SUMMARY AND CONCLUSIONS
CHAPTER IX

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The first introductory food to infants and toddlers in most of the developing countries including India, is in the form of gruels prepared from starchy foods. The swelling of the starch granules and its capacity to bind water during cooking contributes to the dietary bulk of these starchy foods. Dietary bulk problem in the foods of infants and toddlers leads to a lower intake of energy, growth retardation, and undernutrition. So the importance of reducing the bulk of starchy food has been considered as a vital step in the preparation of infant foods especially in the rural settings.

Malting of cereals has shown to reduce the bulk due to the breakdown of the starch moiety of the malted cereal by the enzymes amylases which are produced in the grain during the process of malting. However, malting of cereals on an everyday basis is not only cumbersome for a mother from the low socio-economic group, but requires a lot of space, time and energy. Therefore, other alternative methods to reduce bulk have been explored, one of them being the addition of small amounts of malted flours to the traditional weaning gruels. This study was planned with a view of using malted flours known as Amylase Rich Foods (ARFs) on a wide range of
gruels to determine the effect of these ARFs in reducing the bulk or viscosity of these gruels. The feasibility of feeding the "ARF" and "non-ARF gruels" to infants and toddlers and to investigate the effect of these gruels on the growth and nutritional status of infants and toddlers have also been envisaged through this research.

The general objectives of the study were:

1. to screen pearl millet for amylase activity,
2. to develop wheat ARF,
3. to study the catalytic action of ARF,
4. to evaluate the acceptability and intake of gruels with and without ARF on infants and toddlers,
5. to monitor the intake of gruels prepared with and without ARF by infants and toddlers (6-24 months of age) over a period of six months. And also to document their effect on the morbidity profile of these children,
6. to evaluate the calorie and protein intake of infants and toddlers subjected to the above feeding trial,
7. to investigate the impact of gruels with ARF and those without ARF on the growth and nutritional status of the child subjects (6-24 months) in the six months growth trial.
The study was divided into 3 phases. In phase one, preparation of ARF and the catalytic activity of ARF in reducing the dietary bulk of a large number of traditional starchy gruels was studied.

In phase two, the acceptability and intake of gruels from sago, Soya Fortified Bulgar Wheat (SFBW) and wheat among infants and toddlers was studied.

In phase three, the effect of feeding ARF and non-ARF wheat gruels, on calorie and protein intake, morbidity profile and growth of infants and toddlers was studied.

PHASE I

(1) ARFs from pearl millet and wheat were prepared using previously standardized methods and the amylase activity was determined using the method of Bernfield (1955)

(2) The reduction in dietary bulk of gruels was carried out by the incorporation of pearl millet ARF, wheat ARF and takadiastase at different concentrations into the gruel.

The different gruels were made from the following:

Cereals – rice and wheat
Non-cereal starch – sago
PHASE II

(1) Preparation of ARF and non-ARF gruels or porridges for feeding infants and toddlers (6-24 months)

(2) Acceptability and intake of ARF and non-ARF gruels among infants and toddlers (6-24 months).

The recipe for preparation of gruel was standardized in the laboratory from the following foods - wheat, sago and SFBW. Sago gruel was of 10 g% solid concentration while wheat and SFBW gruels were of 20 g% solid concentration respectively. For the ARF gruel referred to as the Experimental gruel, wheat ARF at 4% of total solid level was incorporated into the respective gruels at the cost of flour from which the gruel was prepared. The non-ARF gruel did not contain any ARF and was referred to as the Control gruel.

For acceptability and intake trials 60 infants and toddlers from the low socio-economic group of people from
two areas of Baroda served as subjects for the study. Subjects were matched for age and nutritional status and were randomly assigned to the Control or the Experimental group. The Control group received the non-ARP gruels, while the Experimental group received the ARP gruel. The intake trial was conducted for 3 consecutive days. The total intake of gruels per day per sitting and the calories obtained from the amount of gruel consumed was calculated for each subject.

