DEVELOPING A WEANING FOOD WITH RICE AND SOYA AS BASIC MIX

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DECLARATION

I hereby declare that this thesis entitled **"Developing a weaning food with rice and soya as basic mix"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellayani,

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CERTIFICATE

Certified that this thesis entitled **"Developing a weaning food with rice and soya as basic mix"** is a record of research work done independently by **Smt. Rosita Jacob** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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ROSITA JACOB

CONTENTS

LIST OF TABLES

Contd....

Contd....

LIST OF ILLUSTRATIONS

LIST OF APPENDICES

INTRODUCTION

1. INTRODUCTION

The national policy for children declares that children are `supremely important asset' of a Nation. (Anon, 1995). It affirms that it shall be the duty of the state to provide adequate services to children, both before and after birth and throughout the period of growth to ensure their full physical, mental and social development.

India along with many other developing countries, has a comparatively young population. The demographic profile shows that 38 per cent are under the age of 14 years and 13.7 per cent are below the age of five years. (Ghosh, 1992).

In the vast biological stretch of early childhood, infancy is perhaps the most critical and vulnerable period and it is during this period that a high incidence of wastage from mortality and morbidity is witnessed. (Dayal, 1983).

The `Progress of Nations Report' of 1996 released jointly by the government of India and UNICEF reveals that as many as 53 per cent of all under - five children are under weight, which is an indication of malnutrition (Anon, 1996).

Although Kerala has captured the attention of the world for its unique achievement in health, a recent survey conducted by NFHS in 1993 has revealed that only 14.5 per cent of children in the state fall in the normal category, and the remaining three fourth of the child population are victims of mild (38.9%) to moderate (34.5%) forms of malnutrition; though the incidence of severe forms of malnutrition accounts for only less than three per cent. (Soman, 1995). Reddy *et al.* (1993) while reviewing the nutritional trends in India, have observed the major nutritional deficiency signs seen among children as Protein Energy Malnutrition (PEM) (Kwashiorkor and Marasmus) Vitamin A deficiency (Bitot spots) and Vitamin B Complex deficiency (angular stomatitis).

Protein energy malnutrition is essentially a syndrome that occur during the crucial transitional phase of child's life from breast milk to other types of food. A study of infant feeding practices conducted in three cities of India indicated that nine to 12 per cent of children lived without any supplements even at the end of eight months, while commercial milk food and cereal foods were used exclusively or as supplements, by 14 to 42 per cent of infants even in cases where families could hardly afford the cost (UNICEF, 1991).

In our country commercially available weaning foods are expensive and so are out of reach of large majority of the population who belong to the lower socio-economic strata. In such cases the child is given the same food that is prepared for the rest of the household or continues to be breastfed, with suboptimal nutrient intake.

The major drawback detected in the commercial as well as the traditional weaning foods is that, they have a high dietary bulk and hence low in calorie density becoming nutritionally inadequate as has been reported by Malleshi and Desikachar, (1986); Gahlawat and Sehgal, (1994).

Therefore there is a need to develop an indigenous weaning food that has low dietary bulk, high in calorie density, easily digestible, nutritionally adequate and acceptable to the local cliantale. In order that a food is to be acceptable, it should be developed from indigenous foods using simple technologies.

Sinha and Nawab (1993) have stated that use of wheat or rice and medium fat soya flour blend for making traditional food items offers an unique opportunity for combating protein calorie malnutrition prevailing among our masses. Rice is the basic ingredient of South Indian dietaries. It is the most socially acceptable indigenous item that merits inclusion in a weaning food, provided it is admixed with other essential complementary foods, judiciously selected from the `Food Square'. A complementary food rich in protein of good biological value and also rich in fat of vegetable origin would make an ideal complement for a rice based basic mix. Therefore soya added to rice could theoretically be considered as a good basic mix of a nutritionally sound weaning food, if a recipe could be designed to suit the palate and cultural practices of Kerala.

Though soya is not cultivated in Kerala it has already found a place in the dietaries of our children through the supplements provided under the nutrition intervention programmes such as ICDS implemented in the state. Since the donors of such foods have already announced their withdrawal in the near future, it is worthwhile to design a rice-soya blended weaning mix, suitable to the children of Kerala.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Literature pertaining to the study entitled "Developing a weaning food with rice and soya as basic mix" is reviewed in the present chapter.

1. Status of infants and children

Mistral, as quoted by Malleshi (1995) reports that "We are guilty of many errors and many faults, but our worst crime is abandoning the children, neglecting the fountain of life. Many of the things we need can wait, the child cannot. Right now is the the time his bones are being formed, his blood is being made and his senses are being developed. To him we cannot answer `TOMORROW' his name is `TODAY'"

Children lay the foundation for future health status of the nation (Geetha and Devadas, 1986). Dayal (1983) is of the opinion that early childhood constitutes the foundation of adult productivity and nutrition is a major determinant of the quality or strength of this foundation. Mugula (1992) opined that nutritional status of children is a crucial indicator in determining the quality of life of people and is linked with their health status.

Yadav and Sehgal (1995) are of the opinion that malnutrition continues to undermine the development of vulnerable groups in the developing countries including India.

UNICEF (1984) has reported that malnutrition at the social level is a consequence of the relation of people with food. Malnutrition according to Alexandar (1985) is a condition, when one or more nutrients are less or are in excess in the body and is said to be the major health problem of our country which is acute and wide spread.

India was reported to have the highest percentage of moderately and severely under weight children, when compared with selected Asian countries and the percentage of children belonging to under weight, wasted and stunted category were found to be 63, 27 and 65 respectively (Grant, 1993). While in Kerala 75.5 per cent of the children were found to be suffering from mild to moderate forms of malnutrition as revealed by the National Family Health Survey (Soman, 1995).

Shukla (1982) has stated that the main causes of malnutrition in India include non availability of food, poverty, population growth, customs, conditions which influence socio economic status, education, industrialisation, urbanisation and modernisation.

According to Ghosh (1986) malnutrition among children results from the interaction of several factors. They are poor socio economic conditions, parental ignorance and illiteracy, repeated infections, large families, closely spaced child births and low birth weight. According to Sharma (1979) the socio economic factors play an important role in the occurrence of malnutrition and includes poor health of the mother, poverty, scarcity of nutritious foods at the critical stages of growth and development, ignorance, socio cultural factors such weaning taboos and prejudices, discrimination against girls and faulty cooking practices.

According to Vijayalakshmi *et al.* (1975) the causes for malnutrition among pre school children are low intake of nutrients, low income, lack of knowledge, infections, improper selection and preparation of foods, poor weaning practices and faulty food beliefs. Ghosh (1992) reported that prolonged breast feeding and late introduction of semi solids result in malnutrition among children.

Shah (1979) concluded that the main factors which leads to malnutrition among young children include late introduction of semi solid foods during infancy, diluted supplementary feeding, daily wages of mother, nuclear and large families, shorter intervals between two pregnancies, jobless period of parents, preferential care of boys and poor antinatal care.

Srikantia (1983) indicated that one of the most important contributing factors for the development of infant malnutrition is the poor infant feeding practices.

Vobecky *et al.* (1986) confirmed that there is an important relationship between the early eating behaviour, eating patterns later in life and health status and that nutritional patterns at age three are affected by time at which solid foods are introduced to the infant and this is influenced or controlled by several familial and environmental factors.

As per the International Conference Report on Nutrition (1992), malnutrition among children is more likely to result from ignorance about hygienic and dietary needs of children than from shortage of food.

According to Tontisirin and Lamborisut (1995), two factors playing major roles in the pathogenesis of protein energy malnutrition and low birth weight are inadequate dietary intake and the combined effect of stress and infections, which may interfere with the intake, absorption and assimilation of nutrients.

However protein and energy malnutrition can be overcome with protein and energy rich supplements as reported by Annie *et al.* (1993).

Udani (1990) has stated that the quantity and quality of supplements provided at the weaning age determines the nutritional status of children. While Desikachar (1982) is of the opinion that by introducing supplementary food of good quality and quantity at the right time and in right proportions, the incidence of protein calorie malnutrition can be prevented to a large extent.

2. Need for developing weaning foods

Weaning has been defined as systematic introduction of food other than milk to provide significant nutrients to the infant by Dayal, (1983). While Mitzner *et al.* (1984) have defined weaning foods as any solid, semi solid or liquid nutrient fed to a nursling in addition to human milk. According to Malleshi (1993) the same solid foods given to the child during the weaning stage are generally called as weaning foods and they are nothing but modified forms of adult food.

According to Devadas *et al.* (1984), breast milk may be sufficient to meet the nutritional requirements of the child upto six months, but not beyond it and hence, supplementary feeding has to be resorted around the sixth month of life of the baby to maintain the expected growth and to bridge the gap of energy and protein requirement.

Chandrasekhar *et al.* (1981) have stated that prolonged breast feeding without appropriate complementary feeding is a crucial contributory factor for malnutrition among children and supplementation has to be instituted after four to six months to overcome malnutrition and related complications due to infections.

According to Malleshi and Amla (1988) the weaning stage is an extremely important one in a child's life and during this period, growth is rapid and the mother's milk alone will not suffice to meet the child's calorie and nutrient requirements. It is essential therefore to introduce semi solid foods as supplements to breast milk.

Gahlawat and Sehgal (1994) have opined that although breast feeding is the best choice for feeding the human infant, it meets nutritional requirements of growing infant only upto four months. Thereafter supplementary feeding becomes a necessity for the optimum development of an infant.

Research findings of Lina and Reddy (1984) indicate that one of the strategies to overcome the nutritional problems of children is to stimulate the preparation and utilization of inexpensive indigenous home-food mixes to meet the basic nutrient needs.

Economically affluent elites meet the nutritional requirements of their children by feeding commercial weaning foods but the cost induced in transportation, storage and distribution of these commercial products make them beyond the reach of common men (Chandrasekhara *et al.* 1988). Hence as reported by Dahiya and Kapoor (1993) there is an urgent need to develop low cost nutritious supplements which is possible by the judicious combination of less expensive foods available in a rural household.

Malleshi *et al.* (1989) have felt the need for the development of nutritionally balanced, calorie-dense, low dietary bulk and easily digestible weaning foods adapting simple traditional technologies.

He has further stated that several weaning foods can be developed using simple household technologies.

According to Marero *et al.* (1988) weaning food needs to be developed from locally available resources which are economical, easily digestible and acceptable to children.

According to Desikachar (1982) the staple of the community should be used as the base for a weaning food and the home should be the place of preparation of the same.

Ahmed *et al.* (1993) have emphasised the effectiveness of supplementation of cereals with legumes in the daily diets of the people.

Gopaldas *et al.* (1982) and Desikachar (1985) have also pointed out that low cost and locally available cereals and pulses should be utilized for preparing weaning foods.

3. Desirable characteristics of a weaning food

Chandrasekhara (1980), Gopaldas *et al.* (1982) and Desikachar (1983) have listed the desirable characteristics of a weaning food as high nutrient density and low bulk property and they have stressed the need for utilization of low cost and locally available cereals and pulses and traditional processing methods for developing indigenous weaning foods at home and village level.

Malleshi and Amla (1988) have reiterated that the developed weaning foods should be easily digestible, nutritionally balanced, of low dietary bulk, high in calorie density and that these be foods that can be sold at a price affordable to low income groups, or even be produced at the household or community levels.

Gahalawat and Sehgal (1993) have advocated that the weaning foods formulated from locally available cereals and pulses should be economical and simple to prepare. They have also stated that foods should be developed in forms which make their preparations easy at the time of feeding and that they should remain free from any toxic compound and be resistant to other changes for a sufficient length of time.

Waterlow and Payne (1975) have observed that in infants, the nutrient intake is limited by a combination of inadequate masticating and swallowing ability and small stomach capacity. Hence the weaning food must supply adequate amounts of metabolizable energy and protein. Consequently a higher energy and nutrient concentration is required in a weaning food.

According to Malleshi (1995) a weaning food should be rich in calorie and adequate in protein, vitamins and minerals, provide protein of high biological value in adequate amounts, soft in consistency and easy to swallow, low in dietary bulk and viscosity, easy to prepare, easily digestible, free from antinutritional factors, low in indigestible fibre and free from artificial colours and flavours.

After much experimentation and field trials, a variety of processed weaning foods and supplementary foods based on cereals and legumes, oil seeds and oil seed meals have been developed in India in the past few decades.

4. Weaning foods developed

Pasricha (1973) had developed a ready-to-mix powder and the main ingredients were cereal (wheat, bajra or ragi); pulse (roasted bengal gram) oil seed (groundnut) and sugar. The supplement was based exclusively on local resources. CFTRI, Mysore (1974) had designed `Energy food' and the raw materials used were wheat flour, bengal gram flour, groundnut flour and jaggery powder. Gopaldas *et al.* (1975) formulated `Poshak'. The main ingredients used were cereals (wheat, maize, rice and jowar) pulse (chana dal or mung dal), oil seed (ground nut) and jaggery in the proportion of 4:2:1:2.

Ralda and Wei (1980) had developed a 'soya bean-banana food bar' which is a pressed form of soyabean and banana flakes. A soya-whey weaning food produced by grinding the soya-whey mixture, oil and oil soluble vitamin was standardised by Kapoor and Gupta (1981). NIN (1981) has developed weaning foods like 'Sajina' and 'Behuna' which are found to be capable of improving the nutritional profile of children. Gupta and Kaur (1982) had formulated a weaning food containing potato, soya bean and skim milk in the ratio of 65:20:15.

Kulkarni *et al.* (1991) formulated low-cost nutritive, but bulk-reduced weaning foods using sorghum malt, green gram malt and sesame flour.

Ashturkar *et al.* (1992) formulated four weaning foods namely RGB (containing rajheera, green gram and bengal gram dal) JSB (containing jowar, soy bean and bengal gram dal) and JPG (containing jowar, puffed bengal gram and green gram) mixes. While Gupta and Sehgal (1992) developed weaning foods from locally available foods viz., barley, bajra, green gram, amaranth grain and jaggery using house hold technologies such as roasting and malting.

Several weaning foods have been developed in Kerala to meet the socio, cultural and nutritional requirements of the children of the state.

Kerala Indigenous Food (KIF) conceived by Chandrasekhar *et al.* (1976) contained tapioca, rava, soya fortified bulgar wheat (SFB) and ground nut flour.

Kerala Agricultural University has developed five different types of weaning foods using locally available and traditionally accepted materials.

Jessy (1987) has developed a ragi based weaning food with ragi, green gram, sesamum, tapioca and skim milk powder. A banana based weaning food was formulated by Sheela (1988) containing banana flour, green gram, sesame and skim milk. Chellammal and Prema (1992) developed a weaning food with tapioca flour, soya flour, ground nut flour and skim milk powder. Rice based supplementary food developed by Sailaxmi (1995) contained rice, soya bean and ground nut flour. Chellammal (1995) has also developed a sweet potato based weaning food with sweet potato flour, soya flour, ground nut flour and skim milk powder.

5. Technologies for developing weaning foods

Desikachar (1982) an authority on development of weaning foods for Indian children has stated that there is a wide choice not only of raw materials but also technologies for the development of weaning foods.

Galhawat and Sehgal (1993) have reported that roasting and malting were the processing techniques commonly used in developing weaning foods from locally available cereals and pulses.

Besides the above traditional methods, simple traditional technologies like baking a chapatti dough, drying and grinding it to a powder (Moussa *et al.* 1992) vermicelli process, popping, flaking of grains and drying of fruits and vegetables (Malleshi *et al.* 1986) are universally used, to prepare home based weaning foods.

For commercial preparation of weaning foods, the most commonly adopted methods are roller drying and extrusion cooking which are classified under modern technologies. (Brandtzaeg *et al.* 1981).

Several weaning foods have been prepared by employing the above technologies with a number of advantages to their credit and limited number of draw backs. The process of malting has been effectively used in the development of several weaning foods. Malted flours of ragi and green gram (in the ratio of 2:1 cereal flour and legume flour) has been used to prepare a weaning mix by Desikachar (1980) which was fortified with synthetic vitamins. Its advantages over commercial products were low bulk, higher calorie density, better digestibility, lower cost and the simplicity of the technology.

Malleshi *et al.* (1986) developed malted weaning foods using sorghum and cowpea in the proportion 70:30 while malted millet and mungbean (70:30) were used for formulating a weaning mix by Maleshi and Amla (1988).

Malted sorghum and malted cowpea flours were blended the ratio of 70:30, to prepare a malted weaning food by Malleshi *et al.* in 1989.

Malleshi *et al.* (1986) conducted studies on protein value of a weaning food based on malted ragi (Eleusine coracane) and green gram (Phaseolus radiatus). The amino acid composition of the malted weaning food was found to be good apart from a deficiency of threonine; however its protein value was equivalent to that of a proprietary weaning food.

Malleshi and Desikachar (1986) reported that finger miller malt had desirable flavour and taste besides high amylase activity and was thus rated highly suitable for formulating calorie dense weaning foods which are low in dietary bulk or viscosity.

Malting quality of rice for use in weaning food formulations was examined by Capanzana and Malleshi (1989). Malt flour gave desirable flavour and taste when roasted. It also had very low cooked paste viscosity, indicating its suitability for use as a base material in low dietary bulk weaning foods. Gahlawat and Sehgal (1993) have reported that roasting and malting were the processing techniques commonly used in developing weaning foods from locally available cereals and pulses which resulted in a significant increase of hydrochloric acid extractable minerals, an index of their bio availability to human. The effect was more pronounced on malting. Kshersagar *et al.* (1994) developed malted weaning foods which were found to have low viscosity and high calorie density. He used roasted ragi, mung bean and pea nut and dried skim milk in the proportion 35:35:10:20 to formulate a weaning food that was highly acceptable.

