DEVELOPING SUITABLE RICE-SOYA FERMENTED PREPARATION

By

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THESIS

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Dedicated to
Chachen and Ammachi

DECLARATION

I hereby declare that this thesis entitled **"Developing suitable rice-soya fermented preparation"** 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.

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CERTIFICATE

Certified that this thesis entitled **"Developing suitable rice-soya fermented preparation"** is a record of research work done independently by Miss. Binila Paul 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.

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INTRODUCTION

1. INTRODUCTION

Fermentation is one of the oldest and most economical methods of producing and preserving foods. It provides a way to reduce volume of material to be transported, enhance nutritive value, to improve appearance and taste, to reduce energy required for cooking and to make a safer product by destroying undesirable constituents in foods. Cereal and legume blends are fermented to prepare a variety of traditional foods.

Fermentation of foods brings about complex, physical, biochemical and nutritional changes in food materials as a result of activity of various micro-organisms. Indian fermented foods also provide a rich source of culture of Lactic Acid Bacteria.

Aside from protein and calories, fermented foods are reported to be important sources of vitamins especially of B-complex, and of minerals like calcium and phosphorus. Fermented foods are also reported to be easily digestible (Parker, 1986).

Since the earliest days of agriculture, cereals and legumes were grown together and their fermented products formed an important part of the daily meals. Among the Indian fermented foods, a popular South Indian preparation viz., `idli' is a fermented steamed product with a soft and spongy texture and is prepared from a mixture of parboiled rice and dehulled blackgram dhal.

In India, among legumes, soyabean is gaining steady consumer acceptance, being low priced and of highly nutritive. But, India being a non-traditional soyabean producing country, there have been some difficulties in promoting the consumption of soyabean.

Now soyaflour is found to be used for making soy idli (Akolkar and Parekh, 1983), chapathi (Bhat and Vivian, 1980), bread and extruded soya rice products (Chauhan and Bains, 1989 and Chandran, 1995) and other soya fortified food items (Patil and Ali, 1990). Experiments conducted by Richard (1975) have revealed that soyaflour could be used at various proportions in the preparations of various Indian savouries and sweets. Extruded products with soyaflour such as noodles, macaroni and wafers (Chellammal, 1995) and weaning mix (Chellammal, 1995 and Sailaxmi, 1995) were also found well acceptable and soyabean is also found to be used for developing products such as high protein beverage, baby food formulations and breakfast foods (Singh and Chauhan, 1989).

Studies have reported that, the beany flavour of soyabean was totally replaced by pleasant flavour during fermentation. According to Kanekar *et al.* (1990) the fermentation process could be fruitfully used to make soyabean popular in Indian diet.

By replacing traditional legumes with soyabean or defatted soyaflour, the nutritive value of various preparations can be enhanced. In the present study on "Developing suitable rice-soya fermented preparation" attempts have been made to develop idli after replacing blackgram dhal in different proportions with either soyabean or defatted soyaflour and to evaluate the acceptability and nutritive value of the preparations.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Literature pertaining to the study entitled "Developing suitable rice-soya fermented preparation" is reviewed under the following headings :

2.1. **Nutritional significance of cereal legume blends**

2.2. **Fermented products based on cereals and legumes**

2.3. **Physico-chemical characteristics of rice-pulse batter and factors associated with them**

2.4. **Acceptability of fermented products**

2.1. Nutritional significance of cereal legume blends

Since the earliest days of agriculture, cereals and legumes have been grown together and their blends form an important part of the daily meals, especially in developing countries like India. The blends prepared from commonly used cereals and legumes are reported to have better quality (Goyal and Khetarpaul, 1995) and form the major source of protein for the vegetarian population in India (Naik and Gliason, 1988).

Cereals contain much less quantity of protein and hence pulses are reported to be the main source of proteins and minerals in a vegetarian diet (Kadwe *et al.*, 1974). Rajalakshmi (1976) has also stressed the nutritional significance of cereal-legume diet in the absence of animal proteins.

It is well known that, the nutritional value of legume proteins can be significantly enhanced by, complementation with cereal protein due to mutual supplementary effect (Yadav and Leiner, 1978). Nelson and Wei (1987) reported that the need for high protein and calorie foods for home preparation by low income people all over the world is great.

As stated by Rajalakshmi (1981) and Ashraf and Bwembya (1988) the beneficial effects of pulses is contingent on their high lysine content as a beneficial complementary effect to cereal proteins and the methionine and cystine deficiency of pulse proteins are made up by the cereal protein constituents.

Pulses are also important in cereal based diets, because of their rich mineral and vitamin profile (Deosthale, 1982 and Sreekumar, 1992). In addition, pulses are reported to contain the niacin precursor "trigonelline" which is absent in cereals (Banerjee *et al.*, 1951).

According to Bishnoi (1991), legumes not only add to variety in human diet, but also serve as an economical source of supplementary proteins, for a large human population in developing countries like India.

Sharma *et al.* (1992) had analysed the proximate composition of two advanced varieties of faba bean and reported that they are rich source of protein (28.65 and 29.22 per cent).

Goranov (1989) reported that as a protein source, soyabean contributes two-thirds of world's consumption of protein grains.

Unlike the pulses, soyabean is found to contain about 40 per cent good quality protein (Patil and Shukla, 1990 and Gandhi, 1991). Soyabean is also reported to be rich in lysine forming 6.51 per cent of the total protein. Wolf (1969), Singh (1987), Synder (1987) and Swaminathan (1990) have also observed soyabean proteins to supply all the essential amino acids except methionine.

Schroder *et al.* (1973) observed that soyabean protein is unique among plant proteins by virtue of their relatively high biological value and essential amino acid pattern. According to Natarajan (1989), soyabean is currently the largest commercially available vegetable protein source in most parts of the world.

Studies conducted at CFTRI (1992) on soyabean have revealed its nutritional supremacy, with twice the protein content of common pulses. As stated by Bhat (1985) it is the best source of protein from vegetable kingdom.

Soyabean is rich not only in protein and fat but also in iron, which is concentrated in the seed coat (Shizuko, 1994). As much as 20 per cent of the iron of the whole seed is reported to be in the hull whereas its mass is less than 10 per cent of the whole seed mass.

Soyabean carbohydrates are in the form of insoluble cellulose and hemicellulose and soluble stachyose and raffinose (Kawamura and Tada, 1967) and it contains little starch (CFTRI, 1992).

Experiments conducted by Nwar (1985) have revealed that unsaturated fatty acids represent 85 per cent of the total lipids in soyabean and approximately 60 per cent of this oil is composed of the essential fatty acids, such as linoleic and linolenic acids.

Soyabean oil resembles butter in its properties and is used for cooking purposes (Kale, 1985). Oil content in soyabean is reported to be around 20 per cent [Patil and Shukla (1990) and Gandhi (1991)].

Goranov (1989) and Manickam (1992) had feeled that in solving the protein supply problems, the criteria applied should not only be protein quality, but protein of animal origin should be replaced partially or fully with pulses.

Defatted soyaflour : Due to exposure to high temperature after oil extraction is found to have higher protein content (Panizzi and Mandarino, 1994). Easter (1981) feels that defatted soyaflour contains two times as much protein as in dhal, three times as much as in eggs and 15 times as much as in milk. Brand and Label (1988) have stated that defatted soyaflour contains 50 per cent protein, unmatched by any other known vegetarian sources. Nikolic and Salihodzic (1988) have stated that addition of soyaflour generally increases the protein content of the product.

Soyaflour is also reported to be rich in fibre (9.90g) and ash (7.252g) (Rounet *et al.*, 1992).

Seralathan *et al.* (1989) have observed that soyaflour had 85 per cent acceptability.

If soyabean as dhal or flour, is used even in smaller percentages in the place of the existing traditional pulses, nutritional and economic gain will be greater (Karuna, 1989). Karuna also reported that in view of the high quality of protein and fat present in soyabean, a substitution by 12 per cent of it with any cereal and 25 per cent with any pulse may double their nutritive value.

Steinke and Hopkins (1983) reported that legume proteins, exemplified by isolated soya proteins, are excellent sources for balancing the amino acid profile of traditional cereal foods, *viz.*, corn, oats, rice and wheat. Domah *et al.* (1985) has stated that addition of 20 per cent legume seeds and 5 per cent skimmed milk powder to cereal flour increased the ash, fibre, protein and fat content. Addition of 15 per cent soyaflour to corn and sorghum meals improved the nutritional quality of the sorghum flour (Jayalakshmi and Neelakantan, 1987). Experiments conducted by Jayalakshmi and Neelankantan (1988) have recorded the higher concentration of protein, ash, fat and calorie contents in soyabean incorporated blends.

Walter (1978) reported that blends of soyaflour with cereals such as corn, wheat, sorghum and oats are widely used in world feeding programmes. `Soyaven' is a nutritious low cost infant formula based on oats and soyabean. It was used in Mexico to alleviate malnutrition (Mermelstein, 1983). Sheikh *et al.* (1986) developed a weaning food `soy lac' based on blends of rice, wheat and soyabean. Biological evaluation showed that it was of high nutritional value. Prema and Chellammal (1986) studied the feasibility of incorporating soyaflour in weaning foods based on fermented cassava flour and found that the nutritive value could be considerably increased. Improvement in the protein quality and lysine content by incorporation of soyaflour in weaning food is reported by Cheriyan and Tarar (1992).

A soya-ragi multimix formulated by Vijayalakshmi *et al.* (1985) was recommended as nutritious mix, used as a pre-school child snack and also a remedial and preventive measure against protein energy malnutrition. According to Sinha and Nawab (1993), use of wheat or rice and medium fat soyaflour blend for making traditional food items can offer an unique opportunity for combating protein calorie malnutrition prevailing among our masses. Supplementary food based on rice, defatted soyaflour and groundnut flour was developed by Sailaxmi (1995) and it was highly nutritious.

High protein snacks from a combination of rice flour and full fat soyaflour by extrusion cooking have been developed by various workers (Paymo *et al.*, 1982; Singh and Chauhan, 1989; Thirumaran and Seralathan, 1989).

Manjhi (1985) has proved that the soyaflour can double the nutritional content of bread at no extra cost. According to Serna-Saldivar *et al.* (1988) wheat flour was fortified with 8 and 12 per cent defatted soyabean and 8 per cent and 4 per cent defatted sesame meal to increase the protein content and amino acid profile of bread. Maida and soyaflour in the proportion of 90:10 can raise the protein content of bread without causing any deleterious effects upon baking and shelf life qualities (Chandran, 1995).

The Protein Efficiency Ratio (PER) which measure the weight gain per gram of protein eaten, was determined according to the rat growth method of Osborne, Mendel and Ferry (Osborne *et al.*, 1919).

Joseph *et al.* (1961) reported that fortification of the idli mix composition with a protein rich food like Indian Multi Purpose Food enriched the growth promoting value very significantly. A higher PER is reported by Ananthachar and Desikachar (1962) as a result of mutual supplementary action of the cereal and pulse proteins. Studies conducted by Veen and Steinkraus (1970) reported a negative result on the total growth promoting value and digestibility coefficient of the idli as a result of fermentation. Protein Efficiency Ratio of sorghum blended with soya was comparable to casein, while that of sorghum with cotton seed was significantly lower than with casein (Janasan *et al.*, 1978).

Tsen and Mustafa (1976) indicated that bread containing 80 per cent wheat flour, 15-30 per cent cassava flour and 4.70 per cent soyaflour have a better PER than wheat bread with same protein content.

According to Bressani *et al.* (1960), an increase of 38.60 per cent in PER values was observed in bread fortified with lysine and methionine. Narayanaswamy *et al.* (1970) studied the effect of amino acid supplementation on PER of a low cost protein food, based on 70 parts wheat flour, 30 parts heated soyabean flour and fortified with essential vitamins and minerals. They found that PER of the food was significantly improved by a supplement of methionine. Marialuz *et al.* (1986) studied on fortification of wheat flour from Hermosillo hard red spring cultivar with various levels of lysine and methionine and observed that PER is significantly improved by this fortification.

The Digestibility Co-efficient (DC), Protein Efficiency Ratio (PER) and Net Protein Ratio (NPR) of fermented soyabeans is reported to be comparable with skimmed milk (Igbedioh, 1991).

Studies have shown that addition of 15 per cent soyaflour to degermed corn meal and sorghum meal separately increased the PER (Jayalakshmi and Neelakantan, 1987).

Donangelo *et al.* (1986) reported that true protein digestibility and energy digestibility of the rice and legume (1:1) mixture were high.

2.2. Fermented products based on cereals and legumes

Fermentation is one of the ancient naturally occurring biotechnology exploited for human welfare as quest for sophistication of life cycle (Balagopalan, 1985). Manay and Swamy (1987) stated that the term fermentation means the breakdown of carbohydrate material by microorganisms (or enzymes) under anaerobic conditions. Beuchat (1995) reported that fermentation and dehydration are among the oldest techniques used to preserve foods.

From the beginning of recorded history, and probably before, people unknowingly relied on fermentation to provide variety to diets consisting largely of grains and vegetables, and to extend the keeping time of oil seeds, grains and roots. In developing countries, as well as in some developed countries, protein in the form of meat, fish and dairy products will be limited or not consumed. Because of religious or cultural preferences, fermented foods are used as flavouring agents for otherwise bland vegetable diets (Beuchat, 1995).

Orejana (1983) reported that the wastage due to periodic surplus in agricultural and marine produce can be reduced by fermentation.

Fermented foods play an important role in the nutrition of the economically deprived people in most Asian countries, because they are relatively cheap and the proteins and calories are generally retained (Ko, 1982). Fermented products are considered to be more nutritious than their unfermented counter parts (Joshi and Thakur, 1995).

The improved flavour, texture and appearance make fermented foods more attractive than the raw materials (Veen and Steinkraus, 1970). Childyal and Jaleel (1993) stated that fermented preparations are reported to produce a variety of flavour and aroma.

Fermented foods are also important sources of vitamins, especially of B-complex and of minerals like calcium and phosphorous (Parker, 1986).

Batra (1981) reported that fermentation of cereals and legumes in India and neighbouring countries were largely undertaken as a cottage industry. Since most of the products are produced in the cottage or home-scale level using crude methods of handling and processing the quality of the finished product varies widely. Furthermore, most of the products are produced under unhygienic conditions, resulting to many failures due to contamination by undesirable microorganisms (Parker, 1986).

Traditional fermented foods play an important role in the lives of people in the Oriental countries, not only as a source of much needed calories, proteins, vitamins and minerals, but also as a source of cheap, attractive, flavourful and highly digestible products. The cost of production and preservation is generally low and some industrial wastes can be utilized for producing foods for human consumption (Parker, 1986). Nirupama (1996) reported that Indian fermented foods provide a rich source of culture of Lactic Acid Bacteria (LAB).

As reported by Rajalakshmi (1981) fermentation can make cereals and pulses more suitable for children in the post-weaning period.

Fermented milk is generally considered to possess some therapeutic value in intestinal disorders. The presence of lactic acid organisms is reported to inhibit the growth of many pathogenic organisms. Lactic acid fermented products are also found to be readily digested than unfermented milk by subjects suffering from intestinal disorders (Joshi and Thakur, 1995).

Kanji, which is a rice based fermented food is reported to have some therapeutic value and can cure some stomach disorders (Srivastav and Jain, 1993). The value of fermented foods containing lactobacilli in controlling the growth of undesirable bacteria and in curing intestinal disorders like constipation, diarrhoea and dysentery (Nirupama, 1996).

Dhokla, a cereal-legume based fermented product is considered as a pre-digested food and is well accepted and tolerated by very young children (Ramakrishnan, 1979).

Pakhala, a rice based fermented food is reported to have some therapeutic value and retrieves the consumer from heat stroke and soothes the stomach in summer. It is also reported to prevent gas formation in the stomach (Srivastav and Jain, 1993).

Among the fermented foods, idli makes an important contribution to the diet as a source of protein, calories and vitamins especially B-complex vitamins (Reddy *et al.*, 1981). They had also stated that idli can be used as a dietary supplement in developing countries to treat people suffering from protein-calorie malnutrition.

Ramakrishnan (1977) conducted studies at Trivandrum Hospital (Kerala, India) where soya idli was used as a dietary supplement for Kwashiorkor and Marasmus children. He has reported that the soya idli was well tolerated by children and there was a disappearance of oedema in the case of Kwashiorkor children. He observed weight gain in children suffering from Kwashiorkor and Marasmus.

Steinkraus *et al.* (1967) have stated that acceptable idlis could be prepared using different proportions of legumes and cereals specially for diabetic patients by increasing the proportion of blackgram dhal.

The acceptability of idli is attributed to its flavour, texture and easy digestibility, which makes it well tolerated by children, infants, convalescing individual and even individuals suffering from typhoid (Ramakrishnan, 1979).

