DEVELOPING RICE BASED COMPLEMENTARY FOOD FOR INFANTS

DHANYA JOSE

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Department of Home Science
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM-695 522

DECLARATION

I hereby declare that this thesis entitled "**Developing rice based complementary food for infants**" 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 of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellayani,
22- 3 -2006.

Dhanya Jose
DHANYA JOSE
(2003-16-08)

CERTIFICATE

Certified that this thesis entitled "**Developing rice based complementary food for infants**" is a record of research work done independently by Ms. Dhanya Jose (2003-16-08) 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.

Vellayani,
22. 3 -2006

Smt. N.K. VIMALAKUMARI
(Chairperson, Advisory Committee)
Associate Professor and Head
Department of Home Science
College of Agriculture, Vellayani
Thiruvananthapuram

Approved by

Chairperson :

Smt. N.K. VIMALAKUMARI
Associate Professor and Head,
Department of Home Science,
College of Agriculture, Vellayani,
Thiruvananthapuram-695522.

Vimalakumari 22/3/2006

Members:

Dr. C.R. SUDHARMAI DEVI
Associate Professor,
Department of Soil Science and
Agricultural Chemistry,
College of Agriculture, Vellayani,
Thiruvananthapuram-695522.

22/3/06

Dr. P.V. NANDINI
Assistant Professor,
Department of Home Science,
College of Agriculture, Vellayani,
Thiruvananthapuram-695522.

Nandini 22/3/06

Dr. C. NIRMALA
Assistant Professor (Sr. Sc),
Department of Home Science,
College of Agriculture, Vellayani,
Thiruvananthapuram-695522.

22/3/06.

External Examiner :

Dr. SUNANDA SHARAN
Associate Professor
Department of Food and Nutrition
UAS, Bangalore

7/3/2006
Dr. SUNANDA SHARAN

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Introduction

1. INTRODUCTION

The family is the basic social unit where a child is reared and nurtured (UNICEF, 2000). Just as a strong foundation is necessary for a tall skyscraper, healthy children are vital for the formation of ideal families, which can contribute towards the progress of society.

The national policy for children declares that children are supremely important asset of a nation. Investing in children is the best investment a government can make. No country has made the leap into meaningful and sustained development without investing significantly in its children (UNICEF, 2000).

According to World Bank (1993), one of the reasons that countries of East Asia were so much more successful than those of sub-Saharan Africa in economic development towards the end of the twentieth century, was that they had invested heavily in children in the preceding decades. They were reaping the harvest of seeds sown in the fertile soil of children's health, nutrition and education. On the other hand, infants and children are the most vulnerable victims of natural or human induced emergencies.

Assuring the best for children throughout their lives depends on assuring them the best beginning. Early initiation of breast feeding and introduction of supplementary foods at right time in right quantity is the apt way to improve and maintain child's nutritional status (Nagi, 2000).

Breast milk is perhaps the greatest gift that nature has given to a child and it is nature's rule that every baby should first and foremost be fed with mother's milk.

Paintail (2003) has reported that breast milk of a well nourished mother is nutritionally adequate to support the growth of her infant; however studies from developing countries have shown that growth faltering occurs in infants after six months of age indicating that infants were not receiving sufficient amount of breast milk.

Abraham (1997) had indicated that there is a reduction in the quantity of breast milk secreted after six months; while Moloya *et al.* (2003) are of the opinion that after six months the need for nutrients increases and this increase cannot be fulfilled by breast milk alone, as the rate of growth of the infant is rapid.

Interrupted breast feeding and inappropriate complementary feeding hightens the risk of malnutrition, illness and mortality (WHO, 2002).

NIN, (1994) confirms that by six months the baby weighs about six kilogram, *i.e*, the birth weight is doubled. NCHS (2001) has proclaimed that the birth height of an infant is about 50.5 cm and by one year it becomes 76 cm. Further Abraham (1997) has indicated that the number of brain cells increases most rapidly during infancy. Moreover, healthy infants are very active, alert and busy exploring the environment and they need extra energy (600 kcals of energy per day) because their metabolic rate is high for growth and for activity.

Therefore, it is essential to introduce complementary foods, when the child is six months old. Complementary foods are any foods whether manufactured or locally prepared, suitable as a complement to mother's milk when it becomes insufficient to satisfy the growing nutritional requirement of the infant after six months of age as explained by Gupta *et al.* (2001).

Weaning age is perhaps the most critical and vulnerable period demarked with high incidence of mortality and morbidity. However, it is a transitional phase, since new foods are introduced at this stage.

As rightly observed by Swamy and Jayaprakash (2003) introduction of appropriate complementary food which is of high biological value, calorie dense, low in dietary bulk and cost effective is of paramount importance in reducing the nutritional problems associated with weaning age.

Irrespective of purchasing power mother's are depending on commercial weaning foods which are highly expensive while the traditional complementary foods used for feeding infants are bulky, viscous and are less calorie dense.

Hence it is essential to develop simple, nutritious, easily digestible complementary foods from locally available food material, having low viscosity and bulk.

As stated by Nema (2003) rice is one of the leading food crops in the world, that sustains two-third of the world population. Archeological evidences suggest that rice has been cultivated for over 5000 years, and has no cholesterol and has minimal sodium and contains almost all essential amino acids. Moreover, rice is the staple food of Kerala and is most socially acceptable indigenous item that is introduced into the dietaries of children, from the age of six months onwards. Rice combined with pulse and processed suitably would give a product of high biological value that helps to enhance growth of children. Addition of mineral, vitamin and energy giving foods to this would further enhance the nutritive quality. With this concept an attempt was made to develop a rice based nutritious complementary food suitable for feeding infants between six months to nine months of age.

Review of Literature

2. REVIEW OF LITERATURE

Webster's Dictionary defines weaning as "accustoming a young mammal to take food otherwise than by nursing". Weaning has been further defined as the time when a baby stops breastfeeding and gets all nutrition from sources other than breast (Emerson, 2002). Gupta *et al.* (2001) are of the opinion that introduction of any non-breast milk food or nutritious food to young children in addition to breast feeding is weaning.

According to Elizabeth (1998) weaning is the systematic process of introduction of suitable food at right time in addition to mother's milk in order to provide needed nutrients to the baby. As per Pitcairn (1971) weaning means changing a baby's food from a milk diet, which he/she has obtained by sucking, to a diet containing solid food, which he/she has to eat by chewing and biting. Sinha and Pandey (2000) have stated that weaning is the stage of baby's life when the baby's transition from breast milk to other sources of nourishment take place. While Lokeshwar (2005) has stated that weaning is the process that begins when breast feeding starts to be replaced by a mixed diet and he has further reported that weaning means to ceases to be sucked. Fidler and Costella (1995) have opined that weaning is a transition from breast milk to solid food and it is divided into following stages

Stage 1: Baby is usually ready to start on solid foods between 4-6 months

Stage 2: 6 – 9 months

Stage 3: 9 – 12 months

Abraham (1997) reviews weaning as the process by which an infant's dietary pattern is gradually changed from liquid food like breast milk and substitute milk preparations, to cooked solid foods. Moreover according to him it is the process by which an infant gradually becomes accustomed to adult diet. As per the international opinion UNICEF (1984) defines weaning as the systematic process of introduction of suitable food at right time in addition to mother's milk in order to provide needed nutrients to the baby. According to Vyas (2004) weaning, is the process when the baby takes semi solid food in addition to breast milk and she gets nutrients from sources other than breast milk. Mitzner *et al.* (1984) have stated that weaning process is the transmission from a diet of breast milk to a diet that includes breast milk and other foods and finally to a family diet.

As a global public health recommendation infants should be exclusively breastfed for the first six months of life to achieve optimal growth, development and health. Thereafter, to meet their evolving nutritional requirements, infants should receive nutritionally adequate and safe complementary food while breastfeeding continues upto two years of age or beyond (WHO, UNICEF, 2003).

Complementary Foods and Complementary Feeding

According to Gupta *et al.* (2001) complementary food means any food, whether manufactured or locally prepared, suitable as a complement to mother's milk, when it becomes insufficient to satisfy the growing nutritional requirement of the infants after six months of age.

King *et al.* (2000) has stated that an infant food is very special because it is intended to be used as the sole source of nourishment from six months of life. It must meet all of an infant's nutritional needs over prolonged critical period.

WHO (1996) has declared that in the second half of first year of life, a child can take a more varied diet, once a child is eating the cereal porridge, cooked legumes and other vegetables can be mixed with cereals or given separately. New items should be added to the diet one at a time. In central and south America and the Caribbean countries there is a renewed interest in the role that processed complementary food can play in providing a nutritionally complete infant and toddler food as stated by Lutter (2004).

Malleshi (1995) has stated that three important aspects should be considered while developing weaning foods *viz.*, should be made from locally available foods; should contain low level of fiber and other materials that are difficult to digest; and that it should be ready-to-eat.

Nair (2004) is of the view that infants are vulnerable during the transition period when complementary feeding begins. Thus complementary food should be given in time and in adequate amounts, which provides sufficient energy, protein and micronutrient and should be safe, *ie*, should be hygienically stored and prepared and should be properly fed.

Gupta *et al.* (2001) have stated that complementary food should be prepared from cereals like rice, wheat, maize, milk and root staples like potatoes and variety should be introduced by adding foods such as pulses, meat, egg, fish, vegetables and fruits, oils, fat and sugar. Bornemann (2002) is of the view that good complementary foods are energy rich, nutrient rich and locally affordable. Rosler *et al.* (2003) reported that complementary food given to the infants and young children should be sufficient in quantity, nutritionally adequate, hygienically prepared and should be fresh. Moreover she proclaimed that semisolid foods should be easy to digest and have high energy value. According to Nair *et al.* (2003) complementary food should be prepared with locally available ingredients using suitable small scale production technologies in community settings. This can help to meet the nutritional needs of older infants and young children.. Kaliyar and Priya (2002) reported that common food supplements used in Varanasi were sago, rice with mashed potato, vegetables and dhal..

WHO and UNICEF (2002) have declared that ideal complementary food should be adequate in quantity and foods that are rich in energy should be combined with those, which are good sources of proteins, minerals and vitamins.

Kumar (2001) has observed that in infants, the nutrient intake is limited by a combination of inadequate masticating and swallowing ability and small stomach capacity. Hence the weaning food must supply adequate amount of metabolizable energy and protein. Consequently a higher energy and nutrient concentration is required in a weaning food.

Energy required from complementary food is estimated to be approximately 275 Kcal at 6-8 months; 450 Kcal at 9-11 months and 750 Kcal between 12-23 months and the best indicator of energy adequacy will be the growth of the infant (WHO, 1998).

Gupta *et al.* (1990) have noted that the use of commercial milk formula had declined from 31 in 1980 to 12 per cent in 1990 in contrast to the fact that use of commercial weaning formula had been extended to 26 per cent as reported by Kushwaha (2002).

According to Malleshi (1995) a weaning food should be rich in calories and adequate in protein, vitamins and minerals and should provide protein of high biological value. He is of the view that the food when prepared should be soft in consistency, easy to swallow, low in dietary bulk and viscosity. He has further ascertained that it should be easily digestible, free from antinutritional factors, artificial colours and flavours.

Goldman (2002) has also pointed out that the cereal based infant food shall be in the form of powder, small granular or flakes free from lumps and shall be uniform in appearance. It shall be free from dirt and extraneous matter and devoid of preservatives, added flavour and added colours. It shall be free from toxic materials and bacteria that are harmful to human health.

Malleshi and Amla (1988) have stated that the developed weaning foods should be easily digestible, nutritionally balanced, low in dietary bulk, high in caloric density and should be sold at a price affordable to low income group or even be produced at the household or at community level.

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

Gupta and Sehgal (1992) developed weaning foods from locally available foods *viz.*, barley, bajra, greengram, amaranth, jaggery using household technologies such as roasting and malting.

Ramasaranya and Kanjana (2003) formulated complementary biscuits with locally available cost effective indigenous foods. Wheat, green gram and soya were incorporated in different proportions wherein four per cent of skimmed milk was also seen included.

Wargovich (1999) points out that "Baby first Bite" is the country's first weaning food made from organically grown food grains and is 100 per cent vegetarian. The product currently available in four combinations, wheat, ragi and dhal combination, rice and dhal, wheat and apple.

Malhotra (2003) formulated weaning mixes with wheat flour, roasted bengalgram, skimmed milk powder, amaranth and jaggery in various proportions. The developed weaning food had 69-73 to 435.88 mg calcium, 255.74 to 440.25 mg phosphorus and 4.53 to 6.98 mg iron per 100 g.

Kerala Agricultural University had developed several weaning foods using locally available and traditionally accepted materials. Chellammal and Prema (1997) had developed a weaning food with tapioca flour, soya flour, groundnut flour and skim milk powder. Chellammal (1995) has also developed a sweet potato based weaning food with sweet potato flour, soyaflour, groundnut flour and skim milk powder.

Rice based supplementary food developed by Sailaxmi (1995) contained rice, soyabean and groundnut flour, while Jacob (1997) had formulated a rice-soya based supplement with raw rice, defatted soya, amaranth leaves and skimmilk powder, while Philip (1987) had developed a ragi based weaning food with ragi, greengram, sesame, tapioca and skimmilk powder. Prasad (1988) had formulated a banana based supplement containing banana, horsegram, sesame and skimmilk powder.

Traditional weaning foods are based on local staples, usually a cereal and is made either into thick porridge or into liquid gruel. These gruels are unpalatable, but also are too viscous for a child to swallow. Liquid gruels added with large amount of water results in dilution of nutrients. This along with low feeding frequencies leads to low food intake and consequently to low nutrient intake. Though several commercial weaning formulae are available in market which seems to offer an alternative but they are expensive and to cater to the needs of only small affluent segment of the society as rightly pointed out by Mehta (2000).

Need for Complementary Feeding

Gogoi (2003) had reported that the nutritional requirement per unit body weight of infants and preschoolers is much higher than that of adults, hence adaptations are needed frequently. After the age of six months however the need for nutrients increases and this increase cannot be fulfilled by breast milk alone as the rate of growth of an infant is rapid (Moloya *et al.*, 2003).

Gupta *et al.* (2001) have stated that breast feeding alone is sufficient for the first six months. Ramasaranya and Kanjana (2003) are of the view that 70 per cent of energy requirement of a child is met by breast milk alone. But as the child grows, breast milk alone will not be able to provide adequate amount of all nutrients needed to maintain growth. Hence at this stage complementary feeding is to be initiated to ensure adequate growth and to prevent malnutrition and stunting which is very common in the age group of six months to 24 months.

Kushwaha (2002) is of the view that protein calorie malnutrition is prevalent in many parts of India and it is mainly due to inappropriate feeding practices and ignorance of mother. Hence it is necessary to find out, viable weaning food which are nutritionally significant and more suitable for infants.

Yegammai *et al.* (2002) had quoted that India accounts for 40 per cent of world's malnourished children with less than 20 per cent of global child population.

Mridula and Mishra (2004) had opined that, during first six months breast milk is well documented but exclusive breast feeding after six months cannot meet the nutritional demands of the infants for optimal growth. Epidemiological studies carried out in India have revealed that exclusive breast feeding beyond six months is customary in poor-economic communities. This is one of the major factors responsible for child hood malnutrition earlier in Indian and other developing countries. They have further opined that though continued breast feeding is advocated the practice of prolonged breast feeding with late weaning could be the major cause of malnutrition.

Malnutrition is implicated in more than half of child death worldwide. Each year six million children in developing countries die from causes that are either directly or indirectly attributed to malnutrition (UNICEF, 2003). The international conference on nutrition (1992) reported that malnutrition among children is more likely to result from ignorance about hygienic and dietary needs of children. FAO (1992) has stated that malnutrition "the man made disaster" is an avoidable tragedy with enormous social and economic potential. It affects growth and reproduction and undermines health, learning and working capacity and overall quality of life and well being. On the other hand Whaley (2003) has ascertained that supplementary feeding is reported to have significant effect on weight gain and on motor development.

WHO and UNICEF (2003) have jointly reported that malnutrition has been responsible, directly or indirectly for 60 per cent of the 10.9 million deaths annually among children under five. Two third of these death which are often associated with inappropriate feeding practices during the first year of life.

According to Michaelsen and Firiis (1993) the growth of children in developing countries often declines with the introduction of supplementary foods that are nutritionally inadequate. These growth deficits are accompanied by delayed development and increased morbidity and mortality.

Begum (1991) had further stated that a child who has failed to grow during the preschool period may not make up the loss in growth even with an excellent diet in later years. Thus supplementary food should be given to improve physical, mental and social development of the child. It is the opinion of UNICEF (2000) health risk that often arise during transition from breast milk to consumption of usual family food can be avoided by appropriate complementary feeding practices

Udani (1990) has stated that the quantity and quality of supplements provided at weaning age determines the nutritional status of children. Hence he opined that the incidence of malnutrition could be prevented by food supplements introduced to the diet of children at different stages of development.

Suriakanthi (1991) had observed that the supplementary foods given by the rural mothers are found to be mainly cooked cereal foods; biscuits, banana and these foods do not supply all the nutrients needed by children. As a result, children suffer from either malnutrition or under nutrition. Hence malnutrition can be solved by providing simple nutritious supplementary foods from locally available food material, which are also cheap.

Caulfield *et al.* (1999) had stated that efficacy trial and programmes in fourteen countries showed that child growth could be improved by 0.10 to 5.0 standard deviation through increased dietary intake. This range of improvement in growth would reduce prevalence of undernutrition at twelve months by 1 to 19 per cent.

According to Annie *et al.* (1993) protein energy malnutrition can be prevented with protein and energy rich ready-to-cook and ready-to-eat mixes developed for supplementary feeding.

Age of introduction of complementary food

Ramasaranya and Kanjana (2003) reports that 70 per cent of energy requirements of a child is met by breast milk alone. But as the child grows, breast milk alone will not be able to provide adequate amount of all nutrients needed to maintain growth after six months. At this stage weaning is to be initiated. Gradual method of weaning is emphasized among the communities to control psychogical stress and strain in children (Sinha and Panday, 2000). Good nutrition in the early months of life is more usually determined by feeding practices, whether the right food is given at the right time and in the right way and by the right frequency (Saadeh, 1998). The introduction of solid foods should be the beginning of a prolonged process by which the infant goes through a smooth transition from breastfeeding to the regular family diet. Weaning should begin gradually from the sixth month of life (WHO, 1996). However Ghosh (1998) has stated that supplementary food during 4-6 months of life is considered to be the appropriate age for introduction of semi-solid food.

But the international organization WHO and UNICEF (2000) insist that by six months of age, all infants should start complementary foods. Breast feeding, however should still be a major source of nutrients. Taneja and Salkar (2001) stated that after the age of six months the need for nutrients increases and this increase cannot be fulfilled by breast milk alone as the rate of growth is rapid. Therefore it is essential to supplement the child's diet with liquid or semi-solid food from the age of four to six months, otherwise the child is likely to go into malnutrition. Sharma and Sharma (2004) reported that single ingredient food should be introduced initially and new foods should be offered at intervals of not less than about 5-7 days. Gupta *et al.* (2001) have ascertained that complementary foods should be given two to three times a day when babies are six to nine months old and three to five times a day when they are nine to twelve months old. Yaming *et al.* (2003) are of view that weaning should start with the introduction of small quantity of a smooth, bland cereal. Amuna *et al.* (2000) says that weaning is the introduction of solids. Solid foods are firstly introduced into the diet as a sloppy gruel along with milk and then progressively in to a more solid consistency. The first solid food given to child should be soft and should not have a strong spicy flavour. If a certain cereal is the staple food of the community it should be used to make the first food for an infant (WHO, 1996).

WHO (1996) had stated that in the second half of the first year of life cooked leguminous and other vegetables could be mixed with cereals and given to the infants. Gradually the quantity should be increased but the child should never be forced to eat more than what he accepts. Gopaldas and Deshpande (1995) have stated that reason for starting mixed feeding is to ensure an adequate intake of iron. She has further stated that iron deficiency will be prevented in the full term infant when mixed feeding is introduced by the age of four to five months. 95 per cent of infants have had tea introduced by the age of twelve months. Tea is commonly given from the age of two to three months of age in bottles with added sugar. The polyphenol content of tea inhibits iron absorption, and ends up with a more serious problem when the overall diet of children from six to twelve months would appear to contain insufficient iron as observed by Laura and Caroline (1999). They have further stated that fruits and vegetables should be introduced at four to six months as complementary food, as they would provide vitamin C, which would help in the absorption of iron. Most of the mothers are of the view that fruits are good for weaning, but the cost was prohibitive especially at times of food insecurity. Elizabeth (1998) is of view that at about six months a normal infant begins to use iron stores and that is probably an appropriate time to start solid foods especially iron – containing ones.

The age at which complementary feeding should be started has been debated a great deal and was found to vary from four to six months (Huffman, 2002). Sharmila (2002) has stated that in Amravathi after six moths 78 per cent mothers were giving supplementary milk feeds with or without breast milk. Semi solid supplementary foods were reported to be given before six months and solid supplementary foods were started after the age of nine months or 12 months. Dahiya and Sehgal (2002) have stated that in Haryana semi-solid and solid supplementary foods were introduced before six months by majority of working mothers, whereas the non-working mothers were giving these foods only between 6-9 months of age.

According to Isherwood and Demond (1998) in Bangladesh, liquid supplements were usually introduced within the first three months. Mean age of introduction of solids to infants was 3.5 months.

Sinha and Pandey (2000) have stated that weaning foods were introduced to young children between 12-18 months of age by 46.50 per cent mothers in Bihar followed by 35.00 per cent moths who supplemented the child's diet between 8-12 months of age. In many parts of Kerala cereal foods were introduced only after the rice giving ceremony and it may be delayed till all the circumstances become favourable (Nair, 2004). However Kumar (2003) is of view that in India 31.5 percent infants receive breastfeeding plus complementary food at 6-9 months of age. Weaning plays an important role in development of chewing and this appears to be a fairly critical time for the introduction of solids by six months to ensure normal chewing development as observed by

(Lokeshwar, 2005). Underwood (1992) opined that there is no rule as to when to introduce thickened foods, but it is better not to introduce complementary feed before four months.

Early introduction of additional food could adversely affect the amount of breast milk because the baby will be less hungry and will suck the breast less often and reduce the amount of milk secretion (Silver, 1997). However it is an accepted fact that after the first year, a child is usually able to eat the food prepared for the family. In other words he starts sharing the family diet as announced by Smith and Skyes (1995). Gnanasundaram (1994) has also stated that by one year infant can be given family diet, slightly modified, in small quantities but at frequent intervals (4 to 5 times). Field studies have also shown that complementary foods introduced between four and six months of age replace nutrients from breast milk and confer no advantage on growth or development (WHO, 1995).

Developing complementary foods

One of the principal strategies for directly improving the nutrition of young child in the lower socio-economic population of developing countries during the weaning period, as observed by Mitzner(1984) is developing and promoting home and village prepared weaning foods .Solanki (1986) feels that there is an urgent need to develop low cost Ready -To- Eat mixes to improve the nutritional status of children. Malleshi (1995) has suggested that one of the important quality of a complementary food should be that, it is Ready- To -Eat.

A variety of processed weaning foods and supplementary foods based on cereals, legumes and oilseed meal have been developed in India Jacob (1997). Malleshi (1995) has pointed out that foods should be prepared using locally available raw materials and should be rich in nutrients. According to Thirumaran (1993) the introduction of locally processed and preserved nutritious ready to use foods will reduce the time spend in drudgery by the woman along with income generation and improved nutritional standards .Ashlesha and Vali (1997) have observed that commercial Ready –To- Eat infants food are very expensive and mothers belonging to low income groups cannot afford to buy them as pointed out by Jacob (1997) in our country commercially available weaning foods are expensive, while most of the traditional foods have high dietary bulk and low calorie density as reported by Gahalawat and Sehgal (1993).

Therefore there is need to develop indigenous complementary food of low bulk, high in calorie density, nutritionally adequate and acceptable to the clientele *viz*, the infants. Therefore an attempt has been made in this study to develop a complementary food with rice as basic ingredient with added legumes and green leafy vegetables and employing extrusion technology.

Srilakshmi (2002) has opined that rice is an important cereal and is the staple for more than half of world's population. It is principally consumed in Asia Seventy per cent of the world dietary energy is reported to obtained from this staple food as noted by Pai (1997). Lucas (1997) has also reported that rice is the chief source of carbohydrates and being a staple food, rice is reported to provide 80 per cent of the calorie requirement of the diet. Even though, rice is a main source of carbohydrate, it also has the highest digestibility coefficient biological value among all cereals (Wargovich, 1999).

Srilakshmi (2002) has also reported that the protein content of rice is seven per cent, which is much lower than that of wheat. But the biological value of rice protein is of high order being superior to that of the wheat and other cereal products. The rice protein is richer in arginine when compared to other cereal proteins. The biological value of rice protein is 80 whereas that of wheat is 66.