Gahlawat and Seghal (1993) roasted wheat / barley and green gram in the proportion (7:3) and mixed them with jaggery to constitute a weaning mix. Gahlawat and Sehgal (1994) have also formulated three weaning mixes using roasted rice, kangini, sanwak and green gram which were then powdered. It was observed that the protein and starch digestibility and iron bio availability were enhanced by roasting.

The feasibility of using germinated seeds to formulate a nutritious weaning food was investigated by Nattress *et al.* (1987) and the final product consisted of germinated wheat, millet, garbango bean, mung bean and sesame in the proportion of 8:4:4:3:1 and was found to be acceptable. Acceptable and microbiologically safe weaning food formulations were prepared from 70:30 combinations of germinated rice : mung bean, germinated rice : cowpea, germinated corn : mung bean and germinated corn : cowpea by Marero *et al.* (1988). They have also reported that the process of germination and gruel preparation of germinated materials contributed to the digestibility of weaning foods prepared from cereals and legumes.

Fermentation has been used as another traditional method of preparation of weaning formulae. `Ogi-baba', a fermented gruel made from sorghum (*sorghum bicolor*) is used as an infant/weaning food and a breakfast meal, (Odunfa and Adeyela 1987), where in sorghum grain soaked for three days at room temperature, is wet milled, seived and filtrated and allowed to stand for two days, permitting time for lactic fermentation. Adesule *et al.* (1981) prepared fermented weaning food using greengram.

Fermented sorghum - based composite weaning foods were prepared by combining sorghum flour, pigeon pea meal, ground nut meal, ground nut oil, sorghum malt and water in various proportions by Nout *et al.* (1988).

Weaning foods were developed through chappati and vermicelli process, popping and flaking by Desikachar (1982), Malleshi *et al.* (1986), Moussa *et al.* (1992) and Malleshi (1995).

Ignoring the fund of information and technologies based on tradition and culture several modern techniques including roller drying, extrusion and spray drying have been developed for the commercial preparation of weaning foods. Iya and Rao (1980) prepared nutritious weaning food from buffalo milk with added sugar and vitamins by vacuum concentration and spray drying or preferably by roller drying in India. Potato, soy bean cotyledons and skim milk solids were used for manufacturing a weaning food by Kaur and Gupta (1982). They employed boiling, peeling and mashing of potatoes, addition of soy bean and skim milk followed by roller drying after pasturization. Weaning food ingredients consisting of flours of wheat, green gram, bengal gram and ground nut have been mixed and roller dried by chandrasekhara and Ramnathan (1983) to develop another modern weaning food.

A pre-cooked weaning food was prepared by roller drying a cold water slurry consisting of 70% pearled sorghum flour and 30% toasted cowpea flour by Malleshi *et al.* (1989). Toasted wheat, chick pea, skim milk powder and sucrose in the proportion of 60:30:5:5 was processed into a weaning food by roller drying by Livingstone *et al.* (1993).

6. Effect of process technology on product quality/character

Though the traditional and modern weaning foods have their own merits, most of these foods were found to have a major draw back of high dietary bulk, being highly viscous (Brandtzaeg *et al.*, 1981).

Effects of malting and of traditional heat processing operations (toasting, sand roasting, parboiling, and steaming) on cereals, millets and legumes were studied by Desikachar (1980) and the results showed that heat treatment reduced hot-paste viscosity while gelatinization of starch during heating increased cold-paste viscosity. He observed that maximum reduction in hot-paste (slurry) viscosity was achieved by cooking under pressure or puffing for 1-2 minutes at 200-250 degree. He further reported that maximum reduction in both hot and cold-paste viscosity was achieved by malting. The malted weaning food thus prepared was found to have much lower viscosity and higher calorie density than conventional roller dried weaning foods.

Use of germinated cereals and legumes to reduce bulk of weaning foods was investigated by Marero *et al.*

(1988). The above workers formulated germinated corn-mungbean and germinated corn-cowpea mixtured and germinated rice-mung bean, germinated rice-cowpea, (germination period 72h for rice/corn and 48h for mungbean/cowpea) studied their viscosity and acceptability and quality. They found viscosity reductions of about 3000-20000 CP at the 70:30 ratio (compared with ungerminated variants) with concomitantly good scores for general acceptability. They found that germination reduced dietary bulk of formulations due to decreased viscosity of gruels, thus increasing their nutrient density (Marero *et al.* 1988). Malleshi and Desikachar in 1988 found that addition of approximately 2.5 per cent barley malt flour or 0.15 per cent fungal alpha-amylose to a proprietary brand of roller-dried weaning food reduced paste viscosity of a 20 per cent slurry from 15000 to 1000 CP.

Malting quality of rice for use in weaning food formulations was examined by Capanzana and Malleshi (1989) and the results indicated that malt flour had very low cooked paste viscosity compared with ungerminated, expanded, puffed and flaked rice flours. The possibility of enzymic liquifaction of foods by means of malted cereals or industrial enzymes have been found to have the advantage of reducing viscosity, while increasing nutrient density (Anon, 1991).

Effects of `amylase digestion' of weaning foods on digestibility of a corn-based weaning food were determined in gambian children by (Weaver *et al.*, 1994). It was concluded that partial digestion of weaning foods with alpha-amylase may improve nutrition of children by reducing viscosity of the food.

An attempt was made by Kulkarni *et al.* (1991) to formulate low-cost, nutritive, but bulk reduced weaning foods using sorghum malt, green gram malt and sesame flour. Hot and cold paste viscosities of 10 per cent and 15 per cet gruel of experimental formulations were much lower than those of the commercial sample.

Kikafunda and Walker (1994) evaluated effects of adding peanut (Arachis hypogaea) and milk on viscosity and energy density of corn based porridge. Porridges were cooked for 5-10 min and viscosity was measured at 30 or 40^{o} C using a shear speed of 256 or 512 rpm and shearing time of 20 or 60s. Addition of peanut paste or milk significantly reduced viscosity of porridge (P less than 0.001). Pea nut paste had a greater effect at increased cooking time and with fine flour.

Kshersagar *et al.* (1994) found that malting and addition of 5% barley malt were found to reduce the cold, hot and cooked paste viscosity of the weaning food, thus causing an increased calorie density.

Use of `amylase rich wheat flour', prepared from germinated wheat, to reduce the viscosity of cereal porridge and thus to increase its suitability as a weaning food was investigated by Wahed *et al.* (1994). Three porridges (20 per cent rice porridge, 20 per cent wheat porridge and khichuri - a traditional porridge containing rice flour, lentils and oil) were tested for viscosity before and after addition of 2g Amylose Rich Food (ARF) to 100g porridge and viscosity reductions were 87-98 per cent.

It is concluded that production of ARF is feasible and presents a possible solution to the problem of formulating energy-dense, non viscous foods for infants.

7. Nutritional adequacy and organoleptic quality

Pedersen *et al.*(1989) has stated that the weaning foods developed should be tested for their nutritional adequacy.

Ahmed *et al.* (1981) formulated 10 weaning mixes based on rice or wheat, with bengal gram, black gram, lentil, mung bean or khesari at ratios 1:1, 2:1, 3:1 and 4:1, as second ingredient and cooked into a thick porridge. A daily feeding plan comprising of 200 ml breast milk and 3 servings of weaning mix supplied FAO/WHO recommended intakes for energy, protein and other nutrients and 85 per cent of calcium requirements. Mixes based on rice with pulses were reported to have 10-12 per cent PE% (protein energy %) and an evaluated NPU of 66 to 75. While a weaning food manufactured by Kaun and Gupta (1982) containing potatoes, soybean and skim milk in the ratio 65: 20: 15 was found to have a protein efficiency ratio of 1.9.

Various infant formulae were compared by Oyeleke *et al.* (1985), for their composition and nutritional quality, ie., (i) a mixture simulating a popular Nigerian sorghum-skim milk powder (830 : 170 w/w) preparation and (ii) a mixture of 58: 280: 160 by weight of sorghum cowpea-skim milk powder. In (i) and (ii) the protein content was 96 and 133 g/kg and BV was 0.74 and 0.87 respectively.

A weaning food formulated by Nattress *et al.* (1987) contained germinated wheat, miller garbango bean, mung bean and sesame in the proportion of 8:4:4:3:1. On a freeze dried weight basis, 100g of the sample contained 390 K Cal, 18 g protein, 11g fibre and 3.1, 5.5, 133, 29 mg of Zn, Fe, Ca and vitamin C respectively.

Weaning foods prepared from sesamina (60% wheat flour, 30% yellow lentils and 10% decorticated sesame) were evaluated chemically and biologically by Moussa *et al.* (1992). Protein and fat contents were higher in the weaning foods produced from germinated seeds, wheareas mineral content was higher in nongerminated seeds and the PER and NPU were highest in weaning foods produced using germinated seeds. Asiedu *et al.* (1993) have shown that germination increased the gross energy of cereals used as a component in infant weaning foods.

While comparing the energy density and nutritive value of malted and malt added food slurries containing 60%

wheat, 30% chickpea, 5% skim milk powder and 5% sucrose and containing about 16% protein, Livingstone *et al.* (1993) found that the PER (2.91), biological value (88.3) and true digestibility (87.5) values of malted foods were higher than that of other formulations. A supplementary food gruel for infants and children, consisting of flours of processed brown rice, germinated mungo, sesame and carrot blend at 50:50:5:5 ratio, was reported to contain 17.3% protein, 65.5% carbohydrates, 4.9% fat, 2.5% ,minerals, 346 mg of B carotene and 518 K Cal of energy per 100 g (Naikare and Malesa, 1993).

Nutritional quality of three weaning foods prepared from locally available cereals and pulses such as rice, kangeni, sanwak, green gram and jaggery were evaluated by Gahlawat and Sehgal (1994) and they found that these weaning foods contained (per 100g on DM basis) 5.1-5.7% of moisture, 10.3-13.7 g of protein, 2.9-3.8 g of ash, 0.8-1.9 g of fat, 14.4-15.3 mg of iron, 1.0-1.3 g of crude fibre and 357-374 K cal/100 g of energy. In vitro protein digestibility ranged from 72.1 to 75.7%.

Sodium, zinc, iron, and iodine contents of home-prepared sweet weaning foods were determined by Stordy *et al.*

(1994). They found that the mineral (Na, Fe and Zn) contents were higher in home prepared foods when compared to commercial weaning foods.

Redfern *et al.* (1994) determined the sugar contents of home-prepared sweet weaning foods, (total sugars, sucrose, glucose, fructose, lactose) and it was shown that home prepared foods contained 12% less sugar than ready to use varieties, but variation in sugar content was great in home-prepared foods.

Several investigators have not only evaluated the nutritional adequacy of the weaning mixes but have evaluated the their organoleptic qualities also through sensory evaluation.

According to Manay and Swamy (1987) 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.

The weaning mixes formulated by Lina and Reddy (1984) (LIFT 1-6) were evaluated for their acceptability and physiological tolerance. All the six mixes were well accepted by the children and no adverse effects were noticed in terms of diarrhoea or discomfort of the digestive tract. The weaning mixes were also well liked by the mothers. The same trend was noticed in the case of a weaning mix prepared by Gupta and Sehgal (1990) and this consisted of malted barly or pearl millet (60 g): roasted amaranth grain (20 g): roasted green gram (40 g): jaggery (45 g).

The weaning mixes formulated by Reddy *et al.* (1990) using foods and traditional processing techniques was evaluated for acceptability using a target population of mothers and infants and all the mixes were found acceptable. Rathod and Udipi (1991) carried out acceptability trials for the four weaning mixes and they were found to be most acceptable by the panelists or judges. In the acceptability trials, 76-85 per cent of the mothers reported that the mixes were acceptable to children.

Based on the relevant and salient findings reviewed from the literature cited above an attempt was made in this study to develop an acceptable weaning food for infants between the age of 6 to 9 months using Rice and Soya as a basic mix.

Rice and defatted soya flour were the ingredients pre determined to formulate the `basic mix' of the weaning food in the present study. The facts which merits the inclusion of rice and soya flour have been reported by several workers.

Rice (*Oryza sativa*) is an important cereal and is the staple of majority of Asia's population (Capanzana and Malleshi, 1989).

According to Juliano (1985) 70 per cent of the world's dietary energy is reported to be obtained from this staple food. Grist (1986) has also reported that rice is the chief source of carbohydrates and being a staple food, rice is reported to provide 80 per cent of the calorie requirement of the diet.

Although rice is primarily a source of carbohydrate, it also deserves to have the highest digestibility co-efficient, biological value and protein efficiency ratio among all cereals (Ananthachar *et al.*, 1982). Among cereals, it has a comparatively high content of essential amino acids as revealed by Pillayar (1988). He has also stated that the true digestibility and the biological value of rice protein are the highest when compared to wheat and other cereals. Bandyopadhyay and Roy (1992) have reported that rice protein has higher content of lysine when compared to other cereals.

Capanzana and Malleshi (1989) have concluded that since rice protein is of good quality and its carbohydrates are also easily digested, it forms an ideal base for weaning foods.

Soyabean is reported to be a good source of essential amino acids except methionine and tryptophan (Wolf, 1969). Sinha and Nawab (1993) reported that soya flour is a very good source of quality protein which can supplement the lysine deficiency in cereal flour.

According to Jayalekshmi and Neelakantan (1988) soyabean and its products have become increasingly popular but a large section of the population in India are still not aware of the food value of the soyabean.

Varma *et al.* (1987) feel that the lower cost of soy proteins when compared with milk, meat and fish is the most favourable point in utilizing soyabean in human food preparations. As a protein source, soyabean contributes two thirds worlds consumption of protein grains. It is also the source of oil, providing for one-third of world's consumption by man (Goronov 1989). According to Natarajan (1989) soyabean is currently the largest commercially available vegetable protein source in most parts of the world.

Brand and Label (1988) feel that defatted soy flour contains 50 per cent protein, unmatched to any other known vegetarian sources. Easter (1981) also feels that defatted soy flour contains two times as much protein as in dal; three times as much as in eggs and 15 times as much as in milk.

The increased protein, ash, fat and calorie contents in soyabean incorporated blends were recorded by Jayalekshmi and Neelakantan (1988). Seralathan *et al.* (1989) have observed that soy flour had 85.00 per cent digestibility.

According to Jimbu and Ige (1990), the quantity of Vitamin A is low in soyabean but the vitamin is present to a level of 1.4 mg/g which helps to prevent the oxidation of fatty acids. Raunet *et al.* (1992) have reported that soy flour contains 9.90 g of fibre, 7.52 g of ash and 53.54 g of protein in 100 g. Linko *et al.* (1981) have reported that legumes including soyabean and oil seeds improved the protein digestibility and bioavailability of sulphur amino acids by thermal unfolding of globulins. Tandon and Singh (1981) feel that soy flour can be incorporated in various food preparations. Its use in bread, biscuits, chappatties, snacks and texture products have been successfully demonstrated by them. Incorporation of defatted soy flour in such products has also been demonstrated by Sushma*et al.* (1979) and Chauhan and Bains (1988).

The successful incorporation of soy flour in the development of weaning foods has been reported by Easthan *et al.* (1978), Radha and Wei (1980), Kapoor and Gupta (1981), Gupta and Kaur (1982) and Ashturkar (1992).

Improvement in the protein quality and lysine content by incorporation of soy flour in a weaning food has been reported by Cheriyan and Tarur (1992).

Dharamitta *et al.* (1983) have reported that in Thailand the distribution of supplementary food mixtures containing rice, soybeans and groundnuts or rice, mung beans and sesame providing 13.2-16.5 g/100 g protein and 437-451 KCal was extremely successful in ameliorating the nutritional status of children, as indicated by a decrease in the prevalence of PEM from 55 per cent to 21 per cent in eighteen months.

A feeding trial conducted to assess the nutritional quality of rice-soya supplementary food by Sailexmi (1995) for a period of six months revealed a significant improvement in height, weight and upper arm circumference of pre school children.

Thus an attempt is made in the present study to develop a nutritious and acceptable weaning food for infants (6 to 9 months) using household / village technologies of roasting and powdering, which is high in colorie density but low in bulk, with rice and soya as basic ingredients, the methodology of which is detailed in the next chapter.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The study on "Developing a weaning food with rice and soya as basic mix" comprises of :

3.1. Formulation of the basic mix

3.2. Formulation of the multimix

3.3. Standardization of the recipe

3.4. Assessing the nutritional quality of the multi mixes through :

3.4.1. Assessing the nutritive value through computation

3.4.2. Assessing the nutrient composition through chemical analysis

3.4.3. Assessing the quality of protein through animal experiments

3.5. Assessing the physical qualities of the selected multi mixes

3.6. Yield ratio

3.7. Storage stability of the multimixes

3.8. Ease of preparation

3.9. Acceptability of the product

3.10. Economic evaluation

3.11. Statistical analysis

3.12. Quality of the product in comparison with ISI specifications

3.1. Formulation of the basic mix

The simplest recipe for a weaning food is one which has only two ingredients. This is called as "Basic Mix" (Mitzner *et al.*, 1984). An example that is often quoted to describe a basic mix is that it has a cereal or a root mixed with a pulse.

In the present study based on its objective raw milled rice and defatted soy flour were selected for formulating the `basic mix'.

3.1.1. Selection of the best combination for the basic mix

Though the ingredients of the basic mix were predetermined it was essential to find out the most nutritionally combatible proportion in preparing rice-soya blended basic mix.

In order to arrive at this, different combinations of the basic mixes were designed by varying the proportions of rice and soya flour.

An ideal basic mix, to be used as weaning food should have a chemical score above 60. Jansen and Harper (1985) have reported that amino acid scores provide an useful estimate of the protein quality of blended foods and is an acceptable substitute for biological assays. Hence the amino acid score and chemical score of seven basic mixes were worked out in order to select the best combination.

