REVIEW OF LITERATURE
CHAPTER II

REVIEW OF LITERATURE

The review of literature will be discussed under the following broad categories:

I Nutrition during infancy and early childhood

II Energy density and dietary bulk of cereal foods

III Studies on food intake in infants and toddlers in relation to dietary bulk and energy density

IV Practical approaches to solve the dietary bulk problem

V Formulation of supplementary infant foods at the home and village level

VI Process of malting and germination

VII The effect of malting on micro-nutrients

VIII Malted foods for infants and toddlers

IX Amylase Rich Foods

X Role of energy as the major cause of Protein Energy Malnutrition (PEM)

XI Energy intake and growth.
I. NUTRITION DURING INFANCY AND EARLY CHILDHOOD:

A newborn child is entirely dependent upon his mother for sustenance and life. His dependence continues well through the weaning period until the age of 2 to 2½ years when he can begin to express himself more clearly as well as to assume some responsibility for his own nutrition through food seeking behaviour.

Major deviation in growth occurs between 6-24 months of age. This is the time when the child's nutrient needs are the greatest and his growth rate is most rapid (Ghosh 1980, Burman 1982). Undernutrition usually occurs among children who have passed unsuccessfully through the weaning period and nutrition intervention has occurred too late (Graham et al 1963, Waterlow et al 1980).

Studies on infant feeding practices from many countries indicate that most infants who are breastfed grow well up to 4 to 6 months of age (Venkatachalam et al 1967, WHO 1981, Persson and Samuelson 1984, Ebrahim 1986). Growth retardation begins at this age. This faltering of growth becomes more obvious when growth is measured by its velocity rather than the total period of growth. Studies in Uganda (Rutishauser 1975) showed that the velocity of growth in Ugandan infants is similar to that of their British counterparts up to the
age of 6 months after which age, the velocity of growth is about half of that in British children and remains so up to the age of about 18 months. After this age even though the velocity of growth recovers and is the same as that in British children, the ground lost is never recovered. About 91% of the deficit in weight and 98% of the deficit in height at 3 years can be ascribed to the slow rate of growth between the ages of 6 and 18 months.

The normal healthy infant doubles his birth weight by the age of 4 to 6 months. At no time in his life afterwards does an individual grow at that speed and so the nutritional requirement to support such rapid growth must be great (Ebrahim 1983). Breastmilk is usually the only food that is given to the child during this period although in some countries bottlemilk has replaced breastmilk (Trusswell 1985; Ebrahim 1986). Considering the growth during this age, breastmilk with as little as 1.2% protein is able to satisfy this need. It stands to reason that it is something other than protein that must be providing the nutrients for this rapid growth and now it is known that it is the energy content of milk which is important (Ebrahim 1983). Commonly known as energy density, it is the measure of the amount of energy per gram of food (WHO 1985). At 6 calories per gram solid matter, breastmilk has the highest energy density of all the commonly used infant foods whether traditional or
commercial. Most traditional weaning foods have an energy
density of 2 cal/g (Ebrahim 1983).

At 4 to 6 months, the infant that is being weaned from
breastmilk should be provided with a food which is equivalent
to the energy density of breastmilk. Usually the faltering of
growth at this stage onwards is due to the cessation of
breastfeeding. A longitudinal study of infant growth in
Uganda (Butishauer 1974) showed that in the second year of
life those children who had been taken off the breast consumed
25% less energy even though the intake of other foods like
cow’s milk, fruits and cereals was increased by about 60%.
Since the energy density of human milk is regarded as optimal
to sustain satisfactory growth of the infant, any replacement
of human milk should have almost the same energy density
whether it be infant formula or any other weaning mixes
(Hambraeus 1977). The more these foods differ from human milk
in its composition, the greater is the likelihood of harmful
effects occurring.

II. ENERGY DENSITY AND DIETARY BULK OF CEREAL FOODS

In a mixed weaning diet, the solid component should have
an energy density exceeding 0.7 Kcal/g if liquids of low
energy density are consumed because average values of 0.7
Kcal/g have been reported for mature breastmilk (Macy and
Kelly 1961). It is, therefore, reasonable to assume that young children can satisfy their energy requirement on a diet with an average energy density of above 0.7 Kcal/g on condition that the children are healthy and with good appetite and that the food is divided into more than 3 meals per day.

According to Fomon (1974) the quantity of food willingly accepted by an infant is determined to a large extent by the calorie requirement for maintenance and growth. Among the more important characteristics of the food are energy density, digestibility, nutritional adequacy, taste and such physical properties as consistency and particle size. Therefore, nutritional adequacy of the food for infants depends on the one hand on calorie density and on the other hand on consistency of the diets.

Traditional weaning foods in most cultures are in the form of a gruel made from local staples usually a cereal such as corn, sorghum, wheat, rice or millets. Sometimes non-cereal staples such as potatoes (Solanum tuberosum), cassava and plantains are used. When these staples are prepared as a weaning food, they are normally made into a thick porridge or a more liquid gruel. Prepared in this way, these starch rich staples will bind large amounts of water and thus become voluminous with a low nutrient and energy density (Mellander and Svanberg 1984). Apart from
nonavailability of food, the other factor which causes low energy intake of poor pre-school children is the low energy density of starch based diets. The flour concentration of a low energy density gruel is around 5% which would provide an average density of 0.1 Kcal/g of prepared gruel (Ibrahim 1986). A young child (6-30 months) has to consume about 3 to 5 litres of such a thin gruel to meet his daily energy requirement and that is impossible. The intake studies on milk based diets of children about 4 months of age have revealed that the possible volume that an infant can consume is around one litre (Fomon et al 1971). But no such data is available for starchy gruels for children of this age.

Considering the infant's high energy requirement in relation to body size and his small stomach, it is simply impossible for him to eat enough of a 5% solid concentration gruel particularly if the number of meals per day is low. If the volume is diminished by the lower dilution of the food with water, the thickness/viscosity of the food will increase. If the solid concentration of a thick gruel is above 20% (25-30%) then it would provide an energy density of 1.0 Kcal/g (Svanberg 1987). But the viscosity of this gruel would make it less easy to consume especially for younger children when fluid or semifluid food is preferred, as only such consistencies can be swallowed without choking.
Either way, the gruel intake is limited among younger children due to high volume or high viscosity. This high volume viscosity characteristic of a diet is usually referred to as the dietary bulk. There is an inverse relationship between dietary bulk and energy density. So it would be desirable to combine these two characteristics of the diet i.e. high energy density and low bulk consistency when formulations of weaning foods are considered.

III. STUDIES ON FOOD INTAKE IN INFANTS AND TODDLERS IN RELATION TO DIETARY BULK AND ENERGY DENSITY

Very few attempts have been made to study systematically the importance of dietary bulk in the feeding of children. Those studying the feeding of pre-school children in areas where starchy staples are the main foods and where Protein Energy Malnutrition (PEM) is also prevalent, seem to agree that the bulkiness of the diet is a major constraint in providing the children with enough food. Further, few studies have been devoted to measuring the actual quantitative intake of different foods in children.