Thirumaran (1976) reported that idlis can be prepared by making use of different pulses like greengram, horsegram and sprouted horsegram in the place of blackgram dhal, without much differences in the nutritional value, weight and volume. She also reported that addition of bhindi with other pulses improved the quality of the idli. Susheelamma and Rao (1980) found that peanuts could be substituted for blackgram in the preparation of idli. Sathe and Salunke (1981) have observed whole great Northern beans as a suitable substitute for blackgram cotyledons in the preparation of idli. Idli is one of the traditional fermented cereal pulse product popular in South India and prepared from rice and blackgram dhal (Thyagaraja *et al.*, 1992).

Idli is an excellent food item which can adopt the use of soyabean instead of blackgram dhal and ipso facto meet the processing requirements of soyabean, needed for its optimum nutritive value (Aykroyd, 1964). Proteins from oil seed flours such as soyabean have been shown to possess high surface activity and could replace the surface active proteins of blackgram dhal (Susheelamma and Rao, 1980). Reddy *et al.* (1981) had also reported that soyabean could be substituted for blackgram dhal in the preparation of idli.

Idli and dosa are commonly prepared from mixtures of rice or rice semolina with blackgram dhal (Thirumaran, 1976). Chopra *et al.* (1984) reported that 15 per cent sesame supplemented dosa had increased levels of S-amino acids, especially methionine compared to plain dosa.

Fermented rice and defatted soyaflour blends are reported to have better protein quality, mineral profile, enhancement in the digestibility of starch and protein and also an increase in polyphenolic contents (Goyal, 1991 and Grewal, 1992).

Reddy and Salunka (1980) stated that fermentation of idli mixtures had no effect on the content of calcium, magnesium, zinc and iron.

Veen and Steinkraus (1970) stated that fermentation does not increase protein nutritive value. Goyal and Rakhi (1991) reported that fermentation of all the cereal - legume blends either lowered or did not change the protein content.

While Khader (1983) has reported that fermented soyabeans indicate a slight increase in protein quality. And Blakeman *et al.* (1988) have also reported that fermentation of a mixture of soya grits and rye flakes resulted in increase in protein content upto 36 per cent. *In vitro* digestibility of proteins are stated to be improved significantly as a result of fermentation (Yadav and Khetarpaul, 1995).

Soya-corn mixtures when fermented was observed to have significantly higher amino acid content (Kazanas *et al.*, 1981). According to Goyal and Mathews (1985), during fermentation of khamman and dhokla (rice and bengalgram), there was an increase in lysine and tryptophan content.

Decrease in sugar content was observed during fermentation of khamman and dhokla (Goyal and Mathews, 1985). As a result of fermentation *in vitro* digestibility of starch improved significantly (Yadav and Khetarpaul, 1995).

During the process of fermentation vitamins are produced (Khandwala, 1959). Dentis and Bisping (1994) stated that vitamins are found to increase during fermentation. Ananthachar and Desikachar (1962) reported that the thiamine content of idli was not altered by fermentation.

Kasturbia and Phadnis (1987) indicated that increase in riboflavin content of idli, an Indian batter produced by the fermentation of mixtures of rice and blackgram, was greatest when the rice : gram ratio was 2:1 and the time of fermentation was 18h. He also reported that 2:1 and 3:1 cereal : pulse ratio were found to be the best ratios for the synthesis of vitamins.

With respect to changes in vitamin content during the fermentation process, the results are somewhat contradictory. Rajalakshmi and Vanaja (1967) reported that increase in thiamine and riboflavine content was observed during fermentation. Steinkraus *et al.* (1967) observed a small but significant loss of riboflavin during fermentation.

An increase in niacin as a result of fermentation was reported by Reddy and Ramamurty (1971).

Tongnual (1983) reported that fermented corn and corn soyabean mixtures resulted in potentially available magnesium and zinc.

According to Tongnual (1983), fermentation of mixtures of autoclaved soyabean meal : corn meal resulted in decrease in trypsin inhibitors and phytic acid. Fermentation has been reported to be one of the potential processing methods of reducing the antinutrients and enhancing the nutritive value of certain cereals and legumes (Grewal, 1992). Yadav and Khetarpaul (1995) reported that fresh batter of greengram dhal contained high amounts of phytic acids and polyphenols. Indigenous fermentation at 35^{o}C for 18 hr reduced the levels of these antinutrients to approximately half.

2.3. Change in physico-chemical characteristics of the rice-pulse batter and factors associated with them

Major physico-chemical characteristics in which changes expected are pH, acidity, volume increase, bulk density, porosity and amylose.

Decrease in pH was observed in rice / blackgram dhal blend, after fermentation (Steinkraus *et al.*, 1967). Similar observation in pH, after 30 hr of fermentation was observed in dosa batter (Soni *et al.*, 1985). Goyal and Rakhi (1991) worked on fermentation of different cereal-pulse blends and results revealed that the pH of all the fermented cereal legume blends dropped. Maximum drop in pH was observed by Goyal and Khetarpaul (1994) in rice-defatted soyaflour blend after fermentation.

Desikachar and Subramaniyan (1959) reported that during fermentation of idli batter the pH was fallen from 6.0 to 4.3. A batter with low pH values is reported to give a good product. According to Thirumaran (1976) the idli batter with an initial pH, ranging from 6.2 to 6.4 was reduced to 3.9 after fermentation. Reddy and Salunkhe (1980) have reported that the pH of other fermented preparations dropped from the initial value of 6.0 to 4.3. Subbiah *et al.* (1985) have stated that the role of lactic acid bacteria is only to reduce the pH of the idli batter to a level of 4.00 to 4.50. Joshi *et al.* (1989) have shown that the pH of the dhokla batter (blends of rice / bengalgram flour) dropped from 5.25 to 4.00. Gowri (1990) reported that the pH was found to decrease from the initial value of 6.20 in idli batter fermentation. Decrease in pH was significantly more in 2:1 ratio than in 3:1 ratio. Thyagaraja *et al.* (1992) observed that during the fermentation of idli, pH change ranged from 6.3 to 4.4.

Acidity was found to increase during fermentation of idli batter (Desikachar and Subramaniyan, 1959). Similar results were observed in rice / blackgram dhal blend by Steinkraus *et al.* (1967). Joshi *et al.* (1989) have shown that, total titrable acidity of the dhokla batter increased from 0.33 to 1.2 per cent indicating the production of acids by micro organisms. Gowri (1990) reported that during idli batter fermentation, the production of acid was sharp and rapid between 6^{th} and 18^{th} h of fermentation and continued fermentation brought about a further small increase in the acidity. The increase in acidity due to fermentation was highly significant as the incubation period increased.

Desikachar *et al.* (1959) reported that the increase in batter volume was observed only after about 10 h fermentation in idli batter. According to Steinkraus *et al.* (1967) approximate rise expected in the batter was 50 per cent above its original volume, but they have observed that the batter may rise by as much as three times its original volume also. Soyabean as an alternative for blackgram in the idli preparation was suggested by Ramakrishnan (1977). He reported an increase in the volume of batter also. According to Sarasa and Nath (1985), although batter volume and displaced volume of the test batter increased tremendously at 12 h of fermentation, a maximum rise was attained at 16 h of fermentation and got stabilized thereafter.

Soni *et al.* (1985) conducted experiments on dosa batter fermentation and observed an overall increase in the batter volume. Joshi *et al.* (1989) also reported that during dhokla fermentation, volume of the batter increased from zero to 95.61.

Bulk density is an important characteristic influencing the acceptability of the fermented products. The specific volume (v/w) is reported to be an indication of the fluffiness of the idli which increased as the fermentation progressed (Desikachar *et al.*, 1959).

Susheelamma and Rao (1979) reported that proportion of blackgram flour and rice semolina in the batter of 1:1 to

1:2 are optimal to achieve a balance between surface activity and viscosity to obtain products with low bulk density. Susheelamma (1989) studied the possibility of substituting blackgram polysaccharide with polysaccharide preparations from raw and roasted linseeds (*Linum usitalissimum*) in the preparation of idli type steamed pudding. Results revealed that increasing the concentration of polysaccharide optimal levels in the idli mix resulted in puddings with increased bulk density.

Porous texture of the idli was stabilized satisfactorily by the linseed polysaccharide which was a satisfactory replacement for blackgram polysaccharide as reported by Susheelamma (1989).

According to Tewary and Muller (1992) reduced oligasaccharide levels was found in rice-blackgram dhal blend fermentation.

Kazanas and Fields (1981) have reported that soya corn mixture was fermented to have significantly high amino acid content for the product. Idli made from blackgram dhal-rice blends are reported to have high amounts of sulphur containing amino acid (cystine and methionine) in experiments conducted by Jadhav (1982).

According to Lee (1986), the average relative nutritive value of protein increased by 11 per cent during fermentation. Blakeman *et al.* (1988) reported that fermentation of mixtures of cereal and pulses resulted in an increase in protein content.

Achinewhu (1986) reported that fermentation did not have much effects on the fatty acid composition except for a very slight reduction in the total saturated fatty acids and an increase in the total unsaturated fatty acids. During the course of fermentation of dhokla batter, total volatile fatty acids (VFA) comprising acetic, propionic, isobutyric and iso-valeric acids were reported to increase from 54.8 to 582.8mg.

Antinutrients like phytic acid or inositol 1, 2, 3, 4, 5, 6-hexaphosphate and polyphenolic compounds are present in considerable amounts in cereals and legumes including rice and soyabean (Goyal, 1991). In these plant foods, phytic acid is present as phytate, salt or a complex with protein and chelates with metal ions such as calcium. iron, zinc and copper to form insoluble protein mineral-phytate complexes. These complexes do not readily break down and may pass through the digestive tract unchanged, thereby, rendering minerals especially divalent cations unavailable (Davies and Nightingale, 1975). Phytic acid is also known to inhibit the proteolytic and amylolytic enzymes (Sutardi and Buckle, 1985), which results in lower digestibility of proteins (Khuckles *et al.*, 1985, Serraino *et al.*, 1985) and starch (Yoon *et al.*, 1983). Fairly high amounts of polyphenols present in these food grains may also adversely affect the mineral availability and digestibility of protein and carbohydrates (Aw and Swandon, 1985).

In order to bring significant improvement in the nutritional value and effective utilization of plant foods including rice and defatted soyaflour blends, it is essential to reduce the concentration of these antinutrients (Goyal and Khetarpaul, 1995).

An important phenomenon in the fermentation of oil seeds and legumes is the breakdown of anti-nutritional factors like trypsin inhibitors, haemaglutinins, phytates and flatulence causing compounds. The trypsin-inhibitors are destroyed by the heat treatment given to these products during preparation. During fermentation phytates and oligosaccharides such as stachyose and raffinose on the other hand, are reported to be reduced as a result of microbial activity (Parker, 1986).

According to Reddy and Salunka (1980) the idli mixture with one per cent salt fermented for 20 h and then steamed had 1.5 mg/g of phytate phosphorus. He has also reported that at 45 h of fermentation, about 48.40 per cent of phytate phosphorus was hydrolyzed in blackgram rice blends with subsequent increase in non phytate phosphorus. Phytate was also reported to be reduced in idli (Jadhav, 1982). Tongnual (1983) observed that whole soyabean fermentation resulted in decrease in trypsin inhibitors and phytic acid. Yadav and Khetarpaul (1995) have also noted indigenous fermentation at 35^{o}C for 18 h reduced the level of phytic acid and polyphenols to approximately half.

2.4. Acceptability of fermented products

Consumer awareness and preference decide the success of a food product. Consumer awareness of quality of food is essentially determined by the desirable sensory qualities he expects and perceives in the sample. Sensory perception of appearance, texture, taste, aroma and residual mouthfeel have guided in the selection and avoidance of a food (Govindarajan, 1991).

Success with products is highly dependent on careful evaluation of products and sensory evaluation is used to predict the consumer acceptance of a food item (Clement and Kubena, 1989).

When the quality of food is assessed by means of human sensory organs, using scientific testing methods the evaluation is said to be sensory analysis (Skelton, 1984). Ylimaki *et al.* (1989) opined that sensory analysis is a multi-disciplinary science that uses human panelists and their senses to measure the sensory characteristics and acceptability of food products.

Commonly consumed fermented products in India are idli (Reddy *et al.*, 1986), dosa (Reddy and Ramamurti, 1971), warri (Soni and Sadhu, 1989), soya sauce (Steinkraus, 1985), Tarhara (Oner *et al.*, 1994) and soya rabadi (Grewal and Chauhan, 1993).

According to Herrington (1991) sensory evaluation technology is a method using skilled management and trained panelists to provide confirmation on the acceptability of the product profile, consumer acceptability and consistency. Sensory method in which palatability is evaluated by a panel of judges is essential to every standardisation procedure because they answer all important questions of the food taste, smell, look and feel (Mc Dernoot *et al.*, 1992).

According to Mc Laren (1984) the criteria included in food quality system are general acceptance, taste, appearance, texture and aroma of food.

Fermentation produces the desirable qualities in products (Thyagaraja *et al.*, 1992 and Joshi and Thakur, 1995) and especially major changes in colour, aroma, flavour and texture (Beuchat, 1995).

Swamy and Shrihara (1976) studied the acceptability of soyabean incorporated rice idlis. Sensory evaluation indicated that there would be no difference among the regular idlis served and wholly substituted soyabean idlis.

Contradictory to this observation, Yajurvedi (1980) reported that acceptability of soya idli and those prepared from blackgram has shown that the idlis prepared from soyabean is in no way similar in terms of the texture, colour and aroma with those prepared from the combination of blackgram dhal and rice.

Blackgram dhal substitution by oilseeds such as soyabean (Steinkraus *et al.*, 1967, Ramakrishnan, 1977, Susheelamma and Rao, 1980), peanuts (Susheelamma and Rao, 1980) and dry beans of *Phaseolus vulgaris* L. (Sathe and Salunkhe, 1981) are reported to be acceptable in the preparation of idli.

Thirumaran (1976) reported that idlis can be prepared by making use of different pulses like greengram (*Phaseolus aureus*), horsegram (*Dolichos biflorus*), sprouted horsegram (*Dolichos biflorus*) and cowgram (*Vigna catiang*) and lablab (*Dolichos lablab*), in the place of blackgram dhal. Joseph *et al.* (1994) has also suggested that common beans may be substituted for Indian blackgram for the preparation of comparable, acceptable steamed idli.

Sarasa and Nath (1985) have observed that idli prepared from bhagar (*Panicum milliaceum*) and either blackgram or rajmah (*Phaseolus vulgaris*) were satisfactorily acceptable and compared favourably with idli prepared in conventional method.

Radhakrishnamurthy *et al.* (1961) had studied the influence of blackgram dhal concentration on the acceptability of idli. As per the findings of this experiment, if the proportion of blackgram flour was less than 25 per cent, the steam-cooked idlis were hard and unacceptable organoleptically. If it was more than 50 per cent, the idlis tended to be sticky and were, hence, unacceptable. Best results were obtained when the proportion of rice semolina to blackgram flour was 2:1.

Idli made from parboiled rice was observed to obtain lower scores for the attributes like colour, appearance and texture for all the pre-release cultures of Kerala Agricultural University (Neelofar, 1992). In this experiment appearance, colour, flavour, texture and taste were the quality attributes tested to decide the acceptability of idli. Among the different varieties, raw samples of Annapoorna, Aruna, Jayathi, Pavizham and Nila were found to be highly acceptable for the preparation of idli (Nandini, 1995).

Dholka products prepared from batters of soyabean flour, either exclusively or admixed with bengalgram flour and also with wet ground soyadhal, fermented with and without curds were subjected to sensory evaluation by inhouse trained judges for flavor, taste, texture and overall quality. Statistical analysis of the data revealed that the product made out of soyaflour admixed with bengalgram flour (1:1 w/w) and fermented without curds were found acceptable and almost reached the score of the traditional `dhokla' (Kanekar *et al.*, 1990).

Experiments conducted by Chopra *et al.* (1982) on sesame supplemented dosa revealed that 15 per cent supplementation was most acceptable organoleptically.

Fermented maize meal was air dried at 62^{o}C and fortified with defatted soyaflour at levels of 0, 10 and 20 per cent (dry basis). Consumer preference tests showed that maize meal containing $\leq$ 10 per cent soyaflour were acceptable (Plahar, 1984).

Effect of substitution of 5, 10 and 15 per cent field pea or defatted soyaflour for wheat flour in a chemically leavened quick bread and sensory characteristics of bread were studied. Results indicated that defatted soyaflour can be successfully substituted for wheat flour in quick breads at levels upto 15 per cent whereas at the same substitution levels, field pea flour had adverse effects on both physical and sensory characteristics (Raidl and Klein, 1984).

Sensory characteristics of wheat rotis supplemented with soyaflour at 0, 5, 10, 15, 20 per cent levels were studied. As per the findings of this experiment, addition of soyabean flour upto 20 per cent had no adverse effect on the sensory acceptability of the rotis (Maqbool *et al.*, 1988). Sensory evaluation studies done by Vaidehi *et al.* (1992) on bread have shown that the best acceptable level of soyaflour was 5 to 10 per cent. Bread can be prepared without altering the organoleptic qualities using maida and soyaflour in the proportion of 90:10 (Chandran, 1995).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The study entitled "Developing suitable rice-soya fermented preparation" provides comprehensive information on the nutritional and organoleptic qualities of a soya-rice fermented preparation, *viz.*, "idli" developed by partial replacement of blackgram dhal either with defatted soyaflour or whole soyabean, in different proportions.

