin-B, furazolidone and neomycin was variable. Only one of the two isolates of *S. typhimurium* selected was sensitive to gentamicin, furazolidone, nitrofurantoin and nalidixic acid, while the other was resistant to all antibiotics tested. *S.tennessee* was sensitive to nitrofurantoin, chloramphenicol, gentamicin, furazolidone, streptomycin and cotrimoxazole, while *S. gallinarum* was sensitive to nitrofurantoin, nalidixic acid, gentamicin, polymyxin-B, chloramphenical and furazolidone. The isolates of *S. tennessee* and *S. gallinarum* were, however, resistant to remaining antibiotics used in this study.

In the present investigation, 5 of the 102 (4.9%) samples of egg shell were *Salmonella* positive and the isolates of *Salmonella* were serotyped as *S. infantis*, *S. newport* and *S. tennessee* (Table 1). Isolation of *S. newport* and *S. infantis* from shells of eggs have been reported earlier by D'Aoust et al (1980) and Alboudi et al (1989), but isolation of *S. tennessee* from egg shell seems to be the first report. However, Tamasikova and Kovacova (1985) isolated this serotype from dried egg products. One hundred of the 101 egg yolk samples were found to be free from *Salmonella*. However, the isolation of *S. infantis* from yolk of one egg is in agreement with the earlier finding of D'Aoust et al (1980). *S. enteritidis* from hens' egg contents has also been isolated earlier (Humphrey et al. 1991).

The isolation of *S. gallinarum*, *S. newport*, *S. bareilly* and *S. typhimurium* from the poultry meat has been reported earlier (Panda 1973; Saxena et al. 1983). Except *S. gallinarum*, these serotypes of *Salmonella* are among the ten most frequently isolated serotypes from human sources in India. Consumption of uncooked or inadequately cooked meat of poultry may, therefore, be an important vehicle of *Salmonella* infection to human beings.

Fourteen of the 15 (93.3%) strains of *Salmonella* isolated from eggs/meat were sensitive to gentamicin. Many were resistant to nitrofurantoin (33.3%), oxytetracycline (86.6%), cephaloridine (93.3%), ampicillin (100%) and erythromycin (100%), whereas only 3 of the 15 (20%) strains were resistant to chloramphenicol, streptomycin and cotrimoxazole. Gentamicin may be the drug of choice in containment of meat/egg borne salmonellosis.

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Texture Profile Analysis of *Tofu* and Milk *Paneer* Before and After Deep-Fat-Frying

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A comparative study was carried out on *tofu* and milk *paneer* by employing Instran - 6021. *Tofu* exhibited significantly higher springiness than milk *paneer*. However, fried *tofu* exhibited significantly higher hardness, springiness and chewiness but significantly lower cohesiveness than fried milk *paneer*. The springiness of *tofu* and milk *paneer* remained more or less unaffected by frying, while the other characteristics increased significantly upon frying.

Keywords : *Tofu*, Milk *paneer*, Springiness, Hardness, Chewiness, Texture profile, Deep-fat-frying.

Texture profile analysis is commonly used as an objective method of food texture determination. It yields many textural parameters such as hardness, cohesiveness, springiness, gumminess and chewiness for the product. In the present investigation, the texture profile analysis of *tofu* and milk *paneer*, before and after deep-fat-frying, was studied.

'PK-942' variety of soybean and cow milk were procured, respectively, from the Department of Plant Breeding and the Livestock Research Centre of the University. For making *paneer*, buffalo milk was also used by earlier workers (Bhattacharya et. al. 1971; Sachdeva and Singh 1987). For preparing *tofu*, whole soybeans were soaked in tap water (1:3 w/v) for 8 h, the beans were washed with tap water (3-4 times) and extracted with hot water (85-90°C, 1:10 ratio of bean to water) for 2-3 min in a blender. The slurry was filtered through a double layered cheese cloth and the soy milk thus obtained was boiled for 5 min. It was cooled to 85°C and coagulated for 5 min using calcium chloride solution (10%, w/v). The coagulum was transferred to a perforated wooden box, lined with a double layered cheese cloth, and pressed for 5 min initially with a weight of 2 kg, followed by a weight of 8 kg for another 5 min. *Tofu* was then removed from the wooden box and cooled by dipping in cold water (4°C) for 10-20 min. For preparation of milk *paneer*, the cow milk was boiled for 1 min, cooled to 75°C and coagulated using citric acid solution (10%, w/v). The rest of the steps were same as in case of *tofu*.

Soybean, *tofu* and milk *paneer*, raw as well as fried, were analysed for moisture, protein, fat and ash contents by AOAC (1975) methods. Carbohydrate content was calculated by difference. Texture profile analysis of *tofu* and milk *paneer* was carried out using Instron Universal Testing Machine (Instron Ltd., U. K.) employing the method of Bourne (1978). The Instron crosshead was cycled at a compression speed of 1 mm/sec and a return speed of 16.67 mm/sec, with a stroke length of 7.5 mm. The maximum clearance between the moving cross-head and stationary horizontal bed plate of the machine was 10 mm, while the minimum clearance was 2.5 mm, thereby resulting in 75% compression. Twelve cubical samples (each side 10 mm) were taken out from *tofu* and milk *paneer* using a die. Half of them were deep-fat-fried in refined vegetable oil (hydrogenated fat) (185°C, 4 min).

Each sample was compressed twice to give a first and second bite at room temperature. The different textural parameters, viz., hardness, cohesiveness, springiness, gumminess and chewiness were derived from the texture profile curves (Bourne 1978). The data were analysed statistically on a completely randomized design using analysis of variance technique (Snedecor and Cochran 1968), to determine the significance of the differences.

Table 1 shows the proximate composition of soybean *tofu* and milk *paneer*. From the results,

TABLE 1. PROXIMATE COMPOSITION (DRY WEIGHT BASIS) OF SOYBEAN *TOFU* AND MILK *PANEER*.

Sample	Moisture %	Total solids %	Protein %	Fat %	Ash %
Soybean	10.2	89.6	43.9	23.0	6.5
Unfried *tofu*	74.2	35.8	57.8	24.0	4.0
Fried *tofu*	54.6	45.4	47.4	36.9	ND
Unfried milk *paneer*	61.5	38.5	42.8	42.2	2.8
Fried milk *paneer*	37.2	62.8	40.6	50.7	ND

Average of three determinations. ND = Not determined

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it can be seen that *tofu* contained higher protein, ash and carbohydrates and much lower fat, than milk *paneer*. This shows that *tofu* is more suitable than milk *paneer* for those suffering from cardiac diseases.

Deep-fat-frying of *tofu* and milk *paneer* resulted in expulsion of 26.5 and 39.4% moisture, respectively, with a simultaneous increase in total solids content. After frying, fat content in *tofu* increased by 170.6%, whereas in milk *paneer* it increased by only 95.8%. This implied that the absorption of fat by milk *paneer* was less than that by *tofu* upon deep-fat-frying, but the total fat content of fried milk *paneer* was higher than that of fried *tofu*. The same trend has been reported by Naseem (1982). This might be attributed to the differences in the fat binding capacity of the two proteins, and also in the expulsion of moisture during deep-fat-frying. Increase in protein content was primarily because of expulsion of moisture from *tofu* and milk *paneer* during deep-fat-frying.

Unfried *tofu* exhibited slightly lower hardness, greater cohesiveness, springiness and chewiness, than milk *paneer* (Table 2). However, the differences were significant ($p < 0.01$) for the springiness only. These observations are in agreement with those reported in literature (Sreedharan 1990). In contrast, fried *tofu* showed significantly ($p < 0.01$) higher hardness, springiness and chewiness. The differences in the gumminess of unfried milk *paneer* and *tofu* were non-significant and remained non-significant even after frying. However, cohesiveness of fried milk *paneer* was significantly ($p < 0.01$) higher than that of *tofu*. The springiness of *tofu* and milk *paneer* remained more or less unaffected by frying, while the other characteristics increased significanlty ($p < 0.01$). However, Sreedharan (1990) reported that the springiness of milk protein and soy protein gets decreased upon frying. These differences with respect to springiness, observed in the present investigation, may be ascribed to the differences in the factors, such as variety and processing conditions of *tofu*. The % increase in hardness, gumminess and chewiness upon frying, was more pronounced in *tofu* than in milk *paneer*. However, the opposite was true for cohesiveness. It was observed that chewiness of the sample is directly proportional to the gumminess.

TABLE 2. TEXTURE PROFILE ANALYSIS OF UNFRIED AND FRIED *TOFU* AND COW MILK *PANEER*

	Characteristics[1]				
Sample	Hardness, Newton	Cohesiveness A2/A1	Springiness cm	Gumminess Newton	Chewiness, Newton cm
Milk *paneer*	3.7[a]	0.4[a]	5.5[a]	1.4[a]	7.7[a]
Tofu	3.4[a]	0.4[a]	6.4[b]	1.4[a]	8.9[a]
Fried milk *paneer*	10.4[b]	0.6[b]	5.6[a]	5.6[b]	32.6[b]
Fried *Tofu*	13.2[c]	0.5[c]	6.4[b]	6.3[b]	40.4[c]
C.D. at 1%	2.11	0.05	0.55	1.13	7.58

[1] Average of 6 determinations
Exponent letters differing within a column, means significant differences ($p < 0.01$)

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Processing of Supplementary Food Prepared from Rice - *Mungo* - Sesame - Carrot Blends

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A supplementary food gruel for infants and children, consisting of flours of processed brown rice, germinated *mungo*, sesame and carrot blend at 50:50:5:5 ratio, exhibited 17.3% protein, 65.5% carbohydrates, 4.9% fat, 2.5% minerals, 346 μg/100 g β-carotene and 518 Kcal energy per 100 g. The preparation was most acceptable in terms of sensory quality attributes. The protein efficiency ratio was 1.4 times higher than its raw counterpart. The dietary bulk was found to be reduced and the nutrient density of gruels increased.

Keywords : Supplementary food, Children and infants, Brown rice, Germinated *mungo*, Sesame, Carrot, Dietary bulk, Nutritive quality.

To meet the recommended dietary allowances (RDA) of infants and pre-school children, a low cost supplementary food could be processed domestically by employing a simple and inexpensive processing technology, provided the constituents are selected appropriately (FAO 1971). In India, several types of supplementary foods have been developed based on groundnut, soya and *Bengalgram* flours (Pereira et al. 1968; Chandrasekhara et al. 1966; Swaminathan 1980). Germinated *mungo* has good digestible proteins and low anti-nutritional factors, while the brown rice is nutritionally superior and less expensive than the polished rice (Juliano 1985). Sesame seeds provide good essential fatty acids and pleasant aroma, while the carrot is a rich source of pro-vitamin A (Florentino 1990a). Combination of these raw materials could provide an excellent nutritious supplementary food and may become useful in improving the nutritional status of the malnourished population. The present investigation, therefore, was undertaken with the objectives to process these components in a simple manner, evaluate the chemical composition of the resultant flours, determine the most acceptable level of the flour-blend formulation and study its nutritional quality.

Seeds of paddy (*Oryza sativa* L.) cultivar "IR 74' and *mungo* (*Phaseolus aureus* R.) cultivar 'Pagasa 7' were obtained from the College Laguna, while the other constituents were procured from Los Banos public market. The grains were cleaned, packed in the polyethylene bags and stored in refrigerator.

Processing of paddy : Dehulling of paddy was done in an huller rice mill (Taiwan Industries), the brown rice was cleaned, roasted in an iron skillet at 80-90°C over low fire for 5 - 6 min, cooled to room temperature and powdered in a spin-mill (Taiwan Industries) to yield a fine flour of 60 mesh.

Processing of mungo : For germination of *mungo*, the seeds were soaked in 1% sodium chloride solution for 10 min, floated seeds (lighter, immature, infested) were discarded, while the immersed seeds were removed and washed twice thoroughly. These were soaked in lukewarm (50°C) water (1:3 w/v) for about 5-6 h, till the cotyledons became sufficiently moist and soft by imbibition of water. The excess water was drained, the seeds were tied in a cheese cloth and kept in a closed container for 18 - 20 h at room temperature (32.5°C) for germination. The length of sprout was recorded, the sprouts (2 mm long) were washed thoroughly, drained and dried in a forced draft dryer at 50 - 55°C for 10 - 12 h. The sprouts were cleaned to remove hulls by winnowing. Roasting was done in an iron skillet at 80 - 90°C, over fire for 8 - 10 min, and cooled to room temperature. Grinding of seeds was carried out in a spin-mill (Taiwan Industries) to obtain fine flour of about 60 mesh.

Processing of sesame seeds: Soaking, polishing, roasting and flour making were done according to the standard methods (Florentino 1990 b). The seeds were pulverised into flour just before use.

Processing of carrot : Carrots were washed and tops as well as root hairs were removed. These were peeled, grated into shreds immediately in a food processor (Sanyo, Japan), steam-blanched for 1 - 2 min, dried as above at 50 - 55°C for 6 - 8 h till dry and crisp (14% moisture content) and cooled

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to room temperature. The samples were pulverised into fine flour (60 mesh) using the spin mill.

