FEASIBILITY OF FORMULATING 'READY TO EAT' PRODUCTS BASED ON CASSAVA

By

SYAMA MARY MATHEN

THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Feasibility of formulating 'Ready-to-eat' products based on Cassava"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Shyama

College of Agriculture,
Vellayani.

SYAMA MARY MATHEN

CERTIFICATE

Certified that this thesis entitled **"Feasibility of formulating 'Ready-to-eat' products based on Cassava"** is a record of research work done independently by **Mrs. Syama Mary Mathen** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

College of Agriculture,
Vellayani.

Dr. (Mrs.) S. CHELLAMMAL
(Chairman, Advisory Committee)
Associate Professor,
Department of Home Science

Approved by

Chairman :

Dr. (Mrs.) S. CHELLAMMAL
Associate Professor,
Department of Home Science,
College of Agriculture, Vellayani.

Members :

1. **Dr. (Mrs.) L. PREMA**
Professor and Head,
Department of Home Science,
College of Agriculture, Vellayani.

2. **Dr. (Mrs.) P. SARASWATHY**
Professor and Head,
Department of Agricultural Statistics,
College of Agriculture, Vellayani.

3. **Smt. N. K. VIMALAKUMARI**
Associate Professor,
Department of Home Science,
College of Agriculture, Vellayani.

External Examiner : Dr. M. Raheena Khader 12/3/98

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SYAMA MARY MATHEN

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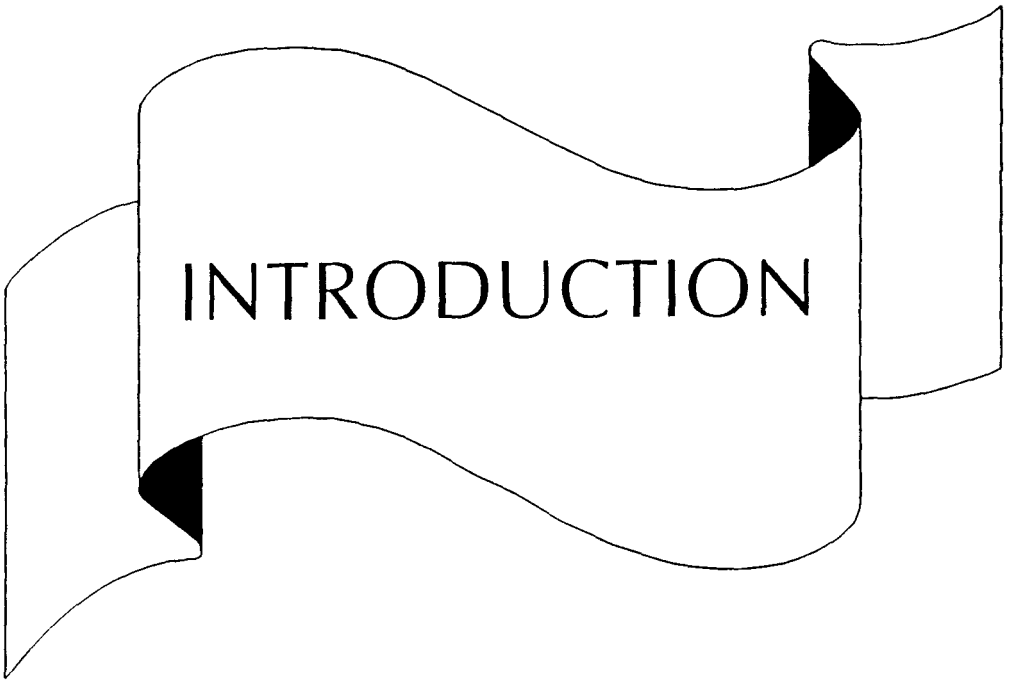

INTRODUCTION

INTRODUCTION

Food, clothing and shelter are the three basic requirements of human life. Of these food is of prime importance as it is required to sustain life and good health. Food production and processing have been the traditional occupation of the countrymen from time immemorial, as it is evident from ancient mythological and historical literature. In order to avoid waste and build up a resource for use in the `out of season' days, food has to be stored and preserved. Wastage of food grain, vegetables and fruit at post harvest stages can be prevented if appropriate processing technologies are developed. (Geervani, 1990).

The change in day to day life of an average Indian due to urbanisation, increase in percapita income, change in life style and increase in working women population has resulted in an increase in consumption of processed foods (Anvita *et al.*, 1993). Consumers today want at short notice, foods which are not only nutritious, but also catering to their tastes. Diversity in culinary preparation has led to varied practices in the case of both fresh and stored food

products. One such product is the `Ready-to-Eat' product. Extruded food falls under this category and these include items like vermicelli, noodles, macroni and spaghetti. The demand for these products in domestic markets has gone up. The exact origin of extruded food is not known but is reported to have taken place somewhere in China. Today extruded products are consumed by nearly all people in large quantities. (Harper 1981). The popularity of extruded foods is because of its relativity inexpensive quality, variety in shape and size and long shelf life without refrigeration or elaborate packing.

Kerala amounts for 70 per cent of the annual production of about 5.8 million tonnes of cassava in India from about 80 per cent of acreage under cultivation. Cassava is comparable with energy rich staple foods like rice, wheat and maize. Cassava is the common staple food of the ordinary man in Kerala but now a days the trend is changing. More than 70 per cent of the annual production of cassava is used for industrial purposes rather than for food. The main reasons for this is that cassava deteriorate rapidly after harvesting accounting for huge post harvest losses. This could be prevented by developing suitable processing technologies for the crop.

Processed cereal based `Ready-to-Eat' extruded foods are already available in the market. If a suitable technology could be developed for processing `Ready-to-Eat' extruded foods based on cassava, it can add variety in the dietaries of the consumers and also be profitable to the farmers. The protein content of such food could be improved by the incorporation of protein rich defatted soy or maize flour.

The objective of the present study "Feasibility of formulating `Ready-to-Eat' products based on cassava" is therefore to utilise the major root crop cassava for the development of cassava based extruded food along with locally available low cost and food articles that can be easily processed and to ascertain the nutritional adequacy, physiological tolerance, acceptability and shelf life qualities of the developed product.


REVIEW OF
LITERATURE

REVIEW OF LITERATURE

Literature available on different aspects related to the present study, "Feasibility of formulating Ready-to-Eat products based on Cassava" is furnished under the following headings :

2.1. Utilisation of cassava and soya in processed foods

2.2. Ready-to-Eat and Extruded foods

2.3. Acceptability studies on processed foods and

2.4. Storage studies on processed foods

2.1. Utilisation of cassava and soya in processed foods

2.1.1. Cassava

Coursey (1973) has stated cassava was more closely identified as a subsistence crop. Cassava's centre of origin is Tropical America. From the point of view of food energy output versus labour input, cassava is reported to be very efficient (Chandra *et al.* 1974). Cassava otherwise known as tapioca is the fifth important staple food in the world (Philips 1974). Oyefeso (1976) reported that cassava

productivity in terms of calories per unit land area per unit time appears to be significantly higher than that of other staple food crops. Cassava offers considerable scope for genetic improvement. Cassava has important use as human food, with potential role as cheap energy source. According to Onwume (1978) cassava is important as food industrial raw material or animal food in many tropical countries. Toma and Tahekhia (1979) have reported that the staple food for Nigeria is cassava. Cassava is grown in about 80 countries, 90% of production comes from 25 countries; with four countries accounting for 53.4% of world production (FAO 1980). Davidson (1980) viewed that cassava is the main source of food item in Zambia. Cassava is responsible for the supply of 38% calories in African diets, 12% in Latin American diets and 7% in the diets of the Far East countries. Maharana (1980) Menon (1980) have stated that Kerala accounts for about 75 per cent of the area of production for cassava.

Meuser and Smolnik (1980) have reviewed the processing of cassava to gari and other food stuffs. Padmaja (1980) reported that cassava was used as a primary and secondary staple by about one fifth of the world population of the low income group of the tropical countries. Ghosh

(1984) reported cassava as poor man's food crop, used as a partial substitute for cereals. Poulose *et al.* (1984) stated that the increase in population and decrease in production of rice have made cassava an important food item in Kerala. Cock (1985) reported that cassava produces four times more carbohydrate than rice from the same area. Since it is mainly a carbohydrate food, it can be used in place of cereals partly supplemented with protein. The Diretorate of Economics and statistics (1985) has stated that production of cassava in Kerala was 39-53 lakh tonnes and the area under production 2, 32, 752 hectares. The agro-socio economic survey conducted by CTCRI around 3000 households residing in Trivandrum rural areas in 1976 indicated that cassava is the major crop raised by them (Ramanathan, 1985).

Cassava or tapioca is an important tuber crop cultivated in tropical and subtropical regions of the world and it forms the staple food of more than 30 million people all over the world. (Karuna and Neelakantan 1987). Kumalaningsih (1992) stated that cassava is economically and socially one of the most important crops in Asia. In India especially in Kerala state cassava is consumed as a staple food by a large number of low income people. The utilisation

of cassava as a traditional food offers good prospects for further development both with respect to marketability as well as improvement of processing techniques.

The protein content of cassava is low even though the protein contains all the essential aminoacids. The starch content ranged from 78.1 to 90.1 per cent on dry basis. The protein content of cassava was reported to be as low as 1.6 to 2.6 per cent (Anon 1975). Cock (1985) feels that cassava produces four times more carbohydrate than rice from the same area. Since it is mainly a carbohydrate food it can be used in place of cereals partly supplemented with protein. Jacob (1985) in her study on nutritive value of tuber crops has observed that cassava starch was found to contain 20 per cent amylase and 80 per cent amylopectin and had a digestability of 48 per cent in the raw state and 78 per cent when cooked. Meera (1985) has reported that cassava is nutritionally very much inferior to other cereals due to its low protein content. Brandburg (1990) in his study on the chemical composition of tropical root crops and its implication for nutrition has found out that cassava is a good source of phosphorus and fair source of calcium and iron.

In India cassava is traditionally processed into several products. Nair (1976) has stated that in India cassava is used as a fresh root, as chips and flour. Yoshi and Garcia (1979) have studied the suitability of cassava flour substitution in the preparation of puttu. Prema *et al.* (1982) have developed different receipies based on fresh cassava and cassava chips. Prema and Chellammal (1986) explained the method of processing and protein quality of gari-based weaning foods based on fermented cassava. Chellammal and Prema (1986) reported that different types of pickles could be processed with cassava and their acceptability and shelf-life were good. The possibility of incorporating cassava flour into some traditional Kenyan foods was studied by Imungi (1990) and he found out that cassava flour upto 50 per cent could be incorporated in the recipes. The feasibility of developing macroni based on cassava was also studied by Chellammal and Prema (1993).

2.1.2. Soybean

Gandhi *et al.* (1985) has reported that the demand for soybean products was consistently increasing in India as they have a great potential in solving the food shortage created by ever expanding population. According to

Jayalekshmi and Neelakantan (1985) soy bean and its products have become increasingly popular but a large section of the population in India is still not aware of the food value of soy bean. Varma *et al.* (1987) stated that the lower cost of soyprotein when compared with milk meat and fish is the most favourable point in utilising soy bean in human food preparation. As a rich protein source, soy bean contributes two thirds of world consumption of protein grains. It is also the major source of oil providing for one third of world's consumption by man (Goronov 1989). According to Natarajan (1989) soy bean is currently the largest commercially available vegetable protein source in most part of the world.

Easter (1981) reported that defatted soyflour contains two times as much protein as in dhal, three times as much as in eggs and fifteen times as much as in milk. Linko *et al.* (1981) has reported legumes including soy bean and oilseeds improved the protein digestability and bioavailability of sulphur aminoacids. Brand and Label (1988) stated that defatted soy flour contains 50 per cent protein, unmatched by any other known vegetarian sources. The increased protein, ash, fat and calorie contents in soy

bean incorporated blends were recorded by Jayalekshmi and Neelakantan (1988). Seralathan *et al.* (1989) have observed that soy flour had 85.00 per cent acceptability. According to Jimbu and Ige (1990), the quality of vitamin A is low in soy bean but the vitamin is present to a level of 1.4 meq/g and prevents the oxidation of fatty acids. Improvement in the protein quality and lysine content by incorporation of soyflour in a weaning food is reported by Cheriyan and Tarar (1992). Rounet *et al.* (1992) has reported that a fibre content of 9.90 g, ash 7.52 g and protein 53.54 g in soy flour.

Chopra *et al.* (1984) have prepared an acceptable youghurt-like fermented product from soymilk. Soy flour incorporated cassava chapathi as well as its acceptability was successfully demonstrated by Prema and Chellammal (1986). The feasibility of incorporating soy flour in weaning foods based on fermented cassava flour was studied by them. It was found that the nutritive value could be considerably increased.

The successful incorporation of soy flour in the development of weaning foods was reported by Easthan *et al.* (1978) and Raida and Wei (1980).

Jayalekshmi and Neelakantan (1987) found that soy flour could be incorporated with sorghum flour upto 50 per cent level for making deep fat fried products like methupakkoda and murukku. For the preparation of puttu, laddu, sevai, uppumav and roti, soyflour could be blended with sorghum flour upto 30 per cent level. Tandon and Singh (1987) state that soy flour can be incorporated in various food preparations. Its in bread, biscuits, chapathis, snacks and texture products has been successfully demonstrated by them. Incorporation of defatted soy flour in such products has also been demonstrated by Sushma *et al.* (1979) and Chauhan and Bains (1988) Singh and Chauhan (1989) found that equally acceptable noodles of better nutritional value can be manufactured by supplementing of semolina flour with 10 per cent defatted soy flour. Thirumaran and Seralathan (1989) conducted a study to incorporate whole and defatted soy flour at 10, 20, and 30 per cent levels for the manufacture of vermecelli. It was found that incorporation of defatted soy flour for the extrusion of vermecelli was feasible at 30 per cent level with increased nutritive value. Lundborg (1990) explained the manufacture of soy cassava gari. Cassava contains only 1 per cent protein with the addition of soybean, the protein content increases to 6 per cent, cost

are similar to those of pure cassava gari and no difference in taste is noted.