Milk based diets:

Fomon et al (1971) have carried out a series of studies on food intake of infants given milk formula ad libitum with different energy concentrations. Inspite of the much greater
volume of liquid food consumed by infants fed on low calorie formula, the mean calorie intake of these infants (107 Kcal/kg body weight/day), was considerably less than that of the infants fed on the high calorie formula (126 Kcal/kg/day). After the age of 4 months, the mean quantity of food consumed was 939 ml/day for the low calorie group and 582 ml/day for the high calorie group resulting in an equal intake of calories/kg/day and weight gain for all the infants. These studies however, refer to milk based formulae and the same cannot be applied to starch based weaning foods.

One litre of milk or milk formula can be consumed by children daily. The same volume may not be applicable to starch based porridges because in milk, water molecules are free and can be absorbed quickly in the stomach or the upper part of the intestinal tract but in the case of starch based porridge, water gets bound to the starch during the cooking and this water can be absorbed only after degradation of the starch molecules through digestive amylase. This will delay the process of absorption in comparison with milk and therefore, the interval between meals will be prolonged and the number of feeds per day for starch based foods will be lower than that for the milk based formulae (Mellander and Svanberg 1984).
Starch based weaning foods:

Hicol (1971) was one of the first to make some quantitative estimates of the dietary bulk factor based on the studies of food intake in children. He concluded that the volume of the starch based foods required to cover the energy needs of pre-school children was between 900 ml to 1650 ml and the actual range of consumption was from 660 ml to 1250 ml. For a one to three year old child, the amount required would be 900 to 980 ml for cereal based diets and 1450 ml of a thick yam porridge. While a young child could satisfy his needs for energy and protein from cereal gruels if divided into 4 meals per day, it would be impossible for him to consume 1450 ml of yam porridge even if the food was divided into 4 meals per day. Rutishauser and Frood (1973) reported that in Uganda where plantain is the staple even with good appetites, children had difficulty in eating enough of food to cover their energy requirements. In their study, a group of 10 Ugandan children were given traditional home diet which was a mixture of plantain and sweet potato combined either with beans, groundnut or meat. Another similar group of children were given milk based diets with the same protein concentration as the traditional diet. The mean intake of traditional food was 700 g/day amounting to 79 g/kg body weight while the mean intake of milk based food was 300 g/kg body weight amounting to 41 g/kg body weight. It was observed...
that the energy and protein intakes of the children fed on the home diet were significantly lower than that of those children fed on the milk based diet which indicates that the dietary bulk was the limiting factor for their food intake. Binns (1975) reported similar findings from Papua New Guinea where sweet potato is the staple. Whitehead (1973) compared the intake of Ugandan and English children of 2 years of age and found that the intake of liquid components was similar amounting to 775 ml but the intake of solid foods to obtain the equivalent energy was 1 kg for the Ugandan children and 244 g for the English children.

Studies by the Tanzania Food and Nutrition Centre (1978) on food intake in pre-school children (one to five years) indicate a maximum capacity of about 900 ml to 1400 ml per day. On an average an energy density of about 1.25 Kcal/g of prepared food was needed in order to meet the total daily energy requirement but more than 70% of the children were eating meals with lower energy density.

Hellstrom et al (1981) compared the amount of food required to cover the energy and protein requirements for a 12 months old child from commercially prepared supplementary weaning foods like Paffa and Superamine. The investigators reported that while it was necessary to give 1440 ml of Paffa to meet his energy requirement, only 980 ml of
Superamine would fulfill his need for energy. The latter amount is a possible volume for a one year old child to consume over 24 hours, as reported by Ljungqvist et al (1981), but the former volume is just not possible for him to consume. The dietary bulk of Faffa would limit his intake thus leading to inadequate intake of calories and protein.

Susheela and Rao (1983) investigated the energy intake and the energy density of the diets of 194 pre-school children of rural and urban areas in Hyderabad, India. The energy intake of children from the urban area was higher than that of the children from the rural area although the total solid intake among the groups was not different. However, the energy density of the diets of the urban pre-school children was 1.7 Kcal/ml as compared to the energy density of the diets of rural children which was 0.74 Kcal/ml. The difference in energy density was attributed to the high fat intake among urban children. Since the poor families cannot afford this, bulk reducing methods need to be explored for the diets of the poor rural children.

Araya et al (1983) studied the effect of energy density on the food intake of 240 healthy pre-school children (2-4 years of age) of Santiago, Chile. The food and energy intake corresponding to 8 different types of lunches commonly prepared from cereals, legumes and tubers were studied for
8 days. The energy density of the 7 diets (predominantly cereal based) ranged from 0.4 Kcal/g to 0.8 Kcal/g and the average consumption of these diets ranged from 333 g to 485 g per sitting. Only one diet had an energy density of 1.9 Kcal/g and its average consumption was 229 g per meal. Only this diet covered 30% of the daily energy need suggesting that dietary bulk and low energy densities were the limiting factors in the other diets of these pre-school children.

Svanberg (1987) studied the food intake and energy density of food for 20 pre-school children (2-5 years of age) from Ethiopia consuming a traditional Ethiopian diet which was divided into 3 meals per day. The range of daily intake of food varied from 912 g to 1367 g for the whole group of children. The energy density of the diet was 1.15 Kcal/g. The author concluded that the maximum capacity for food intake among pre-school children ranged from 900 ml to 1400 ml/day. These figures should correspond to an energy density of 1.2 Kcal/g if energy requirements of this age group are to be satisfied.

Church (1977) discussed the consistency of weaning foods particularly in relation to age and development as well as to diseases in children. The preference for more liquid foods is higher in younger children and also increases with increasing severity of illness.
Preference for more liquid food and higher consumption of the same by infants and toddlers was established by Gopaldas et al (1986). Rice gruels with the same solid concentration but different viscosities were served to infants (6-12 months of age). While the mean intake of thick gruel (2780 cp units) was only 55 ml, the mean intake of a thin gruel (632 cp units) was 107 ml per sitting. Studies with maize and sorghum gruels (Gopaldas et al 1988) and wheat gruels (Gopaldas et al 1988) have shown similar trends where the mean intake of thinner gruels with free flowing consistency was significantly higher as compared to thick gruels of the same solid concentration but higher viscosity. Although the energy densities of both the gruels (thick and thin) were the same per ml of gruel, yet because of the higher intakes of the thin gruel, the child was able to imbibe more energy at one sitting. Other investigators have also demonstrated similar findings when feeding young children with thin and thick gruels of same solid concentration (Svanberg 1987, Mosha 1987). Although the energy densities of the gruels were the same, dietary bulk limited the intake of the thicker gruel.

From the above cited literature on energy density and dietary bulk, it can be concluded that:

(1) Young children need to consume a diet with an energy density of 1.2 Kcal/g to fulfill their energy and protein requirement as per FAO/WHO (1973) recommendations
(2) The maximum amount of food that can be consumed by pre-school children ranges from 900 to 1400 ml if served as 4 meals per day.

