CHAPTER 8

Summary and conclusions

Malting is a traditionally used processing procedure. The process of malting consists of germination and subsequent drying of a grain. During germination of cereals and pulses increases in amylases (Kruger 1972, Lineback and Ponpipom 1977), starch hydrolysis (Jaya and Venkataraman 1980, Chavan et al 1981, Taur et al 1984), protein hydrolysis and increases in lysine, tryptophan (Tsai et al 1975, Dalby and Tsai 1976, Wu and Wall 1980, Wu 1983), vitamin C and B complex vitamin contents (Shastri et al 1975, Babu 1976) have been observed. Because of these nutritional benefits and because of the decreased viscosity of gruels made from malted versus raw grains, the former have been used in the preparation of weaning foods for infants (Malleshi and Desikachar 1982, Nayak 1983, Gandhi 1985) and ready to eat mixes for children (Master 1981, Tajuddin 1981, Gopaldas et al 1982). In the present study an attempt has been made to prepare a snack, biscuit, for vulnerable groups, and to investigate the effect of further heat treatment on the nutritional quality of the malted mix in the preparation of a snack.

In order to enhance the calcium, iron and beta carotene contents, green leafy powder was incorporated into the biscuits. The acceptability, nutritive composition, keeping quality, growth promoting ability and protein quality of these biscuits were evaluated against these qualities of similar biscuits prepared from mix made from raw grains.

Wheat and bengal gram, the most commonly used gains in Gujarat State, were selected for the present study. Colocasia leaves being rich in calcium, iron and beta carotene and fairly low in oxalic acid and also being commonly used in the said State, were incorporated into the biscuits in order to enhance their nutritive value in terms of minerals and vitamins.

The present study was planned with the following objectives:

1. to determine the optimal soaking and germination time for wheat and bengal gram grains as indicated by their germinative capacity,
2. to study the changes in carbohydrate profile and protein content of wheat and bengal gram in response to the process of germination,
3. to prepare biscuits from malted wheat and bengal gram mix with or without green leafy powder and to determine the acceptability of these biscuits in comparison to that of biscuits prepared from raw mix,
4. to determine the nutritive composition of mixes and biscuits,
5. to determine the keeping quality of mixes and biscuits, and
6. to evaluate the growth promoting ability and protein quality of mixes and biscuits in an animal model.

Determination of optimal soaking and germination time for wheat and bengal gram grains as indicated by their germinative capacity

One of the favourable conditions required for a viable seed to germinate and develop sprouts is an adequate water supply (Mayer and Poljakoff-Mayber 1982). The water uptake by a seed, however, is influenced by certain factors such as initial moisture content, grain size, nutrient composition, and structure and composition of grain layers (Butcher and Stenvert 1973, Brookes et al 1976). These factors are known to vary from grain to grain. Therefore an experiment was planned to determine the optimal soaking time for wheat and bengal gram in terms of their germinative capacity.

The parameters used were (a) increases in moisture content as an indicator of water uptake, (b) percentage of germinated grains and (c) percentage of grains having measurable sprouts of more than 0.2 cm after 24 and 48 h of germination at various soaking periods. The percent germination and sprout length were the indicators of germinative capacity of the grains.

Cleaned wheat and bengal gram grains were soaked in thrice their volume of water for 4 to 24 h to determine their moisture contents at various soaking periods. At each 2 h interval, in triplicate, the sample of soaked grains was wiped with dry filter paper to remove the surface moisture. The grains were weighed and placed in an oven at 65°C for 24 h and reweighed. The difference in weight was considered as the moisture content. In order to determine the germinative capacity of grains soaked for various periods, at each 2 h interval of soaking, 100 grains were germinated for 24 or 48 h and the germinated grains were counted. The sprout lengths of randomly picked up 10 grains were measured and the number of germinated grains with measurable (more than 0.2 cm) and non-measurable (less than 0.2 cm) sprout length was recorded.

The moisture content of wheat grains exhibited a 4 fold increase (from 6.0 to 26.6%) after 4 h of soaking period. Thereafter the increase in soaking period from 4 to 12 and 24 h led to smaller increases. The moisture content of 12 h soaked wheat grains was 35.1% while that of 24 h soaked grains was 40.7%.