Patel *et al.* (1990) studied the extrusion of rice soya blend in proportion of 70:30 and found that moisture level of the final product was lower (6 per cent) avoiding the need of further drying. Siwawaj (1990) has reported vermicelli from sorghum and soya. Protein and fat content, were increased by inclusion of soyflour. Incorporation of 10, 20 and 30 per cent soyflour gave products of acceptable flavour and texture. Incorporation of > 30 per cent soy flour improved rehydration capacity but decreased the strength of pasta products. The successful incorporation of soy flour extruded products was also reported by Lunine *et al.* (1992). The feasibility of incorporating soy flour in extruded food macroni as well as the acceptability was studied by Chellammal and Prema (1993). Effect of soy fortification on quality characteristics of chapathi was described by Anvita *et al.* (1994). Soy fortified chapatti contained 28.8 and 19.0 per cent higher protein and available lysine than whole wheat chapathies. The former also contained higher amounts of calcium, phosphorus and iron than the latter. Soy fortification increased Protein Efficiency

Ratio of chapathi from 1.7 and vitro protein digestability from 71.3 to 73.1 per cent.

2.2. Ready-to-Eat and Extruded foods

2.2.1. Ready-to-Eat Foods (R.T.E)

Fan and Koski (1990) reports Ready-to-Eat cereal compositions of reduced salt content, which provide enhanced cooked cereal flavour are described together with their method of preparation. The combination of ingredients and cooking conditions provides cooked cereal dough and R.T.E. cereals which possess increased levels of pyrazine flavour constituents. Ishigaki *et al.* (1990) reported process for producing extruded noodles capable of being instantly cooked. The process involves kneading a starting powder mixture and passing kneaded material through an extrusion molding machine to obtain instant noodles. Siwawej (1990) has reported R.T.E vermicelli from sorghum and soya with acceptable colour, flavour and texture. Tomoda (1991) has described instant noodles and method of manufacturing instant noodles. Gonzalex (1992) describes influence of extrusion conditions on maize flour characteristics of instant soup preparation. The sample was used as an ingredient in soup formulation,

with addition of soy okara as a protein source to improve nutritional value. Ozawa *et al.* (1992) described process of preparing frozen instant cooking noodles. The strings of noodles are randomly arranged and quickly thawed using heat to produce cooked noodles with good texture and eating properties. Process for the production of pre-cooked cereal food as described by Almeida (1993). Comprised of injecting a compressed gas into the moist cereal blend before extrusion and sugar may also be added to the extruded product.

Arya (1993) has reported R.T.E. convenience foods include shelf stable fried products, moist fried products, popped or puffed cereal, expanded cereal, extruded foods, traditional sweets, papads, instant mixes based on chemical leavening and pre-cooked dehydrated products, R.T.E. products stabilized by antimycotic agents, retort pouch foods, breakfast cereals, canned convenience foods and fruit and vegetable based convenience foods. Byrne (1993) has reported new Ready-to-Eat food products from around the world include low fat foods, low calorie foods, snacks and sweets including sugar free products, flavoured foods, beverages, fortified drinks, flavoured mineral water, yoghurt and sweet sauces.

Chauhan *et al.* (1993) described apricot soy fruit bar a protein enriched product ready for consumption having 70% apricot pulp and 30% soy slurry and 7.8% protein. An ingredient buyers survey conducted by Dillon (1993) came into conclusion that consumers are aware of the limited nutritional value of fast ready-to-eat meals but choose to consume these meals for reasons of taste, quality, service, variety and convenience. Friedman (1993) described R.T.E. cake mixes in which the manufactures assembles a variety of premeasured ingredient into a kit form. Process for the production of fibre containing Ready-to-Eat cereal product with improved texture and appearance was described by Heman and Hamitton (1993). Hollingsworth (1993) stated simplicity, time saving, minimal packaging and good taste as key characteristics of Ready-to-Eat convenience foods. Thulin *et al.* (1993) described method and dough composition for making shelf-stable soft Ready-to-Eat chewy cookies prepared by co-extrusion of an inner adherent dough. Weidmann *et al.* (1993) has reported process for manufacture of bakery products and similar products like bread rolls, bread crumps, long life products in an extrusion cooker ready for consumption. A method of forming R.T.E. noodle bundle was described by Wing *et al.* (1994). Murthy *et al.* (1995)

described roasting of cereals and pulses is traditionally practised in India for enhancing storage life improving organoleptic properties and ease of incorporation in preparation of breakfast and Ready-to-Eat foods. He also reported viable technology for manufacture to ready-to-use cake mix. The mix can be produced on cottage scale, utilising the readily available facilities with minimum investment.

2.2.2. Extruded foods

Webster (1974) defines the word extrude as to shape by forcing through a specially designed opening often after a previous heating of the material. Extrusion is a high temperature short time process. Tribelhorn and Harper (1980) stresses the importance of extrusion cooking over conventional cooking because of versatility, high productivity, low cost, variety in product shapes, high product quality, energy efficiency, economy of space and labour and production of new foods. Harper (1981) report extrusion is found to maximise the beneficial effects of heating foods ie, improved digestability, instanisation, minimising the detrimental effects like browning, production

of off flavour etc. According to Cheftel (1986) extrusion cooking has become a well established industrial technology with number of food applications. Singh and Charuhan (1989) report extrusion cooking combines the heating of food products with the act of extrusion to create a cooked food product with a desired shape.

Southard and Mega have (1978) reported extrusion cooking is capable of over coming the flavour problems associated with certain foods. Extrusion substantially reduces the intensity of most flavour components. Anderson *et al.* (1981) observed a reduction of 13-35% in phytate content after extrusion of a wheat bran starch gluten mix. Linko *et al.* (1981) report extrusion seen to permit the inactivation of several antinutritional and toxic factors. Berset *et al.* (1984) studied the suitability of carotenoid pigments during extrusion and storage of corn starch and reported that carotenoid resists extrusion fairly well but were oxidised during storage depending on their chemical structure. Bjorck *et al.* (1984) stated that extrusion cooking is used to produce flours and starches with a whole range of functional and rheological properties. Cheftel (1986) stressed the advantages of extrusion cooking are

gelatinisation of starch, denaturation of proteins, in activation of many raw food enzymes which cause food deterioration of naturally occurring toxic substances such as trypsin inhibitors in soy bean and diminishing microbial counts in the final product. Cheftel (1986) also reported a decrease in the nitrogen solubility index, trypsin inhibition up to 70-95 per cent and also improved nutritional value of the protein. Eggum *et al.* (1986) studied effects of extrusion on nutritional value of rice flour. He reported that extrusion cooking in a twin screw extruder of milled rice batter of two rice varieties at 15 per cent moisture and 120-150^{o}C reduced the total lysine content 17-15 per cent, true digestability 3%, biological value 4-5% and net protein utilisation 7-8% in growing rats. Hurek and Huber (1989) have reported that in 1987 about 3 million tonnes of products made by extrusion in the USA.

Effect of extrusion cooking in vitro protein digestability of sorghum was reported by Fapojinov *et al.* (1987). Extrusion improved digestability from 45.9-74.6 and 43.9-68.2% for two varieties of sorghum. Dublish *et al.* (1988) found that extrusion cooking resulted in the inactivation of trypsin inhibitor.

Dhawan *et al.* (1991) conducted studies on preparation of sev from blends of bengal gram flour, defatted soy flour and rice flour. The mixture of dough extruded through hand operated sev press into frying pan about 1 litre of refined groundnut oil maintained 180 $\pm$ 5^{o}C.

For the extruder flour dispersion a good correlation exists between viscosity, solubility, concentration and shear rate contribution of starch and non-starch parameters to the eating quality of Japanese white salted noodles was described by Konik *et al.* (1992). Park *et al.* (1993) reported single screw extrusion of defatted soy flour, corn starch and raw beef blends. Dahlim *et al.* (1993) studied the digestability of laboratory extruded cereal grain. Extrusion variables included cereal variety, extrusion temperature, screw speed and feed moisture.

2.3. Acceptability Studies on processed foods

Ericson and De Santis (1983) have stated efforts in product development and testing cover a broad spectrum. Any product that is new, changed should be tested in small quantity before being used in regular production. Converted

standard product should be first tested by producing in small quantities and then carefully evaluating the product. Adjustments should be made if needed and quality should be increased four to six times evaluated and adjusted. Each converted product should be tested three times before it is accepted. Mc. Laren (1984) reported that the criteria included in food quality system are general acceptance, taste, appearance, texture and aroma of food. Shelton (1984) reported when the quality of food is assessed by means of human sensory organs, the evaluation is said to be sensory analysis. Sensory analysis of food relies upon evaluation through the use of our senses only, by applying exact scientific testing methods. According to Rose (1987) success with products is highly dependent on careful evaluation of products and their potential in the generation. Watts *et al.* (1989) reported that the information on specific sensory characteristic of a food must be obtained by using product oriented tests.

Ylimaki *et al.* (1989) stated sensory analysis is a multi-disciplinary science that uses human panelists and their senses to measure the sensory characteristics and acceptability of food products. It is applicable to product

development and quality control. A sensory panel must be treated as a scientific instrument to produce reliable valid results. Portability, ease of use and training flexibility, cost saving, easy and inexpensive maintenance and operational conformity are various advantages of sensory evaluation system as expressed by Bill Meyer and Wyman (1991).

A nutritional evaluation of sorghum blended with soy or cotton seed by Janson *et al.* (1978) revealed that the PER of the blend with soy was comparable to casein while that of sorghum with cotton seed was significantly lower than with casein. Inamdar (1980) conducted acceptability studies on weaning mixes based on malted and roasted cereal and legumes. The study revealed that fully malted and fully roasted mixes were well accepted by children. Tandon and Singh (1987) studied the acceptability of soya incorporated extruded product. Statistical analysis of consumer acceptability data revealed that addition of defatted soy flour up to 15 per cent in the product did not bring any significant difference in their overall acceptability. Reddy (1990) found that four weaning mixtures formulated using local foods and traditional processing techniques were highly acceptable to children and their mothers even after a storage

period of one month. Dhavan and Singh (1991) reported studies on sev preparation and organoleptic evaluation of the product made from blends containing bengal gram flour, defatted soy flour and rice flour in the proportion 75:10:15 and 70:15:15 were similar to control preparation in their overall acceptability where as other products differed significantly.

Lundgren *et al.* (1992) explained extruded wheat flour flavour, texture comparisons of evaluation by two laboratories. Intensities of flavour and texture attributes of 23 extruded wheat flour samples (produced under different conditions representative of foods such as crisp bread, snack, biscuits and breakfast cereals were evaluated by two laboratory pannels in Sweeden and UK. For most attributes good agreement between the two pannels was obtained. The quality of glandless cotton seed flour compared to soy bean prepared in the same way was assessed by Rouanet *et al.* (1992) PER, BV amd NPU demonstrated a good intrinsic nutritional quality for cotton seed proteins when compared with casein and soy bean. Santhosh Kumar (1992) reported effect of soy flour supplementation on the sensory characteristics of some traditional foods. The replacement

of beasan with defatted soy flour up to 20-30 did not lower the sensory properties of the product but rather improved them.

Taha (1992) has reported biochemical, rhelogical, cooking quality and acceptability of defatted soy supplemented whole durum meal noodles. Fortification of whole durum flour (WDF) with DSM increased proteins, ash, fat, carotene, dough mixing strength, pasta firmness and cooking loss but decreased swelling and tolerance to over cooking compared to the non-fortified product. Bekholet and Saygin (1993) report on the quality of the dough products. A mathematical model to describe relationship between two major physico chemical properties of durum wheat and cooking quality of resultant paste products. Cooking quality of paste was determined from cooking loss and by sensory evaluation. Rhelogical characteristics of dought are of vital importance to bakery industry in predicting processing characteristics dough and the quality of end products.

Vaidehi and Varalakshmi (1992) have reported protein quality of extrusion cooked foods of blended wheat, sorghum, horsegram and sunflower seed cake. The study revealed that extruded weaning foods based on blends of

cereals, legumes and oilseed meals can be used as a supplement to the diets of pre school children. Consumer acceptability trials with sugar and spices are acceptable to the pre-school children.

Sharma (1993) has reported defatted soy flour substitution in some traditional foods and effect on sensory characteristics. Consumer acceptance test returned 82.8% positive results and indicated that the snacks were well liked.

Venketwara Rao and Haridas Rao (1993) explain methods for determining rheology characteristics of doughs. Noodles eating quality by quantification analysis has reported by Walane and Suzuki (1993) Anvita Rowat and Gurmigh Singh (1994) reported effect of soy-fortification on quality characteristics of chapatis. Soy fortified chapathis were softer than whole wheat chapatis. Studies on rhelogical properties of Rice-Soya crackers was conducted by Prince *et al.* (1994). Soya at 20-30% level in the mix was found to be optimum from textural point of view of the final product, rhelogy, sensory quality as well as product rhelogy. Vetrimanni and Rahim (1994) explained effect of drying of

vermicelli of good quality can be obtained by drying the extruded vermicelli at 30^{o}, 45^{o}, 85^{o}, and 95^{o} for 60, 30, 30, and 60 min respectively. The results could be beneficial to small scale manufactures of vermicelli in improving quality.

2.4. Storage and shelf-life studies

According to Bhattarjece and Bhole (1984) food packaging and storage is the vital step to ensure product quality because it provides protection againt deterioration and damage during storage, transportation and distribution.

Kumar and Anandaswamy (1980) have reported packaging and storage of dry tapioca products. The packaging requirement of dry tapioca products such as flour, chips and starch to be packed in bulk and of converted tapioca products such as sago vermicelli and macroni to be packed in unit consumer packages are discussed. The standards specified by ISI for all products with respect to maximum permissible moisture content have been given.

Solanki (1986) assessed shelf life of weaning mixes. Different parameters such as moisture, alcoholic

acidity, peroxide value and bacteriological count were analysed. All the malted RTE mixes could meet the ISI specifications for processed foods up to 42 days.

Kalra *et al.* (1987) reported studies on the preparation, packing and storage of potato snacks from cold stored potato. Physico-chemical and organoleptic changes in the products were investigated during the storage period of six months at room temperature (13-38^{o}C RH 30-90%). The products were found to be good in respect of colour, taste and flavour. The products packed in 150 gauge LDPE bags were found to be acceptable up to six months.

Premavalli *et al.* (1987) studied development and storage stability of upma mix. An instantt upma mix which can be reconstituted in 6 min with boiling water has been developed and the role of packaging and fat in the storage stability of the product has been investigated. The product remains stable at room temperature for 10 months and 3 months respectively in paper Al-foil polyethylene laminate and polypropylene pouches. Changes in peroxide (PV) free fatty acids (FFA) and malonaldehyde (MA) content taking place during storage did not correlate with acceptability scores.