**PHASE III**

Sixty-eight infants and toddlers (6-24 months) from Karelibaug slum of Baroda were pair-matched for age and nutritional status and were randomly assigned to the Control or Experimental group. The Control group received wheat gruel of 20% solid concentration without ARP (Control gruel) and the Experimental group received the Experimental gruel of 20% solid concentration with 4% ARP (0.8 g) for a period of 180 days, continuously. Intake of gruel, morbidity pattern, calorie and protein intake and the growth pattern of these child subjects were evaluated.

Parameters studied were:

- Weight for age (Jelliffe 1966)
- Height for age (Jelliffe 1966)
- Arm circumference (Jelliffe 1966)
- Dietary data (Pasricha 1959)
- Morbidity pattern (Mother's response and investigator's observation per child per day for 180 days)
The results of the study are presented under three sections:

(1) Preparation of ARP and viscosity reduction studies

(2) Acceptability and intake trials of sago, wheat and SFBW gruels among infants and toddlers (6-24 months)

(3) Feeding trials with 20 g% wheat porridge with and without ARP and its effect on morbidity pattern, calorie and protein intake and growth and nutritional status of infants and toddlers (6-24 months).

(1) Preparation of ARP and Viscosity Reduction Studies

(1) Preparation of pearl millet ARP

Seven varieties of pearl millet were purchased from the market. Pearl millet ARP was prepared by steeping the grains in water for 2 hours, germinating for 72 hours, air drying for 12 hours and roasting the germinated grains in an open iron pan for 10 minutes at 70-80°C and milling the roasted and devegetated grains. Amylase activity of pearl millet ARP prepared by these steps ranged from 57 to 224 mg of maltose released per g of malt. 'Maharashtra bajri' which had the highest amylase activity was subjected to either 5 hours of sun drying at 40°C±2°C or 5 hours of oven drying at 50°C after the grains were germinated.

The oven dried sample had an amylase activity of 566 mg of maltose units while the sun dried samples showed an
amylase activity of 727 mg of maltose units. The lower values for the roasted samples were attributed to the destruction of the alpha amylase when subjected to high temperature. Although oven drying is not a possible technology to be transferred to the rural setting, sun drying can be employed for drying of germinated seeds in any rural or urban setting as plenty of sun light is available in this part of the country for 10 months in the year.

(ii) Preparation of wheat ARF

Wheat is the most commonly used cereal in India and previous studies in this department had shown that there was no marked varietal difference in the alpha amylase activity of wheat ARF. Therefore a common market variety of wheat was purchased and wheat ARF was prepared by steeping the grains for 12 hours, germinating for 48 hours, oven drying for 5 hours at 50°C and milling the dried and devegetated grains. Amylase activity of wheat ARF thus prepared, compared well with previous studies from this department (4500 mg of maltose units).

Of all the grains studied for amylase activity wheat ARF has so far shown the highest alpha amylase activity.
Viscosity Reduction Studies

The main purpose of developing ASF was ultimately to incorporate it into traditional high viscosity gruels used for young child feeding.

The gruels were prepared from:

i) Cereals - rice and wheat
ii) Non-cereal starch - sago
iii) Donated food - Soya Fortified Bulgar Wheat (SFBW)
iv) Commercially processed foods - biscuits and bread
v) Traditionally processed foods - Chapati and Khichdi

(i) Reduction in dietary bulk of cereal gruels

(a) Effect of pearl millet and wheat ARF on rice gruels

Pearl millet and wheat ARF at 4% levels of total solid concentration was used to reduce the dietary bulk of 10, 15, 20 and 25 per cent solid concentration cooked rice gruel. Although both the ARFs could reduce the viscosity of the gruels considerably, wheat ARF fared better than pearl millet ARF. The higher reduction in viscosity of rice gruel by wheat ARF than pearl millet ARF was attributed to the higher levels of alpha amylase in wheat ARF as compared to pearl millet ARF. The effect of different concentrations of pearl millet and wheat ARF on 20 g% rice gruel showed that 4% (of total solids) of pearl millet and wheat ARF brought
about optimum viscosity reduction. Again, on comparing the liquifying power of both the ARFs, it was observed that wheat ARF performed better than pearl millet ARF. Therefore, wheat ARF was used for further viscosity reduction studies.