Following 24 h of germination, the percentage of germinated wheat grains increased from 70% in 4 h soaked grains to 100% in 12 h soaked grains. Likewise, the percentage of germinated grains with measurable sprout length was 21% in 4 h soaked grains which increased to 88% after 12 h of soaking period and was between 93 and 97% when the soaking period was increased from 12 to 24 h. The sprout length of 4 h soaked and 24 h germinated wheat grains was 0.38 cm. It increased by 0.22 cm (from 0.38 to 0.60 cm) when the soaking period was increased to 12 h. The sprout length of 24 h germinated wheat grains was 0.85 cm.

In response to 48 h of germination, on the other hand, the percentage of germinated grains was 99% following 4 h of soaking which became 100% when the soaking period was increased from 4 to 12 h. Thereafter, however, the percentage of germinated grains remained between 95 and 100% in 14 to 24 h soaked grains. Also the percentage of germinated grains with measurable sprout length was 87% following 4 h of soaking, which increased to 100% after 12 h of soaking period. Similarly, the sprout length of 48 h germinated and 4 h soaked grains was 1.62 cm which increased to 2.32 cm after 12 h of soaking. The sprout length of 24 h soaked grains was 2.88 cm. These data indicated that 12 h of soaking and 48 h of germination exhibited maximal germinative capacity of wheat grains in terms of percentage of germinated grains.

In bengal gram grains, the moisture content increased markedly from the initial value of 5.7 to 44.2% after 4 h of soaking. With the increase in soaking period to 12 h, the moisture content of bengal gram grains increased at a slower rate (from 44.2 to 53.9%). Thereafter, no further increase in moisture content was observed when the soaking period was increased from 12 to 24 h (53.9 Vs 54.3%).

As a result of 24 h of germination, the percentage of germinated bengal gram grains was 54% following 4 h of soaking which increased to 83 and 91% after 12 and 24 h of soaking periods, respectively. The percentage of germinated grains with measurable sprout length was 70% in 4 h soaked grains and remained between 66 and 81% throughout the soaking period of 24 h. The value for sprout length of 4 h soaked grains was 0.46 cm which increased to 0.59 cm in 12 h soaked grains and to 0.74 cm in 24 h soaked grains.

As a result of 48 h of germination and 4 to 24 h of soaking, the percentage of germinated bengal gram grains was between 99 and 100%. Also cent percent grains had measurable sprout lengths. The sprout length of 12 h soaked grains was 2.58 cm and that of 24 h soaked grains, 3.05 cm.

Since after 12 h of soaking and 48 h of germination period, wheat and bengal gram grains had exhibited 100% germination and all the germinated grains had sprout lengths more than 0.2 cm, 12 h of soaking and 48 h of germination were considered optimum for wheat and bengal gram grains.

Changes in carbohydrate profile and protein content of wheat and bengal gram in response to the process of germination

In order to explore the effects of various periods of germination on the carbohydrate profile and protein content of wheat and bengal gram grains, 100 g of each grain were soaked in thrice their volume of water for 12 h. The soaked grains were germinated in separate plastic bowls for 24, 36, 48, 60 and 72 h. The germinated grains were weighed to obtain the green weight. The seeds that had not germinated or with relatively very small sprouts were weighed and discarded. The sprout lengths of 20 randomly selected grains were measured. The germinated seeds were dried for 2 h under the fan, and were oven dried at 70±5°C. The dried grains with rootlets were cooled and weighed to obtain dry weight. The dried grains were milled and whole flour (100% extraction) was used for the analysis of starch, total and reducing sugars and protein content.

The weight of germinated wheat grains increased from 100 to 145 g in the first 24 h of germination. Thereafter, until 72 h of germination period no appreciable changes in green weights were observed. The dry weight of the malted wheat grains ranged from 92 to 95 g exhibiting a weight loss of 5 to 8% during the process of malting. The sprout length of 24 h germinated wheat was 0.50 cm which increased 3 fold (from 0.50 to 1.49 cm) when the germination period was increased from 24 to 36 h. Thereafter until 72 h of germination, there was an additional increase of only 0.55 cm in sprout length.

The weight of bengal gram grains nearly doubled (from 100 to 199 g) following 24 h of germination. However when the germination period was increased from 24 to 72 h, no marked variations in green weights of bengal gram grains were observed. During the process of malting there was 8 to 10% loss in dry weight of the grains. The sprout length of 48 h germinated grains was 3.34 cm which was 2.20 cm higher than that observed in 24 h germinated grains. Thereafter, an increase of 1.5 cm was observed following additional 24 h of germination.