(3) Depending on the dietary bulk of the gruel, the intake may be reduced for a thick gruel and increased for a thinner gruel.

(4) It is the energy density and dietary bulk of the diet which are the causes of lower consumption of calories among pre-school children.

Thus if the dietary bulk of starchy gruels could be reduced without reducing the energy density, infants and toddlers could meet their energy requirement provided enough of the gruel is made available to them. One way of increasing energy and nutrient density in weaning foods is by the addition of oil, fats and sugar (Susheela and Rao 1983, Luhila and Chipulu 1987). Since both these commodities are expensive, the possibility of its inclusion in the diets of poor infants and pre-school children especially in rural areas is remote. Therefore, the remaining possibility is to try and modify the starch base of the food by reducing its bulk.
IV. PRACTICAL APPROACHES TO SOLVE THE DIETARY BULK PROBLEM

There are two major options to solve the problem of dietary bulk by modifying the starch in the diet. They are:

(1) Central processing
(2) Home or village level processing

(Harper and Jansen 1985)

Centrally processed foods

Two categories of centrally processed foods are identified. They are:

(i) Commercial foods produced in the West and imported by developing countries, and

(ii) Title II blended foods supplied by USAID through the PL 480 Food for Peace programme which include Corn Soy Blend (CSB), Corn Soy Milk (CSM), Instant Corn Soy Milk (ICSM) and Wheat Soy Blend (WSB)

(Sahn et al 1981).

Commercial weaning foods have been formulated, produced and are in use for supplementing the diet of infants and toddlers in many countries including our own. A list of these mixes is given in Table 1.

Different methods employed for commercial weaning foods are:

(1) Extrusion processing
(2) Roller drum drying process
(3) Spray drying process
<table>
<thead>
<tr>
<th>Product</th>
<th>Country</th>
<th>Primary Ingredients</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Balanced malt food</td>
<td>India (CFTRI)</td>
<td>Cereal, malt, pulses and skim milk powder</td>
</tr>
<tr>
<td>2) Bal-ahar (dry blend)</td>
<td>India (PCI formulated by CFTRI)</td>
<td>Wheat flour, groundnut flour, bengal gram flour or skim milk powder</td>
</tr>
<tr>
<td>3) Flakes (Macaroni process)</td>
<td>India (CFTRI)</td>
<td>Edible groundnut cake flour, Bengalgram flour, green gram flour, wheat flour</td>
</tr>
<tr>
<td>4) Precooked weaning food of different formulae (Roller dried)</td>
<td>India (CFTRI)</td>
<td>Cereal flours, pulses and oilseed cakes</td>
</tr>
<tr>
<td>5) Bal-Amul and Bal-Amul cereal with milk (roller dried)</td>
<td>India (NDDB formulated by CFTRI)</td>
<td>Cereals, flours, pulses, soya flour, skim milk powder</td>
</tr>
<tr>
<td>6) Nestum</td>
<td>India (Nestle's product)</td>
<td>Soyabean flour, milk powder, malt extract, cereals</td>
</tr>
<tr>
<td>7) Farex</td>
<td>India (Glaxo)</td>
<td>Cereals and milk powder</td>
</tr>
<tr>
<td>8) Lactogen</td>
<td>India (Nestle's product)</td>
<td>Wheat flour, milk</td>
</tr>
<tr>
<td>9) Incaparina</td>
<td>Columbia</td>
<td>Maize flour, cottonseed flour, soyabean flour, vitamin A, calcium carbonate</td>
</tr>
<tr>
<td>Product</td>
<td>Country</td>
<td>Primary Ingredients</td>
</tr>
<tr>
<td>--------------</td>
<td>---------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Pronutro</td>
<td>S Africa</td>
<td>Maize flour, soya, groundnut, wheat germ, skim milk powder, fish flour</td>
</tr>
<tr>
<td>Corn Soya Milk</td>
<td>USA</td>
<td>Precooked maize, defatted soya flour, skim milk powder, CaCO₃, vitamins</td>
</tr>
<tr>
<td>Caplapro</td>
<td>USA</td>
<td>De-germinated maize flour, wheat flour, soy flour, skim milk powder, CaCO₃, vitamins</td>
</tr>
<tr>
<td>Superamine</td>
<td>Algeria and Turkey</td>
<td>Hard wheat flour, chick-pea lentil flour, skim milk powder, vitamins</td>
</tr>
<tr>
<td>Faffa</td>
<td>Ethiopia</td>
<td>Wheat flour, field pea flour, skim milk powder, chick pea lentil</td>
</tr>
<tr>
<td>Duryea</td>
<td>Columbia</td>
<td>Defatted soya flour, high lysine corn flour, corn starch, milk powder, vitamins, minerals</td>
</tr>
<tr>
<td>Peruvita</td>
<td>Peru</td>
<td>Cottonseed flour, Quinua flour, skim milk powder, sugar, spices, vitamins</td>
</tr>
<tr>
<td>Laubina</td>
<td>Beirut</td>
<td>Wheat, chick pea and skim milk powder</td>
</tr>
</tbody>
</table>

Source: Desikachar H S R (1979)
Considerable variations exist in the types of weaning food products which can be produced by the types of systems listed above. The extrusion and milling systems produce products which will make gruels or porridges. The drum and spray driers produce products with higher solubility resembling more closely the infant foods sold in the West. The baking line produces crackers, biscuits and cookies which are normally consumed as finger foods.

Of all these processes, extrusion cooking in cereal technology has become increasingly popular during the last decade (Hellstrom et al 1981). An extruder is a type of food equipment which can combine a variety of cereal and legume ingredients and cook them at high temperatures (150-160°C) for short periods of time (60-120 seconds) (Harper and Jansen 1985). The final cooked paste viscosity at 50°C of gruels from extruded products will depend on such parameters as the temperature of extrusion, moisture content of the product before extrusion, amylose/amylopectin ratio and interaction between the blended products.

Jansen et al (1981) compared the viscosity and calorie density of corn-soy milk and instant corn soy milk which are made commercially and distributed in the US Food for Peace
The viscosities of these gruels were compared with a standard cereal gruel which has a viscosity of 1600 cp units when measured at 45°C. Results showed that while raw corn which is ungelatinized resulted in low viscosity, cooked corn produced very high viscosity and the extruded corn produced intermediate viscosity that were similar to the standard cereal gruel.

**Enzyme Treatment**

During extrusion cooking or roller drum drying process, enzymes (amylases) in small amount are added to the dry blend which partially break down the starch and give lower slurry viscosity, increase the digestibility and add sweetness to the mixtures (Jansen et al 1981). Examples of enzyme treated weaning foods are Nestrum, Superamine and CSB (Corn Soy Blend). Corn Soy Blend when treated with Rhozyme H$_{39}$ (0.01%) gave a calorie density of 0.8 Kcal/ml when cooked. On the other hand a non-enzyme treated CSB gave a calorie density of 0.64 Kcal/ml when cooked to a gruel form.

