DEVELOPING INDIGENOUS WEANING FOOD BASED ON RAGI FLOUR

BY

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THESIS

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1987

DECLARATION

I hereby declare that this thesis entitled "Developing indigenous weaning food based on Ragi flour" 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.

Jessy Philip

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CERTIFICATE

Certified that this thesis entitled "Developing indigenous weaning food based on Ragi flour" is a record of research work done independently by Jessy Philip, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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INTRODUCTION

INTRODUCTION

Children are the most vulnerable of all victims of nutritional problems. Hunger, malnutrition or undernutrition in the younger years of life can have tragic and often irreversible effects on a childs' development. Malnutrition among children poses a great challenge to national development and varying degrees of growth retardation have been observed in Indian infants, because of this condition. While good nutrition is important throughout childhood, it is crucial during the first five years of life. Therefore existence of the problems of malnutrition and undernutrition pose a serious threat to their growth and development.

Weaning is a process in which an infant is gradually introduced to a variety of liquid, semisolid and solid foods to effect a smooth shift to the adult or family food pattern. The weaning period is considered as a time in the baby's life when the immunity to common infections inherited from mothers and complemented by the anti-infectious property of the breast milk diminishes and finally disappears. The danger of weaning a baby on to a food from the family pot, arises when the adult foods are nutritionally inadequate for the child. Satisfactory rate of growth is seen upto the age of 4 to 6 months, beyond which period, infants belonging to undernourished mothers tend to exhibit a slower rate of growth. The main reason for this observation is that the nutrients supplied by breast milk are sufficient to sustain, satisfactory growth only up to the age of 4 to 6 months, and supplementary foods are necessary beyond this age. In most of our poor rural communities supplementary feeding is not started till at a much later date, and even when supplementary foods are introduced relatively early, both the quantity and quality of the supplements are far from satisfactory. Unscientific infant weaning practices contribute largely to the unsatisfactory rate of growth beyond 6 months of age among infants, belonging to the poor socio economic classes.

Protein calorie malnutrition is essentially a disease that occurs during the crucial transitional phase of a child's life from breast milk to other types of foods. Though there are a number of commercial preparations specifically designed for purposes of weaning, it must be pointed out that such products are expensive, and beyond the economic reach of the rural population. There is thus an urgent need to develop satisfactory, cheap infant weaning foods which can be prepared from locally available resources in a community for use among the poor socio-economic classes. Making available such infant weaning food is an important measure in the control and prevention of protein calorie malnutrition during late infancy and early childhood. Therefore the present study was conducted to develop a weaning food based on ragi flour with the following objectives:

1. To develop a weaning food which is nutritious, low cost and acceptable using ragi flour as a basic ingredient;

2. to assess the net protein utilization and protein efficiency ratio of the weaning formula;

3. to standardise recipes with the weaning food developed; and

4. to assess the acceptability of the recipes.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Infancy is the most critical and vulnerable period in childhood and it is during this period that we witness a high incidence of mortality and morbidity due to many factors (ICMR, 1984). According to UNICEF report on the state of world's children (1987) of the 14.5 million infants and children in the world currently dying each year, nearly 5 million are above the age of one. It was also reported that the under 5 mortality rate in the year 1985 in India is 158 and the infant mortality rate under 1 is 105. In India during 1980-84, 33 per cent and 5 per cent of children under fiveware suffering from moderate and severe malnutrition respectively. Ghosh (1980) reported that infant mortality rate in developing countires is 7 to 8 times more than that in developed countries. Deaths during the period of weaning in developing countries are 15 times higher than that in industrialised countries (Haxton, 1984). According to Health statistics of India (1978) infant mortality rate is higher in rural areas compared to urban areas. Jwani (1978) reported that nutritional problems are very common in infants and young children of Asian migrants as a result of inadequate weaning. According to Ghosh (1980) malnutrition and under nutrition were the important underlying causes of mortality in this country.

Ghosh (1976) reported that weaning is the most vulnerable period in the life of an infant. It was also reported that due to prolonged breast feeding and late introduction of semisolids to the child's diet, the period between six months and two years is one of continuous hunger and results in malnutrition. According to Cameron and Hofvander (1971) most of the children in developing countries have moderate to severe malnutrition during transition from breast-feeding to adult diet, owing to the combined effect of inadequate diet and infection. According to Srikantia (1983) signs of malnutrition begins to manifest during weaning period and ultimately results in long term deficiencies in physical, mental and total development of our children. Hofvander (1973) reported that the incidence of protein calorie malnutrition among weaned infants is quite high in India. A survey conducted in south India showed that about one per cent of children aged one to five years showed signs of kwashiorkor, two per cent of marasmus, 3.5 per cent of vitamin deficiency diseases and five per cent anaemia (Swaminathan, 1974). According to Patodi et al. (1976) in rural and urban communities near Indore, 18.4 per cent and 12.8 per cent of the infants respectively showed signs of nutritional deficiencies of protein, calcium, Iron and

B group vitamins after the age of six months. According to Semwal et al. (1986) in Delhi urban slums 45.1 per cent and 47.2 per cent of the children at one and two years of age were undernourished. Geetha (1986) reported that in Coimbatore, severe forms of malnutrition were found to be more in the age group of 2 to 3 years. Protein energy malnutrition was present in 44 per cent of the children. Next to protein energy malnutrition, iron deficiency anaemia and vitamin A deficiency were widely prevalent. According to Devadas and Saroja (1980) Xerophthalmia is a significant health problem in the selected villages of Coimbatore district and it was found that 12.5 per cent of rural children developed Bitot's spots.

Srikantia (1983) reported that one of the important contributing factors for the development of infant malnutrition is the poor infant feeding practices. Sataputhy et al. (1984) have announced that in lower socio-economic groups in Berhampur, in South Orissa 72 per cent of the children were undernourished due to poor quality food and delayed weaning. In rural areas of Bangladesh energy intake of young children were inadequate due to the decreasing intake of human milk with out a sufficient intake of complementary solid foods (Chaudhury, 1984).

One of the major issue concerning weaning is the age at which supplementary or complementary food should be introduced (Srikantia, 1983). Waterlow (1979) reported that the average amount of breast-milk produced by western mothers (750 ml/day) will not meet the energy requirement of an average infant. Therefore he suggested that supplementary feeding should be initiated between two and three months of age. Srikantia (1983) reported that supplements has to be initiated after the third month to prevent malnutrition and related complications due to infection and infestation. According to Mitzner et al. (1984) complementation may be advisable as early as two to four months after birth depending upon the quantity of mothers milk, baby's ability to suck, mother health and mother's activities or her availability to breast-feed. Govindankutty (1984) reported that after the age of 3 or 4 months breast milk is not sufficient to satisfy the nutritional requirement of the child. So other foods must be added. Kumari et al. (1985) reported that breast-milk was insufficient beyond four months of age. Hence for prevention of infant malnutrition, introduction of weaning food should be encouraged by four to six months of life. According to Devadas et al. (1984) from the fourth month of infancy along with breast milk, the infants should be gradually introduced to liquid and solid supplements. Studies done by Damodaran (1979) showed that breast milk alone can sustain proper growth till 4 to 5 months of age. Beyond that age unless additional food is provided, growth slows down. Breast-milk is usually capable of meeting an infants total nutritional need for his first four to six months of life (Report of Ministry of Social Welfare, 1981). A study undertaken by National Institute of Nutrition in India (1981) found that breast milk appears to produce adequate nutrition for about six months of life and therefore supplements must be introduced after six months.

The age at which supplements were introduced varied from place to place. Osuhor (1980) studied the weaning practices of the poor farmers or small traders of North Nigeria and the results indicate that supplementary feeding was introduced during five to nine months. Anyanwu and Enwonwu (1985) studied the impact of urbanization and socio-economic status on infant feeding practices in Lagos, Nigeria. According to this survey majority of the mothers introduced supplementary feeding before the third month and only very few women waited until their infants were 6 months old. Chung (1979) studied the weaning practices of infants in Daejeon city, South Korea and it was revealed that by six months, 60 per cent of the infants had been weaned and supplementary foods made at home were popular (64.2 per cent) while 23.1 per cent used commercial infant foods. Patodi et al. (1976) reported that in rural and urban communities near Indore, age of weaning was around 13-15 and 10-12 months respectively. According to Kaur et al. (1983) most mothers in rural Ludhiana introduced milk supplements before six months. Awasthi et al. (1983) studied the feeding practices in rural areas of Jhans. According to them 60.8 per cent of children received semisolids and solids very late by second year. A 'WHO' study of weaning practices by rural mothers in India showed that by six to seven months only 12 per cent of the mothers gave complementary foods (UNICEF, 1984). According to Samal (1984) in rural Orissa, Semisolids were introduced around 13 to 18 months by 53.2 per cent of the mothers. The findings of the study on infant feeding and weaning practices conducted by Bhat and Kheberpal (1983) in the selected village of Hissan district revealed that the infants were breast-fed for a very long period, upto two to three years without giving adequate amounts of supplementary foods. According to Rao (1983) in rural India introduction of food supplements is usually delayed and in more than 90 per cent of the children, complete weaning takes place only towards the end of the third year.

It was also reported that by the age of twelve months almost all the infants were fully weaned. According to Ramachandran (1984), among the more traditionally inclined urban poor in Hyderabad, the introduction of semisolid supplements begins by about sixth month after birth. Semwal et al. (1986) studied the feeding and weaning practices of infants in Delhi urban slums. It was found that for 43.3 per cent of children, supplements were introduced at 4 months, while for 23.3 per cent prolonged breast-feeding and delayed weaning at 1 year were practiced. Survey conducted by Geetha (1986) in coimbatore revealed that only 9 per cent of the children were breast-fed beyond one year. It was also found that no special weaning food was given and supplementary feeding was started beyong seven months with cereals. A survey conducted by Devadas et al. (1977) in Coimbatore city reveal that supplementary feeding was generally started at around 3 months. According to Dube (1986) in many rural communities in India, weaning does not start until 2 years and in rare cases upto 4 years where as in urban communities weaning often starts much earlier and additional foods are sometimes given when the infant is only a few months old. The survey conducted in Kayamkulam and Sherthala, two municipalities of Kerala, by Beegum and Prema (1984) reveal that women in the two areas have introduced too many foods, before six months. It was also found that 25 per cent and 47 per cent of women in Kayamkulam and Sherthala have accepted commercial infant foods as substitutes for breast-milk.

There are different factors which affect the weaning practices. Puri et al. (1983) reported that infant feeding practices are strongly associated with the culture of the society. And rapid cultural changes due to industrialization and urbanization have largely modified weaning practices. According to Geervani (1983) the type of weaning practices that the mother employs depends upon the customs, superstitions and beliefs, religion, cultural pattern, place of residence, socio-economic status of the family and literacy status of the mothers. She also reported that the weaning practice depends on the knowledge, beliefs and attitudes of the mother. According to Puri et al. (1976) duration of breast-feeding and therefore initiation of weaning has a definite inverse relation to the education of the mother and economic status of the parents. Semwal et al. (1986) reported that young educated mothers from high socio-economic status tended to control the duration of breast-feeding and wean the child earlier than the older uneducated mothers. Mitzner et al. (1984) reported that the length of the weaning period may be influenced by the availability of appropriate weaning foods, technological and economic factors such as the need for economic independence by women. Govindankutty (1984) reported that due to economic, cultural and other reasons children are very often deprived of the additional food they need. Economic factor is the most important constraint for utilization of weaning food (Menon et al., 1980). According to Mitzner et al. (1984) the knowledge, attitude and perception of mothers about infant formula as an indicator of social status, cultural factors such as dietary and sex related taboos and restrictions, economic concerns, kinship, social network, religion, traditions and behaviours prevalent in a community affects the weaning practice. Chung (1979) reported that some children are weaned when they demand for other foods. It was also reported that failure of lactation is one of the major causes of weaning. According to Kaur et al. (1983) solids were introduced earliest by brahmin mothers and latest by the backward and scheduled caste. Dattal et al. (1984) reported that supplementary foods in very diluted form were introduced to all children in rural and urban areas of Himachal Pradesh. The survey further revealed that urban mothers tended to introduce supplementary milk foods earlier than rural mothers. The survey conducted by Samal (1984) in rural Orissa revealed that mothers held strong beliefs regarding hot and cold foods. The urban based educated and gainfully employed women tend to breast-feed their infants for not more than five months. Damodaran (1979) reported that most often the mothers do not prepare any special foods for weaning because of poverty, ignorance or lack of time.

