IMPROVEMENT OF THE NUTRITIONAL QUALITY OF BREAD

BY

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THESIS
Submitted in Partial Fulfilment of the Requiremer
for the Degree
MASTER OF SCIENCE IN HOME SCIENCE
Food Science and Nutrition
Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF HOME SCIENCE
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

1995

DEDICATED TO MY PARENTS

DECLARATION

I hereby declare that this thesis entitled "**Improvement of the nutritional quality of bread**" 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 or other similar title, of any university or society.

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EXTERNAL EXAMINER

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACKNOWLEDGEMENT

With immense pleasure, I wish to express my sincere and deep sense of gratitude to Dr.(Mrs) L. Prema, Professor and Head, Department of Home Science, College of Agriculture, Vellayani and chairman of my advisory committee for her versatile and inspiring guidance, timely and valuable suggestions, unfailing patience and constant encouragement during the conduct of this research work and for co-operation and help in the preparation of this thesis.

I should specifically mention my thankfulness to Dr. Mary Ukkuru, Associate Professor, Department of Home science, and Smt. C. Nirmala, Assistant professor, Department of Home Science for serving in my advisory committee and for their valuable guidance, critical evaluation and generous help extended to me throughout the course of my research work and in the preparation of this thesis.

I am gratefully obliged to Dr.(Mrs) Saraswathy P, Professor and Head, Department of Statistics, college of Agriculture and member of my advisory committee for her ever willing help and valuable advise rendered throughout the course of this study and in the preparation of this thesis.

My sincere thanks are also due to Dr. Haridas Rao, and Dr. Leelavathi of CFTRI, Mysore and Smt. Raechael Jacob and Sri. Pai of Modern Food Industries, Cochin for their constant and valuable help extended to me during the course of my research work.

I take this oppertunity to express my gratitude to all my friends, especially Geethu, Sai Laxmi and Bindu and also to all the teaching and non - teaching staff of Department of Home Science for their everwilling help and constant encouragement.

I thank the Dean, College of Agriculture for providing me all the facilities during the period of my study and the Kerala Agricultural University for having endowed me with a fellowship during the period of study.

Finally, my reverential thanks are due to my parents and brothers for their constant encouragement and sustained interest for the successful fullfilment of this endeavour.

SINDHU J. CHANDRAN

INTRODUCTION

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Baking industry is one of the largest organised food industry in India and bread is one of the major wheat products consumed by large sections of Indians. Convenience in use and economy, simplicity in developing the product, ease in packaging and transport, moderate shelflife at normal temperature and popularity among children have made bread an ideal food. Bakery products are increasingly becoming popular in India as indicated by over two and half fold increase in their production during the last decade (Haridas Rao, 1993).

These products have also been recognised as most efficacious means of delivering supplementary nutrition in hygienically packed ready to eat form to the weaker and vulnerable sections of our society who are suffering from malnutrition. Because of these qualities, bread will also be an ideal food supplement for any nutrition intervention programmes if nutritionally improved.

At present crores are spent by government to import, transport and distribute food supplement for various nutrition intervention programmes and there is a great scope for introducing variation in this food supplement by developing alternative food products with locally available nutritious foods. In this experiment such an attempt is made through soya fortification of bread since it increases its protein content and improves the amino acid balance. Since bread is eaten by a large segment of the population, the supplementation with defatted soya flour in bread would improve their nutrient intake and help in combating protein malnutrition. Hence feasibility of soya fortified bread with the following objectives was attempted:

(i) to improve the nutritional quality of bread,

(ii) to ascertain the baking characteristics, organoleptic and shelflife qualities of the developed product; and

(iii) to test the feasibility of introducing the product as a supplementary food for nutrition intervention programme.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

According to Atkins (1971) bread is fundamentally foamed gluten. The accepted term for baked foods made of flour,sugar, shortening, salt and liquid and leavened by the action of yeast is known as bread. (Gopal, 1993).

Present status of bread industry

Baking industry is one of the largest organised food industries in India, with an annual turn over of Rs.1200 crore (Bhattacharya, 1980). An assessment of bread industry in India by Sanjeev Chowdary (1990) had depicted a turn over of 1.20 million tonnes with an investment of Rs.750 crores. More than 2 1/2 fold increase in bakery production during the last decade was reported by Haridas Rao (1993). A study conducted by Gaur et al. (1993) concluded that the annual production of baked products in India is about 2 to 6 million tonnes, with 1.85 million tonnes of bread, 0.50 million tonnes of biscuits and 0.18 million tonnes of other baked products.

History of bread making

The profound statement, "In the sweat of thy brow shall thou eat bread" dominated men's life for 1000's of years. The art of bread making was being practised before 4000 B.C in egypt, while the archaeological exploration of swiss lake habitator is dated back to 4000 B.C for fermented cake. A revolutionary breakthrough in bread making was heralded in 1926 at the Kansas state Agriculture College where a laboratory mixer (Do-maker) was designed to get a dough which could produce good bread without bulk fermentation.

In 195Ø, Wallace and Tierman used mechanical dough ripening in its continuous bread making process where flours, shortening and a pre - cultured yeast were metered continuously into a pre - mixer and the resulting dough was fed into a mechanical developer that ripens the dough in about 9Ø seconds instead of 3 to 4 hours of bulk fermentation.

A common shape for Egyptian bread revealed by ancient monument or in exacavated tombs is a small round loaf with muffins or elongated rolls, springled on top with seeds like modern Vienna bread. However public bake house came into existence during 171 to 168 B.C.

In the ruins of Pompelli, several home mills and ovens were detected and round loaves which found stamped with the makers name, fixing responsibility for purity and weight on the manufacturer known as pistories or pounders. About 1ØØ A.D , the emperor Trojan founded the college of pistories, leading Juvenal in his famous satire to make the remark that Romans only needed two things, Paneemet circenses, bread and circuses.

Nutritional significance of bread in the diet

Bread contains a high percentage of carbohydrates, a fair percentage of protein but a very low percentage of fat (Albert Daniel, 1971). Tsen et al. (1975) found that bread made with wheat and corn germ flour are rich in oil, nutritive proteins and vitamins. According to Ranhotra (1981) flour and bread products supply a wide variety of nutrients at reasonable cost.

A survey carried out by Rognerud et al. (1982) found that bread consumption has increased during the last five years, particularly of dark varities. He also reported that quality factors considered important for bread are taste, nutritional value and maintenance of freshness. An attitude survey conducted by Rognerud et al. (1983) towards bread consumption revealed that quality factors such as taste, nutritive value and maintenance of freshness; convenience and economy were the major determinants prompting its purchase. According to Haridas Rao (1993) the popularity of the bakery products is due to their ready to eat convenience nature, unique taste and ready availability at reasonable cost in different parts of the country including remote and rural areas.

Meiss et al. (1966) conducted studies on the effect of nutritive improvement of bread on growth. Salient findings of the study revealed that about 22 per cent of the energy in the human diet was provided by a standard commercial white bread enriched with proteins, vitamins and minerals.

As reported by Stellar and Becker (1982) the structure of protein supply in the Federal Republic of Germany showed that bread and bakery products are the second most significant protein suppliers in relation to vegetable protein accounting for about 20 per cent of the total daily protein intake. Vanick and Turek (1982) reported that bread as a basis of daily carbohydrate - protein nutrition, Protein deficiencies at individual meals are reported to be removed or lowered. Many reports indicated that breads produced from cereal grains in general and wheat in particular are the main source of proteins and energy intake in South East Asia, Middle East and North African countries (F.A.O, 1960; Waslein, 1981). According to Pomeranz (1969) high consumption, acceptability and low price have made bread an ideal vehicle for protein supplementation.

Stellar et al. (1983) in a study on the role of bread as a source of supplying protein revealed that 201 g of bread and roll supplied 14.50 g of protein. Rajalakshmi and Shanti (1989) reported that high protein foods contain protein levels ranging from 20 to 50 per cent if whole or skimmed milk powder or protein isolates from peanut or soya bean are included.

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. Supplementation with lysine or threonine caused no significant improvement but a supplementation of all the three amino acids increased the PER to a value not significantly different from that of dried skimmed milk. They also suggested that a daily supplement of 50 g of this food would supply 11 g of additional protein. Marialuz and her coworkers (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. Overall bread acceptability made from lysine and methionine fortified wheat flour is not significantly different from unfortified samples.

According to Campbell (1960), a protein fortified bread must have at least 14 per cent protein on a 36 per cent moisture basis and a PER rating greater than 1.80 to be considered as an excellent source of protein.

Weanling male rats of mean weight 55 g in the first trial and 80 g in the second trial were given for 3 weeks diets with 10 per cent casien or isolated soyabean protein. Weight gain, feed efficiency, nitrogen efficiency and nitrogen retention were found to be significantly less with soya than with casien (Yoshida and Edagawa, 1978).

Tsen *et al*. (1976) prepared hot dog buns from wheat flour and wheat flour fortified with 12 per cent defatted soya flour. The fortified buns contained 27.50 per cent more protein and 29.20 per cent more minerals than wheat flour buns. Tsen and Mustafa (1976) also reported that bread containing 80 per cent wheat flour, 15.30 per cent cassava flour and 4.70 per cent soya flour have a better Protein Efficiency Ratio than wheat bread with same protein content. Nikolic and Salihodzic (1988) have stated that addition of soya flour generally increased the protein content.

Enrichment of bread of known composition at 1, 2, 3, 6 and 10 per cent level with Candida utilis grown on sugar beet molasses with increasing content of yeast 3, 6, and 10 per cent enhanced the protein content from 14.40 per cent to 15.80, 18.40 and 21.30 per cent and PER increased from 0.80 to 1.14, 1.45 and 1.74 (Yanez *et al*, 1973).

Bread prepared by replacing 20 per cent of the wheat flour with air classified pea protein concentrate has an excellent rating. However, acceptable bread with excellent protein rating has been produced using a formula that included 83 per cent of the wheat flour, 2 per cent vital gluten and 15 per cent pea protein concentrate, provided that 1 per cent of a suitable emulsifier is added (Fleming and Sosulski, 1977).

According to Ching (1986) bread fortified with 8 per cent torula yeast flour raised the protein content from 12.42 to 14.22 per cent for supplemented bread. Amino acid analysis indicated a marked increase in amino acid content especially lysine. The PER for rats on all wheat flour bread was 1.31, replacing 8 per cent of the wheat flour with torula yeast, raised PER of the supplemented bread to 2.28. A jowar - soya bean - skim milk high protein biscuit blend was evaluated by Rao et al. (1987) for PER before and after baking to study the loss in nutritive value. The results revealed that the PER of unbaked jowar - soya bean- skim milk blend (2.30) was reduced slightly by baking (2.10). The resultant biscuits were reported to be nutritious and palatable.

Rao and Vakil (1987) reported that replacement of wheat flour with more than 5 to 10 per cent bengal gram increased the protein content of the bread mix by 3 per cent. Similarly, the content of limiting essential aminoacids in wheat such as lysine and threonine can be raised.

Application of dried algal powders in bread making using the species Oscillatoria amphibia and Spirulina platensis increased the crude protein content from 10.30 per cent in control wheat bread to 14.10 per cent to 14.40 per cent (Saleh et al, 1987).

According to Serna et al. (1988) wheat flour was fortified with 8 and 12 per cent defatted soya bean, 8 per cent and 4 per cent defatted sesame meal to increase the protein content and amino acid profile.

Rao (1990) reported that surfactants added to bread enriched with soya flour, accentuate the binding of lipids to soya protein instead of interacting with lipids.

Dietetic value of bread

According to Meiss et al. (1966) diet containing special formula bread was reported to give significantly greater weight gain and food efficiency. Bread products are also reported to permit dietary modifications to promote health by suitable combinations of carbohydrate and plant proteins, fat and simple sugars (Ranhotra, 1981).

Menden (1987) reported that low calorie bread with a high fibre content support a weight reducing diet programme effectively and safely. Stellar (1989) found that a reducing diet with bread providing 46 per cent of the calories and supplying 1,200 to 1,500 calories per day reduce 13 pounds on an average over a 4 week period. According to Chase (1989) replacement of refined carbohydrates by fibre containing bread resulted in the decline of diabetes mortality and frequency of occurrence in industrialized countries during World war II. Trover (1989) reported that soluble fibre accounted for

40 per cent of the total dietary fibre contained in cassava bread. Retardation of gastric emptying caused by its fibre constituents is observed to make cassava bread an interesting product for its in vitro glycaemic response. According to Vaidehi <u>et al</u>. (1992) the reduction in weights may be attributed to the fibre and soya protein content present in the tested dietetic baked products. It was also found to be useful for maintenance of better health and to prevent the onset of diseases like diabetes, obesity and hypertension in those who are regular users of baked foods.

Different types of baked products suitable for anaemia and Vitamin A deficiency conditions were developed where wheat flour was supplemented with defatted soya flour at 10 to 15 per cent level in biscuits and 5 to 10 per cent level in cakes and bread (Vaidehi <u>et al</u>, 1992). The sensory evaluation of these products showed a high acceptability for these dietetic products. Storage study also revealed that biscuits had longer shelflife of 9 days and 4 to 5 days for cakes, bread and puffs.

Factors affecting the quality of bread

Different factors affecting the quality of bread are the raw materials added, temperature during the process of bread making, fermentation time and moisture retained in the final product.

The raw materials used in bakery products are wheat flour, sugar, shortening (fat and emulsifiers), yeast, milk products, sugar products, liquid glucose, malt extract, eggs, flavouring agents, colouring agents, preservatives, proteolytic and amylolytic enzymes (Rama,1991). According to Hemard (1992) bread dough may contain wheat flour, barley, wheat, maize and oat flakes, liquid honey, dried semi-skimmed milk, invert sugar, yeast, salt, gluten, additives, calcium propionate and water.

Simon (1989) stated that saltiness is an important flavour without which white bread has a flat unappealing taste. A loaf of bread contains 1 to 2 per cent salt. Salt is also reported to strengthen the gluten so as to increase the resistance to extension. Rama (1991) also reported that salt improves colour of the crust, taste and volume.

Incorporation of salt in bread is reported to have a definite undesirable effects in a dough such as inhibiting yeast and enzyme activity, decreasing the water holding capacity of flour and increasing the mixing requirements of a dough (Gross et al, 1986). Rama (1991) has also reported that too much salt slows down yeast activity and too less makes bread acidic due to lack of control over yeast activity.

Bread is normally made with 2 to 4 per cent fat and the primary function of shortening is to tenderize the product. It increases the loaf volume, produces much uniform and soft crumbs, enhance keeping quality and improves slicing characteristics (Rama, 1991). Baker et al. (1982) reported that fat used in bakery products, called as shortening shortens the gluten structure resulting in tender products. He also reported that the type of fat used influenced the quality of bread. Baldwin et al. (1985) found that loaf volume, texture and crumb quality are improved when dough contains high melting point fat.

Sugar added to bread is reported to impart colour and taste (Rama, 1991). Siffring (1993) found that loaf volume was greater at lower proof temperature. Differences of upto 700 cubic cm in loaf volume were observed between lowest and highest proof temperature. Crumb grain and texture were also found to improve at lower temperature.

According to Faridi and Finney (1980) Iranian breads generally are produced from flours of higher extraction rates and are usually produced using shorter fermentation time. Simon (1989) has reported that fermentation activity in the bread is due to yeast Saccharomyces cerevisiae, which is added at a level of 2 to 3 per cent of the flour weight. Schieberle et al. (1991) reported that in the wheat bread baked from doughs given long (3hrs) or short fermentation time, crust and crumb were separated immediately after baking. Increased fermentation time changed crumb flavour owing to increase in the concentration of 3-methyl butanol and 2-phenyl ethanol. Crumb flavour is also reported mainly due to the aroma compounds formed by the peroxidation of linoleic acid.

Studies conducted by Waizman *et al*. (1983) on freezing or interruptions of dough fermentation revealed that interruption of fermentation generally gave good flavour quality. According to Pringle and Moran (1942) phytate destruction increased with increasing fermentation time.

Sensory evaluation studies on bread

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.

Johnson *et al*. (1985) reported that soyabean hulls can be added to the bakery product without deleterious effects in sensory acceptability.

Full fat soy and other full fat soy - whole egg, soy - egg yolk and soy - egg white flours were produced and utilized as 12 per cent supplements for wheat flour in breads. Organoleptic evaluation of bread type indicate that 100 per cent wheat flour and soy - egg yolk supplemented loaves scored well in most quality characteristics (O' Connor *et al*, 1979).

Studies conducted by Penna *et al*. (1988) on the effect of addition of 6,9 and 12 per cent sweet lupin flours to wheat flour on the sensory quality and acceptability of 2 types of chilean breads found that the best quality for both bread types was obtained with the addition of 6 per cent lupin flour. Sensory evaluation studies done by Vaidehi et al. (1992) have shown that the best acceptable level of soyaflour was 10 to 15 per cent in biscuits, 5 to 10 per cent in cakes and breads.

Significance of Soyabean as a Constituent in bread

Soyabean is reported to be a good source of essential amino acids except for methionine and tryptophan and the high lysine content of soyabean proteins can complement lysine deficient flour proteins (Wolf, 1969). Abdel et al. (1980) reported that defatted soyabean are found to be higher in protein and some other essential amino acids. Sinha et al. (1993) reported that soya flour is a very good source of quality protein which can supplement the lysine deficiency in cereal flour.

Tsen et al. (1973) found that soya flours (defatted and full fat) and protein isolates are suitable fortifiers to improve the nutritional value of cookies by raising their protein content and balancing their amino acid. Tsen and Hoover (1973) also reported that fortifying wheat flour with full fat soya flour in making bread can raise the protein content, balance essential amino acids and increases the bread calorific value.

According to Vaidehi et al. (1992) the reduction in weights of the subjects fed on dietetic baked products may be attributed to the soy protein content present in the products. The impact of the consumption of soy food on a range of diet and health issue analysed by Erdman (1989) revealed its protein quality, growth promoting effects, hypocholestrolaemic effects, glucose tolerance, bioavailability of zinc and iron and also on the prevalence of allergies in children.

Effect of fortification in bread making

Arabic bread supplemented with 10 per cent soya flour showed high level of acceptability when compared to unsupplemented bread (Hallab et al, 1974). Acceptable cookies are reported to be prepared from wheat flour fortified with 12 to 15 per cent of soyaproducts (Tsen et al, 1975).

Studies conducted by Shehata and Fryer (1970) revealed that supplementing wheat flour with chick pea flour at 5, 10, 15 or 20 per cent level had little effects on the physical properties of the dough or acceptability of bread.

Enrichment of bread of known composition at 1, 2, 3, 6 and 10 per cent level with Candida utilis grown on sugar beet molasses is found to influence baking properties by > 1 per cent and darkening of colour with increasing content of yeast (Yanezet al, 1973).

Advantages of incorporating 2 per cent by weight of potato granules in wheat flour for bread making are reported to give bread with softer crumb, reduced mixing requirements and higher water absorption (Finney and Pomeranz, 1977).

Rao and Vakil (1987) reported that replacement of wheat flour with more than 5 to 10 per cent bengal gram changes some of the rheological properties of the dough mix. Dough rheological properties, gas retention capacity and loaf volume were also reported to be improved by enrichment with algal proteins (Saleh <u>et al</u>, 1987).

Rao and Malini (1991) studied the rheological characteristics and bread making quality of flour as affected by the incorporation of wheat bran. Water absorption capacity increased from 59 to 67 per cent. Incorporation of bran was found to affect adversely texture, grain and loaf volume of bread while improving the aroma. Maximum level of bran that could be used to obtain the acceptable quality high fibre bread was found to be 30 per cent.

Skimmed milk powder is the usual form of milk used for bakery products. Its addition to dough causes the use of more water and increases the water content of the goods and this addition increases the shelf life of the product (Chaturvedi, 1977). According to Kasatkina (1980) addition of whey reduced proteolytic activity, which is significant for gluten and dough properties and reduced lysine content, affecting bread crumb colour. Silageidze (1980) found that addition of

20 to 30 per cent whey to bread reduce the processing time by 12 to 13 per cent.

Non fat dry milk is often used in bread formula in North America as a source of enrichment and also because of its desirable effects on loaf properties (Patel et al, 1981). An experiment conducted by Stellar and Becker (1983) revealed that essential amino acids percentage in bread proteins enriched with caseinate was considerably superior to casein-enriched bread.