The complementary food formulated by adding protein, vitamin, mineral and energy supplement was processed by extrusion method. As pointed out by Garcia (2003), for commercial preparation of complementary food the most commonly used method are roller drying and extrusion cooking. Further, Malleshi (1995) has opined that extrusion cooking is a versatile process as the product is fully cooked and is "ready-to-eat", and that it mixes easily with milk or water. Liu and Maga (1993) have remarked that low cost food extruders are being used for preparation of complementary foods.

Extrusion is a popular means of preparing Ready-To-Eat products (Jha and Prasad, 2003). According to Smith and Singh (1996) protease inhibitors are inactivated in the extrusion cooking, which increases the digestibility of protein, although these is often loss of essential amino acid and cross linking which occur on heating. However, lysine reduction is least at high extrusion temperature. Southard and Maga (1993) have stated that due to high pressure and resulting temperature, extrusion promotes more acceptable flavour by the rapid expansion of the extruded product.

Devadas (1983) had opined that development of complementary food should be governed by certain principle: She reports that supplements should have high nutritional value and good supplementary value, high acceptability, easiness to prepare, low in cost and should be made from locally available materials and that it should have a low shelf life of at least 4-6 months in a tropical environments. Therefore in this study the developed rice based complementary food was evaluated for its nutritional adequacy, acceptability, cost and shelf life as envisaged in the objective of the study.

Materials and Methods

3. MATERIALS AND METHODS

The materials and methods employed in the study entitled "Developing rice based complementary food for infants" are detailed in this chapter.

3.1 FORMULATION OF BASIC MIX

Weaning food which has only two ingredients is called as the basic mix and most of the basic mixes contain a cereal or a root mixed with a pulse (Mitzner *et al.*, 1984).

In the present study rice was selected as the basic cereal and was admixed with commonly available pulses in different proportions to formulate basic mixes.

As envisaged in the objective of the study rice was specially selected as the base material because it is the staple for majority of Asian population (Lucca, 1999) and is the chief source of carbohydrate supplying 80 per cent of the calorie requirement of Indian diet (Potty, 2004). Among the different types of rice available in the market the one having low stickiness after boiling was selected for processing the supplement. Pulses such as blackgram dhal, bengal gram dhal, greengram dhal, cowpea, peas, red gram dhal and soya were selected to be combined with rice, since they are cultivated extensively and are consumed by majority of population in India. These pulses are also familiar to Keralites.

Different combinations of basic mixes were worked out by varying the proportions of rice and various pulses. However care was taken to see that rice contributed not less than 50 per cent of the basic mix, since the objective of the study is to develop a rice based complementary food.

Initially combinations were worked out so as to contain rice and one pulse. Thus 64 combinations were formulated varying the proportion and type of pulse used. In these combinations the quantity of pulse added to rice varied from 10 to 50 per cent.

In order to select an ideal basic mix from among 64 combinations amino acid score and chemical score were worked out utilizing the following formulae.

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

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

Amino acid and chemical score were computed since they would give an indication to the protein quality which can be used as a proxy for biological assays.

The amino acid and chemical scores of the above combinations are given in Appendix I.

Out of 64 combinations 11 combinations that had high chemical score (above 80) were identified at the primary level to be used as basic mix. Jansen and Harper (1985) have reported that an ideal basic mix, to be used as weaning food should have a chemical score of 60.

The chemical score of the selected eleven combinations with their composition are presented in Table 1.

The amino acid score was not used for the selection since these values varied considerably between combinations and also because the amino acid score and chemical score of the combinations did not tally with each other.

Table 1. Composition and chemical score of basic mixes containing one cereal and one pulse

Sl. No.	Ingredients in basic mix	Proportion	Chemical score
1	Rice + Green gram	80:20	86
2	Rice + Green gram	65:35	85
3	Rice + Green gram	60:40	87
4	Rice + Green gram	70:30	84
5	Rice + Bengal gram	75:25	83
6	Rice + Bengal gram	85:15	84
7	Rice + Bengal gram	70:30	85
8	Rice + Bengal gram	90:10	84
9	Rice + Black gram	70:30	86
10	Rice + Black gram	80:20	87
11	Rice + Black gram	65:35	86

3.2 FORMULATION OF MULTIMIX

Mixes containing more than two items have been designated as multimixes by Mitzner *et al.* (1984) and are reported to be more suitable for children in the later months of the weaning period. Therefore primary multimixes were formulated by adding other ingredients to the basic combinations in two different ways.

In the first method a second cereal was introduced along with rice to the basic mix. Thus 108 combinations containing either ragi or wheat as an additional cereal having varying proportions were formulated and their amino acid score and chemical score were worked out.

In the second method an additional pulse was added to the basic mix .In this context 139 combinations containing two different pulses were added to rice in different proportions and their chemical score and aminoacid score were also computed and are given in Appendix II.

Among these 247 (108 + 139) multimixes those having a chemical score above eighty were identified. From these, eleven multimixes were taken by lot. Eleven such multimixes were selected purposefully as there were eleven basic mixes. Thus eleven basic mixes and eleven multimixes were selected for further study. The selected eleven primary multimix combinations along with their chemical score are given in Table 2.

As indicated in Table 2 four of the multimixes were found to contain ragi as an additional cereal along with rice and seven combinations had an additional pulse.

Table 2. Chemical score of selected multimixes

Sl. No.	Ingredients in the multimixes	Proportion	Chemical score
1	Rice + Ragi + Green gram	65:15:20	96
2	Rice + Ragi + Green gram	75:10:15	93
3	Rice + Ragi + Bengal gram	75:10;15	95
4	Rice + Ragi + Black gram	65:15:20	86
5	Rice + Black gram+ Bengal gram	60:20:20	83
6	Rice + Black gram+ Bengal gram	65:15:20	83
7	Rice + Black gram + Bengal gram	55:15:30	82
8	Rice + Black gram + Green gram	60:20:20	84
9	Rice + Bengal gram + Green gram	65:15:20	84
10	Rice + Bengal gram + Green gram	60:30:10	83
11	Rice + Bengal gram + Green gram	70:15:15	84

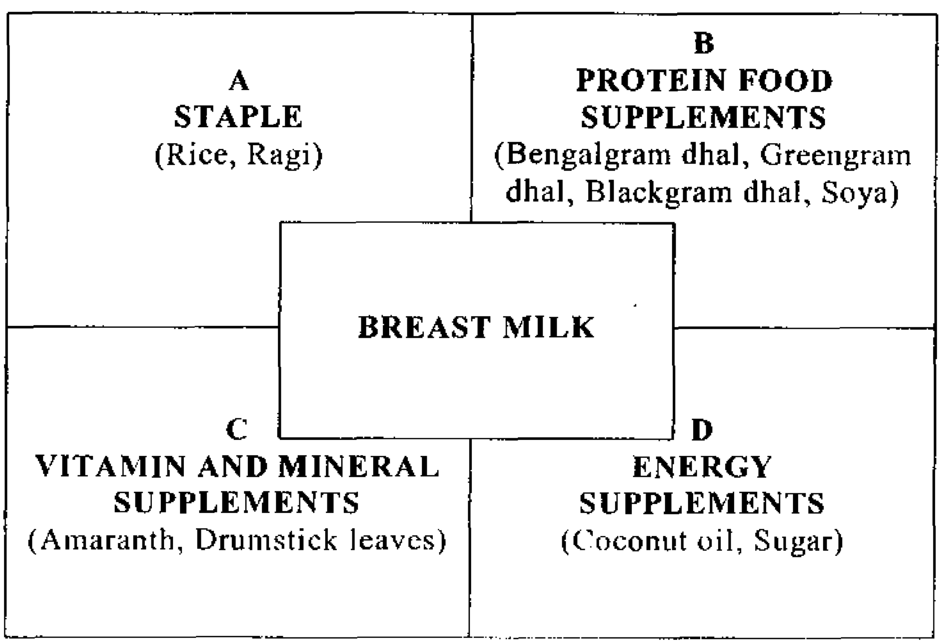
3.3 SELECTION OF OTHER INGREDIENTS TO FORMULATE A COMPREHENSIVE MULTIMIX BASED ON THE PRINCIPLE OF "FOOD SQUARE"

As per the concept of "food square" suggested by PAG (1975) four components are essentially needed to fabricate a complementary food suitable for feeding an infant, a staple, a protein food, a vitamin-mineral supplement and an energy supplement.

Accordingly as the staple and the protein components are already available in the basic mixes and in the primary multimixes, vitamin – mineral supplements and energy supplements had to be selected and added to the primary mixes to make them effective multimixes.

Therefore locally used green leafy vegetables *viz*, amaranth /drumstick leaves were selected as vitamin – mineral supplement. Sugar and coconut oil were selected as energy supplements being substances of high calorie content and items of universal use in Kerala. The ingredients selected in the study to formulate the complementary food based on "food square" principle are shown in Fig. 1.

Fig. 1 Food square



The nutritive value of the above 22 combinations were worked out using Nutritive value table of ICMR (1991) and the details are presented in Appendix II. The overall picture revealed that the selected mixes had protein content ranging from 8 – 12 g per 100 g. But an ideal cereal based weaning food should supply at least 14 g of protein per 100 g. as per **IS** 1656 – 1969 recommendation. Being a non-milk formulation, in order to meet standard IS requirements for protein, soya was also chosen as an ingredient of the multimix.

3.4 PROCESSING OF MULTIMIXES

The methodology adopted for converting raw ingredients into multimixes are shown in the two flow charts Fig. 2 and Fig.3.

3.5 STANDARDIZATION AND PREPARATION OF RECIPE

The mixes are to be converted into a recipe in order to feed the same to an infant. As suggested by Malleshi (1995) the complementary food given to a child should form a slurry or semi-solid mass of soft consistency in order to enable the child to swallow it easily.

Based on the above criteria the multimixes were further processed individually in to thick porridges suitable for spoon feeding of infants of six to nine months of age .

For converting the developed multimixes in to a porridge procedure used by Gopaldas and Deshpande (1995) was adopted with required modifications and was standardized. Thus twenty five gram of multimix was made into a slurry without lumps by adding 150 ml to 175 ml water. Fifteen grams of sugar was also added and cooked over flame by constant stirring in order to prevent lump formation or charring. After cooking three drops of coconut oil was added.

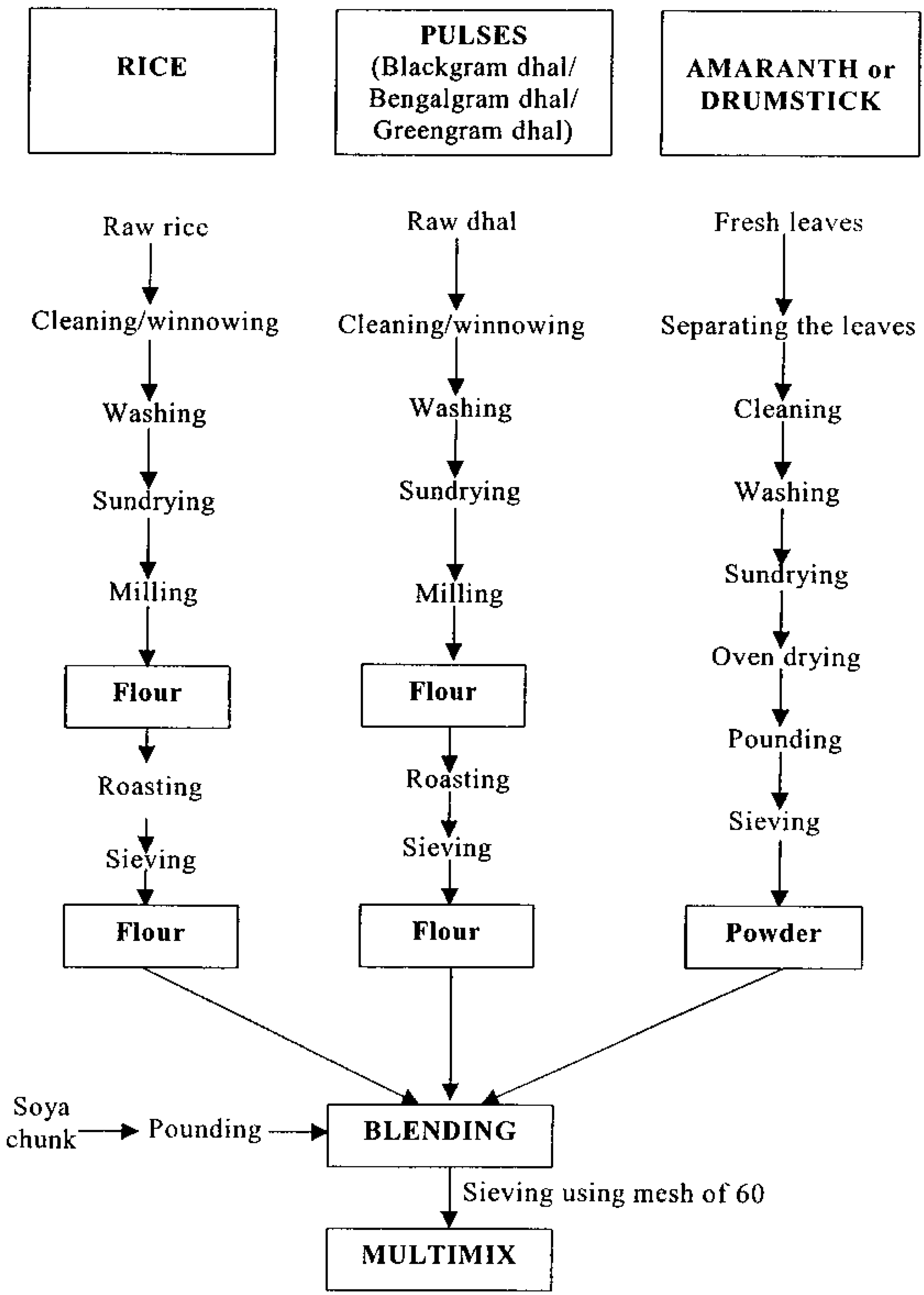


Fig. 2. Processing of multimixes (Rice with one/two pulses)

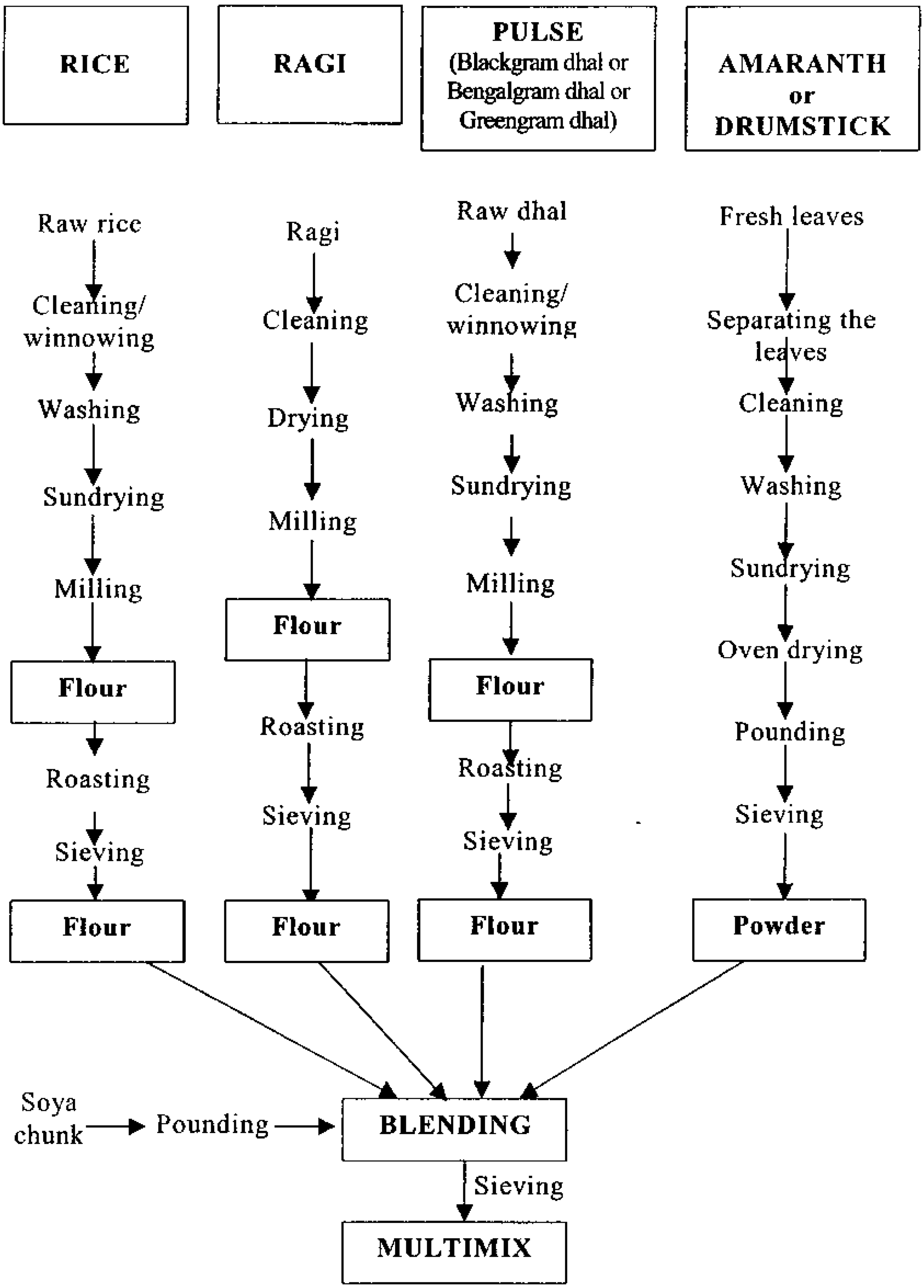


Fig. 3. Processing of multimixes containing two cereals and one pulse

3.6 ORGANOLEPTIC EVALUATION

In order to identify the most suitable product from the 22 combinations an attempt was made to evaluate the acceptability through organoleptic evaluation using a score card given in Appendix IV. The overall acceptability score of each recipe was found out separately by adding the individual scores for six characters given in the score card, such as appearance, colour, flavour, consistency, taste and doneness. The organoleptic evaluation was done by a panel of ten expert judges using standard procedure under recommended conditions.

The maximum score for a recipe as per scoring system adopted was 30 and the minimum was 5. The overall acceptability scores of the 22 multimixes were compared and ten mixes having the highest acceptability scores were selected for large scale processing.

3.7 LARGE SCALE PROCESSING FOR COMMERCIAL EXPLOITATION

An attempt was made to process the selected ten mixes on a large scale for commercialization.

All the ten multimixes were further diversified in to two groups of ten each, one set containing amaranth and other set containing drumstick as the mineral and vitamin supplement so as to find out which is more effective and acceptable. Thus there were 20 multimixes for large scale processing for commercial exploitation and the composition is given in Table 3.

Table 3. Code number and composition of multimixes

Sl. No.	Code number of multimix	Ingredients	Proportions
1	1A/1DS	Rice + ragi + blackgram + soya + amaranth/drumstick	55:10:15:15:5
2	2A/2DS	Rice + blackgram + soya + amaranth/drumstick	70:10:15:5
3	3A/3DS	Rice + Ragi + greengram + soya + amaranth/drumstick	60:10:10:15:5
4	4A/4DS	Rice + greengram + soya + amaranth/drumstick	60:20:15:5
5	5A/5DS	Rice + bengalgram + soya + amaranth/drumstick	75:5:15:5
6	6A/6DS	Rice + blackgram + bengalgram + soya + amaranth/drumstick	60:10:10:15:5
7	7A/7DS	Rice + bengalgram + soya + amaranth/drumstick	70:10:15:5
8	8A/8DS	Rice + blackgram + soya + amaranth/drumstick	55:25:15:5
9	9A/9DS	Rice + bengalgram + soya + amaranth/drumstick	65:15:15:5
10	10A/10DS	Rice + Bengal gram + greengram + soya + amaranth/drumstick	50:25:5:15:5

A: Amaranth, DS : Drumstick

3.7.1 DRUM DRYING

One of the most commonly employed modern methods of processing of weaning foods, *viz*, drum drying was initially envisaged for commercial large scale processing of the multimixes. However the process failed due to gelatinisation of mixes while feeding the material in to the roller drums. Hence the process was abandoned and extrusion, another modern food processing technology, was adopted to process the complementary food.

3.7.2 EXTRUSION

A laboratory model of *Lamonferrina* an Italian extruder was used for processing the multimixes.

The steps involved in extrusion of multimixes are shown in Fig.4. Extrusion of mixes are given in plates 1 and 2.

3.8 SELECTION OF BEST COMBINATION

As there were 20 multimixes, it was essential to identify best mixes for large scale production. Therefore, the extruded mixes were made into a porridge of spoon feeding consistency, adopting a standard procedure, and were subjected to organoleptic evaluation, by a panel of 10 expert judges using score card method. Based on organoleptic scores, the twenty mixes were ranked. Based on the ranking, four multimixes were selected for further detailed analysis, *viz.*, chemical, physical and rheological, nutritional, sanitary and shelf life for identifying the most suitable multimix.

3.9 ASSESSMENT OF CHEMICAL COMPOSITION OF THE MULTIMIXES

The chemical composition of the selected four mixes were ascertained by estimating selected nutrient and non-nutrient content using standard laboratory methods shown in Table 4.

MULTIMIX

↓

Steaming (5 mts)

↓

Sieving

↓

Loading into the extruder

↓ Addition of water (150-200 ml)

Kneading (15 mts)

↓

Extrusion

↓

Steaming (5 mts)

↓

Drying in hot air oven (150°C)
(2 – 3½ hours)

↓

Pulverizing

↓

Sieving (60 with mesh)

↓

Packing

Fig. 4. Steps involved in extrusion

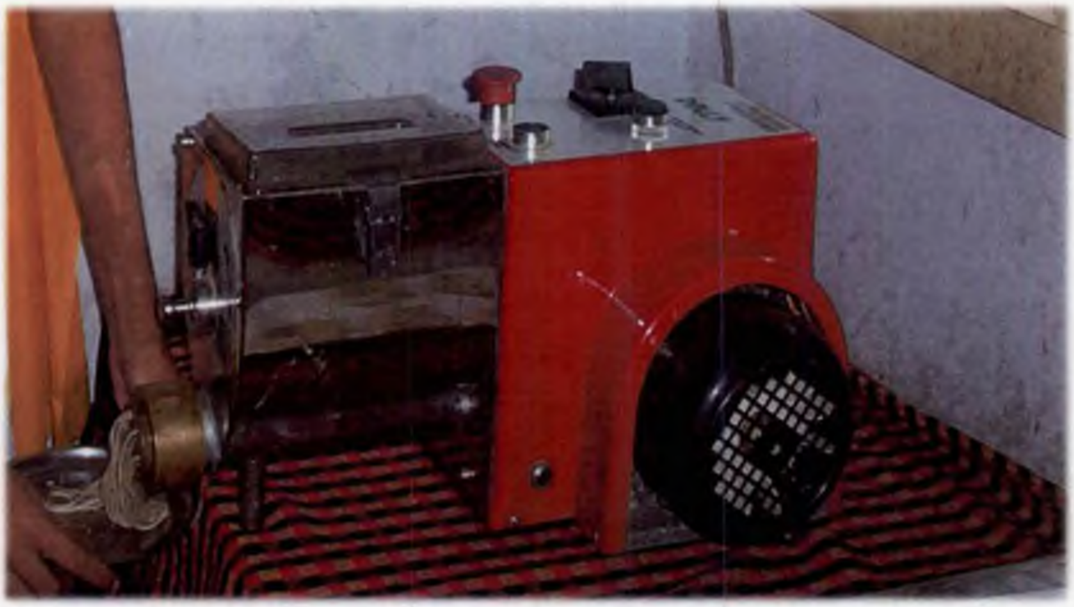


Plate 1. Mixes extruding

Plate 2. Extruded mixes

Table 4. Methods used for estimation of nutrient and non-nutrient content of multimixes

Components	Methods used (References)
Total protein	Jackson (1973)
Fat	Sadasivam and Manikam (1992)
Total carbohydrate	Sadasivam and Manikam (1992)
Iron	Jackson (1973)
Calcium	Tandon (1993)
Sodium	Tandon (1993)
Potassium	Jackson (1973)
Moisture	AOAC (1984)
Crude fibre	Sadasivam and Manikam (1992)
Total ash	AOAC (1984)

Triplicate samples of each of the four multimixes were analysed for obtaining reliable data.

3.10 ASSESSMENT OF PHYSICAL AND RHEOLOGICAL CHARACTERISTICS OF THE FOUR MULTIMIXES

Physical and rheological characteristics are one of the important criteria which determines the acceptability of a product. The characteristics such as bulk density, viscosity, particle size, yield ratio and ease of preparation were ascertained utilizing the methodologies detailed below.

3.10.1 Bulk Density

Bulk density is the ratio of the weight of the sample to that of an equal volume of water. Bulk density is used as an index for comparing the volume of different foods. The sample was taken at a height of 20 ml in a 250 ml graduated measuring cylinder. It was levelled without compressing. The weight of the sample with the cylinder was recorded.

The sample was then removed from the measuring cylinder and water was filled to the same level (20 ml). The weight of the water with the measuring cylinder was recorded and bulk density was calculated using the formula

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

3.10.2 Viscosity

The viscosity of four mixes were measured using Rapid Visco Analyser (RVA).