3.1. SELECTION OF GRAINS

The food articles selected for the study were rice (*Oryza sativa*) (parboiled), blackgram dhal (*Phaseolus mungo*), soyabean (*Glycine max*) and defatted soyaflour.

3.2. SAMPLE PROCUREMENT

Parboiled rice is considered to be better than raw rice for fermentation process (Thirumaran, 1976). In this experiment good quality parboiled rice *viz.*, doppi rice, decuticled blackgram dhal and dry soyabean were procured from local super market. The rice and pulse grains were cleaned to remove all the impurities, dried and stored in airtight containers. Defatted soyaflour, the common form in which soyabean can be incorporated in various food preparations (Chauhan and Bains, 1989) was procured from M/s. Shakthi Soyas, Pollachi, Tamil Nadu. The flour was roasted and packed in sealed polythene cover.

3.3. PROCESSING THE SAMPLES

Various steps in processing ingredients were :

Rice, blackgram dhal and soyabean were washed three times with tap water to remove adhering dirt and dust particles and surface microorganisms. According to Reddy *et al.* (1981) and Desikachar *et al.* (1959), rice and pulses like blackgram dhal and soyabean are to be soaked in water for six hours before grinding the mixture, while Swaminathan (1988) has stated that the ingredients need to be soaked in water only for three hours. In this experiment, the ingredients were soaked for six hours.

The soaked grains were ground well using a wet grinder. A study conducted by Reddy *et al.* (1981) indicated that 0.8 per cent salt is sufficient to give taste and hence the same quantity was added to the batter, in this experiment also. Defatted soyaflour was added before mixing the batter.

Most important step in idli making is the time given for fermenting the ground mixture. Khandwala *et al.* (1962) has stated that 20 - 24 h fermentation is needed for idli batter to ferment. While Ananthachar and Desikachar (1962) have stated that 20 h fermentation is sufficient for the same. Experiments conducted by Reddy and Salunkhe (1980) have reported similar findings. Reddy *et al.* (1981) have also observed that idli made from 20-24 h of fermentation had a fine net work (spongy), but it has sour taste. Thirumaran (1976) and Sowbhagya *et al.* (1991) have studied the effect of 18 h fermentation of idli batter and obtained encouraging results. Studies conducted by Swaminathan (1988) and Swamy and Shrihara (1976) indicated the need for overnight fermentation. In the present study the fermentation time selected was 18 h.

Temperature at which fermentation occurs has an important role to play in determining the quality of fermentation. Temperature of $40^{o}C$ accelerated the rate of fermentation, but some undesirable smell occasionally developed (Desikachar *et al.*, 1959). According to Desikachar *et al.* (1959), temperature range of 25-30^{0}C has been found to be optimal for fermentation. Swamy and Shrihara (1976) have also supported this study. Khandwala *et al.* (1962) and Thirumaran (1976) have reported that normal room temperature is sufficient for the process of fermentation. In this experiment also the batter fermented at room temperature.

Standard method, generally used for idli making is that, the fermented batter is poured on a wet muslin cloth spread over idli moulds in a cooker and cooked in steam for 25 minutes (Swaminathan, 1988). The same method was applied in this experiment.

Grinding time, duration of fermentation, temperature of keeping batter for fermentation and process of idli making were uniform for all the 13 formulations attempted in the experiment (Table 1 and Fig. 1).

Principles governing the selection of the suitable combination were nutritional adequacy, cost and acceptability

3.4. NUTRITIONAL ADEQUACY OF DIFFERENT COMBINATIONS

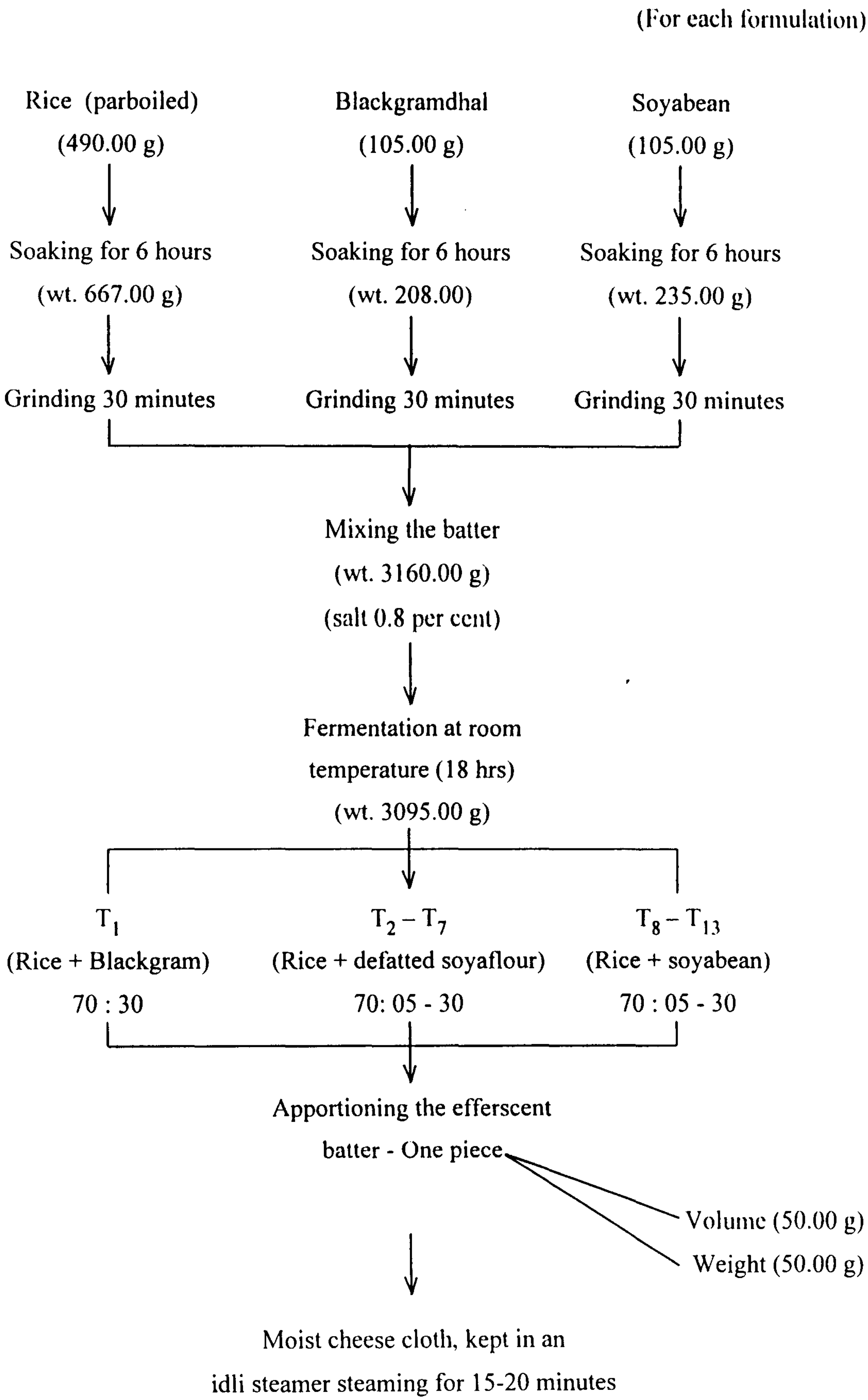
Nutritional adequacy of different combinations were ascertained by computing the nutritive value of the ingredients, amino acid score and chemical scores.

Table 1 Different formulations attempted for the development of idli

Treatments	Rice (g)	Blackgram dhal dhal (g)	Soyaflour / Soyabean (g)
T_1	70	30	0
T_2	70	25	5
T_3	70	20	10
T_4	70	15	15
T_5	70	10	20
T_6	70	5	25
T_7	70	—	30
T_8	70	25	5
T_9	70	20	10
T_{10}	70	15	15
T_{11}	70	10	20
T_{12}	70	5	25
T_{13}	70	—	30

Note : From T_8 to T_{13} soyaflour is replaced by soyabean

Fig. 1. STEPS IN IDLI FERMENTATION



3.4.1. Computing the nutritive value of the ingredients in the formulations

Summing method was administered to convert measures of ingredients to corresponding gram weight. These weights were summed up to determine total grain weight per recipe. The nutritive value for each ingredient was calculated per 100g portion. Nutrients such as proteins, minerals and vitamins and energy were calculated (ICMR, 1991). For each product the above nutrients were calculated and the total nutrients present in each formulation were assessed.

3.4.2. Computation of amino acid score of different forumulations

Amino acid score provides an useful estimate of the protein quality of blended foods and this is an acceptable substitute for biological assays. Because of this reason the amino acid contents of different formulations were worked out (ICMR, 1991).

3.4.3. Computation of chemical score of different formulations

Chemical score of the different formulations worked out from the ratio between the content of the most limiting amino acid in the test protein to the content of the same amino acid in egg protein. The ratio is expressed as percentage.

Chemical score =

$$\frac{\text{limiting amino acid content of the test protein}}{\text{content of the same amino acid in egg}} \times 100$$

3.4.4. Standardisation of rice-soya fermented preparation

Recipes on different formulations were tested for quantity, quality, procedures, cooking time, cooking temperature, equipment and yield. Preparations developed from different formulations were standardised to the extent that when specified conditions were followed in them, the result was always a product which is similar in all respects.

The ingredients were accurately weighed and cooked at specific heat in accordance with the standardised recipe, the finished product was tested by the same panel, each and every time it was prepared. The paramount factors taken into consideration were cost control and portion control. Every time after mixing the correct amount of ingredients, same volume and weight for batter was ensured.

In this experiment, the yield with respect to volume and weight was standardised by using trial and error method. The recipe standardised was first tested in small quantities and evaluated. After making the adjustments the quantity was increased 4-6 times, evaluated and adjusted. Each formulation was tested three times before it was subjected to other tests.

3.4.5. Quantitative analysis of selected nutrients

Quantitative analysis of cooked product (idli) was done to find out the nutrients present in the product by using valid analytical procedures. A sample (5g) was weighed and dried in the oven and the digested sample was taken to find out protein and energy by analytical procedures listed below.

Protein - Microkjeldahl (ICMR, 1983)

Energy - Swaminathan (1984)

3.4.6. Comparison of calculated and analysed value

The calculated value of each product was compared with the analysed value to check the differences in the nutrient (protein and energy) contribution between the raw foods and cooked products. With the help of the data, a ready reckoner for idli was evolved.

3.5. COST OF DIFFERENT FORMULATIONS

The cost of the ingredients in the combinations were computed as per the present market rates for 1 kg each of the ingredients used in the product. Twenty per cent overhead charges were also added to account the cost of fuel and labour charges.

3.6. ACCEPTABILITY OF DIFFERENT FORMULATIONS

Acceptability of different formulations were ascertained through assessment of physico-chemical characteristics of the batter and final product through suitable laboratory tests. Organoleptic qualities of the final product were also determined to measure acceptability through sensory evaluation studies.

The successful incorporation of soyabean into traditional food product usually requires this protein ingredient to exhibit properties in the food product similar to that of the pulses being replaced and not being detrimental to the overall quality. On the other hand, soyabean can also improve the characteristic properties of food products.

3.6.1. Physico-chemical characteristics of the batter and cooked product

Physico-chemical characteristics of the batter were determined in all the formulations by estimating pH, acidity, volume increase, total amylose, water insoluble amylose, water soluble amylose and in cooked product bulk density, porosity, total amylose, water insoluble amylose and water soluble amylose.

3.6.1.1. pH

pH of the idli batter was determined directly using a pH meter.

3.6.1.2 Acidity

A sample (10g) of the idli batter was taken in a 100 ml beaker and 25 ml of distilled water and a few drops of phenolphthalein indicator were added. The sample was mixed well and titrated with 0.1N NaOH. The end point was indicated by the appearance of faint but permanent pink colour (Thyagaraja *et al.*, 1992).

3.6.1.3. Determination of volume increase during fermentation

One hundred ml of the batter was taken in a graduated glass measuring cylinder. The batter was allowed to ferment for 10 h at 29^{o}C and the volume increase was noted, and expressed as ml per 100 ml of batter (Thilagam and Neelakantan 1986).

3.6.1.4. Bulk density of idli

Idli was cut into pieces (2.6 cm diameter) for determination of bulk density. The pieces were waxed by dipping in hot wax to plug the air pockets on surface. Bulk density was determined by water displacement of the waxed idli piece in a graduated cylinder (Sowbhagya *et al.*, 1991).

3.6.1.5. Texture of idli (Stamp pad impressions)

Idli was cut into two pieces vertically at the centre using a sharp knife and the impression of the idli slice was taken using a stamp pad. The texture of the idli was evaluated by observing the porosity as evident from the impression (Thilagam and Neelakantan 1986).

3.6.1.6. Determination of total amylose

One hundred mg of the sample was weighed accurately and transferred to 100ml volumetric flask. One ml distilled ethyl alcohol was added to it and were mixed thoroughly. 10 ml sodium hydroxide solution was introduced and kept overnight. There should be no lumps or clots after this period. It is diluted to 100 ml. It can be left overnight to achieve complete dilution. Five ml of the sample was transferred to a 100 ml volumetric flask. Three drops of phenolphalein indicator and 50 ml distilled water were added. Dilute acid (0.1N Hcl) was added drop wise with shaking till the pink colour just disappeared. Two ml iodine solution was added and made up to 100 ml after shaking. Standard amylose solution and iodine blanks were read at 630 mm along with the test samples (Mc Cready and Hassid, 1943).

3.6.1.7. Water soluble amylose

Water soluble amylose content was determined, using the method of Mc Cready and Hassid (1943) in the filtered sample after treating the test sample in boiling water for five minutes.

3.6.1.8. Water insoluble amylose

The water insoluble amylose content was calculated as the difference between total and water soluble amylose (Shanthy *et al.*, 1980).

These three estimations (total amylose, water soluble amylose and water insoluble amylose) were done in batter as well as in the cooked product.

3.6.2. Sensory evaluation of the cooked product

The overall acceptability of the cooked product was ascertained through organoleptic evaluation using score card method with the help of a panel of judges.

Evaluation with the help of sensory organs is defined as sensory evaluation. The products were subjected to sensory evaluation and were tested for their acceptability with the help of well experienced taste panel. The mode of sampling for taste panel was convenient sampling in which the sample is selected neither by probability nor by judgment but by convenience (Gupta 1991). The recipe after each trial of standardisation was given for testing to the taste panel. A five point scale scoring sheet was formulated (Appendix-I) and the taste panel was asked to score the product in terms of appearance, flavour, taste, texture and colour. The testing was conducted in the afternoon between 3PM to 4PM, since this time was considered as the ideal time for conducting the acceptability studies (Swaminathan 1975).

3.7. STATISTICAL ANALYSIS

The data obtained from the laboratory estimations were subjected to statistical analysis to find out the impact of different treatments on the physico-chemical characteristics and organoleptic qualities of the batter as well as the cooked product. Completely Randomised Design (CRD) was applied for the above analysis. With respect to the acceptability test, the statisticsl analysis was done for the individual quality attribute and CRD was applied for the same.

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

In this chapter, salient findings of the study "Developing suitable rice-soya fermented preparation" are presented under

4.1. Selection of rice-soya fermented preparation

4.2. Nutritional adequacy of different formulations

4.3. Cost of different formulations

4.4. Physico-chemical characteristics of batter and cooked products

4.5. Acceptability of different formulations

4.1. Selection of rice-soya fermented preparation

In this experiment `idli' the popular fermented breakfast food was prepared, from rice (70 per cent) and decuticled blackgram dhal (30 per cent), as standard or control. In the remaining experimental samples decuticled blackgram dhal was replaced either by defatted soyaflour or whole soyabean from 5 per cent to 30 per cent. Several variations were prepared by changing the proportion of blackgram dhal, soyabean and defatted soyaflour. First variation was done with 70g of rice and 5g of soyabean replacing 25g of blackgram dhal, second variation with addition of 10g of soyabean, third variation with 15g of soyabean, fourth with 20g of soyabean, fifth with 25g of soyabean and sixth variation with 30g of soyabean by complete replacement of blackgram dhal. Same way, the alteration were done with defatted soyaflour also (Table 1).

Quality of these formulations were determined by assessing their nutritional adequacy, cost and acceptability.

The nutritional composition of the formulations were assessed (ICMR, 1991). Energy, protein, mineral and vitamin content of the 13 formulations were worked out and are presented in Table 2.