Preparation of flour-blends and gruels : The flour blends of rice and *mungo* were prepared at the ratio of 100:0, 80:20, 60:40, 50:50, 40:60, 20:80 and 0:100. To each of the blend was added 5 g each of sesame and carrot flours. The gruels were prepared by mixing 100 g flour-blend sample, 350 ml hot water, 50 g sugar and little flavour, to a smooth paste consistency.

The proximate analysis of the samples was carried out using standard methods (AOAC 1984) and energy value was determined according to the methods of the Food and Nutrition Research Institute (Florentino 1990 a). The sensory evaluation of the gruels was carried out by a trained panel of judges, using a 7-point Hedonic scale (Mabesa et al. 1984). The protein efficiency ratio of the formulation was determined by standard methods (Marero et al. 1988).

The processed brown rice was nutritionally superior to milled rice as evidenced by the higher levels of proteins, fat and minerals (Table 1). The yield of brown rice was significantly higher and the price-estimate was lower as compared to the milled rice. As regards the optimum soaking time, the *mungo* seeds soaked in hot water (50°C, 1:3 w/v) for 6 h had led to sufficiently soften cotyledons, than the usual soaking method for 12 - 14 h. As reported earlier, the soaking time of less than 6 h, had resulted in uneven germination, while beyond optimum period, the seeds started deteriorating (Salunkhe et al. 1985). Increased temperature of soaking water is known to reduce the soaking time by improving imbibition rate (Marero et al. 1991). The earlier reports on nutrient losses stated that the losses were minimal, when grains soaked at 50°C, whereas the use of water at 60°C showed poor germination and 3 to 4 times more nutrient losses (Kon 1979). The experimental results on germination of *mungo* seeds indicated that the germination period of 18 - 20 h was found to be ideal for the growth of embryo to 2 - 3 cm length. Germination has been reported to improve the nutritional quality of legumes by increasing vitamins content and reducing the anti-nutritional factors (Marero et al. 1991). The processed sesame flour showed higher levels of fat and proteins, as well as imparted pleasant aroma; hence is used widely in baby food formulations. The processed carrot flour exhibited higher levels (6912 μg/100 g) of pro-vitamin A (β-carotene). Deficiency disorders of vitamin A are reported to cause night blindness, particularly in children. Carrot offers to be the cheapest source of pro-vitamin A to alleviate the disorder.

TABLE 1. NUTRITIVE VALUE OF PROCESSED RICE, *MUNGO*, SESAME, CARROT AND GRUEL (Values per 100 g[a])

Nutrient	Brown rice (BR)	Milled rice (MR)	Germinated *mungo* flour (GM)	Sesame flour (S)	Carrot flour (C)	Gruel formulation BR:GM:S:C 50:50:5:5
Crude protein	7.8	6.8	25.6	18.1	1.2	17.30
Crude fat	2.5	0.4	2.1	52.2	0.5	4.91
Carbohydrates	73.0	77.8	58.2	13.2	10.2	65.50
Dietary fibre	0.9	0.4	2.5	6.3	0.8	1.01
Minerals (ash)	1.4	0.6	3.2	4.8	1.1	2.54
Moisture	14.4	14.0	8.4	5.4	56.2	8.74
Energy Kcal	345.7	341.6	354.1	595.0	48.4	518.39

[a] Means of two determinations. Pro-vitamin A in gruel formulation was 345.6 μg./100 g. BR = Brown rice; GM = Germinated *mungo*; C = Carrot

Among the various gruel formulations tested, the 50:50:5:5 (brown rice : germinated *mungo* : sesame : carrot) blend was rated as the most acceptable formulation, in terms of sensory quality attributes (Table 2). It exhibited significantly higher levels of proteins, minerals and energy value, than the recommended dietary allowances (Florentino 1990a). The gruels prepared were intended to supplement a child's main diet. Hence, it must supply one-third of the recommended dietary allowances of nutrient requirements of the child. The volume was just enough to consume weaning food in one sitting (Marero et al. 1988). The PER

TABLE 2. SENSORY QUALITY ATTRIBUTES OF GRUELS PREPARED FROM DIFFERENT FLOUR-BLENDS.

Flour blend, g*		Sensory quality attributes**			
Brown rice	Germinated *mungo*	Taste	Appearance	Consistency	Overall acceptability
100	0	6.0	6.2	6.2	6.1
80	20	6.0	6.2	6.0	6.1
60	40	6.0	6.4	6.2	6.2
50	50	6.8	6.8	6.8	6.8
40	60	5.6	6.2	6.0	5.9
20	80	4.8	5.8	5.5	5.3
0	100	4.4	5.4	4.4	4.7
S E		0.3	0.2	0.3	0.30
C D at 5%		1.0	0.7	1.1	0.95

* Sesame and carrot were added each at 5 g levels to the blend.
** Means of ten independent experiments.

of the most acceptable formulation was observed to be 2.4, which was significantly higher than the value of 2.10, which is the requirement specified by the Protein Advisory Group of FAO (1971), and 1.4 times higher than its raw counterpart.

Such a low cost supplementary food, prepared from locally available food crops, was found to be highly nutritious, inexpensive, easily processed at home-scale level, with reduced dietary bulk and increased nutrient density as well as ideal for the nutritionally vulnerable population. Hence, it could be extensively used for supplementary feeding programmes to alleviate the malnutrition problems.

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Effect of Partial and Full Substitution of *Bengalgram* and Blackgram *Dhals* with Ricebean on Essential Amino Acids and Mineral Contents of *Vada* and *Pakora*

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Blends of ricebean with blackgram *dhal* and *Bengalgram* flour improved the organoleptic quality of *vada* and *pakora*. The crude fibre, calcium, iron, zinc and copper contents increased significantly ($P < 0.01$), whereas methionine, cystine, tryptophan and available lysine contents decreased significantly ($P < 0.01$) in supplemented *vada*. The crude fibre and calcium contents increased significantly ($P < 0.01$), whereas methionine and cystine contents decreased significantly ($P < 0.01$) in supplemented *pakora*.

Keywords : *Vada*, *Pakora*, Proximate composition, Minerals, Amino Acids, Ricebean incorporation.

Ricebean (*Vigna umbellata*), a native of South and South-East Asia, is cultivated by the tribals in various ethnic groups in the Eastern and North-Eastern regions and to some extent in South India (Singh et al. 1989). Ricebean is adopted to high temperature and humidity as well as to heavy soils. Seeds are large and 100 grains weighing 5 g. It matures in about 125-135 days and is harvested in the last week of November. Average yield is 170 kg/ha. As a nutritious pulse, it contains about 20% protein in grains, has good cooking quality, fine taste and is free from hard grains (*kokru*) (Singh et al. 1989). Earlier, some studies have been carried out on the nutritional quality of ricebean (Singh et al. 1985; Hira et al. 1988). It is also a good source of calcium, phosphorus and methionine (Malhotra et al. 1988). Consequently, ricebeans can be an efficient substitute, either partly or fully, to traditionally used legumes in the preparation of foods. As the information on the utilization of ricebean and the effect on nutritive quality of the resultant food items are limited, the present work was undertaken. The scope was confined to two most popular snack foods (*vada* and *pakora*), while the nutritional aspect was restricted to proximate analysis, mineral and essential amino acid contents and energy values of the resultant snack foods.

Ricebean 'RBL-1' was procured from the Plant Breeding Department of Punjab Agricultural University, while *Bengalgram* flour and blackgram *dhal* were purchased from the local market. Coarsely ground ricebean grains were soaked overnight to remove the outer covering. After drying in sunlight for 3-4 days, ricebean was ground to flour. Ricebean flour with husk and its various combinations with blackgram *dhal* in the ratio of 0:100, 50:50, 75:25 and 100:0 were used for the preparation of *vada*. Both the *dhals* were soaked overnight and ground to coarse paste (*peethi*), which was kept at room temperature for 4 h for fermentation. The mixture was beaten for 7-10 min. Chopped onion, garlic, ginger, coriander leaves, green chillies and salt were added to the mixture. *Vadas* were shaped like doughnuts (0.5 inch thickness and 2 inch diam) and fried for 1 min in oil heated at 190°C. For *pakora*, ricebean without husk was mixed with *Bengalgram* flour and spinach leaves in the ratio of 0:75:25, 75:0:25 and 37.5:37.5:25. *Bengalgram* flour and ricebean flour were mixed with water and the mixture was beaten for 5-7 min. Chopped onion, spinach, coriander leaves, green chillies and salt were added to the mixture and again beaten well. *Pakoras* (0.5 inch thickness and 2 inch in diam) were fried in heated oil at 190°C.

The cooked samples were served to a panel of ten judges for organoleptic evaluation using a score card. The prepared products were dried at 60°C, ground to fine powder in an electric grinder, placed in polythene bags and stored in air tight containers. Both raw and cooked samples were analysed for proximate compositon (AOAC 1985). Energy value was determined using Ballistic bomb calorimeter (Gallenkamp). Standard methods were employed for the determination of lysine, tryptophan, methionine and cystine (Carpenter 1960; Concon 1975; Horn and Blum 1946; Liddell and Saville 1959). Calcium, iron, zinc and copper were estimated using Varian atomic absorption spectrophotometer (GBC model), as per the method of Piper (1950).

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Statistical analysis of data was done by analysis of variance.

Vadas prepared from ricebean were quite comparable to those prepared from blackgram *dhal*. Mean scores for colour and appearance of ricebean *vadas* were significantly ($p < 0.01$) lower as compared to *vadas* prepared from blackgram *dhal*. Mean scores for various parameters of organoleptic evaluation of *pakoras* were non-significant. The results of proximate composition of raw and cooked samples are given in Table 1 and the mineral and amino acid composition in Table 2.

In supplemented *vada*, the average crude fibre content increased by 204.8%. The average calcium content of supplemented *vada* increased significantly ($p < 0.01$) by 78.2%, iron content by 47.9% and zinc content by 10.0%. The average methionine content of supplemented *vada* decreased significantly ($p < 0.01$) by 21.3%, cystine content by 8.9%, tryptophan content by 13.0% and available lysine content by 13.5%.

In ricebean supplemented *pakora*, the average fibre content increased by 58.7%. *Pakora* prepared from ricebean flour without husk had almost double the amount of calcium, as compared to *pakora* prepared from *Bengalgram* flour alone. In supplemented *pakora*, the average methionine and tryptophan contents decreased significantly ($p < 0.01$) by 10.7% and 10.7%, as the level of ricebean flour in the blend was increased.

Thus, ricebean, being a cheap crop, could be suitably supplemented with *Bengalgram* flour and blackgram *dhal*. Moreover, due to less fat absorption, it can replace the costly blackgram *dhal* and

TABLE 1. PROXIMATE COMPOSITION (% DRY MATTER BASIS) OF RAW INGREDIENTS AND RECIPES.

	Moisture	Crude protein	Ether extract	Ash	Crude fibre	Energy, Kcal
Ingredients						
Ricebean flour with husk (RBFWH)	10.8	19.8	1.4	3.9	4.7	396.0
Ricebean flour without husk (RBFWH)	9.8	17.5	1.0	1.6	2.8	391.0
Bengalgram flour (BGF)	10.6	19.4	5.3	2.7	1.5	398.0
Blackgram *dhal*	9.9	20.6	1.8	2.4	1.2	396.0
Vada						
Blackgram	15.5	20.1	23.9	2.4	1.2	689.9
Blackgram + RBFWH + (50:50)	16.3	19.8	22.5	2.4	2.8	677.0
Blackgram + RBFWH + (25:75)	16.9	19.5	19.5	2.5	3.7	655.1
RBFWH	17.5	19.0	18.7	2.5	4.3	636.8
Pakora						
BGF + leafy vegetable (75:25)	16.0	14.5	22.3	3.0	1.2	660.5
RBFWH + leafy vegetable (75:25)	15.5	13.1	16.8	2.3	2.1	627.4
BGF + RBFWH + leafy vegetable (37.5:37.5:25)	15.6	13.8	18.7	2.6	1.7	639.3

TABLE 2. MINERAL (mg/100 g) AND AMINO ACID COMPOSITION (g/16 g N) OF RAW INGREDIENTS AND RECIPES

	Calcium	Iron	Zinc	Copper	Methionine	Cystine	Tryptophan	Available lysine
Ingredients								
Ricebean flour with husk (RBFWH)	336.7	4.8	3.4	0.9	1.0	1.1	0.9	5.3
Ricebean Flour without husk (RBFWH)	162.3	4.8	3.2	0.6	1.0	1.1	0.8	4.9
Bengalgram flour (BGF)	57.3	7.9	3.0	0.9	1.3	1.1	0.9	5.9
Blackgram *dhal*	149.2	3.8	3.0	0.9	1.4	1.3	1.1	6.1
Vada								
Blackgram	138.0	4.5	2.9	0.9	1.3	1.1	0.9	4.8
Blackgram + RBFWH + (50:50)	209.2	5.4	3.1	0.9	1.1	1.1	0.8	4.3
Blackgram + RBFWH + (25:75)	245.8	6.6	3.2	0.9	1.0	1.0	0.8	4.1
RBFWH	282.6	7.8	3.3	0.9	0.9	1.0	0.7	4.0
Pakora								
BGF + leafy vegetable (75:25)	60.2	8.3	3.0	0.9	1.2	1.0	1.0	4.1
RBFWH + leafy vegetable (75:25)	138.5	6.7	3.1	0.6	1.0	1.0	0.9	4.0
BGF + RBFWH + leaf vegetable (37.5:37.5:25)	98.9	7.5	3.0	0.8	1.2	1.0	0.9	4.1

Ricebean contained good amount of protein 19.8%, crude fibre 4.7%, available lysine 5.3 g/16 g N, calcium 336.7 mg/100 g, zinc 3.4 mg/100 g and copper 0.9 mg/100 g (Tables 1 and 2). Similar findings have been reported by Singh and Misra (1980) and Malhotra et al (1988). The milling of ricebean into flour resulted in significant decrease ($p < 0.01$) in crude protein 11.6%, crude fibre 39.8%, available lysine 6.9%, calcium 51.8% and copper 38.5%.