(b) Effect of wheat ARF on a 30% wheat slurry

Maximum solid concentration slurry that could be subjected to amylase activity was a 25% solid concentration slurry. On increasing the solid concentration further, the calorie density of the gruel would concomitantly increase. But, for feeding trials it is important to have matched gruels with and without ARF. Therefore, the solid concentration of the gruel so far used for the feeding trial had been limited to only 20 g%. However, for everyday feeding purposes when only a gruel with ARF would be used, it would be important to feed a gruel with as high an energy density as possible, but one having low bulk. Therefore the feasibility of increasing the solid concentration to 30 g% was studied. Although the mixture was thick and dough-like and ARF upto 3% of solid concentration did not show any change in the viscosity, the addition of 4% and higher amounts of ARF had a marked effect on its viscosity. Maximum reduction in viscosity was obtained when ARF at 6% of total solids was added to the gruel (6000 cp units). In the Indian setting, mothers prefer gruels of thicker consistency (3000-6000 cp units) as they reported that a thicker gruel is more
nutritious than the thinner gruel. Therefore, a 30% slurry with 6% ARF (of total solids) would not only increase the energy density to 2.44 Kcals/ml, but it would also increase the acceptability.

(ii) **Reduction in dietary bulk of non-cereal starch namely sago**

Gruels from sago were prepared with different solid concentrations and as the solid concentration increased, its viscosity too increased making the slurry non-spoonable at 20 g% solid concentration. The 10% slurry had the most suitable consistency for child feeding. Therefore a 10% slurry was used for further viscosity reduction studies.

Viscosity reduction of a 10% sago gruel was studied using 1–7 per cent (of total solids) of wheat ARF and takadiastase. As in the case of cereal gruels, optimum reduction in viscosity was obtained when 4% of wheat ARF (0.4 g) was added to the 10% sago gruel. ARF had better thinning power than pure enzyme takadiastase.

Addition of ARF prior to or after cooking brought about a similar per cent reduction in viscosity. This makes the procedure of preparing the 'ARF gruels' simpler because even if the mother forgets to add the ARF before the gruel is prepared, she can always incorporate the ARF on taking the gruel off the fire.
Viscosity reduction of sago slurries was studied using sago flour to obtain a homogenous mixture. However, sago is generally used in globule form by mothers to prepare porridge or puddings. Therefore the effect of ARP on whole sago was studied and the results show that the addition of ARP to whole sago gruels dissolved the globules and brought about a similar viscosity reduction as when ARP was added to sago flour gruel. These findings are of practical significance to child feeding because, the mother need not grind the whole sago to prepare "ARP'sago gruel". She can add the ARP to whole sago and then cook it.

**Addition of fat and jaggery and reduction in dietary bulk**

Both these ingredients are an essential part of Indian gruels enhancing the palatability and taste of the gruel. They also increase the energy density of the gruel. More importantly, the infant who was receiving breastmilk in his early months was getting a high level of fat from the mothers milk. Therefore, any weaning food that replaces breastmilk should have an equal amount of fat.

Since fat is known to have a positive effect on reducing the viscosity, the effect of these two ingredients namely fat and jaggery was studied. Although addition of fat and jaggery did show some viscosity reduction (20%) maximum reduction in viscosity (99%) was achieved only when ARP was added to the gruel.
Reduction in the dietary bulk of donated weaning food namely Soya Fortified Bulgar Wheat (SFBW)

Bulgar wheat in combination with soya grits forms part of the World Food Programme's (WFP) project 2206- "Supplementary nutrition for pre-school children, pregnant and nursing mothers". The acceptability of this new item has been minimal among the pre-school children. Therefore, the feasibility of feeding the younger children with gruels prepared from SFBW flour and the viscosity reduction of the same with wheat ARF was studied.

In gruel form, a 20 g% solid concentration slurry was the most feasible concentration that could be used for child feeding. Therefore, viscosity reduction was carried out with 20 g% solid concentration slurry.