Five grams of the sample was weighed into the Cannester and 25 g of water was added. The paddle was introduced into the Cannester and was attached to the RVA. The instrument was started and programmed for the run. Sample was heated from 50-95° C (@ 12 degree per minute) and allowed to stand for four minutes at 95° C. It was then cooled back to 50°C and allowed to stand for another two minutes. The viscosity was measured at regular intervals.

3.10.3 Particle Size Distribution

The particle size of the multimixes were evaluated by passing the multimixes through a standard sieve as suggested by Kulkarni *et al.* (1991).

3.10.4 Yield Ratio

A product after processing and preparation should have maximum yield and minimum processing loss. Therefore the processing loss and yield ratio were calculated.

3.10.4.1 Processing Loss (Raw Ingredients)

The difference between the weight of the ingredients "as purchased" (AP weight) and that of the 'edible portion' (EP weight) gives the processing loss. The processing loss was calculated using the formula.

$$\text{Processing loss} = \frac{\text{AP weight} - \text{EP weight}}{\text{AP weight}}$$

3.10.4.2 Yield Ratio

To determine the yield ratio, yield of the raw multimixes as well as that of the recipe prepared from it were analysed.

3.10.4.2.1 Yield Ratio of Raw Ingredients

Yield ratio of the raw ingredients was determined by finding out the ratio between final weight and initial weight of the raw ingredients using the following formula.

$$\text{Yield ratio} = \frac{\text{Final weight}}{\text{Initial weight of raw ingredients}}$$

3.10.4.2.2 Yield Ratio (recipe)

The yield ratio of the recipe was computed using the formula given below.

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

3.10.4.3 Ease of preparation (recipe)

The time required for processing the multimix into a recipe (porridge) was determined to find out the ease of preparation.

3.11 ASSESSMENT OF NUTRITIONAL ADEQUACY

To determine the nutritional adequacy calorific value, protein energy ratio, chemical score and amino acid score of the four multimixes were computed using the methods described below.

3.11.1 Calorific Value

The calorific value of multimixes were calculated using energy content of the raw ingredients in the multimix as given in "Nutritive value of Indian foods" (ICMR, 1991).

3.11.2 Protein Energy Ratio

The protein energy ratio of the product was computed (Swaminathan, 1984).

$$\text{Protein energy ratio} = \frac{\text{Protein content in food} \times 4}{\text{Energy value of food}} \times 100$$

3.11.3 Chemical and Amino Acid Score

Chemical and amino acid score were determined using the formula given under 3.1.

3.12 PRODUCT QUALITY INDEX

Product quality index for chemical, physical and rheological and nutritional adequacy were calculated to find out the most acceptable product with respect to the above three parameters using the formula given below.

$$\text{Adequacy index of } i^{th} \text{ product} = \sum_{j=1}^{K} \left[x_{ij} - s_j \right] \Big/ \sigma_j$$

K = number of characters under respective parameters

x_{ij} = value of j^{th} character of I^{th} product

s_j = standard value for j^{th} character

σ_j = standard deviation for j^{th} character

3.13 SANITARY QUALITY OF MULTIMIXES

The sanitary quality of the multimixes were assessed by enumerating the total bacterial count and testing the presence of *E. coli*, if any. The four multimixes were assessed for their total bacterial count by serial dilution plate technique recommended by Mehrotra (1980). They were also evaluated for the presence of *Coliform* bacteria using the presumptive test explained by Collins and Patricia (1976).

3.14 SHELF LIFE OF MULTIMIXES

To determine the shelf life, the multimixes were packed in polyethylene covers and were stored for a period of three months. The products were opened and examined for chemical, physical, microbial and organoleptic quality parameters after a period of 90 days.

3.14.1 Chemical Parameters

Chemical characters of the multimix were analysed after a period of 90 days by estimating peroxide value (Sadasivam and Manikam, 1992) and moisture content (AOAC, 1984).

3.14.2 Physical Parameters

Extend of damage by insect/pests in the four multimixes were found out by visual examination.

3.14.3 Total Bacterial Count

Total bacterial count of the multimixes after 90 days were also analysed by serial dilution (Mehrotra, 1980) method.

3.14.4 Organoleptic Evaluation

Organoleptic quality of the four multimixes were also analysed by a panel of 10 judges after the storage period.

3.15 COMPARISON OF DEVELOPED PRODUCT WITH IS: STANDARD AND CONTROL

The four developed products were compared with IS standard specification stipulated under 1656-1969 for processed cereal weaning foods. The products were also compared with a control which is a popular commercial complementary food used for feeding infants in Kerala *i.e.,* Nestum. Moreover, Nestum was selected as control because, it is a rice based product and is given to infants of age group 6-12 months. The parameters used for comparing the developed products with the IS standard were moisture, total protein, fat, total carbohydrate, calcium, iron, total ash, acid insoluble ash and fibre.

3.15.1 Cost

Cost of the multimixes were computed according to the existing market price of individual ingredients used in the four developed formulations and by adding 20 per cent as overhead charges. This was compared with that of the commercial formula 'Nestum'.

3.16 PREFERENCE TEST FOR SELECTED MULTIMIXES

Preference test for selected multimixes were assessed using hedonic rating scale suggested by Srilakshmi (2002). Ten mothers of children attending, Anganwadi Centre-19 at Poonkulam were chosen as judges to find out the most preferred formulation.

3.17 STATISTICAL ANALYSIS.

The data generated were compiled, tabulated and analysed statistically using simple statistical tools.

Results

4. RESULTS

The results of the investigation entitled "Developing rice based complementary food for infants" are presented in this chapter.

4.1 FORMULATION OF BASIC MIX

According to Lokeshwar (2005) a basic mix for an infant formula comprises of two ingredients namely a cereal and a pulse.

In the present study rice formed the cereal component and pulses such as black gram dhal, bengal gram dhal, green gram dhal, red gram dhal, cowpea, peas and soya were selected to formulate the basic mix.

Sixty four combinations of basic mixes were formulated with different quantities of pulse added to rice and it varied from ten to fifty per cent; while rice contributed not less than fifty per cent of the basic mix.

In order to identify a basic mix that has an ideal admixture of rice and pulse, amino acid score and chemical score were workedout as they would give an indication to protein quality.

Amino acid and chemical scores of the above combinations are given in Appendix-1.

Among the sixty four combinations eleven combinations that had high chemical score (above 80) were identified at the primary level to be used as basic mix. The eleven combinations are given in Table 1. The combinations having rice and green gram in the ratio of 80 : 20, 65 : 35, 60 : 40 and 70 : 30 were found to have a chemical score of 86, 85, 87 and 84 respectively.

The basic mixes with rice and bengal gram in the proportion of 75 : 25, 85 : 15, 70 : 30, 90 : 10 had chemical scores of 83, 84, 85 and 84 respectively.

Rice and black gram combinations exhibited a chemical score of 86, 87, 86 for combinations 70 :30, 80 : 20 and 65 :35 respectively.

Based on the result presented in Table 1, it is observed that rice + green gram combination and rice + black gram combination in the proportion of 60 : 40 and 80 : 20 respectively have high chemical score, *i.e.*, 87, while rice + bengal gram in the ratio of 75 : 25 has the least chemical score of 83.

4.2 FORMULATION OF MULTIMIX

Multimixes were formulated by adding other ingredients to the basic mix in two different ways.

In the first method, a second cereal was added to the basic mix. Ragi or wheat were chosen as second cereal ; and 108 combinations were formulated and their amino acid and chemical score were calculated.

In the second method, an additional pulse was added to the basic mix. Thus 139 combinations having two pulses added to rice in various proportions were worked out and chemical score and amino acid score of these combinations were computed. Among these 247 (108 + 139) combinations those having chemical scores above 80 were further identified. The selected multimix combinations along with their chemical score are given in Table 2.

The combinations containing wheat were excluded since rice + wheat + pulse combinations are very common.

Multimixes containing rice + ragi + green gram in the proportion of 65 : 15 : 20 and 75 : 10 : 15 were found to have a chemical score of 96 and 93. While rice + ragi + bengal gram and rice + ragi + black gram in the proportion of 75 : 10 : 15 and 65 : 15 : 20 had a chemical score of 95 and 86 respectively.

As far as the rice + black gram + bengal gram combinations of 60 : 20 : 20 , 65 : 15 : 20 and 55 : 15 : 30 were concerned, they had a chemical score of 83, 83 and 82 respectively while, rice + black gram + green gram in a proportion of 60 : 20 : 20 had a chemical score of 84. It was also noted that rice + bengal gram + green gram in the ratio of 65 : 15 : 20, 60 : 30 : 10 and 70 : 15 : 15 had a chemical score of 84, 83 and 84 respectively. Hence from the data, it was clear that rice + ragi + green gram in the proportion of 65 : 15 : 20 have the highest chemical score of 96

4.3 SELECTION OF OTHER INGREDIENTS TO FORMULATE A COMPREHENSIVE MULTIMIX BASED ON THE PRINCIPLE OF "FOOD SQUARE."

The concept of "Food Square" system has been adopted for formulation of a comprehensive multimix. To make an ideal complementary food four components are essentially needed : a basic staple, an energy rich supplement, a protein supplement and a vitamin-mineral supplement which has been illustrated in a "Food Square" suggested by PAG (1975).

It may be noted that the staple and the protein components are already available in the basic mixes and in the primary multimixes given in Tables 1 and 2 (Chapter: 3).

Further, following the principles of "Food Square" amaranth leaves were selected to be incorporated into the mixes as vitamin - mineral supplement and sugar and coconut oil were selected as energy supplements. Thus, 22 combinations of multimixes as per "Food Square" were formulated. However, when the nutritive value was calculated, it was seen that the mixes supplied only 8 to 12 grams of protein, and hence powdered soya chunks was added to all mixes so as to enhance the protein value as per IS requirements. The composition of the comprehensive multimixes thus formulated are given in Table-5.

Table 5. Composition of multimixes based on "Food Square"

Code. No.	Ingredients	Quantity in grams
A1	Rice + Green gram + Soya + Amaranth	70 : 10 :15 : 5
A2	Rice + Green gram +Soya + Amaranth	55 : 25 : 15: 5
A3	Rice + Green gram +Soya + Amaranth	50: 30:15:5
A4	Rice + Green gram + Soya + Amaranth	60:20:15: 5
A5	Rice + Bengal gram + Soya + Amaranth	65:15:15:5
A6	Rice + Bengal gram + Soya + Amaranth	75:5:15:5
A7	Rice + Bengal gram + Soya + Amaranth	60:20:15:5
A8	Rice + Bengal gram + Soya + Amaranth	70:10:15:5
A9	Rice + Black gram + Soya + Amaranth	70:10:15:5
A10	Rice + Black gram + Soya + Amaranth	60:20:15:5
A11	Rice + Black gram + Soya + Amaranth	55:25:15:5
A12	Rice+ Ragi + Green gram + Soya + Amaranth	55:10:15:15:5
A13	Rice + Ragi + Bengal gram + Soya + Amaranth	60:10:10:15:5
A14	Rice + Ragi + Greengram + Soya + Amaranth	60:10:10:15:5
A15	Rice + Ragi + Black gram + Soya + Amaranth	55:10:15:15:5
A16	Rice + Black gram + Bengal gram + Soya + Amaranth	50:15:15:15:5
A17	Rice + Black gram + Bengal gram + Soya + Amaranth	55:10:15:15:5
A18	Rice + Black gram + Bengal gram + Soya + Amaranth	60:10:10:15:5
A19	Rice + Black gram + Green gram + Soya + Amaranth	50:15:15:15:5
A20	Rice + Bengal gram + Green gram + Soya + Amaranth	55:10:15:15:5
A21	Rice + Bengal gram + Green gram + Soya + Amaranth	50:25:5:15:5
A22	Rice + Bengal gram + Green gram + Soya + Amaranth	60:10:10:15:5

4.4 PROCESSING OF MULTIMIX

The twenty two multimixes were processed initially using cottage level techniques. In the case of multimixes containing rice with one or two pulses, raw rice was cleaned, washed, sun dried and subjected to milling to obtain rice flour. This flour was further roasted and sieved (60 microns mesh size) to obtain fine flour having even particle size. Flours using pulses (dhals) were also prepared following the same procedure. In the case of amaranth and drumstick leaves, fresh leaves were separated from the stalk, shriveled and spoilt ones were discarded. The sound leaves were washed in running water and sun dried. These were further oven dried, pounded, sieved and made into a fine powder. Rice and pulse flours along with amaranth or drumstick leaves powder were blended together in prescribed proportion after addition of powdered soya chunks. These blends were sieved independently using sieve of 60 mm mesh size to get twenty two multimix formulations. The same procedure was followed in the preparation of multimixes with two cereals and one pulse. The second cereal ragi was cleaned, dried and milled and made into flour which was further roasted and sieved. Other three components (rice, pulse, amaranth/drumstick leaves) were prepared by the same method as in the former case. Rice, ragi and pulse flours were mixed with amaranth or drumstick powder and sieved.

Through the above process, 22 different weaning mixes in the form of "Blended flours" having fine consistency, attractive cream colour and even particle size of 60 mm size were obtained. In order to utilize the mixes as a complementary food, the flours had to be converted into a 'recipe' suitable for feeding an infant of six to nine months of age.

Therefore, each of the 22 mixes were processed into a "Porridge" suitable for spoon feeding of an infant, adopting the procedure recommended by Gopaldas and Deshpande (1995). These porridges were subjected to organoleptic evaluation by a panel of ten judges using the score card method to select acceptable mixes. The mean acceptability scores of the porridge made from the mixes are given in Table 6. The acceptability scores assigned by the judges are given in Appendix-V.

Table 6. The mean acceptability score of selected multimixes

Multimixes	Parameters						Total score	Rank order
	Appearance	Colour	Flavour	Consistency	Taste	Doneness		
A_1	3.7	3.7	3.9	3.6	3.6	4.2	23.3	XI
A_2	4.0	3.6	3.3	3.9	3.0	4.3	22.1	XVII
A_3	4.3	4.0	3.3	3.5	3.2	4.4	22.7	XVI
A_4	3.7	4.2	4.0	4.8	4.3	3.5	24.3*	IV
A_5	3.9	3.8	4.4	4.2	3.7	3.5	23.5*	IX
A_6	3.7	3.4	4.3	4.2	4.3	4.4	24.3*	V
A_7	3.3	3.4	3.5	3.5	3.2	4.4	21.3	XVII
A_8	4.1	3.7	3.4	4.7	3.5	4.6	24.0*	VII
A_9	4.1	4.3	3.7	4.3	4.2	4.4	25.0*	II
A_{10}	3.3	3.5	3.0	3.4	3.3	4.5	21.0	XIX
A_{11}	4.3	4.3	3.3	4.3	3.0	4.4	23.6*	VIII
A_{12}	3.5	3.4	3.5	4.5	3.4	4.4	22.7	XIV
A_{13}	4.2	3.7	3.3	3.9	3.0	4.3	22.4	XV
A_{14}	4.1	4.0	3.5	4.5	3.6	4.7	24.4*	III
A_{15}	4.1	4.2	4.5	4.5	3.6	4.7	25.6*	I
A_{16}	3.8	3.8	3.0	4.3	3.7	4.4	23.0	XIII
A_{17}	3.9	3.0	3.8	4.1	3.3	4.1	23.1	XII
A_{18}	3.9	4.1	3.7	4.5	4.2	3.8	24.2*	VI
A_{19}	4.0	3.7	3.4	4.2	3.5	4.2	23.0	XIII
A_{20}	4.0	3.5	3.3	3.9	3.0	4.3	22.0	XVI
A_{21}	3.8	3.9	4.2	4.4	3.5	3.7	23.5*	X
A_{22}	4.1	4.2	3.0	4.0	3.6	4.1	23.0	XIII

*Mixture selected for large-scale processing

From the total score, it was seen that multimix A15 had secured the highest score (25.6) whereas, least score was for A10 (21.0). Ten mixes (marked* in the table) had scores above 23.5 out of 30. These multimixes were considered as most acceptable and were observed to contain amaranthus as the vitamin-mineral supplement. As drumstick is a cheap and easily available green leafy vegetable available in plenty, 10 more mixes were processed replacing amaranth with drumstick. The twenty mixes (10 containing amaranth and 10 containing drumstick leaves) were then redesignated and were given code numbers ranging from 1 to 10 based on the ranking order and the suffixes 'A' or 'DS' were given depending on the presence of amaranth or drumstick leaves in the multimix. These were further processed for large scale commercial exploitation.

4.5 LARGE SCALE PROCESSING FOR COMMERCIAL EXPLOITATION

One of the most commonly practiced modern method of processing weaning food, *viz.*, drum drying, was envisaged for large scale processing of rice based complementary food. But due to the gelatinization this process could not be employed. Hence the most modern food processing technology, *i.e.*, Extrusion was adopted. Thus multimixes were processed by extrusion as per the method given in Fig. 4.

Quality of these mixes were evaluated based on four parameters, *viz.*, yield ratio, nutritive value, cost and organoleptic quality.

4.5.1 Yield Ratio

Yield ratio of the 20 multimixes are given in Table 7. Yield ratio of both multimixes with amaranth and drumstick were found to range between 0.61 to 0.73. 9DS was found to have the highest yield ratio 0.73 while 3A, 7A, 9A, 3DS and 6DS had a value of 0.71. The table further gives the fact that multimixes 6A and 5DS were found to have the lowest yield ratio of 0.61.

Table 7. Yield ratio of 20 multimixes

Multimixes	Yield ratio	Multimixes	Yield ratio
1A	0.68	1DS	0.68
2A	0.70	2DS	0.67
3A	0.71	3DS	0.71
4A	0.67	4DS	0.63
5A	0.68	5DS	0.61
6A	0.61	6DS	0.71
7A	0.71	7DS	0.68
8A	0.68	8DS	0.62
9A	0.71	9DS	0.73
10A	0.64	10DS	0.70

4.5.2 Nutritive Value

The nutritional superiority of the mixes were evaluated based on the content of major nutrients such as carbohydrate, protein and fat and the values are presented in Table 8. The energy content of the mixes were also calculated and recorded.

From the table it was found that among twenty multimixes, 5DS had the highest energy content of 394 kcals and 2A secured the lowest value of 314 kcals. While carbohydrate content was high in the multimix 3DS (70.55 g) and low in 10A (60.47 g). Protein and fat content of the twenty multimixes were calculated and from the data it was found that protein content was highest in 6DS (18.92 g) and it was low in 5DS (14.49 g) and the fat content ranged from 4.93 g (7A) to 3.01 g (8DS).

Table 8. Nutritive value of 20 multimixes per 100 gram

Sl.No	Multimixes	Nutrients			
		Energy (Kcal)	Carbohydrate (g)	Protein (g)	Fat (g)
1	1A	341	62.59	17.45	4.79
2	2A	314	63.87	18.32	4.32
3	3A	339	70.23	18.16	4.76
4	4A	341	61.70	15.17	3.32
5	5A	392	65.08	16.32	3.10
6	6A	352	62.03	18.42	4.62
7	7A	345	64.16	16.42	4.93
8	8A	343	60.85	17.50	3.91
9	9A	347	63.11	16.37	4.01
10	10A	349	60.47	15.48	3.01
11	1DS	343	62.91	17.37	4.04
12	2DS	316	64.19	18.14	4.62
13	3DS	342	70.55	18.26	4.56
14	4DS	343	62.02	15.18	3.01
15	5DS	394	65.40	14.49	3.19
16	6DS	356	62.35	18.92	4.52
17	7DS	347	64.48	16.31	4.86
18	8DS	345	61.17	17.40	3.01
19	9DS	349	63.4 3	16.39	4.39
20	10DS	351	60.79	14.69	3.73

4.5.3 Cost

The cost of the multimixes were calculated on the basis of market value of the ingredients used to process one kilogram, to which 20 per cent was added as overhead charges.Cost of 20 multimixes is presented in the Table 9.

Table 9. Cost of 20 multimixes per kilogram

Multimixes	Cost	Multimixes	Cost
1A	23.00	1DS	18.00
2A	27.00	2DS	22.00
3A	32.00	3DS	22.00
4A	30.00	4DS	24.00
5A	24.00	5DS	18.00
6A	35.00	6DS	29.00
7A	34.00	7DS	29.00
8A	29.00	8DS	23.00
9A	23.00	9DS	18.00
10A	23.00	10DS	18.00

The cost of multimixes varied from 18 Rs per kilogram to 35 Rs per kilogram. Another feature which was clear from the table was that the mixes containing drumstick leaves had a lower cost (ranging from Rs.18 to 29 per kg) when compared to those containing amaranth leaves (23 to 35 Rs). It was further noticed that among the mixes containing drumstick leaves 1DS, 5DS, 9DS and 10DS were lower in cost (Rs.18 per kg) when compared to other mixes; while 6DS and 7DS had higher cost (29 Rs per kg). It was also noticed that mixes containing amaranth leaves 1A, 9A and 10A were lower of cost Rs.23 per kg while 6A was found to cost Rs. 35 per kg, being the costliest.

4.5.4 Organoleptic Evaluation

All the twenty multimixes were subjected to organoleptic evaluation using a score card by a panel of ten expert judges and six characteristics namely, appearance, colour, flavour, consistency, taste and doneness were evaluated. The mean scores were tabulated and the results are presented in Table 10.

In the case of appearance, the mean score was found to range from 2.7 for the multimix 9A to 4.3 for the multimix 8A out of a maximum score of 5.0. Scoring for colour revealed that the highest score was recorded for 8A (4.3) and lowest was for 9A (2.7). Three multimixes, *viz.*, 2DS, 2A and 10DS had the maximum scores of 3.9 for flavour, while 6A had the minimum score of 2.9, while scoring for consistency the values were found to vary from 3.0 (6A) to 4.7 (3A). For taste, 10DS was found to have the highest score of 3.8 and 10A and 6A were recorded to have the lowest score of 2.7. When doneness was considered the score was found to range from a minimum of 3.7 (6DS) to a maximum of 4.7 (8DS).

Significant difference at one percent level was found with respect to appearance and consistency between the various mixes, while in the case of colour, the difference was significant at five per cent level. For the rest of the quality parameters, the difference were found to be nonsignificant

The mean score obtained for six characteristics of individual mixes were added up to find the total mean score. Here the mean score of those mixes in DS stream (drumstick leaves added mixes) ranged from 19.9 (6DS) to 24.6 (8DS) and that of A (amaranth leaves added mixes) ranged from 18.6 (6A) to 24 (3A) out of a maximum attainable score of 30. Significant difference (at five percent level) were observed between the different multimixes as far as their total acceptability scores were concerned.

Table 10. Mean acceptability score for different organoleptic characteristics of the multimixes

Sl. No	Multi-mixes	Appearance		Colour		Flavour		Consistency		Taste		Doneness		Total mean score			
														DS		A	
		DS	A	DS	A	DS	A	DS	A	DS	A	DS	A	Mean	Rank	Mean	Rank
1	1	3.9	3.7	3.9	3.7	3.8	3.5	4.2	4.5	3.3	3.4	4.1	4.4	23.2		23.2	
2	2	3.8	3.3	3.1	3.3	3.9	3.9	4.3	3.4	3.7	3.3	4.4	4.5	231		21.7	
3	3	4.2	4.1	3.8	4.1	3.7	3.4	4.5	4.7	3.1	3.5	4.2	4.2	24.1	II	24.0	III
4	4	3.6	3.1	3.8	3.1	3.6	3.6	3.7	3.3	3.2	3.1	4.3	4.3	22.2		20.5	
5	5	3.4	4.0	3.7	4.0	3.5	3.3	4.0	3.9	3.4	3.0	4.1	4.3	22.1		22.5	
6	6	3.1	2.8	3.4	2.8	3.1	2.9	3.7	3.0	2.9	2.7	3.7	4.4	19.9		18.6	
7	7	3.3	3.8	3.4	3.8	3.5	3.4	3.9	4.2	3.2	3.6	4.5	4.3	21.8		23.1	
8	8	4.1	4.3	4.2	4.3	3.5	3.3	4.5	4.0	3.6	3.0	4.7	4.4	24.6	I	23.3	IV
9	9	3.2	2.7	3.2	2.7	3.7	3.7	4.1	3.8	3.5	3.0	4.5	4.4	22.2		20.3	
10	10	3.3	3.2	3.3	3.2	3.9	3.4	4.1	3.7	3.8	2.7	4.5	4.3	22.9		20.5	
F value		3.337**		1.744*		1.323^{NS}		2.743**		1.280^{NS}		0.998^{NS}		1.93*			
CD		0.71		0.76		0.64		0.77		0.80		0.59		0.52			

NS – Not significant, *Significant at 5 per cent level, **Significant at 1 per cent level

Based on the total acceptability scores, the twenty mixes were ranked. Based on ranking, multimixes 8DS, 3DS, 3A and 8A were found to occupy the first four positions.

As acceptability is one of the most important characteristics for selection of a food, these mixes that had high rank order, *viz.*, 3A, 3DS, 8A and 8DS were selected for further detailed analysis for identifying most suitable multimix. The composition of the four multimixes selected are given in Table 11.

