# INTRODUCTION

# Chapter-I

## INTRODUCTION

Dietary bulk is regarded as a possible or even probable factor in the etiology of malnutrition (PAG 1973, Waterlow and Payne 1975, Payne 1976). Protein Energy Malnutrition (PEM) continues to be the major form of malnutrition especially in the under fives. International agencies like UNICEF and WHO have played a pivotal role in drawing the world's attention towards the problem by collating and presenting relevant data for all the countries and especially the developing ones. The picture that emerges on putting together the information from the latest UNICEF report is extermely disturbing (UNICEF 1993). A global review of prevalence of PEM shows that South Asia accounts for 60% of the malnourished children under five years of age and 72% of these live in India. This figure is alarming when read as numbers i.e. 72 million malnourished children under five years of age. Further, the highest levels of severe malnutrition (27%) and moderate malnutrition (42%) in the same age group is reported from India. This age specific phenomenon manifests at 11 months of age, reaches a peak during the second year of life and declines steadily then onwards. Concerted efforts are required in this direction in order to reduce severe and moderate malnutrition in the under fives by half which forms the major goal of the World Summit for Children's Declaration (1993). Since the incidence of underweight coincides with the weaning period, the above phenomenon can be understood better by looking at the diet of a young infant in developing countries.

The earliest descriptions of infant feeding in West Africa are given by Cicily Williams, first in 1933, in her classical account of Kwashiorkar and later in 1938, in the survey of the general child health situation in the Gold Coast (Ghana). She vividly describes the ill effects of the bulky, spiced carbohydrate foods given to older infants. In East Africa, Trowell and Muwazi emphasized as early as 1945 the bulky, indigestible nature of the food on which infants are weaned. These researchers state that the 1200 calories required by a child of 2 years of age must be obtained from the consumption of bulky vegetable foods. In most cultures, the traditional weaning foods are non-milk foods based on the local staple generally a cereal like wheat, maize, sorghum, corn, rice or a non-cereal staple like potato, cassava or plantain. According to the recent survey data, cereals are reported to form 77% by weight of the total diet of preschool children in South India where rice forms the staple (Jones and Periera 1974). Similarly, children fed a mixed diet were found to derive 70-80% of their total energy requirements from cereals, while energy dense foods like fats and oils formed a very small portion of their diet (NNMB 1983). When the staples are cooked in the form of a porridge they hold a substantial amount of water and swell. The paste on cooling sets into a thick gel due to a three dimensional network formation between starch and water molecules (Whistler and Paschal 1967). A young child with an underdeveloped swallowing reflex can not consume enough of this porridge to meet his energy requirements. If the consistency is maintained within desirable limits, the flour concentration in these porridges can be as low as 5%. This provides only 0.2 Kcal/g of food. The volume of food required to meet the child's energy requirements is too high considering his limited gastric capacity. Thus the starch contained in the cereals and staples lends to

`dietary bulk' which manifests itself in two forms viz. high viscosity or high volume. Thus, dietary bulk properties of weaning foods affect the nutrition of young children by regulating the following factors :

(1) Amount of food consumed at each meal,

(2) Number of meals per day, and

(3) Energy and nutrient density of the food consumed

(Ljungqvist et al 1981).

Since the above factors are interrelated, it is pertinent to discuss their collective effect on the nutrition of the young child.

Nicol (1971), in a maiden attempt to examine the role of food consistency on the amount of food consumed per sitting by preschool children (1-3 years of age) estimated the actual food intake on a starch based traditional diet. The volume of starch based foods required to cover the energy needs of preschool children was between 900 and 1650 ml. The amount of food eaten ranged from 660 to 1250 ml divided into two meals per day; this certainly was not enough to meet the stipulated energy requirements (FAO/WHO 1973). It was possible for a young child to consume a cereal based diet (900-980 ml) if served over four divided meals. However, it was impossible for the 1-3 year old child to consume 1450 ml of a thick sticky yam porridge even if the food was divided into several meals.