Kulkarni *et al.* (1989) reported that the quality of papads made from blends containing bengal gram or red gram was comparable to that of papad made from black gram. Papad remained quite acceptable in 200 gauge LDPE and 120 gauge PP bags during 4 months storage without much change in quality. According to Malleshi *et al.* (1989) under ambient storage LDPE packed weaning samples showed fair quality up to a period of 120 days.

Bastetti and Veronessi (1990) have reported method, of making long term preservation cooked pasta products packed within sealed containers ready for direct consumption has organoleptic characteristics similar to those of fresh pasta.

Kalra *et al.* (1990) studied on the preparation, packaging and storage of dehydrated colocasia snacks. Physico-chemical and organoleptic changes on the products were investigated during the storage period of six months at room temp.(13-38^{O}C RH 30-90%). The products were found to be quite acceptable without any aerid effect up to 6 months and may be consumed after deep fat frying. The effect of ingredient ccomposition and packaging on the storage stability of fried wheat snacks was studied by Kapoor and

Kapoor (1990) Frying medium and packaging material unfluenced the product. Vasin *et al.* (1990) studied keeping quality of pasta products with added protein starch improver. The products were considered suitable for use in soups or as a part of ready to serve meals, which may be stored for 10 months without quality changes. Suitability of different containers like glass jars, tin cans, and poly ethylene bags were used to store snack chips from cassava reported by Van Den (1991). Dried cassava chips could be stored in polyethylene bags, glass jars and tin cans for 6 months without affecting the eating quality while fried chips could be stored in glass jars for one week only.

Natesan *et al.* (1992) report studies on RTE flakes and snack products from sorghum. According to him both the products remained stable for 1yr. When packed in paper-Al-foil polyethylene laminate, polyethylene and poly propylene pouches and stored at room temperature and 37 + 1^{o}C. Ruth *et al.* (1992) reported that storage of soymeal containing bread improver resulted in a lower increase in peak area percentage compared to values obtained using fresh soy meal containing bread improver. Formation of secondary lipid oxidation products was reduced after storage of the

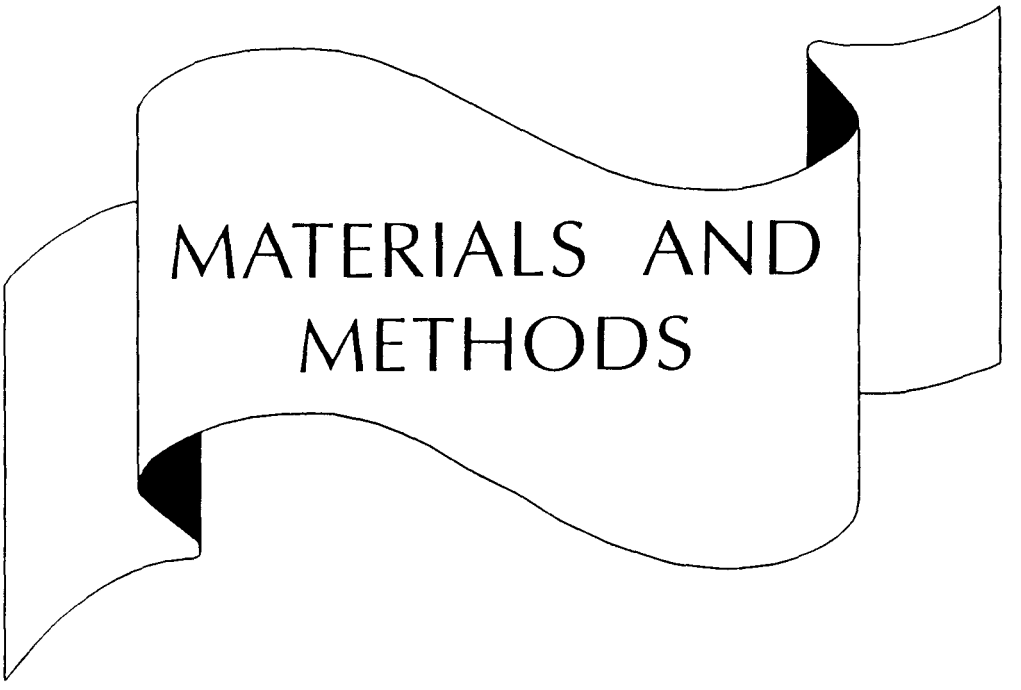
bread improver, bleaching action and lipoxigenase activity also decreased. Distribution of fungal biomass among fine bran, coarse bran and flour from wheat stored at four different moisture levels was described by Schnurer (1992). Storage at higher moisture levels gave a more even distribution of fungal biomass.

Srivastava (1992) has reported changes in the pasting, rhelogical and baking qualities of flour during short term storage. Ukhun and Dibie (1992) studied the ascorbic acid contents of selected marketed foods and influence of water activity during storage. He observed significant losses (between 21 and 83%) of ascorbic acid after 4 and 8 wk of gari and cassava storage. Increasing water activity led to increasing storage losses of the vitamin in both foods ie, six months infestation. Wheat papads packed in 120 gauge bags and the products remained free from insect/mould plastic jars remained well up to 6 months at room temperature. (18-31^{o}C RH 51-84%) Yadav *et al.* (1993) stated bio-chemical changes in defatted soy flour during storage. Defatted soy flour exhibited more pronounced decrease is proteins, pH and increase in acidity at 80% RH and 37^{o}C than at 57% RH and 22^{o}C over 90 days storage. Gawin

(1994) has reported the keeping quality of dough products, instant dough products and couscous (traditional North African wheat product. The finished products were packed in permeable polyethylene pouches and stored in the dark for 11 months at 22-25^{o}C/RH 50-60% (summer) and 18-20^{o}C/RH 30-40% (winter and also 35^{o}C/RH 65%). Effect of storage conditions on the products, moisture content, fat oxidation, colour, stickiness, bite firmness and taste were determined. Definite changes were observed in all products eventhough the overall shelf life was good. Upadhyay *et al.* (1994) reported storage studies on suji in different packages. Effect of storage studies of suji, packed in low density polyethylene, high density polyethylene, high molecular-high density polyethylene, poly propylene, cloth and jute bags, under accelerated environment (38^{o}C and 90% RH) on moisture, total ash, acid insoluble ash, gluten and alcoholic acidity has been studied. Some bio-chemical and micro-biological changes during dehydrated attieke (a form of cassava root) storage was reported by Aboua (1993). Shelf life an quality of dehydrated attieke packed is polyethylene bags purchased from a local producer were evaluated during storage at 10.5, 18.3 and 22% initial moisture contents. Bio-chemical changes due to low moisture storage appeared to be minor compared to

those which occured in high moisture products. Berkowitz and Oleksyk (1993) have reported leavened breads with extended shelf life by inclusion in the dough of appropriate levels of a sucrose ester emulsifier, a poly vinyal pyrolidone synthetic hydrocolloid and alcohol and minimisation of the residual O_2 levels in packaging used used for the breads. Kotwaliwale (1993) has reported storage stability of commercially available weaning foods. He states that a range of water activity exists at all temperature at which major moisture related changes take place is these foods. With increase in moisture content, the moisture binding energy decreases and moisture becomes more free. Storage studies on wheat pappads conducted by Manan *et al.* (1993) has stated the moisture content in dried wheat papad when packed in 120 gauge polypropylene bags and plastic jars increased from 8.0 to 8.9 and 8.6 per cent respectively at the end of six months storage at room temperature 18-31^{o}c and 51-85 per cent RH. After 6 months of storage peroxide value (mcq O_2/kg product) of wheat papad when packed in 120 gaugepolypropylene and plastic jars increased from 0.2-0.79 and 0.85 respectively. Colour and texture remained good throughout the storage period. Kulkarni *et al.* (1995) reported studies on storage of papads made from Rice flakes (Poha) flour. Colocasia and

sago blends. He stated that the product remained well up to 12.9% moisture content corresponding to 65% RH. The percentage change in moisture content of papads packed in 120 gauge polypropylene bags decreased from 11.3-10.4% after 4 months storage at ambient conditions (temp $27^{o}C$-$40^{o}C$ RH 38-63%) Rao *et al.* (1995) reported data on different heat treatment methods for hard cooking of eggs in as such or packed forms (polypropylene or paper aluminium foil polyethylene laminating pouch) for enhancing the shelf life of boiled eggs.


MATERIALS AND
METHODS

MATERIALS AND METHODS

The present investigation on "Feasibility of formulating `Ready-to-Eat' product based on cassava" comprises of :

3.1. Formulation and standardisation of Ready-to-Eat product

3.2. Determination of quality of the developed product

3.3. Assessing the acceptability of the product

3.4. Package and shelf life studies of the developed product

3.1. Formulation and standardisation of Ready-to-Eat product

3.1.1. Selection of Ready-to-Eat product

Ready-to-Eat foods are foods that require no cooking before serving. These are economical, convenient and flavoured foods, suitable for daily consumption by all age groups (Manay, 1987). `Ready-to-Eat' extruded products are very popular with children and they can serve as an effective means for the introduction of important nutrients (Eldash and

Chang, 1990). In the present study vermicelli was selected as Ready-to-Eat product. Vermicelli can be defined as shaped dried dough made from semolina or wheat flour with water, sometimes egg and milk. The dough is partly dried in hot air and then more slowly (Bender, 1976). Cassava flour and starch provide an excellent raw material for extruded foods and breakfast cereals (Eldash and Chang, 1990). In the present study attempts were made to standardise vermicelli based on cassava.

3.1.2. Different combinations tried for development of product

The different foods used to develp the product included cassava flour, maida, soy flour, blackgramdhal flour, milk powder, sugar/salt, greengram flour, rice flour. Twelve combinations (C1...C12) of cassava flour along with the above products were tried for selection of the preparation of vermicelli. These combinations are listed out in Table 3 under (Results and Discussion) indicating the percentage combinations of the food ingredients tried. The principles governing the selection of combination were protein quality, extrusion behaviour and cost.

Protein quality was evaluated by calculating amino acid score. By amino acid scoring procedure one can evaluate the capacity of a given protein or mixture of proteins to meet the essential amino acid and nitrogen requirements of the recipient (Codex committee). The amino acid scores for different combinations were computed and scores obtained are presented in (Appendix 1).

Extrusion behaviour was assessed through observation by technical experts.

Cost of the different combinations were computed as per the market price of the ingredients.

3.1.3. Development of the Ready-to-Eat product

Because of the resulting increase in demand for food there is a need for incorporating high yielding root crops that have a wide range of production and acceptability in developing new products. Good quality flour was prepared from M_4 variety of cassava purchased from the Instructional Farm, College of Agriculture, Vellayani. The tubers were washed to remove the impurities. Peeling and chipping were

done manually with sharp knives. The thickness of the chips ranged form 0.25-0.5cm. The fresh chips were sun dried and finally milled to obtain the flour. The flour was seived through 100 mesh seive to remove the impurities. Eight kilograms cassava flour was thus prepared.

Four kilograms of defatted soy flour were purchased in bulk from Sakthi soya, Pollachi. Six kilogram good quality maida was purchased from local market. It was sieved twice to remove impurities. Blend of selected combination was prepared by mixing cassava flour, maida and soy flour. All the ingredients taken in a bowl were sieved several times in order to get a uniform mixture. The quantity of water was adjusted to such a level that a pliable dough was obtained. Salt or sugar was added at this time to the dough. The flour blends were made into a dough containing 22 to 23 per cent moisture and fed into an extruder to get a fully cooked product. The products thus obtained containing 12 to 15 per cent moisture were further dried to a moisture content of 10.25 in an air drier and packed in polyethylene bags. For the preparation of savoury vermicelli salt and seasonings were added and packed (Fig. 1).