3.1.2. Computation of amino acid score and chemical score

The amino acid content of the ingredients of the seven proportions of the basic mix were calculated using the

Food Composition Tables given in Nutritive value of Indian foods (ICMR, 1991).

The amino acid score was calculated as a percentage of adequacy as follows :

$$\text{Amino acid score} = \frac{\text{mg of amino acid in 1g test protein}}{\text{mg of amino acid in the requirement pattern (like egg / milk)}} \times 100$$

Using the amino acid content, chemical scores were worked out from the ratio between the content of the most limiting amino acid in the test protein and that of egg expressed as a percentage.

$$\text{Chemical score} = \frac{\text{Limiting amino acid content of the test protein}}{\text{Content of the same amino acid in egg}} \times 100$$

Among the seven basic mixes the proportion that gave the highest chemical score was selected for further investigation.

3.2. Formulation of the multi mix

It is necessary that other foods be added to the basic mix to make a complete meal, so as to feed an infant.

Mitzner *et al.*, (1984) has stated that, recipes containing more than two items, which are more suitable for the weaning period and for later months are called "multi mix".

To formulate an adequate multi mix, four components are essentially needed, a basic staple, an energy rich supplement, a protein supplement and a mineral and vitamin supplement which has been illustrated by PAG (1976) as the `Food Square'.

Accordingly a multi mix was developed by selecting suitable local foods from the food square.

3.2.1. Selection of ingredients

The ingredients selected for formulating the multi mix from the food square were

1. Staple : Rice

2. Protein supplement : Soya flour and skim milk powder

3. Vitamin and mineral supplement : Amaranth (*Amaranthus tricolor*) and skim milk powder

4. Energy supplement : Jaggery

Thus the composition of one kilo gram of the multi mix was worked out without altering the proportion of the basic mix, while supplying other essential nutrients.

Table 1. Composition of multimix

Ingredients	Quantity (g)
Rice flour	615
Soya flour (defatted)	154
Amaranth	77
Skim milk powder	154
Total	1000

3.2.2. Variations of the multi mix

Variations of the multi mix were further tried out as detailed below to identify the best product.

3.2.2.1. Replacement of raw rice by other processed products of rice

Variations of the `basic mix' were tried replacing raw milled rice with parboiled / puffed / flaked rice because Desikachar (1982) has reported that using the technology of popping and flaking highly acceptable, nutritious and easily digestible weaning foods could be formulated. The above processes have also been found to improve the taste and aroma of the formulations.

The variations were tried because, the above processed products of rice have been customarily used in Kerala since time immemorial. They have been used to feed the sick and convalescent being easily digestible and acceptable.

3.2.2.2. Variations in the incorporation of amaranth

Amaranth in three different forms namely, fresh amaranth leaves, amaranth leaves extract and dried and powdered amaranth leaves were tested, for their suitability for incorporation into the multi mix.

3.2.3. Processing of the ingredients

The individual items of the multi mix were pre-processed as detailed below.

Raw rice

Good quality raw milled rice was purchased from the market, cleaned, soaked and powdered. The flour was then roasted and sieved.

Parboiled, flaked & Puffed rice

Good quality parboiled, flaked and puffed rice were purchased from the market, cleaned, roasted, powdered and sieved, separately.

Defatted soya flour

Defatted soya flour was purchased, roasted and sieved.

Amaranth (Leaves)

The amaranth (*Amaranthus tricolour*) leaves were purchased from the Instructional Farm of the College of

Agriculture, Vellayani. Three forms of amaranth were prepared for incorporation into the multi mix.

a) The leaves were departed from stalks; washed, cleaned, shredded and cooked.

b) The leaves were separated from stalks, washed and cleaned. They were dried in the oven; powdered and sieved.

c) Amaranth leaves were washed, cleaned, cooked in excess volume of water and its juice extracted and filtered.

Skim milk powder

Skim milk powder was procured from the market and was used directly.

3.3. Standardization of the recipe

Since the multi mix is to be converted into a recipe to feed the infant, as a simple meal, it is necessary to formulate a recipe and to standardize the same.

3.3.1. Selection of a recipe

Suitability to the clientele was considered as the prime factor in selecting and preparing the recipe.

As suggested by Malleshi (1995) the weaning food given to a child should form a slurry or semi solid mass of soft consistency in order to enable the child to swallow it easily. He has also pointed that the food should be pre-cooked and pre-digested or processed in such a way that it needs minimum preparation prior to feeding and is easily digested by the child.

Based on the above criteria the recipe evolved was that of a porridge and it was planned so as to meet one third of the daily dietary requirements of infants between six to nine months of age.

Composition of the selected recipe is given in Table 2, which is followed by the method of preparation.

Table 2. Composition of the selected recipe

Ingredients	Weight	Equivalent measures
Multi mix	25 g	5 Tsp
Jaggery	25 g	5 Tsp
Water	175 ml	1 Cup

Procedure

1. Dissolve Jaggery in water; heat for a minute and strain.
2. Add the above to the multi mix and mix well.
3. Cook for two minutes, stirring continuously under simmering temperature to prevent lump formation.

3.3.2. Identifying the best recipe

An attempt made to identify the best recipe from among the 12 combinations of the multi mix (4 variations of rice x 3 forms of amaranth) were tested. It was necessary to identify the most acceptable form of rice and amaranth, to be used in the preparation of the recipe.

All the recipes were standardized with respect to time taken for preparation and volume of water added. The above recipes were prepared simultaneously and presented to technical experts to identify the best one. The above exercise was repeated twice with an interval of one week to get confirmative reactions.

Based on their critical evaluation and sound judgment two combinations viz., raw rice and puffed rice with amaranth powder were found to be the most acceptable multi mixes to formulate the recipe.

3.4. Assessing the nutritional quality of the multi mixes

3.4.1. Assessing the nutritive value through computation

The nutritive value of the different multi mixes were worked out using the food composition tables given in Nutritive Value of Indian Foods (ICMR, 1991).

Based on the preference test (3.3.2) and from the computation of nutritive value, the best two variations of the multi mix were selected for further evaluation.

3.4.2. Assessing the nutrient composition through chemical analysis

The nutritional composition of the selected combinations of weaning foods were ascertained by estimating the major nutrients by standard laboratory methods, as detailed below.

Estimations	References
Energy value	Swaminathan, 1984
Protein	ICMR, 1983
Fat	
Fibre	
Vitamin C	AOAC, 1980
Carotene	
Iron	
Calcium	

3.4.3. Assessing the quality of protein through animal experiments

A weaning food should be nutritionally adequate. One of the methods to assess the nutritional adequacy of a food is to find out its protein quality. The protein quality of the weaning food can be evaluated by various standard rat bio assay procedures as cited by Pellet and Young (1980).

In the present study the Protein Efficiency Ratio (PER) and Net Protein Utilization (NPU) were estimated to determine protein quality of the multimixes.

3.4.3.1. Protein Efficiency Ratio (PER)

The Protein Efficiency Ratio (PER) which measures the weight gain per gram of protein consumed was determined by rat growth method of Osborne *et al.* (1919).

To find out the PER, the following procedure was adopted.

a. Formulation of diets

The test diet consisted of the two selected multi mixes, a control diet containing casein and a diet incorporating cerelac, which were included for comparison. The diets were formulated in such a way that each provided protein at 10 per cent level. The diet also contained vitamin and mineral mixtures, oil and starch. The composition of the diets are given in Table 3.

Table 3. Composition of the diets

Sl. No.	Ingredients	Quantity in g/ml
Diet I	Rice flour	34.74
	Soya flour	8.7
	Amaranth	4.4
	Skim milk powder	8.7
	Starch	28.5
	Mineral mixture	4.00
	Vitamin mixture	2.00
	Ground nut oil	9.00
	Total	100.00
Diet II	Puffed rice (flour)	33.88
	Soya flour	8.48
	Amaranth	4.24
	Skim milk powder	8.48
	Starch	29.92
	Mineral mixture	4.00 ml
	Vitamin mixture	9.00 ml
	Ground nut oil	9.00 ml
	Total	100.00

Contd...

(Table 3. Contd...)

Sl. No.	Ingredients	Quantity in g/ml
	Cerelac	64.5
	Starch	20.5
Diet III	Mineral mixture	4.00 ml
	Vitamin mixture	2.00 ml
	Ground nut oil	9.00 ml
	Total	100.00
	Casein	10 g
	Ground nut oil	9.00 ml
	Starch	75 g
	Mineral mixture	40
	Vitamin mixture	2.00 ml

The composition of the vitamin and mineral mixture used are given in Table 4 and 5 respectively.

b. **Method**

Weanling male albino rats (Sprague Dawley strain) aged 28 days and weighing about 25 g were obtained from the

Table 4. Composition of vitamin mixture

Ingredients	Quantity
Vitamin A	2000 IU
Vitamin D	200 IU
Vitamin E	10 IU
Vitamin K	0.5 mg
Riboflavin	0.8 mg
Pyridoxine	4.0 mg
Calcium Pantothenate	4.0 mg
Niacin	10.0 mg
Inositol	10.0 mg
Para amino benzoic acid	40.0 mg
Biotin	0.2 mg
Folic acid	0.2 mg
Vitamin B_{12}	3.0 mg
Choline chloride	200.0 mg

(NIN, 1983)

Table 5. Composition of mineral mixture

Ingredients	Quantity
Calcium carbonate	38.1400
Cobalt chloride	0.0023
Cupric sulphate	0.0477
Ferrous sulphate	0.7000
Magnesium sulphate	5.7300
Manganese sulphate	0.4010
Potassium Iodide	0.0790
Potassium phosphate (mono basic)	38.900
Sodium chloride	13.9300
Zinc sulphate	0.0548

(NIN, 1983)

disease and germ free animal house of Kerala Agricultural University at Mannuthy. Twenty four rats divided into four groups each consisting of six rats were used for the feeding trials. Group I and II received weaning food diets I and II containing the multi mixes of raw rice and puffed rice respectively; group III received diet containing the commercial weaning formula (cerlac) and group IV received the control casein diet. The composition of the diets are given in Table 3

The rats were housed individually in cages with wire mesh floor. Fifteen grams of the respective diets were weighed, cooked and given to rats and the unconsumed portion was collected, dried and weighed every day separately. Water was given *adlibitum*. The rats were maintained on the respective diets for 28 days. The body weights of the animals were recorded once in four days during the experimental period. The test conditions were maintained as uniform as possible during the entire period of study.

Utilizing the data on the quantity of food consumed and the weight gain by the rats the Protein Efficiency Ratio (PER) and Food Efficiency Ratio (FER) were calculated using the formula :

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

$$FER = \frac{\text{Gain in body weight (g)}}{\text{Food intake (g)}}$$

3.4.3.2. Nitrogen balance studies

Further animal experiments were conducted to find out the extent of utilisation of proteins from the multi mixes in comparison with the test diets.

3.4.3.2.1. Net Protein Utilisation (NPU)

Mitchell (1924) introduced the term "Net Utilisation of Dietary Protein" which is a product of digestibility co-efficient and biological value divided by 100.

The Net Protein Utilisation was found out by standard experimental procedures suggested by Mitchell (1924).

Procedure

Male albino rats weighing 100-120 g were divided into four groups of two each. The animals were housed in individual metabolic cages. The whole experiment was divided into three phases. During the first phase of four days, all the rats were fed with non protein diet to measure the endogenous nitrogen. During the second phase of two days, the rats were fed with stock diet. The composition of non-protein diet and stock diet are given in Table 6.

Table 6. Composition of non-protein diet and stock diet

(In percentage)

Ingredients	Non-protein diet	Stock diet
Starch (g)	85	80
Groundnut oil (ml)	9	9
Mineral mix (ml)	4	4
Vitamin mix (ml)	2	2
Casein (g)	--	4

During the third phase of four days, the rats were fed with the test diets (puffed rice and raw rice diets), cerelac diet and control diet (Table 3).

The animals were given 15 g of the diets. The quantity of left over food and actual amount of food consumed were recorded everyday.

During the first and third phase of the experiment, stools and urine samples of the rats were collected. Two drops of toluene was added to urine samples as a preservative.

The nitrogen content of urine and faecal samples and that of the diets were estimated by microkjeldhal method (Hawk and Oser, 1965).

Net Protein Utilisation was calculated using the formula :

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

BV = Biological value

DC = Digestibility Co-efficient

Biological value (BV) Digestibility Co-efficient (DC)

From the above details Biological Value and Digestibility Co-efficient were calculated for each of the four diets using the formulae.

$$BV = \frac{IN - (FN-FE) - (UN-UE)}{IN - (FN-FE)} \times 100$$

$$DC = \frac{IN - (FN-FE)}{IN} \times 100$$

where,

IN = Nitrogen intake

FN = Nitrogen in faeces

FE = Endogenous faecal nitrogen

VN = Nitrogen in urine of protein diet

VE = Nitrogen in urine of protein free diet

3.5. Assessment of the physical quality of the selected multi mixes

Physical characteristics are one of the important criteria that determines the acceptability of a product. The important physical characteristics essential for a weaning formula includes low viscosity, low bulk density and an acceptable particle size (Kulkarni *et al.*, 1991).

Therefore the viscosity, bulk density and particle size of the selected two mixtures viz. multi mix containing raw milled rice and puffed rice were assessed.

3.5.1. Viscosity

Since most of the commercial and traditional weaning foods are highly viscous, an attempt was made to determine the viscosity of the multi mixes. To measure viscosity, the mixes were made into a paste using cold water at 10 per cent concentration. The slurry was then boiled over an open fire for two minutes and cooled to room temperature.

The viscosity of these mixes were measured using Brook Field synchroelectric viscometer (RVT model) at 100 rpm using appropriate spindles as suggested by Brandtzaeg *et al.* (1981).

3.5.2. Bulk density

Bulk density is the ratio of the weight of the sample to the weight of equal volume of water. It is used as an index for comparing the volume of different foods.

The bulk density of the two mixes were found out using the method followed by Chellammal (1995).

3.5.3. Particle size

Particle size is an important feature of any granular mix that requires reconstitution with water. (Kulkarni *et al.* 1991). An optimum distribution of particle size is essential in order to get a food that is even in its consistency.

Hence the particle size of the two multi mixes were evaluated by passing the multi mixes through a standard sieve as suggested by Kulkarni *et al.* (1991). The percentage fraction of the sample retained on the sieve was measured by weighing.

3.6. Yield ratio

Since the multi mixes are to be prepared in bulk, and stored for future use it is essential to work out the yield ratio. This is also necessary for the commercial production of weaning foods either for income generation or for free distribution under feeding programmes.

3.6.1. Preparation / processing loss (multi mix)

The weight of the food ingredients as purchased (AP weight) minus that of the edible portion of the ingredients included in the formula (EP weight) gives the preparation / process loss and the ratio of preparation loss was calculated using the following formula :

$$\text{Preparation loss} = \frac{\text{AP wt} - \text{EP wt}}{\text{Ap wt}}$$

3.6.2. Yield ratio (recipe)

The yield ratio will be influenced by the cooking time and temperature used for preparation of the recipe. This was found out using the formula.

$$\text{Yield ratio} = \frac{\text{Cooked weight}}{\text{Weight before cooking}}$$

3.7. Storage stability of the multi mixes

Since the weaning food is designed to be a ready to cook formula requiring minimum time for preparation, it is necessary to test the shelf life, of the multi mix as it has to be prepared and stored in order to be ready to use, just before feeding the child. It has been suggested by Gahlawat and Sehgal, (1993) that such foods should have a shelf life of six months.

Therefore the shelf life of the two weaning mixes were tested. For this the mixes were packed in six polythene bags containing 500 g of each mix and were stored in air tight containers at room temperature for a period of six months. At the end of each month, one packet was opened and was examined for the presence of insect infestation. At the end of the six months period the total microbial count was taken using serial dilution technique.

3.8. Ease of preparation

Any weaning formulae should be easy to prepare, and should take only minimum time for cooking. The time taken for the preparation was hence assessed, taking it as a measure that decides the ease of preparation.

3.9. Acceptability

The acceptability of the product will depend on the organoleptic characteristics of the mixture when reconstituted into a meal. The two weaning mixes were subjected to sensory evaluation for organoleptic qualities and acceptability by a 20 member trained panel using five point Hedonic scale for rating. The regulations for conducting the trials were maintained as suggested by Swaminathan (1975).

3.10. Economic evaluation

Cost of the two multi mixes were computed according to the exsisting market price of each ingredient used in the formula. The cost of each ingredient was worked out using the formula :

$$\text{Cost} = \frac{\text{Total cost}}{\text{EP weight}}$$

Cost per unit serving, cost of one kg of the mix and cost of one kg of the mix after adding 20 per cent overhead charges (for commercial use) were worked out and compared with the cost of a popular commercial weaning food.

3.11. Statistical analysis

Analysis of variance, t-test and Mann-Whitney test were the statistical tests used to draw valid conclusions from the data. (Broota, 1989; Siegel and Castellan, 1988).

An index was developed for each product based on their organoleptic qualities as

$$I = W_1X_1 \times W_2X_2 \ldots + \ldots\ldots W_nX_n$$

where, $W_i = \frac{1}{i^2}$, being the variance with respect to character X_i, $i = 1,2.....n$

3.12. Quality of the product

The product was finally evaluated for its quality by comparing the quality parameters stipulated by Indian standards for cereal based weaning foods. (IS:1656-1969). On the basis of the above tests the best mix was identified.

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

Results of the present investigation entitled "Developing a weaning food with rice and soya as basic mix" are presented and discussed in this chapter.