Fleming (1976) conducted a study on the bread making characteristics of sunflower, fababean, field pea and soy protein concentrates, the protein quality of bread fortified with the concentrates had a higher loaf volume than sunflower, fababean and field pea bread, but fababean and field pea bread had more desirable crumb texture. When using blends containing 12 per cent sunflower or 15 per cent soy or field pea or fababean concentrate, it was necessary to add 2 per cent vital gluten and 1 g dough conditioner per 100 g flour to restore bread quality. Taste panel analysis indicate that the high protein breads were organoleptically acceptable. All concentrates produced marked improvement in the nutritional value of breads. Breads containing concentrates were rated as excellent or good sources of protein. Addition of lysine further improved the protein quality of the breads.

A study was undertaken by Rastogi and Gurmukh (1989) to observe the effect of addition of full fat soya flour on quality characteristics and bread making quality of wheat flour. For preparation of blends white flour and fullfat soya flour of different varities were mixed separately in ratios 95:5, 90:10, 85:15 and 80:20 and were kept in air tight containers. Results showed that blends varied in quality parameters and also that the finished loaves varied in their loaf weight, volume and sensory quality. Satisfactory quality bread could be produced at 5 per cent level of fullfat soya flour. At higher levels, the acceptability was reduced due to the poor texture of the crumb and undesirable flavour of bread.

According to Nazarenko et al. (1981) when dried soya protein preparations were added, physicochemical properties and organoleptic properties of the bread were impaired.

Bread prepared with 10 per cent soya flour with maida gave the best results in farinograph water absorption, mixing tolerance index, loaf volume and for acceptability (Selvaraj and Shurpalekar, 1982). According to Sarhan et al. (1986) sedimentation value, fermentation time and relative volume of flour mixtures and bread decreased with increasing addition of soyabean (3, 6, 10 per cent) to wheat flour in blends. Wheat breads baked with various levels and combinations of rye, oats and soya flour and maize gluten by Gruener et al. (1986) were studied for protein content and quality and the results revealed that protein content and available lysine and methionine of the fortified breads were increased over the content of

100 per cent wheat bread (control). Biological value of protein in breads was between 50 and 60 and in most breads Biological Value was significantly higher than the control.

The effect of adding soyabean, whey, ascorbic acid and sunflower or soyabean oil on the quality of standard types of bread was studied by Skorikova (1979). Soyabean flour was added during kneading. Quality of the finished product was assessed by appearance, aroma, condition of crumb, volume, porosity and crumb compressibility. In the straight dough process, the best method was the addition of soyabean flour with vegetable oil or whey. When combining with ascorbic acid the product volume was observed to drop. Addition of sun flower oil or soyabean oil improved bread quality especially if whey was added at the same time. The nutritionally optimum addition of soyabean flour was up to 10 per cent when thick sponge was used, with 15 per cent addition of whey.

The effect of partial substitution of wheat flour on bread baking properties was studied by Martiis (1969) and baking tests were performed with 10 commercial wheat flours supplemented with 3, 6.50 or 10 per cent cassava starch, corn flour or pre-cooked corn flour and the results revealed that effects on bread volume varied for each flour; all the domestic and 3 imported flours produced bread of reduced volume when partially substituted. Volume reduction of 2.14 to 3.70 per cent were produced by 3 or 6.50 per cent corn flour or 3, 6.50 and

10 per cent cassava starch; 20 per cent volume reduction was obtained with 10 per cent pre - cooked corn flour. Additions to imported wheat flours produced smaller losses of bread volume than with pure domestic wheats. Quality was affected adversely in all supplemented breads made from domestic wheat. Better results were obtained with corn flour and cassava starch than with pre - cooked corn flour.

According to Eggleston et al. (1993) cassava flour diastatic activity was highly dependent on the moisture contents of the respective tuberous roots and affected the extent of starch gelatinization in the bread crumbs.

Effect of additives on bread making quality

Additives are substances that are added in smaller quantities with a view to enhance the functional performance of either the raw materials or to improve the processing characteristics and or to enhance the quality of the baked product or to improve the storability of product (Ranganna, 1984). The additives usually used in bread making are Glyceryl Monostearate (GMS), Sodium Stearoyl Lactate (SSL), Guargum and Lecithin.

Alder and Pomeranz (1959) found that in bread baked by a lean formula (without shortening) adding commercial lecithin improved loaf volume and crumb grain of bread when supplemented with soya flour.

Kim and Lee (1977) reported that 1 per cent glyceryl monostearate and 0.50 per cent sodium stearoyl lactate gave increased loaf volume with composite flour containing 30 per cent naked barley, corn, potato or sweet potato flours. Singh and Muguria (1977) found that addition of sodium stearoyl lactate to triticale flour improved bread texture and dough handling. Addition of sodium stearoyl lactate and gluten improved loaf volume significantly.

Selvaraj et al. (1986) reported that inclusion of 2 per cent salt and 0.50 per cent glyceryl monostearate along with one of the additives such as sodium stearoyl lactate, enzyme active soya flour, lecithin or cysteine hydrochloride further improved the dough and bread characteristics of sprouted wheat.

Amylograph peak viscosity, dough elasticity, dough stability and volume of bread fortified with 8 and 12 per cent defatted soyabean meal, 8 per cent and 4 per cent defatted sesame meal improved when sodium stearoyl lactate was used. Addition of 1 per cent sodium stearoyl lactate improved rheological properties and bread volume to a greater extent than 0.50 per cent sodium stearoyl lactate (Serna et al, 1988).

According to Collins and Smith (1976) the use of 1 to 2 per cent fat enzyme active soya flour as an improver in white bread improved gas retention and oven spring, softer whiter crumb and increased shelf life.

According to Tsen et al. (1974) surfactants aided the production of acceptable breads from non wheat flour or starch and delayed staling. Surfactants added can overcome the adverse effects of soya flour and produce acceptable protein enriched bread (Chung et al, 1981). Addition of surfactants were observed to allow the incorporation of non - wheat proteins into bread without quality deterioration (Rao, 1990).

Use of guar gum up to a level of 1 per cent in wheat flour improved the dough properties but greatly improved the over all bread making quality of the flour with special reference to water absorption capacity of the dough, yield of bread, crumb softness and crust appearance (Venketeswara Rao et al, 1985).

Addition of potassium bromate up to 18 ppm to flour mixture containing 3 per cent soyabean flour enhanced quality of both flour and bread. The improving effect of L- ascorbic acid up to 30ppm was better than that of potassium bromate. No improving effect was noticed with flour mixtures containing 6 per cent soya bean flour (Sarhan et al, 1986).

Siebel et al. (1988) found that addition of ascorbic acid as an oxidant at 6 to 8 g/100kg flour improved volume yield and fermentation stability.

Full-fat soy and other full-fat soy-whole egg, soy-egg yolk and soy-egg white flours were produced and utilized as 12 per cent supplements for patent wheat flour in breads.

Addition of 0.50 per cent sodium stearoyl lactate improved loaf volume of all bread types except soy-egg yolk. Generally, 30 or 45 ppm bromate supplementation also resulted in increased loaf volume (O' Connor et al,1979)

Studies conducted by Hart et al. (1970) on bread from sorghum and barley flours reported that several additives were used with both sorghum and barley flours since the same did not make good bread. Methocel, 1 part to 50 parts flour, was found to be the best additive for barley flour.

Significance of non-wheat flours in bread making

Badi et al. (1976) reported that a 10 per cent addition of millet flour increased loaf volume and improved crumb and when added to a formula containing no malt or sugar, significantly improved loaf volume. They also reported that high alpha amylase content of millet flour used, improved bread quality.

Seyem and Kidman (1976) found that although the addition of rice starch weakened the dough, bread of acceptable quality was obtained when rice starch was added at 25 per cent level.

Eldash and his co-workers (1977) showed that caraflour when blended with medium strength wheat flour at levels less than 10 per cent excellent bread was produced.

Bastos (1981) conducted a study on the utilization of composite wheat and sorghum flour for bread making and revealed that no adverse effects on bread properties were observed up to 10 per cent sorghum flour. Sensory analysis of the product also showed that addition up to 60 per cent sorghum flour did not produce significant change in bread flavour or aroma.

Tomic et al. (1983) conducted a study on the replacement of wheat flour in bread making and reported that the protein contents of the bread decreased with increasing level of addition of buckwheat; concentration of moisture, lipid, ash, crude fibre and carbohydrate were found not to differ significantly in the blends studied. 20 per cent buck wheat flour bread was found to have the highest loaf volume. Sensory quality was unacceptable at buckwheat levels of 30 per cent and 40 per cent. The protein value was also found to increase by addition of 30 or 40 per cent buckwheat flour.

Studies conducted by Shehata and Fryer (1970) on the effect on protein quality of supplementing 80 per cent extraction of hard red winter wheat flour with chick pea flour revealed that chick pea flour at 5,10,15 or 20 per cent levels had little effect on the physical properties of the dough or acceptability of bread.

Effect of germination on the baking properties

According to Morad _et al_. (1980) germination appears to have a more detrimental effects on the baking properties of yellow pea starches than on those of lentil and faba bean flours and starches.

Savitha _et al_. (1988) reported that blending of 10 to 30 per cent sprouted grains with sound wheat produced substantial improvement in loaf volume of bread.

According to Leelavathi _et al_. (1990) overall quality of bread improved on germinating wheat upto 24 hours.

Ranhotra _et al_. (1977) conducted a study on bread making quality and nutritive value of sprouted wheat and reported that the white bread made by adding 20 per cent sprouted wheat to normal flour of good appearance and texture. Sprouting was observed to increase protein content from 13.60 to 15.10, fibre from 2.70 to 6.60 and lipid from 2.90 to 3.50 per cent.

Zagibalov _et al_. (1983) conducted a study on improving the nutritional value of bread products and found that to improve the nutritional values of bakery products, bun and school bread were made according to control recipies containing 15 per cent tomato seed paste or 15 per cent safflower paste or additions of yeast dough resulted in a firmer, more porous crumb, better products with similar organoleptic quality and better protein /fat/

carbohydrate ratios than the controls. The test products were found to have better nutritional value than controls at reduced costs.

Shelflife qualities of bread

According to Finney and Pomeranz (1977) incorporation of 2 per cent by weight of potato granules in wheat flour for bread making gave bread with longer shelflife. Drobot et al. (1986) reported that the effect of adding apple powder at 6 different concentration to bread to extend its freshness found that best results were obtained with 5 per cent apple powder, which also increased bread volume.

D' Appalonia and Morad (1981) found that starch retrogradation is the most important factor causing crumb firmness.

Bechtel and Meisner (1954) have proposed the loss of moisture from gluten system as the main reason for bread staling. It was postulated that hydrated proteins of natural crumb undergo mild changes of first order during baking and storage; which may be due to the denaturation of proteins leading to configurational changes and this results in the irreversible modifications in the water structure of gluten. He et al. (1990) reported that moisture play an important role in crumb firming. Higher moisture of crumb resulted in slower firming rate and lower equilibrium firmness.

Scoch and French (1982) suggest that staling is associated with gradual and spontaneous aggregration of the amylopectin giving rise to crystalline structure. Lin et al. (1990) reported that bread containing alpha amylase became firm more slowly than those without the added enzyme. The alpha amylase acts on starch during baking to form predominantly branched - chain polymers of lower molecular weight. These polymers apparently have a decreased ability to retrograde, interfere with the ability of amylopectin to retrograde after the bread is baked or interfere with other interactions involved in firming thus reducing the extent of firming.

According to Finney and Shogren (1971) surfactants are of tremendous use in improving the quality of bread, shelflife and reducing the cost. Tenney (1978) reported that bread containing surfactants retain their softness for a longer period of storage. Maximum improving effect was found with sodium stearoyl lactate. According to De renzo (1985) surfactants which are antistaling agents act by delaying and reducing the retrogradation and firming of starch granules in stored bread.

Ronfeld (1963) demonstrated the benefical effects of addition at 2 per cent level of albumin, gelatin and casein on bread staling. Among these additives albumin was the most effective in retarding staling.

In yeast raised baked foods, higher levels of surface active agents increases the shelf life of baked products and impart a dough conditioning action that results in improved product quality and uniformity (Knightly, 1981).

In a study conducted by Kawka (1989) it was found that rye bread wrapped in aluminium foil and kraft paper and sterilized at 130 °C scored higher than the control and retained satisfactory quality for seven days.

Bread as a food supplement to preschool children

Swaminathan (1977) has stated that supplementary feeding programme has always been one of the basic measures adopted for raising the levels of nutritional status of vulnerable segments of population of India. According to him beneficiaries selected for such welfare programmes were mostly preschool children belonging to low socio - economic group.

Patel <u>et al</u>. (1980) concluded that mild malnutrition can be corrected with appropriate nutritional supplementation. Kardonsky <u>et al</u>. (1981) had reported that the supplementary feeding programme in day care centres appeared to compensate for deficiencies in the nutritional status of socially and economically deprived children.

Bealon and Ghassemi (1982) had also reported that the important and direct effect of supplementary programme considered was the reduction in the mortality and morbidity in the preschool children. While Kielman (1982) had reported that the nutritional supplementation to preschool children were found to reduce significantly the mortality in the weaning age group.

According to a report in 1974 bread is now accepted as a part of school feeding and other nutrition supplementation programmes. Biscuits are not yet in common use. Most important factor against the use of biscuits in these programmes is their cost per kg.

Walter et al. (1993) reported that a selected group of children was supplied with 3 to 10 g cookies per child per day with 6 per cent bovine haemoglobin concentrate designed to provide 1 mg bioavailable iron per day. It is concluded that haem, iron - fortified cookies are a feasible and effective way to improve the iron status of school age children. In region of high prevalence of iron - deficiency anaemia, the effect of a haem - fortified cookie programme should be even more important.

The results of a study done by Zentgraf and Stellar (1983) about breakfast and school breakfast of school children show that bread and rolls, hearty spreads and fruits are playing the most important role in these meals. Most important thing seems that the children prefer to get their snacks ready - made from their parents.

In Jamaica, the Government has given high priority to a National Nutrition policy aimed at improving the diets of school children and the health and well being of malnourished children. To accomplish their goals, soyaflour is being imported to produce baked roll for daily mass distribution to the nations schools. Corn soyablend, soya fortified bulgar wheat and soyafortified corn meal are also imported for distributing to government health clinics. (Bookwalter, 1982).

Raheena Begum (1991) reported that under the special nutrition programme (SNP), special sweet bread and special milk bread were given to selected beneficiaries to supplement their diet with additional protein and calories to make up the deficiency in their daily food intake.

MATERIALS AND METHODS

MATERIALS AND METHODS

The study on "Improvement of the nutritional quality of bread" provides comprehensive information on nutritional, shelflife and organoleptic qualities of bread developed by replacing maida partially by soya flour, tapioca flour and milk powder in different proportions with variations in the fermenting time. The feasibility of introducing this product as a supplementary food for nutrition intervention programme was also tested.

3.1 Plan of Action

Plan of action of study comprised of

(i) Standardisation of different combinations of bread.

(ii) Ascertaining the overall acceptability of fresh bread.

(iii) Determining the shelflife qualities.

Based on the findings of nutritional composition, overall acceptability, baking characteristics and shelflife qualities of the eight combinations of bread, bread composed of maida (90 per cent) and soya flour (10 per cent) with fermentation time one and half hours was selected as the most ideal combination. Further study was conducted on this selected combination viz.,

(iv) Nutritional quality of bread through laboratory experiments.

(v) Protein quality of bread through animal experiments.

(vi) Quality of bread as a food supplement through feeding trials for 6 months on preschoolers.

3.2 Conduct of the study

3.2.1 Standardisation of different combinations of bread

Bread is generally made of maida. In the present study the different combinations of bread tried were supplying 13.3 g to 15.84 g of protein per 100 g. The different combinations of bread tried were :

Formulation No.	Ingredients	Fermentation time (hours)
F1a	Maida (100 g)	1 1/2
F1b	Maida (100 g)	3
F2a	Maida (90 g) + Soya flour (10 g)	1 1/2
F2b	Maida (90 g) + Soya flour (10 g)	3
F3a	Maida (80 g) + Soya flour (10 g) + Tapioca flour (10 g)	1 1/2
F3b	Maida (80 g) + Soya flour (10 g) + Tapioca flour (10 g)	3
F4a	Maida (70 g) + Soya flour (10 g) + Tapioca flour (10 g) + Skimmed milk powder (10 g)	1 1/2
F4b	Maida (70 g) + Soya flour (10 g) + Tapioca flour (10 g) + Skimmed milk powder (10 g)	3

Fig. 1 to Fig. 4 explain the procedures observed while baking bread.

When bread is leavened chemically, without fermenting, the resulting flavour is substantially different from that which is identified as white bread flavour. When the fermentation period is lengthened under proper conditions, flavour level of the white bread is also reported to increase.

Fig. 5 and 6 present the products of eight combinations fermented for 1 1/2 hours and 3 hours.

3.2.2 Over all acceptability of fresh bread

Based on the baking characteristics and organoleptic qualities, over all acceptability of the different combinations of bread were ascertained. Baking characteristics of the eight combinations were ascertained by the procedures given by AACC (1982). The baking characteristics ascertained were:

FIG.1-4 - THE PROCEDURES OBSERVED WHILE BAKING BREAD

FIG.1 - MIXING

FIG.2 - FERMENTING

FIG.3 - PANNING

FIG.4 - BAKING

FIG.5 - PRODUCTS FERMENTED FOR 1 1/2 HOURS

FIG.6 - PRODUCTS FERMENTED FOR 3 HOURS

Sl.No.	Baking Characteristics	Details of figures
i)	Colour, texture and weight of the food mixture.	Chromaticity chart indicating the colour variation in 8 combinations. (Fig.7)
ii)	Colour, texture and weight of the dough.	
(iii)	Water absorption	Equipment (Farinograph) used for testing water absorption rate. (Fig.8)
(iv)	Acidity and moisture of the dough.	
(v)	Kneading quality	
(vi)	Rate of dehydration	
(vii)	Puffing rate	Measuring the puffing rate of bread. (Fig.9)
(viii)	Baking loss	
(ix)	Baking time	
(x)	Porous nature	Porous nature of 8 combinations of bread. (Fig.10)
(xi)	Loaf volume and cost	Measuring the loaf volume by rape seed displacement method. (Fig.11)

Through a triangle test, two panels consisting of 10 members each were selected for the sensory evaluation studies; one panel consisted of experts in the field and the other consumers. The acceptability trials were done by using a score card. Two different score cards were used for the two panels. [Appendix I].