Table 11. Composition of the four selected multimixes

Multimixes	Ingredients	Proportion (g)
3A/3DS	Rice	60
	Ragi	10
	Greengram dhal	10
	Soya	15
	Amaranth/Drumstick leaves	5
8A/8DS	Rice	55
	Black gram dhal	25
	Soya	15
	Amaranth/Drumstick leaves	5

As indicated in table 11 the multimix 3A and 3DS contained rice, ragi, green gram , soya and amaranth in the proportion of 60 per cent, 10 per cent, 10 per cent, 15 per cent and 5 per cent respectively. The only difference that existed between 3A and 3DS was that 3DS had drumstick leaves in the place of amaranth added to 3A. The multimixes 8A and 8DS had 55 per cent of rice, 25 per cent of black gram dhal, 15 per cent of soya and 5 per cent of the green leafy vegetable. While 8A had amaranth, 8DS contained drumstick leaves.

In order to analyze the suitability of four multimixes for feeding infants they were further subjected to chemical, physical and rheological, nutritional, sanitary quality evaluation and for shelf stability test. The results obtained from the above investigations are detailed below.

4.6 THE CHEMICAL COMPOSITION OF MULTIMIXES

In order to assess the chemical nature of the selected four multimixes, they were subjected to chemical analysis. They were analyzed for their moisture, total protein, fat, total carbohydrate, crude fibre, iron, calcium, sodium, potassium, total ash and acid insoluble ash content through standard laboratory techniques and the results obtained are presented in the Table 12. They are the mean values of triplicate samples analyzed.

Table 12. Chemical Composition of the selected multimixes

Components/100g of the Multimix	**Multimix**					
	3A	**3DS**	**8A**	**8DS**	**F**	**CD**
Moisture (g)	3.75	2.99	2.83	2.38	17.419**	0.5338
Total Protein (g)	17.45	16.35	16.50	15.80	41.810**	0.41660
Fat (g)	4.10	4.00	3.10	2.20	23.470**	0.7376
Total Carbohydrate (g)	68.00	70.50	54.00	56.50	179.777**	2.404
Total Ash (g)	0.0785	0.0745	0.093	0.084	22.849**	6.9405
Acid Insoluble Ash (g)	0.0034	0.0034	0.0038	0.0038	0.439 ^{NS}	1.517
Crude Fibre (g)	1.525	1.97	0.7	0.825	29.099**	0.436
Calcium (mg)	320	340	240	180	27.33**	55.52
Sodium (mg)	0.013	0.009	0.011	0.008	716.298**	3.101
Potassium (mg)	0.064	0.050	0.067	0.056	782.216**	8.7426
Iron (mg)	10.5	11.75	6.75	8.75	100.777**	0.8499

** Significant at 1 percent level , NS Not Significant

As shown in Table12, the moisture content of the multimix 3A was 3.75 g whereas 3DS contained 2.99g and 8A and 8DS were found to contain 2.83 g and

2.38 g of moisture per 100g of the sample. As revealed from the table multimix 8DS had the lowest moisture content while 3A had the highest value. The data also revealed that there was significant difference between the four samples, as far as the moisture content was concerned.

Total protein content of the multimixes ranged from 15.80g to 17.45g and highest protein content was observed in multimix 3A while 8DS had the lowest value of 15.80g per 100g. 3DS and 8A had a protein content of 16.35g and 16.50g respectively.

Fat content was found to be high in the multimix 3A *i.e.*, 4.1 g while 8DS recorded the lowest value (2.20 g). The estimated value for fat was 4.00 g and 3.10 g for 3DS and 8A respectively. Significant difference was observed between the samples and the difference was significant at one percent level.

The total carbohydrate content were 68.00g, 70.50g 54.00g and 56.50g for the multimixes 3A, 3DS, 8A and 8DS respectively.

The total ash content varied from 0.074g to 0.093g for the four combinations. Acid insoluble ash content of the multimixes were 0.0034g, 0.0034g, 0.0038g and 0.0038g for 3A, 3DS, 8A and 8DS respectively. However the difference in this component among the mixes was not significant.

The lowest content of crude fibre was observed in multimix 8A *i.e.*, 0.70g followed by multimix 8DS (0.825g); where as 3A and 3DS contained higher fibre content compared to 8A and 8DS. The fibre content of 3A and 3DS were found to be 1.52g and 1.97 respectively per 100 g of the sample.

The multimix 3DS had the highest calcium content of 340 mg out of the four samples tested .The combinations 3A, 8A and 8DS contained 320mg, 240mg, 180mg of calcium respectively.

The sodium content of the four multimixes ranged from 0.008mg to 0.013 mg. The highest sodium content was found in the multimix 3A and lowest was for 8DS.

As shown in Table12, the content of potassium in the four multimixes were 0.064 mg, 0.056mg, 0.067mg and 0.050 mg in 3A , 3DS, 8A and 8DS respectively .

The iron content was found to be highest in the multimix 3DS being 11.75mg/100g, while 8A contained lowest iron content of 6.75 mg/100g among the four mixes analyzed. 3A and 8DS contained 10.50mg and 8.75mg of iron respectively in 100g of the sample.

In a nutshell, from the data presented in Table 12, it was observed that 3A was found to contain highest amounts of protein and fat. While considering the content of minerals such as iron and calcium 3DS was found to be superior to other three combinations. While analyzing the trace element content in the four combinations it was found that 8DS had the lowest value for sodium and potassium.

The over all picture revealed that as far as the chemical composition was concerned there was significant difference between the four mixes.

Vitamin C content were calculated and the 3A and 3DS found to be 4.9 mg per 100 g while 3DS and 8DS gave a value of 11 mg. Vitamin A content of the developed products was from 350.5 to 417.7 IU per 100 g. Thiamine and riboflavin content of the developed products ranged from 0.23 to 0.25 mg per 100 g and 0.14 to 0.155 mg per 100 g respectively.

4.6.1 Product Quality Index based on Chemical Composition

The product quality index based on chemical composition was worked out to identify the best mix.

In order to determine the quality index based on chemical composition. eleven characters such as moisture, total protein, fat, total carbohydrate, crude fibre, iron, calcium, sodium, potassium, total ash and acid insoluble ash content of four multimixes were taken into account. The quality indices obtained for the four products are presented in Table 13.

Table13. Product quality index based on chemical composition

Multimixes	Index value	Rank
3A	76754.02	II
3DS	76267.53	III
8A	85717.00	I
8DS	72071.32	IV

As shown in Table 13, the multimix 8A was found to secure the highest index value of 85717.00 and the least index value was for 8DS, 72071.32. 3A and 3DS were found to have values of 76754.02 and 76267.53 respectively.

4.7 PHYSICAL AND RHEOLOGICAL CHARACTERISTICS OF THE SELECTED MULTIMIXES

Nutritional requirement is not the only prerequisite in formulating complementary food for an infant. It should also have other favourable qualities. that makes it suitable to feed a child. Therefore physical qualities like yield, ease of preparation, particle size and rheological properties such as bulk density and viscosity were ascertained. Moreover process loss and yield were also estimated to assess commercial and economic viability of the products.

4.7.1 Yield of the Multimixes

Yield of complementary food both after processing and while converting the same into a recipe is a major factor that determines the suitability of mixes for large scale processing and commercialization. The ingredients of the mixes should give a maximum yield both after processing and during preparation. Keeping this in view, processing loss and yield ratio of multimixes during processing and yield ratio after cooking were worked out.

4.7.1.1 Processing Loss and Yield Ratio

Processing loss and yield ratio of raw ingredients are given in Table 14.

Table 14. Process loss and yield of raw ingredients

Multimix	AP (g)	EP (g)	Process loss	Yield
3A	11000	6130	0.44	0.55
3DS	11000	7400	0.32	0.67
8A	9000	4340	0.51	0.48
8DS	9000	5610	0.37	0.62

Process loss was found to range from 0.32 to 0.51 and it was found to be high in multimix 8A and low in mix 3DS and the other two mixes had a loss of 0.37 (8DS) and 0.44 (3A).

The data revealed that the highest product yield was observed for the mix 3DS followed by 8DS and 3A, while 8A recorded the lowest yield.

4.7.1.2 Yield Ratio (recipe)

Yield ratio of different supplements while converting the multimix into a recipe were worked out and details are given in Table 15.

Table 15. Yield ratio (recipe)

Multimix	Yield ratio
3A	5.80
3DS	6.67
8A	6.52
8DS	6.00

The data revealed that 3DS has the highest yield while 3A was found to be a poor yielder. While converting the dry mix into a recipe, yield ratio of 8A and 8DS were close to each other.

From the above details it was clear that product 3DS has high process yield, low processing loss as well as high yield ratio during cooking, when compared to other three mixes.

4.7.2 Ease of Preparation

The time spent for processing the multimix into a recipe (porridge) was used to determine the ease of preparation and the result obtained are depicted in Table 16.

Table 16. Time needed for preparation

Multimixes	Time (minutes)
3A	3.20
3DS	3.00
8A	3.10
8DS	3.10

From Table 16 it was understood that the time required for the preparation of a suitable recipe from these four mixes is appropriately same *i.e.*, around 3 minutes.

4.7.3 Particle size distribution

The particle size of four mixes were found to be similar because they were all sieved through a standard sieve of 60 mm mesh size.

4.7.4 Bulk density

Bulk density of the multimixes are presented in Table 17.

Table 17. Bulk density of the multimixes

Multimixes	Bulkdensity (g/ml)
3A	0.082
3DS	0.084
8A	0.075
8DS	0.078

The bulk density varied from 0.77 for 8A to 0.85 for 3A. Therefore from this point of view. 8A is superior to other mixes since a complementary food should have lesser bulk.

4.7.5 Viscosity

Viscosity of four multimixes were measured with the intention of ascertaining the suitability of mixes to feed an infant of six to nine months of age and the details are represented in Table 18.

Table 18. Viscosity of multimixes

Viscosity (cp)	Multimixes			
	3A	3DS	8A	8DS
	1627	1638	1577	1586

Viscosity of four multimixes were analysed using Rapid Visco Analyser and 8A showed lower viscosity of 1577 cp and the multimixes 3DS, 3A and 8DS had a viscosity of 1638 cp. 1627 cp and 1586 cp respectively and are presented in Fig. 5.

4.7.6 Product Quality Index based on Physical and Rheological character

A product quality index based on physical and rheological characters were worked out to identify the mix that is most suitable for feeding infants. Four parameters, *i.e.*; bulk density, viscosity, yield ratio and ease of preparation were taken into account to work out the product quality index. The quality index for physical and rheological characters of the four multimixes are presented in the Table 19.

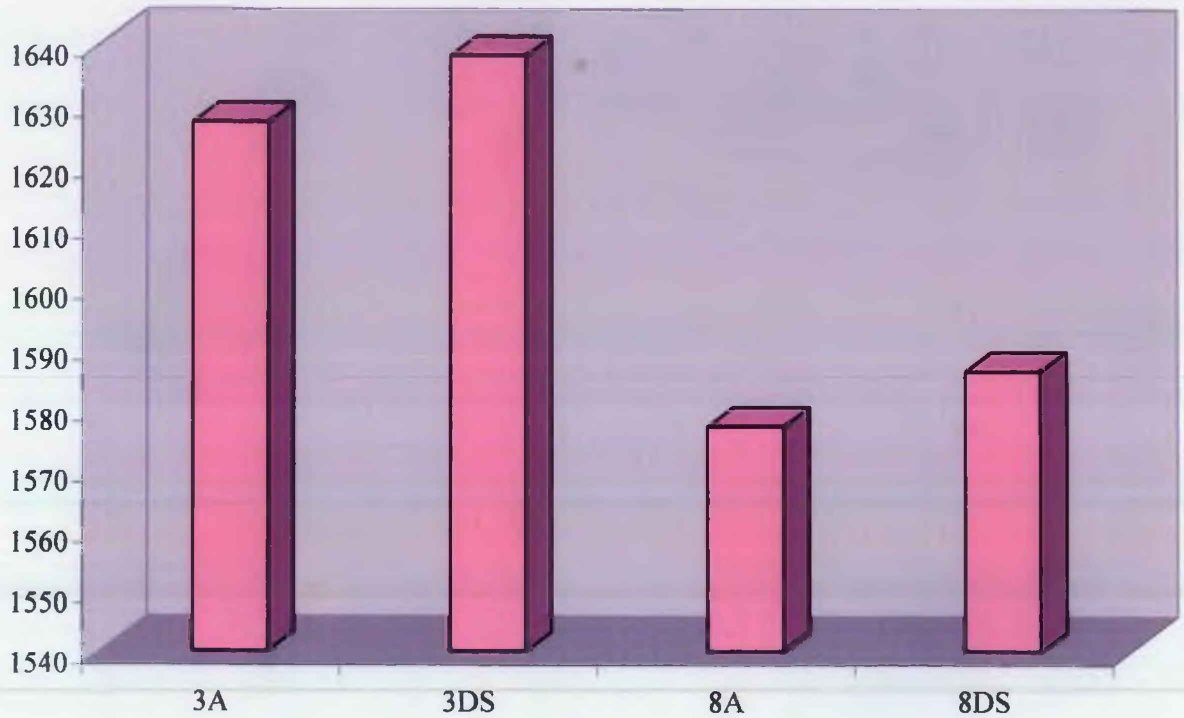


Fig. 5. Viscosity of multimixes

Table 19. Product quality index for physical and rheological characters

Multimixes	Index value	Rank
3A	478.148	IV
3DS	502.833	III
8A	544.202	I
8DS	518.648	II

The values presented in Table 19 shows that the multimix 8A has the highest score for physical and rheological characters, ie; 544.202. The multimix 8DS had an index value of 518.648 which was next to 3DS (502.833) and 3A had the index value of 478.148, which was the lowest.

The above details reveals the fact that 8A has superior physical and rheological qualities when compared to other three mixes.

4.8 NUTRITIONAL ADEQUACY

The nutritional adequacy of the four multimixes were assessed on the basis of four characters such as, calorific value, protein energy ratio, chemical score and amino acid score and the details are presented in Table 20.

Table 20. Nutritional adequacy of the multimixes

Parameters	Multimixes			
	3A	3DS	8A	8DS
Calorific value (kcal)	339	343	342	345
Protein energy ratio	21.42	21.35	20.40	20.17
Chemical score	95	95	86	86
Amino acid score	87	87	82	82

The calorific value for multimixes when computed revealed that 3A would supply 339 kcal of energy and 3DS, 8A and 8DS were found to supply 343 kcal, 342 kcal and 345 kcal of energy respectively. The calorific value of multimix 8DS (345) was found to be the highest and that of 3A was the lowest (339) when compared between the mixes.

However the protein energy ratio was found to be high in 3A (21.42) and it was slightly low in 3DS (20.17). 8A and 8DS had still lower values of 20.40 and 20.17 respectively.

Chemical score of 3A and 3DS were 95 while 8A and 8DS had lower values of 86 each. The amino acid score was found to be 87 for 3A and 3DS and 82 for 8A and 8DS.

Elizabeth (1998) reports that by five months of age weight of the child doubles and becomes around six kilogram and the baby needs 600 to 700 calories per day. 600 ml of breast milk can supply 400 calories. Rest of the requirement (about 300) is to be fulfilled up by the supplementary food. Here the developed mixes supply 339 calories to 345 calories per 100 gram. This indicates that all the four mixes can effectively meet the energy requirements of an infant. As far as energy supply by protein is concerned. the protein energy ratio suggests that the four mixes have adequate amount of protein and energy. ICMR (1991) has stated that the diet of an infant should have a protein energy ratio not less than 6.8. Here all the mixes have the protein energy ratio above 20. Moreover, the protein quality of mixes are found to be of excellent nature. as the chemical score of 3A. 3DS were 95 and that of 8A, 8DS were 86. Malleshi (1995) has stated that a weaning food should have a chemical score above 60.

Hence based on the above findings all the four mixes are found to be nutritionally adequate.

4.8.1 Product Quality Index based on Nutritional adequacy

To find out nutritional adequacy index of four multimixes four parameters were taken into account such as the calorific value, protein energy ratio, chemical score and amino acid score. The quality index for nutritional adequacy and quality are shown in the Table 21.

Table 21. Quality index for nutritional adequacy

Multimixes	Index value	Rank
3A	38.25	I
3DS	37.31	II
8A	33.84	IV
8DS	33.93	III

As shown in Table 21 the index for nutritional adequacy and quality varied from 33.84 to 38.25 and 3A had the highest index value while 8A secured the lowest index score.

4.9 SANITARY QUALITY OF MULTIMIXES

In order to ensure that the mixes are safe for feeding infants an attempt was made to assess the total bacterial count, and also to find out the presence of *E. coli* contamination, if any. These two would give an insight into the sanitary quality of the mixes and the details are presented in the Table 22.

Table 22. Total bacterial count of the multimixes

Parameter	Multimixes				F value	CD
	3A	3DS	8A	8DS		
Total bacterial count ($100\ g^{-1}$)	1425	1225	2275	650	190.3**	2.40

**Significant at 1 per cent level

Total bacterial count of multimixes 3A, 3DS, 8A and 8DS were found to be 1425, 1225, 2275 and 650 respectively. The lower bacterial count was observed in 8DS. Though these values indicate that the mixes are not absolutely sterile, the values are much below the admissible levels suggested by BIS (5000 per g) and the result revealed that significant difference was observed at one per cent level between the different mixes. Further, the presence of *E. coli* when assessed revealed that it was absent in all of the four multimixes, indicating the absence of faecal contamination, ensuring the sanitary quality of the mixes.

4.10 SHELF LIFE

In the process of ascertaining the shelf life, the multimixes were packed in polyethylene covers and stored for a period of three months under ambient conditions.

Storage stability of the mixes were assessed by suitable chemical, physical and microbiological methods. Primarily the peroxide value and moisture content after a period of three months of storage were assessed. Moreover, the variation in the total bacterial count was assessed by serial dilution technique and the extend of damage by insects/pests were also assessed by visual examination. The results of the above trials are detailed in Table 23.

Table 23. Shelf life quality of multimixes

Parameters	Multimixes				F value	CD
	3A	3DS	8A	8DS		
Peroxide value (meq / 100g)	0.7	0.7	0.7	0.8	0.33^{NS}	0.218
Moisture content (g/100g)	3.9	3.5	3.7	3.5	24.72^{NS}	0.157
Bacterial count (g/ 100g)	1725	1575	2425	1100	104.92**	1.64
Insect and pest infestation	Absent	Absent	Absent	Absent		

**Significant at 1 per cent level

The peroxide value of multimixes after storage for three months were found to be 0.7 for 3A, 3DS and 8A. 8DS showed a value of 0.8 which indicates that chemical change due to oxidation of fat either by air or by microorganism has set in the mixes in a mild way. Highest peroxide value was observed in 8DS when compared to other mixes which showed similar values.

In the initial stage, moisture content of multimix as shown in Table 12 was found to be lower than stored product (Table 23). The moisture content of the stored products were 3.9 g, 3.5 g, 3.7 g and 3.5 g for multimixes 3A, 3DS, 8A and 8DS, while the moisture content in the initial stage was 3.75 g, 2.99 g, 2.83 g, 2.38 g respectively. This picture indicates that all the mixes have absorbed moisture from the atmosphere since there is a increase in the moisture content in all samples.

Bacterial count was taken before and after storing the product for three months. Initial bacterial count of the multimixes as shown in the Table 20 were lower than that of stored products. When the product was stored for 3 months the bacterial count were1725, 1575, 2425, 1100, but in initial stage it was 1425, 1225, 2275 and 650 for 3A, 3DS, 8A and 8DS respectively. This indicates that there is an increase in bacterial count in all the mixes; while maximum increase was observed in 8A followed by 3A and 3DS.The least increase was recorded in 8DS. However increase in total bacterial count was still within the acceptable range suggested by ISI. Significant difference was observed at one per cent level for bacterial count. But for peroxide value and moisture content, the difference were found to be nonsignificant.

No pest or mould infestations were observed in any of the four samples when stored in polyethylene covers for a period of three months under ambient condition.

After storage of three months the multimixes were evaluated using a score card by a panel of 10 expert judges for determining the organoleptic quality. The total mean scores are presented in Table 24.

Table 24. Mean total acceptability scores of multimixes after storage

Multimixes	Quality evaluation	Rank
3A	23.5	III
3DS	23.5	III
8A	26.5	I
8DS	24.5	II

Maximum score: 30

From the above table it is clear that 8A had the highest score (26.5), while 3A and 3DS secured similar scores of 23.5 and 8DS obtained a score of 24.5. The above data indicated that 8A is the most acceptable one even after storage as per judgment given by the experts.

4.11 COMPARISON OF DEVELOPED PRODUCTS WITH IS STANDARD AND CONTROL

In order to justify the quality of the developed products with a goal to check the suitability of the material for commercial exploitation the characteristics of the mixes were compared with IS standard specification for "processed cereal weaning food" stipulated under IS 1656 to 1969. These products were also compared with a control which is a popular commercial rice based complementary food used for feeding infants in Kerala, *i.e.*, Nestum. The parameters used for comparing the developed products with the IS specification were the moisture, total protein, fat, total carbohydrate, calcium, iron, acid insoluble ash and fiber which ascertained through chemical analysis and the results of such comparison are given in Tables 25 to 33.

4.11.1 Moisture

Moisture content of multimixes were compared with IS standard and that of control and the details are presented in Table 25.

Table 25. Moisture content of multimixes in comparison with IS standard and control

Multimixes	Moisture (g /100 g)
3A	3.75
3DS	2.99
8A	2.83
8DS	2.38
Control	4.15
Standard	10 (maximum)
F value	502.07 **
CD	0.438

** Significant at 1% level

The maximum permissible moisture content of a weaning mix as per IS specification is 10 g per 100 g. The moisture content of the developed products ranged from 2.38 to 3.75g. While the moisture content of control (Nestum) sample was 4.15. Hence form the data it is clear that all the developed products and control satisfied the standard recommendation however, significant difference in the moisture content between the standard and the different product was observed to exist.

4.11.2 Total Protein

Total protein content of multimixes in comparison with IS standard and control are presented in Table 26.

Table 26. Protein content of multimixes compared with IS standard and control

Multimixes	Total Protein (g /100 g)
3A	17.45
3DS	16.35
8A	16.50
8DS	15.80
Control	6.85
Standard	14.00 (minimum)
F value	854.57**
CD	0.463

** Significant at 1% level

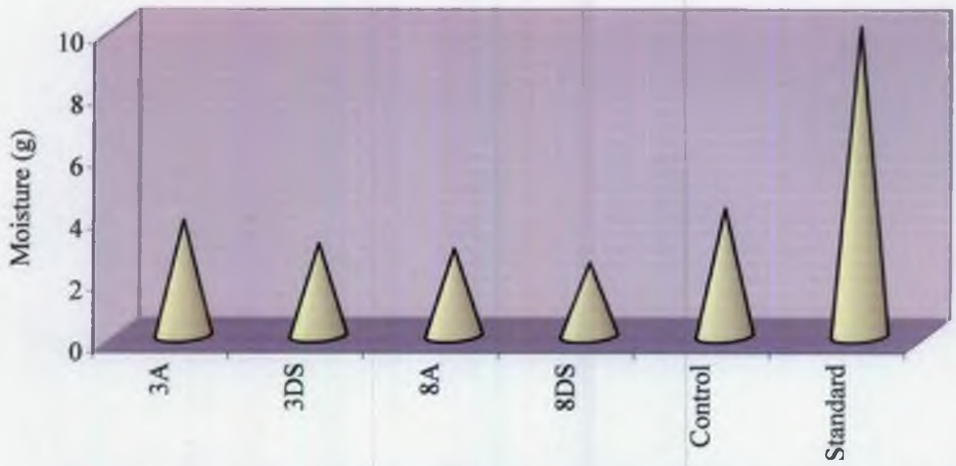


Fig. 6. Moisture content of multimixes in comparison with IS standard and control

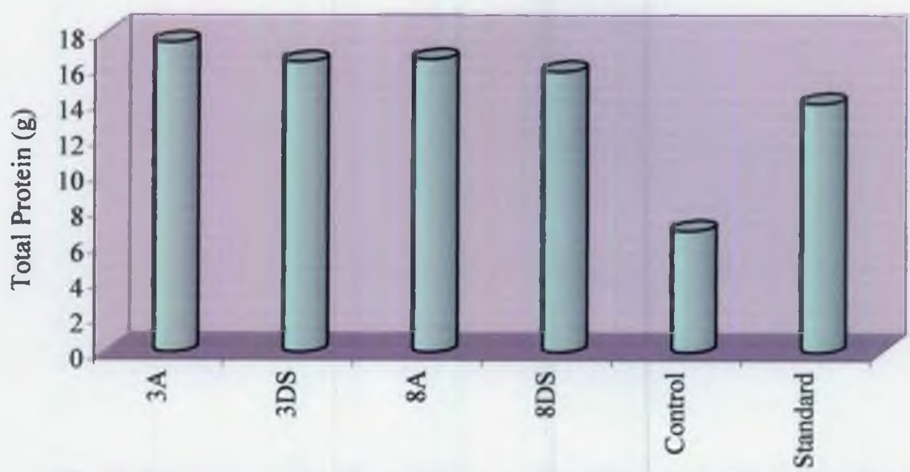


Fig. 7. Protein content of multimixes in comparison with IS standard and control

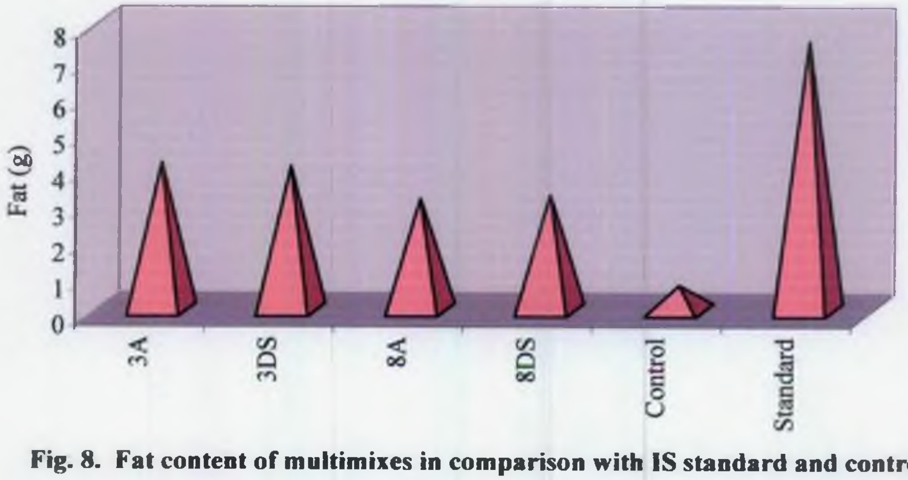


Fig. 8. Fat content of multimixes in comparison with IS standard and control

Though the minimum amount of protein a cereal based complementary food should contain as per the IS standard is 14g /100g the multimix 3A has a protein content of 17.45g while 3DS, 8A and 8DS have a protein level of 16.35g, 16.50 g and 15.80 g respectively. It is of special interest to note that the control was analysed to contain only 6.85 g /100 g.Hence all the developed mixtures were found to satisfy the standard requirement for protein. But the control do not even supply half of the requirement.