As there seems to be variation in the age and introduction of supplements, there is also a major variation in the kind of supplements used. Chung (1979) studied the weaning practices of infants in Daejeon city South Korea. According to him for the preparation of the supplementary food cereals, fruits and vegetables were used. Osuhor (1980) reported that in North Nigeria supplementary feeding was introduced mainly withgruel of guinea corn, millet or maize. These formulae were deficient in energy essential nutrients and proteins. Survey conducted by Winzerling et al. (1980) from Tuesor, Arizerier area of USA revealed that it is the custom of Chinese mothers to wean their children with rice gruel or rice paste. Shawqi et al. (1985) reported that in Egypt 90 per cent of the children were breast-fed and about 80 per cent received supplementary foods prepared with rice. Patodi et al. (1976) reported that weaning foods mostly used in rural communities near Indore were pulses, vegetables, fruits and occasionally some kind of pudding. A survey of infant feeding practice in Madhya Pradesh conducted by

Mudgal _et al_. (1979) revealed that cereals in the form of semi-solids were introduced with in six months. A study conducted by Puri _et al_. (1976) in South India reveal that idli, a cereal legume mix was the commonest initial weaning food. According to Ramachandran (1984) rice and dhal were the initial semi-solid supplements for the urban poor in Hyderabad. Devadas _et al_. (1977) reported that in Coimbatore city ragi porridge and cows milk were used by the low income groups and cows milk and baby foods such as Farex by the higher income groups. Idli and rice were common solid supplements in all income groups. According to Srivastava and Rathor (1983) in Ludhiana cereals were not given before six months and if at all given by very few between seven and nine months. According to Rao (1983) in rural India weaning food is often home made and in the poorer segments of the population it consists of modified adult food. The survey conducted by Samal (1984) in rural Orissa revealed that rice flakes and puffed rice were the preferred semi-solids.

In order to improve the nutritional status of the infants there is the need to change the infant feeding practices. According to Govindankutty (1984) under the influence of advertisements many mothers of urban poor and rural population run after baby foods. Therefore

efforts to promote the maintenance of breast-feeding and counteract the factors responsible for its decline and to improve weaning practices in the local context, while respecting traditional values can go a long way towards providing a better diet for young children. Devadas (1983) feels that breast-feeding should be continued at least throughout the first year of life and suitable weaning foods should be used to complement breast-milk as the childs nutritional requirements increase beyond the level that can be met by breast-milk alone. Development of weaning and supplementary foods based on cheap locally available food stuffs which are familiar to rural mothers has been one of the strategies suggested to combat protein energy malnutrition (ICMR, 1974). Swaminathan (1975) reported that large scale production and distribution of supplementary foods based on oilseeds and nuts are effective in improving the nutritive value of poor diets consumed by children in the developing countries and will help to overcome protein energy malnutrition among weaned infants and children.
A supplementary study conducted by Hofvander (1973) among healthy infants of four to six months with milk protein and fish protein concentrates gave positive results. It was also reported that infants will grow normally with an average protein intake of 26 g. per day. Elizbieta et al. (1983) studied the effect of diets high in soy protein on

nitrogen metabolism and found that lowest level of protein in the diet was the 5 per cent to maintain nitrogen balance. Hanna et al. (1983) found that diets high in soy protein negatively affects protein utilization when the requirements for amino acids are not met.

After much experimentation and field trials several weaning foods have been developed by research institutions. They varied in their composition and nutritive value. A study conducted by Mankernika et al. (1964) revealed that a blend of sesame and Bengal gram or sesame and soyabean were ideal mixture, for weaning infants. This findings is of great practical and economic importance to India and other developing countries in which skim milk powder is costly. Weaning food developed by Kaur and Gupta (1982) contain potato, soyabean and skim milk in the ratio 65:20:15 with requisite quantity of protein, fat, moisture ash and crude fibre and with a PER of 1.9. Another weaning food with wheat flour and peanut flour was developed by Chengavi et al. (1983). A protein rich vegetable mix with rice, wheat, chickpea, milk and drumstick leaves was developed by Bushra et al. (1983). The infant food 'Kuzhandai Amudhu' developed, tested and patented by Sri Avinashilingam, Home Science College, Coimbatore is a combination of cereal, pulse, roasted groundnuts and jaggery in the ratio of 3:2:1:2 respectively. Human and animal feeding trials were conducted to establish the growth promoting value of these mixtures on par with skim milk powder (Devadas, 1983). The Indian Council of Medical Research set up a working party on infant weaning foods to carry out studies in depth in different parts of the country to develop suitable weaning foods. A total of 82 recipes were developed at different centres like Coimbatore, Gandhigram, Hyderabad, New Delhi, Poona and West Bengal. Among the different weaning foods 12 of them contain ragi as a basic ingredient. Other ingredients used along with ragi are bengal gram dal, red gram dal, green gram dal, groundnut, horse gram, jaggery, skim milk, coconut etc. (ICMR, 1984).

Apart from its nutritive value an ideal weaning food should have other characteristics. Devadas (1983) reported that the complementary foods for the young children must necessarily be low in cost and the product should remain acceptable from the organoleptic and nutritional point of view and should be free from any toxic or other changes for a period of at least 4 to 6 months in a tropical environment. Mitzner *et al*. (1984) stated that solid weaning foods should be as concentrated in energy and good quality protein as is practical and should contain adequate iron and other essential nutrients as well. According to Devadas (1983) weaning food mixture should have the highest possible energy value. The protein content should not be lower than 20 per cent and the quality of the protein should be good. Abrahamson <u>et al</u>. (1978) reported that in developing countries the energy density or bulk must be considered. Referring to the percentage of protein in the infant food, it was pointed out that it was not necessary to have a protein level of 20 per cent and above. It was reported that 12 per cent protein content would be adequate containing the essential amino acids. Lonnerdal <u>et al</u>. (1983) reported that several infant formulae had lower concentration of trace elements than human milk. It was found that in addition to the wide variation in absolute amounts of the trace elements in the formulae large variation in the ratios of trace elements were found. These differences in the ratios may be important as the ratio can affect the absorption of the individual elements. Therefore more attention should be given to the trace elements levels in infant formulae.

MATERIALS AND METHODS

MATERIALS AND METHODS

A study on developing indigenous weaning food based on Ragi flour was conducted with the following objectives.

1. To develop a weaning food which is nutritious, low cost and acceptable using ragi flour as the basic ingredient.

2. To assess the Net Protein Utilization and Protein Efficiency Ratio of the weaning formulae.

3. To standardise recipes with the weaning food developed.

4. To assess the acceptability of the recipes.

A. Plan of Action.

1. Formulation of different combinations of nutritious low cost and acceptable weaning food using ragi flour as a base.

2. Assessing the nutritional quality of the weaning formulae developed.

3. Assessing the nutritional quality of the weaning formulae developed through suitable animal experiments.

4. Standardising recipes in the laboratory using weaning formulae developed.

5. Assessing the acceptability of the recipes.

1. FORMULATION OF DIFFERENT COMBINATIONS OF NUTRITIOUS, LOWCOST AND ACCEPTABLE WEANING FOOD USING RAGI FLOUR AS A BASE.

Recipes which are suitable for the weaning period and for later feeding are called "multimix". To make an adequate infant multimix, four components are essentially needed, a basic staple, an energy rich supplement, a protein rich supplement and a mineral and vitamin supplement (Mitzner et al., 1984).

1.1. Justification for the selected ingredients in the multimix.

The ingredients selected for the weaning food formulated in the study were based on the local availability, nutritional value, economic significance, shelf life qualities acceptability, easiness for processing and digestability

(Mitzner et al., 1984). Accordingly ragi, green gram, sesame, tapioca and skim milk powder were chosen as materials for the multimix. Ragi was chosen as the basic staple because it is a poor man's millet popular in central and southern parts of India and the average annual production of ragi in Kerala itself is 1.1 thousand tonnes in the year 1985-86 (Saini and Sharma, 1986). This millet has been used as a basic item for weaning infants in Kerala from time immemorial. Further it is available in the markets in Kerala. According to Rao (1986) it is the best millet suited for weaning food being rich in calcium, iron, B vitamins and proteins. Kuppuswamy et al. (1958) and Kurien et al. (1960) have reported that ragi is deficient only in two essential amino acid namely lysine and threonine. Mudaliar (1960) has reported that the grain keeps well in storage for a number of year without damage by insect and pest. These are good attributes for a basic staple in a weaning diet.

Protein rich complement should form a part of the weaning formula and Christobal et al. (1968) suggested that a mixture of plant proteins is the most economical complement and can be nutritionally quite satisfactory. According to Desikachar (1983) cereals and pulses in the right proportion can ensure an adequate supply of good quality proteins

Deosthale (1982) reported that pulses are rich in protein, minerals and vitamins, hence they are important in the diets based on cereals and millets. This justifies the inclusion of green gram.

According to Rice (1971) effective use of oilseed proteins can go a long way towards correction of dietary protein deficiencies. Among oil seeds sesame is very commonly cultivated in the country. The annual production of sesame in India during 1985-86 is 520.7 thousand tonnes and in Kerala it is 3.6 thousand tonnes (Food digest, 1986). Girija Devi (1984) reported that the principal protein in sesame seeds are globulin and the limiting amino acid is lysine. She also reported that it is rich in tryptophan and sulphur amino acids particularly methionine. Therefore, sesame proteins constitute a valuable supplement to pulse protein justifying its inclusion along with green - gram in the multimix formulae.

Tapioca was chosen as the energy rich complement as it functions as a concentrated source of energy. In Kerala people have adopted tapioca as their basic food and it yields the highest quantity of starch per unit of land with minimum of inputs as compared to any other crop (Gopalan, 1979).

It was also reported that eventhough the protein content is very low it is easily digestable and is of good quality. It is a fair source of phosphorus and calcium and has traces of iron and vitamins. (Gopalan, 1979). According to Lakshmi and Pal (1986) Kerala accounts for nearly 75 per cent of the area and 71 per cent of the tapioca production in India.

According to Desikachar (1983) supplementation with skim milk solids could increase the nutritive value of weaning foods and make them nutritionally complete. Therefore in this study skim milk was used as the protein vitamin and mineral supplement.

1.2. Formulation of the multimix.

On the basis of the nutritive value and the chemical score of the ingredients, the proportion of the ingredients in the multimix were worked out. The chemical score gives an indication on the protein quality of the product. Jansan and Harper (1985) have reported that amino acid scores provide an useful estimate of the protein quality of blended foods and are an acceptable substitute for the biological assays. Therefore, several formulations and combinations of the ingredients selected were worked out. 12 combinations thus formulated are presented in Table 1).

Table 1. Percentage composition of the food ingredients in the weaning formulae.

Ingredients(g)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Ragi	40	35	60	35	30	50	50	25	40	30	45	35
Green gram	20	25	10	20	20	10	10	25	20	20	20	25
Sesame	10	15	10	15	10	10	15	10	15	15	10	20
Tapioca	10	10	10	15	30	20	10	25	15	20	10	10
Skim milk	20	15	10	15	10	10	15	15	10	15	15	10
Chemical score	76.3	74.19	72.03	77.4	74.19	73.7	72.03	68.8	77.4	75.27	77.4	76.4

The amino acid scores were worked out using the food composition tables of ICMR (1982). Using these values chemical scores were worked out from the ratio between the content of the most limiting amino acid in the test protein to the content of the same amino acid in egg protein expressed as a percentage. The combinations which had chemical scores below 75 per cent were discarded. Six combinations were selected by this method.

1.3. Preparation of the multimix

For the preparation of the multimix good quality ragi was purchased from the local market and was cleaned to remove all the impurities. The cleaned ragi was soaked in water for 24 hours (Fig.1) and germinated for 48 hours (Fig.2). The germinated ragi (Fig.3) was dried in shade. When the grain was completely dry it was roasted slightly and then powdered and sieved following the procedure recommended by Snehalatha (1985).