TITLE : BLENDS

DATE : 30/06/93

SAMPLE : FLOUR

OPERATOR : CIL&S

SLIT : 5.0nm   SPEED : FAST   ILLUMINANT : C   VIEW ANGLE : 2°

No.	CH1 C	CH2 C'	CH3 1	CH4 1'	CH5	STD WHITE
X	83.842	84.966	76.599	76.184		98.087
Y	85.614	86.810	78.026	77.596		99.993
Z	87.511	89.052	76.665	75.641		118.268
x	0.3263	0.3258	0.3312	0.3321		0.3101
y	0.3332	0.3328	0.3374	0.3382		0.3161
L	92.528	93.172	88.332	88.089		99.996
a	-0.181	-0.271	0.208	0.221		0.098
b	8.694	8.552	10.374	10.750		-0.126
ΔE	11.561	11.046	15.695	16.128		0.000
ΔL	-7.469	-6.825	-11.664	-11.908		0.000
Δa	-0.279	-0.369	0.110	0.123		0.000
Δb	8.820	8.678	10.501	10.876		0.000
W	74.122	75.427	64.935	64.068		100.173

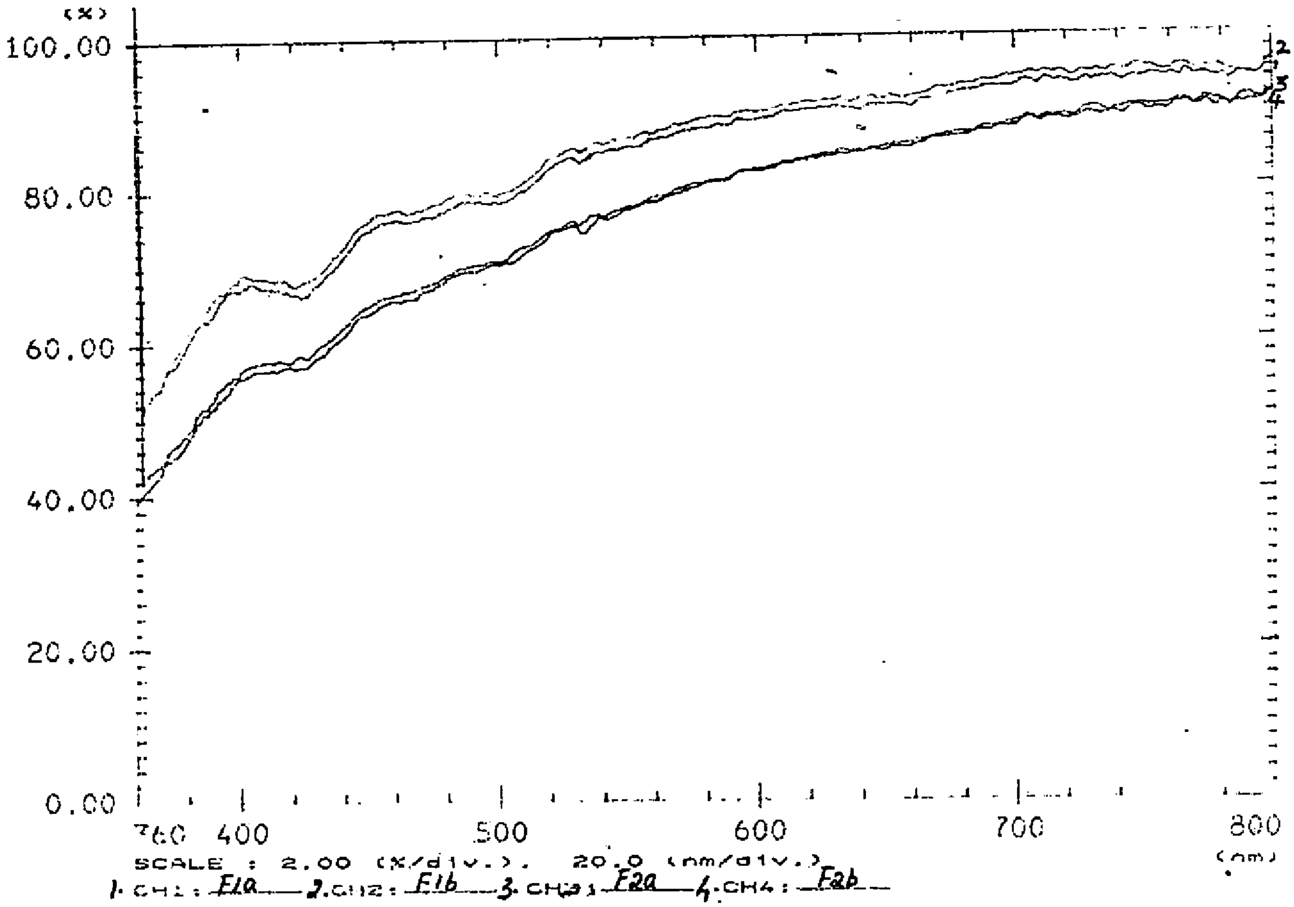


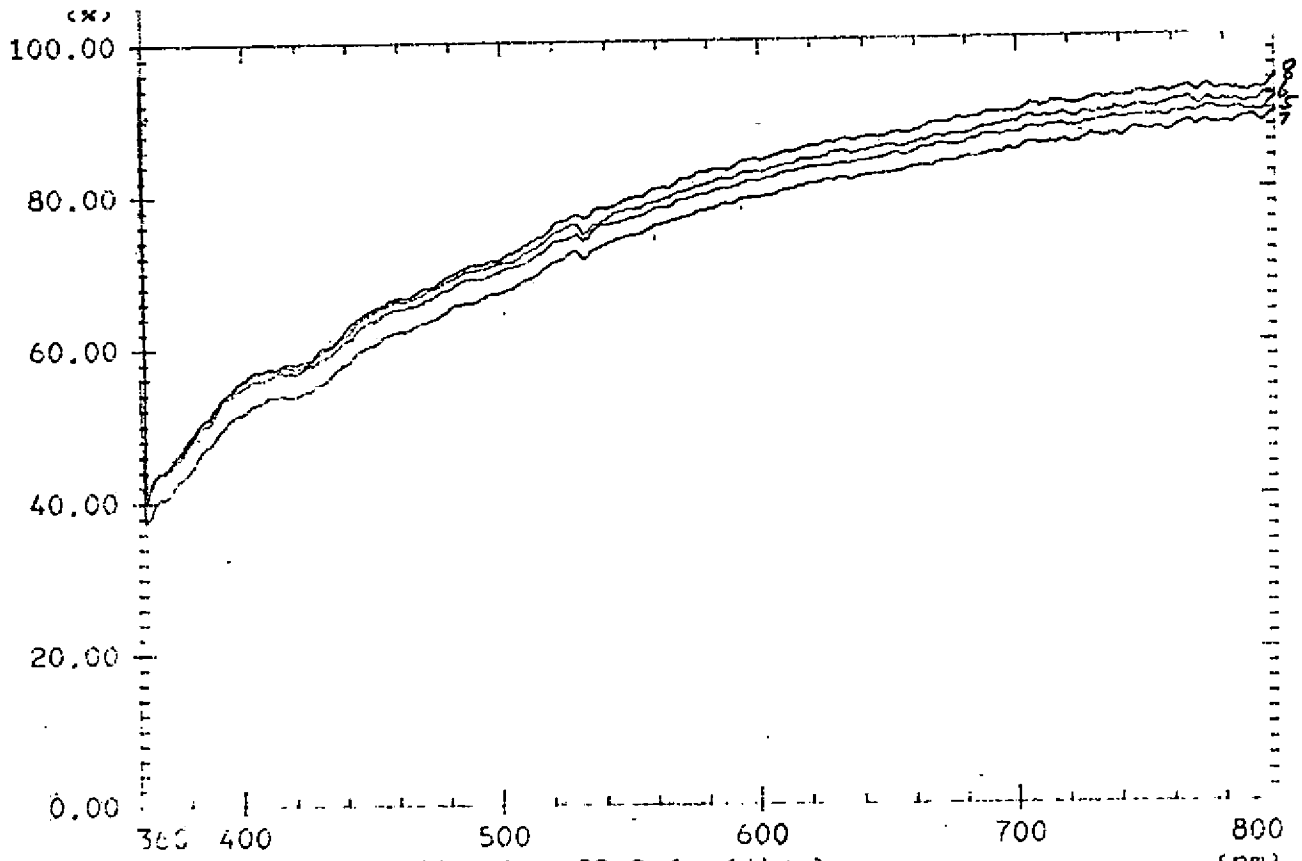
FIG.7 - CHROMATICITY CHART INDICATING THE COLOUR VARIATION IN 8 COMBINATIONS.

TITLE : BLEND — DATE : 30/06/93

SAMPLE : FLOUR — OPERATOR : CIL&S

SLIT : 5.0nm — SPEED : FAST — ILLUMINANT : C — VIEW ANGLE : 2°

No.	CH1 2	CH2 2'	CH3 3	CH4 3'	CH5	STD WHITE
X	75.745	76.946	73.441	78.146		98.087
Y	77.137	78.362	74.832	79.634		99.993
Z	75.287	76.523	71.725	76.977		118.268
x	0.3320	0.3319	0.3338	0.3329		0.3101
y	0.3381	0.3380	0.3401	0.3392		0.3161
L	87.827	88.522	86.506	89.238		99.996
a	0.245	0.243	0.157	0.146		0.098
b	10.655	10.712	11.394	11.322		-0.126
ΔE	16.259	15.784	17.741	15.710		0.000
ΔL	-12.169	-11.474	-13.491	-10.759		0.000
Δa	0.147	0.145	0.059	0.049		0.000
Δb	10.781	10.838	11.520	11.448		0.000
W	63.768	64.815	60.751	65.200		100.173

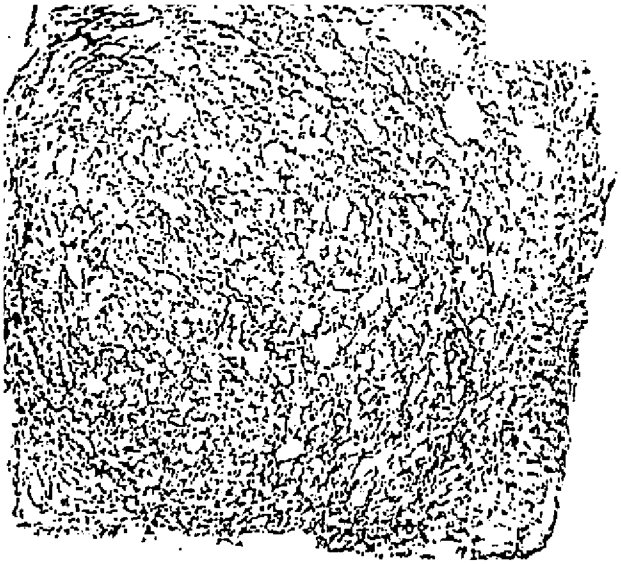


SCALE : 2.00 (%/div.). 20.0 (nm/div.)

5. CH1 : E3a 6. CH2 : E3b 7. CH3 : E4a 8. CH4 : E4b

FIG.8 – EQUIPMENT USED FOR TESTING WATER ABSORPTION

FIG.9 – MEASURING THE PUFFING RATE OF BREAD



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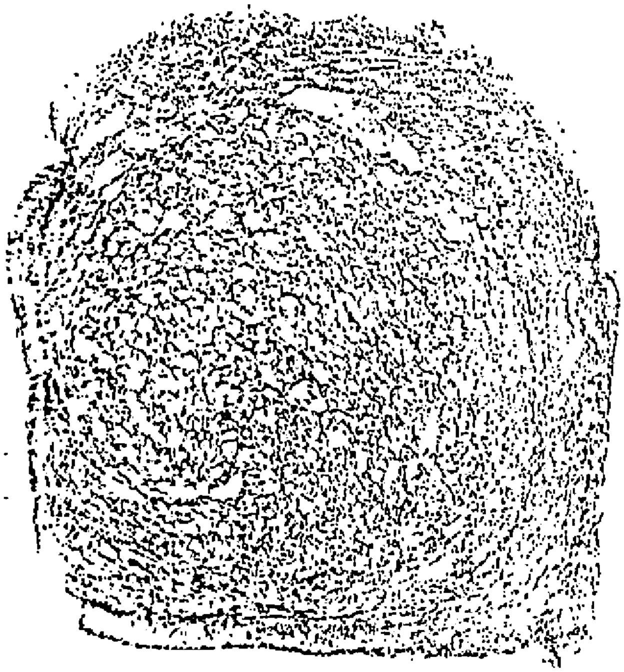
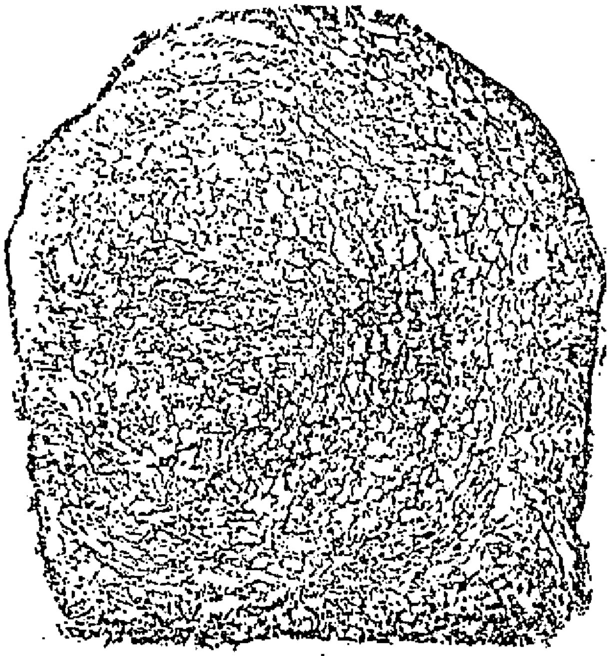


Fl-

Fla

F1b

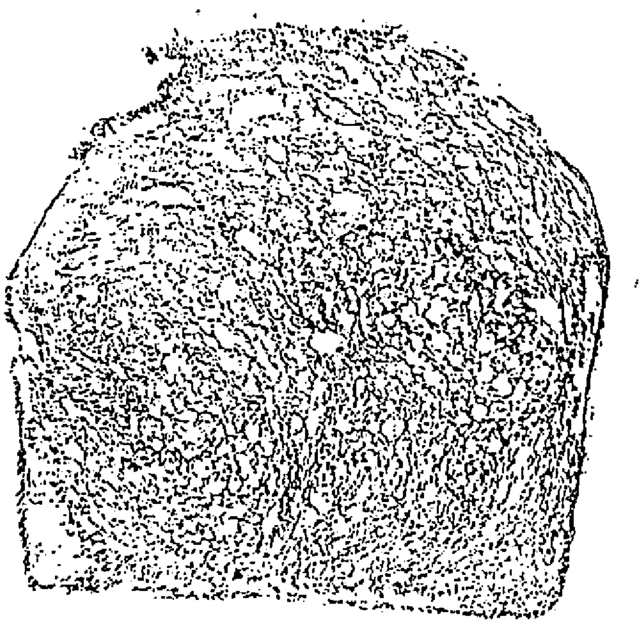


F1b

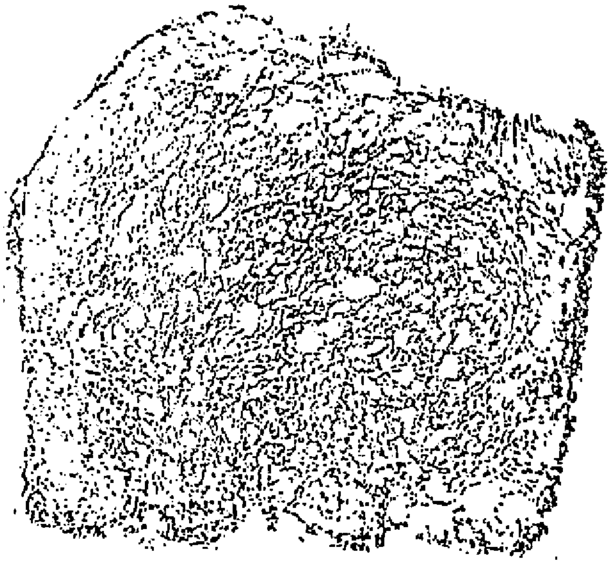
F1b

F2a

F2a



F2a



F2b

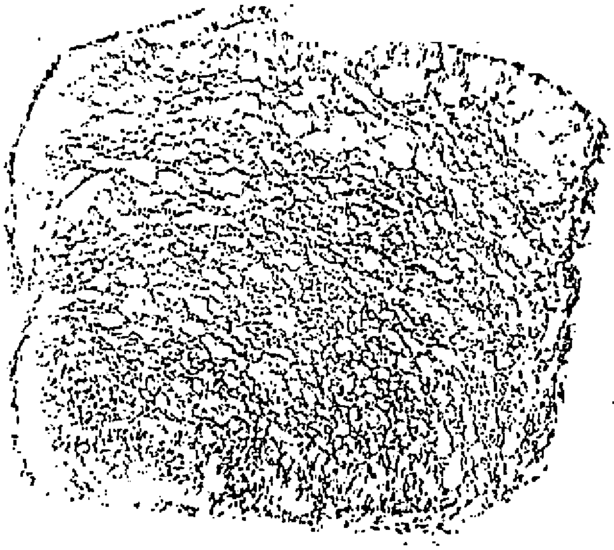
F2b

F2b

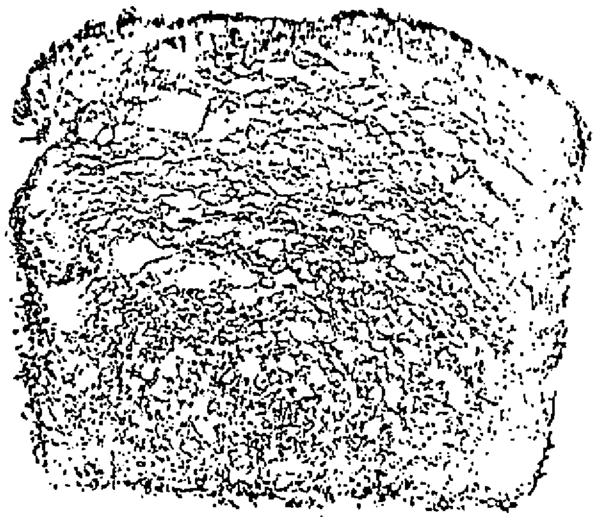
F3a

F3a

F3a



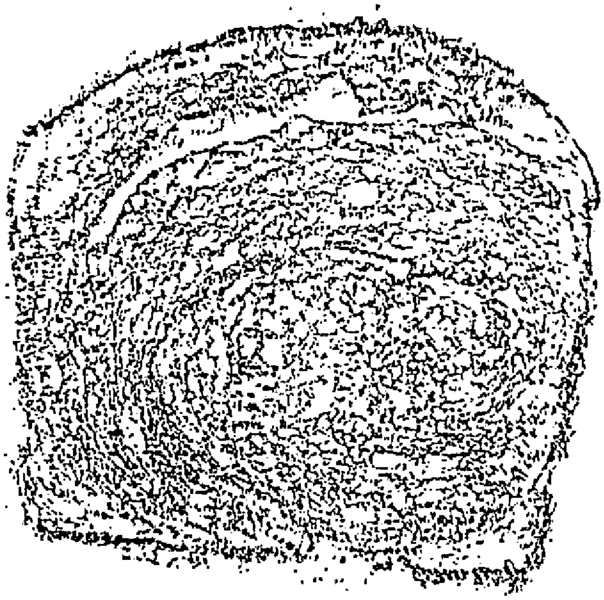
F3b



F3b

F3b

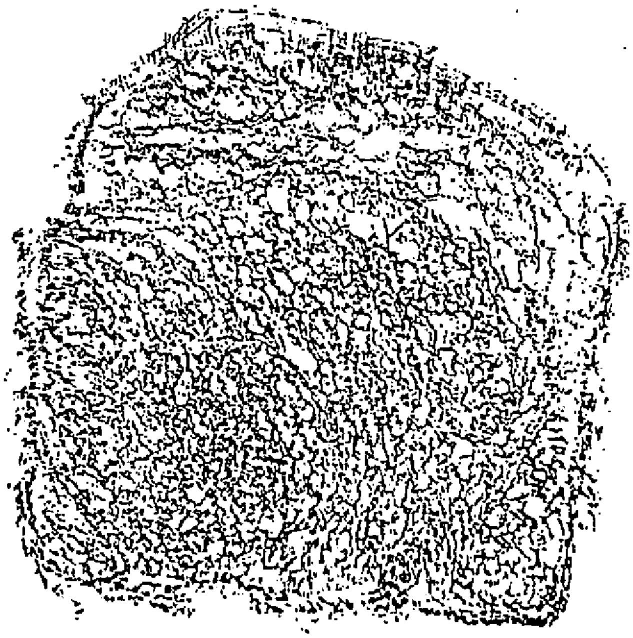
F4a



F4a

F4a

F4b



F4b

F4b

FIG.11 - MEASURING THE LOAF VOLUME BY RAPE SEED DISPLACEMENT METHOD

The major quality attributes included in the score card for consumers were appearance, masticability, flavour, texture, taste and doneness on a five point hedonic scale. The score card developed for experts in the field consisted of 3 sections viz., external, internal and organoleptic. The external characters assessed were presentation (general appearance), crust colour and shape. The internal characters assessed included crumb colour, crumb texture, thickness of cellwall and size of the grain in the crumb. The organoleptic characters ascertained included aroma (flavour), masticability, taste and over all acceptability.

The testing was conducted in the afternoon between 3 and 4 pm, since this time was considered as the ideal time for conducting the acceptability studies (Swaminathan, 1974).

3.2.3 Nutritional composition of the different combinations of bread

The nutritional quality of different combinations of bread were computed using the food composition tables of ICMR (1991).