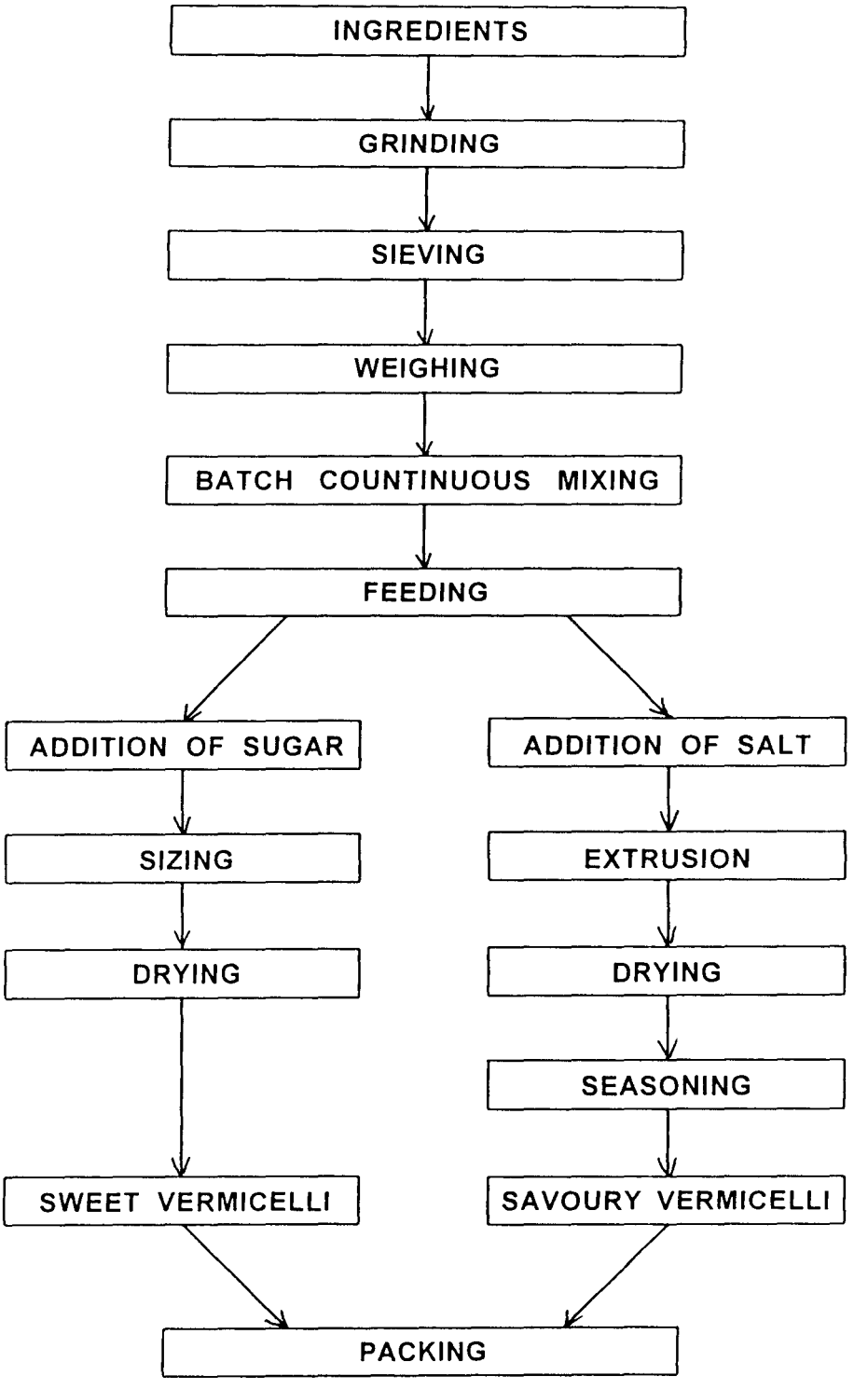


Fig. 1. Flow chart for the processing of vermicelli

Fig 1 EXTRUSION OF VERMICELLI

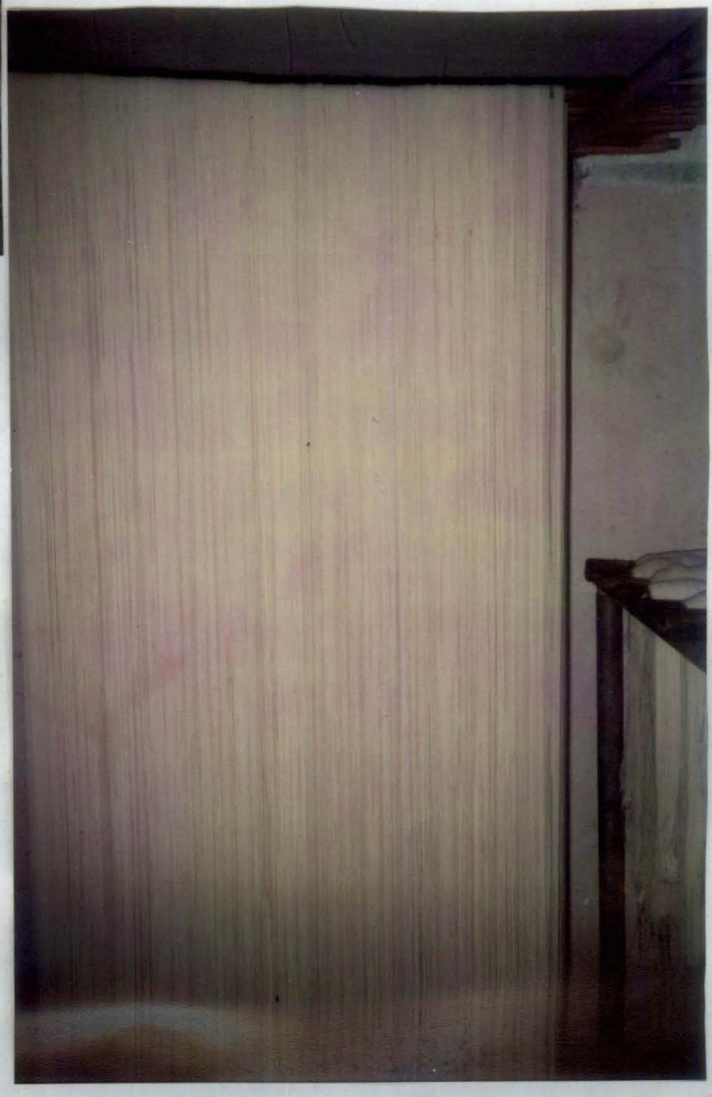


Fig 2 DRYING OF VERMICELLI

Extrusion behaviour

The extrusion behaviour of the developed product was ascertained through observation by technical experts for the uniformity in flow of strands and external appearance during extrusion.

Cooking quality

The cooking quality of the product was ascertained through cooking time, water absorption index and bulk density.

Cooking time

The cooking time of the product was assessed by cooking 25g of vermicelli with 100ml water. The product was cooked till done and the time taken was recorded. The end point was tested by pressing the cooked samples between two glass slides.

Water absorption index

Water absorption index is the quantity of water absorbed by a known quantity of food sample. This is mainly

used to assess the rehydration capacity of the extruded product. 50g of raw vermicelli was taken in a glass beaker. 100 ml of water was added to it. The water was drained after 10 minutes. The weight of hydrated sample was recorded. The water absorption index was calculated by weight of hydrated sample minus weight of raw sample.

Bulk density

Bulk density is the ratio of the weight of sample to the weight of equal volume of water. Bulk density is used as an index for comparing the volume of different foods. The required quantity of vermicelli sample was taken at a height of 20 cm in a 250ml beaker until it filled up. It was leveled without compressing. The weight of sample with beaker was recorded. The sample was then removed from the beaker and water was filled to the same level (20cm). The weight of water with beaker was recorded :

$$\text{Bulk density} = \frac{\text{Weight of sample}}{\text{Weight of equal volume of water}}$$

3.2. Determination of quality of the developed product

Quality of the developed product was assessed with reference to nutritional significance and physiological tolerance.

3.2.1. Nutritional significance

Nutritional significance of the food product was assessed by determining nutrient using standard techniques as detailed below.

Sl.No.	Estimations	References
1.	Energy	Swaminathan (1984)
2.	Protein	Microkjeldahl (ICMR 1983)
3.	Minerals (Fe, Ca & Mg)	Jackson (1973)
4.	Carbohydrates	Anthrone method.

3.2.2. Physiological tolerance

Physiological tolerance was assessed through animal experiments by determining Protein Efficiency Ratio (PER),

Net Protein Utilisation (NPU), Biological Value (BV) and Digestability Coefficient (DC).

Required quantity of vermicelli was powdered and passed through a 60 mesh seive and used for animal experiment.

3.2.2.1. Determination of PER

The PER of proteins of food product as compared with skim milk powder were determined by modified methods of Osborne, Mendek and Ferry (1919) as described in ISI bulletin. The diet contained 10 per cent protein and was adequate in other dietary essentials. Animals (albino rats) of more or less identical weights (45 to 50g) were selected and divided into 2 groups of 6 rats each and fed the respective diet as detailed below.

Composition of experimental diet

Experimental diet	Amount of various ingredients (G)
Vermicelli mix	81.76
Starch	3.24
Groundnut oil	9.00
Mineral mix	4.00
Vitamin mix	2.00

Fig 3 ANIMAL STUDIES

The rats were housed in individual cages with wire mesh flour. Water and the cooked weighed vermicelli mix was fed to the animal. The left over food was collected daily and were dried and weighed. The food consumption was calculated by subtracting the left over from the quatity served. The body weight of the animals was recorded once in 3 days during the experimental period. During experimental period conditions were maintained as uniform as possible. The rats were maintained on the respective diets for 28 days. PER was calculated from the gain in body weight and protein intake using the formula :

$$\text{Protein Efficiency Ratio (PER)} = \frac{\text{Gain in body weight (g)}}{\text{Protein intake (g)}}$$

3.2.2.2. Nitrogen balance studies

The extent of utilisation of proteins of the combination selected was also estimated. The Net Protein Utilisation value was found out by standard experimental procedures suggested by Mitchel (1923-24). Male albino rats weighing 100-120 g were divided into two groups of two each,

were housed in individual metabolic cages. The whole experiment was divided into 3 periods. During the first period of 4 days all the rats were fed with non protein diet to measure endogenous nitrogen. The composition of non protein diet and stock diet are given in Table 2. During the second period of two days the rats were fed with stock diet. During the third period of 4 days the rats in one group were fed with experimental diet and another one with standard diet. The amount of food given and quantity of left over food and actual consumption were recorded every day. During the first and third periods of experiment stools and urine samples were collected. Two drops of toluene were added to the urine samples as a preservative. Stools collected were dried in the oven. The stools of each group collected for 3 days were pooled together for nitrogen estimation. Urinary and faecal nitrogen were estimated by the microkjeldahl method (Hawk and Oser, 1965).

The nitrogen content of the food materials were also estimated using the same procedure. Using the above value, Biological Value (BV), Digestability Co-efficient (DC) and Net Protein Utilisation (NPU) were calculated using the following formulae :

$$BV = \frac{In - (Fn-Fe) - (Vn-Ve)}{In - (Fn - Fe)} \times 100$$

$$DC = \frac{In - (Fn-Fe)}{In} \times 100$$

$$NPU = \frac{BV \times DC}{100}$$

BV = Biological Value
DC = Digestability Co-efficient
NPU = Net Protein Utilisation (NPU)
Fn = Nitrogen in Faeces
Fe = Endogenous faecal nitrogen
Un = Nitrogen in urine on protein diet
Ue = Nitrogen in urine on protein free diet
In = Nitrogen intake

Table 2. Composition of non protein diet and stock diet

Ingredients	Non protein diet	Stock diet
Starch (g)	85	80
Groundnut oil (ml)	9	9
Mineral mix (ml)	4	4
Vitamin mix (ml)	2	2
Skim milk powder	Nil	5

3.3. Assessing the acceptability of the developed products

The acceptability of the developed product was assessed experts, housewives and at local institutions.

Efforts in product development and testing cover a broad spectrum, states Ferison *et al.* (1983). According to Watts *et al.* (1989) the conformation on the specific sensory characteristic of a food must be obtained using product oriented tests. Sensory evaluation consists of judging the quality of food by a panel of judges.

3.3.1. Among experts

Through a triangle test, two panels consisting of ten members each were selected for sensory evaluation studies. The judges were requested to take sample after washing their mouths.

Each quality was assessed by panel members after testing the same sample several time. If needed, the panel members were permitted to take their own time and to judge the sample leisurely. The testing was conducted in the

afternoon between 3-4 pm. since this time was the ideal time for conducting acceptability trials (Swaminathan, 1974). The panel members were requested to allot scores in the score card provided. The score card contained quality parameters such as appearance, flavour, texture, taste and colour (Appendix 2).

3.3.2. Among housewives

The investigator visited fifty individual households and recipes based on the developed vermicelli were distributed to the housewives and their preference for the products were assessed using a seven point rating scale (Appendix 3).

3.3.3. Local institutions

Recipes based on both sweet and savoury vermicelli were distributed among twenty inmates of an oldage home and their preferences were recorded by the investigator.

3.4. Package and shelf life studies

The mechanism and the kinetics of food deterioration is controllable by storage and packaging

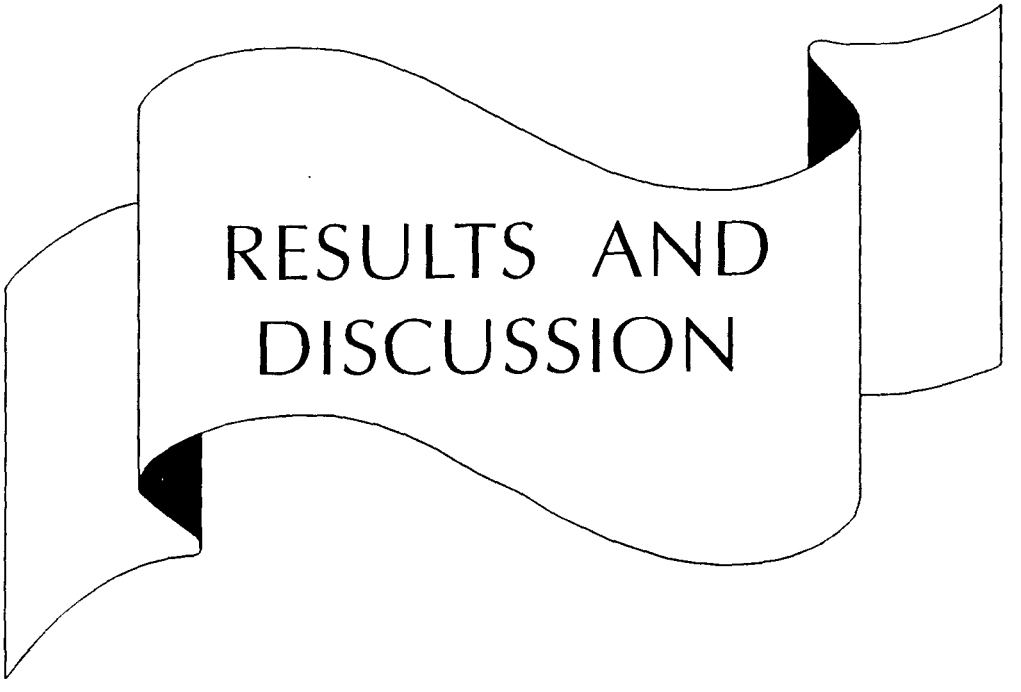
technique (Varsanyi, 1993). Shelf life is most vital for product quality and is the key component of marketability shelf-life qualities of the product was ascertained by packing in polythene covers, sealed and studied for a period of 6 months. Changes in moisture content peroxide value and total sugar were determined once in three months interval during storage under ambient conditions as detailed below.

Assessment of shelf life qualities

Parameters	Methods	Relevant details
Moisture	AOAC (1976)	Once in 3 months for sweet vermicelli and savoury vermicelli
Peroxide value	AOAC (1975)	
Total sugar	AOAC (1976)	

Statistical analysis

The data generated during the study were compiled, analysed statistically and are presented under results and discussion.


RESULTS AND
DISCUSSION

RESULTS AND DISCUSSION

Salient findings of the study entitled "Feasibility of formulating Ready-to-Eat products based on Cassava" are presented under the following sections :-

4.1. Formulation and standardisation of `Ready-to-Eat' product

4.2. Determination of quality of the developed product

4.3. Assessing the acceptability of the product

4.4. Package and shelf-life studies of the developed product

4.1. Formulation and standardisation of `Ready-to-Eat' product

4.1.1. Selection of food ingredients

The raw ingredients selected for any food product play an important role in determining the quality of the product. Cassava, a major tuber crop of Kerala is comparable with energy rich staple foods like rice, wheat and maize and is the basic ingredient used for developing the product vermicelli. In this study, different percentages of cassava flour were combined with soyflour, maida, rice flour,

blackgram flour or milk powder to improve the quality of the composite flour used for processing vermicelli.