As indicated in Table 2, the protein content of the formulations were in the range of 11.68 to 20.38g. Nutrients such as protein, calcium and iron were found to enhance quantitatively as the concentration of defatted soyaflour was

Table 2 Nutritional composition of different formulations (100 g)

	Protein (g)	Energy (Kcal)	Calcium (mg)	Iron (mg)	Thiamine (mg)	Riboflavin (mg)
Food materials						
Blackgram	24.00	347.00	154.00	3.80	0.420	2.000
Soyabean	43.00	432.00	240.00	10.40	0.730	3.200
Defatted soyaflour	53.00	346.00	210.00	4.60	0.040	0.020
Combinations						
T_1 (Control)	11.68	346.30	52.50	1.84	0.288	0.098
T_2 (Soyaflour)	13.13	346.25	55.30	1.88	0.267	0.089
T_3	14.58	346.20	58.10	1.92	0.245	0.075
T_4	16.03	346.15	60.90	1.96	0.224	0.071
T_5	17.48	346.10	63.70	2.00	0.202	0.060
T_6	18.93	346.05	66.50	2.04	0.181	0.051
T_7	20.38	346.00	69.30	2.08	0.159	0.041
T_8 (Soya~~flour~~bean)	12.64	350.55	56.80	2.17	0.301	0.107
T_9	13.60	354.80	61.10	2.50	0.314	0.116
T_{10}	14.56	359.05	65.40	2.83	0.327	0.125
T_{11}	15.52	363.30	69.70	3.16	0.340	0.134
T_{12}	16.48	367.55	74.00	3.40	0.353	0.143
T_{13}	17.44	371.80	78.30	3.82	0.366	0.152

increased. In protein content, defatted soyaflour was better than soyabean. However nutrients like B_1, B_2 and energy were found to decrease in the formulations where soyabean was replaced by defatted soyaflour. A comparison between defatted soyaflour and soyabean revealed the advantages of soyabean over defatted soyaflour with respect to energy, calcium, iron, B_1 and B_2. Earlier experiments conducted on defatted soyabean by Abdel *et al.* (1980) had also given similar results with respect to protein content.

Nutritive value of rice proteins in these formulations were found to be significantly enhanced by complementation with pulse protein, due to mutual supplementary effect. Because of this reason, legumes are considered as valuable supplement to cereal diet especially when the diet is lacking in animal protein.

Rice proteins are lacking in lysine, and this was supplied by including blackgram dhal or soyabean, which have a higher protein and lysine content. The high lysine content of these pulse protein has a beneficial complementary effect on cereal proteins and the methionine and cystine content of rice proteins are also found to complement similar pulse, constituents.

Unlike rice, soyabean is rich in protein, oil and mineral salts. It consists of approximately 40 per cent protein, 20 per cent oil, 4 per cent minerals and 2 per cent phospholipids. It is a good source of phosphorus and lecithin. Soyabean is considered to be nutritionally comparable to animal foods except for the methionine content, and because of this reason soyabean is referred to as meat for the vegetarians. Protein is the second major chemical component (40 per cent of the seed) of the soyabean. They are unique among plant protein by virtue of their relatively high biological value and essential amino acid pattern.

Role of rice is relatively less important in fermentation. In this context, when compared to pulses, although the microorganisms of rice sometimes are important. Fermentative changes caused in and by rice is also relatively less, while in the case of pulses, organisms responsible for fermentation are believed to be in it. Replacement of blackgram dhal either by soyabean or defatted soyaflour has only enhanced the nutritional quality of the formulations.

Percentage composition of amino acids in blackgram dhal, whole soyabean and defatted soyaflour is presented in Table 3. As revealed in the Table, defatted soyaflour was found nutritionally superior to blackgram dhal and whole soyabean with regard to various amino acids. A comparison between blackgram dhal and soyabean reveals the nutritional supremacy of the latter over the former, with regard to all the essential amino acids.

Distribution of essential amino acids in different formulations are presented in Table 4. Amino acid analysis of the formulations provides information about their protein quality. Replacement of blackgram dhal either by defatted soyaflour or soyabean had resulted in enhancement of all the essential amino acids in the formulation. A comparison between defatted soyaflour and soyabean revealed the nutritional supremacy of the former over the latter.

Methionine is the most limiting amino acid in soyabean and other legumes. However combination of blackgram and soyabean in these formulations, had improved this amino acid content also. This is mainly because of the nutritional contribution of soyabean.

Chemical score and amino acid score were worked out and are presented in Table 5.

Table 3 Percentage composition of amino acids in blackgramdhal, whole soyabean and defatted soyaflour

Amino acids	Blackgramdhal	Whole soyabean	Defatted soyaflour
Arginine	2.00	3.11	7.70
Histidine	0.65	1.04	2.70
Lysine	1.54	2.76	6.50
Tryptophan	0.26	0.55	1.50
Phenylalanine	1.19	2.07	5.00
Tyrosine	0.54	1.45	3.80
Methionine	0.35	0.55	1.40
Cystine	0.31	0.69	1.60
Threonine	0.84	1.66	4.10
Leucine	1.92	3.32	7.80
Isoleucine	1.31	2.21	5.00
Valine	1.19	2.21	5.10

Table 4 Amino acid content of different formulations

Combinations	Arginine (mg)	Histidiine (mg)	Lysine (mg)	Tryptophan (mg)	Phenylalanine (mg)	Tyrosine (mg)	Methionine (mg)	Cystine (mg)	Threonine (mg)	Leucine (mg)	Isoleucine (mg)	Valine (mg)
T_1	604.00	184.00	274.00	70.00	338.00	252.00	181.00	94.00	269.00	542.00	319.00	415.00
T_2	634.40	195.76	301.76	78.08	498.18	272.50	189.63	10158	288.39	573.44	338.18	437.13
T_3	663.43	206.07	320.07	84.71	379.36	292.99	192.26	109.15	306.33	604.88	357.36	457.81
T_4	693.15	217.11	355.10	92.06	400.04	313.49	197.89	116.73	325.00	636.32	376.54	479.21
T_5	722.87	228.15	382.13	99.42	420.72	333.99	203.52	124.31	343.67	667.76	395.72	500.61
T_6	752.58	239.18	409.16	106.77	441.40	354.48	209.15	131.89	362.34	699.2	414.90	522.02
T_7	782.30	250.22	436.20	114.12	462.08	374.98	214.78	139.47	381.00	730.64	434.08	543.42
T_8	600.50	183.00	274.00	70.50	337.50	255.50	180.50	95.00	270.00	540.00	318.00	415.50
T_9	597.00	182.00	274.00	71.00	337.00	259.00	180.00	96.00	271.00	540.00	317.00	416.00
T_{10}	593.50	181.00	274.00	71.50	336.50	262.50	179.50	97.00	272.00	539.00	316.00	416.50
T_{11}	590.00	180.00	274.00	72.00	336.00	266.00	179.00	98.00	273.00	538.00	315.00	417.00
T_{12}	586.50	179.00	274.00	72.50	335.50	269.50	178.50	99.00	274.00	537.00	314.00	417.50
T_{13}	583.00	178.00	274.00	73.00	335.00	273.00	17830	100.00	275.00	536.00	313.00	418.00

Table 5 Amino acid score and chemical score in different formulations

Treatments	Amino acid score	Chemical score
T_1	70.92	77.78
T_2	69.47	86.76
T_3	68.02	94.12
T_4	66.96	102.29
T_5	66.08	110.47
T_6	65.33	118.63
T_7	64.69	126.80
T_8	65.53	78.33
T_9	60.88	78.89
T_{10}	56.86	79.44
T_{11}	53.36	80.00
T_{12}	50.27	80.56
T_{13}	47.49	81.11

The chemical score gives an indication of the protein quality of a product. Chemical score is the ratio between the content of the most limiting amino acid in the test protein and content of the same amino acid in egg protein expressed as percentage. Theoretically, combinations which have chemical score below 75 per cent are nutritionally inferior.

Jansen and Harper (1985) have reported that amino acid score provides an useful estimate of the protein quality of blended foods and is an acceptable substitute for the biological assays. The amino acid score for the formulations were worked out and the values were compared to identify the lowest. The quantity of the protein of the particular formulation will be that of its lowest Amino Acid Score. This lowest score gives an approximate index of how effectively a food protein can be used.

Details of Amino Acid Score worked out for the 13 formulations are presented in Appendix II.

A comparison of amino acid score obtained for the 13 treatments (Table 5) revealed that, they were in the range of 47.49 to 70.92. The highest amino acid score was for the control. T_{13} had secured lower amino acid score because the amino acid contents in the soyabean were found to be low when compared to the defatted soyaflour.

4.2. Nutritional adequacy of different formulations

The nutritive value of any product should be assessed on the cooked material, and not only in its raw state. Even though food products are very complex with minutes of thousands of chemical substances and with different chemical and physical properties, nutrients are certain proximate components, which may group together and decide the complex properties of the particular food.

The usual and simple procedure to find out the nutrient content is by calculating the nutrients present in the raw ingredients and summing it. But to get the accurate value and to rectify the differences in cooking, the major nutrients *viz.*, energy and protein present in the formulations, were analysed quantitatively using the cooked samples. In this experiment, the calculated value of each formulation was compared with that of analysed value. This was done to check the difference in the nutrient contribution between the raw foods and cooked items. With the help of the above two methods, a ready reckoner for each formulation was evolved.

Comparison between the calculated value of the raw ingredients and analysed value of the cooked products are presented in Table 6.

The values obtained by actual analysis were found to be lower when compared to computed values. With regard to protein, the loss shown in the Table was in the range of 3.17 to 15.06 per cent and for calories it was in the range of 0.16 to 0.42 per cent.

Data generated through chemical estimation of samples were subjected to statistical analysis. When T_1 (control) was compared with other treatments, proportionate increase in protein content was observed. From five per cent replacement of blackgram with either defatted soyaflour or soyabean, protein content in every

Table 6 Nutritional significance of the cooked product with reference to protein and energy

Sl. No.	Treatments	Protein (g/100g))		Loss (%)	Energy (Kcal)		Loss (%)
		Computed Value	Analysed Value		Computed Value	Analysed Value	
1.	T_1	11.68	11.31	3.17	346.30	345.45	0.25
2.	T_2	13.13	12.37	5.79	346.25	345.30	0.27
3.	T_3	14.58	13.47	7.61	346.20	345.15	0.30
4.	T_4	16.03	14.45	9.86	346.15	345.00	0.33
5.	T_5	17.48	15.68	10.30	346.10	344.85	0.36
6.	T_6	18.93	16.52	12.73	346.05	344.70	0.39
7.	T_7	20.38	17.31	15.06	346.00	344.55	0.42
8.	T_8	12.64	12.00	5.06	350.55	349.51	0.30
9.	T_9	13.60	12.70	6.62	354.80	353.94	0.24
10.	T_{10}	14.56	13.51	7.21	359.05	358.31	0.21
11.	T_{11}	15.52	14.32	7.73	363.30	362.60	0.19
12.	T_{12}	16.48	15.04	8.74	367.55	366.90	0.18
13.	T_{13}	17.44	15.87	9.00	374.80	371.22	0.16
CD			0.546			0.616	

formulation was found to increase significantly. Comparison between T_2 and T_8, T_3 and T_9, T_4 and T_{10}, T_5 and T_{11}, T_6 and T_{12} and T_7 and T_{13} also indicated similar results. Among the formulations protein content of T_{13} and T_5, T_4 and T_{11}, T_{10} and T_3, T_9 and T_2, were on par.

When T_1 (control) was compared with other treatments proportionate increase in energy content was also noted in soyabean supplemented formulations. However, significant difference in energy was observed between T_2 and T_8; T_3 and T_9; T_4 and T_{10}, T_5 and T_{11}, T_6 and T_{12}, T_7 and T_{13} (Details pertaining to this is presented in Appendix III).

The highest protein content was obtained for T_7 (Rice 70g, defatted soya flour 30g) and the lowest value was observed for control. T_{13} (70g of rice and 30g of soyabean) had attained the highest energy value, and lowest value for energy was observed for T_7. Out of formulations tested, T_1, T_2, T_3, T_4 and T_5, T_2, T_3, T_4, T_5, T_6 and T_7 were on par.

Ready reckoner worked out for the formulations are presented in Table 7.

Table 7 Ready reckoner for different formulations of idli

Quantity = 1 serving = 2 idlis

Formulations	Wt. of raw ingredients (g)				Cooked weight (g)	Diameter (cm)	Volume (ml)	Calories (K Cal)	Protein (g)
	Rice	Blackgram dhal	Soya bean	Soya flour					
T_1	70	30	—	—	50.00	7.20	50.00	345.45	11.31
T_2	70	25	—	5	51.00	7.27	52.00	352.21	12.62
T_3	70	20	—	10	52.33	7.27	52.00	361.23	14.10
T_4	70	15	—	15	52.67	7.36	52.66	363.42	15.22
T_5	70	10	—	20	53.00	7.40	53.00	365.54	16.62
T_6	70	5	—	25	53.33	7.50	53.33	367.66	17.20
T_7	70	—	—	30	53.67	7.47	53.66	369.84	18.58
T_8	70	25	5	—	52.33	7.20	52.33	365.80	12.56
T_9	70	20	10	—	52.67	7.23	52.66	372.84	13.38
T_{10}	70	15	15	—	53.00	7.30	53.00	379.81	14.32
T_{11}	70	10	20	—	53.33	7.33	53.00	386.75	15.27
T_{12}	70	5	25	—	55.67	7.37	53.66	393.83	16.14
T_{13}	70	—	30	—	54.00	7.47	54.00	400.92	17.14

As revealed in Table 7, the weight, volume as well as the diameter of cooked the product was found to be steadily increasing with the replacement of soyabean or defatted soyaflour. Data in the Table also indicates the enhancement of calories or protein per serving in different formulations.

From the facts, following aspects are predicted.

Among the 13 formulations tried the treatments with defatted soyaflour were found to be the best as it contained comparatively more protein than other combinations. On the basis of the amino acid score, chemical score and estimations, this combination was found to be energy rich too.

During cooking, definitely the loss of nutrients occur. However the nutritional supremacy of soyabean / defatted soyaflour incorporated formulations was retained in the cooked samples also.

The ready reckoner table helps to create an awareness about the nutritional significance of different formulations both in quality and quantity.

4.3. Cost of different formulations

The cost of the formulations were in the range of Rs. 1.74 to 1.26. As revealed in Table 8, the cost was lowest for formulation 7 where defatted soyaflour was completely replaced by blackgram dhal. The highest cost was for the formulation 1 where the constituents were only rice and blackgram dhal.

This indicates that replacement of blackgram dhal either by defatted soyaflour or soyabean helps to enhance the nutritional quality of the product, at a lower cost.

4.4. Physico-chemical characteristics of batter and cooked products

Idli batter was obtained by auto fermentation and natural microbial load of the ingredients and of the environment, which served as an inoculum for the initiation of fermentation. The pH changes in fermented substrates were related to the nature of ingredients used. Details pertaining to pH, acidity and volume increase are presented in Table 9 and Appendix IV. A marked reduction in pH was

Table 8 Cost analysis of different idli formulations

Sl. No.	Treatment	Cost / 100g (Rs.)
1.	T_1	1.74
2.	T_2	1.66
3.	T_3	1.58
4.	T_4	1.50
5.	T_5	1.42
6.	T_6	1.34
7.	T_7	1.26
8.	T_8	1.67
9.	T_9	1.60
10.	T_{10}	1.53
11.	T_{11}	1.46
12.	T_{12}	1.39
13.	T_{13}	1.32

Table 9 Changes in pH, acidity and volume increase due to fermentation of batter

Sl. No.	Treatments	pH	Acidity percentage	Volume increase ml
1.	T_1	4.24	0.57	270.00
2.	T_2	4.21	0.63	371.67
3.	T_3	4.18	0.67	378.33
4.	T_4	4.16	0.72	385.00
5.	T_5	4.15	0.77	320.00
6.	T_6	4.13	0.81	276.67
7.	T_7	4.08	0.84	163.33
8.	T_8	4.18	0.65	56.67
9.	T_9	4.17	0.71	63.33
10.	T_{10}	4.16	0.75	76.67
11.	T_{11}	4.14	0.80	63.33
12.	T_{12}	4.12	0.84	58.33
13.	T_{13}	4.06	0.87	53.33
CD		0.010	0.046	95.428

observed when rice and blackgram / soyaflour (defatted) / soyabean were fermented. Acid development and leavening of the batter were also other important changes during the fermentation of these rice / legume mixtures.

In this experiment, when control (T_1) was compared with other formulations, reduction in pH was noted in all the treatments. As the concentration of whole soyabean or defatted soyaflour was increased in various formulations, there was a steady decrease in pH. A comparison between soyabean supplemented formulations, revealed a greater influence of soyabean, since lower pH was observed in the formulation in which soyabean was added in the same concentration as of defatted soyaflour, except in the case of T_4 and T_{10}.

These observations clearly denote higher production of acid by the proliferating microorganisms in these formulations. The decrease in pH was sharp and rapid between formulations like T_6 and T_7, T_{12} and T_{13}. However, when the data was tested statistically, there was significant variation in pH, only at 5 per cent replacement formulations (T_2 and T_8) and 30 per cent replacement formulations (T_7 and

T_{13}). Amongst the formulations pH of T_1 was significantly higher than the others followed by T_2, T_8, T_3 and T_9, T_3, T_9 and T_4, T_4 and T_{10}, T_{10}, T_5 and T_{11}, T_6 and T_{12} which were on par.