Weaning foods manufactured commercially are expensive and only the rich and upper class can afford to use them. Table 2 gives an estimate of the cost of some of the processes used for the manufacture of weaning foods (cost is given in US $ as most of these processes are common in that country).
Table 2 Estimate of the cost of some of the processes used for the manufacture of weaning foods

<table>
<thead>
<tr>
<th>Process</th>
<th>Capital Cost/MT*</th>
<th>Operating Cost US $/MT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extrusion</td>
<td>200 - 250</td>
<td>125 - 200</td>
</tr>
<tr>
<td>(low cost)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>250 - 400</td>
<td>100 - 200</td>
</tr>
<tr>
<td>Drum drier</td>
<td>400 - 500</td>
<td>300 - 500</td>
</tr>
<tr>
<td>Spray drier</td>
<td>400 - 500</td>
<td>300 - 500</td>
</tr>
<tr>
<td>Baked goods</td>
<td>150 - 250</td>
<td>200 - 300</td>
</tr>
<tr>
<td>Fluid products</td>
<td>80 - 150</td>
<td>150 - 250</td>
</tr>
<tr>
<td>Milling</td>
<td>75 - 125</td>
<td>50 - 125</td>
</tr>
</tbody>
</table>

*MT = Metric Tonnes

Due to its cost, the foods manufactured by these methods are beyond the economic reach of the majority of the population for the feeding of their children. The need was therefore, felt, for seeking alternative formulations which may be within the reach of the majority of the population.
V. FORMULATION OF SUPPLEMENTARY INFANT FOODS AT THE HOME AND VILLAGE LEVEL

During the last 20 years great efforts have been made to develop, produce and distribute supplementary weaning foods to alleviate protein energy malnutrition in developing countries. According to Hofvander and Underwood (1985) the guidelines for the production of these foods should be:

1. the cost should be minimum
2. locally available raw materials should be used
3. the food should be nutritionally adequate
4. the process should be hygienic and simple
5. the food should be acceptable to the target population.

Low cost multimixes have been formulated in different countries with adequate protein, fat and good acceptability among the target population. However, most of these formulations did not consider the dietary bulk problem (Tontisirin et al 1981, Devdas et al 1984, Romon et al 1987).

In a country like India where 70-80% by weight of the total food consumed is comprised of cereals (Pushpamma et al 1983, Ramachandran 1984, Indirabai et al 1984), where 87-90% of the mothers prepare no special foods for their children and where the children are fed adult diets after making some physical modification like soaking, mashing,
chewing etc (Venkatachalam et al 1967, Devdas et al 1984), the need is to develop indigenous multimixes using locally available low cost foods and simple household traditional processing methods. Table 3 presents data on indigenous weaning foods formulated from locally available food items. But none of these foods had applied any alternative technology to decrease the dietary bulk of the food although energy density was increased by the addition of oilseeds. Hence emphasis is now being placed by nutritionists on the weaning foods with low dietary bulk and high energy density (Hellstrom et al 1981). Desikachar (1980) suggested that while keeping in mind the children's nutritional requirement, emphasis should be on a high calorie density of the weaning foods and low cooked paste viscosity of the same. In formulating such weaning foods for use in the developing countries, the processing modifications for reducing the viscosity of the starch base, is that the mix should be simple and cheap and should fit into the traditional culinary and child feeding practices of the region. In this context a preliminary study was conducted on the effects of different traditional heat processing operations on the paste viscosity of cereal flours by Desikachar (1980). These processes included parboiling, flaking, toasting, puffing and malting of different grains like paddy, wheat, sorghum, finger millet, pearl millet, maize and bengalgram. All forms of heat processing decreased
<table>
<thead>
<tr>
<th>Reference</th>
<th>Product</th>
<th>Ingredients</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Pasricha et al (1973)</td>
<td>Ready to mix powder</td>
<td>Cereal (wheat, pearl millet or finger millet), pulse (roasted bengal gram), oilseed and sugar/jaggery</td>
</tr>
<tr>
<td>2) Devdas et al (1974)</td>
<td>Weaning mix</td>
<td>Cereal (sorghum, finger millet, maize), pulse (roasted green or bengal gram), oilseed (roasted groundnuts) and jaggery</td>
</tr>
<tr>
<td>3) Gopaldas et al (1975)</td>
<td>Poshak</td>
<td>Cereal (wheat, maize, rice or sorghum), pulse (bengal gram or green gram dhal), groundnut and jaggery in the ratio of 4:2:1:2</td>
</tr>
<tr>
<td>4) Gopaldas et al (1975)</td>
<td>Poshak (b) least cost weaning mix</td>
<td>Same ingredients as above in the ratio of 60:17:14:9</td>
</tr>
<tr>
<td>5) Rau et al (1975)</td>
<td>Extruded RTE</td>
<td>Corn Soya Milk and Salad oil</td>
</tr>
<tr>
<td>6) Chandrasekhar et al (1976)</td>
<td>Kerala indigenous food</td>
<td>Tapioca rava, soya fortified bulgar wheat (SFBW), rava and groundnut flour</td>
</tr>
<tr>
<td>7) ICMR* (1977)</td>
<td>Ready-to-consume mixture</td>
<td>Roasted cereal (sorghum, maize, finger millet or pearl millet), pulse (roasted or sprouted bengal gram), oilseed (groundnut/seasame cake)</td>
</tr>
</tbody>
</table>

*Indian Council of Medical Research
the cooked paste viscosity of the flours as compared with the untreated control samples. However, the maximum reduction both in cooked and cold paste slurry was achieved by the malting of the grains (Fig 1).

With the discovery of the low viscosity of cooked slurries of malted weaning foods an entirely new field of research in young child feeding was opened up.

VI. PROCESS OF MALTING OR GERMINATION

The malting of cereals especially barley for use in brewing has been in practice from time immemorial (Munck 1981). Malt can be made from any cereal but is commonly made from barley and unless otherwise specified, the term malt is understood to refer to barley. Barley, corn, wheat, rye, finger millet and sorghum have been used as raw materials for malting in different countries. Sorghum malting, largely to prepare local beer, at household and on industrial scale, is practised in African countries (Novellie 1977).

Malting is a controlled germination process which is concerned with modification of the grains i.e. the liberation of starch granules from the endosperm cell matrix by enzymes which become active during germination (Briggs 1981). Malting is essentially a three step process viz. steeping, germination and kilning. Each step is almost independent of the other but
FIG. 1  EFFECT OF MALTING & TRADITIONAL HEAT PROCESSING ON
PASTE VISCOSITY OF 10% COOKED SLURRY (DESIKACHAR - 1980)
the quality of the malt depends upon all the three processes. Steeping hydrates, germination facilitates enzyme elaboration, kilning of germinated grain terminates growth of seedling, facilitates development of aroma and enhances storability of the malt (Malleshi 1983).

Steeping of grains

The first process which occurs during germination of a seed is the uptake of water due to the process of imbibition. The water uptake is not related to the viability of the seeds because it occurs equally in live and dead seeds. It is influenced by certain factors such as the composition of the seed, seed size and the permeability of the seed coat to water (Brooks et al 1976, Mayer and Poljakoff-Mayber 1982).