3.2.4 Shelflife qualities

The shelflife qualities of the eight combinations of bread were ascertained by monitoring the quality attributes like stale odour, crumbling nature and change in colour and texture using a score card [Appendix II]. Microbial status of the different combinations of bread were estimated by serial dilution technique.

Based on the above assessment one combination of bread with maida (90 per cent) + soya flour (10 per cent) with fermentation time of 1 1/2 hours was selected for detailed studies.

3.2.5 Nutritional quality of selected combination of bread through laboratory estimation

The nutritional quality of the selected combination was ascertained by estimating major nutrients following internationally accepted methods, as indicated below:

SL. No.	Estimations	References
(i)	Calories	Swaminathan (1984)
(ii)	Protein	Hawk and Oser (1965)
(iii)	Iron, Calcium, Magnesium	Jackson (1973)
(iv)	Lipids	AOAC (1960)
(v)	Crude fibre	Chopra and Kanwar (1978)
(vi)	Ash	AOAC (1960)

3.2.6 Protein quality of the selected combination through animal experiment

The Protein Efficiency Ratio (PER) which measures the weight gain per gram of protein eaten was determined according to the rat growth method of Osborne, Mendel and Ferry (1919). Weanling male albino rats (Sprague Dawley Strain) of 28 days of age were used for the experiment. Animals of more or less identical weights (40 to 50 g) were selected and divided into two groups of 6 rats each and fed the respective diets as detailed in Appendix III. The rats were housed in individual cages with wire mesh floor (Fig. 12). Daily 15 g of bread was fed to the animals. Water was also provided. The left over food was collected daily and were dried and weighed. The food consumption was calculated by substracting the left over from the quantity served. The body weights of the animals were recorded once in 3 days during the experimental period (Fig. 13). During the experimental period conditions were maintained as uniform as possible. The rats were maintained on the respective diets for 28 days. The PER was calculated using the formula:

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

The extent of utilisation of proteins of the combination selected was also estimated. The net protein utilisation values were found out by standard experimental procedures suggested by Mitchell (1923 to 24).

Male albino rats weighing 100 to 120 g were divided into two groups of two each. The animals were housed in individual metabolic cages (Fig. 14). The whole experiment was divided

FIG.12 - RATS HOUSED IN A CAGE FOR THE PER STUDY

FIG.13 - WEIGHING OF RATS IN THE TRIPLE BEAM BALANCE

FIG.14 – RAT HOUSED IN A METABOLIC CAGE FOR NITROGEN BALANCE STUDY

in to three periods. During the first period of 4 days all the rats were fed with nonprotein diet to measure the endogenous nitrogen. The composition of nonprotein diet is given in Table 1.

Table 1

Composition of Nonprotein diet and Stock diet. (In percentage)

Ingredients	Nonprotein diet	Stock diet
Starch (g)	85	80
Groundnut Oil (ml)	9	9
Mineral mix (ml)	4	4
Vitamin mix (ml)	2	2
Casein (g)	-	4

During the second period of two days the rats were fed with Stock diet. During the third period of 4 days the rats in one group is fed with the experimental diet and the other one with standard diet. The animal were given 15 g of bread. The amount of food given, the quantity of left over food and actual consumption were recorded every day. During the first and third periods of the experiment, stools and urine samples were collected. Two drops of toulene were added to the urine samples as a preservative. Stools collected were dried in the oven. The stools of each group collected for 3 days were pooled together for nitrogen estimation. Urinary and faecal nitrogen were estimated by the microkjeldahl method (Hawk and Oser, 1965). The nitrogen content of the food mixtures were also estimated using the same procedure. Using the above value,Biological value

(BV), Digestibility Co-efficient (DC), Food Efficiency Ratio (FER) and Net Protein Utilisation (NPU) were calculated using the following formulae:

$$BV = \frac{In - (Fn - Fe) - (Un - Ue) \times 100}{In - (Fn - Fe)}$$

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

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

$$FER = \frac{\text{Gain in body weight} \times 100}{\text{Food intake}}$$

BV = Biological value

DC = Digestibility Co-efficient

NPU = Net Protein Utilisation

Fn = Nitrogen in faeces

Fe = Endogenous faecal nitrogen

Un = Nitrogen in urine on protein diet

Ue = Nitrogen in urine on protein free diet

In = Nitrogen intake

3.2.7 Feeding trials for 6 months on preschoolers to find out the impact of the selected combination on their nutritional status

The feeding trial was conducted on about 15 preschoolers for 6 months. Every day bread was made at the laboratory and was fed to preschool children under the direct supervision of the investigator (Fig. 15). Records of the daily attendance and food intake were maintained. Before starting the feeding trials, anthropometric measurements were taken since anthropometry has been accepted as an important tool for assessment of nutritional status, particularly of growing childern by Vijayaraghavan (1987). According to Chen et al. (1978) anthropometric measurements are internationally accepted system for classifying protein energy malnutrition and it will accurately portray the nature, severity and prevalence of the problem. In this study, body weight, height, upper and lower arm circumference and chest circumference were measured.

According to Swaminathan (1986) clinical examination is the most important part of the nutritional assessment as a direct information of signs and symptoms of dietary deficiencies prevalent are obtained. In the present study the investigator with the help of a qualified physician assessed the clinical symptoms of malnutrition among the selected preschoolers before starting the actual feeding trial.

Anthropometric measurement of all preschoolers were carried out before and after the experiment was over and the clinical examination was conducted at the beginning and completion of the feeding programme. The height of the preschool children is measured and the height is a measurement of long

FIG.15 - FEEDING TRIALS IN PRE SCHOOL CHILDREN

standing nutritional status. The procedure is presented in Appendix IV.

The weight of the childern were weighed wearing very light clothes and the weight was measured using a weighing balance (Fig. 16).

The upper and lower arm circumference were also measured by using a tape. The chest circumference were also measured (Fig. 17).

3.2.8 Statistical analysis

Data collected were statistically analysed as detailed below:

(i) Baking characteristics, organoleptic and shelflife qualities of the different combinations were ascertained by Analysis of variance (ANOVA).

(ii) Paired t-test is applied to:

(1) To find the nutritional quality of the selected formula.

(2) To find the significance of increase in anthropometric measurements of the experimental group after the feeding trial.

(iii) Students t-test is applied to compare the anthropometric measurements of the experimental group with the ICMR standards.

FIG.16 - WEIGHING CHILDREN USING A WEIGHING BALANCE

FIG.17 – MEASURING CHEST CIRCUMFERENCE USING A MEASURING TAPE

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

In this chapter, salient findings of the study entitled "**Improvement of the nutritional quality of bread**" are presented under

4.1. Standardisation of different combinations of bread

4.2. Assessment of their -
- Nutritional composition
- Baking characteristics
- Organoleptic qualities

and

- Shelflife qualities

4.3. Assessment of the nutritional quality of the selected combination of bread.

4.4. Suitability of selected combination as a supplement for nutrition intervention programmes.

4.1 Standardisation of different combinations of bread

Maida is the basic ingredient for preparing bread. In this experiment, different percentages of maida were replaced by soya flour, tapioca flour and skimmed milk powder to improve the quality of food mixture used for making bread. While formulating different combinations of bread, care was taken to incorporate tapioca flour to reduce the price and defatted soya flour and skimmed milk powder to reach 14 per cent protein. Details pertaining to major food materials used to formulate four formulations (eight combinations) of bread are presented in

Table 2. One set of food mixtures of 3 formulations (2a, 3a and 4a) were fermented for 1 1/2 hours along with one control sample (1a) while another set of same formulations (2b, 3b and 4b) and one control sample (1b) were given 3 hours fermentation. The flow chart for bread making are presented in Fig. 18.

Amino acid scores provide an useful estimate of the protein quality of blended foods and are an acceptable substitute for the biological assays. Therefore the aminoacid scores of the different combinations of bread were worked out using the food composition tables of ICMR (1991). With these values, chemical score for each combination was computed using the ratio of the most limiting aminoacid in the test protein to the same aminoacid in the egg protein expressed as percentage.

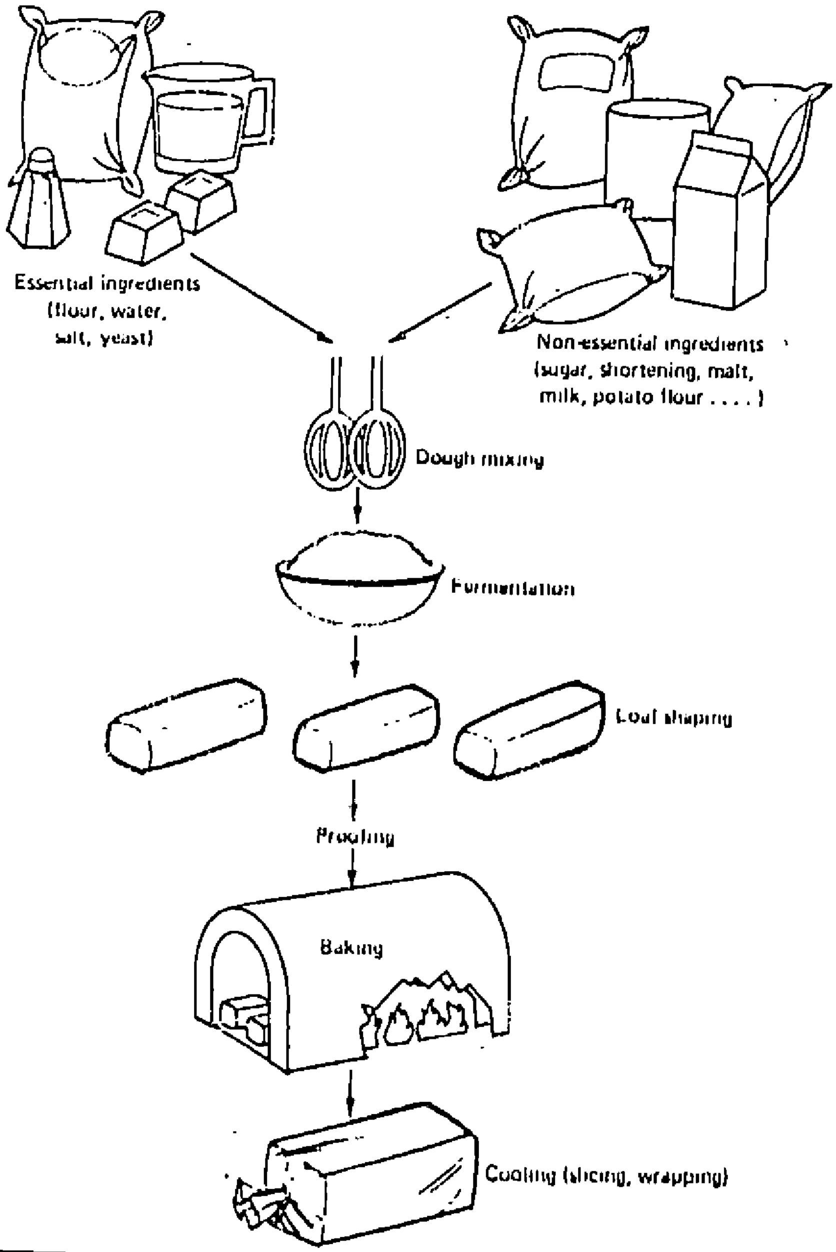


FIG.18 - FLOW CHART OF BREAD MAKING PROCESS

Table 2

Percentage composition of food ingredients used in different formulations of bread

Food Ingredients	Different combinations of bread							
	F1a	F1b	F2a	F2b	F3a	F3b	F4a	F4b
Maida	100	100	90	90	80	80	70	70
Soya flour	-	-	10	10	10	10	10	10
Tapioca flour	-	-	-	-	10	10	10	10
Skimmed milk powder	-	-	-	-	-	-	10	10
Chemical Score	66.67	66.67	66.35	66.35	64.78	64.78	63.87	63.87

F1a, F1b - Maida alone (100 per cent)

F2a, F2b - Maida:Soya flour (90:10)

F3a, F3b - Maida:Soya flour:Tapioca flour (80:10:10)

F4a, F4b - Maida:Soya flour:Tapioca flour:Skimmed milk powder (70:10:10:10)

Fermentation time for 1a, 2a, 3a and 4a were 1 1/2 hours.

Fermentation time for 1b, 2b, 3b and 4b were 3 hours.

As indicated in Table 2, the selected food components in the bread formulae in order of their priority were maida, soya flour, tapioca flour and skimmed milk powder. Maida was added in proportion of 70 to 100 per cent in different combinations of bread formulae while soya flour, tapioca flour and skimmed milk powder at 10 per cent level was added. Soya flour was added to all the three combinations (except control). Tapioca flour to two different formulae (third and fourth) and skimmed milk powder to one formula (fourth) were also added. Formulae worked out as first (1a and 1b) consisted of maida alone (100 per cent).

In the formulae listed as 2a and 2b, 10 per cent maida was replaced by soya flour resulting in a ratio of 90:10 while in the formulae listed as 3a and 3b, 20 per cent maida was replaced by 10 per cent soya flour and 10 per cent tapioca flour (80:10:10). In the formulae 4a and 4b, 30 per cent maida was replaced by 10 per cent soya flour, 10 per cent tapioca flour and 10 per cent skimmed milk powder in the ratio of 70:10:10:10. In the above formulae, variations between 1a and 1b, 2a and 2b, 3a and 3b and 4a and 4b were in fermentation time.

One of the major criteria for selecting the ideal formula for bread making was the chemical score of the food mixtures used. As revealed in Table 2, the chemical score of the formulae were found to decrease with the replacement of maida by other food ingredients. Among the different combinations tried, 2a and 2b (maida : soya flour in the ratio of 90:10) with varying fermentation time of 1 1/2 and 3 hours respectively were found to give the highest chemical score of 66.35.

4.2 Assessment of the nutritional composition of different combinations of bread.

The nutritional composition of the bread formulae developed were assessed using food composition tables of ICMR (1991). The calorie, protein, mineral and Vitamin content of the four formulations of bread worked out are presented in Table 3.

Table 3

Nutritional composition of different bread formulae

Nutrients per 100g	Different combinations of bread			
	F 1	F 2	F 3	F 4
Protein (g)	11.00	14.20	13.19	15.84
Fat (g)	0.90	2.76	2.70	2.61
Calorie (kcal)	348.00	356.00	337.00	339.00
Calcium (mg)	23.00	44.70	47.40	173.00
Iron (mg)	2.70	3.47	3.29	2.80
Niacin (mg)	2.40	2.48	2.27	2.13
Thiamine (mg)	0.12	0.18	0.17	0.21
Riboflavin (mg)	0.07	0.10	0.12	0.26
Vitamin A (mcg)	25.00	65.10	62.60	60.10

As seen in Table 3, the protein content of the flour of the four bread formulae (including control) were in the range of 11 g to 15.84 g. Soyaflour has contributed significantly to the protein content of formula 2 as reported by Nikolic and Salihodzic (1988) that addition of soyaflour generally increases the protein content. The protein content of formula 4 was high (15.84 g) when compared to the other combinations mainly because of skimmed milk powder which has more protein content than maida. In similar studies conducted by Campagnoli (1966), it has been stated that the addition of casein to bread permits to improve the nutritional value of this food and to prepare a food of protein content similar to meat both quantitatively and qualitatively.

The calorific value was in the range of 348 kcal to 356 kcal per 100 g of food mixture. Vitamin A content was in the range of 25 to 66 mcg. The calcium content was in the range of 23 mg to 173 mg and iron 2.70 mg to 3.47 mg per 100 g. Replacement of 10 per cent maida by soyaflour in second, third and fourth formulae enhanced all the nutrients in the food mixture. Maida was richer in iron, fat and Vitamin A content when compared to tapiocaflour and skimmed milk powder. Hence the Iron, Fat and Vitamin A content of the formula 2 was high. The Calcium content of the formula 4 was found to be high (173 mg) when compared to all other combinations mainly because of skimmed milk powder. According to Johnson <u>et al</u>. (1985) soyabean hulls are a good source of available iron and hence addition to bakery product enhance the nutritional value, without deleterious effects in baking performance.

For selecting the formula, nutrients such as Protein, Calorie and Vitamin A were considered. Among the different combinations, formula 2 was found to have more calories and Vitamin A. Eventhough the protein content of formula 2 (14.2 g) was found to be less than the formula 4 (15.84 g) due to the absence of skimmed milk powder. As found out, the calorific value of second formula was high (356 kcal). According to Tsen and Hoover (1973) fortifying wheatflour with soyaflour in making bread raises the protein content, balancing essential aminoacids and increasing the bread calorific value. However, the chemical score for second formula was higher (66.35) than the fourth formula (63.87) as soyabean was reported to be a good source of essential aminoacids except for methionine and tryptophan and the high lysine content of soyabean proteins can complement lysine deficient flour proteins. [Wolf,(1969); Abdel et al, (1980) and Sinha et al, (1993)].

4.2.2 Assessment of the baking characteristics of different combinations of bread

Baking characteristics of food mixture, dough and bread were ascertained as detailed below:

(i)	Food mixture	- Colour, texture and weight of food mixture.
(ii)	Dough	- Water absorption, moisture, acidity, kneading quality, colour, texture and weight of the dough.
(iii)	Bread	- Puffing rate, loaf weight, loaf volume, rate of dehydration, porous nature and cost.
(iv)	Process of baking	- Baking time and baking loss.

(1) Food mixture

Observation of colour, texture and weight of the food mixture as well as the dough made from the food mixture indicated that these factors may have an influence upon the colour, texture and weight of the final product - bread. It was also observed that incorporation of toasted soyaflour resulted in the darkening and coarse texture of the bread crumb probably due to the bleaching action of lipoxygenase enzyme in the soyaflour. Similar results were reported by Sinha et al. (1993) who has further reported that as the level of soyaflour increased, the crumb colour of the bread darkened and the crust colour became less brownish progressively. The colour of the food mixture was found out using Schimadzu UV - 2100. The value obtained for different blends were compared with the standard white. More the value for the colour, the brighter will be the flour. It was found that the scores for control were more compared to other combinations (74.122 and 75.427) indicating that it is more whiter than the rest. The control was followed by the formula 2 (64.935 and 64.068) followed by formula 3 (63.768 and 64.815) and formula 4 (60.751 and 65.200). The value for standard white was 100.173.

Texture of the food mixture was found out by scoring method. The parameters for scoring texture was in the range of fine powder (3), slightly fine powder (2), coarse powder (1) and powder with lumps (0). It was observed that all the combinations were given the maximum score of 3 indicating that all the food mixtures were in the form of fine powder.

The weight of the food mixture was found to be constant (100 g). For preparing bread, 100 g each of the food mixture was taken.

(ii) Dough

Under this water absorption, moisture, acidity, kneading quality, colour, texture and weight of the dough were ascertained. Baking characteristics pertaining to water absorption and moisture were presented in Table 4.

Table 4

Baking characteristics of the different combinations of bread with reference to water absorption and moisture

Baking characteristics	Different Combinations of bread					Correlation coefficient
	F 1	F 2	F 3	F 4	CD	
Water absorption (ml)	56.35	63.40	60.80	59.60	0.088	
Protein (g)	11.00	14.20	13.19	15.84		0.580*
Moisture of the dough (per cent)	10.72	11.90	10.90	10.40	0.081	

* : Significant at 5 per cent level.

Among different combinations, formula 2 was found to have highest water absorption of 63.40 ml followed by formula 3 (60.80 ml) and formula 4 (59.60 ml) compared to control (formula 1). For control, the water absorption was found to be 56.35 ml. The water requirement increased in formulae 2,3 and 4 probably because of the higher proportion of protein content. Eventhough the protein content of the formula 4 was high, the rate of water absorption was less than the formulae 2 and 3 probably because of the hygroscopic nature of skimmed milk powder. Hanslas and Sangeeta sikri (1989) have also reported that protein content of a food mixture is a major determinant of its water absorption. In this experiment, it was observed that addition of soyaflour enhanced the rate of water absorption. Statistical analysis of the data revealed that a highly significant difference existed between the four different formulations of bread tried viz; 100 per cent maida; maida : soya flour in the proportion of 90:10; maida : soya flour : tapioca flour in the ratio of 80:10:10 and maida : soya flour: tapioca flour: skimmed milk powder in the ratio of 70:10:10:10. Details pertaining to this are presented in Appendix V.