4.1.2. Different combinations tried for development of product

Significant progress has been made by food industries in our country in recent years in the area of the development of food products (Rao, 1993).

Details pertaining to the development of vermicelli with different combinations of ingredient for the formulation of the product are presented in Table 3.

Table 3. Composition of different combinations in vermicelli

Ingredients (g)	Combinations (C)											
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Cassava flour	50	40	50	60	40	70	50	60	50	70	60	60
Maida	35	40	--	--	30	20	25	30	30	--	--	--
Soyflour	15	20	--	20	20	10	25	10	20	15	--	--
Sugar / salt	--	--	--	--	10	--	--	--	--	--	--	--
Rice flour	--	--	25	--	--	--	--	--	--	--	20	20
Blackgramdhal flour	--	--	25	--	--	--	--	--	--	15	20	--
Milk powder	--	--	--	20	--	--	--	--	--	--	--	--
Greengramdhal flour	--	--	--	--	--	--	--	--	--	--	--	20

While selecting different combinations for processing vermicelli, care was taken to incorporate locally available low cost and food articles that can be easily processed along with cassava flour. Cassava flour was added to different combinations ranging from 40-70 per cent.

4.1.3. Development of the `Ready-to-Eat' product

The food ingredients selected in different combinations will decide the nutritional quality, extrusion behaviour and cost benefit ratio of the food products. Hence the nature and properties of constituents in a combination is very important in deciding the quality of a product.

The protein quality of each combination was assessed on the basic of amino acid score. Amino acid scores provides a useful estimate of the protein quality of blended foods and is an acceptable substitute for biological assays. Therefore the amino acid scores of the different combinations of vermicelli were worked out using the food composition tables of I.C.M.R. (1991). The amino acid scores of the different combinations varied from 6.0 to 7.9 (Table 4).

The extrusion behaviour of the products processed with different combinations were assessed by ten technical experts using a score card. Extrusion behaviour was scored on the basis of the rate of flow and uniformity of strands and showed a range of 4.0 to 7.0 (Table 4).

Table 4. Selection of the best combination mix for vermicelli

Combinations tried	Quality parameters	
	Protein quality (Amino acid score)	Extrusion behaviour (Score)
C1	6.6	7.0
C2	6.6	7.4
C3	7.9	4.8
C4	7.5	4.6
C5	6.0	9.0
C6	6.6	5.2
C7	6.8	6.6
C8	6.5	7.2
C9	6.7	6.8
C10	7.2	4.0
C11	7.6	5.0
C12	7.6	5.2

The cost of each combination was worked out according to the market price of the ingredients. The prices of the food material were collected from the local markets and the actual price of the different ingredients used for production of one kilogram was computed (Table 5). The cost of labour has not been taken into consideration as the processing charge was uniform irrespective of the combinations.

Table 5. Cost of production of different combination

Combinations	Cost Rs/kg
C1	7.2
C2	7.6
C3	11.3
C4	14.7
C5	8.2
C6	6.6
C7	7.7
C8	6.8
C9	7.4
C10	8.0
C11	9.7
C12	9.3

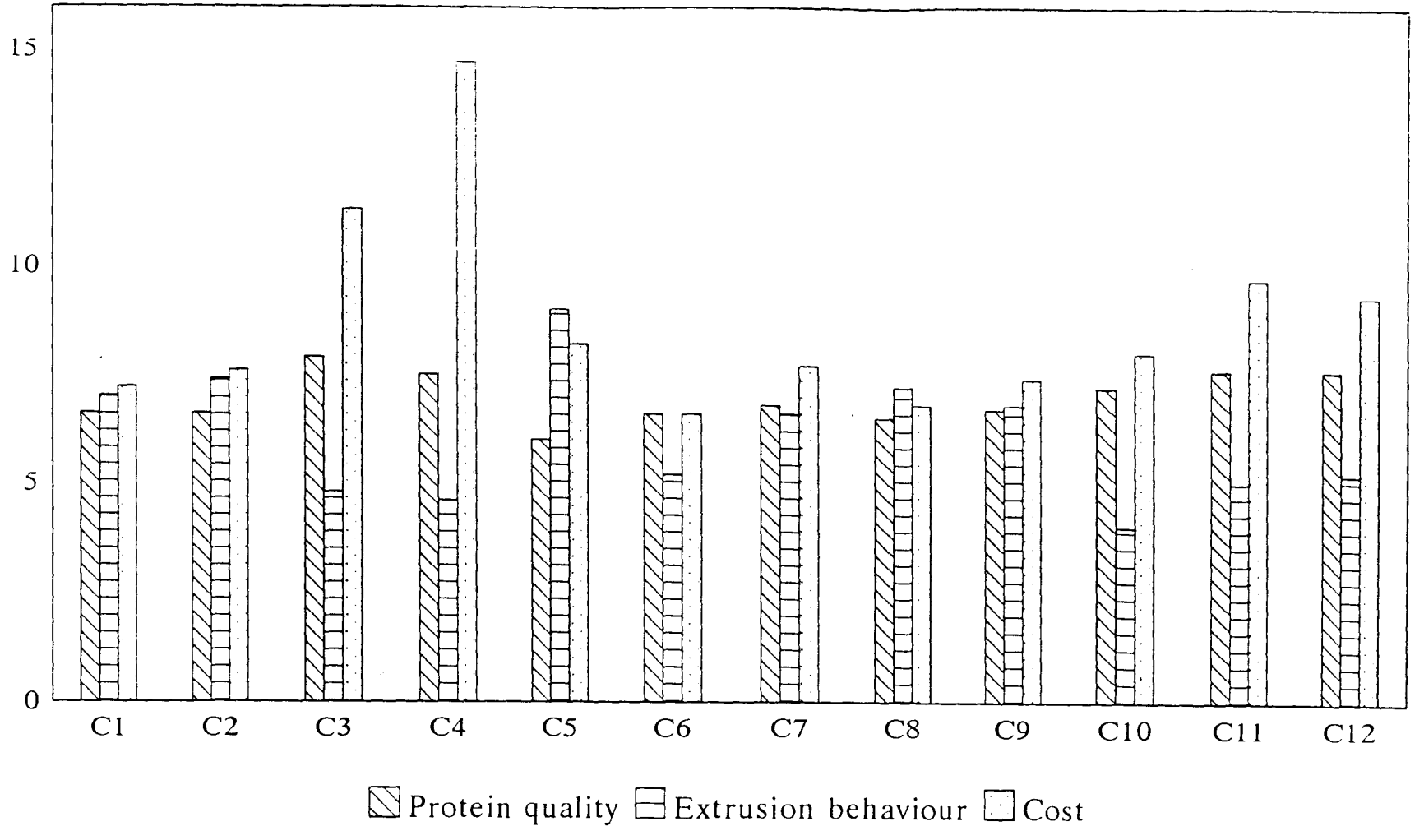


Fig. 2. Graphical representation of parameters (Protein, Extrusion behaviour and Cost of production) of different combinations

The selection of suitable combination is bind on the scores given in Table 4 and 5 and Fig. 2. It may be seen that the parameters varied considerably in different combinations. The extrusion behaviour, for example, was the best in C5 (9.0) and poorest in C10 (4.0) with intermediary grades for other combinations. Similarly the protein quality was highest for C3 (7.9) and least for C5 (6.0). Cost of production was highest for C4 (14.7) and lowest for C6 (6.6). Other combinations presented values in between. When all the three factors were considered together, no single combination yielded the best values for all the parameters. It may be seen that while C3 presented the maximum protein content, its cost of production was high (11.3) and C6 had a low cost of production (6.6) and average extrusion behaviour (5.2). When the twelve combinations were considered, no combination gave the ideal conditions of acceptability for all factors. Therefore selection of the combination for the present study was based on the superior extrusion behaviour with an index score of 9.0 (C5) with an average cost of production although the protein content was low.

The extrusion behaviour of the mixture was good when maida and cassava flour were mixed in equal proportions.

(C2 : 7.4) or nearly equal proportions (C1 : 7.0, C5 : 9.0, C8 : 7.2, C9 : 6.8). In the absence of maida the extrusion behaviour was least acceptable as seen in few combinations (C3 : 4.8, C4 : 4.6, C10 : 4.0, C11 : 5.0 and C12 : 5.2).

Cost of production was highest for C4 (14.7) probably because of the addition of milk powder. In C3 and C11 also the cost was high when rice flour and blackgram dhal flour were added. Similarly when either blackgram dhal flour or rice flour or greengram dhal flour alone was mixed, the cost was high. There was a general reduction in the cost of production in combinations where soyflour was one of the ingredients.

The protein quality of the mix was generally high when pulses were one of the ingredients in combinations like C3 : 7.9, C11 : 7.6, C12 : 7.6.

The influence of individual components on the extrusion behaviour, cost of production and protein quality was responsible for variation in different combinations probably because of the interaction of these factors.

Cooking characteristics of vermicelli

The cooking quality of the product both sweet and savoury vermicelli were ascertained through cooking time,

water absorption index and bulk density and data pertaining to the above factors are presented in Table 6.

Table 6. Cooking characteristics of sweet and savoury vermicelli

Sl. No.	Cooking characteristics	Sweet Vermicelli	Savoury Vermicelli
1.	Cooking time (min.)	4.50	5.00
2.	Bulk density	0.42	0.40
3.	Water absorption index	0.63	0.55

Cooking time

Food products are considered as convenient food because of their three proven advantages in time, labour and fuel saving and these factors play a decisive role in conditioning their popularity among consumers. Nagarajan (1993) in his study has found that products which can be cooked using less energy will have a large potential. Cooking time was determined from the time of adding the product to boiled water till it got completely cooked, using

a stop watch. The time taken for converting the vermicelli into sweet and savoury preparation is minimal which was recorded and given in Table 6. As shown in Table 6 there was no pronounced variation in the time taken for cooking between the two preparations. Cassava starch gelatinises more quickly and this may be the reason for low cooking time. The method adopted for preparing both the preparations are simple and it can be concluded that the product has high potential role when cooking time was considered.

Bulk density

Bulk density is one of the most common simple measurements which can be used for analysis of solid foods (Potter, 1988). The volume of different products can be compared through bulk density. As presented in Table 6 bulk density for sweet vermicelli and savoury vermicelli were 0.42 and 0.40 respectively. There is only slight variation in the bulk density of these two products.

Water absorption index

Water absorption index is directly related to the constituents or raw materials present in any product. The

nature of starch, moisture content of raw materials as well as finished products and the method of processing are some of the factors which affect water absorption index. Table 6 shows water absorption index of 0.63 for sweet vermicelli and 0.55 for savoury vermicelli.

4.2. Determination of quality of the developed products

4.2.1. Nutritive value of the developed vermicelli

Acceptability, nutritive value and cost are the prime elements of good food. Traditional foods are adequately satisfied by these parameters. So any new food product should be developed based on these principles (Potty, 1993). According to Rao (1992) the consumer expects to meet his nutritional needs as much from processed foods as from the natural food when he partially substitutes the latter for the former. Amla (1993) feels that when developing a new food product, the nutritive value may get lost because of inappropriate processing methods.

The nutritional quality of the developed food products before and after processing with reference to

proteins, calcium, magnesium and calories were determined through suitable laboratory techniques and the data are presented in Table 7.

Table 7. Nutritional quality of sweet and savoury vermicelli

Sl. No.	Nutritional quality	Sweet Vermicelli		Savoury Vermicelli	
		Before processing	After processing	Before processing	After processing
1.	Protein (gm)	13.25	12.24	13.42	12.29
2.	Calcium (mg)	17.30	15.92	16.00	15.70
3	Iron (mg)	18.75	16.00	18.35	17.40
4.	Magnesium (mg)	0.40	0.39	0.31	0.30
5.	Energy (Kcal)	460.00	345.00	348.00	323.00

Protein

Protein is one of the most important nutrients required by the body to carry out a wide range of functions essential for the maintenance of life. When the protein content of vermicelli was analysed, it was found that both sweet and savoury contained the good amount of protein ie.,

from 13.25 to 12.24 gm for sweet vermicelli and 13.42 to 12.29 gm for savoury vermicelli resulting percentage loss of 7.6 and 8.4 for sweet and savoury vermicelli respectively. The addition of soyflour during preparation may be the main reason for the higher value of protein both in quantity and quality. Beufrand *et al.* (1978) reported extrusion of cereal mixture and found that during extrusion there was an overall loss of protein with special reference to lysine. Mega and Sizer (1979) also reported a similar significant loss of protein during the extrusion of potato flakes. Chellammal (1995) reported that there is loss of protein during processing of both noodles and macroni.

Energy

Energy is essential for rest, activity, growth and maintenance of sound health. Energy expenditure must be balanced by energy intake. The food developed in this study had a high energy content varying from 323-345 Kcal for savoury and sweet vermicelli respectively. Before processing the values for energy for developed products were higher than ranging from 348-460 Kcals. Respective percentage loss of 25% and 7.2% is seen for sweet and savoury vermicelli. This variation may be due to loss during processing.

Minerals

Minerals play a vital role in nutrition and slight changes in the concentration of the important minerals may rapidly endanger life. Hence, the mineral content of any food product is highly essential and showed a satisfactory result in the present study.

Calcium

The calcium content of the products developed revealed higher score for sweet vermicelli 17.30 mg when compared to savoury vermicelli 16.00 mg before processing. After processing there was decrease content 15.90 mg and 15.70 mg ie., percentage loss of calcium is 7.9 and 1.9 for sweet and savoury vermicelli respectively. This may be due to the processing loss.

Iron

The iron content of the two products revealed a slightly higher value for sweet vermicelli 18.70 mg compared to savoury vermicelli 18.30 mg. A slight variation in the values could be seen after processing, (percentage loss of

14.6 and 5.2 for sweet and savoury vermicelli respectively) indicating the loss of iron during processing.

Magnesium

Magnesium is highly required for cellular metabolism, essential for intracellular enzyme, metabolism of carbohydrates and the structure of DNA and RNA. The magnesium content of the developed products before processing varied from 0.3 to 0.4 mg for savoury and sweet vermicelli and percentage loss of 2.5 and 3.2 could be seen after processing for sweet and savoury vermicelli respectively.