4.11.3 Fat

Fat content of multimixes and control samples in comparison with IS recommendation are presented in Table 27.

Table 27. Fat content of multimixes compared with IS standard and control

Multimixes	Fat (g /100 g)
3A	4.1
3DS	4.0
8A	3.1
8DS	3.2
Control	0.7
Standard	7.5 (maximum)
F value	208.8**
CD	0.549

**Significant at 1% level

The maximum content of fat as recommended by standard specification is 7.5g. The developed products contained fat in the range of 3.1 to 4.1g/100g. The fat content of control was found to be 0.7 g /100 g which is too low a level. 8A and 3A have fat content of about 3.1g and 4.1g respectively. Between the samples significant difference could be observed as per the data presented in Table 27.

4.11.4 Total Carbohydrate

Carbohydrate content of multimixes were compared with IS standard and control and the details are given in Table 28.

Table 28. Carbohydrate content of multimixes in comparison with IS standard and control

Multimixes	Total carbohydrate (g /100 g)
3A	68
3DS	70
8A	54
8DS	56
Control	66
Standard	45 (minimum)
F value	156.7**
CD	2.735

** Significant at 1% level

The amount of carbohydrate when estimated revealed that 3DS has a value of 70 and it was the highest among the mixes. Products 8DS, 8A and 3A were found to have 56, 54, 68 g of carbohydrate respectively per 100 g of sample. The total carbohydrate content of control sample was found to be 66 g while the minimum requirement as per the IS requirement is 45 g. Hence, all the developed products and control samples were found to have a high carbohydrate content and significant difference was observed between the products as far as their carbohydrate content was concerned.

4.11.5 Calcium

Calcium content of the test and control samples are given in Table 29. Higher calcium content was estimated in the multimix 3DS i.e., 340 mg, while 8DS had a value of 180 mg. 3A and 8A had calcium content of about 320 mg and 240 mg respectively. But the standard requirement for calcium is 1000 mg. Hence it is evident that none of the products are eligible to meet the standard recommendation. The control also has a low calcium content i.e., 250 mg and significant difference was observed between the samples at one per cent level.

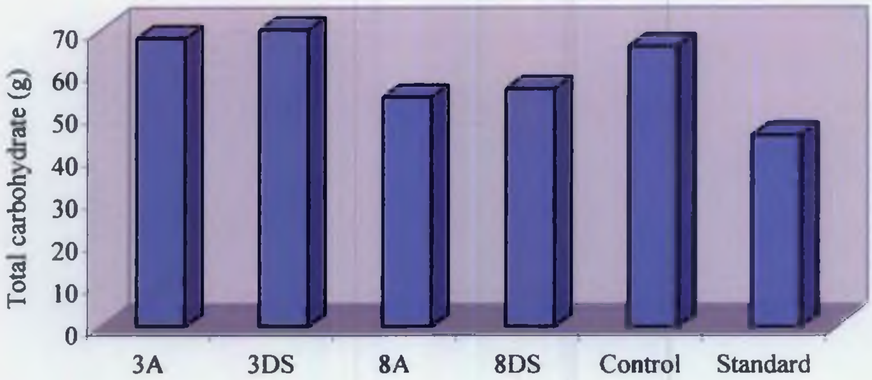


Fig. 9. Carbohydrate content of multimixes in comparison with IS standard and control

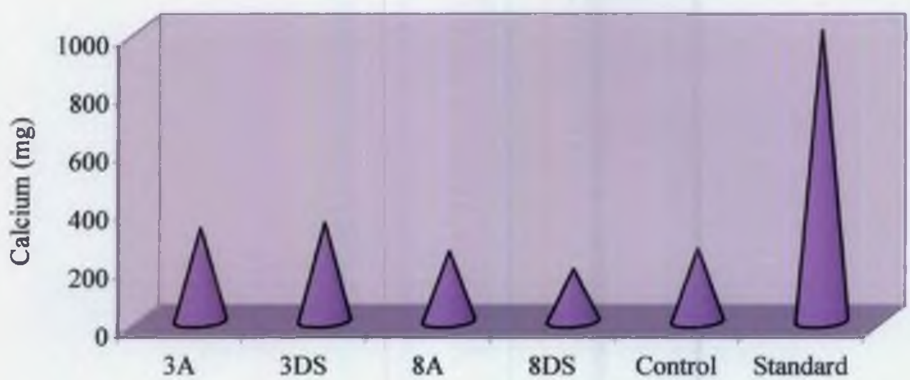


Fig. 10. The calcium content of multimixes in comparison with IS standard and control

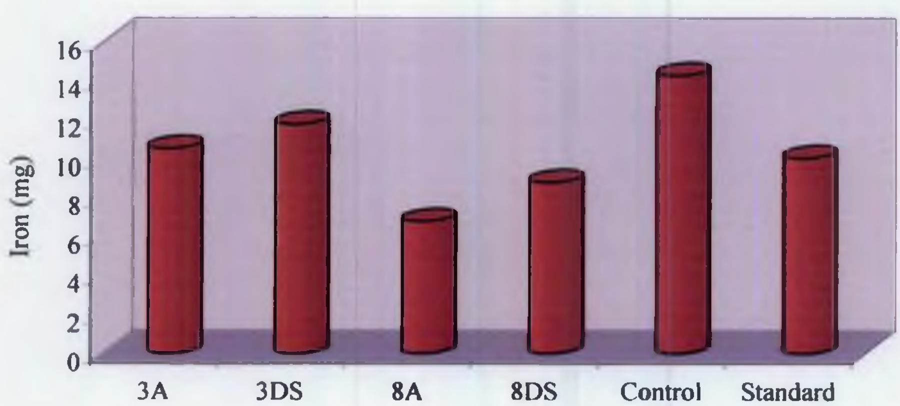


Fig. 11. Iron content of multimixes in comparison with IS standard and control

Table 29. The calcium content of multimixes in comparison with IS standard and control

Multimixes	Calcium (mg /100 g)
3A	320
3DS	340
8A	240
8DS	180
Control	250
Standard	1000 (maximum)
F value	529.1**
CD	0.423

** Significant at 1% level

4.11.6 Iron

Iron content of multimixes are presented in Table 30

Table 30. Iron content of multimixes are compared with IS standard and control

Multimixes	Iron (mg 100/ g)
3A	10.5
3DS	11.75
8A	6.75
8DS	8.75
Control	14.25
Standard	10.00 (minimum)
F value	157.59**
CD	0.706

** Significant at 1% level.

In the case of Iron, the recommended level was 10.00 mg. Two of the mixes had Iron values below standard *viz.*; 8DS (8.75 mg), 8A (6.75 mg). 3DS and 3A were estimated to satisfy the standard requirement. But the control had a high Iron content, *i.e.*, 14.25 mg. This also causes imbalance in the commercial sample.

4.11.7 Total Ash

Ash content of multimixes and control samples are presented in Table 31.

Table 31. Total ash content of multimixes compared with IS standard and control

Multimixes	Total ash (g /100 g)
3A	0.0785
3DS	0.0745
8A	0.0930
8DS	0.0845
Control	1.3500
Standard	5.0000 (maximum)
F value	1034.7**
CD	0.2119

**Significant at 1% level

It has been stipulated that the total ash content of the complementary food should not exceed 5g as per the IS recommendations. The total ash content of the multimixes were 0.0785, 0.0745, 0.0930 and 0.0845 for 3A, 3DS, 8A and 8DS respectively; while the total ash content of control was found to be 1.35g which also falls below the maximum limit. Significant difference would be noticed between the products as far as their ash content was concerned.

4.11.8 Acid Insoluble Ash

Acid insoluble ash content in the samples tested in comparison with the standard specification are shown in Table 32. In the case of acid insoluble ash, the maximum recommended level was 0.0500 g while all the developed products had ash content around 0.003 g per 100g which is an acceptable low level. The insoluble ash content of control was 0.085 g, which is higher than that of the recommended value. However, between the mixes no significant difference was observed.

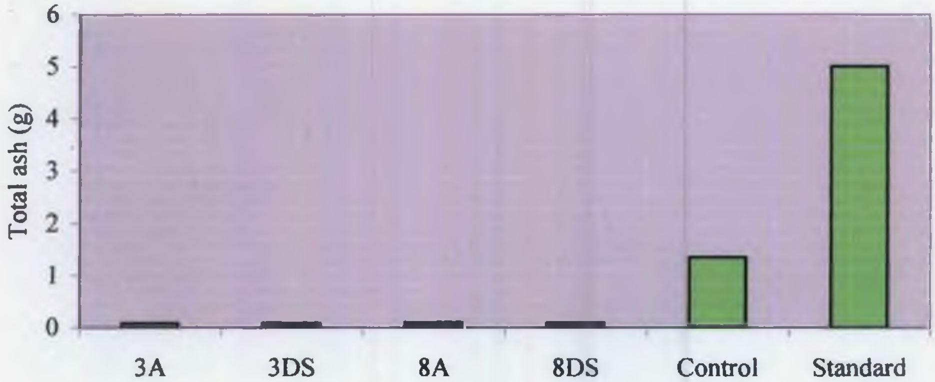


Fig. 12. Total ash content of multimixes in comparison with IS standard and control

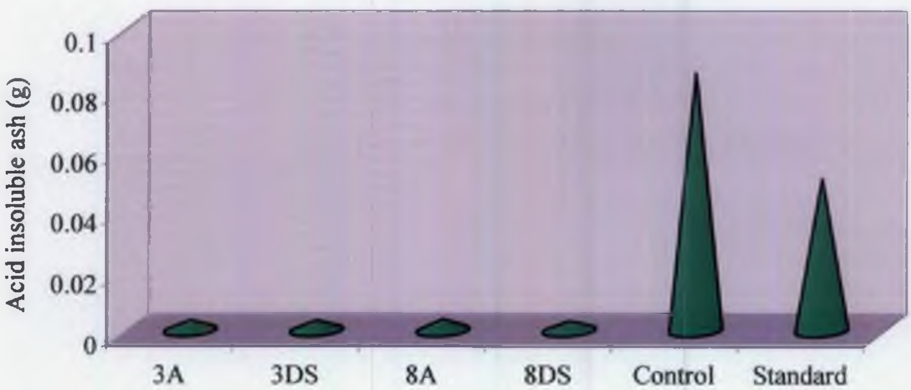


Fig. 13. Acid insoluble ash content of multimixes in comparison with IS standard and control

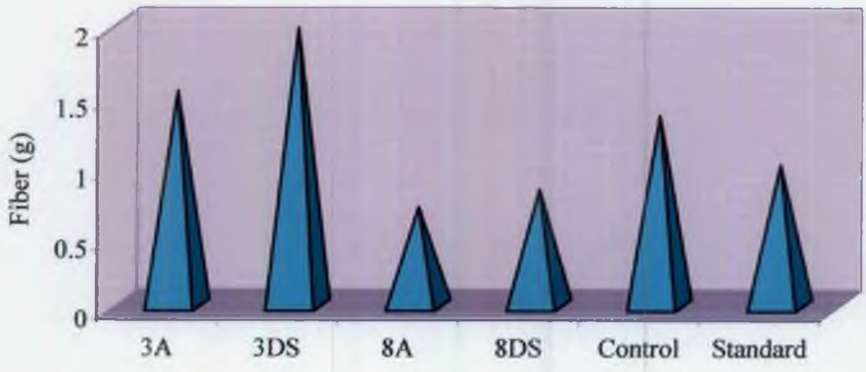


Fig. 14. Fiber content of multimixes in comparison with IS standard and control

Table 32. Acid insoluble ash content of multimixes in comparison with IS standard and control

Multimixes	Acid insoluble ash (g /100 g)
3A	0.0034
3DS	0.0034
8A	0.0038
8DS	0.0031
Control	0.0850
Standard	0.0500 (maximum)
F value	284.8 NS
CD	7.147

NS Non Significant

4.11.9 Fibre

Fibre content of multimixes are presented in Table 33 along with that of the control.

Table 33. Fibre content of multimixes in comparison with IS standard and control

Multimixes	Fiber (g /100 g)
3A	1.525
3DS	1.97
8A	0.70
8DS	0.825
Control	1.35
Standard	1.00 (maximum)
F value	26.54 **
CD	0.3216

** Significant at 1% level.

The fibre content of 3DS was estimated to be 1.97g while 8A had 0.7g of fiber which had the lowest fiber content among the developed mixes. The fibre content of the control was 1.35g. But the standard recommendation for fibre was 1.0 g (maximum). Hence, except the multimix 8A and 8DS others have higher fibre content compared to recommended level. And the mixes showed significant difference at one per cent level, as far as their fibre content was concerned. It may also be pointed out that the control commercial sample has high level of fibre which is not an acceptable trend. Comparison of developed products with IS standard and control with respect to selected parameters are shown in Fig. 6 to 14.

From the chemical and microbial analysis of the mixes and control sample. Nestum for the different parameters suggested by IS 1656 to 1969 the following salient features were observed. The moisture content of the control and developed mixes were found to be lower than the maximum permissible limit. But the mixes had higher content of protein while the control was highly deficient in protein (50%). However the fat content was found to be low in both the control and developed multimixes. In the case of carbohydrate, both the mixes and control were seen to satisfy the standard requirement. But in the case of calcium neither the mixes nor the control do not seem to satisfy even the minimum requirement. But for iron, two of the developed products and control were estimated to satisfy the standard requirement. The ash content (total as well as acid insoluble ash) of the mixes were within the stipulated range, but the control sample had higher value. Analysis of fibre content revealed that two of the developed mixes along with the control had values higher than the IS standard. The overall picture reveals that the developed mixes were capable of meeting the requirement of all the major nutrients except calcium. Moreover they were found to be low in antinutritional factors such as fibre and ash. It is also of interest to note that the commercial formula is highly deficient in the most essential nutrient required to ensure growth of children. viz., protein and it has higher levels of fibre and ash than the permissible level which makes it nutritionally less acceptable to feed infants.

4.11.10 Cost

Cost of the multimixes were computed according to the existing market price of individual ingredients used in the four developed formulations and overhead charge of twenty per cent was also added to ensure additional expenses related to production and it was compared with that of commercial formula

(Nestum). The cost wise difference between the mixes and control are presented in Table 34.

Table 34. Cost of multimixes in comparison with commercial formula

Multimixes	Cost of ingredients (Rs)	Overhead at 20 % level (Rs)	Total cost / kg (Rs)	Rounded value
3A	26.60	5.32	31.92	32.00
3DS	18.00	3.60	21.60	22.00
8A	23.70	4.74	28.44	28.50
8DS	19.00	3.80	22.801	23.00
control	-	-	142.50	142.50

The cost of multimixes 3A, 3DS, 8A and 8DS were Rs.32, 22, 28.50 and 23 respectively, while cost of control was Rs. 142.50 for one kilogram. Hence control was found to be costlier than the developed multimixes. Among the four multimixes 3DS was found to be the least-cost formulation, while 3A was found to be the costliest and are given in Fig. 15.

4.12 ACCEPTABILITY AND PREFERENCE

Even if a food supplement satisfies all the nutritional requisites, it will not be popular if it lacks consumer acceptability. Therefore acceptability was assessed by the experts while preference along with acceptability was assessed by hedonic rating by mothers of infants. The acceptability of four mixes and their mean scores are given in Table 24. The result indicated that 8A secured the highest score of 26.5 out of 30 even after a storage period of three months. While the other three samples had values ranging from 24.5 to 23.5 which also indicates the fact that all the four mixes are acceptable. Preference for the selected multimixes in comparison with control after a period of three months of storage was assessed by 10 mothers of children attending a nearby anganwadi centre and the mean scores of preference are given in Table 35

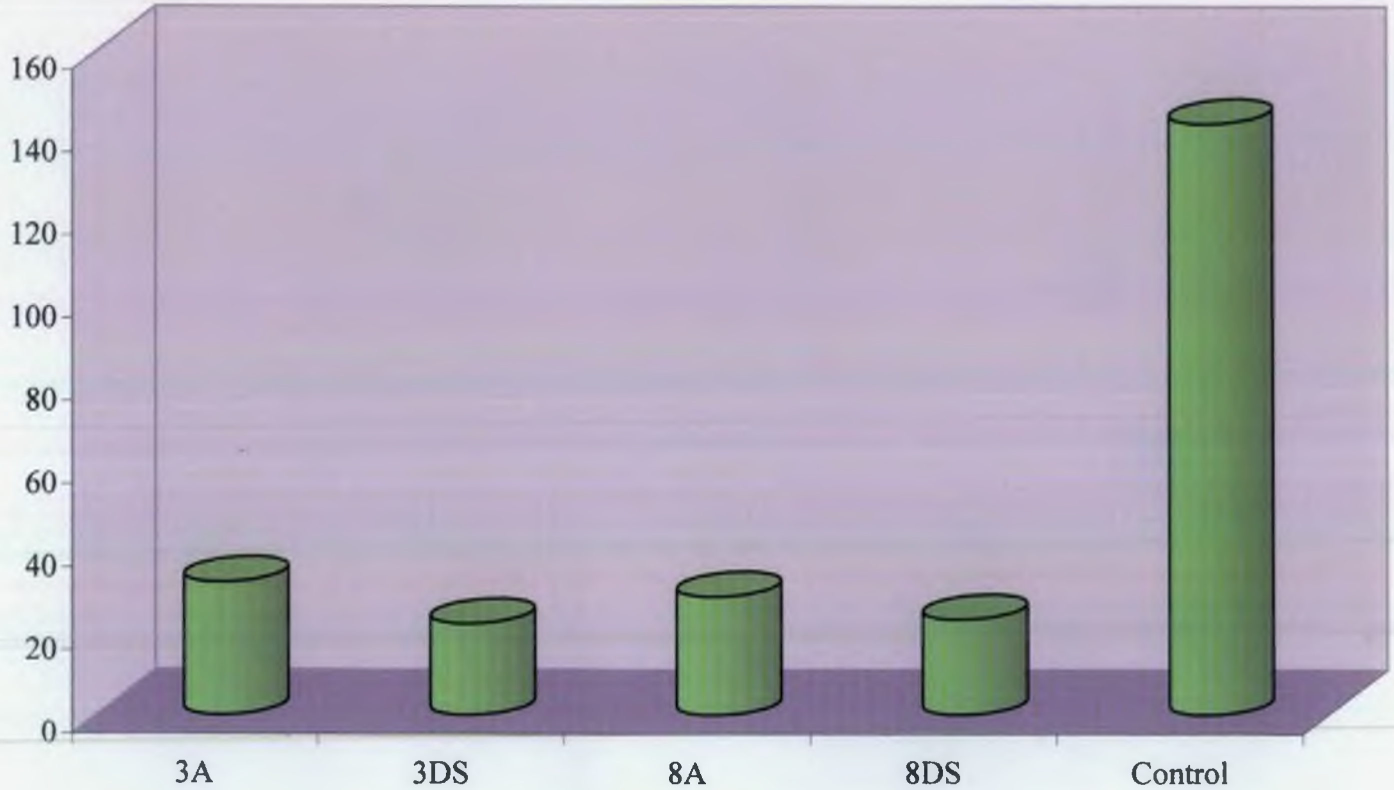


Fig. 15. Cost of multimixes in comparison with control

Table 35. Preference score of multimixes after storage

Multimixes	Preference score	Rank
3A	74	IV
3DS	69	V
8A	88	I
8DS	80	II
Control	78	III
F value	2.87**	
CD	11.91	

** Significant at 1% level.

From the data it is clear that 8A was highly preferred by the mothers followed by 8DS. The least preferred multimix was 3DS. It was also further observed that the control sample has a lower preference score of 78 when compared to 8A (88) and 8DS (80). Analysis of data presented in Table 35 has also revealed the fact that there is significant difference between the four multimixes and the control when preference was measured.

4.13 OVERALL ADEQUACY /SUITABILITY INDEX OF MULTIMIX

An overall adequacy/suitability index was worked out to find out the most suitable combination among the four multimixes. An overall adequacy/suitability index was developed based on chemical (11 characters), physical and rheological (4 characters), nutritional (4 characters), organoleptic (6 characters), preference score and cost. The index value obtained are given in Table 36.

Table 36. Overall adequacy index of selected multimixes

Multimixes	Index value	Rank
3A	19.064	III
3DS	18.373	IV
8A	24.453	I
8DS	23.214	II

The result indicated that adequacy index of 8A was found to be the highest (24.453) followed by 8DS (23.214) while 3A and 3DS had lower values (19.064 and 18.378) when compared to other two mixes. Hence 8A is considered to be the best one among the four developed multimixes.

The ultimate result of the study revealed that the formulation designated as 8A can be used as an adequate multimix that can be used as a complementary food suitable for feeding an infant aged between six to nine months. This formulation contains rice, blackgram dhal, soya and amaranth in the proportion of 55:25:15:5. This was processed in two stages. The first stage consisted of cleaning, drying and milling to obtain rice flour. This flour was further roasted and sieved to obtain a fine flour of even consistency. Blackgram dhal flour was also prepared following the same procedure. In case of amaranth leaves, fresh leaves were separated, cleaned, dried, powdered and sieved. The above three mixes were blended 15 per cent soya chunks powder together in prescribed proportion. These were further sieved through 60 mm mesh size sieve to obtain a mix of even particle size. The blend was subjected to extrusion, followed by oven drying, powdering and sieving. This gave a soft, fluffy, cream coloured powder of uniform particle size. This when made into a thick porridge suitable for spoon feeding, was observed to have high acceptability as proclaimed by expert judges. High preference for the mix in comparison with a commercial formula was also confirmed by mothers of infants. The products seems to be highly viable for commercial exploitation, since it satisfies nine out of eleven parameters prescribed by IS 1656 - 1969. Its nutritional adequacy can be further enhanced if vitamin-mineral premixes are added during commercial processing. Shelf life can also be improved if modern packaging technology is adopted.

Discussion

5. DISCUSSION

The results obtained in the present study entitled "Developing rice based complementary food for infants" are discussed in this chapter.

In an infant formula two ingredients are needed to form a basic mix e.g., cereal and pulse. In this study entitled "Developing rice based complementary food for infants" rice formed the cereal component and pulses such as blackgram dhal, bengalgram dhal, greengram dhal, redgram dhal, cowpea, pea, soya were selected to formulate the basic mix.

There are various reasons to formulate the basic mix with rice as the base ingredient other than the fact that, it was the objective of the study. Manay and Shadaksharaswamy (2002) has reported that rice protein is of good quality and its carbohydrates are easily digested. Among the cereals it has a comparatively high content of essential amino acid as reported by Roy (1992). Moreover, Kelly *et al.* (1989) has stated that cooked and mashed rice or even rice gruel can be used for feeding infants, as such. Moreover Rajalakshmi (1982) has reported that rice is usually used as the cereal base for complementary foods. Potter and Hotchkiss (1996) is of the view that rice has been recognized as a food material of more than half of the world's population. Apart from the above facts it has been well recognized that rice is capable of imparting desirable characteristics like flavour, colour, and taste in reconstituted products (Prince *et al.*, 1994).