4.1. FORMULATION OF THE BASIC MIX

According to Hansen *et al.* (1989) a basic mix for a weaning food comprises of two ingredients namely a cereal and a pulse.

In the present study raw milled rice formed the cereal (staple) component and defatted soya flour was chosen as the pulse (protein) component. These two food items were selected to formulate the basic mix mainly because the objective of the study itself was to develop a weaning food with rice and soya as basic mix.

Though the above mentioned ingredients were pre-determined to formulate the `basic mix' there are various reasons, other than the fundamental fact mentioned above, which justifies the use of rice and soya for the formulation of weaning mix suitable to infants of Kerala.

Sinha and Nawab (1993) have reported that rice or wheat is usually used as the cereal base for supplementary foods. Rice has been recognised as a food material of more than half the world's population as pointed out by Pillaiyar (1988) and Stephanie (1990). Among cereals it has a comparatively high content of essential amino acids as reported also by Pillaiyar (1988) and Bandyopadhyay and Roy (1992). Though it is primarily a source of carbohydrate it has higher digestability and the biological value and protein efficiency ratio when compared to wheat and other cereals. (Ananthachar *et al.*, 1982).

The above observations have been confirmed by Capanzana and Malleshi (1989) who reported that rice protein is of good quality and its carbohydrates are also easily digested and hence forms an ideal base for weaning foods. Moreover as early as in 1985, Kelly has reported that cooked and mashed rice or rice gruel can be used for feeding weaned children.

Apart from the above facts which merits inclusion of rice as an item of the basic mix, it has been well recognised that rice is capable of imparting desirable characteristics like smoothness, flavour, colour and taste in reconstituted products.

Moreover rice lends itself to various processing techniques like parboiling, popping and flaking and the products thus obtained are highly acceptable and they provide variety, as opined by Desikachar (1982).

As rice forms the most frequently used staple of Kerala and its products such as puffed rice and rice flakes are highly familiar and traditional foods which has a cultural rooting, it has been included as the major item of the basic mix.

The pulse complement used to formulate the weaning food along with rice in the present study is defatted soya flour. This product though unfamiliar to Keralites, has been chosen due to several reasons.

Neelakantan and Jayalakshmi (1987) have reported that soya bean is one of the cheapest source of protein available today. Moreover it is found to contain 40 per cent protein, which is twice the protein content of common pulses (CFTRI, 1992).

Soya bean has long been recognised as an excellent source of protein for feeding both animal and man (Irwin, 1994).

Schroder *et al.* (1973) have stated that soya bean protein is unique among plant proteins by virtue of the relatively high biological value and essential amino pattern.

Swaminathan (1990) observed that soyabean proteins supply all the essential amino acid except methionine and is a good source of lysine and threonine and can hence supplement efficiently the cereal protein.

Burnet (1981) pointed out that properly prepared soyabean product is equal or superior to egg albumin.

Therefore as reported by Kanchana and Neelakantan (1994) incorporation of defatted soya flour in diets will not only enhance the protein content of the diet but also raise its overall nutritive value, which would help to combat malnutrition in general.

Though India is known to be a land of vegetarians the incidence of protein deficiency disorders have paved way for the induction of animal foods into our dietaries, which were reported to be rich sources of good quality protein.

Contradictory to this, Naik and Gleason (1988) reported that since animal proteins are now in short supply and costly, plant proteins have received considerable attention by virtue of their availability, low cost as well as nutritional and functional attributes. As an indigenous plant food rich in protein and fat the nutritional significance of soya cannot be ignored.

Although not cultivated as a regular food crop in Kerala, it has been shown by Pushpakumari (1981) that soya bean can be effectively cultivated in the rice fallows of Kerala. Considerable interest has been shown in India since the late 30's on the cultivation of soya bean as a food crop in view of its high protein and oil content (Subramanian, 1983) and soya bean is an important crop of Madhya Pradesh, Tamil Nadu and a few other states in India, the annual production being about 2-2.4 million tonnes (Anon, 1992).

As mentioned earlier, though soya is not cultivated in Kerala it is not unfamiliar to the children in Kerala who are the beneficiaries of the nutrition intervention programmes implemented in the state, since the supplements distributed through the ICDS contains soya.

The facts mentioned above exonerates the inclusion of soya in the basic mix, as an effective complement to rice.

Rice is reported to belong to a second class protein. It is found to be deficit in the essential amino acid lysine, which is the well known limiting amino acid of all cereal and millet proteins. Waninik *et al.* (1993) reports that high quality dietary protein can be created with an ideal amino acid pattern required for human growth and metabolism by combining two or more protein sources to compensate for the limiting amino acids in any of them. An example often quoted is the cereal grain complemented with legumes. Singh (1987) suggests that by the addition of soya flour to rice the deficiency is compensated and a better quality protein is obtained.

Therefore defatted soya flour, which is the protein supplement, was added to rice in different proportions to formulate the basic mix.

In order to identify a basic mix that has an ideal admixture of rice and soya flour, seven combinations of the basic mix were formulated altering the proportions of rice and defatted soya flour. The proportions of the ingredients in the seven combinations of the basic mixes formulated are presented in Table 7.

Table 7. Ingredients in the seven combinations of the basic mix

	Proportion						
Ingredients	1	2	3	4	5	6	7
Raw rice : defatted soya flour	6.0:4.0	6.5:3.5	7.0:3.0	7.5:2.5	8.0:2.0	8.5:1.5	9.0:1.0

From the table it may be seen that the percentage of soya added to rice has been kept below 40 per cent since the food is intended to be a rice and soya blended product of which, rice should form the base. Moreover, with experience it has been found that addition of soya flour above this level would make the beany flavour of soya highly conspicuous which would render the product unacceptable.

4.1.1. Selection of the best combination of the basic mix

It may be pointed out that defatted soya flour has been incorporated in various proportions into the basic mix with the intention of improving the amino acid pattern. Several workers have reported that amino acid scores provide useful estimate of protein quality of blended foods and is an acceptable substitute for biological assays (Jansen and Harper, 1985).

In view of the above fact amino acid score and chemical score of the seven combination of basic mixes were computed inorder to identify the combinaiton which would have a favourable amino acid composition.

The amino acid scores as well as the chemical scores of the seven proportions of the basic mixes are presented in Table 8.

Table 8. Amino acid scores and chemical scores of different combinations of the basic mix

Ingredients	Combinations 1	2	3	4	5	6	7
Ratio between raw rice and defatted soya flour	6:4	6.5:3.5	7:3	7.5:2.5	8:2	8.5:1.5	9:1
Amino acid score	79.9	79.0	79.8	79.7	79.7	79.7	79.7
Chemical score	70.8	65.8	71.6	72.0	73.0	72.8	54.1

Table 8 reveals that the amino acid scores of the different combinations exhibits only minor variations. As indicated in the Table 8, the lowest amino acid score of 79 was obtained for combination 2 (6.5:3.5) while the highest amino acid score was observed for combination 1. (6:4). Combinations 5, 6 and 7 were found to have the same amino acid score of 79.7. Since the difference in scores are not pronounced, amino acid score alone could not be taken as the basis for selection of the best proportion.

The major criterion used, therefore, to select an ideal proportion from among the seven combinations was their chemical score.

As indicated in Table 8, the lowest chemical score of 54.1 was obtained for combination 7 containing 90 per cent rice and ten per cent defatted soya flour (9:1). The highest chemical score of 73 was obtained for combination 5 which had 20 per cent defatted soya flour and 80 per cent rice. Only five combinations viz. 1, 3, 4, 5 and 6 had chemical scores above 70. Thus combination 5 which had the highest chemical score of 73 was selected for formulating the multi mix. It may also be noted that the same combination has a amino acid score of 79.7.

The chemical score of the selected basic mix seems to be low when compared to egg protein (100%). This could be attributed to the fact that the mix was found to be limiting in sulphur containing amino acids (methionine and cystene) and histidine. This need not be a cause of concern since this weaning food is designed to suit an infant between the age of six to nine months, and this multi mix is to be used as a supplement to breast milk. Breast milk being a rich source of the sulphur containing amino acids, would help to rectify this deficit in the weaning food if any. Moreover it may also be noted that Malleshi and Amla (1988) had chosen a multi mix with a chemical score of 70 for developing a weaning mix.

4.2. FORMULATION OF THE MULTI MIX

To make an ideal multi mix, four components are essentially needed; a basic staple, an energy rich supplement, a protein supplement and a mineral and vitamin supplement which has been illustrated as a 'Food Square'. The 'Food Square' has four squates one for the staple and one each for protein, vitamin and mineral and energy supplements with the breast milk in the centre (Fig. 1). This is to indicate that breast milk is the principal part of the infants diet and the the weaning food acts as a complement to mother's milk, in providing the essential nutrients to the child who consumes it.

The concept of multi mixes and the 'Food Square' system has been adopted for formulation of weaning foods by several workers including Livingstone *et al.* (1992) and Dahiya and Kapoor (1994).

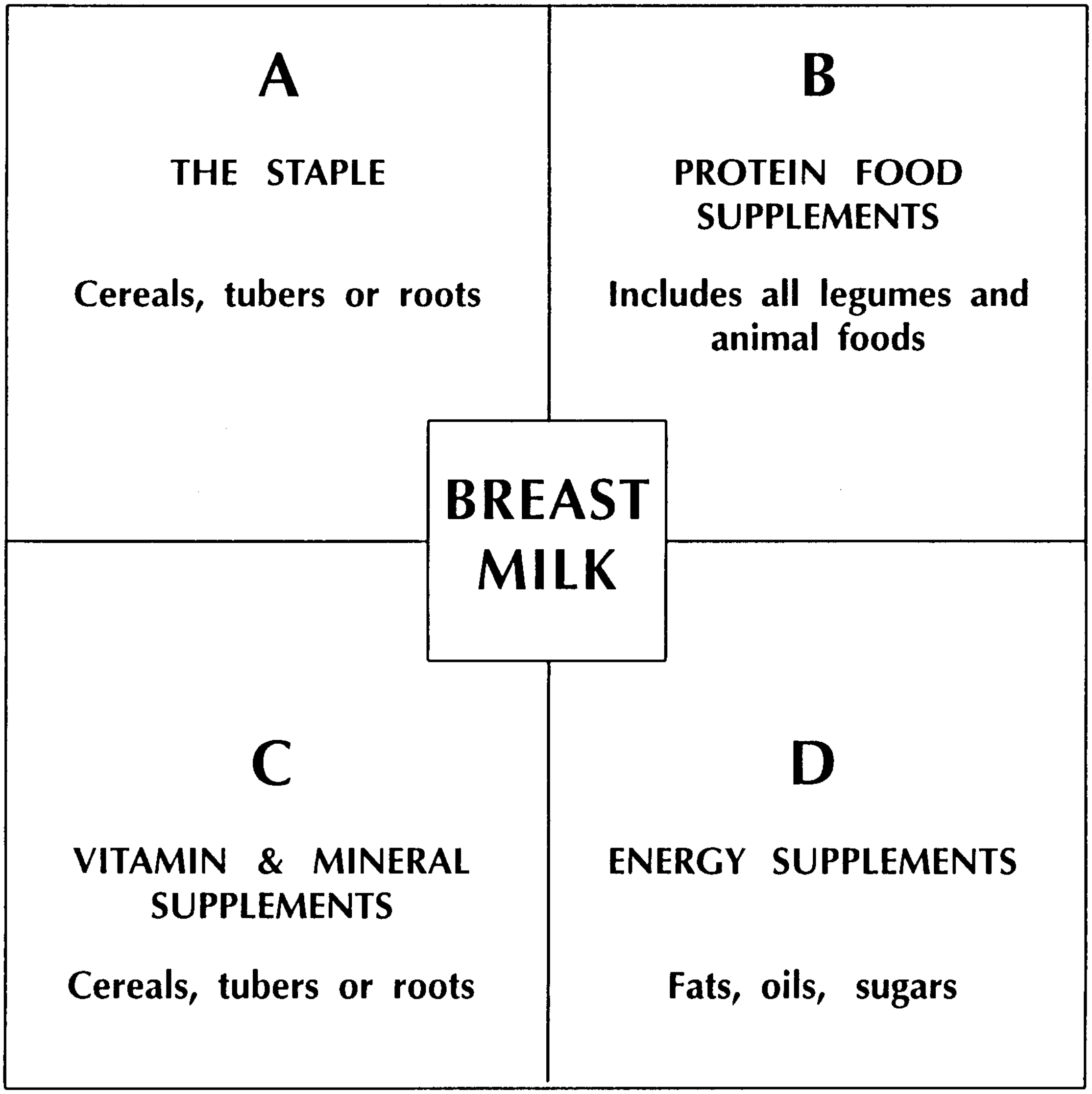

Fig. 1. FOOD SQUARE

A multi mix was generated by adding skim milk powder and amaranth to the basic mix. A food square with the components of the multi mix is given in Fig. 2.

It may be noted that the `basic mix' comprises of Rice and defatted soya flour. Here rice becomes the staple and soya flour is the protein supplement.

Further, with the aid of the food square amaranth leaves and skim milk powder were selected to be incorporated into the `basic mix' to formulate the `multi mix'. The proportion of raw rice and defatted soya flour of the basic mix was maintained as in the selected combination while designing the multi mix. They inturn constituted the basic staple and energy and protein supplements.

Amaranth leaves was chosen as it is locally available, relatively inexpensive, easy to cultivate and cook and is rich in several nutrients essential for human health. It is also one of the protective foods (Rajalekshmi, 1981). Yadav and Sehgal (1995) have opined that vegetables occupy an important place specially in the vegetarian diets of India in

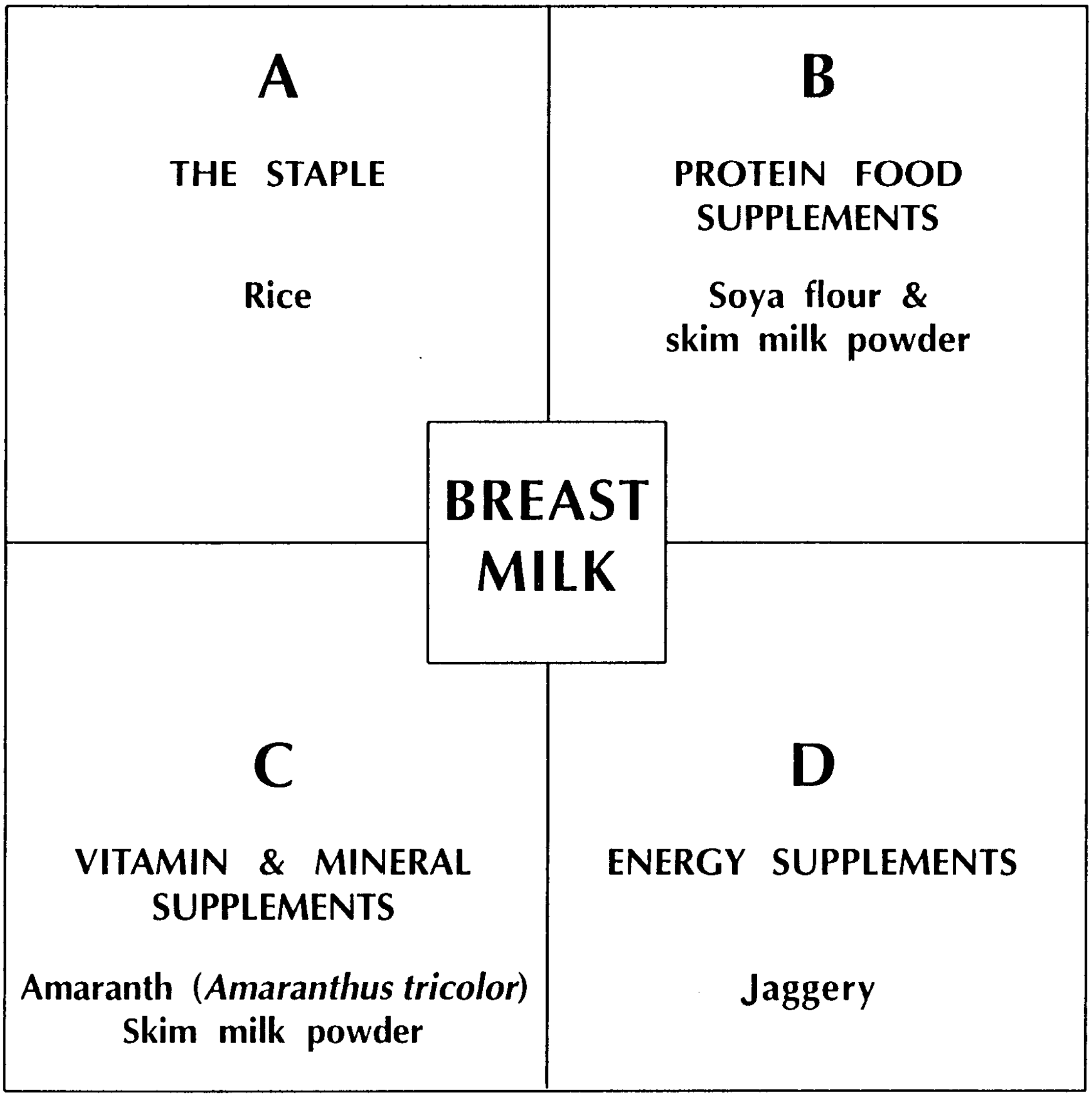

Fig. 2. 'FOOD SQUARE' with components of the 'MULTIMIX'

supplying essential nutrients apart from adding variety to the diet; while Gopalan *et al.* (1971) have emphasized that green leafy vegetables in general are rich sources of B-carotene, ascorbic acid, calcium, iron, riboflavin, folic acid and provides protein as well as appreciable amounts of other minerals.