An association between protein content of the flour mixture and the rate of water absorption of this flour mixture were tested statistically to find out the significance of association. Table 4 also presents the association between protein and water absorption. Statistical analysis of the data revealed that there was a direct association between protein and rate of water absorption by each formula. Similar findings were reported by Hanslas and Sikri (1989).

The moisture of the dough was found to be highest in the formula 2 (11.90) followed by formula 3 (10.90) and formula 4 (10.40). The moisture content of the control was between formula 3 and formula 4 (10.78). It was also revealed that a high significant difference existed between the four formulations of bread tried. Krishnakumar and Phoolka (1990) in their experiment had observed similar properties.

An association between the rate of water absorption and loaf volume of bread were tested statistically to find out the significance of association.

Table 5

Influence of rate of water absorption upon loaf volume of different combinations of bread

Combinations	Water absorption ml	Loaf Volume cc	Correlation coefficient
F1a	56.35	652.00	
F1b	56.35	686.25	
F2a	63.40	538.75	
F2b	63.40	602.50	-0.3490
F3a	60.80	446.25	
F3b	60.80	433.75	
F4a	59.60	344.25	
F4b	59.60	353.75	

[illegible] : [illegible]

As revealed in the Table 5, a negative correlation exist between the rate of water absorption and loaf volume.

Details pertaining to acidity and kneading quality are presented. in Table 6.

Table 6

Baking characteristics with reference to acidity and kneading quality

Baking characteristics	Different combinations of Bread				C D
	F 1	F 2	F 3	F 4	
Acidity of the dough (per cent)	Ø.146	Ø.178	Ø.171	Ø.147	Ø.Ø16
Kneading quality (Score)	1	2	2	3	

Acidity of the dough was ascertained by the procedure given by AACC (1982) and the results showed that the acidity of formula 2 was highest (Ø.178) followed by third formula (Ø.171) and formula 4 (Ø.147). Compared to these formulae, the acidity level for formula 1 (control) was only Ø.146. The acidity of formula 4 was negetively influenced by the inclusion of skimmed milk powder as it acts as a buffer. Similar findings were reported by Chaturvedi (1977) in his experiments on adding milk and milk products to bread.

Statistical analysis of the data revealed that a highly significant difference existed between the four different formulations tried while the difference between the second and third formulations was on par and also the difference between the fourth and the first formulation was on par. Details pertaining to this are presented in Appendix V.

Kneading quality of the flour is the quality of flour with optimum water absorption to form a stable and elastic dough of proper handling properties by kneading action.

Kneading quality was ascertained by scoring method. The parameters for ascertaining the kneading quality were of different grades as in the range of not at all sticky (3), not sticky (2), slightly sticky (1) and sticky (Ø). It was observed that formula 4 has got the maximum score of 3 probably because of the inclusion of skimmed milk powder which resulted in the faster absorption of water. Second and third formulae had a score of 2 whereas formula 1 was found to be slightly sticky with a score of 1. The control was found to be slightly sticky than formulae 2 and 3 probably because of the presence of soyaflour. Similar findings were reported by Sinha et al. (1993). Among the different formulations, formula 4 had the maximum score.

Baking characteristics of bread with reference to colour, texture and weight of the dough were presented in Table 7.

Table 7

Baking characteristics with reference to colour and texture of different combinations of bread

Baking characteristics	Different combinations of bread			
	F 1	F 2	F 3	F 4
Colour of the dough (score)	3	2	2	1
Texture of the dough (score)	4	5	2	1

Colour and texture of the dough was determined by scoring. The parameters for scoring colour of the dough was in the range of creamish white (3), brownish white (2), brown (1) and dark brown (Ø). For ascertaining the quality of the texture, the scores given were in the range of soft and not sticky (5), soft and slightly sticky (4), soft and sticky (3), slightly hard and not at all sticky (2), slightly hard and not sticky (1) and hard and sticky (Ø). It was observed that for formulae 2 and 3, same scores (2) were obtained for colour while for formula 4, the score for colour of dough was 1 and in the case of formula 1 (control) the score was found to be 3. In comparison with the colour of dough of formulae 2,3 and 4, the colour of the dough of control was creamish white as it contained maida alone. Addition of other food ingredients had negatively affected the natural colour of maida, which is an important parameter in determining the acceptability of the product.

The score for texture of the dough was found to be maximum in the case of formula 2. The dough was found to be soft and not sticky whereas the texture of the dough of formula 3 was found to be slightly hard and not at all sticky and was given a score of 2 while for formula 4 the score was 1. The score for formula 1 was found to be 4 as it was found to be soft and slightly sticky. As reported by Sinha et al. (1993) the dough containing raw soyaflour was sticky and difficult to handle compared to toasted soyaflour.

Association between protein content of the flour mixture and the texture of the bread made from this flour mixture was tested statistically to find out the significance of association.

Table 8

Influence of protein content upon the texture of the different combinations of bread

Combinations	Protein (g)	Texture (score)	
		FT 1 1/2 (hours)	3 (hours)
F 1	11.00	5.00	5.00
F 2	14.20	4.00	4.00
F 3	13.19	2.90	2.50
F 4	15.84	1.60	1.50
Correlation coefficient		-0.860**	-0.817**

** : Significant at 1 per cent level

FT : Fermentation Time

Table 8 shows that, though statistically significant a negative correlation existed between the protein content and texture of the different combinations of bread.

Table 9

Baking characteristics with reference to the weight of the dough of different combinations of bread

Different combinations of bread	Weight of the dough(g)	CD
F1a	161.88	
F1b	161.29	
F2a	168.10	
F2b	168.91	0.833
F3a	165.68	
F3b	165.13	
F4a	164.61	
F4b	164.96	

As seen in Table 9, the weight of the different formulae were found to vary. In formula 2b, it was found to have the maximum weight (168.91), followed by sample a in the same formula (168.10), 3a (165.68), 3b (165.13), 4b (164.96) and 4a (164.61). In the case of control, the weight of the dough were 161.88 (F1a) and 161.29 g (F1b) respectively. Although the weight of the raw food mixture before making the dough was uniform (100 g) for all the formulae, the weight of the dough had increased in all the samples due to the addition of sugar, salt, yeast, malt, fat and water during dough making. Variation among the formulae in dough weight may be due to the physicochemical characteristics of individual food ingredients added. According to Nazarenko *et al*. (1981) when dried soy protein preparations were added, physicochemical properties of the bread were impaired. But Almazan (1990) found no correlation among various physicochemical properties of the cassava flour and bread quality.

Statistical analysis of the data revealed that a highly significant difference existed between all the eight combinations tried but the differences between formulae 1a and 1b, 2a and 2b, 3a and 3b, 4a and 4b were on par. Details pertaining to this are presented in Appendix V.

(iii) Bread

Details pertaining to puffing rate, loaf volume and loaf weight are presented in Table 10.

Table 10

Baking characteristics of different combinations of bread with reference to puffing rate, loaf volume and loaf weight

Different combinations of bread	Baking characteristics		
	puffing rate (cm)	loaf volume (cc)	loaf weight (g)
F1a	8.60	652.00	129.58
F1b	8.30	686.25	128.24
F2a	6.60	538.75	136.52
F2b	7.30	602.50	137.31
F3a	5.10	446.25	135.80
F3b	5.30	433.75	137.02
F4a	3.60	344.25	138.53
F4b	3.10	353.75	139.69
CD value	0.437	17.979	1.217

General appearance of the bread will be influenced by loaf volume and loaf weight and puffing rate is an important variable associated with these factors.

Puffing rate is the difference between the height of the dough before and after baking, influencing directly the quality of bread. It was observed that formula 2b had a high puffing rate of 7.30 cm followed by formula 2a (6.60), 3b (5.30), 3a (5.10), 4a (3.60) and 4b (3.10). The puffing rate for control was considerably higher as 8.60 (F1a) and 8.30 (F1b) respectively, as it contains 100 per cent maida, it contains more gluten. It was observed that as the amount of maida decreased, the gluten content decreased; as a result the puffing also reduced. Sinha et al. (1993) reported that the puffing characteristics of soy fortified chapathis were found to be better than the control prepared from the whole wheat flour. Similar findings were reported by Collins et al. (1976). A difference existed between the puffing rate of those fermented for 1 1/2 hours (2a and3a) and 3 hours (1b and 4b). It was observed that the puffing rate of 2b and 3b were higher than 2a and 3a. Similar findings were reported by Sarhan et al. (1986). But in the case of formulae 1 and 4, 1a and 4a have a higher puffing rate than 1b and 4b since skimmed milk powder is added to the fourth formula and since the amount of maida was reduced, the gluten content is less and the gas retaining capacity is reduced. The puffing rate for 4a was found higher than 4b.

Statistical analysis of the data revealed that formulae 2a and 2b are highly significantly different from all the combinations tried while the difference between formulae 1a and 1b, formulae 3a and 3b and formulae 4a and 4b were on par. Details pertaining to this are presented in Appendix V.

Loaf volume was found out by Rape seed displacement method. Loaf volume of 2b was found to be higher (602.50 cc) followed by 2a (538.75 cc), 3a (446.25 cc), 3b (433.75 cc), 4b (353.75 cc) and 4a (344.25 cc). The loaf volume for control sample fermented for 3 hours (1b) was found to be the highest (686.25 cc) followed by 1a (652.00 cc). The loaf volume of formula 1 (control) was found to be higher than the remaining formula. In the case of 2b and 4b which were fermented for 3 hours had a larger loaf volume than 2a and 4a which were fermented for 1 1/2 hours as longer fermentation time resulted in more raising of the dough and more volume. Volume takes into account both length, breadth and height. Formula 2b has got highest loaf volume as it contains more protein and the amount of gluten is also more. Similar findings were reported by Maliki et al. (1980). Since formula 4 contains only 70 per cent maida, the gluten content is less and the gas retaining capacity is less. The loaf volume was found to be less in formula 4 compared to others. The loaf volume of those fermented for 3 hours were found to be high except in the case of formula 3 where tapioca flour was added as reported by Bakshi and Nanda (1990) that the time and temperature of fermentation significantly affected loaf volume.

Statistical analysis of the data revealed that a highly significant difference existed between the eight combinations tried but the difference between the formulae 3a and 3b and the formulae 4a and 4b were on par. Details pertaining to this are presented in Appendix V.

An association between loaf volume of the bread and the protein content of the flour was significantly tested to find out the significance of association.

Table 11

Influence of protein content upon loaf volume

combinations	Protein (g)	loaf volume (cc)	
		FT 1 1/2 hours	3 hours
F 1	11.00	652.00	686.25
F 2	14.20	538.75	602.50
F 3	13.19	446.25	433.75
F 4	15.84	344.25	353.75
Correlation Coefficient		-0.881**	-0.769**

** : Significant at 1 per cent level

FT : Fermentation time

Statistical analysis of the data (Table 11) revealed that there is a negative correlation which is significant at 1 per cent level exist. Similar findings were reported by Sarhan et al. (1986).

Loaf weight of 4b was found to be high (139.69) followed by 4a (138.53), 2a (137.31), 3b (137.02), 2b (136.52) and 3a (135.80). The weight of the control was found to be less than the rest of the combinations. The loaf weight of the formulae 1a and 1b were 129.58 and 128.24 respectively as this formulae contains 100 per cent maida. It contains more amount of gluten and has good gas retaining capacity and the puffing rate. This is the reason for the higher loaf weight for formula 4 as it contains only 70 per cent maida. But the loaf volume and puffing rate was less compared to other formulae as it contains less air cells. The loaf weight of those fermented for 3 hours were found to be high except control as reported by Bakshi and Nanda (1990) that the time and temperature of fermentation significantly affected loaf weight. Chaturvedi (1977) in his experiments on the addition of milk and milk products to bread found that the non fat dry milk solids will normally slow down acid development during the entire fermentation time. Therefore tolerance for a longer fermentation time helps in the production of a satisfactory loaf of bread. Similar results were observed in the case of formula 4b, where the loaf weight was found to be higher.

Statistical analysis of the data revealed that the formulae 1a and 1b was found to be significantly different from the rest of the combinations while the differences between formulae 2a and 3a and formulae 4a and 4b were on par. It was also found that the difference between formulae 2a, 2b and 3a was also on par. Details pertaining to this are presented in Appendix V.

Rate of dehydration was found out by estimating the moisture of the bread after every half an hour for a period of 3 hours and then after 1 hour. Those having less moisture content after 4 hours were found to have a high rate of dehydration (Table 12).

Table 12

Baking characteristics of different combinations of bread with reference to the rate of dehydration

Rate of dehydration %	Different combinations of bread							
	F1a	F1b	F2a	F2b	F3a	F3b	F4a	F4b
1	26.60	23.70	23.80	28.30	24.20	23.50	26.00	23.80
2	31.30	31.30	31.90	32.20	32.60	31.80	31.50	32.20
3	31.50	32.00	32.70	32.50	33.50	32.70	31.90	32.90
4	31.70	32.00	32.90	32.70	33.80	33.00	32.20	33.20
5	31.80	32.10	33.00	32.80	33.90	33.20	32.30	33.30
6	31.80	33.20	33.10	32.90	34.00	33.30	32.40	33.50
7	32.00	32.30	33.20	33.20	34.10	33.50	32.70	33.70

As revealed in Table 12, 4a has low moisture content (32.70 per cent) so a high rate of dehydration followed by 2b (33.20 per cent), 2a (33.24 per cent), 3b (33.50 per cent), 4b (33.70 per cent) and 3a (34.10). Compared to others, the rate of dehydration of control was less. Rate of dehydration of control were found to be 32.10 per cent and 32.40 per cent respectively at different fermentation time. The rate of dehydration was high in the case of samples fermented for 1 1/2 hours except in the case of 2a and 3a as soyaflour was observed to increase water retention. The water absorption and moisture of the second and third formulae were higher than the fourth. Bakshi and Nanda (1991) have reported similar observations.

Statistical analysis of the data revealed that a highly significant difference existed between all the eight combinations (four formulations) tried. Details pertaining to this are presented in Appendix V.

Porous nature of the bread was found out by dipping bread slices of 1 inch thickness in ink pad and then pressing it on paper. Porous nature of bread was found out to estimate the tunnels or holes in the bread. 3a was found to have less tunnels, but the tunnels were not uniform. Similar findings were reported by Skorikova (1981). This was followed by 3a and 4a; 3a was found to be better than the control. The porous nature of those fermented for 3 hours were found to be high compared to those fermented for 1 1/2 hours as the fermentation time increased, the number of air cells also increased due to the large amount of gas formation.

The cost of the bread were worked out by adding the cost of ingredients and the fuel spent for baking. It was found that the cost of formula 4 was high (Rs. 1.98 per 100 g) while the cost of the formula 3 was lowest as it contained tapioca flour. In the formula 4, the advantages of adding tapioca flour was nullified by the addition of costly skimmed milk powder. The cost of formulae 1 and 2 were Re. 1 per 100 g and Rs. 1.10 per 100 g respectively. Addition of soya flour to maida has in no way affected the cost of the formulae. Sinha et al. (1993) has also recommended soya flour as an ideal substitute for expensive ingredients like non-fat dry milk, thereby offering nutritionally better food at lower cost.

(iv) Process of Baking

Under processing of baking, baking time and baking loss are presented. All the formulae were baked uniformily for 25 minutes.

Baking loss is the difference between the final bread weight and initial dough weight. A good bread is reported to have minimum baking loss. Details pertaining to this are presented in Table 13.

Table 13

Baking characteristics of different combinations of bread with reference to baking loss

Different combinations of bread	Baking loss (g)	CD
F1a	32.00	
F1b	33.10	
F2a	30.90	
F2b	31.60	1.505
F3a	31.00	
F3b	28.10	
F4a	26.50	
F4b	25.30	

As indicated in Table 13, 4b was found to have less baking loss (25.30 g) followed by 4a (26.50 g), 3b (28.10 g), 2a (30.90 g), 3a (31.00 g) and 2b (31.60 g). Compared to the other formulae, the baking loss for control was found to be high 32.00 g and 33.10 g for 1a and 1b respectively. In the case of formula 2, the baking loss was higher in samples fermented for longer periods. But in the case of formulae 3 and 4, the baking loss for 3a and 4a which were fermented for shorter period was higher. It was found that baking loss was minimum in formula 1 which had maida alone. As the percentage of maida decreased, the baking loss was also found to decrease.

Statistical analysis of the data revealed that the formula 3a was found to be highly significantly different from the rest of the combinations. The baking loss of the formula 3a was found to be less than the rest of the combinations. It was also found that the differences between the formulae 1a, 1b and 2b were on par. The differences between formulae 1a, 2a, 2b and 3a and also between formulae 4a and 4b were also on par. Details pertaining to this are presented in Appendix V.

4.2.3 Assessing the organoleptic qualities of different combinations of bread

Acceptability of any product can be influenced by their constituents as well as by the procedure selected for processing. Earlier studies have proved that wheat flour used in bread making can be replaced in part by cassavaflour or minced, millets, caraflour, soya flour, corn-flour, bengal gram flour and chick pea flour to produce acceptable bread. The food ingredients selected for making bread shall not possess conflicting qualities. According to Levey (1952) cassava flour is used to replace wheat flour at rates of 20 per cent for bread, 22 to 35 per cent for cakes and 15 per cent for macroni and noodles, giving good quality products. Bread making trials using various levels of Cassava flour to replace wheat flour by Fuenti et al. (1954) indicated that in 10 per cent substitution the bread is acceptable and that the nutritive value is acceptable up to 15 per cent substitution. In an earlier experiment conducted at CFTRI (1979 to 1980) it was observed that tapioca flour incorporated at a level of 20 per cent is found to yield acceptable bread. Soya flour at 10 per cent level was added to all the six combinations. Lipoxygenase enzyme present in the soya flour have a bleaching effect affecting the colour of the crust and crumb of the product. Other food ingredients included in the formulations like cassava flour, soya flour and skimmed milk powder may affect the shape, appearance, texture, grain size and thickness of cell wall of the product. These effects are expected to vary with the level of fortification with these food ingredients in the final product. Observations by Crabtree et al. (1978) did not affect the crumb structure, colour, odour and shape of the bread while Sinha et al. (1993) have reported that an increase in soya flour resulted in darkening of the crumb and less brownish shade in bread crust. Khan and Lawhon (1980) found that breads containing soy protein isolates had superior crumb properties. Sinha et al. (1993) also reported that addition of soya flour did not impart or exhibit any of flavour to the product, although it tended to increase the toughness of the finished product. However, in all the above studies, it has been observed that addition of soya flour, cassava flour and skimmed milk powder can negatively affect the texture of the final product, depending on the quantity added and processing method selected. Hence a detailed assessment of the organoleptic qualities of bread were undertaken.

Organoleptic can be defined as qualities affecting a bodily organ or sense; particularly of the combination of the taste (perceived in the mouth) and aroma (perceived in the nose). The organoleptic qualities of the eight combinations of bread were assessed by using a score card. Qualities were assessed on the external as well as on the internal qualities of the products.

The quality attributes coming under external evaluation were presentation (appearance of the whole bread), crust colour and shape and the qualities identified under internal were crumb colour, crumb texture, thickness of the cell wall and size of the grain in the crumb. Besides these external and internal evaluations, sensory qualities of the products namely aroma flavour, masticability, taste, doneness, texture, appearance and overall acceptability were also ascertained.

The sensory evaluation of the products made from eight combinations were attempted at two levels namely among technical experts and consumers. In this evaluation, the technical experts involved were scientists engaged in cereal research at a national institute (CFTRI, mysore) and the consumers were qualified personnel in the field of Food science and Nutrition.

External quality attributes of the bread

External quality of the products was determined by ascertaining presentation, crust colour and shape and the details were presented in Table 14.