As early as in 1931, Ehrich and Kneip had observed that a sample of barley with the lowest nitrogen content absorbed water most rapidly. However this phenomenon did not hold true in case of wheat as wheat grains containing 14.5 or 8.6 percent protein gained an equal amount of weight on soaking (Frazer and Haley 1932). Likewise in soyabean, no correlation was observed between the water absorption and the protein content (Hsu et al 1983).

When the water imbibition by wheat and corn was compared, Levari (1960) noticed that wheat had imbibed more water than
corn at various soaking periods from one to 48 hours and this was attributed to the higher protein content of wheat in comparison to that of corn. Although in seeds, the chief component which imbibes water is protein, other compounds such as mucilages of various kinds, cellulose and pectic substance were also found to swell. On the other hand, starch in seeds does not swell to any appreciable extent as in the case of cereal grains (Mayer and Poljakoff-Mayber 1982).

**Effect of steeping period and temperature on water uptake by seeds**

Water uptake varied with the length of time that the grains were immersed in water and the temperature of immersion water. Frazer and Haley (1932) reported that the water absorption in wheat increased with the increase in the soaking period from half a minute to 60 minutes and also when the temperature of the immersion water was increased from 55°F to 100°F. Similarly, Hsu et al (1985) noticed that the temperature affected the water uptake by soyabean. At 20°C the beans took about 10.5 hours to reach 90% of the total absorption, at 30°C this same level of absorption took approximately 6 hours and at 50°C, it took only 2.5 hours.

Brooks et al (1976) illustrated that the water uptake by the seeds generally occurred in 3 phases. Phase one covering first 6 to 10 hours of soaking period exhibited a
rapid water uptake of about 60% of the total. This rapid water uptake was attributed to water imbibition by the seed colloids, primary proteins and carbohydrates. In phase two, the following 10 to 20 hour period, the uptake of water was found to be very slow or at times to have ceased completely. During this period, starch was hydrolysed to sugars. It was believed that such hydrolytic processes probably produced increasing osmotic pressure which resulted in the uptake of more water by the embryo because by this time the embryo was found to be sufficiently moist and metabolically active. During phase three (over 20 hours), again there was a rapid uptake which was followed by a plateau. Steeping beyond this phase led to a breakdown of the semipermeable membrane of the grain.

**Moisture content of steeped grains**

Several investigators have reported that for brewing purpose the best malt is produced when grains (barley) are steeped for 15 hours and the moisture content is about 43-46% (Brooks et al 1976, Piendl 1971, Briggs 1981).

The steeping behaviour of 3 varieties of wheat immersed in water for 48 hours was explored by Sethi and Bains (1978). In the first 6 hours of soaking, the moisture content increased from 5% to 30% and then increased gradually to 42% in 48 hours. Malleshi and Desikachar (1979) had observed
slight varietal differences in the water uptake by ragi 
(finger millet) grains. The moisture content ranged from 
34.5% to 39.9% in 9 varieties of ragi after 24 hours of 
soaking. Khan et al (1977) had determined the moisture content 
of maize and sorghum grains after steeping them for different 
periods of time. The water absorption was found to be the 
highest in the initial 8 hours of steeping. The maximum 
moisture gain of 52% was observed at 40 hours in maize and 
42% at 16 hours in sorghum. Malleshi and Desikachar (1986) 
steeped different grains (wheat, rice, maize, sorghum and 
millets) for 24 hours and reported that most of the grains 
attained saturation moisture content within that period except 
for maize which required 30 hours of steeping. The moisture 
content of rice and millets was between 30 to 35% while that 
of other cereals varied from 40% to 50%.

Steeping the grains and the amount of water uptake 
directly affects germination period (Essery et al 1954, 
Malleshi and Desikachar 1979, Malleshi and Desikachar 1982). 
At a given soaking period, the germinating capacity was found 
to vary in response to the germination period. Lukow and 
Bushuk (1984) have reported a steeping period of 16 hours in 
excess water at 4°C for optimum germination. Sheorain and 
Wagle (1973) have reported a steeping period of one hour 
for pearl millet, and barley at 35°C and 25°C respectively, 
satisfactory for germination. Daoude (1986) has reported
16 hour steeping of sorghum to attain 36% moisture content for facilitating effective germination at 25 ± 2°C. Optimum moisture content for effective germination in wheat has been reported as 42% (Singh et al 1983).

Steeping period and conditions are important for malting of grains because undersoaking results in the lowered amylo-lytic activity and sub-optimum germination while oversoaking leads to water sensitivity and less effective germination.

**Germination of grains : Enzyme production**

The primary function of germination is to facilitate the synthesis and the elaboration of starch hydrolysing enzymes.

Starch degrading enzymes are collectively called as diastase. The occurrence and alterations in the levels of the amylases during malting have been extensively studied. As early as in 1934, Acharya had concluded through a series of experiments on sorghum malt that the enzyme diastase was responsible for the hydrolysis of starch and it had 2 main components alpha and beta amylases. About 8 years later, Hildebrand and Burkert (1942) explained that the alpha amylase ruptured the starch molecules at more or less central linkages producing degradation products of relatively high molecular weight. The hydrolytic products of beta amylase were predominantly of low molecular weight.
The other enzymes involved in the degradation of starch are phosphorylase and endo-beta glucanase (Briggs 1981). MacLeod et al (1964) followed the development of hydrolytic enzymes notably alpha amylase, endo-beta glucanase and proteinase in germinating barley. It was noticed that the endo-beta glucanase formation preceded the formation of alpha-amylase which in turn preceded the formation of protease. The time of initiation of the enzymes in the germinating barley grain was 24, 29 and 30 hours of germination for endo-beta glucanase, alpha-amylase and protease respectively. Alpha-amylase came to be known as the liquifying enzyme while beta-amylase was the saccharifying enzyme (Briggs 1981).

Studies on hydrolyzing enzymes of sorghum (Norris and Viswanath 1923, Acharya 1934, Kneen 1945), maize (Patwardhan 1929), finger millet (Patwardhan and Narayanan 1930) and rice (Karmarkar and Patwardhan 1931, Gore and Joisa 1932) revealed that these cereals possess very little or traces of starch saccharifying enzymes and almost no starch liquifying enzymes in ungerminated state but on germination, they develop considerable levels of starch liquifying enzyme activity. The properties of these alpha and beta amylases were almost similar to that of barley enzymes but their ratio in germinated cereals was considerably lower than that of barley. Novellie (1960) reported that on germination the
ratio of alpha to beta amylase in sorghum malt varies from 2:1 to 3:1. In barley malt, it is the beta-amylase activity that plays a very important role in starch hydrolysis (MacLeod et al 1964, Manners 1974).