Green gram obtained from the local market was cleaned of impurities, washed in water and soaked for 12 hours (Fig.1). It was then sprouted following the procedure recommended by Rajalakshmi (1974). The soaked grains were tied in a moist muslin cloth (Fig.2) kept on a plate and covered with a large inverted pan so as to keep the temperature uniform. The germinated grain (Fig.3) was then dried in the sun, roasted, milled and sieved. Malting of the ragi and sprouting of green gram were adopted because they in turn helps partial pre-digestion of the starch and proteins, reduce the viscosity and the phytase hydrolyses the phytin to available phosphate (Desikachar, 1983). Deosthale (1982) reported that during soaking and germination several enzyme systems become active and bring about profound changes in the nutritive value of the pulses. Several studies have shown that vitamin C which is practically absent in the dry seeds of legumes increase in significant amounts (Prabhavathi and Rao, 1979; De and Barai, 1949) even after 24 hours of germination. Similarly 2 to 3 fold increase in the concentration of folic acid and B group vitamins takes place in germinated grains than in raw pulses (Babu, 1976). On the other hand antinutritional factors such as phytate (Reddy et al., 1978) and inhibitors of trypsin are inactivated (Subhalaxmi et al., 1976). Rao and Deosthale,(1982) have shown that by soaking in water for 24 hours about 24 per cent of tannin and by germinating for 24-48 hours, 20-25 per cent of tannin is lost from greengram. The beneficial effect of these changes is seen in the two fold improvement in the bio-availability of iron from pulses after germination. Studies on flatulence factors of the legumes have shown that during 24 hours germination, the concentration of oligosaccharides gets reduced to 50 per cent of the initial value Rao and Belavady (1978). Germinated legumes therefore appear to be less flatus producing than raw grains.

Good quality sesame was purchased from the local market and was cleaned to remove all the impurities. It was then dried, roasted and powdered. Tapioca was purchased from the local market and was peeled, cut into thin chips and dried and powdered.

The above four powdered ingredients and skim milk powder were mixed in weighed quantities as per the six combinations selected (Fig.4).

2. ASSESSING THE NUTRITIONAL QUALITY OF THE WEANING FORMULAE DEVELOPED THROUGH CALCULATION AND SUITABLE LABORATORY TECHNIQUES.

2.1. Assessing through calculation.

The nutrients present in the six combinations were calculated using the food composition tables of ICMR (1982).

Fig. 1. Ragi and Green gram soaked in water.

Fig. 2. Ragi and green gram kept for germination.

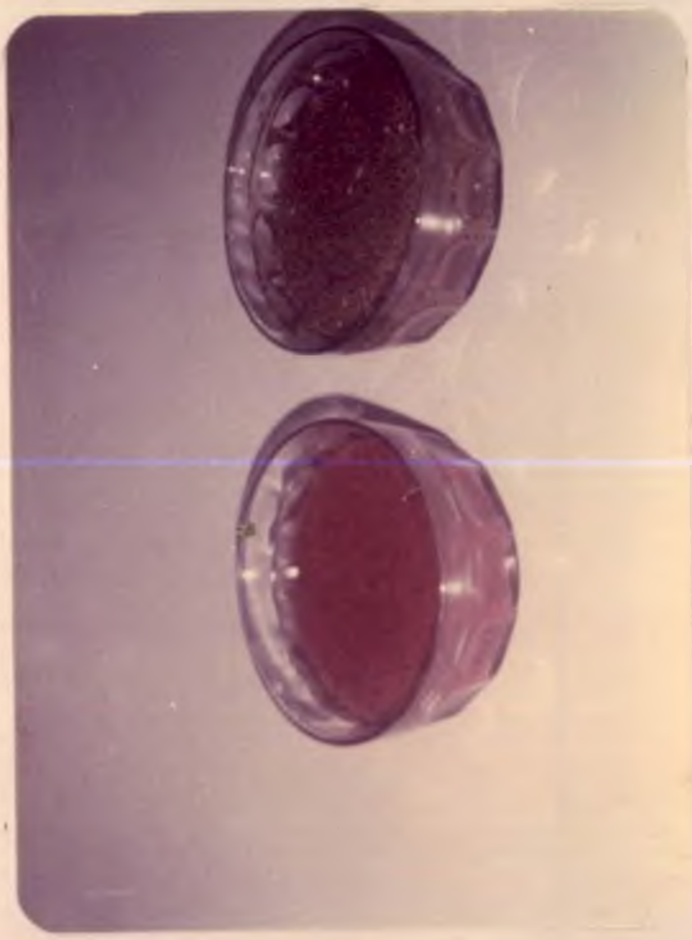
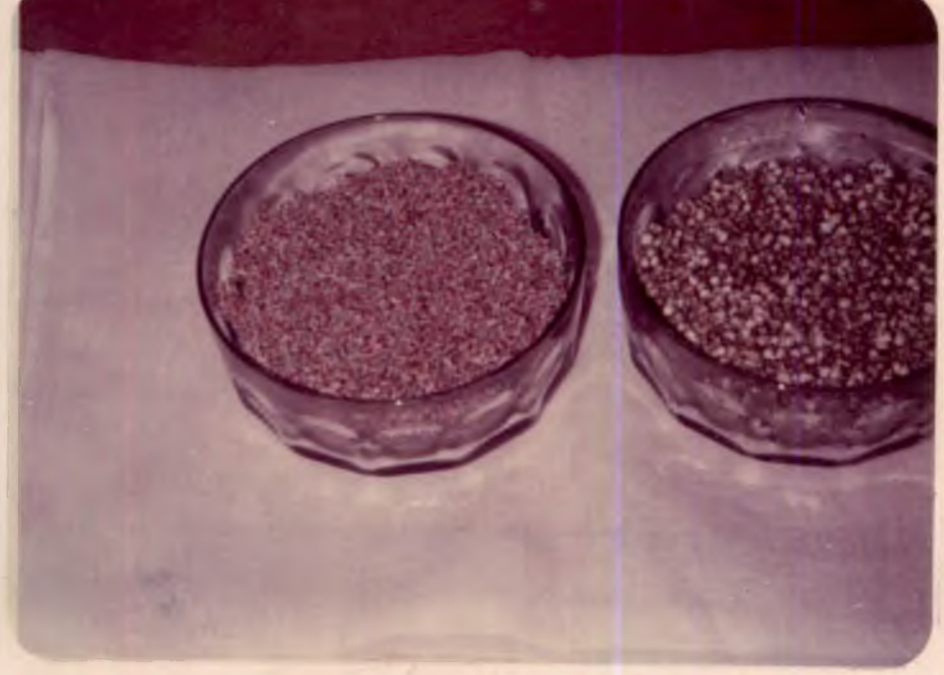


Fig. 3. Germinated Ragi and Green gram.

Fig. 4. The five food ingredients used for the weaning formulae.

Fig. 3. Germinated Ragi and Green gram.

Fig. 4. The five food ingredients used for the weaning formulae.



2.2. Assessing through laboratory techniques.

The six selected combinations were subjected to chemical analysis. The protein content was analysed using the micro kjeldahl method (Hawk and Oser, 1965) given in Appendix I and the minerals were estimated using the Atomic Absorption Spectroscopic method (NIN 1983)given in Appendix II.

3. ASSESSING THE NUTRITIONAL QUALITY OF THE WEANING FORMULAE DEVELOPED THROUGH SUITABLE ANIMAL EXPERIMENTS.

Ritchey and Taper (1981) reported that the most realistic way to assess the nutritional quality of proteins is feeding trials on animals usually rats and chicks. According to him several biological measurements have been proposed as indicaters of protein quality and the simplest among them is the protein Efficiency Ratio (PER). Other methods involve nitrogen balance studies from which several indices of protein quality namely true digestability, biological value and net protein utilization (NPU) are calculated.

Diets were formulated using the six combinations of the weaning formulae standardised earlier. These six experimental diets were formulated so as to supply

10 per cent protein. The details are presented in Table 2. A control diet was also formulated with skimmed milk powder which would supply 10 per cent protein. The composition of the salt mixture and vitamin mixture used in the diets are given in Table 3 and 4. The intake of minerals and vitamins were kept the same in the seven groups.

The animals were maintained on the respective diets to evaluate the protein quality of the weaning formulae.

Table 2. Diets formulated for the animal experiments.

		Percentage of the various ingredients	Percentage of the multimix in the diet.
Diet I	Ragi	23.23	
	Green gram	11.61	
	Sesame	5.81	
	Tapioca	5.81	
	Skim milk powder	11.61	58.07
	Starch	26.93	
	Ground nut oil	9	
	Mineral mix	4	
	Vitamin mix	2	

Diet	II	Ragi	23.35	
		Green gram	13.35	
		Sesame	10.0	
		Tapioca	10.0	
		Skim milk	10.0	66.7
		Starch	18.3	
		Ground nut oil	9	
		Mineral mix	4	
		Vitamin mix	2	
Diet	III	Ragi	28.69	
		Green gram	12.75	
		Sesame	6.38	
		Tapioca	6.38	
		Skim milk	9.56	63.76
		Starch	21.24	
		Ground nut oil	9	
		Mineral mix	4	
		Vitamin mix	2	
Diet	IV	Ragi	19.26	
		Green gram	12.84	
		Sesame	9.63	
		Tapioca	12.84	
		Skim milk	9.63	64.20

	Starch	20.8	
	Ground nut oil	9	
	Mineral mix	4	
	Vitamin mix	2	
Diet V	Ragi	27.83	
	Green gram	13.92	
	Sesame	10.44	
	Tapioca	10.44	
	Skim milk	6.96	69.59
	Starch	15.41	
	Ground nut oil	9	
	Mineral mix	4	
	Vitamin mix	2	
Diet VI	Ragi	21.76	
	Green gram	15.54	
	Sesame	12.43	
	Tapioca	6.22	
	Skim milk	6.22	62.17
	Starch	22.83	
	Ground nut oil	9	
	Mineral mix	4	
	Vitamin mix	2	

Table 3. Composition of Minerals mixture.

	Weight in g
Calcium carbonate	38.1400
Cabalt chloride	0.0023
Cupric sulphate	0.0477
Ferrous sulphate	2.7000
Magnesium sulphate	5.7300
Manganese sulphate	0.4010
Potassium lodide	0.0790
Potassium phosphate monobasic	38.9000
Sodium chloride	13.9300
Zinc sulphate	0.0548

Table 4. Composition of vitamin mixture.

Vitamin A	2000 I. u
Vitamin D	200 I. u
Vitamin E	10 I. u
Vitamin K	0.5 mg
Thiamine	0.5 mg
Riboflavin	0.8 mg
Pyridoxine	0.5 mg
Calcium pantothenate	4.0 mg
Niacin	4.0 mg
Inositol	10.0 mg
Para amino benzoic acid	10.0 mg
Biotin	40.0 kg
Folic acid	0.2 mg
Vitamin B12	3.0 mg
Choline chloride	200.0 mg

3.1. Protein efficiency ratio (PER).

The protein efficiency ratio (PER) which measures the weight gain per gram of protein eaten was determined according to the rat growth method of Osborne, Mendel and Ferry (Osborne _et al._, 1919).

Weanling male albino rats (Sprague Dawley strain) 28 days of age were used for the experiment. Animals of more or less identical weights (29 g ± 4 g) were selected and divided into 7 groups of 6 rats each and fed the respective diets as detailed in Table 2.

The rats were housed in individual cages with wire mesh floors (Fig.5). 15 g of the diet (Fig.6) was mixed with water, cooked in steam for 15 minutes, cooled and fed to the animals. Water was provided aad libitum. The left over food was collected daily and were dried and weighed. The food consumption was calculated by substracting the left over from the quantity served. The body weights of the animals were recorded once in three days during the experimental period (Fig.7). During the experimental period, conditions were maintained as uniform as possible. The rats were maintained on the respective diets for 28 days. The PER was calculated using the formula.

Fig. 5. Rat housed in a cage for the PER study.

Fig. 6. Weighing of diet for the animal experiment

Fig. 7. Weighing of rat in the Triple - Beam Balance.

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

From the PER values, the combination that gave the highest value was adjudged as the most suitable for its growth promoting effect.

The rats used for the PER study were deprived of food over night, stunned by a blow at the back of the neck and killed by decapitation. Blood was collected and the liver was removed to ice cold containers. Whole weight of the liver was recorded and liver and serum samples were taken for protein estimation by micro kjeldhal method (Hawk and Oser, 1965).

3.2. Nitrogen balance study.

To find out the extent of utilization of proteins of the different combinations nitrogen balance study was conducted. The net protein utilization values were found out by standard experimental procedures suggested by Mitchell (1923-24).

Male albino rats weighing 110-120 g were divided into 7 groups of 6 each. The animals were housed in individual metabolic cages (Fig.8). The whole experiment was divided into 3 periods. During the first period of 6 days all the rats were fed with a non-protein diet to measure the endogenous nitrogen. The composition of the non-protein diet is given in Table 5. During the 2nd period of 4 days the rats were fed with the stock diet (Table 5), During the third period of 6 days the different groups were fed with the 6 different experimental diets and one standard diet. The diets used for the study are given in Table 2. The animals were given 15 g of diet mixed with water, steamed for 15 minutes and cooled (Fig. 9). The amount of food given, the quantity of left over food and actual consumption were recorded every day.