Bengalgram flour in the preparation of *vada* and *pakora*.

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Apricot-Soy Fruit-bar: A New Protein-enriched Product

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Fruit-bar, prepared by dehydration of apricot pulp supplemented with soy slurry, had increased protein and fat, decreased titratable acidity and ascorbic acid contents. Product having 70% apricot pulp and 30% soy slurry with 15.3% moisture, 7.8% protein and 16.5 mg/100 g ascorbic acid was found to be the best in sensory qualities. The product had good flavour (no beany flavour), texture and taste. No trypsin inhibitor activity was detected in the apricot-soy fruit-bar.

Keywords : Fruit-bar, Apricot, Soybean, Protein, Sensory qualities, Trypsin inhibitor.

Stone fruits, like plum *(Prunus saliciana)*, peach *(Prunus persica)* and apricot *(Prunus armeniaca)*, constitute about 20% of the total fruit production in Himachal Pradesh (Anon 1988). Out of these fruits, apricot is neither commercially preserved at present, nor has a longer storage life. Owing to its perishable nature and a short harvest season, a glut in the market is created, resulting in unremunerative prices to the growers and considerable wastage. It could be canned, frozen, dried and made into juice with pectinolytic enzymes (Joshi et al. 1991; Sharma et al 1992). It could also be used in sauce and confectionery (Woodroof and Luh 1975).

Soybean is a cheap and excellent source of quality protein (40-42%) and fat (18-20%) and holds a great promise for protein-enriched products, especially the fruits which normally lack protein and fat. Fruit-bar or fruit-slabs or fruit-leather are the terms used for the products prepared by dehydration of fruit pulps. Although study on dehydration of mango pulp for the preparation of fruit-bar has been reported (Rao and Roy 1980). no report on soy-based apricot fruit-bar is available. Trials were, therefore, undertaken to develop and evaluate the apricot-soy fruit-bar.

Apricot fruit ('New Castle') and soybeans ('Yellow Bragg') were procured from the University campus, Solan. Apricot pulp was prepared by adding water (100 ml/kg of fruit), followed by cooking for 5-7 min under pressure and passing through a pulper. Soy flour was mixed with water (1:5) in a blender, followed by heating to boiling (5 min) and passing through a pulper to make soy slurry.

Different combinations of apricot-soy fruit-bar, viz. 100:00 (T_1), 80:20 (T_2), 70:30 (T_3), 60:40 (T_4) and 50:50 (T_5) were made by mixing the pulp with slurry and the total soluble solids (TSS) were raised to 30° Brix by the addition of sugar syrup(70%). Sulphur dioxide was also added to the apricot-soy mixture at 50 ppm level. The apricot-soy mixture of respective treatments was spread on trays (45 x 30 cm) for dehydration at 65 ± 1°C in a mechanical cabinet dryer for 14 h. The mix was spread at a level of 200 g into a layer of 2.0 mm thickness, followed by addition of 2nd, 3rd, 4th layer, after complete drying of each layer. The product, after drying, was packed in polyethylene sheet for further studies.

The apricot pulp, soy slurry and apricot-soy fruit-bar were analysed for proximate composition according to the standard methods (AOAC 1975). Protein content of products was determined by micro-Kjeldahl method (Ranganna 1986), fats by cold extraction method (Folch et al. 1957) and ascorbic acid by titration method. The trypsin inhibitor activity was estimated by method of Kakade et al (1974). All the determinations were made in triplicate and means are reported.

The acceptability of apricot-soy fruit-bar was assessed by a panel of 10 judges. Evaluations were carried out on a 9-point Hedonic scale and the data were analysed for anlysis of variance (RBD) (Amerine et al. 1965).

Comparison of physico-chemical characteristics of soy slurry and apricot pulp (Table 1) shows that soy slurry is a good source of protein and fat, while apricot pulp has more ascorbic acid. Table 2 clearly shows that supplementation of apricot pulp with soy slurry, for fruit-bar making, changed the physico-chemical and nutritional characteristics of the product. The protein and fat contents of the product were found to increase considerably by blending with soy slurry, because of high protein

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TABLE 1. PHYSICO-CHEMICAL COMPOSITION OF APRICOT PULP AND SOY SLURRY.

Constituents	Apricot pulp	Soy slurry (1:5)
Moisture content, %	85.1 ± 1.4	89.2 ± 1.4
Protein, %	0.6 ± 0.0	7.2 ± 0.6
Fat, %	0.2 ± 0.0	3.5 ± 0.2
Vitamin C, mg/100 g	6.5 ± 0.3	Nil
Crude fibre, %	1.0 ± 0.1	0.9 ± 0.0
Total ash, %	0.4 ± 0.0	1.2 ± 0.0
Trypsin inhibitor activity, %	Nil	0.6 ± 0.0
Acidity, % as CA	1.3 ± 0.0	Nil
pH	3.4 ± 0.1	6.8 ± 0.2
Total soluble solids, ° Brix	12.0 ± 0.2	10.0 ± 0.3

Values reported are means ± S. D.

TABLE 2. PHYSICO-CHEMICAL, NUTRITIONAL AND SENSORY CHARACTERISTICS OF APRICOT-SOY FRUIT-BAR

Characteristics	Treatment T_1	T_2	T_3	T_4	T_5	
Yield, %	41.8	41.8	40.6	40.0	39.5	
Final moisture,%	16.8	16.4	15.8	15.0	14.0	
Acidity, % as CA	2.9	2.6	2.3	2.2	1.7	
Protein, %	0.9	7.0	7.8	9.6	12.2	
Fat, %	0.4	2.2	3.3	4.2	5.2	
Vitamin C, mg/100g	26.8	19.1	17.5	15.9	14.2	
Total sugar, %	55.5	57.4	58.1	57.1	57.1	
Reducing sugars,%	33.0	33.2	30.3	29.4	28.5	
Trypsin inhibitor activity, %	0.0	0.0	0.0	0.2	0.4	
Calories (Kcal/100g) contributed by :						
Protein	3.6	28.0	31.5	38.5	49.0	
Fat	3.7	19.4	29.7	37.7	46.8	
Carbohydrates	249.7	258.8	261.6	257.1	257.1	
Total calorific value	257.0	306.2	322.8	333.3	352.9	
Mean sensory scores						CD ($P < 0.05$)
Colour	8.0	8.0	7.0	6.0	4.5	0.38
Flavour	8.0	7.0	7.0	6.0	5.0	0.44
Texture	7.0	7.0	7.0	6.0	5.5	0.64
Taste	7.0	7.0	8.0	6.0	5.2	0.56
Overall acceptability	7.5	7.0	8.0	6.0	5.0	0.35

and fat contents of soybeans (Table 1). As per the recommendations of ICMR, an ideal food should supply 0.7-2.0 g protein/kg to adults and 1.2 - 2.0 g protein/kg to children. Moreover, the contribution of fat to the total calories should not exceed 30% i.e. less than 80 g/day (Gopalan et al. 1989). As per these recommendations, the apricot-soy fruit-bar could be called as a protein-enriched product to meet the protein requirements of adults and children. The contribution made by the fat to the total calories is, however, less than the recommended level. Although there was a slight decrease in ascorbic acid content due to blending of soy slurry with apricot, it is still sufficient in quantity to be nutritionally adequate to meet the requirements. With increased quantities of soy slurry, a decrease in titratable acidity was noted, and this could have been responsible for the improvement of acid-sugar blend of the final product. Among the various combinations, the best treatment T_3 (apricot pulp to soy slurry ratio 70:30) was equally comparable to the control T_4 (apricot pulp to soy slurry ratio 100:00). From the results of the present studies, it can be concluded that the physico-chemical, nutritional and sensory characteristics of apricot fruit-bar could be improved by blending the apricot pulp with soybean.

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Effect of Parboiling on Grain Dimensions of Rice

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Parboiling brought about significant changes in the grain dimensions in rice, the extent varying with the type of parboiling. Roasted-parboiled and pressure-parboiled rices had significantly greater length (L), breadth (B), L/B ratio, but lower thickness as compared to raw rice, and to that produced by normal steam-parboiling. Ridges on lateral regions of grain in raw rice seem to smoothen out in case of normal parboiling, but get pronounced in case of other methods.

Keywords : Rice grain dimensions, Parboiling, Parboiled rice, Rice-photomicrograph, Effect of parboiling methods.

Parboiling is an important pre-milling process for paddy, which brings about profound changes in various properties of rice, including changes in grain dimensions (Kurien et al. 1964; Raghavendra Rao and Juliano 1970; Bhattacharya and Ali 1985; Pillaiyar 1988; Sowbhagya and Ali 1991). The latter results in a bolder appearance which becomes noticeable, particularly after cooking (Sowbhagya and Ali 1991). This has a direct influence on the consumer appeal and its acceptance. The observations, however, are confined to normal parboiled rice. In recent times, some new processes for parboiling, viz., pressure-parboiling (Ali and Bhattacharya 1982), and dry heat (roasting) parboiling (Ali and Bhattacharya 1980) have been reported. Parboiled rice obtained from the latter method was reported to have a rather flat appearance, with somewhat pronounced ridges (Ali and Bhattacharya 1980). Different methods of parboiling, therefore, seem to affect the grain dimensions in different ways. Although individual preferences may exist among different sections of consumers, finer rice is normally preferred. A study on the effect of different parboiling processes on the grain dimensions and a few other related properties has been, therefore, carried out and the results are reported in this communication.

Seven varieties, with different lengths (4.23 ± 0.03 to 7.60 ± 0.08 mm) and different shapes (i.e. length to breadth ratio of 2.09 to 3.27) were obtained from a nearby agricultural research station. About 500 g paddy was used for the preparation of each of the different types of parboiled rices. Normal parboiled (N-PB) rice was prepared by soaking paddy in warm water overnight, draining and steaming at atmospheric pressure for 20 min, according to the method of Bhattacharya and Indudhara Swamy (1967). Pressure parboiled (P-PB) rice was prepared as per the method of Ali and Bhattacharya (1982) by soaking paddy in water for 30 min at ambient temperature, draining and steaming at 2.5 kg/cm^2 pressure for 20 min. Roasted parboiled (R-PB) rice was prepared, as described by Ali and Bhattacharya (1980) by roasting fully soaked (warm water, overnight) paddy in sand at 250°C in an electric roaster. All paddy samples were dried, shelled in a laboratory McGill sheller and milled in a McGill miller No.1, under standard conditions, to yield 8-10% degree of polish. Only whole grains were used for the measurements of the grain dimensions. All the rice samples were exposed together to air at ambient conditions (about 30°C, 65% RH), for about a week to attain a similar moisture content (about 11% w.b).

All measurements were done in triplicate, for brown and milled rices. Hundred-grain weight was determined after random sampling and counting grains manually. Degree of polish was determined, based on the difference of brown and milled rice weights. Grain length and breadth were measured by arranging 20 grains end-to-end length-wise/breadth-wise against a metallic scale, respectively. Thickness was measured in 20 individual grains using the thickness gauge with an accuracy of 0.01 mm. Photomicrography of brown rice (without softening) was done by cutting the grains transversely, approximately in the middle of the length, into 2 pieces by a sharp knife to reveal a smooth transverse cut surface. The cut grain was fixed with adhesive on to a thick black paper, leaving the cut surface exposed. The photograph was taken in a Carl-Zeiss Jena microscope (Amplival pol. u) by projecting incident light at an angle of about 30° to the cut surface, which was normal to the camera lens.

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The data were statistically analysed as 4 x 2 x 7 factorial design according to completely randomised design (Steel and Torrie 1960) with two replicates. The relationship between the effects of processing methods, milling, variety, and their influences on the dimensional parameters was investigated by analysis of variance appropriate to the 4 x 2 x 7 factorial design, with mean separation by Duncan's multiple range test.