Table 14

External quality attributes of the different combinations of bread

Different combinations of bread	External quality attributes					
	presentation		crust colour		shape	
	S	C	S	C	S	C
F1a	4.60	4.80	3.10	4.30	5.00	4.80
F1b	4.40	4.80	3.50	4.30	5.00	4.50
F2a	3.60	3.90	3.10	3.80	4.90	4.10
F2b	3.90	3.20	3.30	3.80	4.60	3.80
F3a	2.40	2.10	2.80	2.80	3.50	3.40
F3b	1.90	2.40	2.80	3.00	2.00	2.90
F4a	1.80	2.30	2.10	3.20	2.10	2.60
F4b	1.50	2.40	2.10	2.70	1.40	2.80
CD	0.755	0.678	0.851	0.865	0.598	0.841

S: Scientist panel C: Consumers panel

The quality presentation is attributed to the general appearance of any product. In this experiment, a comparison among the four formulae revealed that the product identified as control (100 per cent maida) had obtained highest score. Among the experimental groups, 2b got the highest score (3.90) followed by 2a (3.60), 3a (2.40), 3b (1.90) and 4b (1.50). In the consumers panel the highest score for presentation was obtained for 2a (3.90), followed by 2b (3.20), 3b and 4b (2.40) and 4a (2.30). The fermentation rate of the food mixture was observed to be inversely proportional to the size of the final product except in the second set (formulations 2a and 2b) as evaluated by the technical experts. However such trend was not observed in the scores given by the consumers panel.

Statistical analysis of the data revealed that a highly significant difference existed between the formula 1 and the other combinations of bread where as the difference among the formulae 1a, 1b and 2a was on par. It was also observed that the difference between formulae 2a and 2b were also on par. But the data obtained from consumers panel revealed that a highly significant difference existed between the formula 1 and the other combination of bread whereas the difference between the formulae 1a and 1b and also between the formulae 3a and 3b and formulae 4a and 4b were on par. Details pertaining to this are presented in Appendix VI. In the study conducted by Tsen et al. (1971), inclusion of soya flour was observed to influence the size of the final product.

Crust Colour is the colour of the outer portion of the bread. In this experiment, a comparison among eight combinations of bread made revealed that products branded as 2b has got a maximum score of 3.30 followed by 2a (3.10), 3a and 3b (2.80) and 4a and 4b (2.10). In consumers panel also, 2a and 2b was ranked with the highest score of 3.80, followed by 4a (3.20), 3b (3.00), 3a (2.80) and 4b (2.70). In this case also, the fermentation rate of the food mixture was inversely proportional to the colour of the crust. No significant difference was seen among the different combinations in the case of crust colour.

Statistical analysis of the data given by the scientist panel revealed that a highly significant difference existed among the formulae 1a, 1b, 4a and 4b while the difference was on par in the case of all the other combinations. In the case of the consumers panel, a highly significant difference existed among the formulae 1a, 1b, 3a, 3b, 4a and 4b while the difference among the formulae 1a, 1b, 2a and 2b was on par. It was also found that a highly significant difference existed among the formulae 2a, 2b, 4a and 4b where as the difference among the formulae 2a, 2b, 3a and 3b were on par. Details pertaining to this are presented in Appendix VI.

According to Tsen (1976) soy fortified buns were slightly darker. Addition of 0.70 per cent enzyme active soya flour is reported to improve crust appearance (Kent, 1983). According to Sinha et al. (1993) proportion of soya flour added has a direct effect on the crust colour formation. Crabtree et al. (1978) reported that when fresh minced cassava was incorporated into wheat bread at a 20 per cent level substitution, the resultant loaves were acceptable with reference to colour. In this experiment, the scores for colour decreased as the amount of cassava flour increased. There was no correlation among various physical and chemical properties of the cassava flour and the bread quality (Almazan,1990). In an experiment conducted by Jakubczyk (1973) no appreciable difference were observed in the crust colour when soya flour were added at 3 or 5 per cent to type 800 wheat flour of good or inferior quality and to the type 500 wheat flour. Chaturvedi (1977) has also reported that milk and milk products improves crust colour.

In the scientist panel, among the different formulations 2a obtained the maximum score of 4.90 for shape followed by 2b (4.60), 3a (3.50), 4a (2.10), 3b (2.00) and 4b(1.40). As per the mean score obtained for consumers panel,the highest score of 4.10 was given to the 2a followed by 2b (3.80), 3a (3.40), 3b (2.90), 4b (2.80) and 4a(2.60) in the rank order. The scores obtained for those fermented for 1 1/2 hours were higher than those fermented for 3 hours except in the case of 4a and 4b as recorded by the consumers panel.

Statistical analysis of the data given by the scientist panel revealed that a highly significant difference existed among the formulae 1a, 1b, 3a, 3b, 4a and 4b where as the difference among the formulae 1a, 1b, 2a, 2b and formulae 2a, 2b, 3a and 3b were on par. In the case of consumers panel a highly significant difference existed among the formulae 1a, 1b, 3a, 3b, 4a and 4b while the differences between the formulae 1a and 1b and formulae 2a and 2b and formulae 3a and 3b were on par. It was also found that the difference among the formulae 1a, 1b, 2a and 2b and also among the formulae 2a, 2b and 3a were on par. Details pertaining to this are presented in Appendix VI.

According to Crabtree _et al_. (1978) when fresh minced cassava was incorporated into wheat bread at 20 per cent level, the resultant loaves were acceptable with reference to shape. Chaturvedi (1977) has also reported that milk and milk products improves bloom.

Internal quality attributes

Internal quality of a product was determined by ascertaining crumb colour, crumb texture, thickness of the cell wall and size of the grain in the crumb. The bread was cut into slices of 1 1/2 cm thickness and ten slices were presented before the panel members. Details pertaining to this are presented in Table 15.

Table 15

Internal quality attributes of the different combinations of bread

Different combinations of bread	Internal quality attributes							
	crumb colour		crumb texture		thickness of the cell wall		size of grain in the crumb	
	S	C	S	C	S	C	S	C
F1a	4.90	4.20	5.00	4.40	4.50	4.20	3.50	4.30
F1b	4.70	4.50	5.00	4.30	4.70	4.30	4.10	4.20
F2a	3.70	4.00	4.00	4.10	3.60	3.90	3.10	4.10
F2b	3.00	3.40	4.00	4.10	3.80	3.80	3.00	4.10
F3a	2.40	3.10	2.90	3.40	2.60	3.70	1.90	3.00
F3b	1.80	2.90	2.50	3.30	2.20	2.90	2.10	2.60
F4a	1.70	2.30	1.60	2.70	2.00	2.90	1.80	2.90
F4b	1.60	2.20	1.50	3.20	1.70	3.20	1.50	3.00
CD	0.695	0.829	0.369	0.916	0.655	0.711	0.684	0.672

S : Scientist panel C : Consumers panel

Formulae 1 and 2 were observed to have better score for Crumb Colour than the remaining formulae. In the second formulae, 2a was found to have the highest score of 3.70 followed by 2b (3.00), 3a have a score of 2.40 and was followed by 3b (1.70), 4a (1.70) and 4b (1.60). In the case of consumers also, the highest score was for 3a (4.00). Ranking order for the remaining formulations were also in the same order. A comparison between the two groups of the different fermentation rate revealed that higher scores were obtained for the samples fermented for 1 1/2 hours except control (as scored by consumers panel). Increase in fermentation rate of the formulation was found to be inversely proportional to the scores obtained for those fermented for 1 1/2 hours.

Statistical analysis of the data given by the scientist panel revealed that formula 2a was found to be highly significantly different from the rest of the combinations where as the difference between formulae 1a and 1b was on par. It was also found that the difference between formulae 2b and 3a and among the formulae 3a, 3b, 4a and 4b were on par. In the case of consumers panel, statistical administration of the data revealed that formulae 1a and 1b were found to be highly significantly different from the rest of the combination except formulae 2a and 2b. The difference was found to be on par in the case of formulae 1a, 1b, 2a and 2b. It was also found that among the formulae 2b, 3a and 3b; formulae 3a, 3b and 4a and also among the formulae 3b, 4a and 4b the differences were on par. Details pertaining to this are presented in Appendix VI.

According to Lorenz and Maga (1972) the crumb colour improved with the production of bread under decreased atmospheric conditions. Collins and Smith (1976) reported that the inclusion of 1 to 2 per cent full fat enzyme active soya flour as food ingredients improved softer whiter crumb. Similar results were reported by Kent (1983) who had found that addition of 0.70 per cent enzyme active soya flour whitens crumb colour. Crabtree et al. (1978) reported that when fresh minced cassava was incorporated into wheat bread at a 20 per cent level substitution, the resultant loaves were acceptable with reference to crumb structure. Studies conducted by Kasatkina (1980) observed that addition of whey also affects bread crumb colour. Jakubczyk (1973) observed no appreciable difference in the crumb colour when soya flour was added at 3 or 5 per cent to type 800 wheat flour of good or inferior quality and to type 500 wheat flour.

Crumb texture is the texture of the inner side of the bread and is influenced by the water absorption and kneading. In the scientist panel, the highest score of 4.00 was awarded to 3a and 3b followed by 4a (2.90), 4b (2.50), 5a (1.60) and 5b (1.50). Consumers panel also gave a maximum score of 4.10 to 3a and 3b. Unlike the former, ranking order was different for 5a and 5b. Here the score for 5b was greater than for 5a. Fermentation time has no influence upon crumb texture as the scores obtained for those fermented for 3 hours were more or less same to those fermented for 1 1/2 hours except in 5a and 5b (as scored by consumers panel).

Statistical analysis of the data revealed that formulae 3a and 3b was highly significantly different from the rest of the combinations where as the difference between the formulae 1a and 1b; formulae 2a and 2b and formulae 4a and 4b were on par. In the consumers panel, a highly significant difference was noted among the formulae 1a, 1b, 3a, 3b, 4a and 4b where as the differences among the formulae 1a, 1b, 2a and 2b; formulae 2a, 2b,3a and 3b and also among the formulae 3a, 3b, 4a and 4b were on par. Details pertaining to this are presented in Appendix VI.

Tsen et al. (1976) reported that acceptable bread and buns of normal crumb texture can be made from wheat flour fortified with upto 18 per cent defatted corn germ flour. Finney and pomeranz (1977) have also reported that by incorporating 2 per cent by weight of potato granules in the wheat flour for bread making,bread with softer crumb can be produced. Addition of Ø.5Ø per cent of malt, Ø.5Ø per cent of soya flour and 1 per cent of fat is also found to improve crumb softness (Bakshi and Nanda, 199Ø). Kent (1983) reported that Ø.7Ø per cent enzyme active soya flour improves crumb firmness. According to Chaturvedi (1977) milk and milk products if included as food ingredients in the bread softens and mellows the crumb structure. According to

Rastogi and Gurmukh (1989) with higher levels of full fat soya flour, the acceptability of the product was reduced due to poor texture of the crumb. A solid crumb is obtained when defatted soya meal was added (Skorikova, 1981).

Thickness of the cell wall means the thickness of the bread around the tunnels. This parameter was ascertained by touching the walls around the tunnels or holes. The results have revealed that 2b have a maximum score of 3.80 followed by 2a (3.60), 3a (2.60), 3b (2.20), 4a (2.00) and 4b (1.70). But consumers have rated 2a as best (3.90) with a different ranking orer as 2b (3.80), 3a (3.70), 4b (3.20) and 3a and 4a with a score of 2.90. Both consumers as well as scientist panel have given the same score of 3.80 for 2b. In the case of scientist panel, the scores for first and second formulae were found to be high for those fermented for 3 hours (1b and 2b). But in the case of consumers panel the scores for first and fourth formulae were found to be high for those fermented for 3 hours (1b and 4b).

Statistical analysis of the data revealed that formulae 1a and 1b (control) was found to be significantly different from the rest of the combinations where as the differences between the formulae 1a and 1b, formulae 2a and 2b, between formulae 3a, 3b, and formulae 4a and 4b were on par. In the case of consumers panel, a highly significant difference existed among the formulae 1a, 1b, 3a, 3b, 4a and 4b where as the difference among the formulae 1a, 1b, 2a, 2b and 3a were on par. The difference was also found to be on par in the case of formulae 2a, 2b, 3a and 4b and also in the case of formulae 3b, 4a and 4b. Details pertaining to this are presented in Appendix VI.

Size of the grain in the crumb means the size of the tunnels or holes in the crumb. This parameter measures whether the tunnels or holes is fine or coarse. A bread is termed to be good if the grain size is fine. The results have revealed that 2a was found to have a maximum score of 3.1Ø followed by 2b (3.ØØ), 3b (2.1Ø), 3a (1.9Ø), 4a (1.8Ø) and 4b (1.5Ø) while consumers have rated both 3a and 3b as best with a score of 4.1Ø followed by 3a and 4b (3.ØØ), 4a (2.9Ø) and 3b (2.6Ø). In the scientist panel the scores for 1b and 3b were found to be higher than 1a and 3a which were fermented for 1 1/2 hours while in the consumers panel, this difference existed only in fourth formulae where 4b fermented for 3 hours were found to have higher score than 4a, fermented for 1 1/2 hours. In the consumers panel, same score were given for 2a and 2b (4.1Ø).

Statistical analysis of the data revealed that a highly significant difference existed between formula 1b and the rest of the combinations where as the difference between formulae 1a and 1b was on par. It was also found that the difference among the formulae 1a, 2a and 2b was on par. In the consumers panel, statistical administration of the data revealed that a highly significant difference existed among the formulae 1a, 1b, 3a, 3b, 4a and 4b where as the difference among the formulae 2a, 2b, 3a, 3b, 4a and 4b were on par. Details pertaining to this are presented in Appendix VI.

According to Tsen (1976) soya fortified buns have grain similar to that of wheat buns. Lorenz and Maga (1972) reported that bread grain improved with the production of bread under decreased atmospheric condition. Tsen (1975) also reported that acceptable bread and buns of normal grain can be made from wheat flour fortified with 18 per cent defatted corn germ flour. However, Tsen and Hoover (1975) found that when 12 to 15 per cent of soya flour if incorporated in bread, the bread had poor grain. Rao and Malini (1991) reported that incorporation of bran adversely affected grain.

Organoleptic qualities

For determining the organoleptic qualities of the product, parameters like aroma (flavour), masticability, taste, overall acceptability, doneness, texture and appearance were taken into consideration. Details pertaining to this are presented in Table 16.

Table 16

Organoleptic qualities of the different combinations of bread

Organoleptic qualities	panel	Different combinations of bread								CD
		F1a	F1b	F2a	F2b	F3a	F3b	F4a	F4b	
aroma	S	5.00	5.00	4.20	3.90	3.60	3.30	3.00	2.50	0.591
	C	4.40	4.40	4.40	3.80	3.60	3.20	3.60	3.20	0.728
masticability	S	4.60	4.80	4.40	4.10	3.60	3.20	3.60	3.40	0.633
	C	4.80	4.70	4.60	3.80	3.40	3.20	2.80	2.80	0.909
Taste	S	5.00	5.00	4.40	4.00	3.40	2.80	2.70	1.90	0.439
	C	4.70	4.70	4.20	4.10	3.50	3.60	3.30	3.20	0.708
Overall acceptability	S	5.00	5.00	4.40	4.10	3.10	2.60	2.30	1.60	0.435
Doneness	C	5.00	5.00	4.60	4.20	4.00	3.70	3.10	3.30	0.875
Texture	C	4.40	4.90	4.40	3.90	3.60	3.00	3.00	2.90	0.681
Appearance	C	4.80	4.60	4.80	4.20	3.40	2.70	3.00	3.00	0.771

S : Scientist panel   C : Consumers panel

Ranganna (1984) stated that **Flavour** is an important factor which enriches the consumers preference to a particular product. 2a was given the maximum score of 4.20 by the scientist panel followed by 2b (3.90), 3a (3.60), 3b (3.30), 4a (3.00) and 4b (2.50). Consumers panel have also rated 2a as the best with a score of 4.40 followed by 2b (3.80), 3a and 4a (3.60), 4b (3.40) and 3b (3.20). Fermentation time was found to affect the aroma of the bread. It was also observed that the scores obtained for those fermented for 1 1/2 hours were higher than those obtained for breads fermented for 3 hours. The ingredients added have also found to influence the aroma or flavour of bread.

Statistical analysis of the data revealed that a highly significant difference existed between formulae 1a and 1b and the rest of the combinations where as the differences between formulae 1a, 1b; between formulae 2a and 2b and between formulae 3a and 3b were on par. It was also found that the difference between formulae 2b and 3a and also between formulae 3b and 4a were also on par. In the consumers panel, a highly significant difference existed among the formulae 1a, 1b, 3b, 4a and 4b where as the differences among formulae 1a, 1b, 2a, 2b and 3a were on par. It was also found that the differences among formulae 2a, 2b, 3a, 4a and 4b and also among formulae 2b, 3a, 3b, 4a and 4b were also on par. Details pertaining to this are presented in Appendix VI.

Rastogi and Gurmukh singh (1989) reported that at higher levels of full fat soya flour the acceptability was reduced due to undesirable flavour of bread. But Sinha et al. (1993) reported that addition of soya flour did not affect the flavour of bread. Crabtree et al. (1978) reported that 20 per cent replacement of wheat flour by cassava in bread didnot alter the odour. According to Haridas Rao and Malini Rao (1991) incorporation of cereal bran helped to improve aroma of bread. Raidl and Klein (1983) found significant differences among loaves at some substitution levels (5, 10 or 15) of field pea or defatted soya flour for flavour.

Masticability was ascertained to see whether the bread is sticky or not when chewed. The results revealed that the scientist panel have given a maximum score of 4.40 to 2a followed by 2b (4.10), 3a (3.60), 3b (3.00), 4a (2.60) and 4b (2.30). Similar scoring pattern was reported by the consumers also. The scores for those fermented for 1 1/2 hours was found higher than those fermented for 3 hours except in the fourth formulations (as scored by the consumers panel) where both 4a and 4b have a same score of 2.80.

Statistical analysis of the data revealed that formulae 1a and 1b was found to be highly significantly different from the rest of the combinations where as the differences among formulae 1a, 1b and 2a and also among formulae 1a, 2a and 2b were on par. It was also found that the difference between formulae 3a and 3b and formulae 4a and 4b were on par. The difference was also on par in the case of formulae 2b and 3a and formulae 3b and 4a. In the consumers panel, statistical analysis of the data revealed that formulae 1a and 1b were found to be significantly different from the rest of the combinations except formulae 2a and 2b. With formulae 2a and 2b the difference was on par. Among formulae 2a, 2b and 3a the difference was on par. It was also observed that the differences among formulae 3a, 3b, 4a and 4b were also on par. Details pertaining to this are presented in Appendix VI.

2a was given the highest score for Taste of 4.4 followed by 2b (4.ØØ), 3a (3.4Ø), 3b (2.8Ø), 4a (2.7Ø) and 4b (1.9Ø). Consumers have also rated 2a as the best with a score of 4.2Ø followed by 2b (4.1Ø), 3b (3.6Ø), 3a (3.5Ø), 4a (3.3Ø) and 4b (3.2Ø). The ingredients added have also found to affect the taste of bread. In the case of scientist panel, the highest score was given to those fermented for 1 1/2 hours compared to those fermented for 3 hours but in the case of consumers panel, only slight difference existed between those fermented for 1 1/2 hours and 3 hours except in the case of third formulae where 3b has got a score slightly higher than 3a.

Statistical analysis of the data revealed that formulae 3a and 3b was found to be highly significantly different from the rest of the combinations where as the differences between formulae 1a and 1b and formulae 2a and 2b were on par. It was also found that the difference between formulae 3b and 4a was also on par. In the consumers panel, statistical administration of the data revealed that formulae 1a and 1b was found to be significantly different from the rest of the combination except formulae 2a and 2b. With formulae 2, the difference was on par. The differences among formulae 2a, 2b, 3a and 3b and also among formulae 3a, 3b, 4a and 4b were also on par. Details pertaining to this are presented in Appendix VI.

Taste panel analysis indicate that a high protein breads were organoleptically acceptable (Fleming, 1971). Tsen et al. (1976) revealed that the taste of soya fortified buns did not differ significantly from that of wheat bun. Raidl and Klein (1983) found that no significant difference was found among loaves, made by substituting 5, 10 and 15 per cent field pea or defatted soya flour, for mouth feel. Almazan (1990) reported that variations in taste exist as the amount of cassava flour increased in bread.

Overall acceptability of the bread was scored by the scientist panel only. 2a was given the maximum score of 4.40 followed by 2b (4.10), 3a (3.10), 3b (2.60), 4a (2.30) and 4b (1.60). It was also observed that the scores for those breads fermented for 1 1/2 hours were higher than those fermented for 3 hours.

Statistical analysis of the data revealed that formulae 3a and 4b were found to be significantly different from the rest of the combinations where as the difference between formulae 1a and 1b was on par. The difference between formulae 2a and 2b was also on par. It was also observed that between formulae 3b and 4a the difference was on par. Details pertaining to this are presented in Appendix VI.