Histochemical and bio-chemical evidences suggest that ungerminated barley seeds do not contain alpha amylase and it is produced during germination. Initially, it is synthesized de novo in the scutellum and later in the aleurone layer by secretion of gibberellins. Later, the alpha amylase which originates mainly in the starchy endosperm becomes activated possibly by proteases during steeping and germination and develops as a result of the transformation from a bound or a latent form to a free or active form (Varner and Ramachandra 1964, Briggs 1964, MacLeod et al 1964, Manners 1974, Gibbons 1980). The composition and properties of barley amylases have been studied extensively (La Berge and Meredith 1967, Jorgenson 1965, Manners and Marshall 1969, Bilderback 1974).

Kruger (1972) studied the changes in the amylases of hard spring wheat during germination and found that alpha amylase appeared after 2 days of germination and steadily increased in amount with the increase in germination time.

Kneeni in 1944 confirmed their previous findings that the degree of germination of a grain is determined by the
increase in alpha amylase content. In various cereals such as barley, wheat, rye, oats, maize, sorghum and rice, the alpha amylase activity increased during germination.

**Amylase Activity of Malted Cereals**

Malleshi and Desikachar (1986) have compared the amylase activity of different grains. Table 4 shows an increase in amylase activity with the period of germination.

Chandrasekhara and Swaminathan (1953) estimated the amylase activity of malted ragi, rice and barley and reported that barley showed the highest amylase activity as compared to the other two cereals.

Lineback and Ponpipom (1977) studied the effects of germination on alpha amylase activity of wheat, oats and pearl millet and observed that the germinated wheat had the highest amylase activity.

Chandrasekhara and Swaminathan (1957) reported that the diastatic activity of pearl millet was found to be lower than that of barley, wheat and finger millet.

Studying varietal difference in amylase activity Attanda and Miflin (1970) have shown that the levels of alpha amylase activity differed considerably in 20 different varieties of barley germinated for 3 to 4 days. It was observed that alpha
Table 4  Alpha amylase activity* of cereals and millets during germination

<table>
<thead>
<tr>
<th>Sample</th>
<th>Germination period (hours)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Rice</td>
<td>-</td>
</tr>
<tr>
<td>Wheat</td>
<td>2.0</td>
</tr>
<tr>
<td>Maize</td>
<td>0</td>
</tr>
<tr>
<td>Sorghum</td>
<td>0.5</td>
</tr>
<tr>
<td>Triticale</td>
<td>2.5</td>
</tr>
<tr>
<td>Finger millet (ragi)</td>
<td>1.0</td>
</tr>
<tr>
<td>Pearl millet (bajra)</td>
<td>4.6</td>
</tr>
<tr>
<td>Proso millet</td>
<td>1.0</td>
</tr>
<tr>
<td>Fox tail millet</td>
<td>-</td>
</tr>
<tr>
<td>Barnyard millet</td>
<td>-</td>
</tr>
<tr>
<td>Kodo millet</td>
<td>-</td>
</tr>
</tbody>
</table>

*mg of maltose released by the action of enzyme extracted from 1 g malt on 1 ml of 1% soluble starch at 37°C.

*Source: Malleshi and Desikachar (1986)*
Amylase activity ranged from 75 to 337 maltose units per seed. Such variations in amylase activity due to varietal differences have been demonstrated by many investigators in wheat, barley, sorghum, finger millet, corn and triticale (Shands et al. 1942, Jain and Date 1975, Pal et al. 1976, Sethi and Bains 1978, Malleshi and Desikachar 1979, Singh and Bains 1984, Gupta et al. 1985).

The effect of varietal difference on amylase activity of sorghum (Chaudhary 1986), maize (Kapoor 1986) and wheat (Deshpande 1987) was estimated in this department and although all the cereals showed varietal difference in amylase activity, the differences were not statistically significant. Of all the 3 cereals studied, wheat was reported to have the highest amylase activity.

Although there are other enzymes developed during the process of germination, important ones being proteases and lipases, these have not been reviewed here as only amylases are reported to have an effect on reducing the bulk of starchy gruels due to their liquifying power.

**Kilning of germinated grains**

The final step in malting is the kilning of the germinated seed. Kilning dehydrates the germinating seed and arrests the growth and at the same time facilitates the
removal of vegetative growth and improves the storability of malted grains. The process of kilning of barley malt has undergone many improvements and the chemistry and technology of malt kilning has been exhaustively reviewed by Bathgate (1973). The author explained that in the kilned malt, changes occur in 3 phases viz. a germinative phase, an enzyme phase and finally a chemical phase.

The first stage of kilning is regarded as a continuation of the germination of the grain for a limited time while the moisture content is still high and the temperature relatively low. In the enzymic phase some of the enzymes are inactivated while the activities of some of these continue, changes in carbohydrate composition and structure are observed (Pomeranz 1972). In the chemical phase, heating the malt caused browning due to Maillard reaction between the free sugars and amino acids as a result of which an aroma develops (Reed 1965, Barwald 1972). The temperature of kilning determines the quality of the malt. The normal kilning temperature followed is 60-70°C. Narziss et al (1973) reported that kilning of germinated seeds above 65°C destroyed the enzyme activity.
VII. THE EFFECT OF MALTING ON MICRO-NUTRIENTS
IMPROVEMENT IN DIGESTIBILITY AND NUTRITIVE VALUE

Malting of cereals and millets modifies the grain and brings about certain desirable changes. One of the most important characteristic of malting is the development of an assortment of hydrolytic enzymes. Due to the activity of these enzymes starch degradation takes place which has been reviewed earlier.

Improved digestibility of germinated pulses and legumes has been reported as a consequence of lower flatus production (Reddy and Salunkhe 1980, Sood et al 1985, Udayasekhara and Belavady 1978). Besides improved digestibility, an improvement in nutritive value has been observed on germination and malting. Lay and Fields (1981) have reported a significant increase in ascorbic acid, niacin and riboflavin on germination of corn. Germination of sorghum for 120 hours results in an increase in ascorbic acid content (from 2.08 mg/100 g to 6.87 mg/100 g), reduction in starch and protein content and proportionate increase in reducing sugars and free amino acids (Taur et al 1984). Maize protein is of low biological value because it is deficient in lysine and tryptophan. Dalby and Tsai (1976) and Sattar et al (1985) have reported an increase in lysine and tryptophan during germination and nutritional improvement of corn.
A 3% increase in calcium content over the initial value of 34.9/100 g flour prepared from 4 days germinated wheat was observed by Ranhotra et al (1977). The calcium content increased by another 10% when the germination period was extended from 4 to 5 days. However, other investigators (Hemanalini et al 1980, Jaya and Venkataraman 1980, Reddy et al 1978) observed no change in calcium contents of germinated ragi, bengalgram and black gram seeds respectively. Decrease in phosphorus content was observed in germinated ragi by Hemanalini et al (1980). Although Jaya and Venkatraman (1980) had observed no change in the phosphorus content of bengalgram germinated over a period of 72 hours, earlier Belavady and Banerjee (1953) had reported decreases in phytate phosphorus of 2 varieties of bengalgram germinated for 5 days. Sankara Rao and Deosthale (1983) have reported a decrease in phytin phosphorus in pearl millet and finger millet on malting.