A comparison of control (T_1) with other treatments, revealed increase in acidity in all the treatments. Increase in the concentration of soyabean or defatted soyaflour had inversely influenced the acidity. And the production of acid was sharp and rapid between formulations, like T_6 and T_7, T_{12} and T_{13}. A comparison of acidity levels, between soyabean supplemented formulations and defatted soyaflour supplemented formulations, indicated greater influence of soyabean in determining acidity level. Similar studies by Thyagaraja *et al.* (1992) revealed increase in total acidity.

However when acidity level of different formulations with different concentrations of whole soyabean and defatted soyaflour were compared, no significant differences were observed between the formulations of 5 per cent replacement (T_2 and T_8), 10 per cent replacement (T_3 and T_9), 15 per cent replacement (T_4 and T_{10}), 20 per cent replacement (T_5 and T_{11}), 25 per cent replacement (T_6 and replacement (T_6 and T_{12}) and also in 30 per cent replacement (T_7 and T_{13}) of blackgram either by defatted soyaflour or by soyabeans. T_{13} was significantly higher than others.

As revealed in the Table, pH values were in the range of 4.06 to 4.24, for all the 13 treatments. In similar experiments conducted on idli batter by Thirumaran (1976), Reddy and Salunkhe (1980), Subbiah *et al.* (1985), Joshi *et al.* (1989) and Thyagaraja *et al.* (1992), pH values were reported to be in the range of 3.00 to 4.50. A pH range from 6.00 to 4.70 was observed in idli batter by Muthukrishnan and Neelakantan (1990).

Batter samples with low pH values are reported to give better products. Experiments conducted by Thirumaran (1976) revealed that the batter with a pH of 3.90 gave a very good product.

In this experiment, rice and legume mixtures, after grinding were fermented together to enhance the acidity and gas production. Since both rice and legumes acted in the dual capacity of providing microorganisms and also acting as substrates. Variation in acidity and pH may probably be due to the difference in the release of amino acids as a result of fermentation. Part of the amino acids thus released may be undergoing fermentation to generate acidic material. The amino acid mixture was also found to have an isoelectric pH, on the acidic side. An increase in total titrable acidity of cereal pulse batter due to fermentation had been reported by Joshi *et al.* (1989) and Goyal and Khetarpaul (1994).

Volume increase which is an index of the gas retaining capacity of the batter, was high in the formulations with defatted soyaflour, compared to soyabean added batter samples, and the control. Volume increase is due to gas production by the bacteria during fermentation and is a measure of the metabolic activity of organisms.

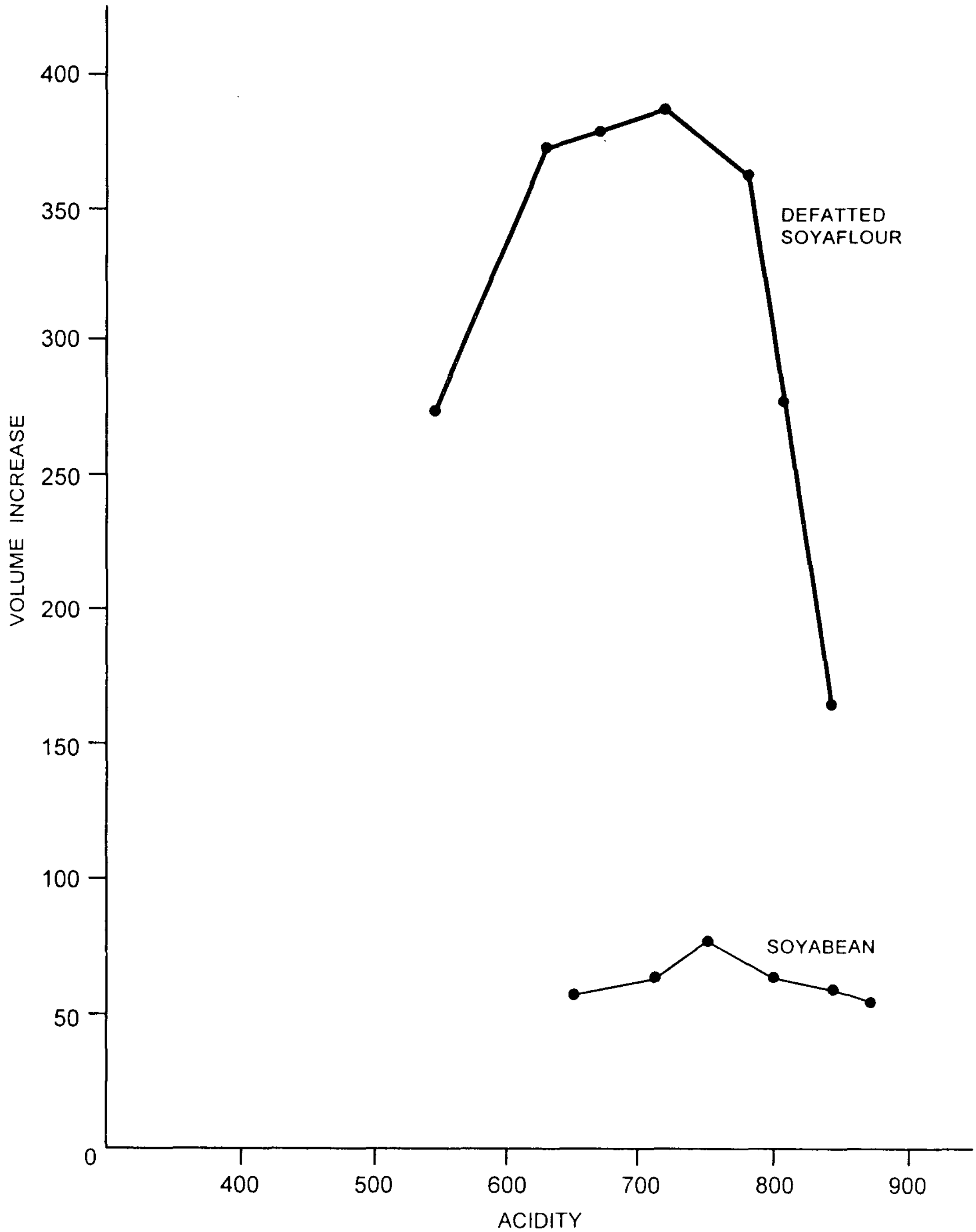
When control (T_1) was compared with other treatments, proportionate volume increase was observed in the defatted soyaflour incorporated formulations (T_2, T_3, T_4) from 5 per cent to 15 per cent replacing blackgram dhal. Compared to control and defatted soyaflour incorporated formulations, volume increase was poor in the formulations in which soyabean was incorporated. A reduction in volume was noted in the formulations T_5, T_6, T_7, T_{11}, T_{12} and T_{13} where the concentration of soyabean or defatted soyaflour was higher (20 per cent to 30 per cent) when compared to formulations with lower concentrations of the same ingredients. T_4 was significantly higher in volume increase than the others. T_4, T_3, T_2, T_5, T_6 and T_1, T_7 and T_{10}, T_{10}, T_9, T_{11}, T_{12}, T_8 and T_{13} were on par.

A comparison between soyabean and defatted soyaflour supplemented formulations at different concentrations with respect to volume increase revealed significant variations.

Fermentation period tried in this experiment was 18 h. During grinding, the mixture became fluffy, small bubbles of air adsorbed and during fermentation process, the expansion of these bubbles has enhanced the volume of the batter.

Volume was steadily rising after 12 h of fermentation and reached its peak after 18 h. A volume increase of 245 per cent was observed after over night fermentation by Thyagaraja *et al.* (1992) and Sarasa and Nath (1985).

Fig. 2 RELATIONSHIP BETWEEN ACIDITY LEVEL AND BATTER VOLUME OF THE DIFFERENT TEST FORMULATIONS



Acidity and batter volume were high in the formulations where defatted soyaflour concentration was enhanced up to 30 per cent. This indicates that a major component, contributing to the fermentation of the formulations (T_2 to T_5) was in insufficient quantity to increase batter volume. However soyabean supplemented formulations did not depict similar results (Fig. 2).

Considering the above three parameters *viz.*, acidity, pH and volume increase, formulations in which defatted soyaflour was incorporated, from 5 per cent to 15 per cent (T_2 to T_4) were found to be well comparable with the control or better, in making the preparation.

Starch, exists in two different forms; amylose, the branched type of starch with glucose residues with 1-4 linkage and amylopectin, the branched form with 1-4 and 1-6 cross linkages. Amylose has a positive influence on the ratio of gas production by yeast and hence indirectly on volume increase. During fermentation and cooking, these constituents are degraded to dextrins and maltose and later to acids. During fermentation, unavailable carbohydrates (oligosaccharides) are also expected to be hydrolysed to simple sugars. Starch granules disappeared as fermentation time increased.

Different processing methods may decrease the total amylose content. In fermented batter, by the action of amylases in microorganisms, amylose were converted to glucose and maltose and these sugars are utilized for producing lactic acid. As reported by Kadkol (1961) amylose content in the batter can be considered as the major determinant of the quantum of sugar product and amylose has a definte role in determining the functional quality of the starch based fermented preparations. According to Sowbhayaga *et al.* (1991), rice having $\geq$ 22 per cent amylose were suitable for a fermented preparation like idli.

In this experiment, when control (T_1) was compared with other formulations, significant reduction in total amylose was observed. As the concentration of whole soyabean or defatted soyaflour increased in various treatments, there was a consistent and significant decrease in the concentration of total amylose (Details are presented in Table 10 and Appendix V).

Table 10 Variation in amylose content of fermented batter samples and cooked products (percentage)

Sl. No.	Treatments	Fermented batter			Cooked product		
		Total amylose	Insoluble amylose	Soluble amylose	Total amylose	Insoluble amylose	Soluble amylose
1.	T_1	25.07	16.66 (66.45)	8.41 (33.51)	10.87	5.78 (53.17)	5.09 (46.83)
2.	T_2	24.78	16.43 (66.30)	8.35 (33.40)	9.99	5.46 (54.65)	4.53 (43.35)
3.	T_3	23.89	15.68 (65.63)	8.21 (34.37)	9.89	5.41 (54.70)	4.48 (44.89)
4.	T_4	23.05	15.07 (65.38)	7.98 (54.62)	9.00	4.80 (53.33)	4.20 (46.67)
5.	T_5	22.54	14.70 (65.22)	7.84 (34.78)	8.91	4.85 (54.43)	4.06 (45.57)
6.	T_6	21.84	14.23 (65.16)	7.61 (34.80)	8.03	4.62 (57.62)	3.41 (42.26)
7.	T_7	20.90	13.48 (64.34)	7.42 (35.42)	7.79	4.43 (56.87)	3.36 (43.13)
8.	T_8	24.83	16.52 (66.53)	8.31 (33.47)	10.03	5.50 (54.84)	4.53 (45.16)
9.	T_9	23.94	15.73 (65.71)	8.21 (34.29)	9.94	5.18 (52.11)	4.76 (47.87)
10.	T_{10}	23.10	15.12 (65.45)	7.98 (34.55)	9.05	4.85 (53.59)	4.20 (46.41)
11.	T_{11}	22.68	14.75 (65.04)	7.93 (34.96)	8.96	4.71 (52.57)	4.25 (47.43)
12.	T_{12}	22.03	14.28 (64.97)	7.75 (35.26)	8.12	4.67 (57.51)	3.45 (42.49)
13.	T_{13}	20.97	13.55 (64.52)	7.42 (35.33)	7.84	4.20 (53.57)	3.64 (46.43)
CD		0.2730	0.3313	0.3875	0.2841	0.4516	0.3629

Values given in parentheses are the percentage variations

Soluble amyloses are those constituents unaffected by fermentation and in this experiment, significant reduction in soluble amylose was noted in different formulations, when compared to the control. As the concentration of whole soyabean as well as defatted soyaflour was enhanced in various formulations, there was a steady decrease in the soluble amylose content.

In the batter, water soluble amylose content was in the range of 7.42 to 8.41. Highest concentration was observed in the control sample. Defatted soyaflour incorporated formulations had lower concentration of water soluble amylose when compared to treatment in which soyabean was incorporated in similar concentration except in T_3 and T_9, T_4 and T_{10}, T_7 and T_{13}.

Insoluble amylose is the difference worked out between the values obtained for total amylose and soluble amylose. When control (T_1) was compared with other treatments, significant reduction in insoluble amylose was noted. As the concentration of whole soyabean or defatted soyaflour was increased in various treatments, there was a proportional decrease in insoluble amylose.

No significant differences in total amylose, insoluble amylose and soluble amylose levels were observed between the formulations with the same concentration of defatted soyaflour and soyabean (T_2 and T_8, T_3 and T_9, T_4 and T_{10}, T_5 and T_{11}, T_6 and T_{12} and T_7 and T_{13}). T_1 was significantly higher than the other treatments.

In cooked product, when control (T_1) was compared with other formulations, further reduction in total amylose was observed. As the concentration of whole soyabean or defatted soyaflour increased in various treatments, there was a consistent decrease in total amylose in cooked product also. A comparison between soyabean supplemented formulations and defatted soyaflour supplemented formulations, revealed lower total amylose content in defatted soyaflour supplemented formulations.

In this experiment, reductions in soluble and insoluble amylose content were observed in different formulations, when compared to the control. As the concentration of whole soyabean or defatted soyaflour was increased in various treatments, there was a decrease in both soluble and insoluble amylose contents.

In the case of insoluble amylose when control (T_1) was compared with other treatments, significant difference existed in 15 to 30 per cent soyaflour incorporated formulations and 10 to 30 per cent soyabean incorporated formulations. No significant difference was observed in T_2, T_3 and T_8. A comparison between soyabean supplemented formulations and defatted soyaflour supplemented formulations revealed lowest insoluble amylose in soyabean supplemented formulations.

No significant differences in total amylose, insoluble amylose and soluble amylose levels were noted between the formulations with the same concentrations either of defatted soyaflour or soyabean (T_2 and T_8, T_3 and T_9, T_4 and T_{10}, T_5 and T_{11}, T_6 and T_{12} and T_7 and T_{13}). T_1 was significantly higher than the others.

During cooking, higher percentage of amylose was converted to water soluble amylose with a decrease in total amylose content. A comparison between the same formulation, before and after cooking had indicated similar trend in all the treatments. In all the cooked products, water soluble amylose content was in the range of 3.36 per cent to 5.09

per cent. Highest concentration was in control (T_1). Defatted soyaflour incorporated formulation had lower concentration of water soluble amylose content, when compared to formulations in which soyabean was incorporated in similar concentrations except in T_2 and T_8, T_4 and T_{10}.

Results related to the amylose content of cooked product revealed that soyabean or defatted soyaflour supplemented formulations could also be considered as an alternative for blackgram dhal in the idli preparations.

Bulk density is the ratio of the weight of the sample to the weight of equal volume of water. Bulk density is one of the most common simple measurements in food analysis, which can be used for the analysis of solid foods. It is the characteristic physical property and serves for identification purposes (Potter, 1988). The volume of different food products can be compared through bulk density. A balance between surface activity and viscosity of the batter needs to be ensured to obtain the desired bulk density.

Traditional wet grinding of the food articles into a viscous batter would entrap air bubbles inside the paste and make for leavening action. It is not only by the physical entrapping of air bubbles, but also the entrapped air assist the fermentation itself making for liberation of more gases for leavening.

Quality of idli is determined by the amount of gas produced and held in the batter. This has a direct influence on the bulk density of the product.

Eighteen hours fermented batter was steamed for 15 to 20 minutes to obtain the cooked product. In the cooked product, bulk density was determined by water replacement method. 1.25 times of water over dry ingredients was used in the case of defatted soyaflour supplemented formulations.

Bulk density values were higher for samples in which defatted soyaflour or soyabean was used instead of blackgram dhal. Variation between defatted soyaflour and soyabean was negligible.

Water intake of batter in which defatted soyaflour or soyabean was used, was higher compared to control. Defatted soyaflour incorporated formulations required more water. Water intake by the formulations had a direct influence on their bulk density (Table 11 and Appendix VI).

When control (T_1) was compared with other formulations, proportionate increase in bulk density was observed in all the treatments. Concentration of whole soyabean or defatted soyaflour had a direct influence on the bulk density of the product. A comparison between soyabean supplemented formulations and defatted soyaflour supplemented formulations, indicated lower bulk density in soyaflour supplemented formulations. T_{13} and T_7, T_{12} and T_6, T_6 and T_{11}, T_{11} and T_5, T_5 and T_{10}, T_{10}, T_4 and T_9, T_4, T_9 and T_3, T_8, T_2 and T_1 were *on par*.

Among the different treatments, T_7 and T_{13} formulations appear to be superior to the remaining in this respect.