Hallab et al.(1974) reported that arabic bread supplemented with 10 per cent soya flour showed high level of acceptability when compared with unsupplemented bread. Tsen et al. (1976) found that acceptable cookies can be prepared from wheat flour fortified with 12 to 15 per cent of soya products. In an annual report of CFTRI (1979 to 1980) it has been stated that high protein bread formulations with maida fortified with defatted soya flour up to 10 per cent level gave acceptable bread. As reported by Sinha et al. (1992) that 5 to 12 per cent soy fortification can produce acceptable bread. Rastogi and Gurmukh singh (1989) and Shurpalekar (1982) also reported the same. Studies conducted by Kim and De ruiter (1968) showed that bread like products can be obtained with a mixture of soya and cassava flour and a suitable starch binder. The process may lead to the development of novel baked foods in countries where traditional forms of bread are available. Mustafa and Tsen (1976) reported that cassava and wheat starches were found to give highly acceptable supplemented breads.

Doneness was ascertained by pressing the crumb with fingers to see whether sticky or not. This parameter was scored only by the consumers panel and 2a was rated high (4.60) followed by 2b (4.20), 3a (4.00), 3b (3.70), 4b (3.30) and 4a (3.10). It was found that the scores obtained for those fermented for 1 1/2 hours were high except in the fourth formulae where 4b has got more score than 4a.

Statistical analysis of the data revealed that a highly significant difference existed among formulae 1a, 1b, 3a, 3b, 4a and 4b while the difference was found to be on par in the case of formulae 1a, 1b, 2a and 2b and formulae 2a, 2b and formulae 2a, 2b and 3a. It was also found that the difference among the formulae 3a, 3b and 4b and also among formulae 3b, 4a and 4b were on par. Details pertaining to this are presented in Appendix VI.

The parameter texture was scored by the consumers panel. 2a was given the highest score of 4.40 followed by 2b (3.90), 3a (3.60), 3b and 4a (3.00) and 4b (2.90). The texture of those fermented for 1 1/2 hours was found to be better than those fermented for 3 hours.

Statistical analysis of the data revealed that a significant difference existed between formulae 1a and 1b and the rest of the combinations. It was also found that the difference among formulae 1a, 1b and 2a and also among formulae 1a, 2a and 2b were on par. The difference was also found to be on par in the case of formulae 2b and 3a and formulae 3a, 3b and 4a. The difference among formulae 3b, 4a and 4b were also on par. Details pertaining to this are presented in Appendix VI.

Texture improved with the production of bread under decreased atmospheric conditions (Lorenz and Maga, 1972). According to Rao and Malini (1991) addition of bran, cassava flour and full fat soya flour are reported to affect the texture of the crumb adversely. Similar findings were reported by Rastogi and Gurmukh singh (1989) and Almazan (1990).

The parameter **Appearance** was scored only by the consumers panel. 2a was given the highest score of 4.80 followed by 2b (4.20), 3a (3.40), 4a and 4b (3.00) and 3b (2.70). It was also found that the score for those fermented for 1 1/2 hours were higher than those fermented for 3 hours except in the case of fourth formulae where both 4a and 4b have the same score.

Statistical analysis of the data revealed that formulae 1a and 1b was found to be significantly different from the rest of the combinations except formulae 2a and 2b. With formulae 2a and 2b the difference was found to be on par. It was also found that the difference among the formulae 3a, 3b, 4a and 4b were on par. Details pertaining to this are presented in Appendix VI.

Tsen _et al_. (1975) reported that acceptable bread and buns of normal appearance can be made from wheat flour fortified with 18 per cent defatted corn germ flour.

4.2.4 Assessment of the Shelflife qualities of the different combinations of bread

Shelflife qualities are essential parameters to be assessed in a product before advocating it to the community and the four formulations of the bread were assessed for these qualities. Indicators selected for assessing shelflife were the development of stale odour, crumbling nature, changes in colour and texture and microbial status. Microbial status of the products were determined by assessing the colony count of micro organisms in the bread by applying serial dilution technique while the other qualities were ascertained by scoring method.

Breads formulated by four combinations were packed in polythene covers and were kept in separate chambers of a cupboard and every day observations were taken for changes in odour, colour, texture and crumbling nature by using a suitable score card. AACC method of determining bread staleness also involves the use of sensory panel proposed by Bachtel and Meisners (1954), who devised 6 point staling scale ranging from very fresh to very stale. They demonstrated that panelists can be screened to choose members who are most accurate in distinguising the various degrees of staling. Scoring was done by persons working in a bread industry. The scoring was done on the fourth day as the changes were noticed on the fourth day through preliminary observations. The changes noted in different combinations were varying during aging and the details pertaining to this are presented in Table 17. It was also observed that the maximum shelflife was for five days except for formulae 3 and 4 (both a and b) which can be kept only for four days. Formula 2a which contained soya flour was observed to have the highest shelflife. Similar advantage of using soya flour was reported earlier by Ronfeld (1963), Nikolic and Salihodzic (1988) and Sinha et al. (1993). The shelflife of the samples fermented for 3 hours were also found low as it was found to be an easy prey to microbes.

Table 17

Shelflife qualities of the different combinations of bread

Quality parameters	Different combinations of bread								CD
	F1a	F1b	F2a	F2b	F3a	F3b	F4a	F4b	
Crumbling nature	4.90	4.50	3.50	3.00	3.30	3.00	2.50	2.00	0.542
changes in colour and texture	4.50	4.00	3.60	3.00	3.00	2.40	3.20	2.10	0.514
Stale odour	4.80	4.00	3.90	3.30	3.00	2.70	2.50	2.00	0.394

As revealed in Table 17, the **Crumbling nature** of the formula 2a was found to be high with a score of 3.50 followed by 3a (3.30), 2b and 3b (3.00), 4a (2.50) and 4b (2.00). The control sample was found to be more crumbly than the other formulae as the rate of water absorption and retention were found low. This is mainly due to the transfer of moisture from the crumb to the crust and from the protein to starch. Similar findings were reported by Wilhoft (1983). The scores obtained for control were 4.90 and 4.50 respectively. It was also seen that the score for those bread whose doughs were fermented for 3 hours were lower than those fermented for 1 1/2 hours indicating that they were soft. Similar observations were recorded by Platt and Power (1940). The formulae 4 (both a and b) were found to be very soft. Similar findings were reported by Platt (1940). The formula 2a was found to be more softer than control as the rate of water absorption was high, the bread was softer initially and remained softer even during storage. Maliki et al. (1980) and Krishna kumar and Phoolka (1990) had also reported similar findings.

Statistical analysis of the data revealed that a highly significant difference existed among all the eight combinations tried while the differences between formulae 1a and 1b, formulae 4a and 4b and among formulae 2a, 2b, 3a and 3b were on par. Details pertaining to this are presented in Appendix VII.

It was found that the scores for **Changes in colour and texture** were found to be high for 4b (2.10) followed by 3b (2.40), 2b and 3a (3.00), 4a (3.20) and 2a (3.60). The colour and texture of 2a were not affected as the initial moisture content was high. Sultan (1980) reported that increased moisture in the dough will also result in a greater percentage of moisture in baked bread and this will provide for a softer crumb and a longer shelflife. The colour and texture of the control bread were found not to be affected much by aging. It was also found that the colour and texture of those samples fermented for 3 hours were more affected when compared to those fermented for 1 1/2 hours because of microbial growth. The crumb as it ages became firmer and less elastic. The bread became leathery and later soft due to the growth of microorganism. A sticky gummy material which can be pulled into threads developed in the centre of the loaf 1 to 3 days after baking. This change is mainly due to the growth of microorganisms and it was distinct in formula 4b

Statistical analysis of the data revealed that formulae 2b, 3a, 3b, 4a and 4b, were significantly different from the rest of the combinations while the difference was on par in the case of formulae 1a and 1b. A significant difference existed between formulae 1a and 2b while the difference between formulae 1b and 2b was on par. It was also found that the differences among formulae 2b, 3a and 4a were also on par. Details pertaining to this are presented in Appendix VII.

The parameter for scoring Stale odour were in the range of highly acceptable - 5; moderately acceptable - 4; slightly acceptable - 3; not that acceptable - 2; not acceptable - 1 and unacceptable - Ø. The score for stale odour was found low for 4b (2.ØØ) indicating that the odour is unacceptable followed by 4a (2.5Ø), 3b (2.7Ø), 3a (3.ØØ), 2b (3.3Ø) and 2a (3.9Ø). The score obtained for control were 4.8Ø and 4.ØØ respectively. Scores obtained for samples fermented for 3 hours were less than those fermented for 1 1/2 hours indicating that their odour was unacceptable compared to those fermented for 1 1/2 hours. The stale odour may be due to the growth of microorganisms like <u>Bacillus mesentricus.</u> Bachrah and Briggs (1947) and Bechtel and Meisner (1954) reported that baked products especially bread suffers from a serious problem of certain physicochemical changes which take place during storage leading to the staling of bread.

Statistical analysis of the data revealed that the formulae 1a was found to be highly different from the rest of the combinations. It was found that the control bread does not have much stale odour while the differences among formulae 1b and 2a, 2b and 3a, 3a and 3b and 3b and 4a were on par. It was also found that the stale odour produced by formula 4b was higher. Details pertaining to this are presented in Appendix VII.

Cant and Vaden (1972) concluded that white bread flavour became less bland and complex with storage.

Herman et al. (1980) have reported that the commonly seen microorganism in bread are Staphylococcus, Lactobacillus sp and Saccharomyces cerevisiae. Microbial changes in bread samples led to various sensory changes. In general red spots were noted on the bread as a result of the growth of the bacterium Serratia marcescens. All the bread samples developed stale or off odour may be due to the growth of micro organisms like Bacillus mesentricus. The results of microbial growth were presented in Table 18.

Table 18

Microbial status of the different combinations of bread

Microbes	Different combinations of bread								CD
	F1a	F1b	F2a	F2b	F3a	F3b	F4a	F4b	
Yeast	59.80	111.00	45.00	52.50	53.00	60.50	55.80	109.50	5.35
Fungus	19.30	35.30	19.30	24.00	23.80	113.80	86.50	110.00	5.04
Bacteria	41.80	86.50	53.30	73.50	53.00	113.00	150.30	218.30	7.51

As revealed in Table 18, the colony count of **Yeast** were found to be more in 4b (109.50) followed by 3b (60.50), 2a (59), 4a (55.80), 3a (52.80) and 2a (45). The colony count of control were found to be 59.80 and 110 respectively. The bread fermented for 3 hours were found to be highly infected by yeast. The colony count for yeast in 2a was lowest compared to control as the defatted soya flour was low in microbial counts. Similar findings were reported by Abdel et al. (1980).

Statistical analysis of the data revealed that the formulae 2a, 2b and 3a were found to be significantly different from the rest of the combination. In the formulae 2a, 2b and 3a the colony count of yeast was found to be lesser than the rest. It was also found that the difference among formulae 1b and 4b and 1a, 3b and 4a were on par. Details pertaining to this are presented in Appendix VII.

In the case of **Fungus**, the colony count for fungus were found to be high in 3b (113.80) followed by 4b (110), 4a (86.50), 2b (24), 3a (23.80) and 2a (19.30). The colony count for fungus in the case of control were 19.30 and 35.30 respectively. The colony count of fungus for those fermented for 3 hours were found higher than those fermented for 1 1/2 hours as it is fermented for 3 hours, it is more likely to be infected. The colony count of fungus for 1a and 2a was found to be the same (19.30).

Statistical analysis of the data revealed that the formulae 1b and 4a were found to be significantly different from all the other combinations while the difference among formulae 1a, 2a, 2b and 3a were on par. Details pertaining to this are presented in Appendix VII.

In the case of Bacteria, the colony count was found high in 4b (218.30) followed by 4a(150.30), 3b (113), 2b (73.50), 2a (53.30) and 3a (53). The colony count of bacteria for control was 41.80 and 86.50 respectively. The colony count of bacteria was found to be high in those fermented for 3 hours compared to those fermented for 1 1/2 hours.

Statistical analysis of the data revealed that a highly significant difference existed among all the eight combinations tried but the difference between formulae 2a and 3a was on par. Details pertaining to this are presented in Appendix VII.

Selection of a suitable combination of bread

From the four formulations standardised, the ideal combination was selected based on chemical score, nutrient composition, baking characteristics, organoleptic qualities and shelflife qualities. Computation of nutrients and calculation of chemical score for all the four formulations revealed that formula 2a was found to be high. The calorie, fat and Vitamin A content of the formula 2 was also found higher than the other formulae. The chemical score was found to be 66.35.

Among the different formulations, the formula 2 was found to have high water absorption, acidity, moisture, puffing rate, loaf volume, texture and rate of dehydration was found to be higher than 4a. The loaf weight was found to be lesser than 4a. The kneading quality of 4a was found to be better than 2a. But the porous nature of 2a was found to be better than other formulae. The cost of control as well as the formula 2 were found to be almost the same (Rs. 1/100 g for control and (Rs. 1.10/100 g for formula 2) but the fourth formula was found to be very expensive (Rs. 1.92/100 g). Breads with three hour fermentation was discarded as the breads baked from the doughs. given long (3 hours) fermentation time, the crust and crumb were separated immediately after baking and also fermentation changed crumb flavour (Schierberle et al, 1991). For this reason, based on baking characteristics, formula 2a was selected.

In the case of organoleptic qualities assessed by both technical experts as well as the consumers panel, highest acceptability score was given to formula 2a.

The shelflife studies of different formulations revealed that bread made from doughs given 3 hour fermentation was more infected by yeast, fungus and bacteria compared to their counterparts. Among the 4 formulations, the control as well as the formula 2a was observed to have a longer shelflife of five days compared to other formulaè which have a shelflife of four days.

On the basis of above findings, formulae 2a was selected for further studies.

4.3 Assessment of the nutritional quality of the selected combination of bread

4.3.1 Nutritional quality of bread formula selected

Nutritional quality of bread with reference to Calorie, Protein, Fat, Crude Fibre, Ash and Mineral content were determined through suitable laboratory techniques and the results were presented in Table 19.

Table 19

Nutrients in the selected bread formula

Nutrients	Selected bread formula (2a)
Calories(cal/100 g)	492.85
Proteins (g)	16.20
Lipids[b]	1.98
Crude fibre[b]	0.28
Ash[b]	2.88
Calcium (%)	0.62
Iron (%)	0.20
Magnesium (%)	0.07

b : Dry weight basis

As revealed in Table 19, the calorific value of the bread formula was found to be 492.85 cal/ 100 g. The protein content was found to be 16.20 g, lipid content 1.98, Crude fibre 0.28 and Ash 2.88. Similar findings were reported by Khan et al. (1975). The calcium, iron and magnesium content of the selected bread formula were found to be 0.62 per cent, 0.20 per cent and 0.07 per cent respectively. Holtmeier (1987) reported that various types of bread contain 30 to 120 mg of magnesium per 100 g.

4.3.2.1 Evaluation of protein quality of bread through PER

The nutritive value of a protein depends primarily on its capacity to satisfy the needs for nitrogen and essential amino acids. Hence the nitrogen and amino acid index are the logical yard sticks and the precise knowledge about their requirements is basic for evaluation of the nutritional significance of dietary protein quality.

A number of methods were attempted for the determination of the protein quality of bread - PER, which is a method based on growth and body weight, NPU, DC and BV based on nitrogen balance; determination of availability of amino acid through chemical scores and essential amino acid index.

Protein Efficiency Ratio

National Research Centre (NRC, 1963) has defined PER as the ratio between body weight and the protein consumed. According to Robinson and Lawler (1986) protein is an index of gain in weight over Mass of Protein Intake (MPI) which is generally measured over a 10 to 28 days period.

$$\text{PER} = \frac{\text{Weight gain (g)}}{\text{Protein intake (g)}}$$

The Protein Efficiency Ratio (PER) of rats fed on the experimental and control diets were given in Table 20.

Table 20

Protein Efficiency Ratio of the selected bread

Groups	PER	't' value
Experimental	1.29	** 105.889
Control	3.28	

** : Significant at 1 per cent level.

The PER of the experimental group was found to be 1.29 while that of control it was 3.28. Statistical analysis of the above data showed that the PER of the control was significantly higher than the experimental group. However, a comparison of PER with the standard value (2.00) revealed that it was much below the standard. Similar findings were reported by Sinha et al. (1993) who found that supplementation of wheat flour with 12 per cent defatted soya flour supplying 50 per cent protein and less than 1 per cent fat raised the Protein Efficiency Ratio of bread from 0.70 for wheat alone to 1.30 for soya fortified bread. Thus supplementation of wheat flour with soya flour not only doubles the PER of the fortified bread but also improves the nutritional significance of the product.

4.3.2.2 Evaluation of protein quality of bread through Digestability Co - efficient

Digestability Co-efficient of a protein is defined as the ratio of food nitrogen intake to food nitrogen absorbed.

Digestability Co-efficient determined in the present study is presented in Table 21.

Table 21

Digestability Co - efficient of the selected bread

Groups	DC	't' value
Experimental	72.43	35.851**
Control	81.13	

** : Significant at 1 per cent level.

As depicted in Table 21, rats fed in the control group showed higher digestability and statistical administration of the data revealed significant variation.

4.3.2.3 Evaluation of protein quality through BV

Biological value of a protein is the fraction of its nitrogen retained in the body for growth and maintenance of cell synthesis. The biological value of proteins can be determined by nitrogen balance experiments (Robinson, 1987).

$$BV = \frac{In - Un - Fn}{In - Fn}$$

where In = Nitrogen intake
Un = urinary nitrogen
Fn = Faecal nitrogen

Biological value of the formula was determined by nitrogen balance study and the results were presented in Table 22.

Table 22

Biological value of the selected bread

Groups	BV	't' value
Experimental	90.77	** 14.120
Control	93.17	

** : Siginificant at 1 per cent level.

As indicated in Table 22, the Biological Value of both experimental and control was found to be significant although the mean value for control was slightly higher than the experimental.

4.3.2.4 Evaluation of protein quality through NPU

Net Protein Utilizaion (NPU) is the ratio of nitrogen retained to total protein nitrogen intake and is influenced by the Biological Value of a protein and its digestability.

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

The Net Protein Utilization of the experimental as well as the control diet were presented in Table 23.

Table 23

Net Protein Utilization of the selected bread

Groups	NPU	't' value
Experimental	65.74	** 44.347
Control	75.59	

** : Significant at 1 per cent level.

As seen Table 23, the NPU of the rats in the control group was high. Statistical analysis of the data revealed that the NPU of the experimental and the control was found to be significantly different.

4.3.2.5 Evaluation of the protein quality of the bread through FER

Food Efficiency Ratio is the ratio of gain in body weight to food intake.

$$FER = \frac{\text{gain in body weight (g)}}{\text{food intake (g)}} \times 100$$

The Food Efficiency Ratio (FER) of the experimental and the control diet were determined and the results were presented in Table 24.

Table 24

Food Efficiency Ratio of the selected bread

Groups	FER	't' value
Experimental	18.22	154.001**
Control	44.77	

** : Significant at 1 per cent level.

Table 24 revealed that the FER of the control was found to be significantly higher than the experimental groups. Similar findings were reported by Yoshida and Edagawa (1978).

The essential amino acid index of the selected bread formula was found out and was then compared with the essential amino acid index of meat, milk, rice and wheat. The essential amino acid index can be defined as the geometrical mean of the ratio of essential amino acid in a protein to those of a standard; usually egg protein (Oser, 1951) and the essential amino acid index of the test protein was found to be Ø.777 indicating that it was below the essential amino acid index of meat (Ø.865), milk (Ø.856) and rice (Ø.895) but slightly more than wheat (Ø.66Ø).

4.4 Suitability of the selected combination as a supplement for nutrition intervention programmes

The suitability of the selected combination as a supplement for nutrition intervention programmes was assessed by conducting a feeding trial at the creche run by the department of Home science.

The preschoolers of the same socio-economic and health back ground were given the selected bread formula for six days in a week and the trial was carried out for a period of six months.

Before starting the experiment, acceptability of the bread was tested among the fifteen preschoolers selected for the experiment. After familarising the bread for a week, the experiment was started and completed in six months. Four slices of bread each weighing 25 g was given to each preschooler so as to meet the protein content as specified under I.C.D.S norms.