The starch content of wheat grains decreased from 60.9 to 50.3 g/100 g after 24 h of germination. With the increase in germination time to 72 h, no further decrease in starch content was observed (from 50.3 to 49.0 g/100 g). On the other hand, the total sugar content increased from the initial value of 3.63 to 5.23 g/100 g following the first 24 h of germination. With the increase in germination period by another 24 h, the sugar content increased from 5.23 to 7.52 g/100 g. Thereafter, a downward trend in sugar content was observed as in 72 h germinated wheat grains, the total sugar content was 5.06 g/100 g. Likewise, the reducing sugar content of malted grains, increased almost 2.5 fold and above 4 fold from the initial value of 1.28 g/100 g following 24 and 48 h of germination period, respectively. Similar to the observations made for the total sugar content, the reducing sugar content exhibited a tendency to decrease when the germination period was extended from 48 to 72 h (from 4.56 to 4.43 g/100 g).

The starch content of bengal gram decreased from 43.1 (initial value) to 42.1 g/100 g after 24 h of germination period. When the germination period was increased from 24 to 48 and 72 h, the starch content decreased from 42.1 (24 h value) to 40.3 and 37.8 g/100 g, respectively. While the total sugar content increased from 3.30 (initial value) to 4.02 and 4.17 g/100 g after 24 and 48 h of germination periods respectively. Thereafter, the total sugar content decreased from 4.17 to 1.24 g/100 g when the germination period was extended by another 24 h. Similarly, the reducing sugar content increased almost 2 and 3 fold from the initial value of 0.48 g/100 g in the first 24 and 48 h of germination period respectively. With the enhancement of germination period by another 24 h, the reducing sugar content tended to decrease from 1.47 (48 h value) to 1.19 g/100 g of 72 h value.

The protein content of wheat and bengal gram consistently increased with increase in germination time. The increase of 8% in malted wheat and of 5% in malted bengal gram grains from their respective initial values of 14.03 and 15.28 g/100g observed after 72 h of germination were considered apparent which probably was due to loss in dry matter.

The changes in the contents of total and reducing sugars suggested that maximal nutritional benefits were of wheat and bengal gram germinated for 48 h. These findings corroborate those of the germinative capacity discussed earlier.

Preparation of biscuits from malted wheat and bengal gram mix with or without green leafy powder and determination of acceptability of these biscuits in comparison to that of biscuits prepared from raw mix

This experiment was undertaken to explore the choice and the level of green leafy powder, fenugreek or colocasia, to be incorporated into the biscuits and to determine the acceptability of the biscuits containing the green leafy vegetable.

Malted and raw wheat and bengal gram were used as the basic ingredients together with fenugreek or colocasia leaf powder, sugar or jaggery and vanaspati.

Initially, biscuits containing 2% fenugreek leaf powder with sugar were prepared and subjected to organoleptic evaluation for detectable bitterness, after taste, flavour and crispness/hardness. The biscuits were found to have a bitter taste. In the next trial, the level of fenugreek leaf powder was reduced from 2 to one percent and sugar was replaced by jaggery. The biscuits still had a bitter taste and at this level the fenugreek leaf powder provided 26 mg of calcium, 1.1 mg of iron and 153 mcg of carotenes (Gopalan et al 1985). Considering that the inclusion of fenugreek leaf powder into the biscuits at such a low level would not provide any nutritional benefits, colocasia leaf powder was used instead.

The colocasia leaf powder was incorporated into the recipe at one or 2% level to determine whether the biscuits with colocasia leaf powder would at all be acceptable to the panel members. The biscuits with both the levels of colocasia leaf powder were found to be equally acceptable. The biscuits containing colocasia leaf powder were also pretested on children of a balwadi and their mothers. The biscuits were acceptable.

After having pretested the biscuits containing colocasia leaf powder, another sub-study was planned to conduct sensory evaluation of these biscuits to determine the optimum level of colocasia leaf powder to be incorporated into the biscuits to achieve maximal nutritional benefits. Biscuits containing 2 or 3%, 3 or 5% and 5 or 10% colocasia leaf powder were subjected to triangle test. The judges could not differentiate between the biscuits containing 2 or 3% and 3 or 5% colocasia leaf powder. While those containing 10% colocasia leaf powder were differentiated from those containing 5% colocasia leaf powder.