Rutishauser and Frood (1973) and Svanberg et al (1987) studied energy density of food as a function of gastric capacity and energy requirements of

preschool children 1-5 years of age. The data on food intake in preschool children (1-5 years), indicate a maximum gastric capacity of about 900-1400 ml/day. The energy requirement figures utilised are those of FAO/WHO (1973). The investigators conclude that if the energy requirements are to be satisfied, these intake figures must be met by an energy density of 1.2 Kcal/g. This estimation is in accord with data obtained from surveillance in villages and nutrition rehabilitation centres in Tanzania (TFNC 1978, Mellander and Svanberg 1984). An estimated energy density of 1.25 Kcal/g of prepared food was needed to provide the daily energy needs and more than 70% of the children were found to consume much less than this figure.

Since the various factors mentioned above viz. food consistency, energy density and food intake are interrelated it is difficult to delineate the influence of a single factor. Rutishauser (1975) identified energy density as the decisive factor over the other factors studied, viz. feeding frequency and appetite in determining the food intake per sitting of a young child. It is therefore important to examine the comparative effect of viscosity and energy density on the volume of food required to meet a young child's nutritional requirements. Table 1 presents the amount of food, generally a porridge, required to meet the nutritional needs of an older infant (12-24 months).

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Table 1: Estimated volume of porridges required to cover energy and protein needs of children 12-24 months of age

| | Faffa | SEF | Supermine | Lisha |
|---|---|---|---|---|
| g flour/100 ml water | 20 | 25 | 30 | 20 |
| Volume to cover protein needs (ml) | 570 | 445 | 400 | 740 |
| Volume to cover the energy needs (ml)[1] | 1440 | 730 | 980 | 1200 |
| Viscosity (BU)[2] after heating and cooling to 50°C | 1250 | 1000 | 20 | 1200 |

Source : Hellstrom et al 1981

1. FAO/WHO 1973

2. Brabender units - Units for measuring viscosity

It is evident that children fed on the traditional porridges are often able to eat enough to meet their protein requirements. However, the volume of food required to cover the energy needs is large indeed. It is impossible for the young child to eat enough to meet his energy requirements. This food gap leads to utilisation of the proteins for energy purpose. The PEM observed among these children is a **secondary protein deficiency arising out of primary energy deficiency.**

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As can be seen from the table, SEF, which has added fat, is required in lower amounts for providing the infants' energy needs. However, its high viscosity limits the food intake. If it is diluted with water the energy density decreases and a high volume of food is required to meet the energy needs.

It ensues from the above discussion that the problem of dietary bulk can be solved by **(i) reducing the viscosity and/or (ii) increasing the energy density. The utmost importance of these two aspects has not been addressed or studied until recently (Gopaldas and John 1992, John and Gopaldas 1993).** Araya et al (1983) observed an inverse and significant correlation between energy density and food intake in preschool children suggesting that the subjects were able to modify their energy intake by modifying the food intake when meals of varying energy content were offered. However, as discussed earlier increasing energy density alone, without lowering the viscosity, cannot improve the energy intake. On the other hand a very high energy density meal can also slow the gastric emptying rate and thereby the frequency of feeding culminating in a low total energy intake (Hunt and Stubbs 1973). Studies carried out in the University Department of Foods and Nutrition, M S University of Baroda have clearly established the beneficial effect of reduction in viscosity as indicated by an improved intake per sitting by children 6-36 months of age. Children fed high viscosity (8000-9000 Cps*) high energy density (1.6-2 Kcal/ml) gruels cannot imbibe more than 109 Kcal per meal. However, the calorie intake per sitting increases 2.25 times when the viscosity of the same gruel is lowered (2000-3000 Cps) keeping the energy density unaltered. It thus emerges that **it is predominantly the high viscosity**

* Centipoise units

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coupled with low energy density which greatly limits the food intake in young children. Hence, both the aspects need due attention (Gopaldas et al 1988).