Hence amaranth (*Amaranthus tricolor*) was chosen as a vitamin and mineral supplement from the food square to formulate the multi mix. Apart from amaranth leaves, another ingredient included in the multi mix was skim milk powder. Desikachar (1983) is of the opinion that supplementation with skim milk solids would increase the nutritive value of weaning foods and make them nutritionally complete.

Here skim milk powder was used as a protein, vitamin and mineral supplement. Though soya by it self is a good source of protein, skim milk powder has been added intentionally because Cameron and Hofvander (1983) have revealed that two protein foods, one from an animal source and another from a plant source can be used together to improve the protein quality of a weaning formulae. Moreover skim milk it is also expected to improve the flavour of the multi mix by masking the beany flavour imparted by soya. Skim milk powder would also improve the colour as well as the taste of the final product, enhancing its overall acceptability.

4.2.1. Variations of the multi mix

Based on the principle on `Food Square' rice, soyaflour, amaranthus and skim milk powder would theoritically form an ideal multi mix, from the nutritional point of view. Since, rice and amaranth are used in different ways and in different forms variations in `multi mix' were tried out to find out the most suitable form in which the above items could be incorporated in to a multi mix for feeding an infant.

From the food square it can be seen that rice has been used as the staple to prepare the multi mix. Rice being the staple, is used in different forms. However, parboiled rice is the preferred form of rice of Keralites. Moreover, rice products such as puffed rice (*Malar*) and flaked rice (*Aval*) are tradition bound food items of Kerala. They have been used as breakfast cereals or as ingredients for snacks.

These products have been used even to feed couvalescents. Moreover parboiled, puffed and flaked products of rice have been effectively incorporated in to weaning food formulations by Desikachar (1982), Sailaxmi (1995), and Malleshi (1995). Therefore an attempt was made to replace raw rice by these more familiar items and to test their suitability in the preparation of weaning foods.

Amaranth is the other indigenous food item used in the multi mix. Generally it is shredded and cooked and is used as a side dish in Kerala. The extract of this leafy vegetable is given to infants directly after three months or it is incorporated into weaning foods in modern days. Dehydrated vegetables and pureed vegetables are also gaining popularity these days as they are convenient to use. Hence an attempt was made to find out the most suitable form of incorporating amaranthus leaves into the multi mix.

Therefore variations of the multi mix were formulated by replacing raw rice with parboiled, puffed and flaked rice and also by varying the nature of incorporation of amaranthus, keeping the rest of the ingredients as constant.

Thus 12 combinations, with four variations of rice and three variations of amaranth were formulated (4 x 3 = 12).

The above mentioned ingredients were then processed separately and mixed together in their respective proportions to formulate the multi mixes. The method of processing of the individual ingredients of multi mix are given under methods and materials.

The mix cannot be fed as such to the child as a weaning food and hence it was necessary to convert it into a form suitable to feed an infant who is six to nine months of age. Therefore an attempt was made to select and standardise a suitable recipe.

4.3. SELECTION AND STANDARDIZATON OF A RECIPE

A child should be introduced to semi-solid foods first to initiate the weaning process or weaning process should commence with semi-solid foods, the main reason being, that the baby cannot chew the foods.

As reported by Ghosh (1992) most mothers do not understand the importance of giving the baby soft mashed foods. From a purely milk diet the infant is expected to go on to thick roti and other foods that constitute the household diet. The baby nibbles at it and spits it out. Learning to swallow semi-solid food is difficult for a baby who only knows how to suck at the breast. Hence the food administered during the weaning period should have a soft and smooth consistency, making it easy for the child to swallow.

Standards laid down by ISI (1969) stipulates that the weaning foods which are cereal based shall be of a soft smooth texture, free of lumps and chewable particles and suitable for spoon feeding of infants and children.

Based on the above guidelines the recipe for the weaning food was designed in the form of a porridge with a smooth and soft consistency such that it could be spoon fed to the child.

Several workers like Nattress *et al.* (1987); Vaidehi and Gowda (1981) and Beryukova (1983) have reported that one serving of the weaning food formulation should supply 1/3rd energy and protein requirement of the infant.

Hence the recipe was formulated so as to provide 1/3rd the requirement of the major nutrients, Jaggery was incorporated in the recipe as a sweetener to enhance the taste and to make the food acceptable to the child since children have been shown to possess a liking for sweet foods rather than salty foods (Ghosh, 1992). Sugar was not chosen as it is more expensive and the multi mix is intended to be a low cost weaning food. Jaggery has the added advantage of increasing the energy density of the feed along with iron, as pointed out by Dahiya and Kapoor (1994).

For preparation of the porridge, 25 g of the multi mix was taken and mixed with jaggery syrup prepared from 25 g of jaggery and 175 ml of water and cooked for 2 minutes by continuous stirring to obtain a porridge of desirable consistency.

The recipe thus formulated was tried out with all the 12 combinations of the multi mix and were standardised. They were then presented before a panel of technical experts inorder to select the best combination with regard to organoleptic qualities and acceptability.

When ranked for colour the combinations containing raw rice emerged as the best followed by parboiled rice. The colour of flaked and puffed products were not acceptable. The colour of all the combinations were dull due to the addition of soya flour and leafy vegetable which imparts a dull yellowish brown to dark brown colour. The appeal of the product further deteriorated when roasted flaked and puffed rice flours were used in the place of raw rice. The change in colour in the above cases could be attributed to dextrinization of starch.

The flavour and aroma of the formulations containing puffed and flaked products were highly preferable to the judges. It has been observed by several workers that the process of puffing and flaking, helps to develop aroma. The difference in aroma was pronounced while the food was served hot. When the formulations were cooled there was no significant difference in aroma.

When compared to quality attributes of taste the formulations containing raw rice and puffed rice were found to be better than that made from parboiled rice and flaked rice.

The difference noticed among the above four forms of rice with regard to consistency of the final product may be accounted to the changes taking place during the various processing to which the rice was subjected to.

During parboiling, the starch in the grain is gelatinized and the grain gets hardened. As a result of the hardening of the grain, the flour obtained will not be very fine which affects the consistency of the cooked product.

While puffing, the paddy is moistened with a little water and tempered at about 230-240°C to obtain puffed rice. In the case of flaking, paddy is steeped in warm water (60-70°C) overnight, which is then drained and heated in a shallow pan till the husk begins to crack. It is then transferred to a wooden mortar and pounded to obtain flaked rice (*Aval*).

The high temperature to which paddy is subjected to during the preparation of aval and malar may be responsible for the difference in the quality of flour obtained from them. Since the flour is very fine, the consistency of the porridges made from flaked and puffed rice flours were found to be better than the ones made from raw rice and parboiled rice.

On the basis of the organoleptic qualities, the recipes made from puffed rice and raw rice with amaranth extract was preferred by the judges. The formulations containing dried and powdered amaranth was ranked as the second best, when compared to those containing the extract. The formulations containing cooked amaranth was not acceptable to the judges.

Eventhough the formulations with amaranth extract was preferred by the judges, in consultation with the judges it was decided to incorporate the dried and powdered form of amaranth in the multi mix, taking into account the practical difficulties associated with the prepartion of the extract. Firstly, the product is intended to be a ready-to-cook multi mix. Preparing the extract will impose an additional burden on the mothers. Procurement of the leafy vegetable every day just before the preparation of the feed poses another problem.

Moreover preparation of extract is a task, which may lead to contamination of the material as it includes boiling of the leaves, crushing and extraction of the juice and filtration of the same. The water and vessels used for the above should be clean and sterilized. One tends to overlook these when pressed for time and this increases the chances of contamination.

On the other hand in the case of dried and powdered amaranth, the amaranth leaves can be collected in bulk from the garden or from the market during the season when it is available in plenty and the prices are reasonable. They can be processed quickly and stored as such or can be incorporated into the multi mix and stored for later use.

In view of the above facts it was decided to incorporate amaranth in the dried and powdered form.

4.4. ASSESSING THE NUTRITIONAL QUALITY OF THE WEANING MIXES

The weaning food given to an infant should be nutritionally adequate (Pedersen *et al.* 1989). Hence it is essential to evaluate the nutritional quality of the developed weaning food in order to ascertain its nutritional adequacy.

4.4.1. Assessing the nutritive value through computation

The nutrients, viz., protein, calorie, carbohydrate, fat, mineral and vitamin content of the four multi mixes made from raw rice, puffed rice, flaked rice and par boiled rice were worked out and the data are presented in Table 9. It may be noted that the four mixes had identical amounts of defatted soya flour, skim milk powder and powdered amaranthus.

As revealed in the Table the protein content of the four multi mixes ranged between 17.40 to 18.20 g. Table 9 shows that the variation containing puffed rice has the highest protein content of 18.20 g. The combination with par boiled rice has the lowest protein content of 17.40 g. The combination containing raw rice and flaked rice has a protein content of 17.70 and 17.60 g respectively.

Neeraja *et al.* (1991) observed that the amount of nutrients increased due to roasting and was attributed to lower moisture content of the material, causing concentration effect. That may explain the high content of protein in the combination containing puffed rice.

Table 9. Nutritive value of the multi mixes (100 gm)

Variations	Protein (g)	Fat (g)	Minerals (g)	Fibre (g)	Carbohydrate (g)	Energy (K Cal)	Calcium (mg)	Phosphorus (mg)	Iron (mg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Folic acid (µg)	Carotene (µg)	Vitamin C (mg)
C_1	17.70	3.40	2.30	0.70	59.70	336	284	441	2.60	0.22	0.38	1.90	7.00	490.15	8.40
C_2	18.20	3.10	4.30	0.80	56.90	325	292	358	6.20	0.32	0.35	3.30	6.20	490.15	8.40
C_3	17.60	3.70	3.20	1.07	59.10	355	290	412	14.40	0.34	0.36	3.20	4.40	490.15	8.40
C_4	17.40	3.30	2.30	0.70	60.10	338	283	354	2.70	0.31	0.36	3.10	9.90	490.15	8.40

Multi mix containing

Raw rice — C_1
Puffed rice — C_2
Flaked rice — C_3
Paraboiled — C_4

The calorific value of the multi mixes were in the range of 325 to 355 K cal/100g. The combination containing flaked rice provided the highest amount of energy ie., 355 K cal/100g. Mixes made from parboiled rice and raw rice had similar calorific value. The lowest energy content was observed for puffed rice which gave 325 K cal/100g.

The combination containing puffed rice had the highest calcium content of 292mg. The combinations containing flaked rice, raw rice and parboiled rice contained 290, 284 and 283 mg of calcium respectively.

The highest content of phosphorus was observed in the combination containing raw rice ie., 441 mg/100g. The flaked rice combination was found to have 412mg and the combination containing puffed rice and parboiled rice gave values of 358 and 354 mg/100g respectively.

The iron content was found to be the highest in the combination with flaked rice being 14.4 mg/100g. This was followed by variation 2 containing puffed rice which had an iron content of 6.20 mg. Raw rice and parboiled rice exhibited almost the same values viz., 2.60 and 2.70 mg respectively.

Coming to the thiamine content of the combinations flaked rice gave the highest value of 0.34mg followed by puffed rice.

The riboflavin content of the multi mixes showed only minor variation ranging from 0.35-0.38mg between the different combinations. The highest content of riboflavin was observed in the combination containing raw rice and the lowest was in the variation containing puffed rice.

The combination containing puffed rice exhibited the highest niacin content of 3.30 mg. The combination containing flaked, parboiled and raw rice gave values of 3.20, 3.10 and 1.90 mg/100 g respectively.

The folic acid content of the combinations varied from 4.4 to 9.9 mg. The lowest and the highest values were exhibited by flaked rice and parboiled rice combinations respectively. Combination containing raw rice and parboiled rice had 7.00 and 6.20 mg of folic acid respectively.

As shown in the Table, the content of carotene and vitamin C is the same for all the four variations. This is because the components that supply carotene and vitamin C to the multi mix is amaranth and soya flour. Since the content of both amaranth and soya flour is the same in all the four multi mixes, all the four has the same carotene and vitamin C content of 490.15 mg and 8.40 mg respectively.

Eventhough a difference was noticed in the nutrient content of different mixes, there was no wide variation among the nutrient content except for the content of iron in the combination containing flaked rice.

From the computed values given in Table 9 it can be stated that the multi mix containing puffed rice was better when compared to the other mixes in terms of protein and minerals even though the multi mix containing flaked rice had a higher content of iron viz., 14.4 mg. Moreover studies conducted by Kelkar *et al.* (1994) have shown that puffing enhanced the digestibility, as against the decrease in case of flaking.

Since there was no wide variation among the multimixes with respect to their nutrient content, the two combinations viz., multi mixes containing raw rice and puffed rice which were identified as the best combinations after preference test, earlier, were selected in order to carry out further evaluation.

The multi mixes containing raw rice (C1) and puffed rice (C2) were thus subjected to further detailed qualitative analysis in order to identify the most suitable multi mix.

4.4.2. Assessing the nutrient composition through laboratory techniques

Eventhough the nutrient composition of the multi mixes were calculated using food composition tables, in order to estimate precisely the nutrient contents the selected two multi mixes were subjected to chemical analysis, since Rajalekshmi (1981) has pointed out that the calculated values are only approximate values.

Hence the nutritional value of the multi mixes containing raw rice and puffed rice were analysed in the laboratory for their energy, protein, mineral, vitamin (A and C), fat and fiber content through standard laboratory techniques and the data are presented in Table 10.

Table 10. Nutrient composition of the selected combination of multi mix (in 100 g)

Nutrients	C1*	C2*
Moisture (g)	8.07	6.43
Protein (g)	16.94	19.33
Fat (g)	0.32	1.23
Fibre (g)	negligible	negligible
Vitamin C (mg)	6.24	6.20
Carotene (mg)	381.20	381.00
Iron (mg)	4.20	3.60
Calcium (mg)	403.00	389.00
Energy (K cal/100g)	358.00	365.00

* C1 - Multi mix containing raw rice

* C2 - Multi mix containing puffed rice

As shown in the Table the calorific value of the combination containing puffed rice was 365 Kcal/100g and that containing raw rice was 358 K cal/100g. The protein content and fat content were also high in the combination with puffed rice being 19.33g and 1.23g while that of the combination with raw rice was estimated to be 16.94g and 0.32g respectively.

Moreover it can be noticed that the calcium and iron content were found to be higher in the multi mix containing raw rice. The iron and calcium content were 4.20 mg and 40.30 mg respectively for the multi mix containing raw rice while that of the combination containing puffed rice were 3.60 mg and 38.90 mg respectively. It may be noted that both the mixes are good sources of all the essential nutrients, at the same time are low in fibre. A comparison between the computed values (Table 9) and the values obtained through laboratory analysis (Table 10) for both the selected multi mixes reveals that the computed values are higher than the estimated values.

In another study a supplementary food for infants and children developed by Naikare and Mabesa (1993) consisting of flours of processed brown rice, germinated mungo, sesame and carrot blend at 50:50:5:5 ratio, was reported to contain 7.30 % protein, 65.50 % carbohydrate, 4.90 % fat, 2.50 % minerals, 346 mg/100g B-carotene and 518 K cal of energy per 100g.

A weaning food developed by Sailaxmi (1995) containing par boiled rice : defatted soya flour : goundnut flour in the proportion 85:10:15 contained 369 K cal, 11.2g protein and 2.7 mg iron.

While Gahlawat and Sehgal (1994) developed a weaning food with roasted rice (70g), roasted green gram (30g) and jaggery (25g) and it provided 300 K cal of energy, 6-9g protein and 6.5 mg iron per day.

The above three studies indicate that the weaning food in question is superior to the ones made by other workers with respect to its nutritive value.

The laboratory analysis of the two multi mixes also revealed that the mixture containing puffed rice (C_2) is better than the one made with raw rice (C_1) with respect to the content of major nutrients such as protein, fat and energy.

While 100 g of the multi mix provides the above mentioned nutrients shown in Table 10, the nutritional adequacy of one serving of the respective mixes to provide

1/3rd the daily requirement of a 6-9 month old child was calculated and the details are presented in Table 11.

Table 11. Nutritional adequacy of the multi mix with respect to calorie and protein

Nutrient	*1/3rd the daily requirement of a 6-9 month old	**Quantity of nutrients provided per serving	
	Child	C1 (raw rice)	C2 (puffed rice)
Energy	190 Kcals	186 Kcal	187 Kcal
Protein	3.3 g	4.3 g	4.9 g

* Source : ICMR (1992)

** Values include 25g of the multi mix (one serving) made in to a porridge with added jaggery

As can be observed from Table 11, one serving of any one of the multi mixes is sufficient to meet 1/3rd requirement of a 6-9month old child. According to PAG guidelines (1975), in addition to breast milk, an infant should be provided with 268 K cal, 6.50 g protein and 6 mg iron to meet its growing requirements at six months of age. Two servings of the multi mix in a day would provide nearly

372 K cals and 8.60 g protein which is more than adequate to meet the requirement, while to meet the requirement of iron, three servings of the multi mix will have to be given to the child, in addition to breast milk.

The protein calorie ratio (PE %)of the multi mixes were also worked out, since a comparison of the PE % value of the child's requirement pattern with the protein energy per cent of the multi mix will indicate wheather the multi mixes can fullfil protein needs if an adequate quantity of the multi mix is consumed to meet the energy requirement. It is seen that a PE% between 8 and 12 would meet the protein requirement of any group of the population category provided its energy needs are met (ICMR, 1992). The protein energy ratio of the two multi mixes are given in Table 12.