4.2.2. Physiological tolerance of the product developed

Physiological tolerance is one of the important criteria to be analysed before the production of any few food. According to Ritchey and Harper (1981) the most realistic way to assess the physiological tolerance and nutritional quality of any new food is to conduct feeding trials on animals. Several biological measurements have been proposed as indicators of the physiological utilization of foods. Among these, the most important is Protein Efficiency Ratio (PER), Biological Value (BV) and Net Protein

Utilisation (NPU). In the present study, experiments were conducted to assess the Protein Efficiency Ratio, nitrogen retension, and Net Protein Utilisation and data pertaining to the above are presented in Table 8.

Table 8. Physiological tolerance of the developed food product

Sl. No.		Experimental group	Control group	Percentage reduction
1.	Mean gain in weight (gm)	34.840	48.400	28.00
2.	Protein Efficiency Ratio (PER)	2.325	3.245	28.30
3.	Biological Value (BV)	74.550	79.920	6.70
4.	Digestability Co-efficient (DC)	93.700	93.840	0.15
5.	Net Protein Utilisation (NPU)	69.860	75.000	6.80

4.2.2.1. Protein Efficiency Ratio (PER)

Protein Efficiency Ratio (PER) is the ratio between the weight gain of the animals and the quantity of protein

consumed. PER gives a clear picture of the quality of the protein. Mean gain in weight in experimental group was 34.84 as against 48.40 for control group. The weight gain of the animals was analysed and are presented in Table 8. It is evident from the table that the PER of control group (3.245) is higher than that of experimental group (2.325). Control group was fed with casein and this may be the reason for high increase. Supporting results were recorded by other authors (Malleshi *et al.*, 1986, Okeke and Obizoha, 1986 and Thirumaran, 1993). Malleshi *et al.*, 1986 noticed an increase in PER from 2.20 to 2.70 by addition of 10 per cent skim milk powder in a malted weaning food containing ragi and green gram and 3.20 for casein diet. A higher PER value of 3.51 was reported by Prasad (1987) for casein diet. Thirumaran (1993) had reported a PER value of 3.27 for casein diet.

Yanez *et al.* (1979) reported PER values of 1.60 and 1.30 for extruded products based on 1:1 and 3:1 blends of sunflower or soyflour meals respectively. Swaminathan *et al.* (1972) reported PER values ranging from 1.93-2.33 for weaning foods based on blends of wheat, chickpea and groundnut flour. Vaidhehi (1992) reported PER of two extrusion cooked foods based on blend of sorghum,

horsegram and sunflower seed cake in the ratio 60:30:10 and blend of wheat (60 %), horsegram (30 %) and sunflower seed cake (10 %) were 1.90 and 2.10 respectively as compared with 2.80 obtained for skim milk powder. Chellammal (1995) had reported a PER of 2.39 for cassava noodles.

In comparison with the above mentioned studies reported by scientists it can be stated that the PER of the developed food product showed satisfactory result. According to ISI specification, a PER of 2.00 and above shows that the quality of protein is good. In the present study, the amino acid profile of maida and soyflower must have complemented each other, which might have been the reason for this enhanced PER. This is in line with results obtained in an experiment with extruded chickpea cereal blend (Anon, 1978).

4.2.2.2. Nitrogen balance studies

Nitrogen balance studies are considered as a measure to find out the extent of utilisation of proteins from any food in the body. Through these studies data on Biological Value (BV), Digestability Co-efficient (DC) and Net Protein Utilisation (NPU) are generated.

Biological Value (BV)

Biological Value (BV) of a protein is the fraction of its nitrogen retained in the body for growth and maintenance of cell synthesis. The Biological Value of proteins can be determined by Nitrogen balance experiments (Swaminathan, 1975). The Biological Value of the food product in comparison with that of control diet are presented in Table 8. The Biological Value of control diet containing casein was highest (79.90) when compared to experimental diet (74.55). This finding is in tune with the finding of Prasad (1987) in which a Biological Value of 80.00 for casein diet has been reported. However, higher values were reported by Okeke and Obizoba (1986) and Philip (1987) as 87.7 and 82.20 respectively. In comparison with above mentioned studies the cassava based vermicelli mix showed satisfactory result.

Digestability Co-efficient (DC)

Digestability Co-efficient of a protein is defined as the ratio of food nitrogen intake of food nitrogen absorbed. The Digestability Co-efficient was 93.70 for experimental and 93.84 for control diet and is presented in Table 8.

In the present study the digestability co-efficient of both experimental and control group were on par. Only slight variation could be seen when comparing the result. Hence it can be stated that the developed food product showed a very satisfactory result. Chellammal (1995) reported in a similar study a digestability co-efficient of 95-96 for cassava based weaning mix and 92.75 for sweet potato based weaning mix.

Net Protein Utilisation (NPU)

Net Protein Utilisation (NPU) is the ratio of nitrogen retained to the total nitrogen intake and it is determined from Biological Value (BV) and Digestability Co-efficient (DC). The NPU was computed and are presented in Table 8.

From the Table it is seen that the Net Protein Utilisation (NPU) of rats in the control group was high (75.00) when compared to experimental group (69.86). In a study conducted by Chellammal (1995), the Net Protein Utilisation by rats fed with cassava weaning mix and sweet potato weaning mix showed values of 72.18 and 71.76

respectively. In a similar study conducted by Sailakshmi (1995) the NPU of rats fed with diet containing parboiled rice, defatted soyflour and groundnut flour (85:10:5) was reported to be 66.83.

As judged by weight increase PER, BV, DC and NPU of developed food showed satisfactory results.

4.3. Assessing the acceptability of the developed product

The quality of a food, is a combination of the attributes that determine the degree of acceptability of the product. These include nutritional value, microbiological safety, cost, convenience and organoleptic qualities. Any product that is new has to be tested in small quantities before being used in regular production. Scientific methods of sensory analysis of food are becoming increasingly important in assessing the acceptability of food products. Quality parameters such as appearance, colour, flavour, texture and taste are assessed by means of human sensory organs. The evaluation is then said to be sensory evaluation. Clement *et al.* (1989) states that sensory evaluation can be used to predict consumer acceptance of a

food item. Consumers toady want at short notice foods that are not only nutritious but also catering to their taste. For an average consumer, the concept of food quality consists of those related to the sensory characteristics which may be classified in accordance with the human senses of perception as appearance, texture, odour and taste (Setty, 1989).

The first impression of food is usually visual and a major part of our willingness to accept a food depends on its appearance. It is a composite of all information about the product and its environment which reaches the eye (Birch *et al.* 1977). Colour, one of the important visual attributes, has been used to judge the overall quality of foods for a very long time. If the colour is unattractive, a potential consumer may not be impressed by the major attributes. Clydesclade (1984) reported that colour affected the perception of other sensory characteristics such as taste and flavour. Odour preference is generated by stimulations of the sensory cells by specific compounds present in the food. According to Birch, 1977, flavour is the mingled but unitary experience of sensation produced by a material taken in the mouth, perceived principally by the senses of basic smell and by the other instantaneous sensations in the mouth.

Texture constitutes a physical property of food stuffs apprehended by the eyes,the skin and muscle senses located in the mouth. Taste is the major attribute which determines the acceptability of a food material. It is only a sensory response to soluble materials but also aesthetic appreciation of the mouth. In the present study, considering all the above quality parameters, the developed food product was subjected to acceptability trials among experts, housewives and inmates of local institution.

4.3.1. Acceptability by experts

The developed food product, both sweet (sugar added and jaggery added) and savoury vermicelli were assessed for organoleptic qualities by technical experts (N = 10) who were persons with experience and expertise.

The information on the specific sensory characteristic of a food must be obtained by product oriented tests and this information was obtained in the laboratory from the selected trained technical experts (Watts *et al.*, 1984). Quality parameters such as appearance, colour, flavour, taste and texture were assessed by them. Manwhitney

test was carried out for the comparison of products for sensory qualities. The mean preference score for sweet and savoury vermicelli for each of the organoleptic qualities and the test criterien value obtained for Manwhitney test is given in Table 9.

Table 9. Acceptability of sweet (Sugar added) vermicelli and savoury vermicelli

Characters	Sweet (Mean score)	Savoury	W	Test Value
Appearance	4.50	4.30	60.00	0.756
Colour	4.60	4.50	57.50	0.567
Flavour	4.50	4.30	60.00	0.756
Taste	4.80	4.20	24.00	1.965*
Texture	4.80	4.40	70.00	1.512

N = 10 * Significant at 5% level

Statistical analysis has revealed that there is no significant difference between the products with respect to

their organoleptic qualities except for taste. The mean preference score for taste of sweet vermicelli was 4.80 and that of savoury vermicelli 4.20 and the test value obtained was 1.96 which showed that the judges preferred the taste of sweet vermicelli, to that of savoury vermicelli. However it could be noticed that the sweet vermicelli bagged slightly higher scores for other organoleptic qualities compared to its counterpart, the savoury vermicelli.

Table 10. Acceptability of sweet vermicelli with sugar and jaggery

Characters	Mean scores		W	Test value
	Jaggery added vermicelli	Sugar added vermicelli		
Appearance	4.10	4.50	35.00	1.334
Colour	4.10	4.60	27.50	1.701
Flavour	4.20	4.50	45.00	0.378
Taste	3.60	4.80	12.00	2.873*
Texture	4.40	4.80	34.00	1.209

N = 10 * Significant at 5% level

The result of acceptability test of vermicelli sweetened with sugar and jaggery are presented in Table 10. The result reveals that the porridge made with sugar was more acceptable than with jaggery. The porridge made with sugar, in general was found to be devoid of beany flavour indicating that it is a good sweetner for porridge.

There is no significant difference between the products with respect to organoleptic qualities except for taste. The mean preference score for sugar added vermicelli obtained was 4.8 and that for jaggery added was 3.60 and the test value obtained was 2.873 which showed that the judges preferred the taste of sugar added vermicelli. Sugar added vermicelli has slightly higher score for organoleptic qualities compared to jaggery added preparation. Hence sugar was selected as the acceptable sweetner for making porridge. A study conducted by Gupta *et al.* (1982) showed that addition of sugar improved sensory score and is in agreement with the result of the current experiment.

4.3.2. Acceptability among housewives

Gitamanian (1987) stated that consumer food preferences are changing rapidly. Working women, a growing

class of consumers are naturally willing to take Ready-to-Eat and easy to prepare foods in to their homes considering their limitations in time. Convenience, novel and instant foods are becoming increasingly popular among Indian households, since women of the high income strata are more exposed to such foods. During the development of new food product or the reformulation of existing products, the identification of changes caused by processing method, by storage or by the use of new ingredients, their acceptability could be assessed by conducting preference test on a large number of consumers (Watts *et al.*, 1989). Hence in the present study an attempt was made to assess the preference of housewives (N=50) of the food developed; and the results are presented in Table 11.

Sweet vermicelli was tested by the housewives and their opinion on the degree of liking was obtained. Data was collected using a seven point rating scale from a score of 7 for `liked extremely well' to a score of 1 for disliked extremely. When considering the percentage score among housewives for sweet vermicelli (Table 11) it was found that the maximum percentage of housewives liked the product `extremely well' ie., 46 %. It was also ascertained that

among the housewives 26 % `liked very much', 20 % `liked' and only 8 % `neither liked nor disliked' the product. Negative scoring was not obtained for sweet vermicelli for rating such as `disliked', `disliked very much' and `disliked extremely' and are therefore deleted while discussing the data.

Table 11. Preference of housewives for the product

Sl. No.	Rating	Sweet vermicelli	Savoury vermicelli
1.	Liked extremely well	23 (46)	9 (18)
2.	Liked very much	13 (26)	20 (40)
3.	Liked	10 (20)	11 (22)
4.	Neither liked nor disliked	4 (8)	9 (18)
5.	Disliked	Nil	1 (2)
6.	Disliked very much	Nil	Nil
7.	Disliked extremely	Nil	Nil
	Total	50 (100)	50 (100)

N = 50, Number in parenthesis denotes percentage

On accounting the percentage score for savoury vermicelli, maximum percentage of women rated the product positively ie., `liked extremely well' 18 %, `liked very much' 40 % and liked 22 %. Negative rating such as `neither liked nor disliked' 18 % and disliked 2 % were recorded by a small percentage. None of the housewives rated the product as `disliked very much' or `disliked extremely' and hence these two ratings are deleted while discussing the data.

While taking into consideration the above two products (ie., sweet vermicelli and savoury vermicelli), maximum positive rating was obtained for sweet vermicelli (ie., 92 % compared with its counterpart rated as 80 %). This result evidently shows that the sweet preparation was preferred by most of the women considering its good taste compared to savoury preparation. Twenty per cent of housewives rated the savoury preparation negatively and the reason for this may be its brown colour or beany flavour.

The mean scores for sweet and savoury vermicelli was 6.10 and 5.54 with W-value 149.2 and Z-value 1.67. There is no significant difference for preference scores obtained for both sweet and savoury vermicelli.

4.3.3. Local institutions : (Oldage Homes)

Preference refers to selection; when presented with a choice, preferences are frequently influenced by prejudice, religious principles, group conformance and status value in addition to the quality of the food (Amerine *et al.*, 1965). While conducting preference test, the consumer expects to be favourably impressed with the food he tastes and expresses displeasure if the product does not measure up to his anticipation. Since in the present study preference test was conducted among old people residing in a oldage home. Good nutrition throughout the life serves as a sound insurance for health for the years of old age. The process of ageing brings about marked physiological changes in the body. Inadequate dentition, diminished sensitivity to taste and smell, diminished secretion of hydrochloric acid in the stomach and digestive enzymes, biliary impairment, if any, which interferes with fat digestion, irregular bowel evacuation, general ill health, economic or emotional inseurity and unwanted feelings are some of the problems common among old age. In our modern society old people often feel neglected and psychological problems created by this reflects as many ailments. Loss of appetite is a common

complaint of old age people. Considering all the above facts geriatric diet should be soft which is easily chewed and digestible and also less time consuming during preparation.

Samples of the developed food, both sweet and savoury preparations, were tasted by old people (N-20) residing in a oldage home and their opinion on the degree of liking was obtained and is presented Table 12.