Results of statistical analysis on the physical properties of rice are shown in Table 1. The data for brown and milled rices, in duplicate, have been taken into consideration, and pooled means have been compared. There was good variation in the grain dimensions and shape of the varieties selected. The L/B ratio for P-PB (2.44) and R-PB (2.47) was higher, while that for N-PB (2.40) was lower, as compared to the raw rice (2.28). The degree of fineness or coarseness of rice grain is well expressed by its weight/unit length (Sowbhagya et al. 1984). The smaller the value, the finer was the variety and *vice versa*. The value of 10 W/L was slightly higher (31.0) in the case of N-PB, but lower in the case of P-PB (29.4) and R-PB (29.1), as compared to raw rice (30.1), thereby indicating that the rice tends to become coarser by normal steam-parboiling method, while it tends to become finer upon roasting-parboiling and pressure-parboiling. As for individual dimensions, there was a slight decrease in the length and breadth, and an increase in the thickness of N-PB, as compared to raw rice. Conversely, the length and breadth increased slightly, but thickness decreased in case of P-PB and R-PB. There were also changes in the peripheral contour around the short axes of the grain throughout the length, which was visible by disappearance of the lateral ridges in case of N-PB, but it got pronounced in case of P-PB and R-PB. The photomicrographs of the transverse sections of raw and variously parboiled rices are shown in Fig. 1. The normal parboiled rice showed

TABLE 1. STATISTICAL ANALYSIS OF THE PHYSICAL PROPERTIES#

Main factors	100-grain weight (g)	Length (mm)	Breadth (mm)	Thickness (mm)	L/B	10 W/L (mg)
Processing method (P)	NS	***	***	***	***	***
Raw	1.65^{a}	5.58^{ab}	2.33^{ab}	1.73^{a}	2.40^{ab}	30.1^{ab}
N-PB	1.68^{a}	5.42^{a}	2.26^{b}	1.76^{a}	2.29^{a}	31.0^{a}
P-PB	1.68^{a}	5.70^{b}	2.35^{ab}	1.74^{a}	2.44^{b}	29.4^{b}
R-PB	1.68^{a}	5.87^{c}	2.37^{a}	1.68^{b}	2.47^{b}	29.1^{b}
Rice form (R)	***	***	***	***	*	***
Brown rice	1.78	5.89	2.37	1.73	2.43	30.6
Milled rice	1.66	5.50	2.28	1.69	2.37	29.4
Varieties (V)	***	***	***	***	***	***
'Badshabhog'	0.89^{a+}	4.23^{a}	1.99^{a}	1.47^{a}	2.12^{a}	21.1^{a}
'Co25'	1.35^{b}	4.68^{b}	2.31^{b}	1.71^{c}	2.02^{a}	29.1^{b}
'Mahsuri'	1.32^{b}	5.26^{c}	2.09^{a}	1.56^{ab}	2.51^{b}	25.2^{c}
'Sukanandi'	2.01^{c}	5.86^{d}	2.63^{c}	1.90^{d}	2.09^{a}	36.3^{d}
'N10B'	1.63^{d}	5.70^{d}	2.32^{b}	1.64^{bc}	2.46^{b}	28.5^{b}
'Jaya'	2.35^{e}	6.45^{e}	2.58^{c}	1.84^{d}	2.50^{b}	36.5^{d}
'SR26B'	2.54^{f}	7.60^{f}	2.32^{b}	1.86^{d}	3.27^{c}	33.4^{e}
Interactions						
(P) x (R)	*	***	NS	*	***	NS
(P) x (V)	***	***	**	*	***	***
(R) x (V)	***	***	NS	NS	NS	NS
(P) x (R) x (V)	*	***	NS	NS	NS	*
SE_M (55df)	± 0.021	± 0.046	± 0.035	± 0.033	± 0.036	± 0.037

All mean values, NS, *, **, *** indicate Not significant, significant at 5%, 1% and 0.1% levels, respectively. Means of the same column for each of the main factors followed by different letters differ significantly (p = 0.01) according to Duncan's new multiple range test, except for 100-grain weight (processing method) and L/B ratio (form of rice) which are tested at p = 0.05. N-PB, P-PB and R-PB = normal-pressure - and roasted-parboiled rice.

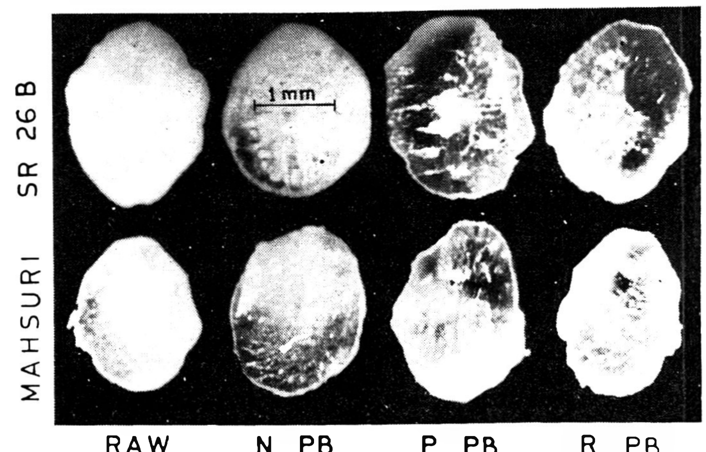

Fig. 1. Photomicrograph of the transverse cut surface of 'SR26B' and 'Mahsuri' raw and parboiled rices (N-PB, P-PB and R-PB = normal-, pressure- and roasted- parboiled rice).

rounding of the peripheral contour and disappearance of the lateral ridges along the short axes, which makes the grain look roundish as compared to raw rice. These observations support the data on breadth and thickness differences (Table 1), and additionally provide information on the visual differences in the grain surface. Table 1 also shows that all the main effects were significant (p = 0.05) at least for the parameters, that were considered, except for 100 grain weight.

Analysis of variance (Table 1) has shown that the two-factor interaction viz., processing method and varieties, were highly significant (p = 0.001) for the parameters, length and L/B ratio. The two -factor interaction of rice form and variety and the three-factor interaction including processing method with the above were also highly significant (p = 0.001) for length.

From the above results, it could be concluded that grain length is significantly influenced by the processing method, irrespective of the size and shape of the grain. The differences in physical properties, amongst different parboiled rices, although small, were significant. In view of the fact that R-PB rice had a finer appearance as compared to N-PB rice, it may have a better consumer appeal. Further, it has been shown (Sowbhagya and Ali 1991) that R-PB rice cooks faster than the N-PB rice, which is an additional advantage in saving time and energy for cooking.

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Studies on the Development of Cashewnut *Burfi*

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Method of preparation, preservation and packing of cashewnut *burfi* has been described. Formulation for preparation and preservation of cashewnut *burfi* was standardised with incorporated preservatives like butylated hydroxy anisole and sorbic acid. The *burfi* had a shefl-life of 3 months at 37°C and 6 months at ambient temperature, with added preservatives and when packed in polypropylene and paper-aluminium-foil-polyethylene laminate pouches.

Keywords : Traditional Indian sweets, Cashewnut *burfi*, Preservatives, Packaging materials, Storage, Shelf-life.

Among the various types of Indian sweets, cashewnut *(Anacardium occidentale. L.)* *burfi* (a delicacy culinary containing sugar/jaggery, coconut, fat, milk solids and cashewnut) is one of the popular sweets in India and other developed as well as developing countries. This may be because of good taste, flavour and colour of the product. There are many other cashewnut-based sweets, such as cashew *halwa*, cashew sweet *milk*, cashewnut *chikki* and sugar or salt-coated cashewnut. Though cashewnut products are costlier than other sweets, their demand is high, because of the distinct flavour and taste. However, the shelf-life is very short in all the cases (Date et al. 1955). It is the experience of sweet-makers that the products could not be stored for more than 10-15 days under normal condition, due to discolouration, development of rancid odour and fat bloom. Of late, because of increase in export of sweets from India to Middle East, the problems of preservation, packing and storage to ensure longer shelf-life, have assumed greater importance (Venkatesh et al. 1983). Moreover, ready-to-eat traditional Indian sweets play an important role in defence services. In addition, there is a great demand in developed and developing countries for Indian sweets based on milk and cashewnut. An investigation was, therefore, undertaken to study the effect of anti-oxidant and preservatives on the shelf-life of cashewnut *burfi* during storage.

Raw materials : Fresh cashewnuts, white in colour and round in shape, were procured from local market. Spray dried whole milk powder, cane sugar, *vanaspati* (hydrogenated fat) and cardamom of good quality were procured from reputed manufacturers or marketers. Analytical grade butylated hydroxy anisole (BHA), potassium sorbate and citric acid were from Loba Chemie-IndoAustranal Co. Bombay.

Preparation and packing of Cashwenut burfi : The required quantity of cashewnuts were cleaned to remove outer skin/extraneous matter, if any, and soaked in twice the quantity of cold water for about 1 h. It was, then, ground into paste in Waring blender, with addition of small quantity of water. (this formed 11% of the total water quantity required for the product). Cane sugar was dissolved in remaining water and heated to make hot syrup. The whole milk powder and *vanaspati* were kneaded well, before adding to *burfi*. Cardamom was powdered, after removing the skin. The sugar syrup was brought to 80° Brix, the cashewnut paste was then added and cooked to 85° Brix. At this stage, the milk powder and *vanaspati* paste were added and the cooking continued to get 82° Brix. Cardamom powder, BHA (0.02%), citric acid (0.004%) and potassium sorbate (0.168%) were added at this stage (Satyanarayana Rao et al. 1990). The mass was, then, poured on aluminium molds, pressed, cooled and cut into 10 x 10 cm pieces, each piece weighing about 50 g . Each cashewnut *burfi* was first sealed in polypropylene (75 μ) pouch and then packed in paper-aluminium foil (0.02 mm) - polyethylene laminate pouch.

Analytical methods : Free fatty acids (FFA), peroxide value (PV), moisture, proteins, total fat, ash and fibre were determined as per AOAC (1960) methods. The total and reducing sugars were estimated by the method of Folin Wu (1920). Thiobarbituric acid (TBA) value was assayed as per the method of Kwon and Norgaard (1966) and expressed as mg of malonaldehyde (MA)/kg sample. Sorbic acid was estimated as described by Vidyasagar and Arya (1983). The non-enzymatic browning (NEB) was determined as per the method of Kannur et al (1973). A 10 g of *burfi* was powdered and

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mixed well in 100 ml of distilled water in a mixi. The pH of this slurry was measured using a pH meter (Model LI-120, Elico, Hyderabad). Colour, texture, taste, appearance and overall acceptability were evaluated by a taste panel, consisting of 8 judges and expressed as scores on a 9 point Hedonic scale.

Moisture sorption isotherm characteristic was determined at ambient temperature by exposing weighed quantities of the samples in the glass petri dishes to relative humidity (RH) ranging from 0 to 97%, using appropriate saturated salt solutions (Rockland 1960). The samples were periodically weighed, till they attained a constant weight or showed sign of fungal growth.

Storage conditions : All the packed samples were stored at 37°C for 3 months, in addition to ambient temperature (19 - 27°C) and control (4°C) for 6 months. These were anlaysed every month upto 3 months at 37°C and every 2 months at ambient temperature and at 4°C.

Standardization of recipe : Several recipes containing different quantities of cashewnut, sugar, milk powder and *vanaspati* were investigated and standardized through a panel of 8 judges. The standardized *burfi* had a composition of (%) cashewnut 22.1, whole milk powder 11.05, sugar 44.2, *vanaspati* 11.05, cardamom powder 0.55 and water 11.05.

Moisture sorption isotherm characteristic of cashewnut *burfi* is presented in Fig. 1. It can be seen that the *burfi*, with an initial moisture content of 9.3% (dry weight basis), equilibrates to a RH of 79%. Since this equilibrium relative humidity (ERH) is close to 80%, which permits the growth of most common moulds (Fennama 1975), the product is likely to become susceptible to mould growth. This was also observed in earlier experiments. For

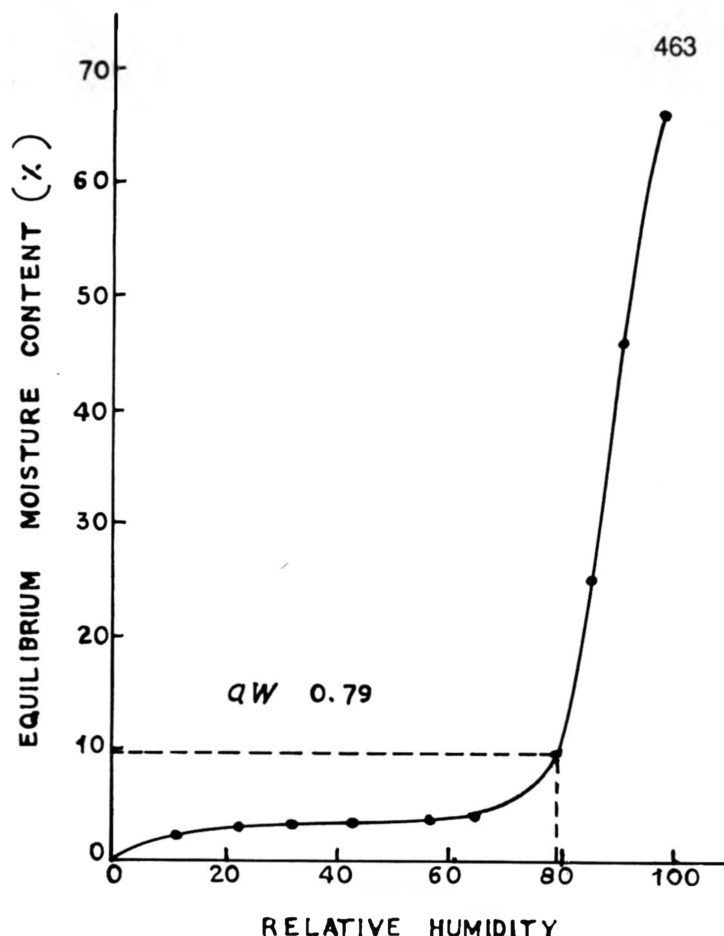

Fig. 1. Sorption isotherm for cashewnut *burfi*

example, the control sample, prepared without potassium sorbate and BHA, became unacceptable due to mould growth and rancid flavour. Any reduction in moisture level below 9.5% (dry weight basis) made the product hard in texture, thereby affecting its acceptability. The data indicate the need for using antimycotic preservatives such as sorbic acid and BHA and proper packaging of the product, for ensuring adequate shelf-life. These preservatives are permitted for use in food products (PFA 1954).