When ARF at 1-7% of total solids was added to 20% solid concentration slurry, optimum reduction occurred at 4% level. Although, further increase in ARF did show insignificant increases in viscosity reduction but the differences were not obvious visually. As in the case of sago, addition of ARF prior to or after cooking of SFBW gruels, did not show any difference in the viscosity reduction. SFBW is being used mostly in ICDS centres of rural villages of India where grinding of cereals is done in a hand operated stone mill. Therefore, the effect of different methods of milling namely,
by stone grinding, and in a flour mill, on viscosity reduction was studied and the results show that reduction in viscosity was not affected by the method of milling employed. These findings suggest that it is feasible, to serve SPBW in gruel form in any situation.

Addition of fat and jaggery and reduction in dietary bulk

Addition of jaggery and fat to the 20% solid concentration gruel brought about 50% reduction in viscosity. But it was ARF at 4% level that brought about maximum reduction in viscosity. Compared to sago, SPBW showed higher per cent viscosity reduction possibly due to the high fat content of the ground soya grits.

(iv) Reduction in dietary bulk of commercial foods

Commercial foods like biscuits are famous as snacks among the low income group. Hot paste slurries from commercially manufactured biscuits (low, medium and high fat) and from bread of 20% solid concentration were treated with 4% of total solids of wheat ARF and it was observed that maximum thinning was seen in bread followed by low, medium and high fat biscuits. The high fat biscuits were salty biscuits and salt is known to inhibit amylase activity. Therefore, high fat biscuits did not undergo significant viscosity reduction.
(v) **Reduction in dietary bulk of traditionally processed foods**

'Chapati' (unleavened bread) and 'Khichdi' (a seasoned cereal-pulse combination cooked in the ratio of 3:1) are two traditional foods commonly consumed in the Gujarat region. Since both these foods are starchy in nature, gruels from both were studied for viscosity and its reduction with wheat ARP.

Maximum viscosity reduction that was observed for a 20% solid concentration Khichdi slurry was around 40% while in Chapati, maximum viscosity reduction observed was 80% when the solid concentration was below 20%.

Since Chapati and Khichdi are traditional foods of this region, these findings if transferred to the village level would solve the dietary bulk problem of home food. Further, it was also observed that when ARP was added to whole mashed Chapati mixtures of 20 g% solid concentration, considerable reduction in the thickness of the mixture was observed visually. (The viscosity could not be measured as the mixture was not homogenous.) This again would enable the mother to feed her child with normal home food in the usual way, (mashed form) and on account of the lowered viscosity the child would have an improved intake per sitting.
Acceptability and Intake Trials of Sago, Wheat and SPFW Gruels (Porridge) Among Infants and Toddlers (6-24 months)

Sago porridge used for the feeding trials was of 10% solid concentration, while SPFW and wheat porridge were of 20% solid concentration respectively. Jaggery was added to the porridge at the level most readily accepted for consumption by children of this region, which was 70% of total solids for sago and 100% of total solids for SPFW, and wheat respectively.

Acceptability trials on mothers and their infants showed that the porridges were well accepted by the mother-child dyad. Intake trials showed that all the three porridges namely sago, SPFW and wheat, with wheat ARF (at 4% of total solids) were consumed consistently and significantly at much higher levels than porridge without ARF by both infants and toddlers. The calorie density/ml of the porridges ranged from 0.8 for a 10% sago porridge to as high as 1.6 for a 20% SPFW gruel which was enhanced by the addition of fat and jaggery. Although calorie densities of both the gruels were the same, the dietary bulk of the Control gruel limited its intake per sitting. The children from Experimental group consumed significantly higher amounts of the Experimental gruel and therefore could imbibe 2-3 times more calories per sitting than the Control group.
Feeding Trial with 20 g Wheat Porridge and Its Effect on Morbidity Pattern, Calorie and Protein Intake and Growth and Nutritional Status of Infants and Toddlers (6-24 months)

The ultimate aim of preparing ARF and non ARF gruels (Experimental and Control gruels) was:

1. to determine the amount of each gruel that can be consumed by the child subjects at one sitting,

2. to determine the improvement in the total intake of food of the child subjects when gruels were fed for over a period of six months,

3. to evaluate the impact of both the Control and the Experimental gruel on the growth and the nutritional status of the child subjects.