Ranhotra et al (1977) reported that in wheat, iron content decreased by 15% after 3 days of germination (from 4.12 to 3.50 mg/100 g) and later tended to return to its original value when the germination period was extended by 2 days. On the other hand Hemanalini et al (1980) had reported a decrease of 33% (from 7.5 to 5.0 mg/100 g) in iron content of flour prepared from germinated finger millet. A decrease of 31% in the iron content of bengalgram from the initial
value of 14.17/mg/100 g seeds, in the first 24 hours of germination was observed by Jaya and Venkatraman (1980). Thereafter, the iron content tended to increase up to 72 hours of germination but remained lower than the initial value (10.0 vs 14.17 mg/100 g seeds). Sankara Rao and Deosthale (1983) observed increases and decreases in the iron contents of 24 and 48 hours germinated pigeon pea, green gram and black gram. The iron content increased by 7% and 28% respectively, in 24 and 48 hours germinated pigeon pea while it decreased by 20% and 6% in 24 and 48 hours germinated green gram respectively. Sankara Rao and Deosthale (1983) had reported that the iron content had decreased by 54% from 8.0 to 3.7 mg/100 g and by 13% from 3.9 to 3.4 mg/100 g in malted pearl millet and malted finger millet respectively. On the contrary, Brandtzaeg et al (1981) had demonstrated a 21% increase from 11.6 to 14.0 mg/100 g in malted finger millet and green gram (7:3) mix in comparison with the raw mix.

Singh and Banerjee (1955) studied the effect of germination on the availability of iron in bengal gram in the in vitro system. It was observed that the available iron increased from 0.86 (before germination) to 0.92 and to 1.19 mg/100 g after 48 and 72 hours of germination respectively. The total iron content of bengal gram was 8.97 mg/100 g. This increase in available iron was attributed to the release
of iron from the protein combination because the protein bound iron content of pulses was found to have decreased considerably during the process of germination with the concomitant increase in the protein-free iron values. Increase in ionizable iron content of cereals and legumes after germination has been reported by many investigators (Prabha-

Hazardous effects of sorghum sprouts

Dry sorghum is reported to contain low or undetectable amounts of dhurrin, a cyanogenic glycoside which yields hydrocyanic acid (HCN) upon hydrolysis (Akazawa et al 1960). The sorghum plant contains appreciable amounts of dhurrin and immature plants contain exceptionally high levels of the cyanogen (Gorz et al 1977, Conn 1979). Because of this cyanogenic properties of sorghum, sorghum sprouts or products derived from them might be potentially toxic. To test this hypothesis, Panasiuk and Bills (1984) evaluated the sprouts of sorghum varieties for potential HCN and reported that these sprouts grown for 3 days in the dark at 30°C contained from 258 to 1030 ppm of potential HCN relative to the weight of the ungerminated dry seed. They further stressed that drying at 50°C and grinding the sprouts did not reduce the potential HCN content. Therefore, sorghum sprouts need to be evaluated
for possible HCN content. Studies carried out in the department of Foods and Nutrition (Gopaldas et al 1988) have consistently stressed on the need to remove the sprouts of all germinated cereals after kilning so that any potent HCN present may be removed.

Dada and Dendy (1987) studied the effect of applying heat treatment on the HCN content of the sorghum sprouts. They observed that drying the sprouts at 50°C had little effect on the HCN level. However, roasting at 100°C and 180°C for 15 minutes before drying at 50°C lowered the HCN level by 83% and 96.5% respectively. Fermentation of both the paste and the slurry of the germinated sorghum for 24 hours resulted in a loss of HCN in excess of 70%. Boiling the slurry and steaming the paste eliminated the HCN completely. Frying or hot grilling the paste removed slightly more than 90% of the HCN. The authors suggest that these simple processes used in the preparation of traditional foods would bring down the HCN content well below harmful levels.

However, from the previous pages it is clear that the temperature treatment of above 80°C would destroy amylase activity and so the purpose of using malted sorghum for reducing bulk would be of no use if subjected to high heat treatment. However, studies are in progress in this department
to measure the HCN content of both the sprouts as well as the germinated seed to arrive at safe method of using malted sorghum. This vital point of HCN in sprouts or "Power flour" have not been attempted by the Tanzanian group.

VIII. MALTED FOODS FOR INFANTS AND TODDLERS

Malting of cereals and millets modifies the grain and brings about certain desirable changes, one of them being the development of an assortment of hydrolytic enzymes. The development of these enzymes namely alpha and beta amylases cause liquifying (viscosity reducing) and saccharifying effect on starch (Desikachar 1980). This characteristic of malted cereals is used to prepare weaning foods. Finger millet malting, mostly to use the malt as supplementary foods for children, is traditionally carried out in many parts of India (Malleshi 1983).

The most important characteristic of malt is its low cooked paste viscosity and high energy density. This characteristic has been extensively used to prepare infant foods which yield low bulk and high energy density foods thus overcoming the problem of dietary bulk and low energy density of infant foods from cereals (Desikachar 1980, Malleshi and Desikachar 1986, Gopaldas et al 1986, Gopaldas et al 1988). Malting in relation to weaning food preparation
has undergone a 3 stage development in India. They are:

1. Fully malted Ready-To-Eat mixes (RTE)
2. Partially malted Ready-To-Eat mixes

(1) Fully malted Ready-To-Eat mixes

Considerable work has been done in India on malted mixes. Desikachar in India is considered the pioneer in the field of the formulation of weaning foods from malted cereals and pulses with low cooked paste viscosity and high energy density.

Desikachar (1980) used malted finger millet and green gram in the proportion of 2:1 to formulate a weaning mix which was well accepted among children between 1 to 3½ years of age. The malted weaning mix had low bulk and high energy density, better digestibility and much lower cost as compared to commercially marketed weaning mix. Malleshi and Desikachar (1982) compared the paste viscosities of a malted weaning food formulated from finger millet and green gram in the ratio of 70:30, with a proprietary weaning food and reported that the malted weaning food had considerably lower viscosity than the proprietary weaning food at all concentrations. The beneficial effect of malting in reducing the paste viscosities and increasing calorie density was established.
In another study, Desikachar (1982) compared the hot paste viscosities of a number of products prepared by using household technologies like chapati making, extrusion cooking, roasting, puffing, flaking and malting. The hot paste viscosities of chapati powder showed highest viscosity while malted mix from different cereals showed maximum reduction in viscosity. Among the cereals finger millet, pearl millet and wheat showed lower viscosities as compared to sorghum and maize.

Brandtzaeg et al (1981) developed a malted weaning mix from finger millet, sorghum and green gram and compared its paste viscosity with a non-malted counterpart. The malted mix had a much lower viscosity as compared to the unmalted mix. When malted mix was compared to commercially manufactured weaning foods like Faffa and Superamine, the amino acid scoring patterns were similar but the NFU values were lower.

Daoude (1986) developed weaning food from malted sorghum, sprouted cowpea, skim milk powder and powdered sugar in the ratio of 60:30:5 and compared it with commercial weaning food. The author reported that for cooked paste viscosity, PER value and the mode of manufacture the malted weaning food was superior as compared to commercial weaning foods.