However Potter and Hotchkiss (1996) has opined that rice has a low total protein content and generally low level of lysine. These short comings can be overcome by appropriate blending with pulses. Manay and Shadaksharaswamy (2002) have further stated that pulses can play an important role in bridging the protein gap. India depends greatly on pulses to meet its demand of protein, and are said to be "Poor man's meat".

Hence by blending rice with different pulses, 64 combinations of basic mixes were tried out. As the objective of the study was to develop rice based complementary food, rice formed 50 per cent of the basic material of the mix, while the pulse contributed 10 to 50 per cent of it.

To select the most appropriate basic mix chemical score and amino acid score of the combinations were worked out because it would give an indication to the protein quality which can be used as a proxy for biological assays.

Multimixes were also formulated by adding a second cereal to the basic mix because as reported by Elizabeth (1998), mono cereal preparation are preferred initially for feeding infants and are to be followed by mutlicereals and cereal-pulse combinations. Further, she had stated that cereals like ragi, rice, wheat are good for weaning and had also opined that cereal-pulse combination is better for weaning due to fortification of amino acids as cereals generally lack lysine and pulse lack methionine. Hence ragi and wheat were chosen to formulate multimixes. Thus 108 combinations were formulated with two cereals and one pulse, and their aminoacid and chemical score were calculated. However combinations containing wheat were excluded from this selection because rice + wheat + pulse combinations are quite common. Gopaldas and Deshpande (1995), CFTRI (1997), Ramasaranya and Kanjana (2003), had already developed such products and the names such as Miltone and Balahar are well known names of yester years. Moreover, Laura and Caroline (1999) reported that introduction of wheat containing products early in life have some negative effects because the infant's intestine is not sufficiently developed until 6-8 months to deal with this protein and the child may have problems of digesting the wheat which can result in diarrhoae. However, as the objective of the study was to develop supplementary food for infants of age group 6-9 months and as wheat has the problem of digestibility the combinations containing wheat were excluded.

Abraham (1997) has stated that rice is our staple food and ragi is a good source of calcium and iron when compared to rice. In fact the calcium content of ragi is 34 times more than that of rice. Hence an effort was made to incorporate ragi as the second cereal for developing complementary food in addition to rice and pulse. Another set of 139 primary multimixes containing an extra pulse were also constituted and their amino acid and chemical score were calculated. Among these 11 combinations were selected at random.

As suggested by GOI (2004) baby needs all foods from six months onwards food such as cereals, pulses, vegetables particularly green leafy vegetables, fruits, milk and milk products, egg, meat and fish (if non-vegetarian), oil/ghee, sugar and iodized salt can be given in addition to breast milk. In order to ensure the inclusion of various food items in the diet of infants, while formulating the complementary food the concept of "food square" as suggested by PAG (1975) was adopted in the present study. In "food square" four components are essentially needed in addition to breast milk, viz., staple, protein food supplement, vitamin and mineral supplement and energy supplement.

As the staple and protein components are already available, vitamin-mineral supplement and energy supplements were to be added to the basic mix. Hence as 'vitamin-mineral supplement' amaranth leaves were selected because as stated by Brown *et al.* (2004) green leafy vegetables should be introduced at four to six months as complementary food; they provide vitamin C which helps in the absorption of iron.

To supplement energy, coconut oil and sugar were selected. Malhotra (2003) had reported that one way to increase the energy content of the food preparation is to increase the fat content; for fat has a higher caloric density. Ministry of Human Resource Development (2004) has stated that fat is a concentrated source of energy and it substantially increases energy content of food without increasing the bulk. The report from the above agency has further stated that the false belief in the community that young child cannot digest fat has to be dispelled with by informing that a young infant digests fat present in breast milk and in all other foods like cereals and pulses and that there is no reason to feel that a child cannot digest visible fat when added to food. Moreover sugar can also provide high amount of energy. The energy content of one gram of sugar is 3.98 kcals (ICMR, 1991). Ministry of Human Resource Development (2004) has reported that children need more energy and hence adequate amount of sugar or jaggery should be added to the child's food.

Thus 22 combinations of multimixes as per "food square" principle were formulated, but when nutritive value was calculated the mixes were found to supply only eight to 12 g of protein hence soya flour was also added to all mixes so as to enhance the protein value. Dahiya and Sehgal (2002) are of view that soya protein is a high quality plant based protein that has been shown to help build and maintain muscle mass and lean body tissue. Using the internationally recognized protein digestibility corrected amino acid method of protein quality evaluation, soya protein is assigned a score of 1.0 which is the highest score that a protein can have and is found to be equal in protein quality to meat, milk and egg. Moreover, the above authors have further explained that soya protein meets the essential amino acid requirement of children and it helps to maintain nitrogen balance when fed as the sole protein source at minimum intake level. Hence soya was added at 15 per cent to all the 22 selected mixes so as to enhance the protein value as per IS requirement.

The raw ingredients had to be processed employing relevant methods so as to make it suitable for feeding infants. Malleshi (1995) reports that grains should be cleaned , powdered , cooked and dried so that soft paste is obtained when the dried food is mixed of reconstituted with milk or water. Further he explains that materials should be processed or heat-treated in such a way so as to readily get cooked when they are mixed with water and or boiled for a few minutes. Moreover weaning foods should be free from antinutritional factors. Hence cleaning, washing, drying, milling, roasting and sieving were done for cereals and pulses and for amaranth leaves fresh leaves were separated, cleaned, washed, sun dried/ oven dried, ground and sieved. Pamer (2003) is of view that both roasting and sun drying significantly reduces the phytic acid and polyphenol content of pulses. Moreover, he explained that cooking and sun drying reduces the antinutritional content of pulses thereby improving the protein and starch digestibility. Roasting followed by milling and sieving in the case of cereals and pulses reduces the content of fibre, and makes the materials smooth and easily digestible.

In order to make use of the multimixes as a complementary food they should be converted into a suitable recipe to feed an infant. Here the multimixes were made into porridge form adding water, serving the same to the infant at the spoon-feeding consistency with few drops of coconut oil. This recipe was chosen because as stated by Vinas and Mondkar (2003) a young infant particularly during six to nine months requires thick but smooth mixtures and hard pieces in the solid food may cause chocking if swallowed. The porridge made from the mixes were organoleptically evaluated by ten expert judges. As stated by Smith (2000), organoleptic evaluation is the most important criteria used for identifying the suitability of the product. Thus, the overall acceptability of the developed products were determined and ten multimixes with high scores (above 23.5) were selected from the 22 combinations for large scale processing.

The selected 10 multimixes were further diversified into two groups of ten each; one set containing drumstick leaves and the other set containing amaranth leaves as vitamin-mineral supplement to find out which is more acceptable and effective. Thus there were 20 multimixes.

Though several studies have been carried out regarding the preparation and use of home made weaning foods, very few efforts have been made for the commercialization of these products. Hence in the present study weaning foods were formulated using locally available ingredients and were processed by novel and modern method.

Drum drying is the most commonly adopted method for processing weaning foods. Most of the commercial weaning foods marketed in India are prepared by this technique. However, this process was a failure in the present study due to the gelatinization of product. Therefore extrusion method was adopted. Malleshi (1995) has proclaimed that extrusion cooking is the most modern food processing technology adopted to produce weaning foods. It is the process by which moistened, expansible, starchy or protenacious materials are plasticized in a tube by a combination of pressure, heat and mechanical shear (Liu and Maga, 1993). A whole range of products with different textures, forms and densities can be developed through extrusion (Malleshi 1995).

The extruded mixes were pulverized and sieved to get uniform products. These 20 blends were subjected to chemical and physical tests followed by evaluation of their nutritional adequacy, acceptability and shelf life since all these characteristics are to be satisfied by an ideal complementary food. At the same time, the cost of the product should be affordable to the common man. Moreover, a new product that is floated into the market should be in a position to compete with the products of a similar nature. Therefore, the mixes were compared with 'Nestum' a rice based cereal weaning food for its composition. A processed food if it is to be accepted by the consumers as a quality product, it should satisfy certain specifications stipulated by law. IS 1656 to 1969 had described such specifications. To endorse such quality attributes, are also present in the complementary multimixes under the study, comparative evaluation of the quality parameters mixes with those stipulated under IS recommendation was also done. As a first step the chemical composition of the selected mixes were ascertained by estimating the major nutrients present in it using standard laboratory methods because as stated by Saxena (2003) a complementary food given to an infant should be nutrient dense and laboratory analysis is one of the best methods to assess the quantity of different nutrients present in the products. The multimixes were analysed for their total proteins, fat, total carbohydrate, iron, calcium, sodium and potassium contents. Non nutrients such as total ash, crude fibre and acid insoluble ash content were also estimated along with the moisture level, in order to find out the composition of the material.

The moisture content of multimixes ranged from 2.38 to 3.75 g per 100 g. The permissible moisture content (maximum) as per ISI recommendation for processed cereal weaning food in 10 g per 100 g. Therefore all the four developed mixes were observed to have a moisture content much below the maximum level. This low moisture level is of added advantage because as the moisture content increases the shelf stability of the developed product would decrease, because moisture is one of the important parameters which determines the shelf stability of any food product. Most stored products are considered to be safe in storage at particular moisture content; and low moisture level is highly important for longer storage period as reported by Shankar (1993).

A weaning biscuit developed for infants containing 10 per cent soya flour and wheat flour developed by Ramasaranya and Kanjana *et al.* (2003) was reported to contain 2.2 g of moisture in 100 g, while the moisture content of the developed rice based complementary food in the present study ranged from 2.38 g to 3.75 g which indicates somewhat similar trends; low level.

The protein content of the four developed products were 17.45 g, 16.35g, 16.50 g and 15.80 g for 3A, 3DS, 8A and 8DS respectively. The minimum standard recommendation for protein for an ideal processed cereal weaning food is 14.00-g/100 g (IS: 1656-1969). This indicates that all developed products can satisfy the protein requirement of infants, if fed in adequate quantity. But when control sample was analyzed for its protein content, it was found to have only 6.85 g which clearly points out that such commercial mixes do not satisfy even half of the requirement.

Committee on Nutrition (2003) has stated that infant formulae should supply an adequate amount of protein, which is necessary for infant's growth. Insufficient amount of protein may lead to slow growth rate, malnutrition and diminished immune response. On the other hand over abundance of protein may lead to constipation, colic and dehydration. The protein content of the selected four multimixes was seen to be adequate. The quality of the protein is also expected to be good. The reason is that, two of the multimixes *i.e.*, 3A and 3DS contains two cereals (rice and ragi) and two pulses (greengram and soya), while the other two mixes 8A and 8DS had one cereal (rice) and two pulses (blackgram and soya). It may be seen that the mutual supplementation of amino acids of cereal-pulse combination has helped to enhance protein content as well as quality. This fact has been confirmed by Mohanram (1997) who has stated that cereal and pulses combinations would give a high quality protein product. It has been further observed that cereal grains are relatively low in total protein and are generally low in lysine and certain other amino acids. These shortcomings can be overcome by appropriate blending with legumes. The most obvious result of such blending is that the mixture is higher in protein than in the cereal component alone. Beyond this, however, legumes improve the quality of cereal proteins by supplementing them with limiting amino acid such as lysine. This is called protein supplementation. On the other hand, legumes which are deficient in methionine, can be supplied by cereal grains, which are not deficient in this amino acid. Such mutual balancing of each other amino acid is known as protein complementation (Srilakshmi 2002). This mutual supplementation has been effectively done in the formulation of the complementary food in the present study. Moreover, in order to enhance the protein content, 15 g of soya had been added intentionally to the multimixes in order to attain the high protein content as per IS requirement. This was done because, soya protein is a high quality plant based protein that has been shown to help, build and maintain muscle mass and lean body tissue (Venkatamaujam, 2002).

The fat content of the four multimixes were 4.1 g, 4.0 g, 3.1 g, 2.2 g for 3A, 3DS, 8A and 8DS respectively but the maximum permissible limit for fat as per IS specification is 7.50 g per 100 g. This indicates that all the four mixes had lower fat content. This may be because cereals and pulses which forms the basis of the complementary mixes in general contain very small amount of fat i.e., for cereal the fat content is 1 g / 100 g as given in nutritive value of Indian foods (ICMR, 1991). Actually the addition of soya should have supplied adequate protein as well as fat. But in the formulations soya chunks was added in very low amounts (15 g/100 g). Though the fat content of the mixes are low, it has been enhanced by adding few drops of coconut oil to the cooked multimix just before feeding. The addition of coconut oil in justified by Yeming (2003), who has proclaimed that coconut oil a typical medium chain triglyceride is preferred for use in food especially when there are disorders in the digestion, absorption and transport of food fats. She has further ascertained that for the same reason it finds a place in infant feeding formulae especially for the treatment of malnutrition.

Moreover, Thampan (1994) had opined that coconut oil differs from most other fats and oils in containing a high percentage of saturated fatty acids, in particular, lauric and myristic acids with notable proportion of still lower fatty acids. Moreover coconut oil, which is endowed with an abundance of short and medium chain fatty acids, is therefore a very valuable fat source for infant feeding. The above fact justifies the use of coconut oil in order to enhance fat content of the complementary food.

When fat content of the control was analysed it was found to be 0.75 g/100 g, which do not supply even 10 percent of the level required. Higher fat content can lead to rancidity in the products thereby lowering its shelf life and acceptability. Hence in order to enhance the keeping quality of the product the fat content might have been judiciously lowered by the commercial manufactures. However this is a major drawback of the commercial formula, since it does not supply required amount of fat and protein, which are two major and essential nutrients.

Saxena and Aggarwal (2003) have confirmed that carbohydrate play a major role in the overall development of children's body and health. Studies have shown that adequate dietary carbohydrate must be consumed on a daily basis to restore levels of carbohydrate (glycogen) stored in the body muscles and liver, which, acts as the preferred fuel. King *et al.* (2000) has further stated that an optimum diet should have at least 55 per cent of total energy coming from carbohydrates derived from a variety of food sources.

The developed four multimixes were found to contain sufficient quantity of carbohydrate. The standard **IS** recommendation for carbohydrates in cereal based complementary foods is 45.00 g/100 g being the minimum level. The carbohydrates content of four mixes were 68.0 g, 70.5 g, 54.0 g and 56.5 g for 3A, 3DS, 8A and 8DS. Thus all the developed mixes are effective in satisfying the requirement for carbohydrate. The total carbohydrate content of control sample was found to be 66 g. As the control is a rice-based product the carbohydrate content is liable to be high. Carbohydrate content of developed multimixes are also found to be high, because, rice has been used as the base material for developing the mix. According to Manay and Shadaksharaswamy (2002) rice is a good source of carbohydrate containing 78 per cent of carbohydrate. As rice in the above mixes constitutes 55 to 60 per cent that itself ensures adequate supply of carbohydrates.

In this context it is of interest to note that complementary mixes developed in this study has comparatively high carbohydrate content and low fat content. This fact seems to be advantageous since Yaming *et al.* (2003) has emphasized that a diet high in carbohydrate as compared to that high in fat reduces the likelihood of developing obesity. The authors have further stated that carbohydrate-containing foods are rich source of micronutrients and phytochemicals. Carbohydrates are also reported to help in the maintenance of glycemic homeostasis and gastrointestinal integrity and function. Therefore the slightly high carbohydrate content found in the mixes can be taken as a positive factor that would help to maintain the health of the infant who receives it.

A wheat based weaning biscuit developed by Rajapaksa (2003) was reported to contain 75-78 g/100 g of carbohydrate. A rice soya based weaning food developed by Jacob (1997) claims to have carbohydrate content of 71 g while in the present study carbohydrate content ranged between 54.0 g to 70.5 g per 100 g. However it may be observed that Swamy and Jayaprakash (2003) had developed a supplementary food for infants with vegetable sangari containing carbohydrate as low as 32.3 g/100 g. It is of special significance here that the least formulation viz., 8A contains just 54 per cent of carbohydrates, which is an optimum level viz., 10 per cent above the minimum level recommended.

Malleshi (1995) has stated that the indigestible fibre content of a complementary food should be low, because the fibre may interfere with the absorption of nutrients. The fibre content of the developed multimixes were 1.97 g, 0.82 g, 0.70 g and 1.52 g per 100 g of the sample, while the maximum permissible fibre content is 1.00 g as per IS recommendation for 100 g. It was clear that among the developed multimixes 3DS and 3A

(1.97 and 1.52) have higher fibre content than that of the recommended value. This is because these two multimixes contained rice, ragi, greengram, soya and drumstick/amaranth, which are good sources of fibre. Drumstick leaves was found to have higher fibre content when compared to amaranth *i.e.*, 1.9 g and 1.0 g / 100 g respectively. A wheat based product developed by Rajapaksa (2003) had a fibre content of 1-2 g / 100g.

The fibre content could have been brought down if ragi and greengram were used in the malted form as Afoakwa (2003) has stated that addition of cereal malts of weaning food could change the physico-chemical properties.

Committee on Nutrition (2003) has stated that the amount of minerals in infant formulae must be highly regulated, because low mineral level may lead to irritability, listlessness, anaemia and rickets while high level of mineral may lead to dehydration, bloating and renal overload. Hence the developed product was designed in such a way to provide optimum minerals to the infant.

The standard recommendation for iron in cereal based weaning food is a minimum of 10.00 mg/100 g but two of the developed products were found to have value below the recommended value i.e., 8A (6.50) and 8DS (8.50) while the other two mixes 3A (10.50) and 3DS (12.00) were found to satisfy the iron requirement. In multimix 3A and 3DS ragi was used as an additional cereal. Ragi is considered to be a good source of iron (3.9 mg/100 g). Hence when ragi was added at 10 per cent level the iron content of the multimix is bound to be higher than that of 8A and 8DS. Malhotra (2003) developed wheat based weaning mixes and the iron content ranged from 4.53 mg to 6.98 mg per 100 g while in a weaning mix developed by Jacob (1997) the iron content was found to be as low as 4.2 mg/100 g. In general rice based products are poor source of iron and their bioavailability is also poor. However in the complementary food developed the iron content has been elevated to the desired level by the addition of ragi and green leafy vegetables.

The developed multimixes had their calcium content as 320 mg, 340 mg, 240 mg and 180 mg per 100 g while the standard IS requirement is a maximum of 1000 mg. As the mixes are non-milk cereal based complementary foods the calcium content was found to be very low. The calcium content of 3A and 3DS were found to be higher than that of 8A and 8DS because 3A and 3DS contained rice (60 per cent) and ragi (10 per cent) as the cereal components, while in 8A and 8DS rice alone was the cereal component; hence the calcium was found to be very low. Abraham (1997) has reported that ragi contains more calcium and iron and that the calcium content of ragi is 34 times higher than that of rice. As reported by Hanchale (2005) calcium is an essential mineral in building and maintaining bone mass, as well as controlling muscle functions. It is critical to have enough calcium rich foods during childhood to buildup adequate bone mass.

The calcium content of weaning food developed by Malhotra (2003) with wheat was found to contain 255.74 to 440.25 mg while in the present study the calcium ranged between 180 mg and 340 mg per 100 g. Though an attempt had been made to enhance the calcium content by incorporating ragi and green leafy vegetables which are good sources of above element, the result obtained have revealed that calcium content needs further enhancement. This can be done by increasing the quantity of ragi and green leaves without altering its acceptability. The calcium can also be increased if milk powder is added or if milk is used while cooking the mix into a porridge.

The sodium and potassium content of multimixes ranged from 0.08 to 0.01 mg and 0.05 – 0.06 mg respectively. Minimum amount of sodium and potassium are required for a weaning food, because excess of these minerals may lead to increase in renal load of infant's kidney.

The vitamin content of mixes were also calculated and vitamin C content of 3A and 8A were found to be 4.9 mg/100 g while 3DS and 8DS gave a value of 11 mg. This major variation is due to the fact that in 3A and 8A amaranth is the ingredient added as vitamin-mineral supplement, which is reported to supply 99 mg of vitamin C per 100 g, while drumstick leaves are noted to supply 220 mg, which is included in 3DS and 8DS. A weaning mix developed by Jacob (1997) had a vitamin C content of 8.40 mg and IS requirement for vitamin C is 25 mg. Hence none of the developed products were found to satisfy the requirement of vitamin C. However the control was noticed to supply 65 mg of this vitamin which could be attributed to the addition of vitamin and mineral mixes to the product, being a commercial formulae.

The range of vitamin A in the developed multimixes was from 350.5 to 417.7 IU/100g. But the IS recommendation for this vitamin in a complementary food is 1500 IU/100 g. However the vitamin A content of control was 1332 IU. Hence it is noticed that vitamin A content of the developed products cannot satisfy the requirement of an infant. Vitamin A content can be elevated in two ways. Addition of extra amount of drumstick or amaranth leaves to the multimix or inclusion of Red Palm Oil (RPO) to the recipe instead of coconut oil would take care of this deficiency. Elizabeth(1998) stated that Red Palm Oil (RPO) is a rich source of beta carotene upto 800 mcg/g. However addition of extra quantities of green leafy vegetable should be done with care so as not to affect the acceptability and also tokeep the fibre content at the admissible limit.

Thiamine and riboflavin content of developed products ranged from 0.23 to 0.25 mg/100 g and 0.142 to 0.155-mg/100 g respectively. But the IS minimum requirement for thiamine is 0.50 mg/100 g and that of riboflavin is 0.60 mg/100 g. But control was shown to have a thiamine and riboflavin value of 0.55 mg/100 g and 0.36 mg/100 g respectively.

Hence it is noted that none of the developed products satisfies the requirement of thiamine and riboflavin while the control sample supplies adequate amount of thiamine, while it is deficient in riboflavin.

To conclude when major nutrients are considered multimix 3DS (70.5 g) had high carbohydrate content, while protein content was found maximum in multimix 3A (17.45 g) whereas for fat 3A (4.50 g) secured highest value and for minerals such as iron and calcium 3DS was found to be better than the other three combinations. To identify the best mix, the product quality index on chemical composition was worked out based on eleven characters such as moisture, total protein, fat, total carbohydrate, crude fibre, iron, calcium, sodium, potassium, total ash and acid insoluble ash (considering minimum and maximum value) and the highest index was found to secured by multimix 8A.

Hence by considering the chemical composition of the multimix 8A can be adjudged as the most nutritious one among the four mixes.

Next to chemical composition rheological properties of the mixes were evaluated to find the suitability of the mixes to feed an infant of 6-9 months and also to select the most suitable one. Physical and rheological characters are one of the important criteria that determines the acceptability of a product. According to Kulkarni *et al.* (1991) complementary foods should have favourable physical qualities like even desirable particle size, low viscosity and bulk and high energy density in order to have the desired consistency, nutrient content and palatability.

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

Since all the four multimixes were sieved through a standard sieve of 60 mm mesh size the particle size of all the four mixes were found to be the same.

The consistency of the developed product was smooth in texture and was suitable for feeding the infants with a spoon. The above fact is confirmed through organoleptic evaluation. The organoleptic evaluation for consistency as shown in Table 7 revealed that 3A, 3DS, 8A and 8DS had all scored high values of 4.1, 4.5, 4.0 and 4.5 respectively against a maximum score of '5'. These were the mean scores as judged by 10 expert judges of a taste panel. Therefore it clearly indicates that consistency of the mixes was acceptable which can be attributed also to particle size.

Malleshi (1995) has stated that a weaning food should not adsorb too much water and should not become bulky when the mix is stirred up and cooked with water or milk. The developed products was found to have a bulk density ranging from 0.77 to 0.85 g/100g. The maximum bulk density was found in multimix 3DS and least was observed in 8A.

Gopaldas and Deshpande (1995) as ascertained that a child finds it difficult to meet his or her nutritional requirement, if the food is bulky and she has further proclaimed that dietary bulk can be reduced by the addition of ARF or by malting. But in the present study even though the bulk density ranged from 0.77 to 0.85 g/100g. It was quite suitable for spoon-feeding and the consistency was also perfectly acceptable. Hence addition of ARF or malting of cereals was not resorted to.

The most common problem of homemade as well as commercial complementary foods are high "viscosity" (Malleshi, 1995). To provide adequate calorie these foods are made with a high solid concentration and hence they become too thick and viscous making it difficult for a young child to consume in adequate quantity. When these are diluted it helps the child to swallow it easily. But at the same time this process reduces the energy content considerably. More over feeding makes a time consuming procedure as observed by Gogoi (2003).

The viscosity of the four multimixes were analysed using Rapid Visco Analyser. Viscosity of the four multimixes were 1627 cp, 1638 cp, 1577 cp and 1586 cp respectively for 3A, 3DS, 8A and 8DS. Formulation 8A was found to have the lowest viscosity however, Gopaldas and Deshpande (1995) has reported 1000 cp as the acceptable viscosity, when measured by a Brook-field viscometer.

Though the viscosity is higher, as per the analysed value the consistency of the product when made into a porridge was highly suitable and acceptable for feeding infants as indicated by the acceptability score for consistency (Table 24) and the preference score (Table 35).