Table 1 gives physico-chemical and organoleptic changes during storage at different temperatures

TABLE 1. PHYSICO-CHEMICAL AND ORGANOLEPTIC CHANGES IN CASHEWNUT *BURFI* TREATED WITH POTASSIUM SORBATE AND BHA DURING STORAGE AT DIFFERENT TEMPERATURES

Storage period, months	Storage temp., °C	Moisture, %	PV, milli eq. of O_2/kg fat	FFA, % oleic acid on fat basis	TBA, mg malonaldehyde/kg sample	NEB, OD at 420 nm	Score
0	-	8.48	1.45	1.26	0.06	0.01	8.0
1	37	8.49	2.85	1.34	0.06	0.02	7.2
2	37	8.49	4.33	1.37	0.07	0.02	7.3
3	37	8.53	5.66	1.58	0.09	0.03	7.2
2	19-27	8.46	2.94	1.32	0.06	0.02	7.3
4	19-27	8.38	3.52	1.33	0.07	0.02	7.1
6	19-27	8.53	4.54	1.28	0.08	0.02	6.8
2	4	8.48	1.44	1.29	0.06	0.01	7.7
4	4	8.51	1.48	1.29	0.06	0.01	7.6
6	4	8.42	1.54	1.26	0.06	0.01	7.6

All values are averages of duplicate determinations. pH was in the range of 6.48 to 6.55. Potassium sorbate was 0.12 - 0.13% in all cases

in cashewnut *burfi* containing 0.02% BHA, 0.004% citric acid and 0.168% potassium sorbate, (0.15% sorbic acid) (Satyanarayana Rao et al. 1990). The cashewnut *burfi* had an initial moisture content of 8.48% and it has not shown much change during storage at all the temperatures tested up to a period of 6 months. The initial PV (1.45 meq of O_2/kg of fat) increased to 5.66 and 4.54 at 37°C at 3 months and at ambient temperature at 6 months storage period, respectively. The FFA content, expressed as oleic acid, was 1.26% initially and increased to 1.58% at 37°C at 3 months, whereas the values at ambient temperature and the control samples remained unchanged upto the end of 6 months storage. Similar results were also noted in coconut *burfi* and dehydrated *chutney* (Satyanarayana Rao et al. 1990, 1991). A slight change in TBA value from 0.06 to 0.09 for 3 months at 37°C and 0.08 mg for 6 months at ambient temperature were noticed. There were no changes in pH values and sorbic acid level throughout the storage period. Similarly, there was no significant change in NEB (OD 0.015 to 0.035 and 0.025) at 37°C for 3 months and at ambient temperature for 6 months, respectively.

The visual colour, taste and texture of all the samples were rated as very good by the panelists up to the end of six month storage period. It is seen from Table 2 that the energy value, as calculated on the basis of the composition (100 g), has contributed 480 Kcal containing 24% fat, 8.7% proteins and 56.8% carbohydrates (by difference).

TABLE 2. CHEMICAL COMPOSITION OF CASHEWNUT *BURFI*

Parameter	(%)
Moisture	8.50
Fat	24.10
Crude protein, N x 6.25	8.70
Ash	1.13
Acid insoluble ash	0.02
Crude fibre	0.80
Carbohydrates, by difference	56.77
Energy, K Cal/100g	480

Average of duplicate determinations

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Effect of Freezing, Thawing and Frozen Storage on Microbial Profiles of Buffalo Meat

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Studies were carried out on microbial profiles of buffalo meat frozen by plate-freezing and blast-freezing, while thawed at room temperature, chill temperature, in microwave oven and under running water. The results revealed a reduction in microbial count during frozen storage. Coliforms were highly sensitive, whereas *Staphylococci* and moulds were resistant to frozen storage. Micrococci were most predominant, followed by staphylococci, pseudomonas and bacilli at the end of three months of storage period. *Penicillium* was the predominant mould during frozen storage of meat.

Keywords : Freezing, Thawing, Frozen storage, Bacteria, Moulds, Sensitivity, Buffalo meat.

Preservation of meat by freezing and frozen-storage maintains the characteristics almost similar to fresh meat by preventing the microbial growth, and this method is extensively used for the meat products intended for long storage and export. The quality of buffalo meat and the characteristics of skeletal and offal meat, have been well documented (Krishnan and Sharma 1991; Kondiah et al. 1986). A variety of meat products such as *patties* (Anjaneyulu and Sharma 1991) *kababs* and croquettes have also been prepared and successfully tested. Buffalo meat has a good potential for export to middle East countries because India has the World's largest population (70 millions) of buffaloes (FAO 1983). Methods of freezing and microbiology of frozen meat have been reported (Jul 1984; Lowry and Gill 1985). It was shown that gram-positive organisms were more resistant to freezing than gram-negative bacteria. However, data on microbial profiles of frozen-storaged buffalo meat are scanty and therefore, the present studies were undertaken.

Buffalo carcasses, soon after slaughter, were chilled at 4 ± 1°C (RH 85-95%) for 24 h and deboned. Cuts of 500-600 g from *biceps femoris* muscles were made and packed in polythene pouches of medium density (200 gauge, 4-5 cm thickness). Similarly, unit packs of minced meat were prepared. The packs of cuts and minced meat were subjected to freezing, either in a plate-freezer (Foster plate freezer), or in a blast-freezer (Bitzer blast freezer), until the internal temperature of -30°C was achieved in meat. The meat packs were stored at - 15 ± 3°C in a deep-freezer for three months. Sampling for microbiological analysis was done at monthly interval, after subjecting the meat packs to different thawing methods, viz., (a) running water (27 ± 1°C for 50 min), (b) room temperature (26 ± 2°C for 180 min), (c) chill temperature (4 ± 1°C for 8 h) and (d) microwave oven (210 w for 10 min). Microbiological analysis was done as per the standard methods (Thatcher and Clark 1978; Buchanan and Gibbons 1974). Moulds were isolated as per the standard procedure (King et al. 1984). The results were analysed by analysis of variance technique (Steel and Torrie 1980), and Duncan's new multiple range test (Duncan 1960).

The data on microbiological changes during different storage periods of meat cuts and minced meat packs frozen, and stored at - 15 ± 3°C for three months are presented in Table 1.

Total plate counts : The methods of freezing, thawing and storage period have a marked ($P < 0.01$) influence on total plate counts. Samples thawed at room temperature showed greater total counts, and those thawed in microwave oven indicated lower counts. Microwaves, perhaps, may exert some lethal effect on microbes. A gradual decrease in total counts was also noticed both in cuts and minced meat (Table 1).

Psychrotrophs : A highly significant ($P < 0.01$) difference was seen between freezing and thawing methods and storage periods. The count of psychrotrophs in blast/plate-frozen cuts and minced meat thawed under running water was greater than the counts recorded in such samples, thawed by other three methods (Table 1). Samples thawed by microwave method showed less count. A gradual decrease in psychrotrophs was noticed during storage period, which was statistically significant ($P < 0.01$).

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TABLE 1. MICROBIAL COUNTS OF MEAT CUTS AND MINCED MEAT FROZEN AND THAWED BY DIFFERENT METHODS

Sample	Storage period, months	Plate-freezing					Blast-freezing				
		Thawing method					Thawing method				
		Running water	Room temp.	Chill. temp.	Micro-wave	Means	Running water	Room temp.	Chill. temp.	Micro wave	Means
					Total plate count, log/g						
Meat cuts	1	3.5	4.1	3.7	2.8	3.5^{x}	3.6	4.0	3.9	3.3	3.7^{x}
	2	2.3	3.1	3.0	1.9	2.6^{y}	2.8	3.2	3.1	2.9	3.0^{y}
	3	2.4	2.9	2.6	1.9	2.4^{y}	2.4	2.9	2.9	2.8	2.8^{z}
	Mean	2.7^{a}	3.4^{b}	3.1^{c}	2.2^{d}	-	2.9^{a}	3.4^{a}	3.3^{b}	3.0^{a}	-
Minced meat	1	3.5	4.0	4.1	3.1	3.7^{x}	3.6	3.9	3.9	3.0	3.6^{x}
	2	3.2	3.4	3.0	2.8	3.1^{y}	2.9	2.6	2.9	3.1	2.9^{y}
	3	2.5	3.0	2.9	2.9	2.8^{z}	2.7	2.7	3.0	3.0	2.9^{y}
	Mean	3.1^{a}	3.5^{b}	3.3^{b}	2.9^{a}	-	3.0^{a}	3.1^{a}	3.3^{b}	3.0^{a}	SEm (115df)
					Psychrotrophs, log/g						
Meat cuts	1	3.0	3.0	2.7	1.8	2.6^{x}	2.9	3.1	2.9	2.6	2.9^{x}
	2	2.7	2.1	2.0	1.1	2.0^{y}	2.6	2.7	2.1	2.1	2.4^{y}
	3	2.0	2.0	1.8	1.0	1.7^{z}	2.3	2.6	2.1	2.2	2.3^{y}
	Mean	2.6^{a}	2.4^{b}	2.2^{c}	1.3^{d}	-	2.9	2.8	2.8	2.6	2.8^{x}
Minced meat	1	3.0	3.0	3.5	2.1	2.9^{x}	2.9	2.8	2.8	2.6	2.8^{x}
	2	2.6	2.7	3.0	1.9	2.5^{y}	2.0	2.4	2.3	2.4	2.3^{y}
	3	2.4	2.6	3.0	2.1	2.5^{y}	2.1	2.2	2.1	2.5	2.2^{y}
	Mean	2.7^{a}	2.8^{a}	3.2^{b}	2.0^{c}	-	2.4^{a}	2.5^{ab}	2.4^{c}	2.5^{b}	SEm (115df)
					Staphylococci, log/g						
Meat cuts	1	3.0	3.0	2.8	2.0	2.7^{x}	2.9	3.1	3.0	2.8	2.9^{x}
	2	2.9	2.6	2.6	1.8	2.5^{y}	2.6	2.9	2.7	2.6	2.7^{y}
	3	2.7	2.5	2.7	1.9	2.4^{y}	2.7	2.8	2.8	2.5	2.7^{y}
	Mean	2.8^{a}	2.7^{b}	2.7^{b}	1.9^{b}	-	2.7^{ab}	2.9^{a}	2.8^{bc}	2.6^{a}	-
Minced meat	1	2.7	2.8	2.7	2.4	2.7^{x}	2.8	2.7	3.0	2.6	2.8^{x}
	2	2.5	2.9	2.5	2.2	2.5^{y}	2.6	2.4	2.7	2.3	2.5^{y}
	3	2.5	2.7	2.6	2.3	2.5^{y}	2.7	2.5	2.8	2.5	2.6^{y}
	Mean	2.6^{a}	2.8^{b}	2.6^{a}	2.3^{c}	-	2.7^{a}	2.5^{b}	2.5^{a}	2.5^{b}	SEm (115df)
					Coliforms, log/g						
Meat cuts	1	0.9^{a}	0.9^{a}	0.8^{a}	0.8^{a}	0.9	1.0^{a}	1.0^{a}	1.0^{a}	0.8^{a}	0.9
Minced meat	1	0.6^{a}	1.2^{b}	0.9^{ab}	0.9^{ab}	0.9	1.1^{a}	1.2^{a}	1.0^{a}	0.6^{b}	1.0
				(level of significance P < 0.05)							SEm (35df)
					Moulds, log/g						
Meat cuts	1	1.3	1.6	1.8	1.3	1.5^{x}	1.6	1.7	1.5	1.5	1.6^{x}
	2	1.2	1.4	1.4	1.1	1.3^{y}	1.4	1.5	1.5	1.5	1.5^{x}
	3	1.2	1.5	1.3	1.1	1.3^{y}	1.4	1.5	1.4	1.5	1.4^{x}
	Mean	1.2^{a}	1.6^{b}	1.5^{b}	1.2^{a}	-	1.5^{a}	1.5^{a}	1.5^{a}	1.5^{a}	-
Minced meat	1	1.6	1.5	1.6	1.1	1.5^{x}	1.6	1.9	1.5	1.6	1.7^{x}
	2	1.5	1.5	1.5	1.1	1.4^{x}	1.5	1.6	1.5	1.6	1.5^{x}
	Mean	1.6^{a}	1.5^{a}	1.5^{a}	1.1^{b}	-	1.5^{a}	1.7^{b}	1.5^{a}	1.5^{a}	SEm (115df)

The data were analysed according to 2 x 4 x 3 factorial design with six replicates. Significance of interactions are at ($P < 0.05$). Means of same row and column followed by different letters (x y, z and a, b, c, d, respectively) differ significantly ($P < 0.01$).