The feeding trial of gruels with and without ARF by child subjects for six months

The feeding trial of 55 infants and toddlers (6-24 months) with wheat gruel (with and without ARF) was carried out for a period of 6 months. The Control group received gruel without ARF (Control gruel) and the Experimental group received gruel with ARF (Experimental gruel). Of the 68 child subjects that were initially registered for the study (pair matched for age and nutritional status) 55 completed the 180 days of
continuous feeding. But only 42 pair matched child subjects were able to conform to all the requirements of the entire study period.

The mean intake of the Experimental gruel was significantly higher among the subjects as compared to the Control gruel. The mean intake of the Experimental gruel was 4 times more than the Control gruel.

The higher intake of the Experimental gruel was attributed to its lower viscosity of about 3500 cp units and semi-liquid consistency. The Control gruel on the other hand was very thick and non-spoonable with a viscosity above 25,000 cp units. The lowered viscosity of the Experimental gruel was due to the small amount of the ARF that was incorporated into it. ARF, because of its high alpha amylase content, catalyses the hydrolysis of starches into lower molecular weight dextrins and maltose. The bonds hydrolyzed are alpha 1-4 linkages. This liquifying power of ARF has been utilized in reducing the dietary bulk of the thick gruel, thereby increasing its consumption by infants and toddlers.

The mean consumption of gruel between the different age groups of child subjects showed that for the Control gruel, the consumption did not vary between 6-12 and 13-18 months age groups. The 19-24 months age group was able to
consume more of the Control gruel than the younger children. But for the Experimental gruel fed children, it was the 13-18 months age group that consumed the highest amount of the Experimental gruel suggesting that a 20 g% solid concentration gruel with ARF may be most suitable for this age group. The higher consumption among this age group may also be due to the fact that they were more hungry than the other two age groups. Since at this age the breast milk output is much lower and the children are not generally provided sufficient food to replace the breast milk.

Monthly consumption of the gruel among the subjects indicated that, except for the first month, the Control gruel consumption among the child subjects did not improve till the end of the study period of 6 months. On the other hand, the Experimental gruel fed children improved their gruel consumption as the study period advanced. The dietary bulk of the Control gruel limited its intake among the child subjects. When consumption of gruels was analysed for different seasons (summer, monsoon and winter) it was observed that the consumption of the Control gruel did not vary in the different seasons. The consumption of the Experimental gruel, on the other hand, increased as the seasons passed with the lowest consumption being recorded during the summer months and the highest consumption, during the winter months. Again, it was the bulk problem of the Control gruel which
prevented the Control group children from consuming more of
the gruel as the time passed.

(ii) Morbidity profile of the gruel fed subjects

During the feeding trials, morbidity history was
collected on every child each day to find out why a child
consumed more or less of the gruel during certain days.
Therefore, the findings on morbidity profile are a by-product
of the feeding trial.

Although the frequency of common illnesses did not vary
in both the Control and the Experimental gruel fed children,
the mean days of illness was lower in the Experimental group
of children. It may be inferred that the Experimental gruel
fed subjects were able to recover faster than their Control
gruel fed counterparts. This may be due to the fact that
the Experimental group of children received more food due
to the higher consumption of "ARF gruels" while the Control
children had limited intake of the Control gruel because of
its dietary bulk.

The common type of illnesses among the child subjects
were, fever, diarrhoea, cough and cold and skin infection.
The frequency of these illnesses was the same in both the
groups but the recovery from each of these illnesses was
faster in the Experimental group. Both the Control and the
Experimental groups of children got sick more often in the rainy months of July and August. In the winter months of October and November, the Experimental gruel fed children showed good health as the mothers did not report any incidence of illness. The Control gruel fed children continued to be morbid even in the winter months. The better morbidity status of the Experimental gruel fed children may be due to the fact that as these children were able to consume more food than those in the Control group, their nutritional status and resistance to infections may have improved. However, this needs to be further investigated.