The high viscosity may be due to the presence of cereals and legumes in the formulations. Mosha and Svanberg (1990) have reported that the high viscosity of gruels prepared from cereal and legume flours is due to the presence of starch and protein. Malleshi (1995) has stated that germination, malting and addition of Amylose – Rich Food (ARF) or alpha amylase enzyme would reduce viscosity or dietary bulk of the product. Though such measures reduce viscosity are well known, they were not employed in the processing of the developed complementary foods, because sensory evaluation conducted at different levels/ stages did not reveal the viscous nature of the product .Moreover the consistency was established to be the most acceptable though theoretically, the values for viscosity were above the optimum valve of 1000 cp.

The physical characteristics further revealed that multimix 8A has lowest viscosity and bulk density this important properties that makes the complementary food acceptable and suitable to feed an infant. Product quality index based on physical and rheological characters when worked out based on yield ratio, ease of preparation, bulk density and viscosity the multimix 8A was found to have the highest index score (544.202) making it most suitable among the four formulations.

Infant formula is a very special functional food product because it is intended to be used as the source of nourishment from a very young age of six months of life. It must meet all the nutritional needs of an infant over a prolonged critical period without any harmful inadequacies or excess. Therefore its composition is crucial to the infant's health as stated by Lokeshwar (2005). Therefore it was essential to evaluate the nutritional superiority over and above its chemical composition revealed in table12. In order to assess the nutritional adequacy, calorific value, protein energy ratio, chemical score and amino acid score of the mixes were worked out, apart from the analysis conducted for estimating the nutrient content of the four multimixes.

Caulfield *et al.* (1999) reported that complementary food must be adequately dense in energy to meet the requirement of an infant. The calorific value of the developed mixes varied from 339 to 345 kcals.

As stated by WHO (1998) calorie required from complementary food is estimated to be approximately 275 kcals at 6-8 months, 450 kcals at 9-11 months and 750 kcals between 12-23 months of age. As the developed product is found to supply 339-345 kcals and the calorie requirement at 6-8 months is 275 kcals all the four mixes will satisfy the energy needs of a child.

Malleshi (1995) has reported that one way to increase the calorie content is to increase the fat content; for fat has a higher calorie density. A second possibility is to give the child more solid food *i.e.,* a food having less water such as cooked whole rice. The third possibility is to partially breakdown the starch so that it will not absorb much water while cooking.

In the present study after preparing the multimixes into a porridge suitable to spoon feed the child, few drops of coconut oil was added which would enhance the energy content. It was also found to improve the flavour as well as the consistency.

The ratio between protein and energy was also computed. The protein energy ratio will indicate whether the food can fulfill the protein needs. Protein energy ratio of four developed mixes (3A,3DS,8A,8DS) were 21.42,21.35,20.40 and 20.17.

Protein quality of a food can be evaluated in chemical terms by comparing its amino acid content with that of a reference protein. The amino acid score and chemical score of mixes 3A and 3DS were 95 while that of 8A and 8DS were 86.

Multimix 3DS had secured high calorie content and the protein energy ratio was found maximum in the case of 3A. Chemical and amino acid score was also found to be high. In order to find out the best product based on nutritional adequacy an index was worked out based on parameters like calorific value, protein energy ratio, chemical score and amino acid score and it was noticed that 3A secured the highest index value compare to other products.

Setty (1989) had defined that for an average consumer the concept of food quality relates to the sensory characteristic, which may be classified in accordance with the human senses of perception as appearance, kinesthetics (texture) odour and taste. Assessment of organoleptic qualities was carried out mainly to draw conclusion about one particular formulation from the four combination through selection of a limited number of panel members. Organoleptic evaluation was done by 10 expert judges using scorecard method and the result revealed that 8A was the most acceptable one because of its fair appearance colour taste and consistency.

According to Thirumaran (1993) the introduction of locally processed and preserved nutrition ready-to-use food will reduce the time and spent in processing and preserving infant food. Rosado *et al.* (2000) had opined that the production process for the supplements should be as simple and cheap as possible so that it allows the supplements to be produced in different regions of the country facilitating their distribution.

One of the major criterion recommended by ICMR (1970) for judging the acceptability of developed supplements is that the method of preparing the supplement should be simple and it should not take more than 15 minutes. Huffman (2002) has remarked that an ideal supplementary food would only need a cooking period, which would save mother's time and enable the food to be cooked each time just before it is served.

The time taken for the preparation of the porridge for the mix was three minutes. Hence the time taken for preparation can be considered as acceptable as per recommendation of ICMR (1970) which declares that the product is ready to cook and makes the job of the preparation very easy and less time takening.

Watts *et al.* (1989) have reported that during the development of new food products or the reformulation of existing products like identification of changes caused by processing method, by storage or by the use of new ingredients, their acceptability should be assessed by conducting preference test on a large number of consumers. They have also stated that preference studied are designed to determine consumer's subjective reactions to external phenomena and their reasons for having them. Hence the four supplements and the control sample (Nestum) were given to ten mothers of children to know their preference. High preference was given to 8A (88) followed by 8DS (80). This is due to the fact that the porridge made from which had an attractive fluffy and soft texture, smooth and free flowing consistency, delicious flavour and befitting taste. These formulae attribute could be due to the presence of rice and blackgram which are familiar and frequently consumed foods of locality and their judicial blending with soya and green leafy vegetables. The extrusion procedure also might have contributed to the aroma and consistency of the product.

The yield of the mixes both during processing and preparation (recipe) is an important factor. The weight loss during processing should be minimum in order to facilitate maximum out put or yield. The processing loss and yield ratio of the supplements were worked out.

The process loss was found to be highest in 8A (0.51). This was mainly because of the low yield of amaranth powder during processing. The quantity of amaranth powder obtained from fresh leaves was found to be very low. Similar results was observed in the processing of rice soya based supplement developed by Kerala Agricultural University as a food supplement under ICDS (Thomas, 2001).

In order to verify the safety of multimixes for feeding young infants, the total microbial count of the multimixes were ascertained by serial dilution technique.

The highest bacterial count was seen in 8A (2200) followed by 3A (1400). 8DS was found to contain lowest number of bacteria. Though all the samples were found to contain few bacteria, the count was much below the limit specified by ISI, *i.e.*, 5000/g (maximum) indicating that all the supplements are safe to be fed to children.

It was further gratifying to note that even after storage in polyethylene covers for three months the increase in bacterial count was only minimum. However, it was taken into account that the control samples were free of contamination. This indicates that commercial sample has been processed under stringent aseptic conditions and are stored in vacuum sealed laminated pouches which are further enclosed in strong laminated cardboard cartons.

As the initial values of the developed products are low, the sanitary quality can be further improved by careful handling of materials at all levels of processing and storage. Apart from the stringent processing procedures, modern packaging techniques are to be applied to ensure the safety of the products developed under the study.

The supplements were also assessed for the presence of *E. coli* and it was found to be absent in all the four supplements which indicates that the supplements have been prepared under hygienic conditions. Walter (1973) has stated that preference of coliform organism determines the sanitary quality of a product. Presence of *E. coli* is an index for excretal contamination; which may contain disease producing microorganism too. The developed mixes are free of faecal contamination, and therefore can be given to the children safely.

Weaning mix developed by Sheng (2005) with soya flour (defatted and roasted) was reported to contain no coliform bacteria.

Apart from the chemical, nutritional, microbilogical, physical and rheological properties the product should have good shelf life and high acceptability.

Kumar (2001) has stated that shelf life can be defined as the length of time that a package or a material in a container will remain in a saleable or acceptable condition under specified conditions of storage. Varsanyi (1993) had observed that storage of food has been so complex that an entire industry has been developed to satisfy the needs of consumers. The mechanism and kinetics of food deterioration can be controlled by storage techniques applied.

Therefore the developed multimixes were packed in polyethylene covers and were stored for a period of three months under ambient conditions. The storage stability of mixes were analysed by measuring the peroxide value, moisture content and extent of damage by insect/pest. Sharma (2004) has stated that most of the precooked dehydrated instant foods are highly susceptible to oxidation leading to development of undesirable flavour. The nature and extent of auto oxidation, degradation depends on the extent of unsaturation of lipids present in cereals or pulses.

The peroxide value of four multimixes after a period of three months storage ranged from 0.7 to 1.0 meq/100g. Highest peroxide value was observed in multimix 3DS. Peroxide value ranging from 0 to 5.00 meq/kg in a weaning mix after a storage period of 42 days was reported by Solanki (1996), while peroxide value of 15.92 meq/kg in stored multimix was reported by Inamdar (1991). Gupta *and* Sehgal (1992) have reported a value of 7.20 meq/kg in ragi based weaning mix after a storage period of 28 days.

When compared to the above data, the peroxide value obtained in the present study seems to be very low. This is a positive feature giving an indication of better storage stability of the developed weaning mixes. The low peroxide value may be due to low fat content of mixes as well as better storage conditions.

Moisture content of the product will effect the shelf life because as stated by Sagar and Roy (1997), by reducing the water content of food, shelf life can be improved. The moisture content of multimixes at the initial stage ranged from 2.3g to 3.7g, while after storage, the moisture was increased, *ie*, it ranged from 3.5g to 3.9g. This picture indicates that all the mixes have absorbed moisture from the atmosphere since there was increase in moisture content and greater increase was observed in3A and 8A.

Bacterial count was also recorded after three months of storage to find out storage stability. According to Leela *et al.* (1993), processed foods and other food materials provide ample scope for contamination with spoilage and pathogenic microorganism, thus necessitating microbiological quality assessment as an integral part. In the present study, lower bacterial count was seen in initial stage than in the stored product. However, the increase in total bacterial count is still within the acceptable range suggested by BIS. However, assessment of incidence of insect/pest in stored product revealed that there was no insect infestation in the product because they were stored in airtight polyethylene covers. According to Leela *et al.* (1993), insect has more preference for moist products. Since the developed mixes were extruded at very high temperatures and lowering the moisture content to a great extent by mechanical drying, the insect /pest infestation was found to be totally absent.

A factor that attracts consumer to a product is its low cost and high acceptability. Here the cost of one kilogram of the multimixes inclusive of twenty per cent overhead charges were also calculated to ascertain the cost of weaning food. The cost of one kilogram of combination ranged from Rs.18 to 28.44, while the cost of commercial weaning food was 142.50 Rs/kg. Malleshi (1995) reports that many of the proprietary weaning food are quite expensive and beyond the purchasing power of the parents belonging to middle and lower income group. The higher cost of commercial weaning food can be attributed to several factors such as cost of packaging materials (aluminium foil, cartons, tin), expense involved in the advertisement of the product, overhead charges etc. Ramasaranya and Kanjana (2003) proclaimed that cost of developed weaning biscuit was Rs.24/kg which is very low when compared to the commercial brands.

Sandhu and Joshi (1995) reported that quality evaluation is the main criteria to find the acceptability of any product. The overall acceptability of the multimixes with different combination revealed that multimix 8A scored high. The high score for overall acceptability for this combination was due to the high score for the parameters like appearance, colour, flavour, taste, consistency and doneness.

During the development of new food products or reformation of existing products, the identification of changes caused by processing method, by storage or by the use of new ingredients, their acceptability could be assessed by conducting preference test (Watts *et al.*, 1989). Hence in the present study, the preference score among mothers for developed products was conducted and multimix 8A showed the high preference, while lower preference was shown for 3DS. This is because appearance and colour of 3A and 3DS were not acceptable.

When overall index was determined to identify the best mix among the four blends 8A was noticed to have highest index value as 8A secured high score for characters such as chemical, physical and reheological, organoleptic and preference test. Hence 8A can be considered as the best one.

Thus based on chemical, physical and reheological, organoleptic and preference test multimix containing rice (55 per cent), blackgram (25 per cent), soya (15 per cent) and amaranth (5 per cent) was found to be the most acceptable one. The mixes was found to satisfy the requirement for the major nutrient such as carbohydrate, protein and fat and it was noted to be an energy rich supplementary food. The mix was found to be highly acceptable when evaluated through scoring technique. This was also found to be safe to feed children even after storing the same for three months. Since it was found to free from *E. coli* and insects and pests contamination. The material was acceptable to rural mothers of infants, which could be due to the fact that it is made from locally available familiar materials like rice, blackgram and amaranth leaves. The consumer preference for the same would be also high because it is very cheap compared to the customary complementary mixes sold in Kerala. It can easily find a place in market because it was found to satisfy nine criteria out of 11 parameters stipulated by IS 1656 to 1969 for cereal based weaning food.

Malleshi (1995) from CFTRI has reported that three important aspects should be considered while developing the weaning food. Firstly, basic raw material of the weaning food should be locally available food grain. Secondly the food should contain low level of fibre and other materials that are difficult to digest. Thirdly, the food should be ready to eat and should enable the mother to prepare the gruel or paste from them at the time of feeding. The rice based complementary food in this study satisfies all the above requirements and hence it can be claimed as an acceptable supplement to an infant in the age group of six to nine months.

Summary

6. SUMMARY

The study entitled "Developing rice based complementary food for infants" was carried out with an objective to develop and evaluate the chemical, physical, nutritional and shelf life qualities of a rice based complementary food suitable for feeding infants of six to nine months of age.

Sixty four combinations of basic mixes were worked out by varying the proportions of rice and different pulses. The amino acid score and chemical score of these combinations were calculated and 11 combinations that had the highest chemical score (above 80) were selected for further study.

Multimixes were formulated from the basic mixes by adding other ingredients in two different ways. In the first method a second cereal was introduced. Thus 108 combinations containing either ragi or wheat as an additional cereal having varying proportions were formulated. In the second method on additional pulse was added to the basic mix and thus 139 combination were worked out. Among these 247 (108 + 139) multimixes an equal number of combination (*i.e.*, 11) as that of the basicsmixes having chemical score above 80 were selected at random. So that there were eleven basic mixes and 11 multimixes.

Further to formulate a comprehensive multimix the "food square" concept was adopted inorder to make an ideal complementary food. As per this concept four components are essentially needed: a basic staple, a protein supplement, a vitamin – mineral supplement and an energy supplement. As the staple and protein components are already available in the primary mixes a vitamin-mineral supplements and an energy supplement had to be added. Therefore amaranth was selected as vitamin mineral supplement while sugar and coconut oil were selected as energy supplements.

However, when the nutritive values of the 22 combinations (11 + 11) were worked out the protein content was observed to ranged from 8 to 12 g. As an ideal cereal based weaning food should contain atleast 14 g of protein per 100 g, soya was also choosen and used as another ingredient that would supply good quality protein.

Each of the ingredients were processed initially by cottage level techniques such as cleaning sundrying, milling, roasting, and sieving and were blended in selected proportions to formulate the 22 comprehensive multimix.

Each of the mixes was individually converted into a recipe suitable for feeding an infant, *i.e.*, porridge of spoon feeding consistency. They were evaluated for their acceptability by ten expert judges with the help of a scorecard. The total scores were compared and ten mixes (from the 22 mixes) having highest acceptability scores were selected for further evaluation. All these multimixes contained amaranth as the vitamin – mineral supplement. As drumstick is a cheap and easily available green leafy vegetables, 10 more multimixes were processed replacing amaranth by drumstick. The ten multimixes with amaranth were designed with a suffix A while those with drumstick had the suffix DS.

These were further processed for largescale commercial exploitation. Two modern methods *viz*., drum drying and extrusion were tried out. As drum drying process failed due to gelatinization, extrusion method was adopted. Thus 20 ready-to-cook multimixes of fine quality were obtained.

In order to identify the best multimixes among the 20, they were further ranked on the basis of organoleptic quality. On this account 8 DS and 3 DS were ranked as 1st and 2nd. As these two contained drumstick leaves on the vitamin-mineral supplement. Corresponding combinations containing amaranth *viz.*, 3A and 8A were also selected for further analysis. Moreover 3A had secured the third rank also. Out of these formulations 3A had rice, ragi, greengram, soya and amaranth, at the rate of 600 g, 100 g, 100 g, 150 g and 50 g respectively per kg. 3 DS also had the same composition except for the fact that it had drumstick leaves in the place of amaranth. The multimix 8 A was comprised of rice (550 g), blackgram (250 g), soya (150 g) and amaranth (50 g) while in 8 DS amaranth was replaced by drumstick.

In order to find out the best one among the above four blends they were subjected to chemical and physical analysis. Moreover their shelf stability, cost, sanitary quality was assed. The acceptability and preference scores, assigned by experts and mothers of children were also considered for selecting the best mix.

The chemical compositions of the selected four mixes were ascertained by estimating selected nutrients (total protein, fat, total carbohydrate, calcium, sodium, potassium and iron) and non nutrients (moisture, total ash, acid insoluble ash, crude fibre) using standard laboratory techniques. Product quality index based on chemical composition was worked out and 8A secured the highest index score.

Physical and rheological qualities like yield, ease of preparation, particle size, bulk density and viscosity were then ascertained. Here again the multimix 8A secured the highest index value.

Nutritional adequacy of four multimixes was assessed on the basis of four characters such as calorific value, protein energy ratio, chemical score and amino acid score. Here again the adequacy scores of the four combinations were worked out. The comparison of the index values revealed that 3A was the most adequate one (38.25) followed by 3DS (37.31), 8 DS (33.93) and 8A (33.84).

To ensure that the mixes are safe for feeding infants, bacterial counts as well as the presumptive test to ascertain the presence of E. coli contamination were carried out. The total bacterial count indicated that the mixes are not absolutely sterile but the counts were much below the admissible level suggested by BIS. The permissible limit was 5000 per gram but the samples had total bacterial count between 600 to 2200 per gram. The presence of *E. coli* when assessed revealed that *E. coli* was absent in all the four multimixes indicating the absence of faecal contamination.

Young mothers are tempted to purchase commercial mixes mainly for two reasons, shelf stability and easiness to prepare the feed. Therefore shelf stability and time required to prepare the mix into a suitable recipe to feed an infant of 6-9 months of age were ascertained shelf life qualities of the multimixes were ascertained through chemical, physical and microbiological methods after storing the mixes in polyethylene covers for three months.

The moisture content of stored product was found to be higher than that at initial stage. This indicated that all mixes had absorbed moisture from the atmosphere. The peroxide value of the mixes also indicated that chemical change due to oxidation of fat either by air or by microorganisms has set in the mixes in a mild way. Bacterial count was also found to be higher in stored products when compared to that at the initial stage. However, bacterial count was found to be still within the permissible limits approved by BIS. Moreover even after three months no pest or mould infestation was observed in the mixes. Organoleptic quality of four mixes were also evaluated after storage of three months and all the mixes were highly acceptable and the most acceptable multimix was found to be 8A.

To justify the quality of the developed product for commercial exploitation the characteristics of the mixes were compared with those specified under IS1659-1969. To assess the commercial viability of the product thus mixes were also compared with selected characteristics of a commercial infant formula (Nestum). This exercise revealed the fact that all the products were effective in supplying adequate amounts of the two major nutrients namely carbohydrate and protein. They were all found to be low in fact content but that deficit has been overcome by the addition of coconut oil while preparing the recipe. As far as the mineral content was concerned, 3DS and 3A were found to supply adequate amount of iron while other two (8A and 8DS) were capable of meeting 60 per cent of the quantity of iron recommended by BIS. It was also seen that the mixes could meet only 30 per cent of the calcium requirement sodium and potassium content of the multimixes were found to be very low 20-30, 25-27 per cent. This could be taken as a positive quality because excess of these minerals may lead to increase in renal load of infant's kidney.

As far as vitamins were concerned, the multimixes could meet only 20 to 44 per cent of the c requirement, while vitamin a content of the multimixes ranged between 350 to 413 μ, which is capable of meeting only 23 to 27 per cent of the. Thiamine and riboflavin content of the multimixes ranged between 0.235 to 0.250 mg and 0.142 to 0.155 mg respectively But the standard minimum requirement for these vitamins in infant formula are 0.50 and 0.60 mg respectively.

However adding commercial vitamin-mineral mixes to the blends while processing the material on a large scale, which is an acceptable practice followed in preparing proprietary infant formulae can make up such deficiency in minerals and vitamins sold in open market. The vitamin A and C content of the multimixes could be improved by adding additional amount of green leafy vegetables also.

The **IS** standard had also stipulated that the mixes should not contain *E.coli* and that the total should not exceed 5000 per gram of the sample. The result obtained revealed that all the four products were free of

E.coli and had a total bacterial count 20-50 per cent below the permissible limit and therefore are safe to be fed to infants.

Another important feature that was highly noticeable was the cost. The developed products can be prepared at a cost ranging from18 to 24 Rs per kg while Nestum is sold at the rate of Rs.57per400g.This fact indicates that the developed mixes are cheap and are made with locally available resources and is affordable and acceptable to mothers belonging to low socioeconomic status.

A food to be given to a child irrespective of all the above mentioned features should be acceptable to mothers because they would decide what is to be given to their children. Hence a preference test was conducted among ten mothers of infants using a hedonic rating scale and it revealed that multimix 8A was the most preferred one followed by 8DS.

The suitability of mixes and their adequacy had been investigated through several indications, *i.e.,* chemical, nutritional, organoleptic and preference score. But an overall picture was needed to identify the most suitable mix. Hence an overall adequacy index was developed. This index value revealed that 8Ais most suitable one, since it had the highest score.

Thus based on chemical, physical and rheological, organoleptic and preference test the multimix containing 55per cent rice, 25 per cent black gramdhal,15 per cent soya and 5 per cent amaranth was found to be the most acceptable combination for preparing an infant formula. This could be reconstituted easily within three minutes into a porridge, which has a desirable consistency for spoon feeding. This rice based complementary food was found to be nutritionally adequate to meet the requirement of the major nutrients of an infant aged between six to nine months. However, it was found to be slightly deficient in calcium and micro vitamins, which could be ameliorated if a minute quantity of vitamin-mineral mix is added to the blend while processing it. The formula had high acceptability as revealed by organoleptic characteristics and preference score given is it's by mothers of infants and expert judges. This acceptability may be due to the use of indigenous materials and also the technology adopted. The material can be stored for an year if stored in vacuum sealed laminated pouches. The most important features worth mentioning easiness to prepare and its low cost. The product can be marketed if it can be popularized through appropriate method.

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DEVELOPING RICE BASED COMPLEMENTARY FOOD FOR INFANTS

DHANYA JOSE

Abstract of the
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Department of Home Science
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM-695 522

ABSTRACT

A study entitled "Developing rice based complementary food for infants" was conducted to formulate a weaning food with rice suitable for feeding infants of six to nine months of age.

Sixty four combinations of basic mixes were worked out combining rice with different pulses in varying proportions. Out of these, eleven combinations having high chemical score (above 80) were selected for formulation of multimixes by adding ingredients in two different ways. In the former method ragi or wheat was added to the basic mix as a second cereal and in the later method an additional pulse was added. Thus 247 combinations were formulated. From these, eleven combinations having chemical score above eighty were selected at random. Thus there were eleven basic mixes and eleven multimixes. These 22 mixes (11+11) were used in the preparation of a comprehensive multimix based on "food square" concept suggested by Protein Advisory Group (1975), which would contain a staple of the locality and a food that would supply protein, a mineral and vitamin supplement and an energy supplement.

As the staple and protein components are already present in the 22 primary mixes, amaranth leaves were added as vitamin-mineral supplement. Sugar and coconut oil were added as energy supplements. While calculating the nutritive value of the 22 combinations, the protein content was found to be very low; hence soya was also included as an additional ingredient to formulate complementary food.

The selected ingredients in the multimixes were processed separately by common cottage level techniques and were blended in specified proportions to formulate the 22 comprehensive multimixes. These were converted into a recipe suitable to feed an infant. They were evaluated organoleptically by ten expert judges with the help of a score card. The total scores were compared and ten mixes having highest acceptability scores were selected. These multimixes

contained amaranth as vitamin-mineral supplement. As drumstick leaves is also a cheap and easily available green leafy vegetable, ten more multimixes were processed replacing amaranth with drumstick leaves. The multimixes with amaranth were designated with a suffix 'A' while those containing drumstick leaves had the suffix 'DS' along with their serial number.

These 20 (10+10) multimixes were processed by "extrusion" to facilitate large scale production for commercial exploitation. These were then evaluated for their yield, nutritive value, organoleptic quality and cost.

In order to identify some of the best multimixes from the above 20, they were further ranked on the basis of organoleptic score. Thus 8DS and 3DS were ranked as first and second respectively. Corresponding combinations containing amaranth, *viz.*, 8A and 3A were also selected for further analysis to find out the best multimix. In order to achieve the mulimixes were subjected to chemical, physical, nutritional and sanitary quality analysis and were evaluated for their shelf stability, acceptability and preference. Several parameters were used to evaluate chemical, physical, nutritional quality of the four mixes. As these parameters varied widely, comprehensive indices were worked out using appropriate statistical tools.

Thus the product quality index for chemical, physical and rheological qualities and nutritional adequacy were worked out. The multimix 8A secured the highest index value for chemical, physical and rheological characters, while 3A secured the highest score for nutritional adequacy.

To identify the most acceptable multimix, an overall adequacy index was also worked out and the index value revealed that 8A is the most suitable one since it had the highest index score.

Total bacterial count and *E. coli* contamination if any also ascertained to ensure that the multimixes are safe for feeding infants. Eventhough all the four mixes were not absolutely sterile, the counts were much below the admissible level suggested by BIS. It was further gratifying to note that *E. coli* was completely absent in all the four multimixes, giving further assurance to sanitary quality.