Staphylococci : Microwave thawing showed less staphylococci in cuts and minced meat, while maximum number of these bacteria was seen in samples thawed under running water and at room temperature. The growth of staphylococci was reduced after a month, and remained almost constant during second and third months of storage (Table 1).

Coliforms : No significant ($P > 0.05$) difference between the methods of freezing and thawing as well as in cuts and minced meat, frozen and thawed by different methods, was observed (Table 1). However, a significant ($P < 0.05$) difference between replicates of cuts and minced meat was observed. Coliforms appeared to be highly sensitive to frozen storage, as indicated by their absence in meat samples stored for second and third months.

Moulds : Highly significant ($P < 0.01$) difference was observed due to influence of method of freezing, thawing and storage period in both meat cuts and minced meat. A reduction in their counts in cuts and minced meat samples was observed

during second and third months of storage. However, this reduction was marginal, indicating that the moulds are slightly resistant to frozen storage.

Reduction in microbial counts on frozen storage, observed in the present study, was in agreement with the findings of earlier workers (Haines 1938; Stille 1950; Ray and Speck 1973). These authors have made extensive studies on pure culture in frozen suspension and reported decline in microbial number during frozen storage. Christophersen (1968) and Lowry and Gill (1985) concluded that loss of viability of bacterial cells during frozen storage is far slower than that observed at the start of freezing. The rate of loss decreased with time, until cell numbers became stable.

Types of microorganisms associated with meat stored at - 15 ± 3°C for three months : Micrococci were found to be predominant in frozen storage of meat, followed by *Staphylococcus*, *Pseudomonas* and *Bacillus* in both plate-and blast-frozen samples (Table 2), as against the literature report on dominance of *Moraxella*, followed by *Staphylococcus*, *Micrococcus* and *Enterococcus* (Kraft et al. 1979). In the present studies, *Morexella* and *Enterococcus* were negligible. With regard to moulds in frozen storage, *Penicillium* were predominant followed by *Aspergillus*, *Rhizopus* and *Mucor* (Table 2). Gill and Lowry (1982) also isolated different types of moulds i.e., *Cladosporium*, *Penicillium*, *Chrysosporium*, *Mucor* and *Thamnidium* species in frozen storage meat. The reason for the presence of different types of bacteria and moulds can be attributable to the surface contamination of the carcasses during processing, handling and cutting of meat in the local slaughter units. Thus, the findings would be useful in understanding the growth of microorganisms in meat, particularly during freezing, thawing and frozen storage.

TABLE 2. TYPES OF MICROORGANISMS ASSOCIATED WITH MEAT STORED FOR 3 MONTHS AT-15±3°C AND THEIR PERCENTAGE

Microorganisms	Plate-frozen	Blast-frozen
Bacteria		
Micrococcus	56	52
Staphylococcus	32	33
Pseudomonas	10	12
Bacillus	2	3
Moulds		
Penicillium	75	74
Aspergillus	11	13
Rhizopus	8	7
Mucor	6	6

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Effect of Combinations of Nitrogen, Phosphorus and Potassium Fertilizers on the Quality of Fresh and Canned Mangoes

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Effect of combinations of nitrogen, phosphorus and potassium fertilizers on the fresh and canning quality of *Dashehri* and *Langra* mango varieties was studied. The physical characters, like weight, size and firmness as well as the quality of fresh fruits, in terms of chemical parameters, were appreciably affected by the combination of fertilizer applied. Similar was the case with respect to physico-chemical parameters of canned mangoes. The canned samples of *Dashehri* mango from different combinations of fertilizers judged superior to the control lot, in respect of overall organoleptic quality.

Keywords : Fertilizer combinations, Fresh mangoes, Canned mangoes, *Dashehri*, *Langra (Banarasi)*, Storage studies.

It is well recognised that the quality of fruit and vegetable crops is influenced by application of various fertilizers. A number of reports are available on the effect of various attributes on the processing qualities as well as the varietal suitability for canning mangoes (Bose 1958; Nanjundswamy et al. 1966). The volatiles in the mangoes play a very important role in flavour and taste (Kapur 1983; Golap and Bandyopadhyay 1975). There are however, no reports available on the relationship between application of nitrogen-phosphorus-potassium (NPK) fertilizer and canning quality of mango. Hence, an experiment was designed to investigate the extent to which the canning quality of *Dashehri* and *Langra (Banarasi)* varieties of mango could be influenced by NPK fertilizers.

Trees chosen for procuring fruits of these two varieties of mangoes were part of a manurial experiment conducted at Government Fruit Preservation Research Station, Basti. The trees were 15 years old and had received uniform cultural practices. Eight trees of each variety were used in each replication. The two levels of each fertilizer, combined in the factorial design of treatments were NO, NI (2 lb N/tree), PO, Pl (1.5 lb P_2O_5/tree) and KO, Kl (2 lb K_2O/tree), were applied as single dose during the month of October, with the last irrigation. N, P, and K were applied in the form of ammonium sulphate, super phosphate and potassium sulphate, respectively. The trial included 8 treatments and was conducted in a confounded design with two replications, with varieties as the main treatments and fertilizer treatments as sub-plots. Fruits required for processing were harvested randomly at the desired stage of physiological maturity (sp. gr. ranges between 1.01 and 1.02), with similar size and colour grade, and stored for 5 days at room temperature (29 to 35.2°C, R. H. 66.5 to 69.30%) to reach the desired ripeness for canning. The properly ripe mangoes were washed, peeled and were cut into suitable sizes (6.25 cm - 7.5 cm). The slices were canned in standard No. A $2\,^1/_2$ internally plain cans, with approximately 425 g of slices/can in 40° Brix sugar syrup, containing 0.25% citric acid, with a headspace of about 0.65 cm. All thirty two filled cans were exhausted at 82.22°C for 6-8 min. Centre of the cans were required a temperature of 79.44°C. Cans were sealed and pasteurized for 18 min in boiling water, cooled in running water and stored at room temperature (16.5-38.6°C, R.H. 69-79%).

Cutout examination was made after the storage for one week as well as four months and the canned mangoes were evaluated for colour, texture, taste and general appearance by a panel of four judges Estimations of sugar, total acidity and ascorbic acid were made as per AOAC (1965) methods. Ten fruit samples were also used to determine physico-chemical attributes prior to canning. Pressure test was done with a Magness Taylor pressure tester, fitted with a plunger of 12.4/39.5 cm diam.

The statistical analysis of the data, concerning different physico-chemical characteristics of the mango fruits, indicated that the application of NPK influenced the fresh as well as canning qualities of both varieties of the mangoes. However, some treatment combinations did not show any significant difference in various physico-chemical characters.

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TABLE 1. PHYSICO-CHEMICAL CHARACTERISTICS OF FRESH MANGO PRIOR TO CANNING

Parameter		T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	C.D. at 5% (NPK)
Pressure test, lb	D	17.3	15.4	16.0	17.0	14.6	14.2	15.5	16.5	0.223
	L	4.5	6.0	5.5	6.5	4.4	5.2	4.6	6.5	0.223
Average weight, g	D	125.0	123.7	126.2	122.5	130.0	122.0	127.5	123.0	0.699
	L	195.2	196.2	191.2	195.0	191.2	190.0	182.5	190.0	0.699
Pulp, %	D	7.1	6.5	6.6	6.5	6.2	6.8	6.1	6.1	0.254
	L	13.0	12.8	12.3	13.2	13.3	13.1	12.7	12.9	0.254
Slices, %	D	60.5	61.0	60.5	61.0	60.5	60.0	61.3	61.5	0.529
	L	55.7	55.9	58.0	54.0	55.0	55.5	56.8	56.0	0.529
Ascorbic acid, mg/100 g	D	14.4	16.2	15.3	15.3	15.6	14.7	17.4	15.3	0.404
	L	112.5	113.2	122.3	126.3	106.2	128.7	96.3	119.7	0.404
Acidity, % (citric acid)	D	0.18	0.16	0.19	0.16	0.17	0.16	0.19	0.16	0.018
	L	0.22	0.21	0.21	0.21	0.21	0.20	0.29	0.29	0.018
Total sugars, %	D	16.33	16.14	16.23	16.86	16.0	17.71	17.75	15.99	0.157
	L	15.24	15.55	15.45	1513	14.14	13.94	14.33	14.50	0.157
Organoleptic rating	D	82.0	82.5	85.0	86.0	79.5	74.5	83.0	76.0	0.401
	L	84.0	68.0	78.0	78.5	69.5	75.5	78.0	84.5	0.401

D = *Dashehri*, L = *Langra*, T_1 = NO, PO, KO; T_2 = NO, P1, KO; T_3 = NO, PO, K1; T_4 = NO, P1, K1; T_5 = N1, PO, KO; T_6 = N1, P1, KO; T_7 = N1, PO, K1; T_8 = N1, P1, K1

Quality of fresh fruits : Data in Table 1 indicate the significant effect of different fertilizer combinations on fruit weight, pressure, pulp and slice % in both varieties. The variety *Langra* had higher pulp content as compared to *Dashehri*, irrespective of fertilizer treatments. However, on the contrary, the % slice in variety *Dashehri* was higher than *Langra*. This could be assigned to its uniform width along the length and lack of stone bulging in the centre. These observations are in agreement with the findings of Adsule and Roy (1974).

Similarly, data in Table 1 indicate that the application of different fertilizer combinations bring about significant effect on the quality of fruits of both the varieties, in terms of ascorbic acid, acidity, sugar content and organoleptic quality. The amount of vitamin C in variety *Langra* was considerably higher than *Dashehri*. Data on chemical composition of both the varieties are within the range reported by Teotia et al. (1968).

Canned mangoes : The cut-out examination and the changes occurring in chemical constituents of the canned samples during storage are presented in Tables 2 and 3. It was found that vacuum decreased with the advancement of storage period. The fall in the vacuum during storage may be assigned to the production of hydrogen due to Maillard reaction (Meyer 1961) and corrosion (Cruess 1958). The drained weight of the slices statistically increased due to the absorption of sugar in the slices during storage. These findings are in agreement with the observations of Adsule and Roy (1974).

TABLE 2. CUT-OUT EXAMINATION OF CANNED MANGO SLICES AT ROOM TEMPERATURE

Treatments	Storage period, month	Vacuum, inch		Headspace, cm		Drained weight, g		Organoleptic rating, %		Internal condition	
		D	L	D	L	D	L	D	L	D	L
T_1	0	14.5	14.2	0.5	0.5	554.0	640.0	70.0	77.0	N	N
	4	14.0	12.2	0.6	0.7	581.5	661.5	68.0	69.0	+	++
T_2	0	14.5	14.0	0.5	0.5	552.5	608.2	73.0	66.0	N	N
	4	13.5	12.0	0.7	0.6	580.0	656.0	71.0	65.0	+	+++
T_3	0	13.5	13.5	0.5	0.4	559.5	649.5	78.0	76.0	N	N
	4	12.0	12.5	0.6	0.6	585.0	668.5	74.0	73.0	+	++
T_4	0	14.0	14.0	0.5	0.4	556.0	645.0	74.0	77.0	N	N
	4	13.0	13.0	0.6	0.5	586.0	680.0	73.0	75.0	+	++
T_5	0	13.5	13.0	0.5	0.5	557.5	607.2	72.0	65.0	N	N
	4	12.0	12.0	0.6	0.6	685.5	626.5	70.0	56.0	+	+++
T_6	0	13.5	14.0	0.5	0.4	555.0	603.0	74.0	75.0	N	N
	4	12.5	12.0	0.6	0.6	590.5	651.0	73.0	73.0	+	+++
T_7	0	14.0	14.5	0.6	0.5	563.5	640.0	74.0	75.0	N	N
	4	13.0	13.0	0.7	0.6	572.5	650.0	72.0	73.0	+	++
T_8	0	14.0	14.5	0.6	0.5	583.5	645.5	75.0	83.0	N	N
	4	13.0	13.0	0.7	0.6	586.0	659.5	74.0	74.0	+	++
C.D. at 5% (NPK)		0.274	0.274	NS	NS	1.541	1.541	2.332	2.332		

D = *Dashehri*, L = *Langra*, N = Normal, + = internal appearance - shining, slight feathering, ++ = Light feathering, faint staining, +++ = Light feathering, moderate staining, T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 as per Table-1.

TABLE 3. CHANGES OCCURRING IN CHEMICAL CONSTITUENTS OF CANNED MANGO SLICES DURING STORAGE AT ROOM TEMPERATURE

Treatments	Storage, month	Acidity, % (citric acid)		Ascorbic acid, mg/100g		Reducing sugars, %		Total sugars, %	
		D	L	D	L	D	L	D	L
T_1	0	0.12	0.19	11.2	100.6	8.01	12.25	19.24	22.75
	4	0.07	0.12	9.8	87.9	10.45	13.40	23.10	24.88
T_2	0	0.13	0.18	12.8	100.8	8.55	11.90	20.40	23.05
	4	0.07	0.14	11.0	91.5	10.87	12.80	23.47	25.40
T_3	0	0.14	0.19	13.2	109.5	8.72	11.70	20.87	22.55
	4	0.09	0.15	11.4	97.3	9.95	13.00	23.65	25.10
T_4	0	0.13	0.18	12.8	112.5	8.11	12.37	20.36	22.76
	4	0.08	0.14	12.5	98.5	10.24	14.10	23.34	25.85
T_5	0	0.12	0.18	12.4	96.2	9.66	12.20	21.61	23.35
	4	0.08	0.15	10.7	84.5	10.75	13.15	23.60	25.65
T_6	0	0.14	0.18	12.5	112.0	9.82	11.75	22.35	22.85
	4	0.08	0.13	9.9	98.4	10.65	12.95	23.66	24.95
T_7	0	0.14	0.16	12.4	87.2	9.06	12.15	21.94	22.85
	4	0.06	0.12	10.2	73.5	11.25	13.50	24.45	25.90
T_8	0	0.14	0.18	13.5	107.5	9.38	11.65	21.28	23.05
	4	0.08	0.12	11.5	95.0	11.65	12.90	24.08	25.58
C.D. at 5% (NPK)		NS	NS	0.283	0.283	0.099	0.099	0.144	0.144

D = *Dashehri*, L = *Langra*, T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 as per Table-1.