Porous nature of the cooked product was found out by dipping idli slices of one inch thickness in ink pad and then pressing it on a paper. Porous nature of idli was estimated on the basis of number of tunnels or holes in the cooked product (Fig. 3).

Table 11 Physico-chemical characteristics of the cooked products with reference to bulk density

Sl. No.	Treatments	Bulk density (g/ml)	Weight of the cooked product (g/one)	Water used for making the batter (ml/gm)
1.	T_1	0.8064	50.00	88.81
2.	T_2	0.8086	51.00	134.61
3.	T_3	0.8174	52.33	134.61
4.	T_4	0.8230	52.67	134.61
5.	T_5	0.8333	53.00	134.61
6.	T_6	0.8427	53.33	134.61
7.	T_7	0.8547	53.67	134.61
8.	T_8	0.8097	52.33	109.64
9.	T_9	0.8196	52.67	109.64
10.	T_{10}	0.8264	53.00	109.64
11.	T_{11}	0.8368	53.33	109.64
12.	T_{12}	0.8474	53.67	109.64
13.	T_{13}	0.8583	54.00	109.64
CD		0.006970		

Fig. 3 RATE OF POROSITY IN DIFFERENT FORMULATIONS

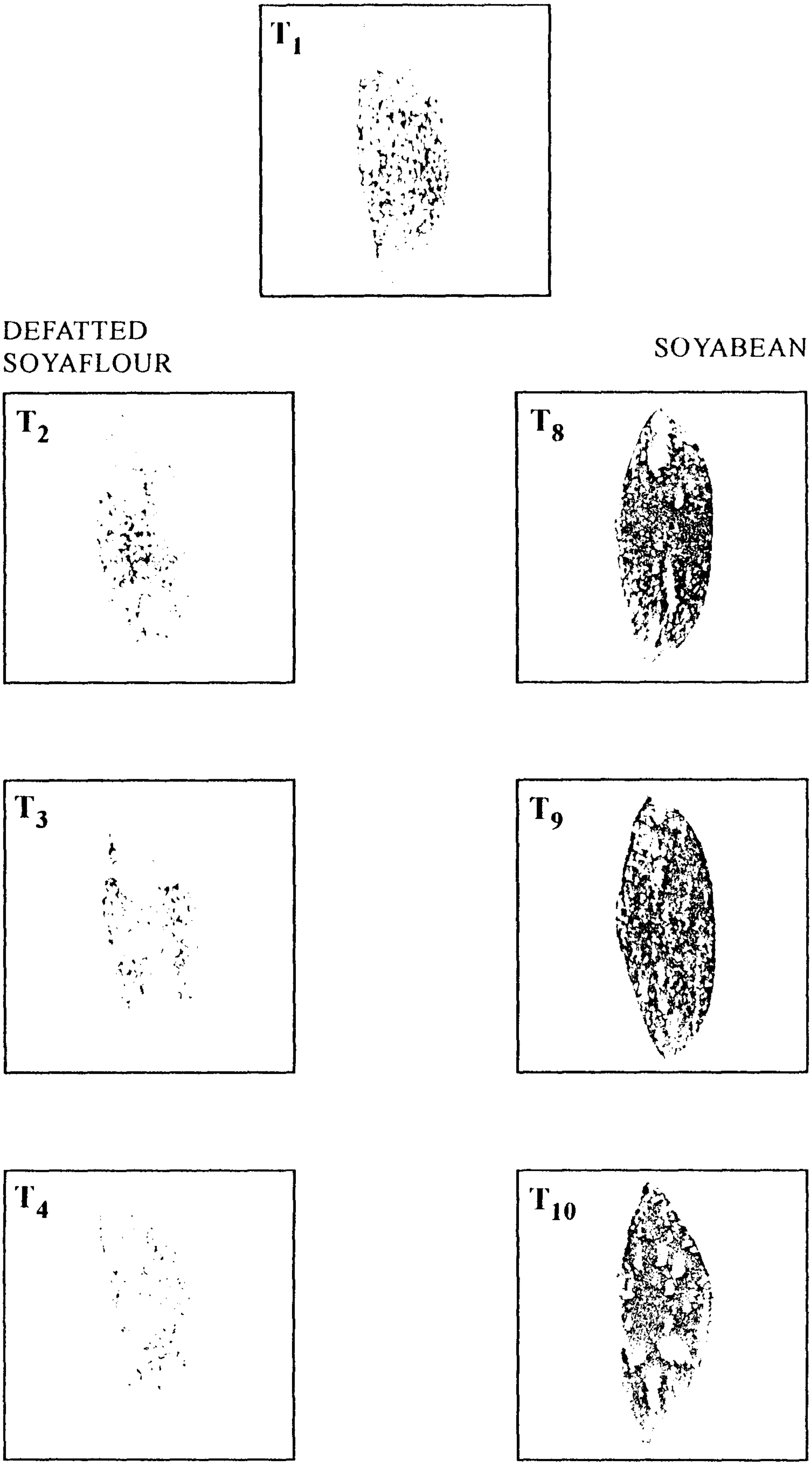


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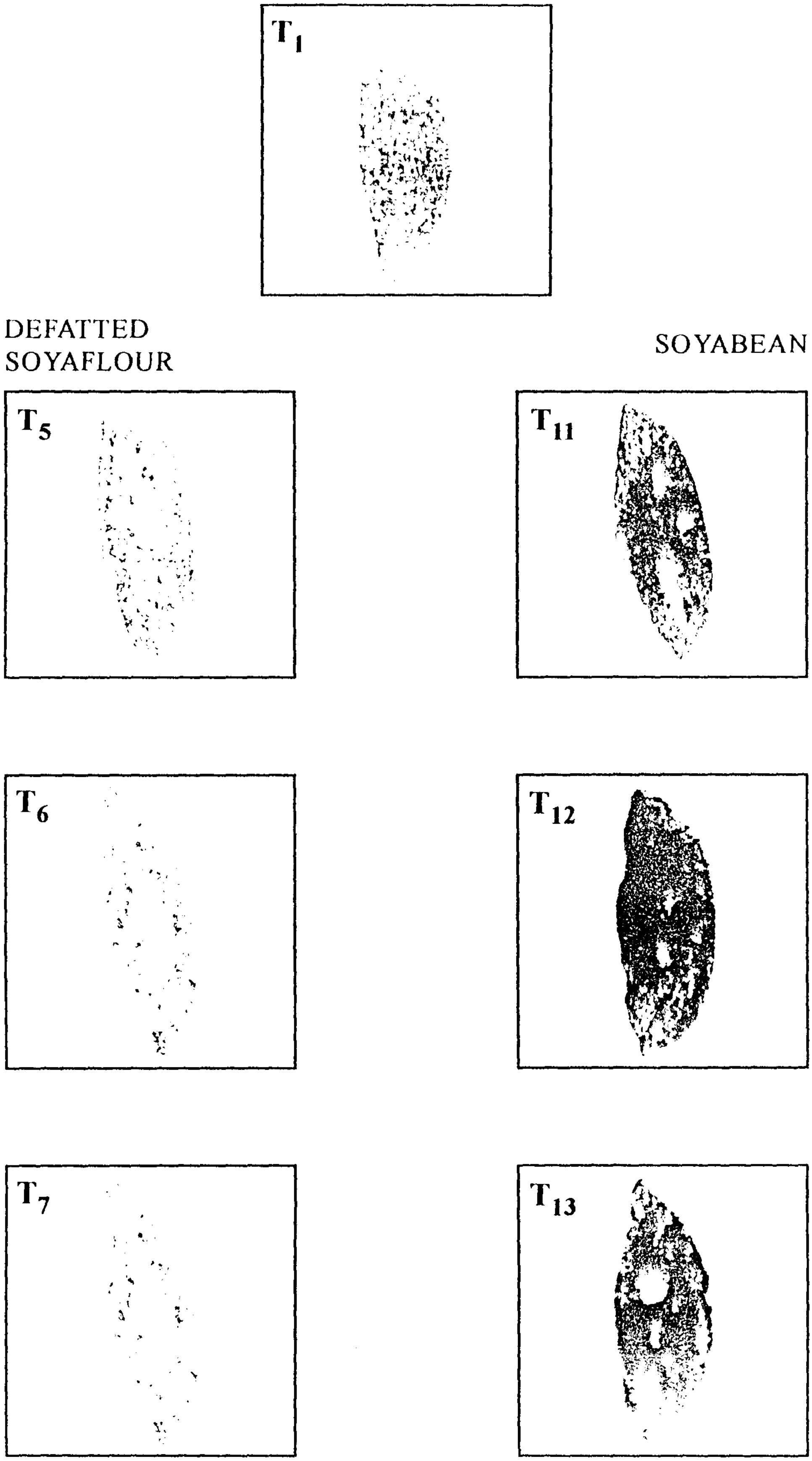
Fig. 3 RATE OF POROSITY IN DIFFERENT FORMULATIONS



When control (T_1) was compared with other formulations, proportionate increase in the holes, in the case of formulations supplemented with defatted soyaflour was observed, while number of holes in the case of formulations supplemented with soyabean was less.

A comparison between soyabean supplemented formulation and defatted soyaflour supplemented ones revealed lower porosity in the product made from soyabean supplemented formulations.

There was no relation or proportionality between batter volume and porosity of idlis, indicating that unduly high retention of gases in the batter doesnot correspondingly increase the porosity of the idli.

Formulations such as T_4 and T_3 were giving higher values for volume increase. However, a scrutiny of the porosity nature of These formulations does not give encouraging results.

Polysaccharides present in blackgram dhal and soyabean decide the viscosity of the batter which helps to stabilise the net work of foam formed by the surface active protein in the batter. These factors act as major determinants of the cooked product.

Development of this fine net work in the cooked product coincides with the disappearance of starch granules in the batter as indicated in the amylose value of the cooked product.

Control (T_1) and defatted soyaflour supplemented formulations (5 to 15 per cent) had small, even pores. Large, even pores were observed in T_5, T_6 and T_7 (defatted soyaflour supplemented formulations (20 to 30 per cent) while in soyabean supplemented formulations, there were uneven pores.

4.5. Acceptability of different formulations

Organoleptic qualities can be defined as qualities affecting a bodily organ or sense, particularly of the combination of taste (perceived in the mouth) and aroma (perceived in the nose) (Chandran, 1995). According to Mohony (1985) organoleptic assessment stands essential for the development of any new or modified product. Idli have established standards of quality, as a traditional food. In an underdeveloped country, like ours, such traditional foods nutritionally improved are the main category of foods to be advocated, to improve the nutritional status of the community. However, such reformulated products must have the same flavour, texture, odour, colour and overall quality as their traditional counterparts as stated by Kolar *et al.*, 1986).

In this experiment scientific methods of sensory analysis of recipes were administered to assess the acceptability of the product, from each formulations, with the help of trained panel members.

Table 12 depicts the mean scores obtained for different parameters in various formulations and other details are presented in Appendix VII.

Appearance

Immediate acceptance of idli is usually on visual impression. As stated by Christensen (1985) consumer preference to appearance is one of the major factor leading to the increasing demand of the product. Table 12 elucidates that the formulations 8, 9 and 10 (where soyabean was added at 5 per cent, 10 per cent and 15 per cent respectively to

Table 12 Organoleptic qualities of the cooked products

Sl. No.	Treatments	Appearance	Flavour	Colour	Texture	Taste
1.	T_1	4.93	4.93	4.87	4.93	5.00
2.	T_2	4.80	4.67	4.87	4.87	4.93
3.	T_3	4.73	4.33	4.67	4.73	4.80
4.	T_4	4.27	3.47	3.53	4.54	4.73
5.	T_5	3.27	2.93	2.93	4.45	3.87
6.	T_6	2.47	2.33	2.27	4.43	3.40
7.	T_7	2.00	2.00	2.00	3.00	2.60
8.	T_8	5.00	4.87	5.00	4.85	4.73
9.	T_9	5.00	4.80	5.00	4.70	4.67
10.	T_{10}	5.00	3.93	5.00	4.20	4.13
11.	T_{11}	4.93	3.73	5.00	4.11	3.47
12.	T_{12}	4.87	3.33	4.93	3.99	2.47
13.	T_{13}	4.73	3.26	4.87	2.66	2.06
CD		0.2879	0.3746	0.2547	0.3315	0.3582

replace blackgram dhal) had obtained the highest score (5) for appearance. While lowest score was obtained for treatment 7, where rice and defatted soyaflour were in the proportion of 70 : 30.

When T_1 (control) was compared with other treatments, reduction in the mean scores for appearance was noted in the first 6 treatments (T_2 to T_7). As the concentration of defatted soyaflour increased in various formulations, there was a steady decrease in the mean scores of appearance. While soyabean incorporated formulations obtained better scores.

Variation between the formulations with lower concentration of defatted soyaflour and soyabean (5 and 10 per cent) was not significant. While significant variation in the mean scores was obtained for formulations with higher per cent of defatted soyaflour and soyabean incorporation (15 to 30 per cent). In appearance, T_8, T_9, T_{10}, T_{11}, T_{12}, T_2, T_3 and T_{13} were *on par*.

Based on the appearance, soyabean incorporated idlis upto 20 per cent were comparable with T_1 (control) or better, while defatted soyaflour incorporated idlis were not acceptable because of the dark brown shade developed by the product after cooking.

Flavour

According to Birch (1988), flavour is the mingled but unitory experience of sensation produced by a material taken in by the mouth perceived principally by the sense of basic smell and by the other cutaneous sensations in the mouth. Ranganna (1991) stated that flavour is an important factor which enriches the consumer's preference to a particular product.

The organoleptic quality of idlis was judged by flavour also, since the flavour has a great influence on the final products of fermentation. In normal, wet ground, idli batters, the flavour is pleasant upto the stage of the optimum ripeness. Statistical analysis of the data revealed that the idlis made out of soyabean admixed with rice, blackgram dhal (5: 70 : 25 w/w) and fermented, was acceptable and it almost had the scores equalent to that of control. The beany flavour of soyabean was totally replaced by pleasant fermented flavour indicating that the fermentation process thus could be fruitfully used to make soyabean popular in Indian diet.

As per Table 12, treatment 1 (control) had obtained highest score (4.93) for flavour while the lowest score was obtained by treatment 7 in which rice and defatted soyaflour were included in the proportion of 70 : 30. When T_1 (control) was compared with other treatments, reduction in mean scores for flavour was noted. As the concentration of soyabean or defatted soyaflour increased in various formulations, there was a steady decrease in the scores obtained for this quality parameter. A comparison between soyabean supplemented formulations and defatted soyaflour supplemented formulations revealed that the latter was less acceptable than the former. Except in 5 per cent incorporations in all the other formulations (from T_3 to T_{13}) significant variation in this quality parameter was observed between defatted soyaflour incorporated and soyabean incorporated formulations in the same concentration. T_1 was significantly better in flavour than others. While T_1, T_8, T_9 and T_2, T_2 and T_3, T_{10} and T_{11}, T_4 and T_{12}, T_{12} and T_{13}, T_{13} and T_5 and T_6 and T_7 were *on par*.

As in the case of "appearance" and in "flavour", soyabean incorporated formulations were better than the defatted soyaflour incorporated formulations. Lower score for the latter was mainly because of the dark shade and beany odour.

Colour

Colour is associated with every aspect of our lives and influences many of our day to day decisions, involving food. According to the reports from CFTRI (1990), the aesthetics, safety, sensory characteristics and acceptability of food are all affected by colour. The joint FAO/WHO Expert committee on food additives recognised that colour has an effect on food choices (Anonymous, 1991). As detailed in Table 12, the treatments from T_8 to T_{11} obtained highest scores. The least score was obtained for T_7 where rice and defatted soyaflour were in the proportion of 70:30.

When T_1 (control) was compared with other treatments, reductions in the mean scores for colour were observed in the first six treatments. The mean scores obtained for the formulations from T_8 to T_{11} were uniform. A comparison of soyabean incorporated formulations and soyaflour incorporated formulations revealed lowest scores for soyaflour incorporated formulations.

Significant differences in scores were observed between defatted soyaflour and soyabean incorporated formulations except in treatments where the same was added at 5 per cent level. T_8 to T_{11} was significantly better in colour than the others. T_8, T_9, T_{10}, T_{11}, T_{12}, T_1, T_2 and T_{13}, T_1, T_2, T_{13} and T_3 were *on par.*

Soyabean incorporated formulations were better than soyaflour incorporated formulations, for this quality parameter also.

Texture

According to Ranganna (1991) texture is the property of food which is associated with the sense of feel or touch experienced by the fingers or the mouth. Idli is considered to be a good food for all the age groups in all countries due to its spongy texture. Popularity of idli is mainly because of its spongy texture.Surface of idli prepared from batter fermentation is expected to be cohesive, dense and spongy or foam like. With regard to texture, a soft spongy texture without being pasty or sticky is desired in idli. Normally hard sticky idlis are obtained when the batter is unripe or when the proportion of blackgram dhal is low.

The desirable spongy texture is contributed by the leavening action of gases when evenly dispersed in the viscous batter.