Table 12. Preference of old people for vermicelli

Sl. No.	Rating	Sweet vermicelli	Savoury vermicelli
1.	Liked extremely well	11 (55)	6 (30)
2.	Liked very much	5 (25)	5 (25)
3.	Liked	2 (10)	6 (30)
4.	Neither liked nor disliked	2 (10)	1 (5)
5.	Disliked	Nil	2 (10)
6.	Disliked very much	Nil	Nil
7.	Disliked extremely	Nil	Nil
	Total	20 (100)	20 (100)

N = 20, Number in parenthesis denotes percentage

Data was collected using a seven point rating scale varied from `liked extremely well' Score 7 to `disliked extremely' Score 1. The result revealed that maximum percentage of old people rated product positively ie. `liked the product extremely well' 5%, `liked very much' 25%, `liked' 10%. None of them rated the product negatively hence `disliked', `disliked very much' and `disliked extremely' are deleted while discussing the data.

When considering the percentage scores assigned by old people for savoury vermicelli, it was found that maximum percentage 55% rated the product positively (`liked extremely well') and 30% `liked' the product. Only a small percentage recorded negative scoring such as`neither liked nor disliked' 5% and `disliked' 1%. `Disliked very much' or `disliked extremely' were not rated by any of them and are hence, deleted while discussing the data.

When the above two products ie. sweet vermicelli and savoury vermicelli were compared, it was found that maximum positive rating was obtained for sweet vermicelli 90 % and for savoury preparation only 75 %. While preparing sweet vermicelli some amount of milk and sugar were added

which in turn enhances the taste of the preparation. This may be the reason for high preference score obtained for the sweet preparation. Seasoning added to the savoury preparation may not be liked by most of them and so the low score for savoury preparation.

Manwhitney test was carried out to analyse the data. The analysis revealed that mean score of 6.25 for sweet preparation and 5.60 for savoury vermicelli gave a W-value 261.5 and Z value of 1.66. There was no significant difference eventhough the mean score for sweet vermicelli was slightly higher than that for the savoury preparation.

4.4. Package and shelf life studies

Shelf life is most vital for product quality as it is a key component of marketability. Shelf life determination and evaluation is a multi dimensional activity, Storage of food has become so complex that an entire industry has been developed to satisfy the need. The mechanism and kinetics of food deterioration can be controlled by the storage techniques applied (Varsanyi 1993).

In the present study, shelf life of both sweet and savoury vermicelli was ascertained by packing in polythene covers, sealed and studied for a period of six months.

Polythene bags which are popular packaging and storage containers are good from the aesthetic and hygienic point of view (Crosby 1981). Polythene bags have better keeping quality in view of economy and transparency. Samples were analysed once in three months for moisture, peroxide and total sugar content. Observation on insect infestation was recorded during storage.

4.4.1. Effect of storage on moisture level of vermicelli

Moisture is one of the important parameters which determine the shelf life quality of any food product. Most stored products are considered to be safe in storage at a particular moisture content, low moisture is highly important for longer storage period (Shanker 1992).

Table 13. Effect of storage on moisture level of vermicelli

Products	Initial	3rd month	6th month	Mean
Sweet vermicelli	10.28	10.96	11.27	10.84
Savoury vermicelli	10.50	11.15	11.65	11.10

CD ~ A = 0.124 CD ~ B = 0.124 CD ~ AB = 0.176

The initial moisture level of sweet vermicelli was 10.28 per cent. There was an increase in moisture content of stored vermicelli irrespective of storage material. It ranged from 10.96 to 11.27 per cent during the storage period of six months. The increase could be observed throughout the storage period.

Increase in the moisture level of savoury vermicelli was observed during the storage period of six months. The initial level of moisture was 10.50 for savoury vermicelli and during the third month it increased upto 11.15 and at the sixth month it came upto 11.65.

While considering the above two products, it could be observed that there was an increase in moisture level throughout the storage period up to six months. Savoury vermicelli has slightly higher moisture content compared to sweet vermicelli. The increase may be due to the water absorption capacity of polythene bags. This observation is in line with the finding of Beerch *et al.*, 1990 who had observed a steady increase in the moisture content throughout the storage period of six months from the initial level of 11.00 per cent to 13.00 per cent of cold stored potato stored in polythene bags.

Two way Anova was conducted on the data of moisture content of vermicelli samples, collected over a period of six months. The results are presented in Table 14.

Table 14. ANOVA Table : Moisture (per cent)

	df	MSS	F
Sweet vs Savoury	1	0.4082	26.68**
Within vermicelli	6	0.0153	
Between periods	2	2.3339	179.52**
Vermicelli x Period	2	0.0199	1.53
Within samples	12	0.0130	

Moisture content was found to increase as the duration of storage advanced. Both sweet and savoury showed the same trend. However the moisture content of savoury vermicelli was higher for all the time periods, though the vermicelli and period interaction was found to be absent. The mean moisture content over the six month duration for savoury vermicelli was 11.10 which was significantly higher than that of sweet vermicelli 10.84.

4.4.2. Effect of storage on peroxide value of vermicelli

The primary products of lipid oxidation are hydroperoxides which are generally present as peroxides. Thus it seemed reasonable to determine the concentration of peroxide as a measure of extent of oxidation and thus of rancidity. In the present study, test was conducted to determine oxidative rancidity. The initial stages of rancidity can be detected by this test even before the spoilage is detected through organoleptic evaluation. The details pertaining to the development of peroxide over the storage period are presented Table 15.

Table 15. Effect of storage on peroxide level (mcq/kg of vermicelli

Products	Initial	3rd month	6th month	Mean
Sweet vermicelli	0.0	0.27	1.05	0.437
Savoury vermicelli	0.0	0.26	1.06	0.439

CD ~ A = 0.015 CD ~ B = 0.011 CD ~ AB = 0.016

For sweet vermicelli, during six months storage period, peroxide value ranged from 0.0 mcq/kg at the initial month 0.27 mcq/kg at the third month and 1.05 mcq/kg at the sixth month.

Increase in peroxide value could be seen in the case of savoury vermicelli also during the storage period. The initial level was 0.0 mcq/kg and during third month it came upto 0.26 mcq/kg and at the sixth month it attained a value of 1.06 mcq/kg.

The data revealed that initially the peroxide value was zero for the two products irrespective of storage material upto three months storage period. A increasing trend could be observed throughout the storage period, the increase was more in the case of savoury vermicelli towards the end of storage period and this may be due to the rancidity of oil added for seasoning while preparing savoury vermicelli. A similar case was reported by Manan *et al.*, 1993 on preparation packaging and storage of wheat papads stored in polypropelene bags over a period of six months. The peroxide value increased from 0.20 to 0.79 mcq/kg over the storage period.

However, the peroxide value for both the products was within the limit specified by ISI.

Table 16. ANOVA table for peroxide (mcq/kg)

	df	MSS	F
Sweet vs Savoury	1	3.719×10^{-5}	0.157
Within vermicelli	6	2.3746×10^{-4}	23003.47**
Between periods	2	2.3949	
Vermicelli x Period	2	1.6308×10^{-4}	
Within samples	12	1.041×10^{-4}	

The statistical analysis of the data revealed that over the months the products showed an increase in peroxide value and the difference observed was significant. The products however showed no significant difference among themselves in the increase over the periods. As the Table reveals the sweet vermicelli had a slightly higher peroxide content than the savoury product during the third month. But as the months passed by the savoury product showed a higher increase in peroxide content (1.06) than sweet vermicelli

(1.05). The vermicelli x period interaction was absent in this case also.

4.4.3. Effect of storage on total sugar content of vermicelli

The change in the total sugar content of both sweet and savoury vermicelli were assessed and the result are presented in table 17.

Table 17. Effect of storage on total sugar content of vermicelli

Products	Initial	3rd month	6th month	Mean
Sweet vermicelli	2.21	2.30	2.48	2.33
Savoury vermicelli	2.21	2.30	2.47	2.33

CD ~ A = 0.013 CD ~ B = 0.019 CD ~ AB = 0.027

Increase in total sugar content of sweet vermicelli was observed during the storage period of six months. The initial reading was 2.21 and during the third month it

increased to 2.30 and at the sixth month it came up to 2.48. When considering the increase in total sugar content of savoury vermicelli the values ranged from 2.21 at the initial month, 2.30 at the third month and 2.47 at the sixth month. A some what similar increase could be seen throughout the storage period. The conversion of starches to sugars during storage may be the reason for increase in sugar content of stored product.

Table 18. ANOVA table for Total sugar

	df	MSS	F
Sweet vs Savoury	1	1.5258×10^{-5}	< 1
Within vermicelli	6	1.7548×10^{-4}	
Between periods	2	0.1419	466.92**
Vermicelli x Period	2	1.5259×10^{-5}	< 1
Within samples	12	3.039×10^{-4}	

Statistical analysis revealed that eventhough the products showed an increase in the total sugar content over the period, the increase among products observed was not

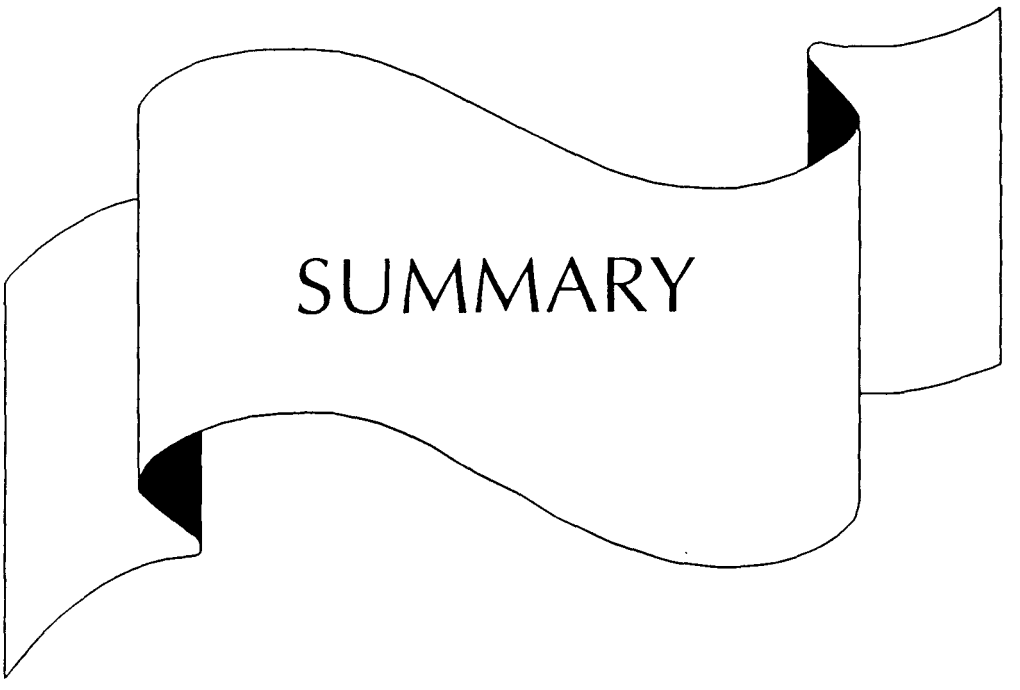
significant. The increase in the total sugar content observed in both the products over the period when compared was also found to be not significant. The vermicelli x period interaction was also found to be absent.

4.4.4. Assessment of insect infestation of stored food product

Food in excess of immediate consumption is stored for future use. One disadvantage of storing food is the deterioration it undergoes during storage. This deterioration is caused by damage due to bacterial and fungal infection and insect infestation. Food grains, flours, dry fruits, oil seeds, tubers, spices and condiments all are subjected to insect damage. Nevertheless the damage caused by the insects may be considerable, since they not only consume stored food but also contaminate them with insect fragments, faeces, webbing and illsmelling metabolic products. The extent of loss due to insect attack depends on atmospheric conditions at the place of store, the length of storage and the method and conditions of storage.

In the present study the assessment of the incidence of insect pests in stored, sweet and savoury

vermicelli was observed once in a month throughout the storage period of six months. It was observed that there was no insect infestation during these storage period. A similar result was also reported by Chellammal (1995) and she observed that there was no insect infestation up to ten months in noodles and macroni, while wafers were free from insect infestation up to eleven months.


SUMMARY

SUMMARY

The present study on "Feasibility of formulating `Ready-to-Eat' products based on cassava" was undertaken to utilise the major crop cassava for the preparation of Ready-to-Eat products. The study comprised of formulation and standardisation of basic product vermicelli, determination of quality of product through organoleptic quality studies and preference tests, assessing nutritional significance as well as physiological tolerance of the developed food product and package and shelf life studies.

Cassava, a major tuber crop of Kerala is comparable with energy rich staple foods like rice, wheat and maize and is the basic ingredient for developing the product vermicelli. Different percentages of cassava flour were combined with soyflour, maida, riceflour, blackgram flour or milk powder to improve the quality of the composite flour used for processing vermicelli Cassava flour was added to different combinations ranging from 40-70 per cent. From among twelve different combinations of cassava flour as basic

ingredient, the one with the best extrusion behaviour was selected (Cassava 40%, maida 30% soyflour 20% and Sugar / salt 10%) to manufacture sweet / Savoury vermicelli. The aminoacid score and cost of the combination was also found to be satisfactory.

Ready-to-Eat savoury vermicelli was prepared by adding salt and seasonings and Ready-to-Eat sweet vermicelli by the addition of sugar during processing. Cooking characteristics of the developed product such as cooking time (Sweet vermicelli 4.5 min. and Savoury vermicelli 5.0 min.) Bulk density (Sweet vermicelli 0.42, Savoury vermicelli 0.40) and water absorption index (sweet vermicelli 0.63 and savoury vermicelli 0.55) were rated as good

The nutritional quality of the developed food products before and after processing with reference to proteins, calcium, magnesium were determined through suitable laboratory techniques. The values of different nutrients before and after processing were 13.25 / 12.24 mg for protein, 17.30 / 15.92 mg for calcium, 18.75 /16.00 mg for iron, 0.40 / 0.39 mg for magnesium, 460/345 Kcl for energy for sweet vermicelli and 13.42 / 12.29 mg., 16.00/15.70 mg,

18.35 / 17.40 mg, 0.31 /0.30 mg and 348/323 KCal respectively for savoury vermicelli indicating loss during processing.

Physiological tolerance is one of the important criteria to be analysed of any new food. Among these the most important is Protein Efficiency Ratio (PER), Biological vale (BV) and Net Protein Utilisation (NPU). The developed food product exhibited a Protein efficiency Ratio (PER) of 2.2 to 2.4 indicating that the quality of protein is good. The Biological Value (74.55), Digestability co-efficient (93.70) and Net Protein Utilisation (69.86) were also found to be satisfactory.