Table 12. Protein energy ratio of the multi mixes

	*Requirement	C1 (raw rice)	C2 (puffed rice)
PE%	6.9	9.2	10.5

* Source : ICMR (1992)

The PE% of both the combinations were found to be above the requirement pattern of 6.9. The combination containing puffed rice showed a slightly higher PE% of 10.5 while that of raw rice gave a PE% of 9.2. The PE% of weaning mixes based on rice and pulses, developed by Ahmed *et al.* (1981) was reported to be 10-12% while that of wheat-pulse mixes was 12-14%. This indicates that the developed multi mix has an effective PE% which would satisfy the growth requirements of children.

4.5.3. Assessing the quality of protein of the multi mixes through animal experiments

As early as 1959, Crampton and Lloyd have promulgated that, data on the quantities of nutrients needed by the body and information concerning the digestibility and biological usefulness of the nutrient components of food stuffs viz., protein are necessary before a diet can be assembled, that will meet specific nutrient needs.

The average or typical composition of commonly used foods may be found tabulated in books and publications in the nutrition literature. Most of the data describing the gross nutrient makeup of foods and food stuffs are obtained routinely by chemical analysis. These chemically determined data gives only an indication to the chemical qualities of the food or feed. But for a complete nutritional evaluation the gross composition must be supplemented with figures of utilization obtainable only from biological assays, ie., from animal or if possible human experimentation.

Hence it was necessary to test the multi mixes for their nutritional quality or growth promoting character by conducting feeding trials and biological assays utilising animals to evaluate the protein quality of the developed mixes. Ritchey and Taper (1981) have reported that the most reliable way to assess the nutritional quality of proteins is through feeding trials. Several biological measurements have been proposed as indicators of protein quality such as Protein Efficiency Ratio (PER), Food Efficiency Ratio (FER) and Nitrogen balance studies.

In the present study the protein quality of the mixes were found out through animal studies and the PER, FER and Net Protein Utilization were calculated.

4.5.3.1. Protein Efficiency Ratio

Protein efficiency ratio is a measure of the weight gain per gram of protein consumed. To assess the protein efficiency ratio feeding trials were conducted on 28 days old male albino rats. The rats were divided into four groups of six each and were fed with the two test diets (one containing raw rice and other containing puffed rice) and a casein diet (as control). A diet containing a commercial formula (cerelac) was included for comparison. Details of the diets are presented under methods and materials. The rats were given the respective diets for a period of 28 days and the weight was recorded once in four days, during the experimental period. The mean weight of animals obtained during the experimental period are presented in Table 13 and Figure 3.

From the statistical analysis of the data pertaining of mean weight of rats fed with the experimental and control diets it has been revealed that there is no significant difference ($F_{3,140}$ = 1.22) between the diets with respect to the weight of the experimental animals over the period of one month or 28 days.

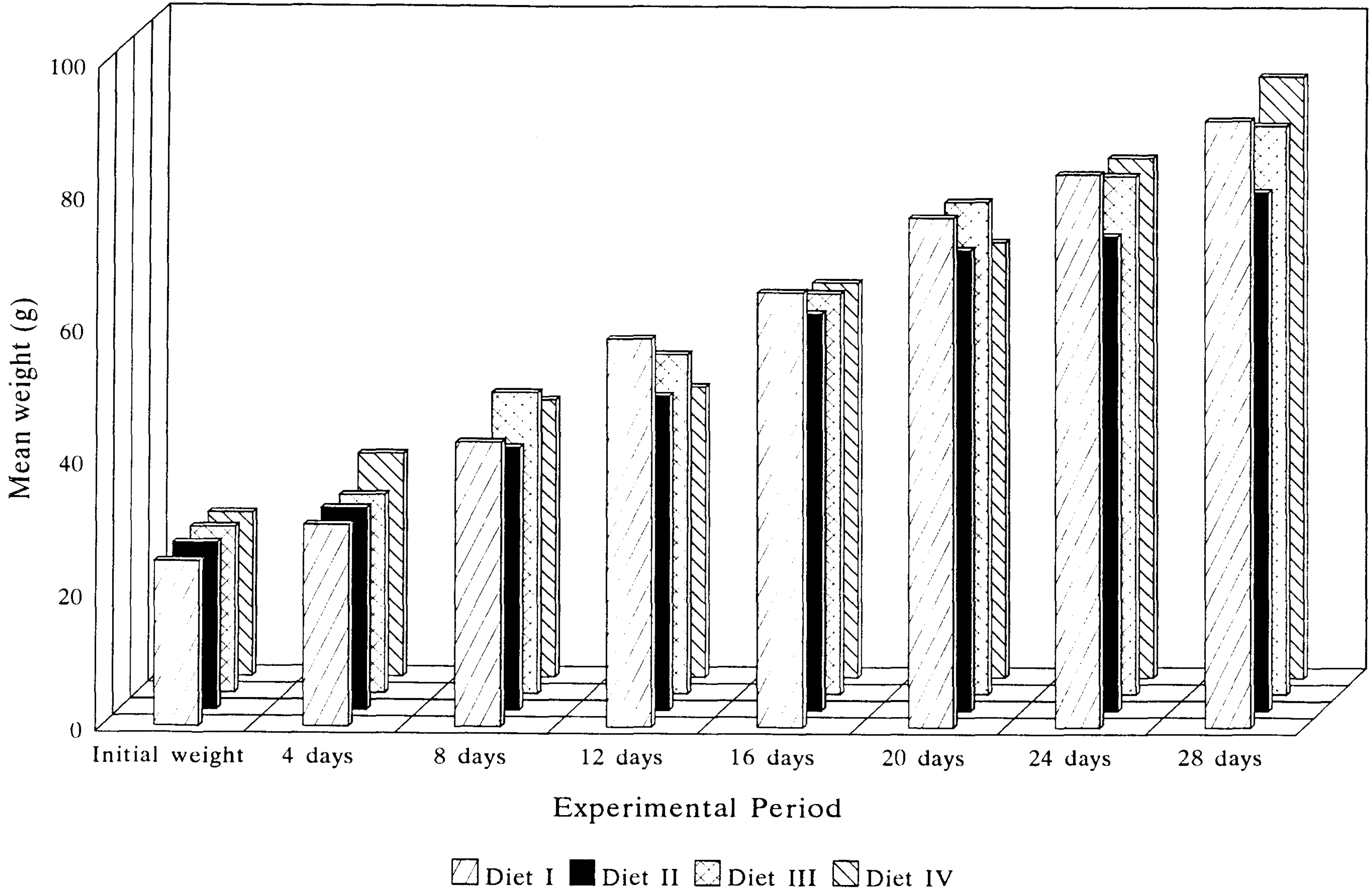

Fig. 3. Mean weight of rats fed with experimental and control diets

Table 13. Mean weight of rats fed with experimental and control diets

Diets	Initial weight (g)	Mean weight (g) during the experimental period (in days)							Mean
		4	8	12	16	20	24	28	
Diet I	24.75	30.25	42.83	58.58	65.56	77.00	83.58	91.67	59.28
Diet II	25.00	30.33	39.58	47.42	59.92	69.67	71.75	78.42	52.51
Diet III	24.92	29.83	45.42	51.25	60.50	74.42	78.33	85.92	56.32
Diet IV	24.58	33.58	41.83	48.83	59.67	65.83	78.58	90.92	55.48
Mean (period)	24.51	31.00	42.42	51.52	60.92	71.73	78.06	86.73	

CD Diet - 7.449
Period - 1.193
Diet x period - 2.387

A significant interaction was noticed between the diets over periods ($F_{21,140}$ = 13.05). Mean weight of rats fed with Diet IV (casein) was significantly higher than that of other diets on fourth day of observation, whereas on the eighth day, rats fed with Diet III (cerelac) recorded higher weight. But from 12^{th} to 24 days of observation, the weights of rats fed with Diet I (raw rice) was higher than those fed with other diets. However on 28^{th} day of observation, no significant difference was seen in the weight of rats fed with Diet I (raw rice) and IV (control/casein). Lowest weight was recorded by rats fed with Diet II (puffed rice) from 20-28 days.

The Protein Efficiency Ratio (PER) and Feed Efficiency Ratio (FER) was then calculated using the mean of weight gain and average protein intake of animals and the data are presented in Table 14.

Table 14. Protein quality indicators of the multi mixes in comparison with control diet

Diet	PER	FER	BV	DC	NPU
I	2.84	28.40	81.00	87.50	70.90
II	2.45	24.50	77.00	85.30	65.70
III	2.66	26.60	77.00	83.00	64.00
IV	3.10	31.10	85.00	64.00	76.50
$F_{3,20}$	9.98**	179.9**	44.00**	309.33**	986.90**
CD	9.98	0.657	1.88	0.19	0.57

** Significant at 1% level

Statistical analysis of the data has revealed that there is a significant difference among the four diets with respect to their PER.

Diet IV containing casein/control was found to be superior than the other three diets which gave the highest PER of 3.10. Diet I with the multi mix containing raw rice has a PER of 2.84 which was higher than the PER obtained for Diet III containing the commercial weaning food.

Diet II containing puffed rice gave the lowest PER of 2.45 but showed no significant difference when compared to Diet III containing the commercial weaning food. Diet I containing raw rice was also found to be significantly better than the Diet II containing puffed rice.

Eventhough the developed multi mixes differed significantly with respect to their PER values compared to the control or casein diet (Diet IV) the PER of the experimental diets was foundto be higher than the value of 2.10, the optimum value specified for `supplementary foods' by the Protein Advisory Group of FAO (1971).

This indicates that both of the multi mixes developed have good growth promoting capacity,if it could be consumed in sufficient amounts.

As per the results of the study conducted by Lee (1970), a supplementary food based on soya bean and sweet potato had a PER of 2.63 and was found to be nutritionally comparable to starch and milk based diet. In another experiment, Gupta and Anil (1982) observed that a supplementary food based on jowar and soya bean had PER values between 2.10 and 2.60. According to the studies of Fashakin *et al.* (1986), a mixture of vegetable protein diet including soya bean, melon and cowpea compared favourably with the milk powder based control diet in terms of growth rate and PER. Rawat *et al.* (1994) have shown that soy fortification increased PER of chapathis from 1.3 to 1.7.

Though the multi mix has rice as the major ingredient, the significant values obtained for PER, indicates that the protein quality of the rice has been elevated by the addition of defatted soya flour, which forms the complement of rice in the formulation of the multi mix., ie., soy protein acts as a complement to the rice protein, mutually supplementing the limiting amino acids. It is a well known fact that the cereals including rice are deficient in lysine and threonine, while soya bean protein is rich in lysine but deficient in methionine (Swaminathan, 1984), which is the limiting amino acid of pulses in general.

The high PER value of the multi mix may also be attributed to the skim milk component. As early as 1957, Chandrasekhara *et al.* have reported that incorporation of 10% milk solids to a food formulation based on sorghum malt and low fat peanut flour increased its PER from 1.2 to 1.5. Similar finding was also reported by Malleshi *et al.* (1986) who noticed an increase in PER from 2.2 to 2.7 by addition of 10 per cent skim milk powder in to a malted weaning food containing ragi and green gram.

Thus the mutual supplementation of rice and soya proteins, along with the added skim milk would have contributed to high PER values obtained for the multi mixes tested in this study.

4.5.3.2. Food Efficiency Ratio

In the present experiment, the data generated during the course of feeding trials were used to calculate the Food Efficiency Ratio (FER) to evaluate the quality of the developed multi mix. The FER of the diets containing the multi mixes (Diet I and II) and the control/casein diet (Diet IV) and the diet containing the commercial weaning Food (Diet III) are also presented in Table 14.

The Food Efficiency Ratio (FER) of Diet I containing raw rice was 28.40 while that of Diet II comprising of puffed rice was 24.50. The FER of the Diet III containing the commercial weaning food was 26.60 and that of the casein/control (Diet IV) was 31.10.

The diet containing casein gave the highest FER (31.10) and that of the diet containing puffed rice, gave the lowest (24.50) value. Though there are marginal variations between the values obtained for different diets the differences are not statistically significant. A weaning food developed by Sailaxmi (1995) containing rice, soya flour and groundnut flour (85:10:5) had a FER of 33.40 which is found to be superior to the multi mix currently under focus.

4.5.3.3. Nitrogen balance studies

4.5.3.3.1. Biological Value (BV)

Biological Value (BV) of a protein is the fraction of its nitrogen retained in the body for growth and maintenance of cell synthesis (Swaminathan, 1995). The biological value of the two multi mixes in comparison with that of cerelac and casein diet are presented in Table 14.

The control diet containing casein (Diet IV) gave the highest BV of 85 per cent. Diet I containing raw rice was found to have a BV of 81 per cent. While Diet II and III containing puffed rice and the commercial weaning food were found to have equal values of 77 per cent each. The values obtained indicates that the BV of diet II and III were on par and were lesser than that of diets I and IV.

In a study conducted by Ifon (1980), BV of soya bean and millet porridge was reported to be 78.93 $\pm$ 1.01 per cent. The BV of weaning food formulated by Gahlawat and Sehgal (1994) with rice, green gram and jaggery was 70.63 $\pm$ 2.05 per cent and it showed no significant difference when compared to a commercial weaning food.

In comparison with the above mentioned weaning foods developed by different scientists the multi mix containing raw rice was found to be superior and that containing puffed rice was comparable in its BV to similar products. This indicates that these two mixes are efficient in promoting growth as well as maintaining the health of infants if fed in insufficient amounts.

4.5.3.3.2. Digestibility Coefficient (DC)

Digestibility Co-efficient (DC) of a protein is defined as the ratio of food nitrogen intake to food nitrogen absorbed. The digestibility co-efficient was calculated for the four diets and the values are presented in Table 14.

The digestibility co-efficient of the diet containing raw rice (Diet I) was 87.50 per cent while that of the diet containing puffed rice (Diet II) was 85.3 per cent. The casein/control diet (Diet IV) and the diet containing the commercial weaning food (Diet III) were found to have a DC of 90.00 and 83.00 per cent respectively. This indicates that the multi mix containing raw rice had the highest DC, which was followed by the one with puffed rice, commercial weaning food and casein in the decending order.

The digestibility co-efficient of a malted weaning food developed by Malleshi *et al.* (1986) was found to have a

DC of 82.80 per cent. While the one developed by Jessy (1987) with ragi as base material was found to have a digestibility co-efficient of 95.02 ± 2.95 per cent.

4.5.3.3.3. Net Protein Utilisation (NPU)

Net Protein Utilisation (NPU) is the ratio of nitrogen retained to the total nitrogen intake and is derived from Biological Value (BV) and Digestibility Co-efficient (DC). The Net Protein Utilisation was computed and the data are presented in Table 14.

From Table 14 it is seen that the NPU of the control diet (Diet IV) containing casein was 76.50 which is the highest followed by the diet containing raw rice (Diet I) in which the NPU was found to be 70.90. The diet containing puffed rice (Diet II) gave a value of 65.70 and the lowest score of 64.00 was obtained for Diet III containing commercial weaning food.

In a study conducted by Gahlawat and Sehgal (1994) on rats fed with a weaning food consisting of rice, green gram and jaggery (70:30:25), the NPU was found to be 53.56 ± 2.48, while in a study conducted by Sailaxmi (1995) the NPU of a diet containing par boiled rice, defatted soya flour and ground nut flour (85:10:5) was 66.83.

In the present experiment the NPU of the rats fed with the two multi mixes (Diet I and II) were 70.90 and 65.70, which is higher than the values reported by other workers as shown above. The reason for the increase may be the presence of soya flour and skim milk powder in the multi mixes since experiments conducted by several workers confirms the above.

Malleshi *et al.* (1986) have reported an increase in NPU from 51.60 to 63.40 by the addition of 10 per cent skim milk powder. Feeding trials using rats conducted by Carrol *et al.* (1952) have shown high digestibility for soya bean and heated soya bean was found to be more digestible than unheated soya bean meal. It has also been revealed that fortification of chapathis with soya increased the *in vitro* protein digestibility from 71.30 to 73.10 per cent from the studies conducted by Rawat *et al.* (1994).

In conculsion, in an attempt to evaluate the nutritional and protein quality of the two multi mixes containing raw rice and puffed rice as the staple ingredients, through animal experiments, it was found that the one containing raw rice was better than the one with puffed rice. The superiority of raw rice has been relevant in all the experiments, namely the experiments to measure the PER, DC, BV and NPU. The study also indicated that the protein quality of the multi mixes were slightly below that of a standard protein supplement, namely casein. However, it is gratifying to find that these mixes are definitely better in their nutritional quality when compared to the most widely used commercial weaning food available in Kerala, when assessed using the standard yard sticks of measurement. Though the multi mix containing raw rice was identified better than the one made with puffed rice, that formula also was not of an inferior nature from the nutritional point of view when compared to the ones available in the market.

4.6. ASSESSING THE PHYSICAL QUALITY OF THE MULTI MIXES

Man is a social being. He eats foods not only to sustain life but also to satisfy his desires. Thus food has psychological and social functions also to perform. Therefore it is evident that nutritional requirement should not be the only prerequisite in formulating a food for a child. Though it forms the foundation for formulation of a supplement, it should satisfy other requisites also.

According to Kulkarni *et al.* (1991) a weaning food should have favourable physical qualities like desirable particle size, low viscosity and bulk density in order to have a desired consistency, nutrient density and palatability.

5.6.1. Viscosity

Increased viscosity is an important constraint of traditional as well as commercial weaning foods. When such supplementary foods are made with a high solid concentration to provide adequate calorie density, they tend to be thick and viscous making it difficult for a young child to consume in sufficient quantity especially if the child is sick and prefers a liquid gruel. Addition of water to lower the concentration of solids, makes the gruel thinner but easier to swallow but at the same time this process reduces the energy content per unit volume. This prevents the child from consuming enough volume of the food to meet his/her energy needs. It also makes feeding, a time consuming procedure, as far as the mother and the child are concerned.