(iii) Energy and protein intake of infants and toddlers subjected to feeding and growth trials

As the Experimental gruel fed child subjects were able to consume much more of the gruel than the Control gruel fed children, subsequently the energy and protein intake also increased. The consumption of both energy and protein from the Experimental gruel was significantly higher than that from the consumption of the Control gruel. The energy intake was almost 4 times more in the Experimental group than in the Control group. When agewise intake of energy and protein was compared to the RDA (Recommended Dietary Allowance) for this age group children as per FAO/WHO (1973) and ICMR (1981), it was observed that for all age groups, the consumption of
"ARF gruel" at one meal provided on average 20% of total energy per day. Protein consumption also ranged from 15 to 24% of RDA per day. On the other hand, the Control group received on average only 5% of RDA for energy and protein through the gruel.

When energy and protein intake from home food (including breast milk) was calculated, it was observed that there is no significant difference in the consumption of both these nutrients among the child subjects from the Control and the Experimental groups. But when mean energy and protein intake from home food and gruel was calculated, it was observed that the Experimental gruel fed children consumed significantly higher amount of calories as compared to the Control gruel fed children. The protein intake did not vary significantly among both the groups. The increased consumption of energy by the child subjects from the Experimental group was attributed to the higher intake of the "ARF gruels". When per cent RDA contributed by home food and gruel was compared between the two groups, even with the additional intake of a modest 124 Kcals/day by the Experimental group, the total consumption did not meet their energy requirement. Home diet contributed almost 40-50 per cent of food energy/day and as discussed earlier, gruel contributed about 20% of the RDA for energy. Therefore, if a child could get two feeds of 'ARF gruel' per day, one could expect approximately 80-90% of his food energy to be met.
(iv) **Impact of gruel intake on growth**

Baseline data on anthropometric measurements (weight, height and arm circumference) pertains to all 68 subjects who were enrolled for the study, while the final data pertains to only 42 pair-matched subjects who were able to conform to all the requirements of the entire study period of 6 months. The reference standard used to compare growth of the present subjects were those of NCHS standard for weight and height for children (6-24 months). Mean arm circumference was compared with standards from the HAMES survey.

Baseline data show that the 50th percentile values for weight for age and height for age were well below the 50th percentile values of the NCHS standard and corresponded with the 5th percentile values of the NCHS standard. The weight and height deficits increased with the increasing age.

According to IAP (Indian Academy of Pediatrics) classification for weight for age, majority of the children were in the 2nd degree of malnutrition. When the subjects were compared by height for age classification, a better picture was observed than by weight for age which means the child subjects were thin rather than short. Comparing the child subjects according to different classifications, namely, weight for age, height for age and weight for height, it was observed that 13-18 months old children were more
undernourished than the others; but according to the wasting/
stunting category, the 19-24 months of age children were more
undernourished than the others. Classification according to
mid-upper arm circumference (MUAC) showed a similar trend as
height for age.

(v) **Increments in anthropometric measurements with feeding
trials**

Mean increments in weight, height and MUAC for the
Control and the Experimental group of child subjects indicate
that the Experimental gruel fed children gained significantly
higher values for all the 3 measurements. The baseline survey
showed more children in the wasted category than the stunted
category, while at the final evaluation it was observed that
children in the wasted category had improved considerably as
compared to those in the stunted category. This observation
is further supported by the fact that weight increments
were far better than height increments.

Since all other factors that affected the growth of the
Control and the Experimental children were similar, the
improvement in growth of the Experimental group of children
as shown by the increments in weight, height and arm
circumference can be attributed to the higher consumption
of the 'ARF gruels' by these children. When the weight
increment was calculated monthwise, it was observed that the Experimental group of children gained more weight in the first and the last month of the study period. It may therefore be concluded that introduction of more food in their daily meal pattern, namely 'ARF gruel' improved their weight in the first month. In the second and third month, as the rate of infection was high, significant improvement in weight did not occur. However, in the last month (sixth) maximum improvement in weight was observed because not only did they consume significantly higher amount of gruels in the last month as compared to the previous months, but the rate of infection was nil during the last month. In the Control group of children, no significant improvement in weight was observed except for the first month which may be due to the fact that there was a small increase in their food intake through the 'non-ARF' gruel.