The energy density can be increased by incorporating fat/oil and sweetening agents like sugar/jaggery. The contribution of fat/oils and jaggery/sugar to the total calorie intake cannot be underscored. An Indian infant from the lower socio-economic group derives 180-243 Kcal per day from fats contained in breast milk. Therefore, children who continue to be breastfed are nutritionally better off than those who are completely weaned off the breast (Achaya 1978). Hence, incorporating fats at an optimum level in young child foods is important and has been proved beneficial since it diminishes the volume of food required to cover the energy needs. The intake of solid foods to obtain equivalent energy was 1 kg for Ugandan children when fed traditional staple based diets versus 244 g for English children offered milk based diet (Whitehead 1982).

Fat/Oil and sugar/jaggery also lower the viscosity though only to a limited extent by making either the starch or water unavailable for gel formation. However, for a significant reduction in viscosity the starch needs to be modified. There are several technologies available ranging from sophisticated ones like extrusion cooking, precooking, roller drying, treatment with commercial enzyme preparations to simple household techniques like malting, toasting, flaking, popping and fermentation.

The technology adopted should be such so as to find social acceptance. The same is dependent on sociocultural, economic and behavioral factors

specific to a community. Though the anecdotal evidences suggest a regional specificity in selection of foods yet, there are certain practices common in the entire region. It is important to **adapt** these simple household methods which are easy to practise, of low cost and those that the rural/urban mothers in India and other developing countries are familiar with. Desikachar (1980) explored the following household bulk reduction methods viz., roasting, flaking, puffing, parboiling and malting. Malting was adjudged the best on account of its simplicity and tremendous viscosity reducing property.

The bulk reducing effect of the malting process depends on the formation of amylases. Enzymatic activity increases rapidly in the germinating seeds; in some cereal varieties (barley, wheat and millets) the amylolytic activity is especially high. The α-amylases which possess the liquifying power, are synthesised in the aleurone layer of the grain and gradually migrate to the starchy endosperm where the hydrolysis of starch begins. The hydrolysed starch loses the capacity to hold water, swell and form a gel. Furthermore, after germination, certain varieties contain amylolytic enzymes that are both soluble and highly active that, they can be used to degrade the starch gel network in gruels prepared from ungerminated flour. This means that, with the addition of a small amount of germinated flour a sticky porridge of about 20% flour concentration can be converted into a thin gruel (Malleshi and Desikachar 1986, Mosha and Svanberg 1983, Gopaldas et al 1986).

Mosha and Svanberg (1983) used the term `Power Flour' for the germinated cereal flour from sorghum. Gopaldas et al (1986) coined the term

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Amylase-Rich-Food (ARF) for the germinated cereal flour. ARFs developed from various cereals and millets viz. wheat, maize, sorghum, pearlmillet, bunti and kodo millet are reported to keep well for 28 days as per stringent PFA and ISI standards under ambient conditions of storage (Gopaldas 1988). Well monitored intake trials have shown that children 6-36 months of age, when fed 20% solid content gruel with 1.2 g ARF/100 ml gruel need to be fed three times a day to cover their energy requirements which is a feasible proposition (John and Gopaldas 1993).

A decades' work in the University Department of Foods and Nutrition has established the feasibility of development of Amylase-Rich Food (ARF) from various cereals and millets consumed in the region and its utilisation in development of low bulk gruels. The controlled feeding and growth trials further established the beneficial effect of reduction in viscosity as indicated by significantly higher increment in height and weight of the children fed low bulk gruel with a viscosity of 3500 cps and energy density of 1.63 kcal/ml (Gopaldas et al 1988, Gopaldas and John 1992, John and Gopaldas 1993).

However, there are several aspects related to the development and utilisation of ARF from various cereals which need to be studied in greater depth. The present study is a consolidated effort towards the same.