However, data in Table 2 indicate that the application of different fertilizer combinations did not produce significant effect on increasing headspace. The overall organoleptic evaluations of canned samples of both varieties appear to be appreciably affected by the application of various fertilizers. The samples of variety *Langra*, which received the combined treatment with NPK fertilizers, scored highest (85.0%) just after canning. However, the samples of this variety, treated with N and P alone, were noted to be comparatively poor (65% and 66%) for the same corresponding period. Moreover, the samples of variety *Dashehri*, from different fertilizer combinations, were judged to be superior to control lot, with respect to overall organoleptic quality. Proebsting et al (1957) found that the quality of canned peaches improved as the dosage of nitrogen was increased upto a certain limit.

It is apparent from Table 3 that there was significant effect of different fertilizer combinations on the changes in the chemical composition of canned mangoes during storage. Both varieties showed appreciable difference in their chemical characters, irrespective of the fertilizer treatments. The variety *Langra* had higher amount of ascorbic acid, as compared to *Dashehri*. Ascorbic acid content continued to decrease during storage. The loss in ascorbic acid during storage may be due to destruction by heating and processing (Lal and Pruthi 1955). Reducing and total sugars showed significant increases during storage and were higher in *Langra* than in *Dashehri*. This may be ascribed to higher amount of acidity in *Langra*, which might have accelerated the hydrolysis. These observations are in conformity with the findings of Adsule and Roy (1974). Acidity percentage tended to decrease during storage. The fall in acid content might be attributed to its leaching out in the covering syrup. However, the effect of NPK on acidity was non-significant.

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Cereals in Breadmaking : A Molecular Colloidal Approach : by Ann-Charlotte Eliasson and Kare Larsson (Eds), Marcel Dekker, Inc., New York, 1993, pp : 392, Price : $ 135

This book is the fifty-fifth volume in the series of monographs, text books and reference books in Food Science and Technology. It describes the breadmaking technology at a molecular level, based on surface and colloidal science. The approach has not so far, been tried and for the first time throws light in a comprehensive manner, on the fundamental aspects of knowledge in breadmaking.

Chapter 1 deals with basic concepts of surface and colloid chemistry, describing very briefly the interfaces, surface active molecules, interfaces of solids, the electric double layer, monomolecular films at the air/water and oil/water interfaces, self-assembly of lipid molecules in water, water and hydration force. colloidal aspects of proteins, colloidal structures, flow properties and porous structures. Here, an attempt has been made to introduce the reader to the fundamental aspects to enable him to understand the breadmaking through surface and colloid science.

The main components of wheat flour namely lipids, proteins, starch and non-starch polysaccharides influence the mixing and baking characteristics. In chapter 2, their structure, interaction with water and physical properties are described. Further, there is a vivid explanation on composition, rheological properties and significance in baking of the components from wheat flour.

The interactions between components of wheat flour in aqueous environment on the molecular and colloidal levels are dealt in chapter 3. Protein-lipid interaction at the air/water interface, protein-starch interactions influencing dough mixing, baking and staling, molecular interactions between amylose or amylopectin and protein, interactions between protein and starch granules, and starch-lipid interactions affecting the starch properties and amylose/amylopectin-lipid complexes are detailed.

Chapters 4 and 5 contain description on properties of lipids, proteins, starch and non-starch polysaccharides from selected cereals like rye, barley, oats, rice and maize as compared to wheat, the structure of wheat kernel, the milling process of wheat and composition of flour.

Chapter 6 deals with the wheat flour dough from the point of view of colloidal and surface chemistry. The wheat flour dough, which is an intermediate stage in breadmaking, has its properties related to machinability and final product quality. The highly complex colloidal system of wheat flour dough derives its properties from the components of flour and the added ingredients. There is a vivid description of the continuous gluten phase with respect to mixing and dough development, oxidation and reduction, mixing requirements and influence of added ingredients. Yeast and fermentation, inclusion of air cells, mixing atmosphere and oxidation are explained under dispersed gas phase. In addition, the visco-elastic behaviour of dough and gluten, the influence of starch on the rheological behaviour of gluten and structure of dough are described.

The physical and chemical changes that take place during baking of bread are discussed in chapter 7. The effect of heat in increasing the volume of bread in the oven, resulting in oven spring is explained in terms of heat and mass transfer, production, solubility and thermal expansion of gas. Further, influence of heat on flour components and gas holding capacity is detailed. Finally, bread structure, baking behaviour of whole wheat flour and non-wheat cereals and staling of bread are discussed briefly.

The authors deserve compliments for presenting clearly and vividly, in an easily understandable manner, the fundamental aspects of breadmaking, utilising the surface and colloid science as base. The book under review, is an excellent text book for advanced studies in cereal technology. It is of immense utility to the teachers, researchers and students associated in the field of wheat technology. The literature cited at the end of each chapter is useful. This book can be a valuable asset to the libraries catering to the needs of food scientists and technologists.

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The Technology of Vitamins in Food : Edited by P. Berry Ottaway, published by Blackie Academic and Professional (Chapman & Hall), Wester Cleddens Road, Bishopbriggs, Glasgow, G 64 2NJ, U.K., 1993; pp ix + 270. Price : £ 65

This book is primarily written for persons involved in product and process development, quality control and analysis of vitamins. The text of the book runs into 9 chapters. Chapter 1 deals with biochemical functions of vitamins and introduces their functions in the body to the reader.

This chapter has been well written and provides information in a concise form. Chapter 2 gives information about vitamin content of natural foods. It is an excellent compilation of the available data. An attempt has also been made to provide background information about vitamins. Chapter 3 describes nutritional aspects of vitamins. The information on deficiency symptoms has been provided in a cursory manner. It would have been desirable, if the same was given in a comprehensive form. Further, this chapter was the appropriate place to provide detailed information on RDA, toxicities and safe limits. The author has rather discussed only their conceptual aspects. According to the title, chapter 4 should have provided information on manfacturing processes of different vitamins. Instead, synthetic routes of different vitamins have been narrated. Chapter 5 aims to discuss stabiltiy of vitamins under different processing conditions. The author should have provided specific information about the effect of different processing conditions on vitamin losses.

For example, the effect of heating should have been discussed in terms of time and temperature of exposures; but the information has been provided in general terms. In addition, the information on storage effect is limited. Fortification of food with vitamins has been described in two chapters. Chapter 6 discusses fortification of different products with vitamins, whereas chapter 9 discusses general aspects of food fortification. In fact, both these chapters should have been combined to provide relevant information in a compact form. Chapter 7 discusses use of vitamins as additives. The information on this aspect about commonly consumed foods has been provided. Chapter 8 describes analytical methods used in determination of vitamins. The coverage of different methods is satisfactory. However, only basic aspects have been discussed. Therefore, this book cannot serve as a practical manual for vitamin determinations as claimed.

There are repetitions in the book. The vitamin content of foods has been given at two places (i.e., Tables 2.16 and 7.2). The stability of vitamins has also been discussed under chapter 9 (p 239-240), whereas chapter 5 has been devoted to this aspect only. In fact, the most appropriate place for Table 9.2 was under chapter 5. Besides this, there are some inconsistencies in the text of the book. At many places, the results of the study have been discussed without citing the source (s). A researcher/ reader has, therefore, been deprived of an opportunity of consulting the original study, if there is a need. The information on bakery products has been discussed under fruits and vegetables (Page 104). However, it may be useful to those who are interested to get general information about vitamins, their occurrence and analysis.

B. K. MITAL
G. B. PANT UNIVERSITY OF AGRICULTURE,
PANTNAGAR

Trichlorfon : Environmental Health Criteria 132, World Health Organisation, Geneva, 1992. Published under the joint sponsorhip of the United Nations Environment Programme, the International Labour Organisation and the World Health Organisation - (IPCS - International Programme on Chemical Safety).
Price : SW fr 22 for developed countries,
SW fr 15.40 for developing countries.

Trichlorfon is an organophosphorus insecticider which is used for the control of pests of agricultural crops and also for the control of parasites in domestic animals and human beings. The major route of metabolism is the production of dhichlorvos whose cholinesterase activity is about 100 times more than that of trichlorfon. This publication gives elaborate, vivid and lucid details on the various toxicological aspects of trichlorfon.

The chemical and physical properties and the analytical procedures for estimation of trichlorfon are well explained. The sources of human and environmental exposure and the route of transporation and distribution of this chemical in the environmental components viz. air, water and soil, have been detailed together with the metabolic pathways.

The exposure of trichlorfon to human beings by way of contamination of air, water, soil and through these routes to food commodities have been well explained with sufficient data on the residues in different crops with relevant references. The metabolic pathways, the biotransformation and the execretory routes of trichlorfon have been scientifically brought out with *in vitro* and *in vivo* studies.

The toxicity studies on the non-target organisms in the environment, the carcinogenicity, teratogenicity and neurotoxicity of trichlorfon are referred to descriptively in the chapters, with the acute poisoning symptoms and the treatment of the poisoning.

The report will be of great importance to toxicologists, researchers and environmentalists for the effective and proper understanding, of the insecticide, trichlorfon.

A. VISALAKSHI
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AFST (I) NEWS

Annual General Body Meeting - 1992

The 28th Annual General Body Meeting of the Association was held on 11th September, 1993 at Kalamandir, Mysore, under the Chairmanship of Dr. A. M. Nanjundaswamy, the outgoing President.

The President welcomed the members and specially thanked all the members for the successful completion of III International Food Convention (IFCON-93) and Food Expo-93.

The Proceedings of the previous AGBM and the Secretary's report for 1992-93 were read by the Hon. Exec. Secretary, After brief discussion, the reports were approved. Treasurer's report was read by the Treasurer and was approved.

Highlights of the AGBM were a) presentation of brief activities carried out by each Chapter by their representatives. b) opening of a new chapter at Jaipur from this year and c) the increase in the membership of the Association at the end of the year 1992 to 2600.

AFST (I) Fellows

The Association honoured the following persons by conferring the title 'Fellow' for their significant contributions in the field of Food Science and Technology.

1. Dr. M. L. Shankaranarayana, Scientist, CFTRI, Mysore
2. Dr. C. P. Ananthakrishnan, Retd. Director, NDRI, Bangalore
3. Dr. T. S. Satyanarayana Rao, Scientist, DFRL, Mysore
4. Dr. P. J. Dubash, Reader (Food Technology), UDCT, Bombay

AFST (I) Awards for the year 1992

AFST (I) awards were presented to the following persons in recognition of their meritorious work in the field of Food Science and Technology.

1. Dr. V. Subrahmanyan Industrial Achievement Award was awarded to Mr. Ramesh J. Chauhan, Parle (Exports) Pvt. Ltd., Bombay.
2. Dr. (Ms) T. N. Prabha, Scientist, Plant Cell Biotechnology Department, CFTRI, Mysore, has been awarded "Laljee Godhoo Smarak Nidhi Award".
3. The Young Scientist Award was presented to Mr. H. S. Satish, Scientist, Food Packaging and Distribution Engineering Department, CFTRI, Mysore.
4. The Best Paper Award was presented to Dr. K. S. Jayaraman and Dr. P. S. Raju, Scientists, DFRL, Mysore for their research paper entitled "Development and evaluation of a permanganate based ethylene scrubber for extending the shelf-life of fresh fruits and vegetables", Published in Journal of Food Science and Technology Vol. 29, No. 2, pp. 77-83, 1992.
5. Mr. N. Bhaskar, College of Fisheries, Mathsyanagar, Mangalore, received the Best Student Award.

Publication of Journals

The two reputed bimonthly journals namely "Journal of Food Science and Technology" and "Indian Food Industry", published by AFST(I), have entered their 30th and 12th Years of publication, respectively. Original research papers and feature articles are being received from R & D workers from countries like, UK, USA, Europe, Japan and Africa for publication in these journals. The circulation of each of these journals reached 2000 copies per issue in the year 1992.

Dr. B. K. Lonsane, Scientist, Microbiology and Bioengineering Department, CFTRI, Mysore, and Mr. S. P. Pillai, Head, Technology Transfer and Marketing Department, CFTRI, Mysore, are doing yeomen services as editors in bringing out these journals.

AFST(I) Education and Publication Trust

The Trust met twice during the year 1992. The Trust offered Scholarships to four students in the field of Food Science and Technology.