In this experiment, control batter was very mucilaginous in texture in contrast with similar batter prepared in which the blackgram dhal was replaced by soyabean and defatted soyaflour. Action of the mucilage seems to be, to give sufficient adhesiveness to the batter without which, the idlis prepared would be hard and inflexible. Traditional wet grinding of the blackgram dhal into a viscous batter would entrap air bubbles inside the paste and make for leavening action not only by physical entrapping of air bubbles but the entrapped air may assist the fermentation itself making for liberation of more gases for leavening.

In general, in this experiment, substituting blackgram dhal by defatted soyaflour or soyabean was found to result in less spongy texture. The speciality of blackgram in making it suitable for idlis arises from the fact that, it contains a mucilaginous principle which is generally not present in any other edible legumes.

Blackgram dhal is also reported to be rich in two components, namely surface active protein (globulin) and an arabinogalactan (polysaccharide) as stated by Susheelamma and Rao, 1980) and are responsible for the texture of the cooked product.

When T_1 (control) was compared with other treatments, lower scores for texture was obtained for six formulations where soyabean was incorporated (5 to 30 per cent). However, a proportionate increase in score for texture was obtained in soyaflour supplemented formulations.

As per Table 12, T_1 (Rice 70g, blackgram dhal 30g) had attained the highest score, while T_{13} had the lowest score. Significant variation in scores for texture was obtained between T_4 and T_{10}, T_5 and T_{11}, T_6 and T_{12} and, T_7 and T_{13}, where the concentration of either defatted soyaflour or soyabean were above 10 per cent. While T_7, T_6, T_1, T_8, T_5, T_9 and T_2 formulations, T_6, T_7, T_{11}, T_5, T_{15}, T_{12} and T_{10}

formulations, T_5, T_7, T_{12}, T_{10} and T_{13} formulations, T_{11} and T_{12} were *on par*.

If the proportion of blackgram flour was less than 25 per cent, the idlis were generally hard and unacceptable organoleptically as far as the texture is concerned.

Unlike the earlier parameters discussed, defatted soyaflour incorporated formulations were better than soyabean incorporated formulations, in texture.

A comparison between texture score and total amylose content of the cooked products were made (Table 13).

In all the formulations, blackgram dhal has a major role as a substrate in the fermentation and is clearly depicted in the variation of proportion of this food article and the amylose content of the formulation is also found to differ with this variation. Idlis prepared from formulations with lower amylose content were found to have lower values for texture, probably due to the fact that the starch available in the formulations were a poor substrate for fermentative organisms. In other words, formulations with

Table 13 Association between the total amylose content and texture quality of the cooked product

Treatments	Texture (scores)	Total amylose content of cooked product (percentage)
T_1	4.93	10.87
T_2	4.87	9.99
T_3	4.73	9.89
T_4	4.54	9.00
T_5	4.45	8.91
T_6	4.43	8.07
T_7	3.00	7.79
T_8	4.85	10.03
T_9	4.70	9.94
T_{10}	4.20	9.05
T_{11}	4.11	8.96
T_{12}	3.99	8.12
T_{13}	2.66	7.84

lower amylose content has yielded hard and sticky textured idli.

Taste

Taste is the major attribute which determines the acceptability of a food material. It is not only a sensory response to soluble materials but also aesthetic appreciation by the mouth (Chellammal 1995). As detailed in Table 12, T_1 (control) had the highest value for taste. The lowest score was for T_7 and T_{13}, where 30 per cent defatted soyaflour and soyabean had replaced blackgram.

When T_1 (control) was compared with other treatments, reduction in mean scores for taste was noted. As concentration of defatted soyaflour or soyabean increased in various formulations, there was a steady decrease in the scores for taste. A comparison between defatted soyaflour supplemented formulations and soyabean supplemented formulations revealed lower scores for soyabean supplemented formulations with respect to this quality parameter.

Significant variations in scores for taste were observed between T_4 and T_0, T_5 and T_{11}, T_6 and T_{12}, and T_7

and T_{13} where the concentration of either defatted soyaflour or soyabean were above 10 per cent. While T_1, T_2, T_3, T_4, T_8 and T_9 , T_{10} and T_5, T_{11} and T_6, T_7 and T_{12} were *on par.*

Based on taste, defatted soyaflour incorporated idlis upto 10 per cent were comparable with control.

On a general assessment, soyabean supplemented idlis were better than the defatted soyaflour supplemented ones.

Based on the scores obtained for the major five quality parameters the cooked products were ranked (Table 14 and Appendix VIII) with control as the best product. With 5 to 10 per cent incorporation of soyabean and with 5 per cent incorporation of defatted soyaflour, the product was found to be acceptable eventhough it had lower scores for appearance, flavour and texture which were observed in the latter. Comparison between the formulations with same concentration of either soyabean or defatted soyaflour, revealed a better rank for soyabean incorporated formulations. However, formulations with higher concentrations of soyabean or defatted soyaflour (15 per cent and above) are not suitable for idli making. Since the major quality attributes expected in idli, *viz.*, texture and taste were found to be affected.

Table 14 Ranking based on scores

Formulations	Appearance	Flavour	Colour	Texture	Taste
T_1	II	I	III	I	I
T_2	IV	IV	III	II	II
T_3	V	V	IV	IV	III
T_4	VI	VIII	V	VI	IV
T_5	VII	XI	VI	VII	VII
T_6	VIII	XII	VII	VIII	X
T_7	IX	XIII	VIII	XII	XI
T_8	I	II	I	III	IV
T_9	I	III	I	V	VI
T_{10}	I	VI	I	IX	VIII
T_{11}	II	VII	I	X	IX
T_{12}	III	IX	II	XI	XII
T_{13}	IV	X	III	XIII	XIII

SUMMARY

5. SUMMARY

A study on "Developing suitable rice-soya fermented preparation" was conducted with the major objective to develop suitable rice-soya fermented preparation and to evaluate the acceptability and nutritive value of the preparation. The food articles selected for the study were rice, blackgram dhal, soyabean and defatted soyaflour. In this experiment the fermented preparation selected was "Idli". 13 formulations were tried out with uniform soaking time (6 h), grinding conditions (using a wet grinder), temperature (room temperature), and time (18 h) for fermentation.

In all the 13 formulations proportion of rice was 70g with variations in blackgram dhal, defatted soyaflour and soyabean. Rice and blackgram dhal in 70 : 30 proportion was taken as standard or control (T_1) and in different formulations from T_2 to T_7 and T_8 to T_{13}, 5 per cent blackgram dhal was replaced either by defatted soyaflour (former) or by soyabean (latter) in the two sets of six formulations.

Principles governing the selection of the most suitable combination were nutritional adequacy, cost and acceptability. Nutritional adequacy of different combinations were ascertained by computing the nutritive value of individual ingredients, amino acid score and chemical score. Highest amino acid score was observed in control and lowest score in T_{13} (30 per cent soyabean formulation), because of the lower concentrations of essential amino acids like tryptophan and methionine. Chemical score was better for formulations with higher proportion of soyabean and defatted soyaflour, when compared with control. Nutrients such as total protein, calcium and iron were found to increase as the concentration of defatted soyaflour increased in the formulations. However, with the increased quantity of defatted soyaflour, energy and vitamin (thiamine and riboflavin) contents were found to be decreasing. There was a proportionate increase in the concentration of these nutrients with the increased proportion of soyabean. A comparison between defatted soyaflour and soyabean supplemented formulations revealed the advantages of soyabean over defatted soyaflour except in protein content. Nutritional significance of the cooked product (idli) was also assessed by estimating protein and energy in the laboratory. These assessments revealed the nutritional supremacy of the formulations with higher concentrations of defatted soyaflour followed by soyabean enriched formulations, over the control sample.

Cost of individual ingredients used in the 13 formulations were computed as per the present market rates and cost of defatted soyaflour supplemented formulations were found cheaper followed by soyabean supplemented formulation and lastly control. Hence, costwise also the soya supplemented formulations (T_2 - T_{13}) were better.

Acceptability of the different formulations were ascertained through assessment of physico-chemical characteristics of the batter and final product, by estimating pH, acidity, volume increase, total amylose, water soluble amylose and water insoluble amylose in the fermented batter and bulk density, porosity, total amylose, water soluble amylose and water insoluble amylose in the cooked product.

Reduction in pH and increase in acidity were noted in all the treatments when compared to control. As the concentration of the whole soyabean or defatted soyaflour was increased in various formulations, there was a steady decrease in pH and increase in acidity. A comparison between soyabean supplemented formulations and defatted soyaflour supplemented formulations, revealed a greater influence of soyabean on pH and acidity.

When control (T1) was compared with other formulations, proportionate volume increase was observed in the defatted soyaflour incorporated formulations (T2,T3 and T4) from 5 per cent to 15 percent replacing blackgram dhal. Compared to control and defatted soyaflour incorporated formulations, volume increase was poor in the formulations in which soyabean was incorporated. A reduction in volume was noted in the formulations (T5, T6, T7, T11, T12 and T13) where the ratio of either soyabean or defatted soyaflour was higher (from 20 per cent to 30 percent). Batter volume was higher in the formulations where defatted soyaflour concentration was upto 30 per cent. An assessment of nutritional and physico-chemical characteristics of the formulations and their cost revealed a better ranking for defatted soyaflour followed by soyabean and control.

When control (T1) was compared with other formulations, reductions in the amylose profile were observed. As the quantity of soyabean or defatted soyaflour increased in various treatments, a consistent decrease in amylose was noted. Lower amylose pattern was observed in the defatted soyaflour supplemented formulations. However, the amylose content in the soyabean as well as in the defatted soyaflour supplemented formulations, indicated that these batters are suitable alternatives for blackgram dhal incorporated batter in idli preparations.

Bulk density influences the total weight and volume of the final product. When control (T1) was compared with other formulations, proportionate increase in bulk density was observed in all the treatments. The addition of whole soyabean or defatted soyaflour has a direct influence on the bulk density of the product. A comparison between soyabean supplemented formulations and defatted soyaflour supplemented formulations, revealed lower values for bulk density in the soyaflour supplemented formulations.

Porosity test revealed that control (T1) and defatted soyaflour supplemented formulations (from 5 to 15 per cent) had small, even pores. Large, even pores were observed in T5,T6 and T7, while in soyabean supplemented formulations there were only uneven pores. A comparison between soyabean and soyaflour supplemented formulations revealed lower porosity in products from soyabean supplemented formulations. Quality parameters such as bulk density and porosity were better in defatted soyaflour supplemented formulations and were well comparable with control.

Consumer acceptance of a product is very important. In this experiment, when T_1 (control) was compared with other treatments, reductions in the mean scores for appearance and flavour in defatted soyaflour / soyabean supplemented formulations were noted. A comparison between soyabean supplemented idlis and defatted soyaflour supplemented ones revealed better scores for soyabean supplemented idlis. Quality parameters such as appearance and flavour were also better in soyabean supplemented formulations, than the defatted soyaflour supplemented formulations. Lower scores obtained for the latter were mainly because of the dark shade and beany flavour of the product. Soya incorporated food products will have a better acceptance when T1 (control) was compared with other treatments. Reductions in the mean scores for colour were observed in the first six treatments (defatted soyaflour incorporations). Mean scores obtained for colour from T_8 to T_{11} (soyabean incorporated) were uniform. A comparison between soyabean supplemented formulations and defatted soyaflour supplemented formulations for sensory evaluation revealed lower scores for the former.

Based on the average scores obtained for the major five quality parameters the cooked products were ranked. With control as the best product, with 5-10 per cent in corporation of soyabean and with 5 per cent incorporation of defatted soyaflour replacing blackgram dhal, the product was found acceptable. Lower ranking for appearance, flavour and texture were observed in the formulation with defatted soyaflour incorporation. Comparison between the formulations with same levels of either soyabean or defatted soyaflour, revealed a better rank for soyabean incorporated formulations. However, formulations with higher concentrations of soyabean defatted soyaflour (15 per cent and above) are not suitable for idli making. Since the major quality attribute expected in idli, *viz.*, texture and taste were found affected.

From the above observations and findings, the products made from a mixture in which 5 per cent defatted soyaflour and 5 to 10 per cent soyabean replacing blackgram dhal were found to be acceptable, of lower cost and highly nutritious.

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APPENDICES

Appendix I

SCORE CARD FOR ASSESSING THE ORGANOLEPTIC QUALITIES OF IDLI

Quality	Grade	Description	Scores	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}
APPEARANCE																
	Excellent		5													
	Good		4													
	Fair		3													
	Poor		2													
	Very Poor		1													
FLAVOUR																
	Most desirable		5													
	Desirable		4													
	Fair		3													
	Flavour of raw product		2													
	Off flavour		1													
COLOUR																
	White		5													
	Whitish yellow		4													
	Yellow		3													
	Brown		2													
	Dark brown		1													
TEXTURE																
	Very soft and spongy		5													
	Soft		4													
	Slightly hard		3													
	Very hard		2													
	Sticky		1													
TASTE																
	Excellent		5													
	Good		4													
	Fair		3													
	Poor		2													
	Very poor		1													

Appendix II

Calculation of Amino acid score

Ingredients	Protein (g)	Arginine (mg)	Histidine (mg)	Lysine (mg)	Tryptophan (mg)	Phenylal-anine (mg)	Tyrosine (mg)	Methionine (mg)	Cystine (mg)	Threonine (mg)	Leucine (mg)	Isoleucine (mg)	Valine (mg)
1. Control (T_1)													
Rice 70g	4.48	448.00	133.00	154.00	49.00	245.00	210.00	154.00	70.00	203.00	392.00	217.00	322.00
Blackgram dhal 30g	7.20	156.00	51.00	120.00	21.00	93.00	42.00	27.00	24.00	66.00	150.00	102.00	93.00
Total	11.68	604.00	184.00	274.00	70.00	338.00	252.00	181.00	94.00	269.00	542.00	319.00	415.00
Per gm of test protein		51.71	15.75	23.46	5.99	28.94	21.58	15.50	8.05	23.03	46.40	27.31	35.53
Amino acid score		171.91	139.63	70.92**	88.48	106.91	114.79	98.23	76.2	95.72	118.67	88.58	105.03
2. Formulation I (T_2)													
Rice 70g	4.48	448.00	133.00	154.00	49.00	245.00	210.00	154.00	70.00	203.00	392.00	217.00	322.00
Blackgram dhal 25g	6.00	130.00	42.50	100.00	17.50	77.50	35.00	22.50	20.00	55.00	125.00	85.00	77.50
Soyaflour 5g	2.65	56.40	20.26	47.76	11.58	36.18	27.50	10.13	11.58	30.39	56.44	36.18	437.13
Total	13.13	634.40	195.76	301.76	78.08	498.18	272.50	186.63	101.58	288.39	573.44	338.19	437.13
Per gm of test protein		48.32	14.91	22.98	5.93	37.94	20.75	14.21	7.74	21.96	43.67	25.76	33.29
Amino acid score		160.64	132.18	69.47**	87.89	140.16	110.37	90.05	73.57	91.27	111.69	83.55	98.40

Contd...

(Appendix II Contd...)

Ingredients	Protein (g)	Arginine (mg)	Histidine (mg)	Lysine (mg)	Tryptophan (mg)	Phenylal-anine (mg)	Tyrosine (mg)	Methionine (mg)	Cystine (mg)	Threonine (mg)	Leucine (mg)	Isoleucine (mg)	Valine (mg)
3. Formulation II (T_3)													
Rice 70g	4.48	448.00	133.00	154.00	49.00	245.00	210.00	154.00	70.00	203.00	392.00	217.00	322.00
Blackgram dhal 20g	4.80	104.00	34.00	80.00	14.00	62.00	28.00	18.00	16.00	44.00	100.00	68.00	62.00
Soyaflour 10g	5.30	111.43	39.07	94.07	21.71	72.36	54.99	20.26	23.15	59.33	112.88	72.36	73.81
Total	14.58	663.43	206.07	328.07	84.71	379.36	292.99	192.26	109.15	306.33	604.88	357.36	457.81
Per gm of test protein		45.50	14.13	22.50	5.81	26.02	20.10	13.19	7.49	21.01	41.49	24.51	31.40
Amino acid score		515.26	125.27	68.02	85.82	96.12	106.91	83.59	71.19	87.32	106.11	79.50	92.81
4. Formulation III (T_4)													
Rice 70g	4.48	448.00	133.00	154.00	49.00	245.00	210.00	154.00	70.00	203.00	392.00	217.00	322.00
Blackgram dhal 15g	3.60	78.00	25.50	60.00	10.50	46.50	21.00	13.50	12.00	33.00	75.00	51.00	46.50
Soyaflour 15g	7.95	167.15	58.61	141.10	32.56	108.54	82.49	30.39	34.73	89.00	169.32	108.54	110.71
Total	16.03	693.15	217.11	355.1	92.06	400.04	313.49	197.89	116.73	325.00	636.32	376.54	479.21
Per gm of test protein		43.24	13.54	22.15	5.74	24.96	19.56	12.34	7.28	20.27	39.69	23.49	29.89
Amino acid score		143.75	120.04	66.96	84.79	92.21	104.04	78.20	69.20	84.25	101.51	76.19	88.35

Contd...