During germination besides the elaboration of amylases other enzymes are also produced. One of these are glycosidases which hydrolyse the cyanogenic glycosides contained in grains like sorghum to liberate free

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hydrocyanic acid (HCN). HCN content of sorghum sprouts is reported to increase 10 times on germinating the grains at 30°C and 95% relative humidity. The average HCN content of sprouts from 100 g of dry seeds far exceeded the fatal dose for an adult. Drying of seeds at 50°C or grinding did not reduce the potential HCN content (Panasiuk and Bills 1984). Dada and Dendy (1988) have reported the presence of HCN (446 ppm) in sprouted sorghum toasted at 100°C and milled. Removal of sprouts was found to lower the HCN considerably (45 ppm). Therefore, the safety of germinated sorghum with respect to its use in young child foods needs to be established. This is the first systematic attempt at studying the effect of cultivar, duration of germination and processing temperature on the HCN potential of grains.

In an enzyme catalysed reaction the ratio of enzyme to substrate is an important factor. The end products desired determine the enzyme substrate ratio. Equal amounts of ARF with amylase activity of 700-800 maltose units and 1300-1400 maltose units brought forth similar reduction in viscosity suggesting that a super abundance of amylase has no beneficial effect (Gopaldas et al 1988). Besides, with progressive germination, the microbial load too is found to increase yielding a product with poor shelf life (Harmon et al 1987). Therefore, the conditions for development of ARF with adequate amylase activity and good shelf life will be determined.

Sprouting of grain legumes is a popular practise for centuries in the Orient (Salunkhe et al 1985). However, the amylase content and liquifying power of germinated legumes has not been studied. The present study aims at exploring the feasibility of utilising legumes as a source of Amylase-Rich-Food.

There are several factors which affect the susceptibility of starch to amylolysis and thereby the resultant viscosity reduction. Cooked starch is reported to be more susceptible to amylase action (Whistler and Paschall 1967). Therefore, it would be interesting to study the viscosity reduction in a system where the ARF is added prior to cooking and in another where it is added to pre gelatinised starch paste.

In a predominantly cereal based diet it is essential to supplement the diet with a legume in order to improve the quality of protein. It is known that not only starch but also protein and protein starch interactions influence the consistency of a gruel. Hellstrom et al (1981) have reported an early swelling of wheat flour at a much lower temperature than a system with wheat starch alone. This aspect is very important since it would decide the highest possible solid content of a cereal + legume based gruel and therefore the energy density and the amount of ARF required for the effective thinning of the gruels.

Of late it has been realised that the bioavailable energy per se is more important than the total energy (FAO/WHO/UNU 1985). Bioavailable energy is determined by the percentage digestibility of the food. Till recently the oligosaccharides were thought to be the non-available energy sources. Recent studies have shown that it is the complex starch and non-starchy polysaccharides which escape enzymatic digestion and pass into the colon where, they are acted upon by the colonic bacteria producing bloat and flatus. This is of concern in young children with underdeveloped digestive system where the brush border amylases are almost absent. A major portion of the complex polysaccharides then passes on to the colon. Development of flatus leads to distension and discomfort (Ring et al 1988, Levitt et al 1987, Bond and Levitt 1972). Therefore, the in vitro digestibility of cereal and cereal + pulse gruels and the effect of addition of ARF if any will also be studied.

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Besides being bulky in character the weaning foods frequently serve as a source of infection due to the poor sanitation and handling conditions. In a typical rural/urban slum setting the main meal is cooked once or at the most twice a day. The keepability of gruels under ambient conditions and the effect of addition of ARF on the same will be investigated indepth.

With this as the background the present study was planned with the following objectives:

## OBJECTIVES

(1) Restandardisation of optimum conditions for steeping and germination for the preparation of ARF from cereals, millets and legumes.

(2) To study the effect of concentration of ARF on viscosity.

(3) To study the effect of temperature on the activity of ARF.

(4) To study the effect of period of germination on the hydrocyanic acid (HCN) content of ARF; its distribution in the grain and the sprouts and the effect of heat treatment on the HCN content.

(5) To study the microbiological quality of uncooked and cooked gruels prepared using ARF that had been stored for 1 to 6 months under ambient conditions.

(6) To study the effect of addition of jaggery and salt on viscosity and the viscosity reduction power of various ARFs on gruels prepared from cereal and pulse mixes, donated foods and commercial weaning foods.

(7) To compare the invitro carbohydrate digestibility of gruels with ARF vs gruels without ARF.