Office-bearers of AFST(I) for the year 1993-94

President	:	Dr. S. K. Roy (New Delhi)
Past-President	:	Dr. A. M. Nanjundaswamy (Mysore)
Vice-President (HQ)	:	Dr. T. S. Satyanarayana Rao, (DFRL, Mysore)

Vice-Presidents (Chapters)	:	Dr. D. S. Chadha (New Delhi) Dr. S. R. Marathe (Bangalore) Dr. S. R. Padwal Desai (Bombay) Mr. B. Raghuramiah (Madras)
Hon. Executive Secretary	:	Mr. G. A. Krishna (CFTRI, Mysore)
Past Hon. Exec. Secretary	:	Dr. M. N. Krishnamurthy (CFTRI, Mysore)
Hon. Joint Secretary	:	Dr. K. Udaya Sankar (CFTRI, Mysore)
Hon. Treasurer	:	Mr. Rajeshwar S. Matche (CFTRI, Mysore)
Editor, JFST	:	Dr. B. K. Lonsane (CFTRI, Mysore)
Chief Editor, IFI	:	Mr. S. P. Pillai (CFTRI, Mysore)

IFCON - 1993

The Third International Food Convention (IFCON-93) was inaugurated on 7th September 1993 at Kalamandir, Mysore. The five day Convention and Food Expo. was jointly organised by the Association of Food Scientists and Technologists (India) and Central Food Technological Research Institute, Mysore. The co-sponsors were : Ministry of Food Processing Industries, Government of India, New Delhi; Government of Karnataka, Bangalore; Defence Research and Development Organisation, New Delhi; and NEPC Agro Foods Limited, Madras.

The IFCON-93 was inaugurated by Sri Tarun Gogoi, Hon. Minister of State for Food Processing Industries, and presided over by Sri P.R. Kumaramangalam, Hon. Minister of State for Science and Technology, Govt. of India. Sri H. Viswanath, Hon. Minister of Kannada and Culture, Govt. of Karnataka read the inaugural address on behalf of the Chief Minister of Karnataka, Sri Veerappa Moily.

The IFCON-93 souvenir was released by Sri Tarun Gogoi and the Abstracts volume of Poster Session by Sri Viswanath. The Convention was attended by more than 1500 delegates.

Several Scientists and Research Scholars received awards on this occasion.

The Food Expo was inaugurated by Sri Tarun Gogoi, Hon. Minister of State for Food Processing Industries, Government of India, New Delhi. Around 75 Industries participated in the Expo.

ASSOCIATION OF FOOD SCIENTISTS AND TECHNOLOGISTS (INDIA)

Central Food Technological Research Institute Campus, Mysore - 570 013, India.

Invites Nominations for Fellows of AFST (I) for the year 1993

The Association has pleasure in inviting nominations from persons to be conferred as "Fellow of Association of Food Scientists and Technologists (India)" (FAFST) to honour those who have contributed significantly to the progress of Food Science and Technology.

General

1. The awardee will be called as Fellow of Association of Food Scientists and Technologists (India) and in an abbreviated form will be termed as FAFST.
2. The total number of Fellows of the Association will not exceed 5% of total membership, including regular and life members of the Association, in any given year or 100, whichever is lower.

The title of Fellows has so far been awarded to 30 AFST(I) members and 6 non-members who have contributed to the progress of Food Science and Technology.

Eligibility

1. The aim is to honour persons of outstanding merit who have contributed significantly in the field of Food Science and Technology, including R & D Product/ Project Development, Industry, Transfer of Technology and Marketing. The merit of contribution should be the main criterion.
2. Among the Fellows to be nominated every year, 70% will be from AFST(I) and remaining 30% may be from non-members who have contributed significantly for the development of Food Science and Technology.

Nominations

1. The nomination for Fellow should be proposed by five AFST(I) members of good standing for a minimum of 5 years or by 2 Fellows of the Association. This is applicable to AFST(I) members as well as non-members.
2. Any regular or life member of AFST(I), who has been continuously a member of the Association can sponsor the nomination for only one Fellow in a particular year.
3. The nomination shall be accompanied by acceptance of the person proposed.
4. The nomination shall be in the format given. A brief bio-data of the nominee, highlighting the Scientific or Technological achievements in the area of Food Science and Technology, supported by a list of publications not exceeding 10 important research papers or other supporting documents **not exceeding 20 pages**, must accompany the nominations.
5. Central Executive Committee Members of AFST(I) are not eligible to be nominated as Fellows.
6. The nomination duly proposed and accepted by the nominee shall be sent to the Hon. Executive Secretary, AFST(I) by **1st March 1994.**

Selection of Fellows

The nominations received will be placed before an Expert Committee, appointed by the CEC for suitable recommendations to CEC each year. CEC by majority decision will finalise the names of Fellows for each year. **The decision of CEC in this matter will be final.**

Privileges of a Fellow

The Fellow shall be entitled to the following rights :

1. The awardee will be entitled to add FAFST after his name as short title.
2. To be present and vote at all general body meetings.
3. To propose and recommend the candidates for Fellow of the Association
4. To receive *gratis* copies of one of the publications of AFST(I).
5. To fill any office of the AFST(I) duly elected.
6. To be nominated to any committee of AFST(I).
7. To offer papers and communications to be persented before the meeting of the Association.

Cessation of Fellow

1. Any Fellow may withdraw his/her title of the Association by signifying his/her wish to do so by a letter addressed to the Hon. Executive Secretary, AFST(I), which will be placed before the CEC for acceptance.
2. The title will remain for life time of the member.
3. If the Association comes to know of any activity prejudicial to the interest and well being of the Association, the CEC will have the right to withdraw the title.

Conferring as Fellows

The Fellow will be conferred with a Citation at the time of AGBM or at any other suitable function of the Association.

The Association may invite some Fellows, nominated each year, to deliver special lectures in the area of their specialisation either at the AGBM or any other function arranged by the AFST(I).

Please forward your nominations duly filled as per the format given and mail it by Registered post to the Hon. Executive Secretary, AFST(I), CFTRI Campus, Mysore-570 013, before **1st March 1994.**

The envelope containing the nomination along with the bio-data and contributions (5 copies) should be superscribed 'Nomination for Fellow AFST(I)'.

Sd/- G. A. KRISHNA
HON. EXECUTIVE SECRETARY

ASSOCIATION OF FOOD SCIENTISTS & TECHNOLOGISTS (INDIA)
CFTRI CAMPUS, MYSORE-570 013.

Nomination Form For Fellows

We, the following members of AFST(I) wish to propose

Full name and academic distinction

FULL NAME

DATE OF BIRTH

AREAS OF SPECIALIZATION

ACADEMIC QUALIFICATIONS

---

for election as the Fellow of AFST(I). We append below the statement of his/her claims for election as Fellow and certify that in our opinion he/she is fully qualified for that distinction. We also certify that he/she has been informed of the obligations attaching the fellowships of the AFST(I) and is agreeable to abide by them, if elected.

Statement of the proposer (not to exceed 100 words) setting out the discovery, invention or other contribution to newer or process/products or the industrial development of the knowledge made by the candidate.

....

Seconder's name & signature	Proposer's name & signature
Date :	Date :
Station :	Station :

(Signature of supporters from personal/general knowledge)

(1) (2) (3)

I agree for the above nomination

(Name & Signature)

....

Note : (1) Five copies of the candidate's bio-data and list of important scientific publications not exceeding 10 pages and one set of reprints or supporting documents not exceeding 20 pages shall be attached to this form.

(2) Additional information that would be of assistance in considering the nomination may be supplied in a separate sheet.

(3) Last date for receipt of nomination at the office is **1st March 1994.**

ASSOCIATION OF FOOD SCIENTISTS & TECHNOLOGISTS (INDIA)

CFTRI Campus, Mysore - 570 013, India

INVITES

NOMINATIONS FOR AFST (I) AWARDS FOR 1993

Nominations for the following awards of the AFST(I) for the year 1993 are invited. All nominations should be sent by Registered Post, so as to reach Honorary Executive Secretary, Association of Food Scientists and Technologists (India), CFTRI Campus, Mysore - 570 013, before **1st March 1994.**

PROF. V. SUBRAHMANYAN INDUSTRIAL ACHIEVEMENT AWARD

The guidelines for the award are :

(i) Only Indian nationals with outstanding achievement in the field of Food Science and Technology will be considered for the award.

(ii) The nominee should have contributed significantly to the enrichment of Food Science and Technology, and the development of agro-based food and allied industries in India.

(iii) The nomination duly proposed by a member of the Association must be accompanied by the bio-data of the candidate, highlighting the work done by him/her for which he/she is to be considered for the award.

(iv) The awardee will be selected by an expert panel constituted by the Central Executive Committee of the Association.

(v) Central Executive Committee Members of AFST(I) are not eligible to apply for the award during their tenure.

The envelope containing the nominations, along with bio-data and contributions (five copies) should be superscribed "Nomination for Prof. V. Subrahmanyan Industrial Achievement Award - 1993".

LALJEE GODHOO SMARAK NIDHI AWARD

The guidelines for the award are :

(i) The R & D group/person eligible for the award should have contributed significantly in the area of Food Science and Technology in recent years, with a good standing in his/her field of specialization.

(ii) The nominee(s) should be duly sponsored by the Head of the respective Scientific Institution and the application for this award should highlight complete details of the contributions made by the candidates and their significance.

(iii) The nomination duly proposed by a member of the Association must be accompanied by the bio-data of the nominee.

(iv) Central Executive Committee Members of AFST(I) are not eligible to apply for the award during their tenure.

The envelope containing the nominations along with bio-data and contributions (five copies) should be superscribed "Nomination for Laljee Godhoo Smarak Nidhi Award-1993".

BEST STUDENT AWARD

This award is to be given to a student having a distinguished academic record and undergoing the final year course in Food Science and Technology in any recognised University in India. The aim of the award is to recognise the best talent in the field and to encourage excellence amongst the student community.

The guidelines for the award are :

(i) The applicant must be an Indian national

(ii) He/She must be a student of one of the following courses :

(a) M.Sc. (Food Sciences/Food Technology)

(b) B.Tech., B.Sc. (Tech), B.Sc. (Chem.Tech) with Food Technology specialization.

(iii) He/She should not have completed 25 years of age on 31st December 1993.

Heads of the Department of Food Science and Technology in various Universities may sponsor the name of one student from each institution, supported by the candidate's bio-data, details starting from high school onwards, including date of birth and post-graduate performance to date (five copies).

The envelope containing the nomination should be superscribed "Nomination for Best Student Award - 1993".

YOUNG SCIENTIST AWARD

This award is aimed at stimulating distinguished scientific and technological research in the field of Food Science and Technology amongst young scientists in their early life.

The guidelines for the award are :

(1) The candidate should be an Indian national, below the age of 35 years on 31st December 1993, working in the area of Food Science and Technology.

(i) The candidate should furnish evidence of either;

(a) Original scientific research of high quality, primarily by way of published research papers and (especially if the papers are under joint authorship) the candidate's own contribution to the work.

OR

(b) Technological contributions of a high order, as reflected by accomplishments in process design etc., substantiated with documentary evidence.

The application along with details of contributions and bio-data (five copies) may be sent by registered post with the envelcpe superscribed "Nomination for Young Scientist Award 1993".

BEST PAPER AWARD

This award is to be given by the AFST(I) Educational and Publication Trust to the author(s), who have contributed the best paper to the Journal of Food Science and Technology published in 1993. A panel of experts, constituted by the Central Executive Committee, will scrutinize the issues and select the best paper for the award.

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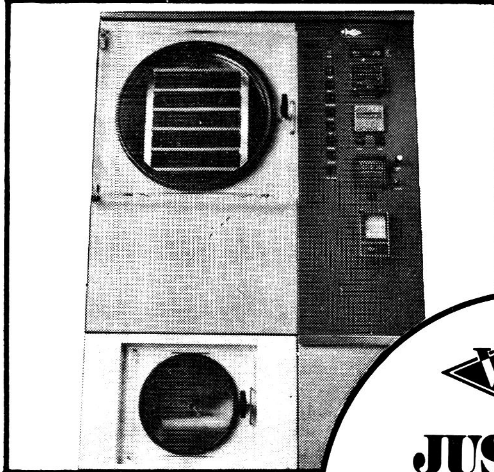

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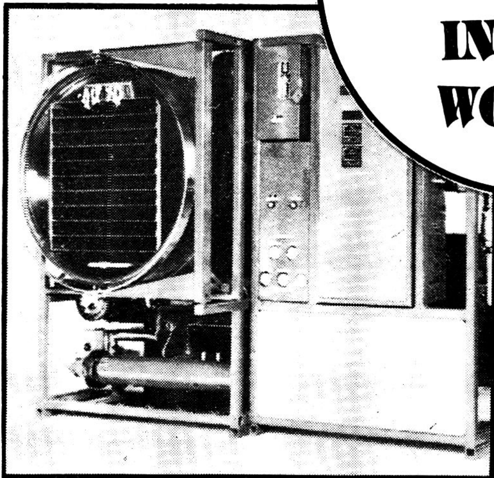

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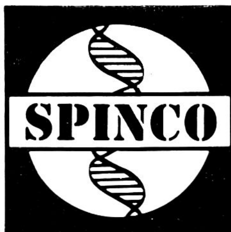

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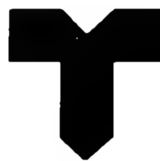

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