During the 1st and 3rd periods of the experiment stools and urine samples were collected. Two drops of toluene were added to the urine samples as a preservative. Stools collected were dried in the oven. The stools of each group collected for 3 days were pooled together for nitrogen estimation. Urinary and faecal nitrogen were estimated by the micro kjeldahl method (Hawk and Oser, 1965). The Nitrogen content of the food mixtures were also estimated using the same procedure. Using the above values biological value, digestability coefficient and net protein utilization were calculated using the following formulae.

Fig. 8. Rat housed in a metabolic cage for nitrogen balance study.

Fig. 9. Rat with food and water in the metablic cage.

$$D\,C = \frac{In - (Fn - Fe)}{In} \times 100$$

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

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

D C = Digestability coefficient

B V = Biological value

NPU = Net protein utilization

In = Nitrogen intake

Fn = Nitrogen in Faeces

Fe = Endogenous faecal Nitrogen

Un = Nitrogen in Urine on protein diet

Ue = Nitrogen in Urine on protein free diet

Table 5. Percentage composition of the stock diet and non protein diet.

Ingredients (g)	Non-protein diet	Stock diet
Starch	85	-
Ground nut oil	9	9
Mineral mix	4	4
Vitamin mix	2	2
Wheat flour	-	15
Roasted bengal gram dhal	-	58
Ground nut	-	10
Casein	-	4

4. STANDARDISING RECIPES IN THE LABORATORY USING WEANING FORMULAE DEVELOPED.

Prior to the standardisation of recipes with the selected weaning formulae, the following tests were conducted.

4.1. Tests on the selected weaning formulae.

Quantity and cost of food ingredients included in the formulae.

Quantity and cost of food ingredients included in the formulae is assessed by estimating.

Percentage preparation loss, cost of food ingredients as purchased, and percentage yield.

i. The weight of the food ingredients as purchased (AP wt) minus the edible portion of the ingredients included in the formulae (EP wt) gives the preparation loss and the percentage preparation loss was calculated using the following formula.

$$\% \text{ preparation loss} = \frac{\text{AP wt} - \text{EP wt}}{\text{AP wt}}$$

ii. Cost of the edible portion of the ingredients used was calculated using the formulae $= \frac{\text{Total cost}}{\text{EP wt}}$

iii. The percentage yield of the recipe will be influenced by the cooking time and temperature used for cooking. Here the percentage yield of the recipe was worked out using the formulae $= \frac{\text{Cooked weight}}{\text{weight before cooking}}$

4.2. Recipes evolved.

Recipes listed below were evolved and standardised.

A. Bland porridge

B. Porridge with Chekkurmanis

C. Porridge with mango

Recipes were standardized for consistent quality production. In this the nutritional quality, availability and cost of various ingredients included in the recipe were considered. Suitability for clientele was considered in selecting and preparing the recipe. Each recipe selected was planned in such a way to meet the $1/3^{rd}$ of the requirement of pre-school children. The amount of the weaning formulae selected was finalised on the basis of the quantity of the protein. Fruits, green leafy vegetables and jaggery which were very commonly available in the state were selected as ingredients in the recipes to meet the requirement of the nutrients like calories minerals and vitamins.

Details regarding the recipes are given in Table 6, 7 and 8.

Table 6. Bland porridge.

Ingredients	Weight (g)	Measure teaspoon	Direction
Ragi flour	11.7	2½	1. Mixed the ingredients from 1-5
Green gram	7.8	1½	2. Boiled the water
Sesame	7.8	2	3. Added the mixed ingredients to the boiling water. Stirred continuously under simmering temperature to prevent lump formation till the mixed was cooked.
Tapioca	5.85	1½	
Skim milk powder	5.85	1½	
Water	117 ml		

Table 7. Porridge with chekkurmanis.

Ingredients	Weight (g)	Measure teaspoon	Direction
Ragi	11.7	2½	1. Roast the ingredients from 1 to 5 in oil and keep away from fire
Green gram	7.8	1½	
Sesame	7.8	2	2. Boiled the water
Tapioca	5.85	1¼	3. Add shredded chekkurmanis to water and boil until it is cooked.
Skim milk powder	5.85	1½	
Ground nut	25		4. Ground nut was roasted and powdered.
Chekkurmanis	14	½ cup	
Cooking oil	15		5. Added the roasted ingredients to the chekkurmanis stirred continuously under simmering temperature to prevent lump formation, till the mixture was cooked.
Water	120		
Salt	to taste		

The quantity of weaning formulae used was decided so as to meet 1/3rd requirement of protein of pre-school children. Chekkurmanis the low cost and locally available green leafy vegetable was added to meet the requirement of vitamins and minerals. Ground nut and cooking oil were added to meet the calorie requirement.

Table 8. Porridge with mango.

Ingredients	Weight (g)	Measure teaspoon	Direction
Ragi	11.7	2½	1. Roast the ingredients from 1 to 5 Ghee and keep it away from fire.
Green gram	7.8	1½	2. Prepare jaggery syrup in water.
Sesame	7.8	2	3. Add the roasted ingredients to the jaggery syrup, stirred continuously under simmering temperature to prevent lump formation till the mixture is cooked.
Tapioca	5.85	1½	4. Prepare mango juice and add it to the cooked porridge.
Skim milk powder	5.85	1½	
Mango	30		
Jaggery	30		
Ghee	15		
Water	120		

Table 8 has been presented the weight of various ingredients used in the recipe. The recipe was formulated so as to meet 1/3rd requirement of pre school children. The nutritious, low cost and locally available fruit mango and jaggery were added to meet the iron and calorie requirement. Ghee was also added to meet the calorie requirement.

4.3. Cost of the recipes.

Cost of the recipe was worked out by assessing the cost of the ingredients used for developing the recipe.

Cost of the fuel was also worked out by recording the time needed for preparing the recipe. Gas stoves were used for cooking the recipes. The weight of a gas cylinder is 14.2 kg. The life span of the cylinder is 120 hrs. The total time required for cooking each recipe was calculated from this the fuel expenditure was worked out.

5. ASSESSING THE ACCEPTABILITY OF THE RECIPES.

Acceptability trials of the selected weaning formulae were planned at the laboratory level and at the field level. The weaning formula which gave the highest value for indices such as protein efficiency ratio, hepatic weight, hepatic nitrogen, serum protein, biological value, digestability coefficient and net protein utilization as well as the various tests and criteria developed for standardising recipes was selected for the acceptability trials.

A series of acceptability trials were carried out at the laboratory with a selected panel of judges. At the field level these trials were conducted among children who are the real clientele and among their mothers, who are responsible for formulating specific desires and attitudes in children (Fig. 10-13).

Fig. 10 & 11. Acceptability trial for children in the field.

Fig. 12 & 13. Acceptability trial for mothers in the field.

The panel members for acceptability trials at the laboratory level were selected from a group of 30 healthy women in the age group of 19 to 23. Triangle test (Jellinek, 1964) was employed to select the panel members. In the triangle test three sets of sugar solutions of different concentrations were used, of the three sets, two solutions were of identical concentrations and the women were asked to identify the third sample which is of different concentration. The evaluation card used for the triangle test is presented in Appendix IV. Small highly sensitive panels would usually give more reliable results than large less sensitive groups. Thus from the thirty women who participated in the triangle test, ten women were selected as judges for the present acceptability trial. The triangle test was not applied among children or mothers, eventhough they were treated as panel members at the field level.

The acceptability trials on panel members were done using the scoring method. A score card developed for the study is presented in Appendix III. The major quality attributes included in the score card were appearence, flavour, texture, taste and overall acceptability on a five point hedonic scale. Each of the above mentioned quality is assessed by a five point rating scale.

The judges were requested to taste one sample and score it. They were requested to taste the second sample after washing their mouths. Each quality was assessed by the panel members after tasting the same sample several times if needed. The panel members were permitted to take their own time and to judge the samples leisurely. The testing was conducted in the afternoons between 3 pm and 4 pm, since this time is considered as the ideal time for conducting the acceptability studies (Swaminathan, 1974). The panel members were requested to give scoring based on two sets of responses; the first giving preference rank and the second an assessment of sensory qualities.

For the conduct of the acceptability trial among children, a nursery school adjacent to the University campus was selected. There were 25 pre-school children attending the nursery regularly. The children were in the age group of 3 - 5 years. Responses of the young children could not be accurately recorded using a score card and hence it was left to the discretion of the investigator to decide if a child "liked" or "disliked". For this each child was brought near the table where the food was kept. He was fed a teasponnful first and his reaction to the food was observed and recorded as pleasant or an unpleasant expression. The pleasant expression may denote acceptance while the unpleasant expression a refusal. His acceptance was further checked by noting whether be voluntarily opened his mouth for a second mouthful of the food. This was also recorded.

Acceptability trial at the field level were conducted among ten women who were the mothers of pre school children attending the nursery. Mothers were not selected by triangle test or any other test but they were selected for the test being mothers. Mothers generally tended to attribute their preference to their children and preferences and convictions of mothers largely determine what the child would receive and what the child would be taught to like. As mothers, they were responsible for preparing foods for their children and hence they were the better judges for deciding the acceptability of the weaning formulae evolved. The score card devised for the laboratory trials were used for the field trial among the mothers.

The weaning formulae was prepared as porridge and offered in four different forms, as (i) bland (no addition of flavour and sugar) (ii) sweetened but no flavour, (iii) bland with flavour but no sugar, (iv) sweetened and flavoured. For the acceptability trial, one part of the weaning formulae was mixed with three parts of hot water to make a bland porridge. These four combinations were used for the trials at the laboratory and at the field levels. At the field level independent acceptability tests were conducted among the children as well as their mothers.

The bland porridge was sweetened at two levels by adding.

(i) 14 per cent sugar
(ii) 28 per cent sugar.

In order to determine the taste preference, porridge prepared with the weaning formulae was mixed with the above two levels of sugar and tested. Through the acceptability trials, the acceptable concentration was identified. These trials were conducted with the panel members at the laboratory level.

The bland porridge was flavoured with different flavours in different concentrations as indicated below:

a) Vanilla	(i)	.025 per cent
	(ii)	.05 per cant
b) Rose	(i)	.025 per cent
	(ii)	.05 per cent
c) Pineapple	(i)	.025 per cent
	(ii)	.05 per cent

To determine the flavour preference three most popular flavours viz., vanilla, rose and pineapple were added to the porridge prepared with the weaning formulae developed. To find out the best concentration of these flavours, the flavours were added at two concentrations (0.025 per cent and .05 per cent). The bland porridge with different flavours were tested to select the most accepted flavour by the panel members at the laboratory level. After identifying the most acceptable concentrations of flavour and sugar among panel members, these two qualities namely sweetness and flavour were combined and were tested. With the variations in sweetness and flavour acceptable to the panel members, combinations of the porridge were worked out as detailed below:

(i) bland porridge

(ii) .05 per cent pineapple with out sugar

(iii) 28 per cent sugar with out flavour

(iv) 28 per cent sugar and .05 per cent pineapple.

These tests were conducted among panel members at the laboratory level and among mothers and children at the field level. Acceptability of these weaning formulae was based on preference ranking on the points scored by each panel member, mothers and children on like/dislike rating scale. Regarding children, besides preference ranking quantity of plate waste was also a criterion.

The acceptability tests among panel members, mothers and children were conducted on different days.

Statistical Analysis.

Statistical significance of all the experiments were calculated using students t - test (Bennet and Franklin, 1967).

RESULTS AND DISCUSSION

RESULT AND DISCUSSION

A study was conducted to develop a weaning food based on ragi. The results of the study are presented and discussed under the following heads.

1. Formulation of different combinations of nutritious, low cost and acceptable weaning food using ragi flour as a base.

2. Assessing the nutritional quality of the formulae developed.

3. Assessing the nutritional quality of the weaning formulae developed through animal experiments.

4. Standardising recipes in the laboratory using weaning formulae developed.

5. Assessing the acceptability of the recipes.

1. FORMULATION OF DIFFERENT COMBINATIONS OF NUTRITIOUS, LOW COST AND ACCEPTABLE WEANING FOOD USING RAGI FLOUR AS A BASE.

Composition of the six combinations of the weaning formulae selected are presented in Table 9.

Table 9. Percentage composition of the food ingredients in the weaning formulae.