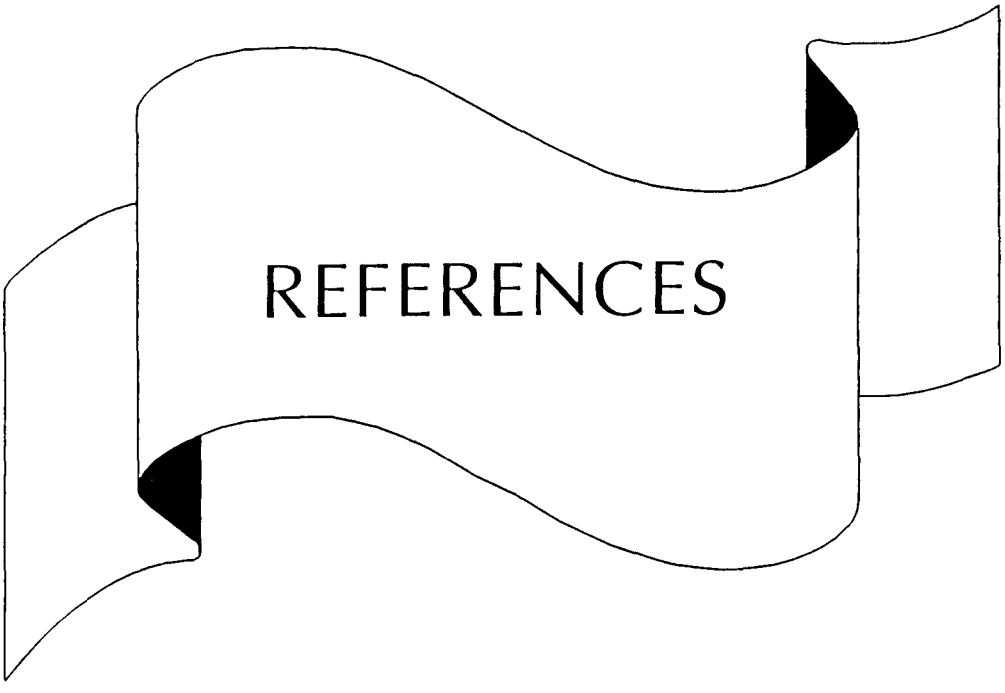
Regarding organoleptic and preference studies of the developed food product was assessed by three groups of consumers viz., experts, housewives and old people. The parameters tested under organoleptic studies were appearance, flavour, taste, texture and colour. The statistical analysis revealed that both the sweet and savoury vermicelli among experts got highest score and there is no significant difference between the products with respect to their organoleptic qualities except for taste. However it could be noticed that the sweet vermicelli bagged slightly higher

score for other organoleptic qualities compared to its counter part, the savoury vermicelli: When the two products were compared among housewives maximum positive rating was obtained for sweet vermicelli 92% and only 80% for savoury vermicelli. Twenty per cent of housewives rated the savoury preparation negatively and the reason for this may be its brown colour or beany flavour. Results of statistical analysis revealed there is no significant difference for preference scores obtained for both sweet and savoury vermicelli. When considering the percentage scores assigned by old people for the two products it was found that maximum positive rating was obtained for sweet vermicelli 90% and for savoury preparation only 75%. There was no significant difference between the products eventhough the mean score for sweet vermicelli was slightly higher than that for the savoury preparation.

Effect of storage on moisture, peroxide and total sugar content revealed that there was an increase in all the three parameters during the six months storage period. Moisture content was found to increase as the duration of storage advanced. The mean moisture content over the six month duration for savoury vermicelli was 11.10 which was

significantly higher than that of sweet vermicelli 10.84. Regarding peroxide value the products showed no significant difference among themselves, Savoury product showed a higher increase in peroxide content (1.06) than sweet vermicelli (1.05). The increase in total sugar content observed in both the products (sweet vermicelli 2.48 and savoury vermicelli 2.47) over the period when compared was also found to be not significant. Observation on insect infestation revealed that there was no insect infestation up to six months of storage period.

The salient features of the present study indicated that it is possible to develop energy rich complementary food based on cassava, the nutritional, organoleptic qualities and physiological tolerance was better and the product developed showed a reasonable long shelf life.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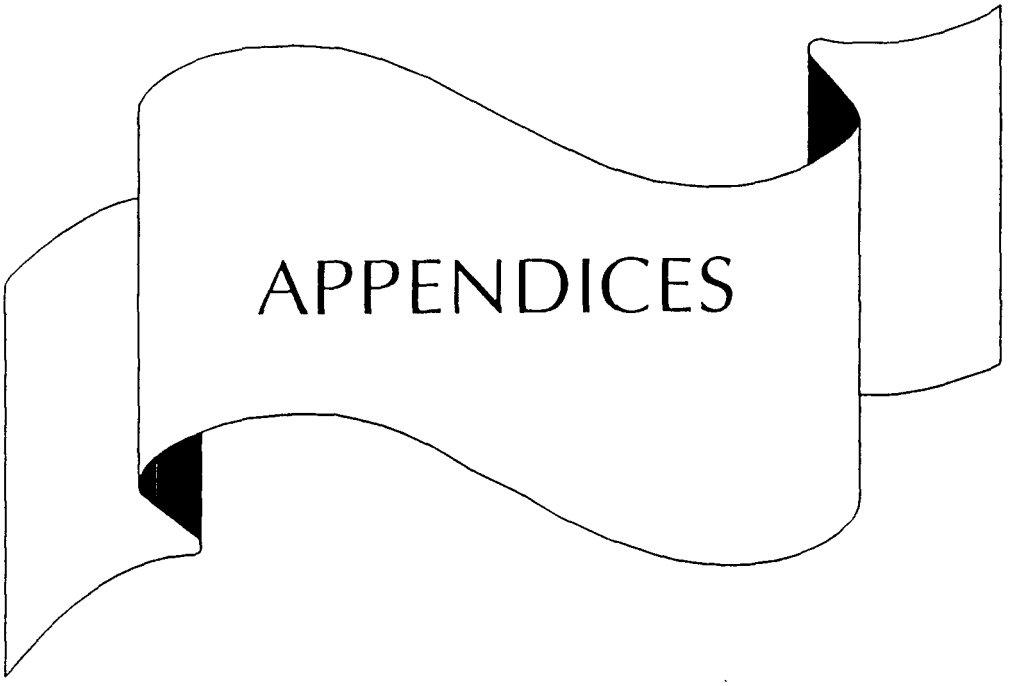
APPENDICES

Appendix - I

Amino acid scores of different combinations tried for cassava vermicelli

	Arginine	Histidine	Lysine	Tryptophan	Phenyl alanine	Tryosine	Methionine	Cystine	Thereonine	Leucine	Isoleucine	Valine
Combination - 1												
Cassava flour - 50	290	55	145	40	90	50	25	45	100	150	125	120
Maida - 35	67	42	39	21	102	46	32	49	53	140	77	84
Soya flour - 15	68	23	60	12	45	32	12	15	36	72	48	48
Amino Acid Score = 65.72												
Combination - 2												
Cassava flour - 40	232	44	116	32	72	40	20	36	80	120	100	96
Maida - 40	76	48	44	24	116	52	36	56	60	160	88	96
Soya flour - 20	90	30	80	16	60	42	16	20	48	96	64	64
Amino Acid Score = 66.04												
Combination - 3												
Cassava flour - 50	290	55	145	40	90	50	25	45	100	150	125	120
Rice flour - 25	160	48	55	18	88	75	55	25	73	140	78	115
Blackgramdhal - 25	130	43	100	18	78	35	23	20	55	125	85	78
Amino Acid Score = 79.01												
Combination - 4												
Cassava flour - 60	348	66	174	48	108	60	30	54	120	180	150	144
Soya flour - 20	90	30	80	16	60	42	16	20	48	96	64	64
Milk powder - 20	44	36	98	18	62	60	34	10	56	126	72	84
Amino Acid Score = 75.08												
Combination - 5												
Cassava flour - 40	232	44	116	32	72	40	20	36	30	120	100	96
Maida - 30	57	36	33	18	87	39	27	42	45	120	66	72
Soya flour - 20	90	30	80	16	60	42	16	20	48	96	64	64
Sugar - 10	-	-	-	-	-	-	-	-	-	-	-	-
Amino Acid Score = 60.32												
Combination - 6												
Cassava flour - 70	406	74	203	56	126	70	35	63	140	210	75	168
Maida - 20	38	24	22	12	58	26	18	28	30	80	44	48
Soya flour - 10	45	15	40	8	30	21	8	10	24	48	32	32
Amino Acid Score = 66.04												
Combination - 7												
Cassava flour - 50	290	55	145	40	90	50	25	45	100	150	120	120
Maida - 25	48	30	28	15	73	33	23	35	38	100	55	60
Soya flour - 25	113	38	100	20	75	53	20	25	60	120	80	80
Amino Acid Score = 68.36												

Appendix - I (Contd....)

	Arginine	Histidine	Lysine	Tryptophan	Phenyl alanine	Tryosine	Methionine	Cystine	Thereonine	Leucine	Isoleucine	Valine
Combination - 8												
Cassava flour - 60	348	66	174	48	108	60	30	54	120	180	150	144
Maida - 30	57	36	33	18	87	39	27	42	45	120	66	72
Soya flour - 10	45	15	40	8	30	21	8	10	24	48	32	32
Amino Acid Score = 65.16												
Combination - 9												
Cassava flour - 50	290	55	145	40	90	50	25	45	100	150	125	120
Maida - 30	57	36	33	18	87	39	27	42	45	120	66	72
Soya flour - 20	90	30	80	16	60	42	16	20	48	96	64	
Amino Acid Score = 66.9												
Combination - 10												
Caasava flour - 70	406	77	203	56	126	70	35	63	140	210	175	168
Soya flour - 15	68	23	60	12	45	32	12	15	36	72	48	48
Blaqckgramdhal flour - 15	78	26	60	11	47	21	14	12	33	75	51	47
Amino Acid Score = 71.52												
Combination - 11												
Cassava flour - 60	348	66	174	48	108	60	30	54	120	180	150	144
Rice flour - 20	128	38	44	14	70	60	44	20	58	112	62	92
Blackgramdhal flour - 20	104	34	80	14	62	28	18	16	44	100	68	62
Amino Acid Score = 76.3												
Combination - 12												
Cassava flour - 60	348	66	174	48	108	60	30	54	120	180	150	144
Rice flour - 20	128	38	44	14	70	60	44	20	58	112	62	92
Greengram flour-20	100	34	92	12	70	20	16	12	40	102	70	64
Amino Acid Score = 76.36												

Appendix - 2

Score card for Vermicelli

Product :

Tested by :

Date :

Age :

1. Appearence

Excellent	5
Good	4
Satisfactory	3
Mediocre	2
Poor	1

2. Colour

White	5
Light Brown	4
Brown	3
Park Brown	2
Blackish Brown	1

3. Flavour

Excellent	5
Good	4
Satisfactory	3
Mediocre	2
Poor	1

4. Texture

Soft	5
Spongy	4
Hard	3
Very hard	2
Shiny	1

5. Taste

Excellent	5
Good	4
Satisfactory	3
Mediocre	2
Poor	1

Appendix - 3

Score card for preference test

Sweet Vermicelli

Liked extremely well	7
Liked very much	6
Liked	5
Neither liked nor disliked	3
Disliked	3
Disliked very much	2
Disliked extremely well	1

Savoury Vermicelli

Liked extremely well	7
Liked very much	6
Liked	5
Neither liked nor disliked	3
Disliked	3
Disliked very much	2
Disliked extremely well	1

FEASIBILITY OF FORMULATING 'READY TO EAT' PRODUCTS BASED ON CASSAVA

By

SYAMA MARY MATHEN

ABSTRACT OF A THESIS
SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE OF
MASTER OF SCIENCE IN HOME SCIENCE
(FOOD SCIENCE AND NUTRITION)
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF HOME SCIENCE
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

1997

ABSTRACT

A study on the `Feasibility of formulating Ready-to-Eat products based on Cassava' was conducted with major objective to utilise the major root crop cassava for the preparation of Ready-to-Eat product. The study comprised of standardisation of basic product Vermicelli; preparation of sweet vermicelli and savoury vermicelli; determination of quality of product through organoleptic quality studies and preference tests; assessing the nutritional significance as well as physiological tolerance of the developed food product and package and shelf-life studies.

The basic product vermicelli was formulated with Cassava flour as the basic ingredient. Twelve combinations were tried with different proportions of Cassava flour. The other ingredients added to Cassava flour were maida, soy flour, rice flour, and milk powder. The selection of the best combination was based on extrusion behaviour, nutritional adequacy and cost benefit ratio. A combination with cassava flour 40%, maida 30%, soy flour 20% and

sugar/salt 10% was selected as the ideal combination since it secured higher score for extrusion behaviour than other combinations. The amino acid score and cost of the combination was also found to be satisfactory.

Savoury Vermicelli was prepared by the addition of salt and seasonings and sweet vermicelli by the addition of sugar during processing. Cooking characteristics of developed products such as cooking time, bulk density and water absorption index were rated as good.

The nutritional composition of the food product revealed that the product contained all the nutrients in optimum quantity. The nutritional quality of the developed food product before and after processing with reference to proteins, calcium, magnesium and calories were determined through suitable laboratory techniques and result showed that there was some amount of loss during processing.

Regarding the physiological tolerance, the developed food product exhibited a Protein Efficiency Ratio (PER) of 2.2 to 2.4 indicating that the quality of protein is good. The other quality parameters such as Biological

value (BV) Digestability co-efficient (DC) and Net protein Utilisation (NPU) of the product were also found to be satisfactory.

Organoleptic and preference studies of the developed food product was assessed by three groups of consumers viz. experts, housewives and old people. The parameters tested under organoleptic studies were appearance, flavour, taste, texture and colour. The analysis revealed that both the sweet and savoury vermicelli got highest scores. There was no significant difference between these two preparations except for taste. Sweet vermicelli had a slightly higher mean score, compared to savoury vermicelli.

Effect of storage on moisture, peroxide and total sugar content revealed that there was an increase in all the three parameters during the six months storage period. The increase in moisture over months was statistically different. Eventhough the products showed an increase in total sugar and peroxide content, over the period, the increase observed was not significant statistically. Observation on insect infestation revealed that there was no insect infestation up to six months of storage period.

As future line of work, the results of the present study suggest the development of proper food processing technology in order to equip the rural people, particularly the women folk for an income generating activity and building up a healthy rural population.