The viscosity of the multi mixes were measured with the intention of ascertaining the suitability of the mixture to feed an infant of six to nine months of age. Therefore the `hot-paste viscosities' of the cooked gruels prepared from 10 per cent slurries of the selected multi mixes (containing raw rice and puffed rice) were measured using Brookfield synchro electric viscometer.

The viscosity of the above formulations were compared with the viscosity of the hot slurry (10 per cent) prepared from a commercial weaning food (cerelac) which was used as a control. The data obtained are presented in Table 15.

Table 15. Hot paste viscosities of the multi mixes in comparison with a commercial weaning food

	C1 (raw rice)	C2 (puffed rice)	Control (commercial formula)
Viscosity at 100 ppm (CP)	720	1160	560

The Table reveals that there is a conspicuous difference in the hot slurry viscosities of the above three samples. The viscosity of 1160 cp of C2 containing puffed rice was found to be higher than that of C1 containing raw rice which gave a viscosity measurement of 720 cp under similar conditions. It may also be noticed that the commercial weaning food has the lowest viscosity of 560 cp.

High viscosity was one of the major limitations of weaning foods containing puffed products as observed by Desikachar (1982) and Malleshi (1995). Mosha and Svanberg (1990) have reported that the high viscosities of gruels prepared from cereal and legume flours is due to the presence of starch and proteins. But it has been shown by several workers that germination or malting and addition of amylase-rich cereal malt or ARF (Amylase Rich Foods) reduces the viscosity or dietary bulk of products.

Desikachar (1980), Brandtzaeg *et al.* (1981) and Malleshi and Amla (1988) have shown a significant reduction in the viscosity of weaning foods as a result of germination or malting. Reduction in the viscosities of rice gruels by addition of ARF was reported by Gopaldas *et al.* (1986) while work done by Gopaldas *et al.* (1992) and John and Gopaldas (1992) have shown a reduction in viscosity of wheat gruels by addition of ARF. Thus a lower viscosity or dietary bulk could be further achieved in the multi mixes if necessary, by adding ARF as suggested by the above scientists.

However, Malleshi and Desikachar (1988) have opined that a slurry viscosity of about 1,000 cp is the desired consistency for spoon feeding a child. Hence eventhough the measured viscosity of the two combinations viz., raw rice and puffed rice multi mixes were 720 cp and 1,160 cp as compared to 560 cp of a commercial weaning food, it need not be a cause for concern since the weaning food is to be spoon fed to the child. Moreover the above multi mixes when made into a porridge were free of lumps, had a smooth texture and the consistency was suitable for spoon feeding and hence it was decided not to add ARF to the weaning food formulations developed.

4.6.2. Bulk density

Bulk density is one of the most common simple measurements in food analysis, which can be used for solid foods. The volume of different food products can be compared through bulk density measurement (Potter, 1988).

No infant can eat the quantity of an adult diet to meet his requirements adequately, especially in the case of rice based diets as pointed out by Geervani (1983). Malleshi (1995) has also stated that the child's stomach capacity is limited, with the result that only a small amount can be fed at a time. Hence the food given to the child should provide large amounts of food solids that are calorie and protein dense.

Therefore in order to assess the bulk and nutrient density of the formulations the bulk density of the multi mixes were measured using the standard procedure. The data pertaining to the bulk density of the multi mixes are presented in Table 16.

Table 16. Bulk density of the multi mixes

Multi mixes	Bulk density (g/ml)
C1 (raw rice)	0.56
C2 (puffed rice)	0.64

The bulk density of C1 (raw rice) was found to be slightly lower than the one containing puffed rice (C2). The decrease in bulk density is due to the simultaneous occurrence of two opposing phenomena as noticed by Kshersagar *et al.* (1994). The first phenomena is the reduction of the true density of the particles due to absorption of water. This is because the true density of water is less than that of the particles. Thus increase in moisture content decreases the true density of individual particle, thereby reducing bulk density.

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

The above mentioned phenomenon may explain the slightly lower bulk density observed in the combination containing raw rice as the moisture content of raw rice combination is 8.07 while that of C2 containing puffed rice is 6.43 per 100gm. Moreover the rate of absorption of water by the two staple ingredients are also directly responsible for the variations in their bulk density.

4.7. ASSESSING THE YIELD OF THE MULTI MIXES

The yield of the weaning formulae both during processing and preparation is one of the major factor affecting the cost of the mixes. The ingredients of a product should give maximum yield both during processing and preparation if the cost has to be kept low. In other words the weight loss during the processing should be minimum in order to facilitate maximum out put or yield. The higher the yield the more is the returns for the amount spent. Hence any weaning food should have minimum processing loss and a high yield.

Keeping this in view the ratio of processing loss and the yield ratio of the multi mix during processing and cooking were worked out.

4.7.1. Processing loss

The ratio of processing loss assessed for the two multi mixes are given in Table 17.

Table 17. Processing loss

Multi mixes	AP weight (g)	EP weight (g)	Ratio of processing loss
C1 (raw rice)	207.9	100	0.52
C2 (puffed rice)	268.34	100	0.63

As indicated in the table, the processing loss of the multi mixes, C2 containing puffed rice was higher than that of C1 containing raw rice. The difference in the processing loss of the two multi mixes is mainly due to the puffed rice component in C2 since the remaining ingredients are the same in both the mixes.

The edible portion of puffed rice `as purchased' was low when compared to raw rice. The puffed rice was found to contain lot of husk and non-edible portion. Moreover the yield of flour from the roasted puffed rice was lesser when compared to raw rice which showed a minimum loss. This may be accounted to the difficulty in powdering the puffed rice even after it has been subjected to roasting which results in a lesser quantity of flour yield than in the case of raw rice.

The decreased yield of amaranth powder during processing accounts for the major share of processing loss in both the multi mixes. The quantity of amaranth powder obtained from the fresh vegetable was found to be very low.

The above mentioned factors account for the processing loss in the multi mixes and the mix made from raw rice had lesser processing loss, hence higher yield.

4.7.2. Yield ratio (Recipe)

The final yield of the multi mix was assessed and the yield ratio is given in Table 18.

Table 18. Yield ratio

Combination	Weight before cooking (g)	Cooked weight (g)	Yield ratio
C1 (raw rice)	25	135	5.4
C2 (puffed rice)	25	130	5.2

There was absence of pronounced variation in the yield ratio of the two combinations. Both the combinations showed nearly five times increase in weight after cooking.

A higher yield ratio may be pronounced as a favourable phenomenon in the case of ready-to-cook mixes that are to be prepared in bulk and stored. This reduces the bulk of the material which is advantageous with respect to packaging and storage of the final product. Moreover, when the yield ratio is high, only small quantities of the nutrient dense multi mix needs to be taken to obtain the desired quantity for feeding an infant.

Weaning foods formulated by Jessy (1987) was also found to have a yield ratio ranging from 3.3-3.4. The high yield ratio of the multi mix in the present investigation is mainly due to the presence of rice which forms a major portion (61.1 per cent) of the basic mix. Rice swells and increases in bulk due to gelatinization when mixed with water. The rate of absorption of water was found to be greater in C1 containing raw rice which accounts for the higher yield ratio (5.4) than that of C2 containing puffed rice (5.2).

4.8. STORAGE STABILITY OF THE MULTI MIX

Shelf life qualities are essential parameters to be assessed since they determine the suitability of a particular product (Livingstone *et al.*, 1993). This should be a matter of great concern in the case of weaning foods. Children are extremely sensitive and vulnerable to various diseases and Mathur and Reddy (1983) have reported that the incidence of diarrhoeal disease is high in children during the weaning stage which could be due to microbial contamination of food and water.

The multi mixes that were packed in polythene covers, kept in air tight containers and stored for a period of six months were subjected to visual examination at the end of each month. There was absence of visible signs of spoilage. Moreover there was no alteration in flavour, colour and taste. The multi mixes were also examined for the presence of storage pests which will affect the quality of the product. But the mixes were free from insect contamination.

In order to ascertain that the mixes are safe for feeding an infant even after six months an attempt was made to assess the total microbial count and to identify the microbes present in the feed if any. For this the multi mixes were subjected to serial dilution technique after six months of storage. The samples were observed daily for the presence of fungus,bacterial and yeast colonies and even after the end of nine days no colonies where observed indicating that the combinations were free from microbial contamination.

Several studies have been carried out on the storage stability of weaning foods based on cereals and pulses (Malleshi *et al.*, (1989); Kotaliwali *et al.*, (1993). The results above show that these foods could be stored upto a period of two to five months depending on the moisture content of the food and the type of container used. The low moisture content of weaning foods have been found to enhance the shelf life of the product.

In a study conducted by Malleshi (1984) a malted weaning food with 11 per cent moisture was tested for its storage stability. The food packed in polythene pouches and stored at ambient storage conditions remained acceptable upto five months. He has further stated that the food may be packed in air tight tins or laminates for longer shelf life, safe storage and wider distribution.

Rathod and Udipi (1991) prepared weaning mixes and stored them in polythene bags for two months. At the end of this time, their acceptability was tested and was found to be no different from that of freshly prepared mixes. No signs of spoilage in terms of rancidity, flavour or colour were observed and the moisture content of the mixes ranged from 7.90 per cent to 12.10 per cent. They have concluded that most dehydrated cereal foods have a good shelf life if their moisture content is below 10 per cent.

In the present study since the multi mixes made with raw rice and puffed rice had a moisture content of 8.07 per cent and 6.43 per cent respectively which is below the stipulated content of 10 per cent, their keeping quality was found to be good.

4.9. EASE OF PREPARATION OF MULTI MIXES

Women's employment has solved the economic problems of the family to some extent, but has created some nutritional problems (Geerwani, 1983). Educated or uneducated working women are dependent on others for feeding their infants and they are willing to buy weaning foods at a higher cost if they can be prepared quickly. But not many weaning foods are available at hand for the people belonging to the low income groups.

Hence if the weaning food is to be advocated in rural areas where women are hard pressed for time, it becomes essential that the weaning food formulated from locally available cereals and pulses should be simple to prepare. According to Gahlawat and Sehgal (1994) the weaning foods should be developed in forms which make their preparation easy at the time of feeding.

Keeping the above principle in view the developed multi mixes does not require elaborate processing like germination or malting which takes time and are laborious. Simple technology of roasting was adopted for processing rice and soya flour and in the case of amaranth, it required drying followed by powdering. The process does not call for expensive and elaborate equipment, but the utensils and simple household devices available at hand could be made use of for roasting and drying the ingredients. The roasted ingredients could be powdered at ordinary flour mills if necessary. Such mills are available even in rural areas of Kerala. The cost of pounding is also low. Hence the processing preparation procedures are simple and wellknown to a rural housewife.

The flours thus obtained could be mixed in bulk in their respective proportions and can be stored for more than three months for use as a ready-to-cook mix. Since the multimix does not require any processing or pre preparation before cooking and is a ready-to-cook mix, it helps to reduce the work load of the mother at the time of preparation.

The time taken for converting the multimix into a porridge is minimal, which was recorded and is given in Table 19.

Table 19. Time expended for the preparation of porridge from the multi mixes

Combinations	Preparing Jaggery syrup (mt.)	Cooking (mt)	Total time expended (mt)
C1 (raw rice)	6.39	2.20	8.59
C2 (puffed rice)	6.39	2.30	8.50

As shown in the Table, the time taken for the product to be fully cooked is two minutes. There was no pronounced variation in the time taken for cooking between the two combinations. The major portion of time expended is for dissolving and straining the jaggery syrup. Instead if jaggery syrup for a week can be prepared and stored, the preparation takes hardly three minutes. If good quality jaggery is available it can be added directly to the porridge which would reduce the cooking time to two minutes.

One of the major criterion recommended by ICMR (1970) for judging the acceptability of developed supplements is that the method of preparing the supplements was simple and did not take more than 15 minutes.

In the case of the multi mixes under focus the method adopted for processing is simple and the preparation time would not exceed nine minutes even if the time taken for preparation of jaggery syrup is taken into consideration.

Hence it can be concluded that the time taken for the preparation of both the multi mixes is acceptable as per the recommendations of ICMR (1970).

4.10. ASSESSING THE ACCEPTABILITY OF THE WEANING FOODS THROUGH ORGANOLEPTIC EVALUATION

In the development and processing of new supplements efforts must be taken to access their acceptability as suggested by Dahiya and Kapoor (1994). Hence an attempt was made to test the acceptability of the selected multimix through organoleptic evaluation. The multimix was cooked into a porridge by adding jaggery syrup and boiling for two minutes. The porridge made from the two multimixes were then subjected to sensory evaluation by a panel of 20 judges selected through the triangle test using a specially designed score card.

The multi mixes were scored by the judges for organoleptic characteristics like appearance, colour, taste, flavour and consistency etc. using 5 point hedonic rating scale.

The scores obtained were then subjected to statistical analysis using Mann Whitney test and the results are presented in Table 20.

Table 20. Comparion of multi mixes based on their organoleptic characteristics

Characters	Mean scores C1 (raw rice)	C2 (puffed rice)	W	Test criterion Z value
Appearance	4.15	3.60	279.0	2.14*
Colour	4.15	3.65	255.0	1.49
Flavour	3.85	3.65	236.0	0.97
Doneness	4.25	4.25	192.5	0.20
Taste	4.25	3.40	314.5	3.10*
Texture	4.10	3.95	216.5	0.45
Consistency	4.50	4.50	181.0	0.51

* Significant at 0.05 level

From the above Table it has been revealed that the two mult mixes differed significantly only with respect to their appearance and taste. In both the above mentioned characters, raw rice based multi mix was found to be better than the multimix containing puffed rice. For the remaining organoleptic characters even though the mean scores obtained were higher for the combination containing raw rice, the difference obtained was not significant as revealed by statistical analysis.

In an attempt to identify and select the best combination of the two mixes the overall acceptability index based on the total scores obtained by summing up the scores for different characters was also computed and the data is presented in Table 21.

Table 21. Overall Acceptability Index

Sl. No.	C1 (raw rice)	C2 (puffed rice)
1.	100.32 (9)	45.94 (9)
2.	91.35 (18)	44.68 (12)
3.	94.41 (12)	53.71 (2)
4.	99.16 (10)	53.35 (4)
5.	99.16 (10)	42.54 (18)
6.	102.53 (6)	51.36 (6)
7.	107.34 (2)	40.89 (19)
8.	94.21 (13)	43.14 (16)

Contd...

(Table 21. Cont...)

Sl. No.	C1 (raw rice)	C2 (puffed rice)
9.	98.39 (11)	48.63 (8)
10.	91.14 (19)	42.63 (17)
11.	91.87 (17)	40.12 (20)
12.	94.21 (14)	44.99 (11)
13.	94.21 (15)	43.14 (15)
14.	102.60 (5)	44.37 (13)
15.	87.31 (20)	53.64 (3)
16.	101.50 (7)	50.33 (7)
17.	107.28 (3)	45.94 (10)
18.	112.74 (1)	51.89 (5)
19.	104.36 (4)	54.01 (1)
20.	101.31 (8)	43.89 (14)
Mean	98.47	46.96
$t_{18} = 28.54^{**}$		

** Significant at 0.01 level

Numbers in paranthesis indicate their rank order

The index of overall acceptability for combination containing raw rice was 98.47 and that of the combination containing puffed rice (C2) was 46.96. The mean value of overall acceptability of C1 containing raw rice was higher and it has been shown that the difference is significant at 1 per cent level.

From the above analysis it can be concluded that the multimix containing raw rice (C1) was superior to that of multimix containing puffed rice (C2) with respect to their organoleptic characters and overall acceptability.

The result further indicates that the raw rice formula has better acceptability, as revealed by its overall acceptability index, which was found to be attributable to two specific characteristics namely appearance and taste. It may be recalled that the multimix was processed into a porridge of suitable consistency to feed a young infant. If such a food has been rated high for its appearance, it would mean that it appeals to the sight.

The appearance of the raw rice based mix could be attributed to the cocoa like colour induced by the mixture of soya, rice, amaranthus and skim milk powder. They are also responsible for the development of appetising taste. It may be noted that the flavour has not received high scores probably because of the poor flavour of soya flour and amaranth which are the two components of the multi mix.

As mentioned above, if the food has an attractive appearance it would automatically increase the acceptability. This appeal has been further enhanced by the taste, which was the other character that was significantly superior. Both these characters together, helps to create a sense appeal, which in turn would help the mother to utilize the material to feed her child.

Hence it could be concluded that the porridge made from the multimix containing raw rice (C1) would be preferred by the mothers to feed their children.

4.11. ECONOMIC EVALUATION OF THE MULTI MIXES

The economically affluent elite meets the requirements of growing infants through commercial weaning foods which are technically standardised. Majority of the population belonging to the low income sector cannot afford these prohibitive prices, hence the weaning food developed should essentially be low in cost in order to make it within the purchasing power of this majority.

Cost of production of each of the formulations was hence computed and compared with the cost of a commercial weaning food available in the market which is presented in Table 22.

Table 22. Cost of the multi mixes in comparison with a commercial formula

Combinations	Cost per kg (Rs)	Cost including 20% overhead (Rs)	Cost of 1 kg of commercial formula (Rs)
1.	37.2	44.6	165
2.	48.00	57.6	

The cost of one kilogram of the multi mix inclusive of twenty per cent over head charges (to include the cost of fuel, the personnel, equipment) were also calculated to ascertain the cost of the weaning food if and when it is to be subjected to large scale production.

The cost of one kg of the combination containing raw rice including overhead charges was Rs. 37.20 while that of multi mix containing puffed rice was Rs. 48 as compared to a commercial weaning food which cost Rs. 165 (as on september 1996). The cost of the commercial formula was nearly four times higher than the developed weaning foods.