	1	2	3	4	5	6
Ragi	40	35	40	30	45	35
Green gram	20	20	20	20	20	25
Sesame	10	15	15	15	10	20
Tapioca	10	15	15	20	10	10
Skim milk	20	15	10	15	15	10
Chemical score	76.3	77.4	77.4	75.27	77.4	76.3

Major criteria for selecting few combinations from the formulae were the chemical score of these mixture. As indicated in Table 9 the selected food components in the weaning formulae in the order of their priority were ragi, green gram, sesame, tapioca and skim milk powder. Ragi was added in the proportion of 30 to 45 per cent in the different combinations of weaning formulae while green gram was added in the proportion of 20 to 25 per cent. Sesame, tapioca and skim milk powder were added in the proportion of

10 to 20 per cent. Weaning formula group 1 was a mixture of ragi, green gram, sesame, tapioca and skim milk powder in the proportion of 4:2:1:1:2. In weaning formula (group 2), compared to group 1, 5 part each of ragi and skim milk powder were substituted with equal quantity of sesame and tapioca. In the weaning formulae group 3, there was slight change in the proportion of one or two ingredients. In this case ragi and green gram were in the same proportion as for the group 1 and tapioca and sesame were same as that of group 2. There was 10 per cent decrease in the quantity of skim milk powder when compared to group 1. The weaning formula (Group 4) was composed of a food mixture with entirely different proportion (3:2:1.5:2:1.5) when compared to the group 1. The amount of ragi and skim milk powder was decreased and sesame and tapioca were increased. The quantity of green gram was same as that of other groups. When compared with other groups the quantity ragi was highest for weaning formula (group 5). The amount of green gram, sesame and tapioca were same as that of group 1 while the quantity of skim milk powder was decreased by 5 per cent. The weaning formula (group 6) has the highest quantity of green gram and sesame. When compared to group 1 the quantity of ragi and skim milk powder were decreased by 5 and 10 per cent respectively the amount of tapioca was the same.

2. ASSESSING THE NUTRITIONAL QUALITY OF THE WEANING FORMULAE DEVELOPED.

The nutritional quality of the weaning formulae developed were assessed using food composition tables of ICMR (1982) and through suitable laboratory estimations.

2.1. Assessing the nutritional quality of the weaning formulae developed using food composition tables.

The protein, mineral and vitamin content of the six combinations as worked out from the food composition tables are given in Table 10.

Table 10. Nutrient composition of weaning formulae developed, using food composition tables. weaning formulae(100 g).

Nutrients	1	2	3	4	5	6
Protein (g)	17.22	14.99	14.37	15.57	15.68	16.08
Fat (g)	5.15	5.09	7.31	7.2	5.21	9.47
Calorie (Kcal)	341.4	315	341.7	334.6	339.95	362.3
Niacin (mg)	1.53	1.66	1.66	1.62	1.53	1.92
Riboflavin (mg)	0.502	.4325	.33	.428	.429	.376
Thiamine (mg)	0.458	.4675	.466	.449	.4565	.5165
Vitamin A (µg)	41.6	42.5	44.6	40.4	43.7	50.2
Vitamin C (mg)	3.5	4.5	4.25	5.75	3.25	3
Calcium (g)	.586	.575	.536	.561	.524	.579
Iron (mg)	5.43	5.62	5.69	5.33	5.88	6.39

As revealed in Table 10 the protein content of the six combinations of weaning formulae were found to have 14.37 g to 17.22 g per cent and the calorific value of the weaning formulae was in the range of 315 to 362Kcals. per 100 g of the sample. All the weaning formulae were found to contain adequate amounts of protein, calorie, fat, calcium and thiamine so as to meet the requirements for cereal based complementary infant foods.

2.2. Assessing the nutritional quality of the weaning formulae developed using laboratory estimation.

The protein and mineral quality of the six combinations were determined through suitable laboratory techniques and the results are presented in Table 11.

Table 11. Nutrient composition of weaning formulae developed.

Nutrients (g per cent)	1	2	3	4	5	6
Protein	16.69	14.84	20.41	20.41	16.69	18.55
Calcium	1.028	.975	.945	1.155	.975	1.87
Magnesium	1.395	1.125	1.595	1.245	1.295	1.27
Manganese	.00197	.0017	.00212	.00148	.00193	.00188
Copper	.00061	.00053	.00058	.00053	.00057	.00068
Zinc	.00126	.00118	.00125	.00122	.00115	.00135
Iron	.00641	.00533	.00518	.00518	.00617	.00584

As revealed in Table 11 protein content of the six combinations were in the range of 14.84 g to 20.41 g and the protein content of weaning formulae group 3 and group 4 were the highest. Minerals like calcium, iron, magnesium, manganese, zinc and copper were essential for the normal upkeep and maintenance of the body. The weaning formulae were found to contain adequate amounts of calcium, magnesium, iron and zinc

3. ASSESSING THE NUTRITIONAL QUALITY OF THE WEANING FORMULAE DEVELOPED THROUGH ANIMAL EXPERIMENTS.

3.1. Gain in body weight.

Effect of selected six combinations of the weaning formulae with the various ingredients like ragi, green gram, sesame, tapioca and skim milk powder in different propertions were assessed through animal experiments of 28 days duration. Gain in weight of the experimental animals in this experiment is presented in Table 12.

Table 12. Effect of selected six combinations of the weaning formulae and standard diet on the growth of experimental animals.

Diets	I	II	III	IV	V	VI	VII
Mean initial body weight (g)	35 ±.875	36.40 ±.873	41.80 ±1.25	34.97 ±.944	40.03 ±1.12	39.40 ±1.02	36.90 ±1.03
Mean final body weight (g)	92 ±2.48	92.70 ±2.59	83.60 ±2.09	92.23 ±2.77	88.80 ±2.57	97.37 ±2.63	90 ±2.25
Mean gain in weight (g)	57	56.30	42.80	57.26	48.77	57.97	53.10
Mean gain in weight (%)	162.86 ±4.23	154.67 ±3.71	100 ±2.8	163.74 ±4.75	122 ±2.93	147.13 ±3.68	149.9 ±3.16

As revealed in Table 12, animals fed in group IV gave the highest gain in weight followed by the animals included in group I. Group II was ranked as third in the order. The results of the statistical analysis are given in Table 13.

Table 13. Statistical analysis of Table 12.

Groups	I vs VII	II vs VII	III vs VII	IV vs VII	V vs VII
% weight t value	3.59*	2.2	10.39**	3.48*	5.08**

Groups	VI vs VII	IV vs I	IV vs II	IV vs VI	IV vs V	IV vs III
% weight t value	0.666	0.138	1.50	2.76*	7.48**	11.56**

Groups	I vs II	I vs VI	1 vs V	1 vs III	II vs VI	II vs V
t value	1.45	2.81*	7.94**	12.39**	1.44	6.91**

Groups	II vs III	VI vs V	VI vs V	VI vs III	V vs III
t value	11.69**	5.34**	5.34**	10.19**	5.43**

* significant at 5 per cent level
** significant at 1 per cent level

Statistical analysis showed that the growth gained by the animals in Group IV and I were significantly higher when compared to the animals who were fed skim milk diet (Group VII). Where as group II and VI were equally efficient in promoting growth when compared with Group VII. Group V and III were least effective in promoting growth where the difference was significantly low. When the different ragi based diets were compared among themselves, the growth promoting value of

Group I and II were comparable with that of Group IV where the differences were not significant. While the values were significantly lower in Group III, V and VI. When compared with Group I the difference was not significant in the case of Group II where as it was significantly lower for Group III, V and VI. The growth promoting value of Group VI was comparable to Group II where as the difference was significantly lower in the case of group III and V. When compared with Group VI the difference was significantly lower for Group V and III. The value was significantly lower for Group III when compared to Group V.

3.2. Protein Efficiency Ratio.

Weight gain and protein intake of rats fed on different diets along with the PER of the diets are given in Table 14.

Table 14. Protein Efficiency Ratio (PER) of different experimental diets.

Diets	I	II	III	IV	V	VI	VII
Weight gain (g)	57	56.3	42.8	57.26	48.77	57.97	53.1
Protein intake(g)	17.06	18.64	15.59	15.86	16.93	19.72	17.18
PER	3.34± .093	3.02± .072	2.68± .077	3.61± .108	2.88 ±.089	2.94 ±.076	3.09 ±.083

The rats in Group IV showed the highest PER (3.61) followed by Group I (3.34) Group VII (3.09), Group II (3.02), Group VI (2.94), Group V (2.88) and Group III (2.68). The PER values of the experimental groups were compared with the control group (Group VII). The experimental groups were also compared among themselves. The results of the statistical analysis are given in Table 15.

Table 15. Statistical analysis of Table 14.

Groups	I vs VII	II vs VII	III vs VII	IV vs VII	V vs VII	
t value	2.01	.637	3.62*	3.82*	1.73	
Groups	VI vs VII	IV vs I	IV vs II	IV vs VI	IV vs V	IV vs III
t value	1.33	1.89	4.54**	5.07**	5.22**	7.01**
Groups	I vs II	I vs VI	I vs V	I vs III	II vs VI	II vs V
t value	2.72*	3.33*	3.57*	5.47**	.76	1.22
Groups	II vs III	VI vs V	VI vs III	V vs III		
t value	3.22*	.51	2.4	1.69		

* Significant at 5 per cent level

** Significant at 1 per cent level

Statistical analysis showed that the PER value obtained for Group IV (3.61) was significantly higher when compared to that of Group VII (3.09) in which skim milk was the major component. The PER value obtained for Group III was 2.68 and it was significantly lower than Group VII. There was significant difference in PER values of Group I, II, VI and V when compared with Group VII. The PER values of the different groups were compared among themselves and statistical analysis showed that when compared with Group IV, which was the highest PER value, PER values of all the other diets were significantly lower, except that of Group I (3.34). The PER value obtained for Group I was comparable with Group IV where the difference was not statistically significant. When the PER values of the different groups were compared with Group I the values obtained for Group II, III, V and VI were significantly lower. The PER value obtained for Group II was 3.02 and it was comparable to the PER values of Group V and VI where as the difference was significantly low in the case of Group III. The PER value of Group V was 2.88 and was comparable to that of Group VI (2.94) and Group III (2.68), in this context the differences were insignificant. The PER value obtained for Group VI was 2.94 and it was comparable to Group III, the PER value of which was 2.68.

3.3. Hepatic weight and hepatic nitrogen of rats fed on different diets.

Hepatic weight and hepatic nitrogen of rats fed on different combinations of weaning formulae were evaluated. The mean hepatic weight and total hepatic nitrogen of rats fed on different diets are given in Table 16.

Table 16. Hepatic weight and hepatic nitrogen of rats fed on different diets.

	I	II	III	IV	V	VI	VII
Hepatic weight(g)	3.2± .67	3.04± .73	2.48± .074	3.32± .083	2.506± .067	2.98± .074	2.59± .067
Hepatic nitrogen (mg)	132.9± 3.19	112.3± 2.92	100.9± 2.42	154.3± 4.47	102.8± 2.36	109.6± 3.07	107.6± 3.01

Maximum liver weight and the highest hepatic nitrogen were recorded by rats fed on Group IV (3.32, 154.3), next ranked Group I (3.2 and 132.9) followed by Group II (3.04 and 112.3), VI (2.98 and 109.6), VII (2.59 and 107.6), V (2.506 and 102.8) and III (2.48 and 100.9).

The results of the data were statistically analysed and the values are given in Table 17.

Table 17. Statistical analysis of Table 16.

Groups	I vs VII	II vs VII	III vs VII	IV vs VII	V vs VII
Liver weight (t value)	6.44**	4.54*	.86	6.84**	.886
Liver Nitrogen (t value)	5.77**	1.12	1.10	8.66**	1.25

Groups	VI vs VII	IV vs I	IV vs II	IV vs VI	IV vs V	IV vs III
Liver weight (t value)	3.91*	1.12	2.53	3.06*	7.63**	3.06*
Liver Nitrogen (t value)	.465	3.89*	7.87**	8.24**	10.19**	8.24**

Groups	I vs II	I vs VI	I vs V	I vs III	II vs VI	II vs V
Liver weight (t value)	1.61	2.2	7.32**	7.21**	.577	5.38**
Liver Nitrogen (t value)	4.76**	5.26**	7.59**	7.99**	.637	2.53*

Groups	II vs III	VI vs V	VI vs III	V vs III
Liver weight (t value)	5.38**	4.75**	4.78**	.26
Liver Nitrogen (t value)	3.01*	1.76	2.63*	.56

* Significant at 5 per cent level

** Significant at 1 per cent level

Statistical analysis showed that when compared to control diet (Group VII) the difference in hepatic weight was significantly higher for Groups IV (3.32), I (3.2), II (3.04) and VI (2.98) and for the remaining groups when compared to skim milk diet, the differences were not significant. The different combinations of weaning formulae were compared among themselves and when the values were compared with Group IV, Groups I and II were comparable and there was significant difference when compared with Group V(2.506), VI (2.98) and III (2.48). Hepatic weight of rats in Group II (3.04) and VI (2.98) were comparable with Group I (3.2) and in this context the difference was insignificant. The values obtained for Group V and III were significantly low. The hepatic weight of Group II was statistically compared with Group III and V the difference was significantly low, while it was comparable with Group VI. Hepatic weight of Group V and III were significantly lower when compared with Group VI. The values between Group V and III were comparable.