Shelf stability evaluation of the multimixes were carried out through chemical, physical and microbiological methods after storing the mixes for three months in polyethylene covers. Eventhough after storage the peroxide value and bacterial count were within acceptable limits, there was marginal increase in above parameters. Despite of the above variation, the acceptability of the mixes remained unaltered, which confirms the shelf stability.

Organoleptic and preference test conducted after storage also indicated 8A as the most acceptable multimix.

In order to justify the quality of the product the characteristics of the four mixes were further compared with those specified under IS 1659-1969 standard. From this exercise, it was found that the products were effective in supplying adequate amount of two major nutrients namely, carbohydrate and protein. However the fat content was found to be low, but this was overcome by the addition of coconut oil at the time of serving the mix in the form of a porridge. Vitamin and mineral contents were also found to be low, but such deficiency can be made up by adding commercial vitamin-mineral pre-mixes to the blends while processing the material, which is an acceptable practice followed in preparing infant formulae.

To assess the commercial viability of the products, further, the mixes were also compared with selected characteristics of a commercial rice based infant formula (Nestum-control). When nutritional adequacy was tested , the commercial formula was found to be ill-balanced. This control sample was noted to contain excess amount of carbohydrate and very low amount of protein and fat when compared to BIS recommendation. It is of special interest to note that this commercial formula was not adequate even to meet half of the protein requirement of a young infant, while the developed four mixes had a balanced proportion of the three major nutrients (after addition of coconut oil to the recipe). Another important feature was that the control sample had higher proportion of minerals especially sodium and potassium which again introduces another element of ill-balance, which may endanger the kidney function of the infant on prolonged use. However the multimixes developed had low levels of minerals and vitamins. These, if necessary, could be made upto desired level by adding vitamin-mineral pre-mixes in specified amounts while processing the blends.

Another most important feature that was highly noticeable was the cost. The developed mixes were very cheap (18 to 34 Rs/kg) when compared with commercial infant formula (147 Rs/kg).

The study revealed that the developed product 8A containing rice (550 g), black gram dhal (250g), soya (150g) and amaranth (50g) was found to meet the requirements specified by IS (1659-1969) for majority of the characteristics (nine out of eleven) and hence could be proclaimed as a nutritious complementary food for infants of Kerala being indigenous, low cost and easy to prepare and feed.

Appendices

APPENDIX – I

Chemical and amino acid scores of 64 combinations

Rice (g)	55	60	65	70	75	80	85	90
Black gram (g)	45	40	35	30	25	20	15	10
Chemical score	83	84	86	86	85	87	84	84
Aminoacid score	82	83	85	84	83	84	83	83
Rice (g)	55	60	65	70	75	80	85	90
Bengal gram (g)	45	40	35	30	25	20	15	10
Chemical score	73	75	77	85	83	79	84	84
Aminoacid score	86	86	87	85	85	85	80	83
Rice (g)	55	60	65	70	75	80	85	90
Green gram (g)	45	40	35	30	25	20	15	10
Chemical score	78	87	85	84	83	86	84	86
Aminoacid score	84	84	85	84	84	84	85	84
Rice (g)	55	60	65	70	75	80	85	90
Cowpea (g)	45	40	35	35	25	20	15	10
Chemical score	83	84	85	85	86	86	87	87
Aminoacid score	77	75	79	78	82	78	77	75
Rice (g)	50	55	60	65	70	75	80	85
Khesari dhal (g)	50	45	40	35	35	25	20	15
Chemical score	74	73	75	77	78	80	82	83
Aminoacid score	77	75	79	78	77	78	78	77
Rice (g)	50	55	60	65	70	75	80	85
Peas (g)	50	45	40	35	35	25	20	15
Chemical score	77	78	80	81	82	83	84	85
Aminoacid score	84	84	77	78	77	82	83	82
Rice (g)	50	55	60	65	70	75	80	85
Red gram (g)	50	45	40	35	35	25	20	15
Chemical score	66	68	68	73	75	77	80	82
Aminoacid score	78	82	82	84	82	82	83	83
Rice (g)	50	55	60	65	70	75	80	85
Soya bean (g)	50	45	40	35	30	25	20	15
Chemical score	88	88	88	88	88	88	88	88
Aminoacid score	83	83	84	85	84	83	83	83

APPENDIX - II

Chemical and aminoacid scores of 247 combination

Rice (g)	50	50	60	65	70	75	80	85	90
Ragi (g)	25	20	20	15	15	10	10	10	5
Green gram (g)	25	30	20	20	15	15	10	5	5
Chemical score	88	87	88	96	88	93	88	95	88
Aminoacid score	86	85	86	86	85	84	84	84	84
Rice (g)	50	50	60	65	70	75	80	85	90
Ragi (g)	25	20	20	15	15	10	10	10	5
Bengal gram (g)	25	30	20	20	15	15	10	5	5
Chemical score	87	88	88	86	88	95	88	92	84
Aminoacid score	86	85	84	85	85	84	85	85	84
Rice (g)	50	50	60	65	70	75	80	85	90
Ragi (g)	25	20	20	15	15	10	10	10	5
Black gram (g)	25	30	20	20	15	15	10	5	5
Chemical score	85	96	85	86	88	87	84	85	84
Aminoacid score	86	85	84	86	87	84	84	85	85
Rice (g)	50	50	60	65	70	85	80	85	90
Ragi (g)	25	20	20	15	15	10	10	10	5
Red gram (g)	25	30	20	20	15	15	10	5	5
Chemical score	85	85	85	83	85	83	85	84	82
Aminoacid score	86	85	84	86	87	84	88	84	85
Rice (g)	50	50	60	65	70	85	80	85	90
Ragi (g)	25	20	20	15	15	10	10	10	5
Khesari dhal (g)	25	30	20	20	15	15	10	5	5
Chemical score	85	85	85	83	85	83	84	82	83
Aminoacid score	86	85	83	84	85	84	85	83	85
Rice (g)	50	50	60	65	70	85	80	85	90
Ragi (g)	25	20	20	15	15	10	10	10	5
Soya bean (g)	25	30	20	20	15	15	10	5	5
Chemical score	93	94	93	93	93	92	93	93	92
Aminoacid score	91	91	93	92	93	92	93	93	92
Rice (g)	50	50	60	65	70	85	80	85	90
Wheat (g)	25	20	20	15	15	10	10	10	5
Green gram (g)	25	30	20	20	15	15	10	5	5
Chemical score	85	86	88	87	88	87	86	88	87
Aminoacid score	86	85	83	84	83	83	84	82	83
Rice (g)	50	50	60	65	70	85	80	85	90
Wheat (g)	25	20	20	15	15	10	10	10	5
Bengal gram (g)	25	30	20	20	15	15	10	5	5
Chemical score	88	87	86	85	86	87	88	87	88
Aminoacid score	86	85	83	84	82	83	86	87	85
Rice (g)	50	50	60	65	70	85	80	85	90

APPENDIX - II Continued

Wheat (g)	25	20	20	15	15	10	10	10	5
Black gram (g)	25	30	20	20	15	15	10	5	5
Chemical score	85	83	85	83	82	83	81	82	81
Aminoacid score	84	82	84	83	84	82	84	83	84
Rice (g)	50	50	60	65	70	85	80	85	90
Wheat (g)	25	20	20	15	15	10	10	10	5
Red gram (g)	25	30	20	20	15	15	10	5	5
Chemical score	85	83	85	84	85	83	84	83	85
Aminoacid score	84	82	83	84	85	83	84	85	82

Rice (g)	50	50	60	65	70	85	80	85	90
Wheat (g)	25	20	20	15	15	10	10	10	5
Soya bean (g)	25	30	20	20	15	15	10	5	5
Chemical score	84	85	83	84	85	83	84	85	86
Aminoacid score	83	4	85	84	85	84	85	84	85
Rice (g)	50	50	60	65	70	85	80	85	90
Wheat (g)	25	20	20	15	15	10	10	10	5
Khesari dhal (g)	25	30	20	20	15	15	10	5	5
Chemical score	82	83	83	84	85	85	86	86	85
Aminoacid score	81	81	82	83	84	85	84	85	84

Rice (g)	50	50	50	55	55	55	60	55	60	60	65	65	65	65	70	70	75	75	80
Cowpea (g)	25	20	30	25	30	15	20	20	30	10	20	15	25	10	20	10	15	10	10
Red gram (g)	25	30	20	20	15	30	20	25	10	30	15	20	10	25	10	20	10	15	10
Chemical score	75	73	76	77	78	73	77	75	81	74	80	78	81	76	82	78	82	81	83
Aminoacid score	82	83	83	83	83	83	83	82	83	83	84	84	85	84	83	83	83	83	83
Rice (g)	50	50	50	55	55	55	60	55	60	60	65	65	65	65	70	75	75	80	
Black gram(g)	25	20	30	25	30	15	20	20	30	10	20	15	25	10	20	15	10	10	
Soya bean (g)	25	30	20	20	15	30	20	25	10	30	15	20	10	25	10	10	15	10	
Chemical score	86	86	85	86	90	87	86	86	85	87	91	87	86	87	86	87	92	87	
Aminoacid score	83	84	83	83	83	84	84	83	84	84	85	85	85	85	83	83	83	84	
Rice (g)	50	50	50	55	55	55	60	55	60	60	65	65	65	70	75	75	80		
Black gram(g)	25	20	30	25	30	15	20	20	30	10	15	20	10	20	10	10	10		
Green gram (g)	25	30	20	20	15	30	20	25	10	30	20	15	25	10	20	15	10		
Chemical score	80	80	81	81	82	80	82	81	83	81	82	83	82	84	83	84	85		

APPENDIX – II Continued

Aminoacid score	84	84	84	83	84	84	84	84	85	85	85	85	85	84	84	84	84		
Rice (g)	50	50	50	55	55	55	60	55	60	65	65	65	70	70	70	80			
Black gram(g)	25	20	30	25	30	15	20	20	10	15	20	10	20	10	10	10			
Bengal gram (g)	25	30	20	20	15	30	20	25	30	20	15	25	10	20	15	10			
Chemical score	82	76	78	79	80	77	80	78	73	80	81	79	83	81	78	84			
Aminoacid score	89	85	85	85	80	85	85	85	85	86	81	86	84	85	75	85			
Rice (g)	50	50	50	55	55	55	60	55	60	60	65	65	65	65	70	70	75	75	80
Soya bean (g)	25	20	30	25	30	15	20	20	30	10	20	15	25	10	20	10	15	10	10
Green gram (g)	25	30	20	20	15	30	20	25	10	30	15	20	10	25	10	20	10	15	10
Che.score	83	82	84	84	85	82	84	83	86	82	85	84	86	83	86	84	86	85	86
Aminoacid score	84	85	84	83	84	85	84	84	71	85	85	85	85	85	83	84	83	83	84
Rice (g)	50	50	50	55	55	55	60	55	60	60	65	65	65	65	70	70	75	75	80
Bengal gram(g)	25	20	30	25	30	15	20	20	30	10	20	15	25	10	20	10	15	10	10
Soya bean (g)	25	30	20	20	15	30	20	25	10	30	15	20	10	25	10	20	10	15	10
Chemical score	80	82	78	80	78	83	82	82	78	85	82	83	80	85	82	85	83	85	85
Aminoacid score	85	85	84	85	84	80	85	85	85	85	86	81	86	86	85	84	80	84	84
Rice (g)	50	50	50	55	55	55	60	55	60	60	65	65	65	65	70	70	75	75	80
Bengal gram(g)	25	20	30	25	30	15	20	20	30	10	20	15	25	10	20	10	15	10	10
Green gram (g)	25	30	20	20	15	30	20	25	10	30	15	20	10	25	10	20	10	15	10
Chemical score	75	75	74	76	75	77	77	76	76	78	78	79	78	80	80	81	81	82	83
Aminoacid score	85	86	85	85	85	81	85	85	85	86	86	81	86	86	85	85	80	84	85
Rice (g)	50	50	50	55	55	55	60	55	60	60	65	65	65	65	70	70	75	75	80
Bengal gram(g)	25	20	30	25	30	15	20	20	30	10	20	15	25	10	20	10	15	10	10
Red gram(g)	25	30	20	20	15	30	20	25	10	30	15	20	10	25	10	20	10	15	10
Chemical score	80	82	78	80	78	83	82	82	78	85	82	83	80	85	82	85	83	85	85
Aminoacid score	84	83	84	84	84	83	84	84	85	83	86	85	86	85	84	83	84	83	84

APPENDIX – III

Nutritive value of 22 combinations

Ingredients	Proportion	Energy (kcal)	Carbohydrate (g)	Protein (g)	Fat (g)
Rice	80	342	73.90	10.24	0.66
Greengram	20				
Rice	65	341	76.54	12.82	0.78
Greengram	35				
Rice	60	340	69.00	12.00	0.80
Greengram	40				
Rice	70	341	71.00	11.00	0.42
Greengram	30				
Rice	75	325	73.10	9.00	1.70
Bengalgram	25				
Rice	85	350	75.00	8.00	1.20
Bengalgram	15				
Rice	70	354	71.00	11.00	1.70
Bengalgram	30				
Rice	90	347	76.00	8.00	1.00
Bengalgram	10				
Rice	70	345	72.00	11.00	1.00
Blackgram	30				
Rice	80	345	74.00	10.00	1.30
Blackgram	20				
Rice	65	345	71.00	12.00	1.00
Blackgram	35				
Rice	65	340	75.00	9.00	0.70
Ragi	15				
Greengram	20				
Rice	75	347	74.00	8.00	1.30
Ragi	10				
Bengalgram	15				
Rice	75	347	74.00	8.00	0.70
Ragi	10				
Greengram	15				
Rice	65	342	79.00	10.00	0.80
Ragi	15				
Blackgram	20				
Rice	60	388	75.00	12.00	2.20
Blackgram	20				
Bengalgram	20				

APPENDIX – III Continued

Ingredients	Proportion	Energy (kcal)	Carbohydrate (g)	Protein (g)	Fat (g)
Rice	65	331	77.60	12.00	1.70
Blackgram	15				
Bengalgram	20				
Rice	55	354	68.00	12.00	2.10
Blackgram	15				
Bengalgram	30				
Rice	60	343	70.00	11.00	0.80
Blackgram	20				
Greengram	20				
Rice	65	347	77.00	12.00	1.40
Bengalgram	15				
Greengram	20				
Rice	60	352	69.00	12.00	2.10
Bengalgram	30				
Greengram	10				
Rice	70	347	72.21	11.00	1.00
Bengalgram	15				
Greengram	15				

APPENDIX – IV

SCORE CARD

Sl.No	Quality parameters	Score
1	**APPEARENCE**	
	Excellent	5
	Very good	4
	Good	3
	Fair	2
	Poor	1
2	**COLOUR**	
	Excellent	5
	Very good	4
	Good	3
	Fair	2
	Poor	1
3	**FLAVOUR**	
	Very acceptable	5
	Acceptable	4
	Moderately acceptable	3
	Less acceptable	2
	Not acceptable	1
4	**CONSISTENCY**	
	Good consistency	5
	Slightly thick	4
	Slightly thin	3
	Watery with lumps	2
	Thick and sticky	1
5	**TASTE**	
	Excellent	5
	Very good	4
	Good	3
	Fair	2
	Poor	1
6	**DONNENESS**	
	Well cooked	5
	Cooked	4
	Moderately cooked	3
	Raw taste	2
	Charred	1

APPENDIX - V

Organoleptic score of twenty two multimixes

Multimix-1

Appearence	Colour	Flavour	Consistency	Taste	Donneness
4	4	3	4	5	4
3	3	2	4	4	4
3	3	5	4	4	4
4	4	4	5	4	5
4	4	3	4	5	5
3	4	4	5	4	5
4	4	5	4	3	3
4	4	5	3	4	4
4	4	5	4	5	3
4	3	3	5	4	5
3.7	3.7	3.9	3.6	3.6	4.2

Multimix-2

Appearence	Colour	Flavour	Consistency	Taste	Donneness
4	4	2	3	3	4
4	3	3	4	3	4
4	4	3	4	3	4
3	3	3	5	3	5
4	4	4	5	4	4
4	4	3	5	2	4
4	3	4	3	3	4
4	5	2	3	3	4
4	3	5	5	3	5
5	3	4	2	3	5

Multimix-3

Appearence	Colour	Flavour	Consistency	Taste	Donneness
4	5	3	4	2	4
4	4	3	4	3	4
4	4	5	3	5	5
4	5	3	4	3	5
5	2	3	2	3	4
5	2	4	4	4	5
4	4	3	4	3	4
4	4	3	3	3	4
4	5	3	3	3	4
5	5	3	4	3	5
4.3	4.0	3.3	3.5	3.2	4.4

APPENDIX – V Continued

Multimix-4

Appearence	Colour	Flavour	Consistency	Taste	Donneness
4	3	4	5	4	2
4	4	4	5	3	3
3	4	3	5	5	4
5	4	4	5	5	5
4	5	5	5	3	4
3	5	4	5	5	4
3	4	3	5	4	3
3	4	5	5	4	4
4	4	5	4	5	3
4	5	4	4	5	3
3.7	4.2	4.0	4.8	4.3	3.5

Multimix-5

Appearence	Colour	Flavour	Consistency	Taste	Donneness
3	4	4	4	4	4
4	4	5	4	4	3
4	5	4	3	3	4
5	5	5	4	5	4
3	5	5	5	3	4
4	3	5	4	5	2
4	2	4	4	1	3
4	3	4	5	5	4
4	4	4	5	3	3
4	3	4	4	4	4
3.9	3.8	4.4	4.2	3.7	3.5

Multimix-6

Appearence	Colour	Flavour	Consistency	Taste	Donneness
3	3	4	4	4	5
4	4	4	4	5	5
4	4	4	5	4	5
4	5	5	5	4	5
4	4	5	4	5	5
4	2	5	3	5	5
4	2	4	4	4	4
4	4	4	5	4	4
2	2	4	4	4	2
4	4	4	4	4	4
3.7	3.4	4.3	4.2	4.3	4.4

APPENDIX – V Continued

Multimix-7

Appearence	Colour	Flavour	Consistency	Taste	Donneness
3	2	3	3	2	4
4	3	2	4	3	4
3	5	4	3	5	5
4	3	3	4	3	5
2	3	3	2	3	4
4	4	4	4	4	5
4	3	4	4	3	4
3	3	4	3	3	4
3	3	4	3	3	4
3	5	4	5	3	5
3.3	3.4	3.5	3.5	3.2	4.4

Multimix-8

Appearence	Colour	Flavour	Consistency	Taste	Donneness
5	4	3	5	2	4
4	3	4	5	3	5
4	4	3	5	4	5
5	4	5	5	5	5
3	4	3	5	4	5
2	4	2	5	4	5
4	3	2	4	3	4
4	4	4	5	4	5
5	3	4	5	3	4
5	4	4	3	3	4
4.1	3.7	3.4	4.7	3.5	4.6

Multimix-9

Appearence	Colour	Flavour	Consistency	Taste	Donneness
5	4	4	4	4	4
4	5	3	3	4	4
5	5	3	4	4	5
5	4	4	4	4	5
5	4	5	4	3	3
3	2	4	5	5	5
3	4	3	4	4	4
4	5	3	5	4	4
4	5	5	5	5	5
3	5	3	5	5	5
4.1	4.3	3.7	4.3	4.2	4.4

APPENDIX – V Continued

Multimix-10

Appearence	Colour	Flavour	Consistency	Taste	Donneness
5	4	3	5	3	4
3	3	3	3	4	4
2	3	2	3	3	5
4	4	3	4	5	5
4	4	4	4	3	4
2	4	2	2	2	5
3	3	3	3	2	4
3	4	4	3	4	5
3	3	3	3	3	4
4	3	3	4	4	4
3.3	3.5	3.0	3.4	3.3	4.5

Multimix-11

Appearence	Colour	Flavour	Consistency	Taste	Donneness
4	4	2	4	2	4
4	4	3	4	3	5
4	4	3	4	5	4
5	4	4	4	2	5
5	5	3	5	3	5
5	4	3	5	3	5
4	4	4	4	3	4
4	5	4	4	4	4
4	5	3	4	3	4
4	4	4	5	2	4
4.3	4.3	3.3	4.3	3.0	4.4

Multimix-12

Appearence	Colour	Flavour	Consistency	Taste	Donneness
3	3	4	4	3	4
4	4	3	5	4	4
3	3	4	4	4	4
4	4	4	5	5	5
2	2	4	5	4	5
4	4	2	5	2	5
3	4	3	4	2	4
4	3	4	5	4	5
4	3	3	4	2	4
4	4	4	4	4	4
3.5	3.4	3.5	4.5	3.4	4.4

APPENDIX – V Continued

Multimix-13

Appearence	Colour	Flavour	Consistency	Taste	Donneness
4	3	3	3	2	4
4	4	3	4	3	4
4	4	5	4	3	5
5	3	3	3	3	5
3	3	3	3	3	3
5	4	4	4	4	5
4	4	3	4	3	4
4	4	3	4	3	4
4	4	3	5	3	4
5	4	3	5	3	5
4.2	3.7	3.3	3.9	3.0	4.3

Multimix-14

Appearence	Colour	Flavour	Consistency	Taste	Donneness
4	5	3	4	4	5
3	4	3	4	2	5
4	4	3	5	4	3
5	5	4	5	4	5
5	2	4	4	3	5
4	2	3	5	4	5
4	4	4	4	3	4
4	4	3	4	4	5
4	5	4	5	4	5
4	5	4	5	4	5
4.1	4.0	3.5	4.5	3.6	3.7

Multimix-15

Appearence	Colour	Flavour	Consistency	Taste	Donneness
4	4	5	5	4	5
4	4	3	5	3	5
4	3	4	4	4	5
4	4	5	5	4	5
4	5	4	5	4	5
4	4	5	5	3	5
4	4	4	4	3	4
4	5	5	4	4	4
4	5	5	3	3	4
5	4	5	5	4	5
4.1	4.2	4.5	4.5	3.6	4.7

APPENDIX – V Continued

Multimix-16

Appearence	Colour	Flavour	Consistency	Taste	Donneness
4	4	3	4	4	4
4	3	3	4	3	4
3	4	2	3	2	3
4	4	3	5	5	5
5	3	3	5	4	5
2	4	2	4	4	5
3	3	2	5	3	4
5	5	5	5	4	5
4	4	4	4	4	4
4	4	3	4	4	5
3.8	3.8	3.0	4.3	3.7	4.4

Multimix-17

Appearence	Colour	Flavour	Consistency	Taste	Donneness
3	3	3	4	4	4
4	3	3	4	3	4
3	2	4	3	2	3
4	3	5	4	4	4
5	4	3	4	4	5
4	2	4	5	2	5
3	2	4	4	2	4
5	3	4	4	5	4
4	4	4	4	4	4
4	4	4	5	3	4
3.9	3.0	3.8	4.1	3.3	4.1

Multimix-18

Appearence	Colour	Flavour	Consistency	Taste	Donneness
4	4	4	5	4	4
4	3	3	5	4	5
4	4	3	4	4	5
4	5	5	5	4	4
3	5	5	5	5	5
3	4	4	5	5	3
3	4	3	4	4	2
5	4	4	4	4	3
4	4	3	3	3	4
5	4	3	5	4	3
3.9	4.1	3.7	4.5	4.2	3.8

APPENDIX – V Continued

Multimix-19

Appearence	Colour	Flavour	Consistency	Taste	Donneness
5	4	5	5	4	5
4	3	4	5	2	4
3	3	2	4	2	5
4	5	4	5	2	5
5	5	4	5	5	5
4	4	2	5	5	4
4	3	3	4	3	3
4	4	3	4	4	4
3	3	3	3	4	4
4	3	4	3	4	3
4.0	3.7	3.4	4.2	3.5	4.2

Multimix-20

Appearence	Colour	Flavour	Consistency	Taste	Donneness
4	5	5	4	2	4
3	3	3	4	3	5
4	5	2	3	3	5
4	4	4	4	4	5
5	4	4	5	3	5
4	2	2	4	2	5
4	3	3	4	3	4
4	3	4	4	4	4
4	3	3	3	3	2
4	4	3	4	3	4
4.0	3.5	3.3	3.9	3.0	4.3

Multimix-21

Appearence	Colour	Flavour	Consistency	Taste	Donneness
4	5	4	4	3	3
4	3	4	5	4	4
3	5	4	5	4	4
4	5	5	5	3	3
5	4	5	5	4	3
4	3	5	5	4	4
3	4	4	4	3	4
4	4	4	4	3	4
3	3	3	3	4	4
4	3	4	4	3	4
3.8	3.9	4.2	4.4	3.5	3.7

APPENDIX – V Continued

Multimix-22

Appearence	Colour	Flavour	Consistency	Taste	Donneness
4	4	2	4	4	5
4	5	3	4	3	3
5	4	4	3	3	4
5	5	3	4	4	4
4	5	3	5	4	4
4	5	2	4	4	5
4	3	3	4	3	4
5	3	4	4	4	4
3	4	3	4	3	4
3	4	3	4	4	4
4.1	4.2	3.0	4.0	3.6	4.1