Each day 4 packets of 400 g bread (16 slices) were baked for the experiment. The impact of the feeding trial upon preschoolers were assessed by taking anthropometric measurements since they are considered as the best tool to ascertain the impact of various nutrition intervention programmes. As indicated by Scrimshaw et al. (1967), ICMR (1972), N.I.N (1973), Swaminathan (1973) and Gopaldas (1975); a well accepted procedure for evaluating the impact of supplementary feeding is to measure absolute weight gains and the significant growth differences in the beneficiaries as compared with age matched non beneficiaries.

Anthropometric measurements like height, weight, chest circumference, upper arm circumference and lower arm circumference were measured at the initial and final stages of the experiment.

Mean height, weight, chest circumference, upper arm circumference and lower arm circumference of the preschoolers of the experimental group in the beginning and the completion of the feeding trials are presented in Table 25 and the details pertaining to individual children are presented in Appendix VIII.

Table 25

Anthropometric measurements of the preschoolers during the feeding trial

Anthropometric measurements	Initial	Final	't' value
Height (cms)	97.47	103.00	7.61**
weight (kgs)	12.67	15.70	11.78**
Chest (cms) circumference	51.37	53.13	7.26**
Upper arm (cms) circumference	15.77	27.73	5.25**
Lower arm (cms) circumference	14.97	16.00	6.25**

** : Significant at 1 per cent level.

As revealed in Table 25, the mean height and weight of the preschoolers increased after the feeding trials.

Measurement of the chest, upper and lower arm circumference may reveal the Protein - Calorie deficiency state of the preschoolers reflecting indirectly on the body constitution with reference to the fat content in the soft tissues. Data on the initial and final mean values of these measurements strengthens the point that the preschoolers who were mildly malnourished in the beginning of the experiment improved on the completion of the experiment.

Data on the mean values of height, weight, chest circumference, upper and lower arm circumference were statistically tested to find out the significance of increase in anthropometric measurements by administering paired t - test.

Statistical analysis of the data revealed that there was a significant improvement in all the anthropometric measurements at 1 percent level. Similar results were observed in the feeding trial conducted by National Institute of Nutrition (1969), Hofvander and Eksmyr (1971) and Central Food Technological Research Institute (1974).

A comparison of the anthropometric measurements like height and weight taken at the final stages of the experiment with the ICMR standards (1992) had depicted that 80 per cent of the preschoolers had attained better heights than standards while only 46.60 per cent had attained better weight. The data were then statistically tested using t- test and the results were presented in Table 26.

Table 26

Comparison of the mean height and weight of the preschoolers with ICMR standards

Anthropometric measurements	Final	standard	't' value
Height (cms)	103.00	101.11	0.632
Weight (kgs)	15.70	15.88	0.197

As seen in Table 26, the two anthropometric measurements were statistically found to be not significant.

Body Mass Index of the pre schoolers were worked out and the details are presented in Table 27. According to Visweswara Rao and Singh (1970) weight in kilogram divided by height in square cm ratio is normally about 0.0015 + or 0.0001 for infants. The ratio is reduced if the weight of the infants decreases to a greater extent in proportion to his height. If the ratio falls below 0.0013, it indicates the presence of low weight for height or under nutrition.

Table 27

Weight / $Height^2$ ratio of the preschoolers belonging to the experimental group

Grades of malnutrition	preschoolers N = 15			
	Initial		Final	
	number	percent	number	percent
Normal (> 0.0015)	3	20	7	46.70
Moderate malnutrition (0.0013 - 0.0015)	12	80	8	53.30

As revealed in Table. 27, 80 per cent of the preschoolers were showing signs of moderate malnutrition and 20 per cent were found to be normal before starting the feeding trial. On completion of the feeding trial, it was found that 26.70 per cent of preschoolers had been shifted to normal and the remaining 53.30 per cent were moderately malnourished. Evaluation conducted on I.C.D.S by various authors in the different parts of the country indicated a positive change in the nutritional status of the preschool children. (Vivek et al , 1989).

SUMMARY

SUMMARY

A study on the Improvement of the nutritional quality of bread was conducted by selecting four formulations (eight combinations) of bread with two different fermentation time - 1 1/2 hours and 3 hours.

Standardisation of four formulations of bread was done using ingredients like soya flour, tapioca flour and skimmed milk powder. Maida was the basic ingredient in all the four formulations. In the first formulation, 100 per cent maida was used. In the second formulation, 10 per cent maida was replaced by soya flour where as in the third formulation, 20 per cent maida was replaced by 10 per cent soya flour and 10 per cent tapioca flour. In the fourth formulation, 30 per cent maida was replaced by 10 per cent soya flour, 10 per cent tapioca flour and 10 per cent skimmed milk powder.

The chemical scores of these four formulations were worked out and the results revealed that the chemical scores of the formulae were found to decrease with the replacement of maida by other ingredients. Irrespective of control, the chemical score of the second formulation (maida: soya flour in the proportion of 90:10) was found to be high (66.35).

The nutritional composition of the four formulations of bread worked out revealed that the Calorie, Iron and Vitamin A content of the second formulation with 10 per cent soya flour was

high while the protein content of the fourth formulation (maida : soya flour : tapioca flour : skimmed milk powder in the proportion of 70:10:10:10) was found higher (15.84 g) than the second formulation, as the skimmed milk powder is rich in protein.

The baking characteristics of the four formulations of bread was ascertained with reference to food mixture, dough, bread and process of bread making. The food mixture was ascertained for colour, texture and weight while dough was assessed for water absorption, moisture, acidity, kneading quality and colour, texture and weight of the dough. Bread was assessed for its puffing rate, loaf weight, loaf volume, rate of dehydration, porous nature and cost. The baking time and baking loss during the process of baking was also ascertained. An assessment of all the above baking characteristics of the four formulations revealed that maida : soya flour in the proportion of 90 : 10 with a fermentation time of 1 1/2 hours were found to have the most suitable baking characteristics.

An organoleptic study was also conducted on the bread made from these four formulations both by technical experts as well as by the consumers with reference to their external, internal and organoleptic qualities. The parameters under external were presentation, crust colour and shape, those under internal were crumb colour, crumb texture, thickness of the cell wall and size of the grain in the crumb and those parameters coming under organoleptic qualities were appearance, texture, doneness, taste, aroma and over all acceptability. Based on the above external characteristics, second formulations (maida : soya flour in the ratio of 90:10) scored maximum points. In the case of internal characteristics also second formulation scored maximum points except in the crumb texture. Compared to this, the crumb texture of the third formulation (maida : soya flour : tapioca flour in the ratio of 80:10:10) was found to be better. In the case of organoleptic qualities also the formula 2 scored maximum points. Those formulations undergoing 3 hours fermentation were rejected as the flavour of the bread was unacceptable.

Shelflife qualities of the four formulations of the bread was assessed with reference to stale odour, changes in colour and texture, crumbling nature and microbial status. The third formulation (maida : soya flour : tapioca flour in the ratio of 80:10:10) was found to be more crumbly while the second formula (maida : soya flour in the ratio of 90:10) was found to be soft and the colour and texture also of the formula 2 was found not affected. The scores for stale odour was also found to be low for formula 2. An assessment of the shelflife revealed that maida based bread as well as bread baked from maida when 10 per cent soyaflour was added, shelflife was found enhanced to 5 days instead of 4 days. The shelflife of the samples fermented for 3 hours were also found to be low as it was found an easy prey to microbes. The microbial status of the four formulations assessed revealed that formula 2 had lowest count for yeast and fungus. The maida based bread (control) was found to be less affected by bacteria.

On the basis of the baking characteristics, organoleptic and shelflife qualities, the combination in which 10 per cent soya flour was added with 1 1/2 hours fermentation time was selected.

The selected combination was then analysed for its nutrient content and found that it contained 16.20 g of protein and 492.85 kcals per 100 g. An animal experiment conducted revealed that the PER and NPU of the bread formulated were 1.30 and 65.47 respectively. The Biological Value and the Digestability Co-efficient was found to be 90.77 and 72.43 respectively.

A feeding trial was conducted to assess the feasibility of the soya fortified bread in the nutrition intervention programmes. The feeding trial was conducted for a period of 6 months with 15 female preschoolers selected through a preliminary clinical test by a qualified physician to eliminate the preschoolers with the clinical signs of nutritional deficiencies. During the 6 months period, the health status of the preschoolers were ascertained through the monitoring of height, weight, chest, upper arm and lower arm circumference. The anthropometric measurements were recorded before starting the experiment as well as after finishing the experiment.

A comparison made between the initial and final height, weight, chest, upper arm and lower arm circumference revealed that a significant improvement have occured in these measurements. A comparison of the final height and weight with the standard, revealed that these two measurements were statistically not significant. An assessment of the Body Mass Index of the preschoolers revealed that an improvement in their health status. 26.70 per cent of preschoolers were shifted to normal and only 53.30 per cent remained as moderately malnourished after the experiment. A significant improvement noted in the anthropometric measurements revealed that it can be used as a food supplement in any nutrition intervention programmes.

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* Original not seen

APPENDICES

APPENDIX - I

SCORE CARD FOR EVALUATING THE ACCEPTABILITY OF THE DIFFERENT COMBINATIONS OF BREAD

NAME OF THE PANEL MEMBER

	EXTERNAL							
Qualities	F1a	F1b	F2a	F2b	F3a	F3b	F4a	F4b
Presentation								
Colour (Crust)								
Shape								

Basis of scoring

Presentation		Colour		**Shape**	
Excellent	- 5	Golden brown	- 5	Typical	- 5
Very good	- 4	Brown	- 4	Slightly flat	- 4
Good	- 3	light brown	- 3	Flat	- 3
Satisfactory	- 2	Dark brown	- 2	Typical, but uneven	- 2
Poor	- 1	Pale brown	- 1	Slightly flat, but uneven	- 1
Very poor	- Ø	Dull brown	- Ø	Flat but uneven	- Ø

Continued..

Qualities	INTERNAL							
	F1a	F1b	F2a	F2b	F3a	F3b	F4a	F4b
Crumb Colour								
Crumb Texture								
Thickness of Cell wall								
Size of grain in the crumb								

Basis of scoring

Crumb colour

White - 5
Creamish white - 4
Yellowish white - 3
Dull white - 2
Brownish white - 1
Dirty white - Ø

Crumb Texture

Very soft - 5
Moderately soft - 5
Slightly soft - 3
Slightly hard - 2
Moderately hard - 1
Very hard - Ø

Thickness of cell wall

Very fine - 5
Moderately thin - 4
Slightly thin - 3
Slightly thick - 2
Moderately thick - 1
Very thick - Ø

Size of grain in the crumb

Very fine - 5
Slightly fine - 4
Moderately fine - 3
Slightly coarse - 2
Moderately coarse - 1
Highly coarse - Ø

Continued..

Qualities	ORGANOLEPTIC							
	F1a	F1b	F2a	F2b	F3a	F3b	F4a	F4b
Texture								
Aroma/Flavour								
Taste								
Appearance								
Doneness								
Masticability								
Overall acceptability								

Basis of Scoring

Texture

Highly acceptable - 5
Moderately acceptable - 4
Slighltly acceptable - 3
Not that acceptable - 2
Not acceptable - 1
Not at all acceptable - Ø

Aroma/Flavour

Highly aceptable - 5
Moderately acceptable - 4
Slightly acceptable - 3
Not that accepatble - 2
Not acceptable - 1
Not at all acceptable - Ø

Taste

Liked very much - 5
Liked moderately - 5
Liked slightly - 3
Disliked slightly - 2
Disliked moderately - 1
Disliked very much - Ø

Appearance

Excellent - 5
Very good - 5
Good - 3
Satisfactory -
Poor - 1
Very poor - Ø

Doneness

Well cooked - 5
Moderately cooked - 4
Slightly cooked - 3
Slightly uncooked - 2
Moderately uncooked - 1
Uncooked - Ø

Masticability

Non-Sticky - 5
Moderately non-sticky - 4
Slightly non-sticky - 3
Slightly sticky - 2
Moderately sticky
Very sticky - Ø

Over all acceptability

Highly acceptable - 5
Moderately acceptable - 4
Slightly acceptable - 3
Not that acceptable - 2
Not at all acceptable - 1
Unacceptable - Ø

APPENDIX - II

SCORE CARD FOR EVALUATING THE SHELFLIFE QUALITIES OF THE DIFFERENT COMBINATIONS OF BREAD

NAME OF THE PANEL MEMBER

Qualities	Different Combinations of bread							
	F1a	F1b	F2a	F2b	F3a	F3b	F4a	F4b
Crumbling nature								
Changes in colour and texture								
Stale odour								

Basis of scoring

Crumbling nature

Highly acceptable - 5
Moderately acceptable - 4
Slightly acceptable - 3
Not that acceptable - 2
Not at all acceptable - 1
unacceptable - Ø

Changes in colour and texture

Highly acceptable - 5
Moderately acceptable - 4
Slightly acceptable - 3
Not that acceptable - 2
Not at all acceptable - 1
unacceptable - Ø

Stale odour

Highly acceptable - 5
Moderately acceptable - 4
Slightly acceptable - 3
Not that acceptable - 2
Not at all acceptable - 1
unacceptable - Ø

APPENDIX - III

COMPOSITION OF EXPERIMENTAL DIET

Experimental Diet	Amount of various ingredients (g)
Bread crumbs	70.42
Starch	14.58
Groundnut oil	9
Mineral mix	4
Vitamin mix	2

APPENDIX - IV

PROCEDURE FOR MEASURING HEIGHT

Height is measured with an anthropometric rod or a wooden scale

1. The subject will stand erect with heels together after remaining his shoes

2. He will look straight, the head comfortably erect, the arms hanging at the side.

3. The buttocks, shoulders and back of the head will be in the same line and touching the rod.

4. The movable head piece of the rod and wooden pieces will touch the head gently and lowered by its over pressure.

5. Height is measured to the nearest millimetre.

APPENDIX - V

ANOVA-baking characteristics of different combinations of bread

Baking characteristics	Mean Square Treatment D.F=3	Error D.F=12	F value
Water absorption	34.236	0.00326	10517.200**
Moisture	1.671	0.00005	603.765**
Acidity	0.018	0.00277	19.086**
	D.F=7	D.F=72	
Weight of the dough	28.009	0.32552	86.043**
Puffing rate	17.137	0.08958	191.294**
Loaf volume	69893.000	151.75000	460.580**
Loaf weight	69.116	0.69531	99.403**
Rate of dehydration	1.927	0.00016	11838.860**
Baking loss	31.771	1.06299	29.889**

** : Significant at 1 per cent level

APPENDIX - VI

ANOVA-organoleptic qualities of the different combinations of bread

Qualities	panel	Mean Square Treatment D.F=7	Mean Square Error D.F=72	F value
EXTERNAL				
Presentation	S	15.341	0.7153	21.448**
	C	12.713	0.5764	22.055**
Crust colour	S	2.686	0.9083	2.957**
	C	4.184	0.9819	4.261**
Shape	S	22.441	0.4486	50.023**
	C	6.727	0.8875	7.579**
INTERNAL				
Crumb Colour	S	17.764	0.6056	29.336**
	C	7.364	0.8611	8.552**
Crumb texture	S	19.555	0.1708	114.471**
	C	4.027	1.0514	3.830**
Thickness of the cell wall	S	13.541	0.5375	25.193**
	C	3.041	0.6347	4.791**
Size of the grain in the crumb	S	8.650	0.5861	14.758**
	C	5.021	0.5667	8.613**

Continued..

Qualities	panel	Mean Square Treatment D.F=7	Mean Square Error D.F=72	F value
Aroma	S	8.098	0.4375	18.510**
	C	1.964	0.6639	2.959**
Masticability	S	9.050	0.5028	18.000**
	C	6.479	1.0361	6.252**
Taste	S	12.971	0.2417	53.675**
	C	3.584	0.6292	5.696**
Over all acceptability	S	16.698	0.2375	70.308**
Doneness	C	5.270	0.9597	5.491**
Texture	C	5.798	0.5819	9.963**
Appearance	C	7.784	0.7458	10.437**

** : Significant at 1 per cent level

APPENDIX - VII

ANOVA-shelflife qualities of the different combinations of bread

Qualities	Mean Square Treatment D.F=7	Error D.F=72	F value
Crumbling nature	6.307	0.3306	19.080**
Changes in colour and texture	9.341	0.3681	25.380**
Stale odour	8.850	0.1944	45.514**
MICROBIAL STATUS	D.F=7	D.F=24	
Yeast	2765.000	13.4375	205.767**
Fungus	7142.496	11.9063	599.895**
Bacteria	14477.410	635.0000	547.178**

** : Significant at 1 per cent level

APPENDIX - VIII

INITIAL AND FINAL ANTHROPOMETRIC MEASUREMENT OF THE PRESCHOOL CHILDREN OF THE EXPERIMENTAL GROUP

No.of preschoolers	Age (Years)	Height(cm)		Weight(kg)		Head(cm) circumference		Chest(cm) circumference		upper arm(cm) circumference		Lower arm(cm) circumference	
		Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Inital	Final
1	2	85.00	91.00	10.50	12.50	47.50	48.00	48.00	48.00	14.00	15.00	11.00	12.00
2	2	80.50	84.50	8.00	10.50	47.00	48.50	47.00	48.00	14.00	15.50	11.50	12.50
3	3	95.00	102.00	12.00	14.20	46.50	47.00	51.00	52.00	15.00	16.00	14.50	15.00
4	3 1/2	96.50	102.00	12.00	14.50	49.50	51.00	51.00	53.50	17.00	18.50	15.00	16.00
5	3 1/2	85.50	97.00	11.00	13.00	49.00	50.00	52.00	54.00	16.00	18.50	13.00	16.00
6	4	101.00	107.00	12.50	14.50	50.00	52.50	50.00	52.50	15.50	16.50	15.50	16.00
7	4	95.00	102.00	11.50	15.00	50.00	51.00	51.50	55.00	16.50	17.00	15.00	16.00
8	4	97.00	98.50	12.50	17.00	49.00	50.50	52.00	53.50	15.00	16.00	15.50	16.50
9	4	96.50	98.00	10.00	13.50	50.00	52.00	50.00	52.50	15.50	16.50	15.50	16.00
10	4	98.00	104.00	13.00	16.00	50.50	53.00	50.00	52.50	15.50	16.00	16.00	17.50
11	4 1/2	104.50	114.50	13.00	18.00	49.50	52.00	49.50	50.00	16.00	16.50	16.00	16.50
12	4 1/2	109.50	115.00	17.00	21.00	52.00	53.00	53.00	55.00	17.50	18.00	16.50	17.00
13	4 1/2	107.00	110.00	15.50	17.50	47.00	48.00	55.50	56.50	17.50	18.00	16.00	17.50
14	4 1/2	104.00	110.00	15.00	17.00	49.00	50.00	53.50	55.00	15.00	16.00	16.50	17.50
15	5	107.00	109.50	16.50	20.50	51.00	52.50	56.50	59.00	16.50	17.50	17.00	18.00

IMPROVEMENT OF THE NUTRITIONAL QUALITY OF BREAD

BY

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ABSTRACT OF THESIS
Submitted in Partial Fulfilment of the Requirement
for the Degree
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1995

ABSTRACT

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A study on Improvement of the nutritional quality of bread was conducted by selecting different food ingredients like soya flour, tapioca flour and skimmed milk powder and also by varying fermentation time.

The baking characteristics, organoleptic and shelflife qualities of the four different formulations tried were ascertained and based on these 3 aspects, maida : soya flour in the proportion of 90:10 with a fermentation time of 1 1/2 hours were selected for further study.

Results of the nutrient analysis of this combination revealed a high protein, calorie and iron compared to control while the PER and NPU were found to be 1.30 and 65.74 respectively.

The feasibility of this combination as a food supplement in nutrition intervention programme was ascertained by conducting a feeding trial for a period of 6 months for 15 preschoolers and the results revealed a significant improvement in height, weight, chest, upper arm and lower arm circumference.

Hence it can be concluded that using maida : soya flour in the proportion of 90:10 can raise the protein content of bread without causing any deleterious effects upon baking and also without altering the organoleptic and shelflife qualities. It can also be used as a food supplement in any nutrition intervention programmes.