(Appendix II Contd...)

Ingredients	Protein (g)	Arginine (mg)	Histidine (mg)	Lysine (mg)	Tryptophan (mg)	Phenylal-anine (mg)	Tyrosine (mg)	Methionine (mg)	Cystine (mg)	Threonine (mg)	Leucine (mg)	Isoleucine (mg)	Valine (mg)
5. Formulation IV (T_5)													
Rice 70g	4.48	448.00	133.00	154.00	49.00	245.00	210.00	154.00	70.00	203.00	392.00	217.00	322.00
Blackgram dhal 10g	2.40	52.00	17.00	40.00	7.00	31.00	14.00	9.00	8.00	22.00	50.00	34.00	31.00
Soyaflour 20g	10.60	222.87	78.15	188.13	43.42	144.72	109.99	40.52	46.31	118.67	225.76	144.72	147.61
Total	17.48	722.87	228.15	382.13	99.42	420.72	333.99	203.52	124.31	343.67	667.76	395.72	500.61
Per gm of test protein		41.35	13.05	21.86	5.69	24.07	19.11	11.64	7.11	19.66	38.20	22.64	28.64
Amino acid score		137.47	115.69	66.08^{**}	84.04	88.92	101.65	73.76	67.59	81.71	97.70	73.43	84.66
6. Formulation V (T_6)													
Rice 70g	4.48	448.00	133.00	154.00	49.00	245.00	210.00	154.00	70.00	203.00	392.00	217.00	322.00
Blackgram dhal 5g	1.20	26.00	8.50	20.00	3.50	15.50	7.00	4.50	4.00	11.00	25.00	17.00	15.50
Soyaflour 25g	13.25	278.58	97.68	235.16	54.27	180.90	137.48	50.65	57.89	148.34	282.20	160.90	184.52
Total	18.93	752.58	2639.18	409.16	106.77	441.40	354.48	209.15	131.89	362.34	699.20	414.90	522.02
Per gm of test protein		39.76	12.63	21.61	5.61	23.32	18.73	11.05	6.97	19.14	36.94	21.92	27.58
Amino acid score		132.18	111.97	65.33^{**}	83.31	86.15	99.63	70.03	66.25	79.55	94.48	71.09	81.53

Contd...

(Appendix II Contd...)

Ingredients	Protein (g)	Arginine (mg)	Histidine (mg)	Lysine (mg)	Tryptophan (mg)	Phenylal-anine (mg)	Tyrosine (mg)	Methionine (mg)	Cystine (mg)	Threonine (mg)	Leucine (mg)	Isoleucine (mg)	Valine (mg)
7. Formulation VI (T_7)													
Rice 70g	4.48	448.00	133.00	154.00	49.00	245.00	210.00	154.00	70.00	203.00	392.00	217.00	322.00
Soyaflour	15.90	334.30	117.22	282.20	65.12	217.08	164.98	60.78	69.47	178.00	338.64	217.08	221.42
Total	20.38	782.30	250.22	436.20	114.12	462.08	374.98	214.78	139.47	381.00	730.64	434.08	543.42
Per gm of test protein		38.39	12.28	21.40	5.60	22.67	18.40	10.54	6.84	18.69	35.85	21.30	26.66
Amino acid score		127.63	108.86	64.69^{**}	82.72	83.75	97.87	66.79	65.01	77.68	91.69	69.09	78.80
8. Formulation VII (T_8)													
Rice 70g	4.48	448.00	133.00	154.00	49.00	245.00	210.00	154.00	70.00	203.00	392.00	217.00	322.00
Blackgram dhal 25g	6.00	130.00	42.50	100.00	17.50	77.50	35.00	22.50	20.00	55.00	125.00	85.00	77.50
Soyabean 5g	2.16	22.50	7.50	20.00	4.00	15.00	10.50	4.00	5.00	12.00	24.00	16.00	16.00
Total	12.64	600.50	183.00	274.00	70.50	337.50	255.50	180.50	95.00	270.00	541.00	318.00	415.50
Per gm of test protein		47.51	14.48	21.68	5.58	26.70	20.21	14.28	7.51	21.36	42.80	25.16	32.83
Amino acid score		157.95	128.37	65.55^{**}	82.42	98.63	107.50	90.49	71.39	88.78	109.46	81.61	97.04

Contd...

(Appendix II Contd...)

Ingredients	Protein (g)	Arginine (mg)	Histidine (mg)	Lysine (mg)	Tryptophan (mg)	Phenylal-anine (mg)	Tyrosine (mg)	Methionine (mg)	Cystine (mg)	Threonine (mg)	Leucine (mg)	Isoleucine (mg)	Valine (mg)
9. Formulation VIII (T_9)													
Rice 70g	4.48	448.00	133.00	154.00	49.00	245.00	210.00	154.00	70.00	203.00	392.00	217.00	322.00
Blackgram dhal 20g	4.80	104.00	34.00	80.00	14.00	62.00	28.00	18.00	16.00	44.00	100.00	68.00	62.00
Soyabean 10g	4.32	45.00	15.00	40.00	8.00	30.00	21.00	8.00	10.00	24.00	48.00	32.00	32.00
Total	13.60	5.97	182.00	274.00	71.00	337.00	259.00	180.00	96.00	271.00	540.00	317.00	416.00
Per gm of test protein		43.90	13.38	20.14	5.22	24.79	19.04	13.24	7.06	19.92	39.70	23.30	30.54
Amino acid score		145.94	118.61	60.88**	77.10	91.51	101.28	83.90	67.11	82.79	101.53	75.75	90.27

Ingredients	Protein (g)	Arginine (mg)	Histidine (mg)	Lysine (mg)	Tryptophan (mg)	Phenylal-anine (mg)	Tyrosine (mg)	Methionine (mg)	Cystine (mg)	Threonine (mg)	Leucine (mg)	Isoleucine (mg)	Valine (mg)
10. Formulation IX (T_{10})													
Rice 70g	4.48	448.00	133.00	154.00	40.00	245.00	210.00	154.00	70.00	203.00	392.00	217.00	322.00
Blackgram dhal 15g	3.60	78.00	25.50	60.00	10.50	46.50	21.00	13.50	12.00	33.00	75.00	51.00	46.50
Soyabean 15g	6.48	67.50	22.50	60.00	12.00	45.00	31.50	12.00	15.00	36.00	72.00	48.00	48.00
Total	14.56	593.50	181.00	274.00	71.50	336.50	262.50	179.50	97.00	272.00	539.00	316.00	416.50
Per gm of test protein		40.76	12.43	18.81	4.91	23.08	18.03	12.33	6.66	18.68	37.02	21.70	28.61
Amino acid score		135.50	110.20	56.80**	72.53	85.26	95.90	78.14	63.31	77.64	94.68	70.69	84.57

Contd..

(Appendix II Contd...)

Ingredients	Protein (g)	Arginine (mg)	Histidine (mg)	Lysine (mg)	Tryptophan (mg)	Phenylal-anine (mg)	Tyrosine (mg)	Methionine (mg)	Cystine (mg)	Threonine (mg)	Leucine (mg)	Isoleucine (mg)	Valine (mg)
11. Formulation X (T_{11})													
Rice 70g	4.48	448.00	133.00	154.00	49.00	245.00	210.00	154.00	70.00	203.00	392.00	217.00	322.00
Blackgram dhal 10g	2.40	52.00	17.00	40.00	7.00	31.00	14.00	9.00	8.00	22.00	50.00	34.00	31.00
Soyabean 20g	8.64	90.00	30.00	80.00	16.00	60.00	42.00	16.00	20.00	48.00	96.00	64.00	61.00
Total	15.52	590.00	18.00	274.00	72.00	336.00	266.00	179.00	98.00	273.00	538.00	315.00	417.00
Per gm of test protein		38.02	11.60	17.65	4.64	21.65	17.14	11.53	6.31	17.59	34.66	20.30	26.87
Amino acid score		126.40	102.84	53.36**	68.54	79.98	91.17	73.07	59.90	73.18	88.64	65.84	79.43
12. Formulation IX (T_{12})													
Rice 70g	4.48	448.00	133.00	154.00	49.00	245.00	210.00	154.00	70.00	203.00	392.00	217.00	322.00
Blackgram dhal 5g	1.20	26.00	8.50	20.00	3.50	15.50	7.00	4.50	4.00	11.00	25.00	17.00	15.50
Soyabean 25g	10.80	112.50	37.50	100.00	20.00	75.00	52.50	20.00	25.00	60.00	120.00	80.00	80.00
Total	16.48	586.50	179.00	274.00	72.50	335.50	269.50	178.50	99.00	274.00	537.00	314.00	417.50
Per gm of test protein		35.59	10.86	16.63	4.40	20.36	16.35	10.83	6.01	16.63	32.58	19.05	25.33
Amino acid score		118.32	96.28	50.27**	64.99	75.21	86.97	68.63	57.13	69.11	83.32	61.79	78.87

Contd...

(Appendix II Contd...)

Ingredients	Protein (g)	Arginine (mg)	Histidine (mg)	Lysine (mg)	Tryptophan (mg)	Phenylal-anine (mg)	Tyrosine (mg)	Methionine (mg)	Cystine (mg)	Threonine (mg)	Leucine (mg)	Isoleucine (mg)	Valine (mg)
13. Formulation XIII (T_{13})													
Rice 70g	4.48	448.00	133.00	154.00	49.00	245.00	210.00	154.00	70.00	203.00	392.00	217.00	322.00
Soyabean 30g	12.96	135.00	45.00	120.00	24.00	90.00	63.00	24.00	30.00	72.00	144.00	96.00	96.00
Total	17.44	583.00	178.00	274.00	73.00	335.00	273.00	178.00	11.00	275.00	536.00	313.00	418.00
Per gm of test protein		33.43	10.21	15.71	4.19	20.36	15.65	10.21	5.73	15.77	30.73	19.94	23.97
Amino acid score		111.14	90.51	47.49**	61.89	75.21	83.24	64.70	54.47	65.54	78.59	58.19	70.85

Appendix III

ANOVA table on nutritional significance of the cooked products with reference to protein and energy

Particulars	Mean square		F value
	Treatment D.F. = 12	Error D.F. = 26	
Protein	10.15413	0.1059007	95.88**
Energy	274.25	0.1346154	2037.28**

** Significant at 1% level

Appendix IV

ANOVA table on changes in pH, acidity and volume increase due to fermentation of batter samples

Particulars	Mean square		F value
	Treatment D.F. = 12	Error D.F. = 26	
pH	0.006922	0.000038	184.30**
Acidity	0.029332	0.000589	49.80**
Volume increase	59100.64	3231.414	18.28**

** Significant at 1% level

Appendix Va

ANOVA table on amylose pattern of fermented batter samples

Particulars	Mean square		F value
	Treatment D.F. = 12	Error D.F. = 26	
Total amylose	5.830729	0.026442	220.51**
Insoluble amylose	3.416341	0.038949	87.71**
Soluble amylose	0.341512	0.053269	6.41**

** Significant at 1% level

Appendix Vb

ANOVA table on amylose pattern of cooked products

Particulars	Mean square		F value
	Treatment D.F. = 12	Error D.F. = 26	
Total amylose	2.87729	0.028658	100.40**
Insoluble amylose	0.662470	0.072364	9.15**
Soluble amylose	0.896667	0.046736	19.18**

** Significant at 1% level

Appendix VI

Physico-chemical characteristics of the cooked products with reference to bulk density

Particulars	Mean square		F value
	Treatment D.F. = 12	Error D.F. = 26	
Bulk density	0.0009204	0.0000172	53.39**

** Significant at 1% level

Appendix VII

Sensory scores for different quality parameters

Treatments	Sum of scores	Score in range	Average score	Ranking
1. Sensory scores for appearance				
T_1	74	4-5	4.95	II
T_2	72	4-5	4.80	IV
T_3	71	4-5	4.73	V
T_4	64	3-5	4.27	VI
T_5	49	2-4	3.27	VII
T_6	37	2-4	2.47	VIII
T_7	30	2	2.00	IX
T_8	75	5	5.00	I
T_9	75	5	5.00	I
T_{10}	75	5	5.00	I
T_{11}	74	4-5	5.00	II
T_{12}	73	4-5	4.86	III
T_{13}	71	4-5	4.73	IV
2. Sensory scores for flavour				
T_1	74	4-5	4.93	I
T_2	70	4-5	4.67	IV
T_3	60	4-5	4.00	V
T_4	52	3-4	3.46	VIII
T_5	44	2-4	2.93	XI
T_6	35	2-3	2.33	XII
T_7	30	2.00	2.00	XIII
T_8	73	4-5	4.86	II
T_9	72	4-5	4.80	III
T_{10}	59	3-5	3.93	VI
T_{11}	56	3-5	3.73	VII
T_{12}	50	3-4	3.33	IX
T_{13}	49	3-4	3.27	X

Contd...

(Appendix VII contd...)

Treatments	Sum of scores	Score in range	Average score	Ranking
3. Sensory scores for colour				
T_1	73	4-5	4.87	III
T_2	73	4-5	4.87	III
T_3	70	4-5	4.67	IV
T_4	53	3-4	3.53	V
T_5	44	2-4	2.93	VI
T_6	34	2-3	2.27	VII
T_7	30	2	2.00	VIII
T_8	75	5	5.00	I
T_9	75	5.00	5.00	I
T_{10}	75	5	5.00	I
T_{11}	75	5	5.00	I
T_{12}	74	4-5	4.93	II
T_{13}	73	4-5	4.87	III
4. Sensory scores for texture				
T_1	73	4-5	4.93	I
T_2	71	4-5	4.87	II
T_3	68	4-5	4.73	IV
T_4	56	3-4	4.54	VI
T_5	72	4-5	4.45	VII
T_6	73	4-5	4.43	VIII
T_7	74	4-5	3.00	XII
T_8	73	4-5	4.85	III
T_9	72	4-5	4.70	V
T_{10}	69	4-5	4.20	IX
T_{11}	55	3-4	4.11	X
T_{12}	45	2-4	3.99	XI
T_{13}	40	2-4	2.66	XIII

Contd...

(Appendix VII contd...)

Treatments	Sum of scores	Score in range	Average score	Ranking
5. Sensory scores for taste				
T_1	75	5	5.00	I
T_2	74	4-5	4.93	II
T_3	72	4-5	4.80	III
T_4	71	4-5	4.73	IV
T_5	58	3-4	3.87	VII
T_6	51	3-4	3.40	X
T_7	39	2-4	2.60	XI
T_8	71	4-5	4.73	IV
T_9	70	4-5	4.67	VI
T_{10}	57	3-5	3.80	VIII
T_{11}	52	3-5	3.47	IX
T_{12}	37	2-4	2.47	XII
T_{13}	31	2-3	2.07	XIII

Appendix VIII

Statistical Evaluation of Organoleptic Qualities of Idli

No. of judges	No. of samples	Chi-square values for				
		Appearance	Flavour	Colour	Texture	Taste
15	13	142.75**	144.06**	161.37**	130.08**	147.00**

** Significant at 1% level

DEVELOPING SUITABLE RICE-SOYA FERMENTED PREPARATION

By

BINILA PAUL

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

DEPARTMENT OF HOME SCIENCE
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1997

ABSTRACT

A study on "Developing suitable rice-soya fermented preparation" details a comprehensive information on the advantages of preparing idli, in which blackgram dhal was replaced either by soyabean or by defatted soyaflour. Soaking time, grinding conditions, temperature and fermentation time were kept uniform to study the influence of the food ingredients used on the quality of the product. Thirteen formulations were standardised after making variations in the proportion of blackgram dhal (from 5 per cent to 30 per cent).

Amino acid score and chemical score were worked out to determine the nutritional adequacy of various formulations. The data computed revealed the nutritional supremacy of the formulations with higher concentrations of soyabean and defatted soyaflour, when compared with control mainly because of the enhancement of their protein content.

Laboratory analysis of the cooked product for protein and calorie confirmed the computed values.

Cost of defatted soyaflour supplemented formulations were the lowest. Cost-wise, soyabean supplemented formulations were also found to be cheaper than the control.

Reduction of pH and increase in acidity were noted in defatted soyaflour supplemented formulations and soyabean supplemented formulations when compared to control. Batter volume was higher in the formulations where defatted soyaflour concentration was upto 30 per cent. Amylose content in the soyabean as well as in the defatted soyaflour supplemented formulations indicated that these foods are suitable alternatives for blackgram dhal. However, lower values of bulk density was observed in soyaflour supplemented formulations, and uneven and large pores were found in idlis prepared from soyabean supplemented formulations.

In sensory evaluation, soyabean supplemented idlis were found better than defatted soyaflour supplemented formulations when compared to the control samples. Hence, it can be concluded that idlis made from 5 per cent incorporation of defatted soyaflour and 5-10 per cent incorporation of soyabean are more nutritious, acceptable and of low cost when compared to control samples, the ingredients in which 70 parts of rice and 30 parts of blackgram dhal.