The department of Foods and Nutrition, M S University of Baroda has been involved in research on malted foods for the
past 8 years. Fully malted powdered multimixes were prepared from wheat, bengalgram and groundnut in the ratio of 4:1:1 and 8:1:1 by Inamdar (1980). The viscosity of cooked paste slurries of the malted mixes at the level of 10% solid concentration was found to be significantly lower than their counterpart roasted mix slurries.

The results of the mean intake of malted and roasted mixes among young children showed significantly higher intake of malted mixes as compared to their roasted counterparts.

Tajuddin (1981) formulated malted mixes using finger millet, green gram and groundnut in the proportion of 4:1:1. As in the previous study, significantly lowered viscosities of the malted mixes were observed when compared with roasted mixes of the same formulations. Similar observations have been reported by other investigators when working with malted cereal pulse combinations (Master 1981, Fotedar 1981, Pandya 1982).

The literature presented here highlights the point that malting of cereals and pulses for weaning food formulations is able to solve the problem of dietary bulk of infant foods. Besides, the process of germination of cereals and legumes is a traditional technology already existing in many parts of India and some African countries. Therefore, advocating this technology for use in infant foods among the low socio-
economic group would not pose a problem.

However, the process of malting, requires a great deal of time, space and labour which are constraints among the low income groups. So an alternative approach to overcoming the constraints of time, space and labour was taken up and resulted in the formulation of partially malted foods.

(2) Partially malted foods

Unlike fully malted foods, very little work has been done to develop partially malted mixes. Gopalan and Patwardhan (1951) formulated an autoclaved mixture of 150 g sprouted, dried and powdered gram flour, 100 g of peeled bananas and 70 g of jaggery, and reported that this mix was accepted among children. The authors however, have not specified the calorie density of the diet. A partially malted food has been developed by CFTRI Mysore. It is a cereal based protein enriched food containing blends of 40% malted sorghum, 40% low fat groundnut flour, 10% Bengalgram flour and 10% skim milk powder. Rao et al (1983) suggested that malted flour mixed with appropriate combinations of puffed or flaked cereals could give a nutritious and acceptable weaning food with low viscosity suitable for child feeding.

Nayak (1983) developed cereal pulse mixes wherein the viscosity reducing properties of malted cereal to malted
pulse in varying proportions were studied. The results of this study indicated that one could obtain overall reduced viscosity of cooked paste gruels (upto 20% solid concentration) by merely malting the cereal moiety and adding roasted pulse powder of the required proportion.

However, formulation of partially malted mixes still did not entirely solve the problem of labour, time and space involved in making fairly large batches of fully malted cereals.

In 1982, Malleshi and Desikachar reported that 5% of malted barley flour or 20% of malted ragi flour on account of their high amylase content was able to substantially reduce the viscosity of a 15% hot paste slurry of branded Indian weaning foods. Later in 1983, the Tanzanian Food and Nutrition Centre also reported that small quantities of germinated sorghum flour named "Power flour" was successful in thinning hot paste slurries of traditional African weaning gruels. Based on this hypothesis that a small amount of any malted flour may act as a catalyst in reducing the viscosity of bulky starchy gruels, the concept of an Amylase Rich Food (ARF) was first proposed by our laboratory and work on the development of such ARFs commenced.
Although the preliminary observations of both CFTRI and Tanzania were valuable, yet neither group had systematically worked out feasible and optimum conditions of production and shelf life of ARFs nor had they more importantly run well controlled acceptability and intake trials on infants and toddlers.

The first in the series of studies on ARF was reported by Gopaldas et al (1986) who developed pearl millet malt which was later called ARF. This study proved that a small amount of ARF (4% of the total solid concentration used) could reduce the viscosity of a 10% cooked slurry considerably as much as 1% of pure enzyme takadiastase. Acceptability trials on infants and toddlers showed that infants had a significantly higher intake of the gruel with ARF with mean intake being almost double that of gruels without ARF. This study made a breakthrough with respect to the overriding constraint of space, time and cost. Small quantities of any ARF can be effectively used for the reduction of the dietary bulk or the viscosity of the traditional weaning thick starchy gruels. The advantage of the ARF over fully malted foods is that it is required in very small if not catalytic amounts to dramatically liquify a thick viscous gruel. Hence the amount of ARF can be easily prepared and stored for
Table 5 Mean intake of gruels with and without ARF

<table>
<thead>
<tr>
<th>Source</th>
<th>Type of Gruel</th>
<th>Mean Intake (ml)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Infant</td>
</tr>
<tr>
<td>1 Gopaldas et al (1986)</td>
<td>10% rice gruel</td>
<td>(a) Control* 55.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b) Experimental+ 107.6</td>
</tr>
<tr>
<td></td>
<td>10% rice gruel</td>
<td>(a) Control* 56.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b) Experimental+ 94.0</td>
</tr>
<tr>
<td>2 Gopaldas et al (1986)</td>
<td>15% maize gruel</td>
<td>(a) Control* 42.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b) Experimental+ 102.0</td>
</tr>
<tr>
<td></td>
<td>10% sorghum gruel</td>
<td>(a) Control* 65.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b) Experimental+ 115.3</td>
</tr>
<tr>
<td>3 Gopaldas et al (1988)</td>
<td>20% wheat gruel</td>
<td>(a) Control* 62.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b) Experimental+ 131.0</td>
</tr>
</tbody>
</table>

* Control gruel = gruel without ARF
+ Experimental gruel = gruel with ARF
different calorie intakes and 2 levels of protein intakes (≤2.0 g or > 2.0 g/kg/day) were observed. The results indicated that once a minimal protein and calorie requirement is met, weight gain depends on the calorie intake of the children. The study also concluded that there is no proven advantage of the levels of protein intake above the usual, especially among the undernourished children.

The effects of bridging the calorie gap on the growth and development of undernourished children in a poor Indian community was investigated by Gopalan et al (1973) and the results show that the growth of children was strikingly improved by a food supplement which provided adequate calories but increased total protein intake only marginally.

Jones and Pereira (1972) provided a high cereal diet ad libitum to 100 children of pre-school age residing in an orphanage and observed that the children tended to gain weight when their calorie consumption was over 80 cal/kg body weight and lose weight with intake of lower than 80 cal/kg body weight.

The relationship between energy intake and growth rates in height and weight was investigated in 190 Guatemalan children by Martorell et al (1978). The results showed that the effect on growth was principally contributed by an increased energy intake.
amounts to traditional starchy gruels have reduced the viscosity of these thick gruels and ARF incorporated gruels have consistently been consumed in significantly higher amounts by children as compared to the non-ARF gruels. This higher intake of gruels leads to higher intake of energy among this age group which should improve their nutritional status. However, there are no growth studies to correlate the nutritional status of infants and toddlers fed on a calorie dense low bulk cereal gruel.

The major thrust of the present study was, therefore, undertaken in view of the above consideration.