Statistical analysis for differences in total hepatic nitrogen of Group IV and I were significantly high when compared with skim milk diet (Group VII), while the values were insignificant for the rest of the groups. The difference in hepatic nitrogen of all the groups were significantly lower when compared with Group IV. Group I was significantly high in hepatic nitrogen when compared with other experimental Groups. Group II was comparable to Group VI in its hepatic nitrogen content, while it was significantly high when compared with Group III and V. Group VII was comparable to Group V and the difference was significant with Group III. Difference between Group V and III was insignificant.

3.4. Serum protein content.

Serum protein content of rats fed on different diets are given in Table 18.

Table 18. Mean serum protein of the rats fed on different diet.

Groups	I	II	III	IV	V	VI	VII
Serum protein g %	12.41 ±.359	11.79 ±.354	8.05 ±.209	12.87 ±.309	11.51 ±.265	11.59 ±.313	9.73 ±.272

As indicated in the Table 18 the highest serum protein content (12.87) was recorded in Group IV. All the combinations of weaning formulae except Group III showed higher protein content when compared with control diet. The different groups were compared statistically and the results are given in Table 19.

Table 19. Statistical analysis of Table 18.

Groups	I vs VII	II vs VII	III vs VII	IV vs VII	V vs VII
t value	5.95**	4.61**	4.89**	7.62**	4.69**

Groups	VI vs VII	IV vs I	IV vs II	IV vs VI	IV vs V	IV vs III
t value	4.48**	0.97	2.29	2.91	3.36*	12.97**

Groups	I vs II	I vs VI	I vs V	I vs III	II vs VI	II vs V
t value	1.23	1.72	2.02	10.49**	.42	0.63

Groups	II vs III	VI vs V	VI vs III	V vs III
t value	9.09**	0.195	9.4**	10.25**

* Significant at 5 per cent level
** Significant at 1 per cent level

Statistical analysis showed that the difference in serum protein content were significantly higher for all groups except Group III compared with control diet Group VII.

When Group IV was compared statistically with other Groups, Groups I, II and VI were comparable, and the differences were significant with Group V and III. Serum protein content of rats in group I was comparable to other groups except Group III where the difference was significantly low. The difference in serum protein content of Group II was not signifioant when compared with Group V and VI and it was significantly low when compared with Group III. Group VI and V were comparable while Group III was significantly low. The lowest serum protein value was shown by Group III, which was significantly low when compared with all other groups.

3.5. Digestability coefficient.

Digestability coefficient was determined by nitrogen balance study and the results are presented in Table 20.

Table 20. Digestability coefficient of the rats fed on different diets.

Groups	I	II	III	IV	V	VI	VII
Digestability Coefficient	93.49 ±2.15	90.89 ±2.36	84.20 ±1.77	95.02 ±2.95	85.19 ±1.87	92.51 ±2.22	93.53 ±3.27

As indicated in the Table 20 rats in Group IV showed the highest digestability followed by Group I and VII. The least value for digestability coefficient was found in Group III.

Table 21. Statistical analysis of Table 20.

Groups	I vs VII	II vs VII	III vs VII	IV vs VII	V vs VII
t value	0.02	0.65	2.51	0.34	2.21

Groups	VI vs VII	IV vs I	IV vs II	IV vs VI	IV vs V	IV vs III
t value	0.26	0.42	1.09	2.81*	2.81*	3.15*

Groups	I vs II	I vs VI	I vs V	I vs III	II vs VI
t value	0.81	0.32	2.02	3.34*	0.49

Groups	II vs V	II vs III	VI vs V	VI vs III	V vs III
t value	1.89	2.27	2.52	3.73*	0.38

* Significant at 5 per cent level
** Significant at 1 per cent level

The results of the statistical analysis given in Table 21 revealed that even though group IV and I registered high values, the difference was not significant and all the experimental diets were comparable to the control diet in their digestability coefficient. Among the experimental diets, when compared to Group IV, Groups III, V and VI showed significant differences. All Groups were comparable to Group I except Group III where the difference was significant. Group VI was comparable to group V and the difference was significant for Group III. Groups V, II and III were comparable to each other where the differences were not significant.

3.6. Biological value.

Biological value (BV) of the different weaning formulae was determined by nitrogen balance study and the results are presented in Table 22.

Table 22. Biological value of the different experimental diets.

Groups	I	II	III	IV	V	VI	VII
BV	84.66	79.32	71.67	87.22	72.71	79.85	82.22
	±2.03	±2.3	±1.51	±2.35	±1.82	±2.06	±2.96

As indicated in the Table 22, all the experimental diets were comparable with control diet in their biological value except group III and V. The results of the statistical analysis of the above data is given in Table 23.

Table 23. Statistical analysis of Table 22.

Groups	I Vs VII	II vs VII	III vs VII	IV vs VII	V vs VII
t value	0.68	0.77	3.17*	1.32	2.74*

Groups	VI vs VII	IV vs I	IV vs VI	IV vs II	IV vs V
t value	0.66	0.82	2.35	2.4	4.88**

Groups	IV vs III	I Vs VI	I Vs II	I vs V	I vs III	VI vs II
t value	5.37**	1.65	1.74	4.38**	5.13**	0.17

Groups	VI vs V	VI vs III	II vs V	II vs III	V vs III
t value	2.58*	3.18*	2.25	2.78*	0.44

* Significant at 5 per cent level
** Significant at 1 per cent level

As revealed in Table 23 the difference was not significant when group IV was compared with other groups, the difference was significant only for Groups V and III. Group I was comparable to Groups VI and II and the difference was significant for Groups V and III. Statistical difference was significant in the case of Group III when compared with Group II. There was significant difference with Group III and V when compared to Group VI

3.7. Net protein utilization.

Net protein utilizations (NPU) of different groups were determined from biological value and digestability coefficient and the results are presented in Table 24.

Table 24. Net Protein Utilization of rats fed on different diets.

Groups	I	II	III	IV	V	VI	VII
NPU	79.15	72.09	60.35	82.88	61.94	73.87	76.90
	±2.45	±2.09	±1.81	±2.57	±1.49	±1.92	±1.61

As indicated in Table 24, Group IV showed the highest NPU (82.88) followed by Groups I, VII, VI, II, V and III.

The results of the statistical analysis of the above ddata are presented in Table 25.

Table 25. Statistical analysis of Table 24.

Groups	I vs VII	II vs VII	III vs VII	IV vs VII	V vs VII
t value	0.77	1.82	6.83**	0.88	6.82**

Groups	VI vs VII	IV vs I	IV vs VI	IV vs II	IV vs V	IV vs III
t value	0.75	1.05	2.81*	3.26*	7.05**	7.17**

Groups	I vs VI	I vs II	I vs V	I vs III	VI vs II	VI vs V
t value	1.69	2.19	6.00**	6.17**	0.63	4.91**

Groups	VI vs III	II vs V	II vs III	V vs III
t value	5.12**	3.95*	4.25**	0.68

* Significant at 5 per cent level
** Significant at 1 per cent level

Statistical analysis of the data given in the table 25 revealed that the difference in NPU values were significantly higher in Group IV and significantly low in Group III when compared with control Group. All the other groups were comparable to control group in their NPU values. When the NPU values of the experimental groups were statistically analysed, the value was significantly high for Group IV when compared with other groups except Group I. When compared with Group I the difference was significant for Groups III and V. Group VI was comparable to Group II and the difference was significant in the case of Group V and III. The difference in NPU value was significant in Group V and III when compared to Group II.

4. STANDARDISING RECIPES IN THE LABORATORY USING WEANING FORMULAE DEVELOPED.

Weaning formulae was standardised at the laboratory through the following experiments.

4.1. Percentage preparation loss.

Percentage preparation loss assessed for the six combinations of weaning formulae are given in Table 26.

Table 26. Percentage preparation loss for different combination of weaning formulae.

Combination of weaning formulae	AP weight (g)	EP weight (g)	% preparation loss
1	51.14	35	.32
2	64.37	40	.38
3	57.54	39	.32
4	68.04	39	.42
5	68.19	42	.38
6	56.12	38	.32

As indicated in the table the percentage preparation loss was highest for the weaning formulae (Group 4) which gives highest value for protein efficiency ratio, net protein utilization, hepatic weight and hepatic nitrogen and serum protein content for animal experiments. The percentage preparation loss was highest because tapioca was an important ingredient in this weaning formula. The least percentage preparation loss was for weaning formulae (Group 1) which was ranked as two in animal experiments.

4.2. Cost per serving.

Cost per serving of the different combinations were worked out and the details are given in Table 27.

Table 27. Cost per serving for different combinations of weaning formulae.

Combination of weaning formulae	Cost per serving (Ps)
1	45
2	48
3	43
4	47
5	43
6	43

As revealed in the Table 27 the cost per serving was lowest for weaning formulae (Group 3, 5 and 6). The highest cost per serving was for weaning formula (Group 2) followed by Group 4.

4.3. Percentage yield.

The percentage yield were worked out for different weaning formulae and the results are given in Table 28.

Table 28. Percentage yield for different combinations of weaning formulae.

Combinations	Weight before cooking (g)	Cooked weight (g)	Percentage yield
1	35	119	3.4
2	40	132	3.3
3	39	133	3.4
4	39	133	3.4
5	42	139	3.3
6	38	126	3.3

As indicated in the table there was no significant variation in the percentage yield of various weaning formulae tried. Since there was no significant variation among the various weaning formulae tried, the weaning formula which gave the highest values for protein efficiency ratio, hepatic weight nitrogen, hepatic nitrogen, serum protein and net protein utilization was selected for further trials on standardisation.

4.4. The nutritional quality.

The nutritional quality was calculated on the basis of the fact that the supplementary foods included in the diet of pre-school children should meet 1/3rd of his nutritional requirement. In this case the quantity of weaning formulae to be taken for standardisation of recipe selection is on the basis of 1/3rd protein requirement of the pre-school children. 39 g of weaning formula was required to supply 6 g of protein which is the 1/3rd protein requirement and the details of other nutrients supplied by 39 g of the weaning formula was worked out and the details are given in Table 29.

Table 29. Nutrient composition of receipe (a) bland porridge.

Nutrients	Nutrient content	1/3rd RDA
Calorie(k cal)	130	400
Protein(g)	6	6
Vitamin A(µg)	16	333
Vitamin B_1 (mg)	.18	.2
Vitamin C (mg)	2.25	13
Calcium(g)	.219	1.15
Iron(mg)	2.08	6

As revealed in Table 29 the weaning formula was found to be deficient in calorie and nutrients such as vitamin A, Vitamin C and Iron.

The cost of 39 gms of weaning formula was worked out by estimating the cost of food ingredients and cost of fuel needed for preparing the formula. The cost per serving of the formula is given in Table 30.

Table 30. Cost per serving of bland porridge.

	Cost (Ps)
Cost of various food ingredients	47
Cost of fuel needed	4
Total	51

As revealed in Table 30 the cost of the formulae comes around Ps 51.

Three recipes were standardised with weaning formula as the base material. Porridge was one of the recipes developed while standardising the other two recipes, care was taken to make up the nutritional deficiencies in the bland porridge. The nutrient composition of the two recipes were calculated and compared with 1/3rd requirement of preschool children. The weight of various ingredients used in the recipe (b) Porridge with chekkurmanis its nutritive value and cost are given in Table 31.

Table 31. Nutrient composition and cost of recipe (b) Porridge with chekkurmanis.

	Weight (g)	Cost (Ps)	Calorie (kcal)	Protein (g)	Vitamin A (µg)	Vitamin B1 (mg)	Vitamin C (mg)	Calcium (g)	Iron (mg)
Bland Porridge	39	47	133	6	17	.18	1.27	.209	2.22
Chekkurmanis	14	--	14.42	.952	798.84	.0672	34.58	.0798	3.92
Cooking oil	15	39	135	--	--	--	--	--	--
Ground nut	20	20	155	6.93	10.14	.246	--	.0246	.767
Fuel	--	12	--	--	--	--	--	--	--
Total	--	118	434.42	13.88	824.98	.493	36.83	.3234	6.767
1/3rd RDA	--	--	400	6	333	.2	13	.15	6

Cost per serving 118 ps.