On the basis of all the parameters tested it can be concluded that the multi mix containing raw rice was found to excel the one containing puffed rice. Before proclaiming the suitability of the product, it is necessary to ascertain how far the product meets the quality stipulations imposed by Governmental agencies.

4.12. ASCERTAINING THE QUALITY OF THE PRODUCT

If a weaning food is to be marketed the regulations imposed by the governmental agencies are to be observed. Moreover the regulations if observed would help to ensure quality of a product, which assures the consumer that the item is safe to use. In order to justify the quality of the developed product the characteristic features of the product was compared with those stipulated by ISI (1S:1659-1969).

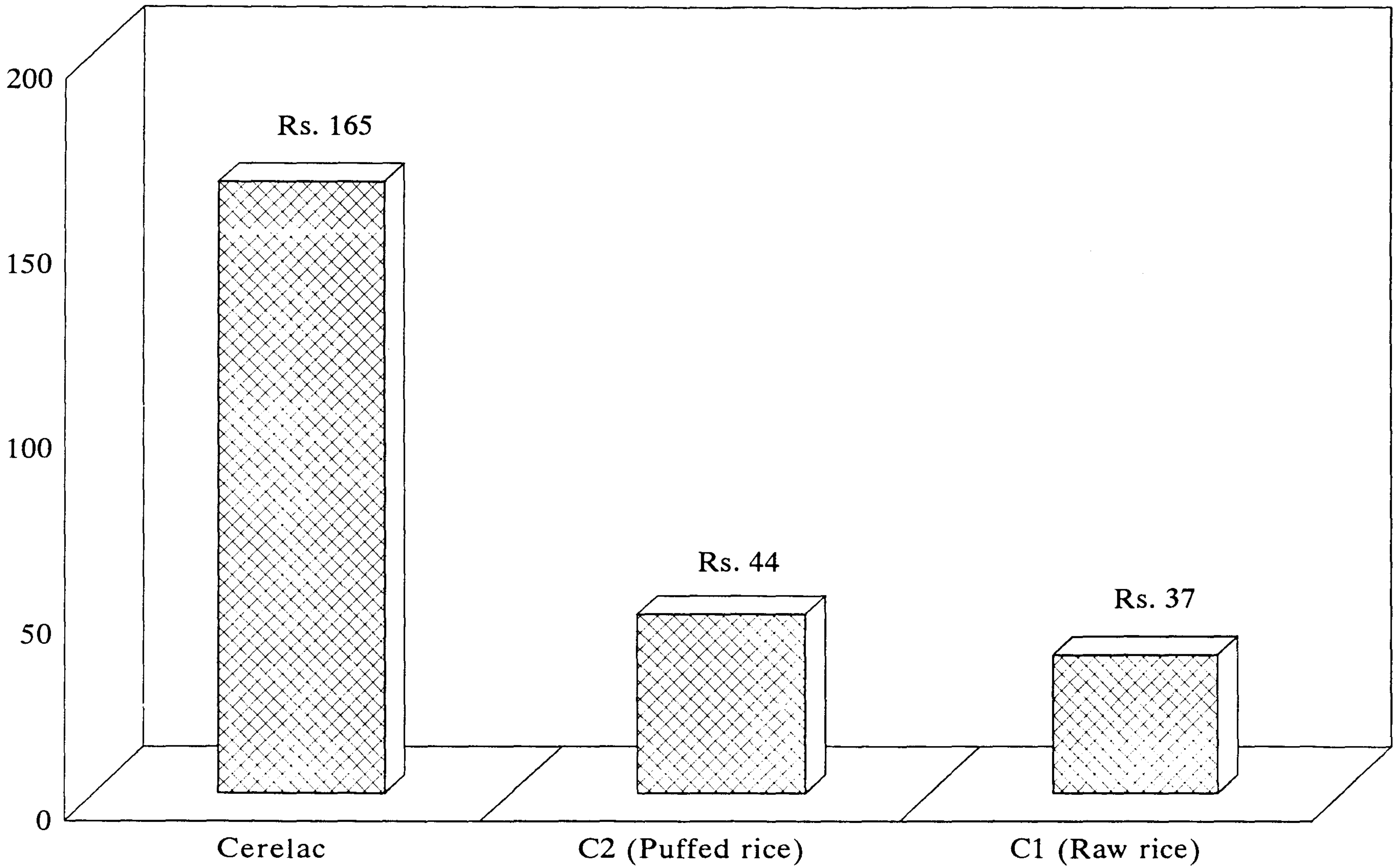

Fig. 4. Cost of the developed weaning mixes in comparison with a commercial weaning food

The details of the above comparison are presented in Table 23.

Table 23. Comparison of the selected multi mix with the ISI standards for processed cereal based weaning foods

Sl. No.	Characteristics	*Specification as per IS:1656-1969	Contents in the raw rice based multimix
1.	Moisture per cent by weight, max	10.00	8.07
2.	Total protein (N x 6.25) per cent weight, min.	14.00	16.94
3.	Fat, per cent by weight, max	7.50	0.32
4.	Total carbohydrates, per cent by weight, min.	45.00	71.77
5.	Total ash, per cent weight, max.	5.00	2.90
6.	Crude fibre (on dry basis), per cent by weight, max.	1.00	negligible
7.	Calcium g/100g, max	1.00	0.40
8.	Iron, mg/100g, min	10.00	4.20
9.	Vitamin C mg/100g, min	25	6.24
10.	Bacterial count per g, max.	5,000	Nil

* After six months of storage

From the above Table it can be seen that the developed product meets the requirements for the various parameters tested except for iron and vitamin C, as specified by IS:1659-1969, `specifications' for processed cereal weaning foods.

The maximum per cent of moisture as per the specification is 10.00. Moisture is an important factor that determines the storage stability of a product and above the specified level the quality of the product is prone to be affected. But the moisture content of the developed product was 8.07 per cent which is below the stipulated maximum level. This is a favourable phenomena which helps to extend the shelf life of the multi mix.

The minimum amount of protein as per the ISI requirement is 14 g/100 g and the selected product has a protein content of 16.94g/100g which satisfies the reference standard.

The maximum content of fat that is recommended is 7.50 per cent by weight. Fat is another component which affects the shelf-life of any product. Fat if it turns rancid imparts an off flavour and rancid taste to the product which affects the acceptability of the product. On the other hand the fat content of the developed product was very low 0.32 per cent by weight. This was because the components included were devoid of the fat (defatted soya flour and skim milk powder). If partially defatted soya flour could be made use of the fat content can be enhanced, which would enhance the energy value as well as the taste of the product.

Total carbohydrates was estimated to be 71.77g in the product and the minimum requirement of carbohydrates as per the IS requirement is 45.00g. However, their high carbohydrate content would supply teh calories, since the multimix is low in fat.

The per cent weight of ash present in any weaning food should not exceed 5.00 as per the IS recommendation. The total ash estimated in the developed product was 2.90 per cent which also falls below the stipulated value.

The percentage of crude fibre present in the developed product was negligible.

The maximum content of calcium as suggested by ISI is 1.00 and the developed product had a calcium content of only 0.4 g/100g.

In the case of iron the minimum recommended level was 10.00 mg/100g while the iron content of the developed mix was only 4.20 even after the addition of jaggery. The same was the case of vitamin C where the recommended level was 25mg/100g while that in the product it was only 6.24mg/100g. Therefore it is advocated that fruit juice and milk may be given to the child to enhance the supply of the above nutrients.

The bacterial count estimated after six months of storage was negative, though the standard permits a maximum count of 5,000 per gram of the sample tested.

From the above it can be stated that the developed product meets seven out of ten of the recommendations of ISI for processed cereal weaning foods and hence could be selected as a nutritious weaning food for the children of Kerala.

To conclude it could be stated that the multi mix made with raw rice and soya as a basic mix could be accepted as a good weaning food for household use since it is low in cost when compared to similar products and could be made using simple household technologies such as drying, roasting, powdering and mixing. A panchayat level processing unit could be established on a community basis, and the local women can take it up as an income generating group activity. All ingredients used in the multi mix are locally available and / or are familiar to the literate mothers of Kerala except the defatted soy flour. This flour is easily available in the market at a cost which is lesser than the other pulses that are used in Kerala. Moreover, soya is an ingredient of the regular supplement given through anganwadies, with which our children are familier.

The technology of preparation of the multi mix is simple and it takes less than two minutes to cook it into a porridge of desired consistency. It may be seen that the product does not have the problem of high viscosity. It has the most desired consistency, suitable for spoon feeding. This formula does not suffer from the draw back of `bulk'. The product is dense in nutrient, without being bulky. The high viscosity and bulk are the common bottle necks of most of the traditional weaning mixes, which has been over come in this product, though laborious procedures such as sprouting/malting has been eliminated. It supplies the major nutrients in adequate amounts with out being bulky and has a desirable protein energy ratio. The product if prepared under hygienic condition remains stable for more than six months without spoilage which ensures that the product can be prepared and stored as a ready-to-cook (instant) mix.

Devadas, (1983) an authority on nutrition in India, has stated that, development of complementary food should be governed by six major principles namely; high nutritional value and good supplementary value, (ie., high energy value and NPU of 60 to 65) acceptability, ease of preparation, low cost, shelf life (4 to 6 months), and local availability of ingredients. When viewed on the basis of the above six principles the weaning food developed satisfies all the above requirements. It has high energy value, and RE% value; it has a high NPU; it is highly acceptable based on the organoleptic and other acceptability characteristics; it just takes three minutes to cook the mix into a porridge of spoon feeding consistency; it is comparatively economical; has a shelf life of six months; and it is made from food items which are locally available and / or familiar to the people. Being simple and easy to prepare it not only helps to save the mother's time and energy but also provides a nutritious, low cost and indigenous, socially acceptable and organoleptically appealing ready-to-cook product. Hence the product could be taken up as a desirable weaning food that satisfies the needs of the local children and their mothers and could be popularised as a weaning mix, for home level or community level production, for sale or for free distribution on a large scale.

SUMMARY

5. SUMMARY

A study entitled "Developing a weaning food with rice and soya as basic mix" was conducted with the major objective of formulating a weaning food using rice and defatted soya flour as basic ingredients and evaluating its physical, nutritional, organoleptic qualities and shelf life.

Seven combinations of the basic mix were formulated varying the proportions of rice and soya flour. The amino acid score and chemical score of the seven combinations/proportions were worked out and the proportion that gave the highest chemical score of 73 was selected for formulating the multi mix.

The multi mix thus developed comprised of raw rice and defatted soya flour amaranth and skim milk powder which were selected from the `Food Square' in the proportion 61.5:15.4:7.7:15.4. Variations of the multi mix were tried by replacing raw rice by parboiled, puffed and flaked rice and also by varying the nature of incorporation of amaranth leaves. Shredded dried and powdered form of amaranth leaves

and amaranth leaf extract were tried out while formulating a recipe with the multi mix. The recipe chosen for feeding the multi mix to the infant was a porridge which was prepared by adding 25g of multi mix to a syrup of jaggery and boiling the mixture over fire for 3 minutes by constant stirring. The recipes were then evaluated for their organoleptic qualities to identify the best multi mix. The mix containing raw rice and puffed rice with dried and powdered form of amaranth was found to be the most acceptable one.

In order to find out the nutritional adequacy, the nutrient content of the four variations of the multi mix viz., multi mix containing raw rice, puffed rice, flaked rice and parboiled rice were computed and compared. Results revealed that all the mixes were adequate to meet one third requirement of an infant per serving and it was seen that the multi mixes did not show great variation with respect to major nutrients.

Hence based on the preference of the judges and the nutrient composition two multi mixes viz., multi mix containing raw rice (C1) and puffed rice (C2) were selected for further detailed evaluation of quality.

Chemical analysis of the two multi mixes was then carried out to measure the nutrient composition and it revealed that C1 (raw rice) contained 358 K Cal, 16.94 g protein, 40.3 mg calcium, 4.2 mg iron, 6.24 mg vitamin C and 381.2 ug carotene per 100g while C2 (puffed rice) had 19.33g protein, 38.9mg calcium, 3.6 mg iron, 6.2mg vitamin C 381 ug carotene per 100g. The protein energy ratio (PE%) when calculated was found to be 9.2 for C1 (raw rice) and 10.5 for C2 (puffed rice).

In an attempt to evaluate the protein quality of the two multimixes, animal experiments were conducted and the PER, FER and NPU of C1 (raw rice) was found to be 2.8, 28.4 and 70.9 respectively and that for C2 (puffed rice) was 2.5, 24.5 and 65.7 respectively. The Biological Value (BV) and Digestibility co-efficient (DC) were found to be 81 and 87.5 per cent for C1 (raw rice) and 77 and 85.3 per cent for C2 (puffed rice). Thus it was found that C1 (raw rice) was superior to C2 (puffed rice), with respect to protein quality.

The multi mixes were then evaluated for their physical characteristics, so as to find out its suitability to feed an infant. The viscosity and bulk density of the mixtures when tested revealed that C1 (raw rice) had a lower viscosity of 720 cp and a bulk density of 0.56 g/dl while C2 (puffed rice) had a viscosity of 1160 cp and bulk density of 0.64 g/dl. The processing loss of the multi mix C1 (raw rice) was estimated to be 0.52 and that of C2 (puffed rice) was 0.63 while the yield ratio was 5.4 in the case of C1 (raw rice) and 5.2 in C2 (puffed rice). Both the multi mixes were stable upto six months since the moisture content of both the mixes were found to be low (below 10%).

The multi mixes were both easy to prepare and would take only three minutes to cook into a porridge of desired consistency for spoon feeding.

Organoleptic qualities of the two multi mixes were assessed by a panel of 20 judges and it was found that the mixes differed significantly with special reference to taste and appearance. C1 (raw rice) was better than C2 (puffed rice). The overall acceptability was superior for C1 (raw rice) compared to C2 (puffed rice) as shown by an index developed for the same.

Cost analysis of the multi mixes further revealed that C1 (raw rice) has a lower cost when compared to C2 (puffed rice), as the cost per kg was worked out to be Rs. 37.20 and Rs 48.00 respectively.

Thus based on nutritional, physical, organoleptic and economic characteristics the multi mix containing 61.5 per cent of raw rice 15.4 per cent of defatted soya flour, 7.7 per cent of amaranth leaves (dried and powdered) 15.4 per cent of skim milk powder (ie., combination C1) is found to be the most acceptable. This could be reconstituted easily within two minutes into a porridge which has a desirable consistency for spoon feeding (low viscosity) and a high nutrient density.

Thus it can be concluded that the developed multi mix containing rice and soya as the basic mix, in the ratio of 61.5:15.4:7.7:15.4 is a nutritionally adequate, ready-to-cook weaning food, suitable to feed an infant of six to nine months of age and that it is indigenous, low cost and stable.

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APPENDICES

Appendix I

Score card for sensory evaluation of the multimixes

		C1	C2
1.	**Appearance**		
	Very Good	5	
	Good	4	
	Fair	3	
	Poor	2	
	Very poor	1	
2.	**Colour**		
	Most acceptable	5	
	Acceptable	4	
	Fairly acceptable	3	
	Not acceptable	2	
	Not at all acceptable	1	
3.	**Flavour**		
	Most acceptable	5	
	Acceptable	4	
	Fairly acceptable	3	
	Not acceptable	2	
	Not at all acceptable	1	
4.	**Doneness**		
	Well cooked	5	
	Cooked	4	
	Partially uncooked	3	
	Uncooked	2	
	Over cooked		
5.	**Taste**		
	Very good	5	
	Good	4	
	Fair	3	
	Poor	2	
	Very poor	1	
6.	**Texture**		
	Smooth	5	
	Soft	4	
	Fibrous	3	
	Hard	2	
	Tough	1	
7.	**Consistancy**		
	Even consistency	5	
	Uneven consistancy	4	
	Waxy	3	
	Watery	2	
	Too thick	1	

Appendix II

ANOVA - Weight of experimental animals

	df	MSS	F value
Between diets	3	372.44	1.22
Within diets	20	306.00	
Between periods	7	12016.33	2700.30**
Diet x period	21	58.10	13.05**
Error	140	4.45	

** Significant at 0.01 level

Appendix III

ANOVA - PER of the diets

	df	MSS	F value
Between treatments	3	0.6409	
Within treatments	20	0.06416	9.98**

** Significant at 0.01 level

DEVELOPING A WEANING FOOD WITH RICE AND SOYA AS BASIC MIX

By

ROSITA JACOB

ABSTRACT OF A THESIS
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ABSTRACT

A study entitled "Developing a weaning food with rice and soya as basic mix" was conducted to develop a nutritionally adequate weaning food intended for feeding infants of six to nine months of age.

The amino acid score and chemical score of seven proportions of basic mix containing varying proportions of rice and defatted soya flour were worked out and the best proportion having the highest score was selected to formulate a multi mix incorporating amaranth and skim milk powder.

Twelve variations of the multi mix were formulated varying the nature of incorporation of the aforesaid ingredients. Recipes (porridge) were prepared from the multi mixes. The recipes prepared were subjected to preference test and based on the preference test and nutritive value, two of the multi mixes were selected which were further evaluated for their protein quality, physical and organoleptic qualities, storage stability and cost. Based on the above the multi mix containing raw rice, defatted soy

flour, skim milk powder, with dried and powdered form of amaranth was identified as the best multi mix.

The selected multi mix was found to be nutritionally adequate to meet the requirement of a young infant. The developed product was also found to meet the requirements specified by IS (1659-1969) for majority of the characteristics tested and hence could be proclaimed as a nutritious weaning food for the infants of Kerala, being indigenous, low cost and easy to prepare and feed.