The nutritional status of children was compared at baseline and after the 6 months of feeding trial and it was observed that in the Experimental gruel fed children, nutritional status improved markedly after the feeding trial. There were more children in the malnourished category in the Control group than the Experimental group at the end of the feeding trial. Improvement in nutritional status was twice as much in the Experimental group as compared to the Control group.
When children in the normal nutritional status were compared at the baseline and final evaluations, it was observed that there was a deterioration in the Control group of children. In the Experimental group on the other hand, the number of normal children tripled by weight, doubled by weight for height and improved marginally by mid upper arm circumference.

Thus, it can be concluded that there was an overall improvement in the nutritional status of the Experimental group of children, while there was a deterioration in the overall nutritional status of the Control group of children. This improvement in the Experimental group could be attributed to the "ARE gruels" where these children were able to imbibe 124 Kcals more per day on an average as compared to their Control group counterparts.

When energy and protein intake per kg body weight was analysed, it was observed that on an average, protein intake was similar for the Control and the Experimental children at baseline and at final evaluation. Although energy consumption too was similar at baseline and the final stage for the Control group, the Experimental group on the other hand received 10 Kcals/kg body weight more than the Control group. The Control group received 63.5 Kcals/kg body weight and the Experimental group received 72.1 Kcals/kg body weight. The
higher consumption of calories by the Experimental group may have been the cause of the overall improvement in the nutritional status of the Experimental group.

It can therefore be concluded that:

(1) The Control group of children were limited in their gruel intake because of the high dietary bulk of the Control gruel.

(2) The Experimental group of children were able to consume much more of the "ARF gruels" because its dietary bulk had been lowered considerably due to the amylase in the ARF incorporated into the gruel.

(3) 'ARF gruels' when fed to infants and toddlers (6-24 months) once a day, improved their nutritional status considerably.

(4) The 'ARF gruel' therefore is a promising solution to the resolution of the problem of dietary bulk among infants and toddlers (6-24 months) whose staple diet is cereal based.

(5) Any starch based food can be treated with ARF to reduce its dietary bulk provided the food is cooked and served in gruel form because amylases require moisture for its activity and acts best at temperature between 60-70°C.
(6) ABF can be prepared from any cereal available in a particular area.

(7) The transfer of this technology namely that of the ARF preparation, has been simplified because the sun-drying process can be employed by any mother from the village or slum. The rest of the procedure is commonly known to people of this region as germinating of cereals and pulses is a common practice for consumption.

**Recommendations for further research**

(1) It has been observed in the present study that pearl millet ARF with 737 mg of maltose units/g of ARF is able to bring about 90% reduction in viscosity of gruels while wheat ARF with 4500 mg of maltose units/g of ARF brought about 92-94 per cent reduction in viscosity. Therefore it would be feasible to further investigate the optimum amount of amylase in the ARF of different cereals that would be required to bring about maximum reduction in viscosity.

(2) The highest possible slurry for the different substrates used in the present study was limited to only 25-30% solid concentration because, its counterpart gruel without ARF, was too thick to
register a viscosity measurement. Therefore, the
feasibility of increasing the solid concentration
and studying the effect of different concentrations
of ARF needs to be further investigated.

(3) As it has been established that the Experimental gruel
is far better in improving the nutritional status of
children, with only a 20 g% gruel, the solid
concentration of this gruel should be increased to as
high a level as possible and further growth trials
need to be carried out. Firstly, to determine the
highest solid concentration that would not interfere
with the subsequent appetite behaviour of the child
and a cutting back of his normal diet. Secondly, to
determine the minimum number and volume of gruel
feeds that would narrow or close the caloric deficit
gap.

(4) Although the morbidity profile in this study was a
by-product of the feeding trial in the present study,
it would be worthwhile to investigate in detail the
effect of "ARF" gruels on the morbidity status of
infants and toddlers.