As revealed in Table 31, the bland porridge was deficient in calorie and nutrients such as vitamin A, vitamin C and iron. To make up the calorie deficiency, vegetable oil and ground nut were added. Similarly deficiency of vitamin, A, vitamin C and iron were made up by adding chekkurmanis. The cost per serving of the recipe is worked by estimating the cost of food ingredients and the cost of fuel needed for preparing the recipe. As revealed in Table 31 the cost of the recipe comes around 118 ps.

The nutritive value and cost of recipe b is given in Table 32.

As revealed in Table 32 the bland porridge was deficient in calorie, vitamin A, vitamin C and iron. To make up the calorie deficiency Ghee and Jaggery were added. The deficiency of vitamin A and vitamin C were made up by adding mango and iron deficiency was made up by adding jaggery and mango. As revealed in Table 32, the cost of the recipe comes around 156 ps.

Table 32. Nutrient composition and cost of recipe (c) Porridge with Mango.

	Weight (g)	Cost (ps)	Calorie (Kcal)	Protein (g)	Vitamin A (μg)	Vitamin B1 (mg)	Vitamin C (mg)	Calcium (g)	Iron (mg)
Weaning food	39	47	133	6	17	.18	1.27	.209	2.22
Mango	30	9	30	.24	1112	.032	6.49	.0057	.53
Ghee	15	75	135	-	300	-	-	-	-
Jaggery	30	13	114.9	.12	-	.006	-	.024	3.42
Fuel	-	12	-	-	-	-	-	-	-
Total	-	156	412.9	6.36	1429	.218	7.76	.2387	6.17
1/3rd RDA	-	-	400	6	333	.2	13	.15	6

5. ASSESSING THE ACCEPTABILITY OF THE RECIPES.

Among the various recipes standardised porridge was selected for the conduct of the acceptability because this recipe, was very easy to prepare without addition of any other food material which may influence the acceptability of a recipe. The porridge was prepared with the combination of weaning formula which gave the highest value for protein efficiency ratio, hepatic nitrogen, serum protein and net protein utilization and for the tests conducted while standardising recipes. Acceptability of the porridge was conducted in the laboratory with the help of ten panel members and at the field among ten mothers and children.

5.1. Preference for the porridge at different sugar concentration.

Preference of the panel members for the porridge at different sugar concentration was tested and the results are given in Table 33.

Table 33. Preference of panel members for porridge at two levels of sugar.

N*=10

	Highly acceptable	acceptable	Slightly acceptable	Neither acceptable nor unacceptable	slightly unacceptable	Unacceptable	Highly acceptable
Bland	-	-	50	40	10	-	-
14 per cent sugar	-	40	50	10	-	-	-
28 per cent sugar	-	40	60	-	-	-	-

* Number of panel members.

As revealed in Table 33 all the panel members like the porridge when the sugar concentration was 28 per cent, while 10 per cent of the panel members had graded 14 per cent sugar concentration as neither acceptable nor unacceptable. Thus the porridge with 28 per cent sugar concentration was taken as the best level of sweetness for the porridge developed. This concentration was used for further testing of sweetned porridge with flavour.

Test was conducted to assess the relative importance of added sugar at two different concentrations on the quality attributes such as over all acceptability, appearance, flavour, taste and texture. The mean scores on a 5 point hedonic scale obtained for bland and sweetened porridge are given in Table 34.

Table 34. Acceptability profile for different levels of sugar.

	Over all acceptability	Appearance	Flavour	Texture	Taste
Bland	4.4	3	3.2	3.7	2.5
14 per cent sugar	5.3	3	3.5	3.7	3.5
28 per cent sugar	5.4	3	3.3	3.7	3.9

As indicated in Table 34 the sweetened porridge was more acceptable when compared with the bland, in qualities such as over all acceptability, flavour and taste. Among the sweetened porridge doubling the concentration of sugar considerably improved the rank and score. As revealed in the table the scores obtained for appearance and texture were same for all the three samples. The over all acceptability and taste were highest for the porridge which contained 28 per cent sugar concentration.

5.2. Preference for the porridge with different flavours.

The preference ranking given for different flavours at two different concentrations are given in Table 35.

Table 35. Preference ranking for different flavours by panel members.

N* = 10

	Highly acceptable	acceptable	Slightly acceptable	Neither acceptable nor unacceptable	Slightly unacceptable	Unacceptable	Highly unacceptable
Bland	-	-	50	40	10	-	-
.025 per cent vanilla	-	-	40	50	10	-	-
.05 per cent vanilla	-	-	40	60	-	-	-
.025 per cent rose	-	-	30	60	10	-	-
.05 per cent rose	-	-	30	70	-	-	-
.025 per cent pineapple	-	-	30	70	-	-	-
.05 per cent pineapple	-	-	40	60	-	-	-

* Number of panel members.

As revealed in Table 35, the porridge prepared with different flavour were neither highly acceptable noracceptable. However 10 per cent of the panel members had graded vanilla and rose as slightly unacceptable at .025 per cent level. But pineapple flavour was not treated as 'unacceptable' at any level. Hence pineapple flavour was selected.

The acceptability profile of the flavours among the panel members were calculated by summing up the scores given for individual quality attributes such as over all acceptability, appearance, flavour, texture and taste. The percentage was worked out from the total scores and the details are given in Table 36.

Table 36. Acceptability profile of the flavours by the panel members.

*N = 10

	Mean scores on 5 point hedonic scale				
	Over all acceptability	Appearance	Flavour	Texture	Taste
.025 per cent vanilla	4.5	3	3.2	3.7	2.3
.05 per cent vanilla	4.6	3	3.8	3.7	2.4
.025 per cent rose	4.2	3	3.1	3.7	2.3
.05 per cent rose	4.3	3	3.4	3.7	2.7
.025 per cent pineapple	4.3	3	3.8	3.7	2.7
.05 per cent pineapple	4.4	3	3.9	3.7	2.7

* Number of panel members.

On the basis of the mean scores obtained, pineapple was considered as the most acceptable flavour. Among various qualities tested there was no variation for scores obtained for qualities such as appearance and texture while variations among different levels of flavours are found in the quality attribute namely "flavour". As revealed from the table .05 per cent pineapple was the most acceptable flavour.

5.3. Acceptability of the porridge.

Acceptability test of the porridge was conducted at the laboratory level with the help of ten panel members and at the field level among ten mothers and children. The sugar concentration for the porridge tested at the field level was 28 per cent and pineapple flavour (.05 per cent) being the most acceptable one, was also used for field trials. The results are presented in Table 37.

Table 37. Acceptability trial of porridge at the field/ laboratory level.

Different forms of porridge	Laboratory level				Field level		
	Panel members N=10		Mothers N=10		Children		
	Liked %	Dis-liked%	Liked %	Dis-liked%	Liked %	Dis-liked%	Number of children *
1. Bland	50	50	80	20	91	9	23
2. Flavoured	40	60	60	40	90	10	20
3. Swee-tened	100	-	100	-	92	8	25
4. Sweetened and fla-voured	100	-	100	-	91	9	23

* Among children each acceptability tests/was conducted independently. Hence there is variation in the number of children.

From the Table 37 it was revealed that among the four forms of the porridge tested, samples which were sweetened with flavour and without flavour were found to be acceptable for all the panel members and mothers. In the case of samples to which flavour alone was added acceptability was not uniform among different panel members. Preference for this recipe was higher among mothers and children compared to panel members who participated in the laboratory trials.

But when sugar was added to the flavoured porridge the acceptability become 100 per cent. The table also indicate that the responses of the members at the field as well as laboratory level are strongly based in favour sweetened samples with sweetened and flavoured ranking the highest. However in the case of children they seem to be not influenced either by sweetness or by flavour since all the four forms including the bland was well acceptable to 90 - 92 per cent of the children. The responses and reactions of the children indicated that they accepted all samples equally well without discrimination among sweetened, flavoured and bland samples.

5.4. Quality responsible for the acceptability of the porridge.

The general acceptability of the product was calculated by summing up the scores given for individual quality attributes such as over all acceptability, appearence, flavour, texture and taste by the panel member at the laboratory as well as at the field level. The percentage was worked out from the total scores. The data obtained for each of the weaning formulae is given in the Table 38.

Table 38. General acceptability of the porridge among panel members and mothers.

Different forms of porridge	Panel members		Mothers	
	Mean score	Percentage	Mean score	Percentage
1.Bland	16.8 ± .42	62.2 ± 1.6	18.3 ± .46	66.8 ± 1.67
2.Flavoured	17.7 ± .55	65.55 ± 2	18.8 ± .56	69.6 ± 2.1
3.Sweetened	19.4 ± .56	71.85 ± 2.1	20.8 ± .58	77 ± 2.2
4.Sweetened and flavoured	21.9 ± .61	81.11 ± 2.3	22.6 ± .66	83.7 ± 2.4

As revealed from Table 38 the sweetened as well as flavoured porridge obtained the highest score followed by the sweetened porridge without addition of flavour. Results of the statistical analysis of the data are presented in Table 39.

Table 39. Statistical analysis of Table 38.

	1 vs 2	1 vs 3	1 vs 4	4 vs 2	4 vs 3	2 vs 3
Panel members	3.7*	1.3	6.88*	3.01*	5.1*	2.16
Mothers	3.37*	.69	5.35*	2.05	4.39*	2.48

* Significant at 1 per cent level.

Statistical analysis showed that the difference between the two were significant in the case of panel members at the laboratory level where as the difference was not significant for the mothers. The least score was obtained for the bland porridge. When compared with the bland porridge the difference was significantly higher for the sweetened porridge. This indicates that sweetness is responsible for the variation in acceptability.

5.5. Preference ranking.

Preference ranking for the porridge by the panel members and the laboratory level as well as the field level are given in Table 40.

Table 40. Preference ranking for the weaning formulae by the panel members.

Different forms of porridge	Highly acceptable	Acceptable	Slightly acceptable	Neither acceptable nor unacceptable	Slightly unacceptable	Unacceptable	Highly unacceptable
Bland							
Laboratory trials	-	-	50	40	10	-	-
Field trials	-	10	70	20	-	-	-
Flavoured							
Laboratory trials	-	-	40	60	-	-	-
Field trials	-	10	50	40	-	-	-
Sweetened							
Laboratory trials	-	40	60	-	-	-	-
Field trials	20	60	20	-	-	-	-
Sweetened & Flavoured							
Laboratory trials	50	40	10	-	-	-	-
Field trials	70	20	10	-	-	-	-

As revealed in the Table 40, the over all acceptability of the porridge at the laboratory level as well as at the field level were found to be influenced by the addition of sugar. However the acceptance of the porridge at the field level was also influenced by the flavour to an extend and the porridge with sugar and flavour was also found to be acceptable. The porridge in which flavour and sugar were added was found to be the most acceptable. Preference ranking further stress that sweetness was the quality responsible for the variation in the acceptability of the porridge.

5.6. Over all acceptability of the porridge.

The over all acceptability was ranked according to laboratory trials and the results are presented in Table 41.

Table 41. Over all acceptability of porridge on a 5 point hedonic scale (Laboratory/field trials)

	Bland	Flavoured	Sweetened	Sweetened and flavoured
Over all acceptability				
Laboratory trials	4.4 ± .11	4.4 ± .12	5.4 ± .14	6.4 ± .15
Field trials	4.9 ± .15	4.7 ± .13	6 ± .12	6.6 ±..18
Appearence				
Laboratory trials	3	3	3	3
Field trials	3.5	3.5	3.5	3.5
Flavour				
Laboratory trials	3.2 ± .09	3.9 ± .12	3.3 ± .09	4.2 ± .12
Field trials	3.0 ± .08	3.9 ± .10	3.3 ± .08	3.9 ± .11
Texture				
Labotatory trials	3.7	3.7	3.7	3.7
Field trial	4	4	4	4
Taste				
Laboratory trials	2.5 ± .07	2.7 ± .08	3.9 ± .10	4.5 ± .12
Field trial	2.9 ± .08	2.7 ± .07	4.0 ± .12	4.6 ± .13

From the table it is revealed that the appearance and texture of the different formulae were the same. But the mean scores obtained for over all acceptability, flavour and taste were highest for sweetened and flavoured porridge. The results were statistically analysed and the data is given in Table 42.

Table 42. Statistical analysis of Table 41.

	1 vs 2	1 vs 3	1 vs 4	4 vs 2	4 vs 3	3 vs 2
Over all acceptability						
Panel members	--	5.6*	10.7*	10.4*	4.9*	5.4*
Mother	.32	5.7*	7.2*	8.55*	2.8	17.3*
Flavour						
Panel members	4.6*	.78	6.7*	1.7	6*	4*
Mother	7.0*	2.7	6.6*	--	4.4*	4.7*
Taste						
Panel members	1.9	11.5*	14.4*	12.5*	3.8*	9.4*
Mother	1.9	7.6*	11.1*	12.8*	3.4*	9.3*

* Significant at 1 per cent level.

As revealed in Table 42 there was no difference in the overall acceptability for bland and flavoured porridge.

But when the sweetened porridge with flavour and without flavour were compared to the unsweetened porridge, the difference was significant. Among the sweetened porridge the over all acceptability was significantly higher for sweetened and flavoured porridge when compared to sweetened unflavoured porridge in the case of panel members, but the difference was insignificant in the case of mothers. When the scores obtained for the quality flavour was compared between the samples, the scores were significantly higher for flavoured porridge when compared with the unflavoured porridge. There was no significant difference for taste when the bland porridge was compared with the flavoured porridge. But the scores obtained for the sweetened porridge were significantly high when compared to the unsweetened porridge. It was also revealed that among the sweetened porridge the score obtained for the sweetened and flavoured porridge was significantly higher when compared to the sweetened unflavoured porridge.

5.7. Acceptability of the recipes.

Acceptability studies of various recipes bland porridge, porridge with chekkurmanis and porridge with mango were also conducted among the panel members and the results are given in Table 43.

Table 43. Acceptability of the recipes standardized among the panel members.

Recipes	Liked %	Disliked %
Bland porridge	50	50
Porridge with chekkurmanis	70	30
Porridge with mango	100	--

As revealed in Table 43, all the panel members accepted the porridge with mango, while porridge with chekkurmanis was accepted by 70 per cent. Among the three, bland porridge was least acceptable.

Mean scores obtained for different recipes are worked out and the results are given in Table 44.

Table 44. Mean scores obtained for different recipes

Recipes	Mean score	Percentage
Bland porridge	16.8 $\pm$ .42	62.2 $\pm$ 1.6
Porridge with chekkurmanis	19.2 $\pm$ .54	71.1 $\pm$ 1.56
Porridge with mango	22.2 $\pm$ .55	82.2 $\pm$ 1.89

Acceptability trials conducted among adults reveal that the highest score was obtained for the porridge with mango and the least acceptable one was bland porridge.

Field trials are conducted separately among children to assess the acceptability of different recipes as a major constituent of their mid day meal and the results collected are presented in Table 45.

Table 45. Acceptability of the recipes among children.

Recipes	Food given cooked weight (g)	Children who consumed fully		Children who wasted		Average quantity wasted (g)
		Number	Percentage	Number	Percentage	
Blend porridge	205	15	83	3	17	23
Porridge with chekkurmanis	185	12	71	5	29	35
Porridge with mango	210	14	61	9	39	45

As revealed in Table 45, bland porridge was the most acceptable recipe. 83 per cent of the children consumed the porridge fully while 17 per cent wasted. In ranking bland porridge was followed by porridge with chekkurmani's ~~is~~ added. Porridge with mango was least acceptable. Average plate waste was also found to be the lowest for the bland porridge compared to the porridge with chekkurmanis in salt medium and porridge with mango in sweet medium.

Acceptability studies conducted among panel members and children indicate that the response of the panel members were based in favour of sweeted porridge. However in the case of children they seem to be not influenced by sweetness.

SUMMARY

SUMMARY

Infant weaning practices contribute largely to the unsatisfactory rate of growth among infants belonging to the poor socio-economic classes. Though there are a number of commercial preparations specially designed for the purpose of weaning, such products are expensive and beyond the economic reach of the rural population. Thus there is an urgent need to develop a satisfactory, cheap infant weaning foods which can be prepared from locally available resources for use among the poor socio-economic classes. In this context the present study was undertaken to develop a weaning food based on ragi flour which is nutritious, low cost and acceptable.

The ragi flour was supplemented with different proportions of food articles such as green gram, sesame, tapioca and skim milk powder to enhance the nutritive value and protein quality of weaning formulae. Thus six combinations of weaning formulae were developed.

A skim milk based diet was used in the animal experiments as standard for evaluating the protein quality of the six combinations of ragi based weaning formulae developed.

Weight gain, protein efficiency ratio, liver weight, liver nitrogen, serum protein, biological value, digestability-coefficient and net protein utilization were the important criteria for evaluating the protein quality of the weaning formulae. The weaning formulae in which the food articles namely ragi, green gram, sesame, tapioca and skim milk powder were in the proportion of 3:2:1.5:2:1.5, gave significantly better values for all the above criteria than the skim milk diet.

The organoleptic qualities of the weaning formulae were assessed by the panel members at the laboratory level and by the mothers and children at the field level. The results of the study indicate that addition of sugar and flavour increases the acceptability of the bland porridge. In the case of pre-school children the bland porridge was highly acceptable among 83 per cent of the children, when the porridge was supplied to them as a constituent of their mid day meal.

As the bland porridge was deficient in nutrients such as calories, iron and vitamin A, other food ingredients were added to make up these deficiencies while standardising recipes. Thus two recipes were standardized such as porridge with chekkurmanis in salt medium and porridge with mango in sweet medium. The acceptability trials of these two recipes were conducted at the field level and laboratory level. Among the three recipes, bland porridge was most acceptable to the children while the porridge with mango was more acceptable for the panel members.

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* Original not seen.

APPENDIC

APPENDIX - I

Micro kjeldahl method.

Prindple:

The nitrogen present in combined organic form is converted to ammonical form by digestion with concentrated H_2SO_4 in the presence of catalyst mixture. The digest is made alkaline and ammonia liberated is distilled off into an acid solution. Quantity of ammonia liberated is determined by titration against standard acid.

Reagents:

1. Conc. H_2SO_4
2. Digestion mixture
3. Standard acid
4. Mixed indicator
5. 4 per cent boric acid
6. 40 per cent NaOH

Preparation of Reagents:

1. 4% Boric acid - Dissolved 4 g boric acid in 100 ml water.
2. 40% NaoH - Dissolved 40 g Na OH in 100 ml water.
3. Mixed indicater - Dissolve 3 g of bromocresol green and 2 g of methyl red in 400 ml of 90% ethenol. The indicator colour changed from red in acid to blue in alkaline solution.

4. Digestion mixture - 10:5:1 of $K_2 SO_4$: $Cu SO_4$ and selenium powder.

5. Conc $H_2 SO_4$ for digestion

6. 0.1 N $H_2 SO_4$

7. 0.1 N Na_2CO_3 - 5.3 g of AR Na_2Co_3 to 1 litre and standardised with N_2SO_4.

Standardization of acid.

Reagents required:

1. Methyl orange indicater 0.1 % in water.

2. Reference solution 80 ml Co_2 free water with 3 drops of methyl orange indicator.

3. Na_2Co_3 solution 0.02 N dry Na_2CO_3 at 120°C kept for 2 hrs. Cool in a descicater and weigh 1.008 into 100 ml volumetric flask and made up to mark with distilled water. This gives 0.2 N solution 20 ml of the solution diluted to 200 ml to get 0.02 N solution.

Procedure for standardisation:

40 ml 0.02 N Na_2Co_3 solution was taken in a 250 ml conical flask. Three drops of methyl orange indicator was added and this was titrated against Hcl to be standardised until the colour began to deviate from water tint. Boiled the solution gently for 2

minutes to expel Co_2 cooled and titrated against the acid until the colour was water tint of indicator.

Procedure:

One gram sample was placed in a digestion flask. About 1 g digestion mixture and 10 ml H_2SO_4 were added to the sample and digestion was effected in a kjeldhal digestion track with low flame for the first 10-30 minutes until the frothing stoped. Then the flame was gradually increased until the sample was completely chared. The flask rotated at intervals and heating was continued until organic matter was destroyed and their end point was judged by timing the digestion for 15 minutes after the solution has cleaned. At the end of the digestion the flask was kept for cooling and then made up to 100 ml.

Distillation:

10 ml of the digest (made up to 100 ml) was transferred into the vaccuum mental of the steam distillation assembly. 10 ml of 40 per cent NaOH was added and washed in with distilled water. The ammonia was distilled out for about 5 minutes and collected in a 100 ml conical flask containing 10 ml 4% boric acid. 30 ml of the distillation was thus collected.

Calculations:

Weight of sample	- 1 g
Volume of acid used	- x
Blank value	- y
Normality of acid	- .02 N
1 ml 1 N acid	$\approx$ .014 g of N_2

(x-y) .014 x N of acid

$$\% \text{ of total } N_2 = \frac{(x-y)\ .014 \times 0.02 \times 100 \times 100}{1 \times 10}$$

APPENDIX - II

Atomic Absorption spectroscopic determination of minerals.

Representative sample in a suitable liquid form is sprayed into the flame of an atomic absorption spectro photometer and the absorption or erossion of the mineral to be analysed is measured at a specific wave length.

Reagents:

Standard solutions:

1. Stock solution, 1000 μg/ml; Dissolve 1 g mineral equivalent of mineral salt in a minimum amount of redistilled hydrochloric acid (about 10 ml). Dilute to 1 litre with deionised water.

2. Working standard solution. Dilute aliquots of the stock solution with deionised water to make atleast 4 standard solution of each element within the range of determinations.

Procedure:

1. Depending upon the mineral to be determined standards and blank solutions may be aspirated into the flame directly or after suitable dilutions to attain working range of the instrument.

2. The optimum operating conditions recommended bythe instrument manufacturer should be used.

3. Read atleast 3-4 ranges of standard solutions before and after sample readings. Flush burner with deionised water between samples and check for zero setting.

4. Prepare calibration curve from the readings of standards.

5. Determine the concentration of samples from the standard graph.

Calculation:

$$\text{ppm mineral} = (\mu g\ \text{mineral/ml}) \times \frac{\text{dilution factor}}{\text{ml alquots} \times \text{g sample}}$$

Operation parameters:

Mineral	Wave length nm	Flame	Optimum range	Working ug/ml
Calcium	422.7	Rich air-C_2H_2 (oxidising)	0.5	2.5
Copper	324.7	Air - C_2H_2 (oxidising)	2.0	8.0
Iron	248.3	Rich air - C_2H_2(oxidising)	2.0	8.0
Magnesium	285.2	Rich air - C_2H_2(oxidising)	0.1	0.6
Manganese	279.5	Air - C_2H_2 (oxidising)	1.0	4.0
Zinc	213.9	Air - C_2H_2 (oxidising)	0.4	1.6

APPENDIX - III

Score card for acceptability test of food products

Quality attributes	Sub-division of attributes	Score for each sub-division attribute	Score for Samples Code No. 1	2	3	4
Appearance	Very poor	1				
	Poor	2				
	Fair	3				
	Good	4				
	Very good	5				
Flavour (Aroma)	Not at all pleasant	1				
	Not pleasant	2				
	Neither pleasant not unpleasant	3				
	Pleasent	4				
	Very pleasant	5				
Texture	Very sticky	1				
	Moderately sticky	2				
	Slightly sticky	3				
	Not sticky	4				
	Others	5				
Taste	Not at all tastey	1				
	Not tastey	2				
	Slightly tastey	3				
	Moderately tastey	4				
	Very tastey	5				
Over all acceptability	Highly unacceptable	1				
	Unacceptable	2				
	Slightly unacceptable	3				
	Neither acceptable nor unacceptable	4				
	Slightly acceptable	5				
	Acceptable	6				
	Highly acceptable	7				

APPENDIX - IV

Evaluation Card for Triangle test

Name of the Product : Sugar solution

Note:

Two of the three samples are identical.

Identify the odd sample.

Serial No.	Code No. of sample	Code No. of identical samples	Code No. of odd sample

DEVELOPING INDIGENOUS WEANING FOOD BASED ON RAGI FLOUR

BY

JESSY PHILIP

ABSTRACT OF A THESIS
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ABSTRACT

A study was conducted to develop a weaning food based on ragi flour which is nutritious, low cost and acceptable.

The ragi flour was supplemented with green gram, sesame, tapioca and skim milk powder to improve the nutritive value. Based on the nutritive value and chemical score, six combinations of weaning formulae were developed. Protein quality of the weaning formulae assessed through animal experiments reveal that the weaning formulae which contains ragi, green gram, sesame, tapioca and skim milk powder in the ratio 3:2:1.5:2:1.5 gave significantly better values for all the criteria.

The acceptability of the weaning formulae was assessed by the panel members, mothers and children. The results of the study indicate that the bland porridge prepared with the weaning formulae was acceptable. The bland porridge was deficient in calories, vitamin A and iron. Other food ingredients were added to make up these deficiencies and two recipes were standardized. The recipes were also found to be acceptable for the panel members and children.