For further evaluation, the biscuits containing 5 and 10% colocasia leaf powder were subjected to composite scoring test and hedonic scale preference test. Both the tests indicated that the overall acceptability of 5% colocasia biscuits was higher than that of the 10% colocasia biscuits although trend analysis on the data of composite scoring test showed that there were no significant differences in the scores of appearance, leafy flavour, after taste and acridity of the 5 and 10% colocasia biscuits. The choice of the level of colocasia leaf powder to be incorporated into biscuits was therefore based on the fact that 100 g of biscuits should provide calcium, iron and beta carotene as close to the recommended daily allowance (RDA) for a 4 to 6 year old child as possible. Based on this criterion it was found that the inclusion of colocasia leaf powder at 7.5% level into the biscuits would meet the RDA for iron and beta carotene and almost half of that of calcium (Gopalan et al 1985). Hence the colocasia leaf powder was incorporated into the biscuits at 7.5% level (7.5 g of leaf powder/100 g dry ingredients).

The acceptability trials for biscuits were conducted on 75, three to six year old children of low socio-economic group attending a balwadi. MM biscuits and C-MM biscuits were evaluated against RM biscuits for 3 consequtive days each. The data on only 42 children who were regular in attending the balwadi, were analysed. Although, on an average, the children tended to eat about one biscuit more when the biscuits were prepared from raw mix (4.6 biscuits) than when they were prepared from malted mix (3.8 biscuits) or malted mix plus colocasia leaf powder (3.9 biscuits), The differences between the mean intakes of C-MM, MM and RM biscuits were statistically non significant suggesting that all the 3 types of biscuits were equally acceptable.

The mothers of these children were asked to evaluate the biscuits and it was observed that more than 75% of the mothers found the biscuits acceptable in terms of appearance, colour and taste indicating that the biscuits were acceptable to the mothers of these children.

Nutritive composition of mixes and biscuits

The mixes and biscuits were analysed for moisture, crude protein, fat, available carbohydrate, ash, crude fibre, calcium, phosphorus, total iron, soluble iron, ionizable iron, carotene, thiamine and riboflavin contents.

Under the experimental conditions the process of malting did not appreciably alter the nutritive composition of the mix except that the ionizable iron and riboflavin contents of the malted mix were significantly higher than those of the raw mix. Likewise, there were no marked differences in the nutritive composition of MM and RM biscuits, and C-MM and C-RM biscuits. But the incorporation of colocasia leaf powder had markedly enhanced the protein, calcium, phosphorus, iron-total, soluble and ionizable, carotene, thiamine and riboflavin contents of the biscuits.

The cost of one kilogram of MM and RM biscuits was Rs.14.00/kg while those of the C-MM and C-RM biscuits was Rs.15.75/kg (prevailing prices).

An intake of 100 g of MM and RM biscuits would meet one-third of the energy, protein and iron requirements while an intake of 100 g of C-MM and C-RM biscuits would, in addition, meet one-third of the calcium, two-thirds of the beta carotene and about one-fourth to one-fifth of the thiamine and riboflavin requirements as compared to the RDA of a 4 to 6 year old child thereby illustrating the nutritional beneficial effects of addition of colocasia leaf powder to biscuits at an additional cost of about 17 paise/100 g.

Keeping quality of mixes and biscuits

The keeping quality of malted and raw mixes, and of MM and RM biscuits with or without colocasia leaf powder was determined under 2 storage conditions (a) 37°C and 90% RH (accelerated conditions) and (b) 28°C ranging from 25 to 34°C, and 78% RH ranging from 46 to 99% RH (room conditions). The experiment was conducted for a period of one month keeping in mind the preparation and distribution of biscuits from local bakeries where the flour and the biscuits are generally not stored for more than one month.

About 50 g of the mixes and 35 g of the biscuits were packed in 200 gauge LDPE bags. The packets were heat sealed with a burner and kept under accelerated and room conditions for 28 days. The contents of each packet were analysed at weekly intervals (accelerated conditions) and after 28 days (room conditions) for their moisture content, alcoholic acidity, acidity of extracted fat and peroxide value.

The initial moisture content of the malted mix was 7.95 g/100 g and that of the raw mix, 9.80 g/100 g. After 28 days of storage under accelerated conditions the moisture content of the malted mix had increased to 10.26 g/100 g and that of the raw mix to 11.78 g/100 g and under room conditions it increased to 8.65 g/100 g in malted mix and to 10.22 g/100 g in raw mix. The moisture content of both the mixes remained below the IS specification (IS:1155-1968, 1983) of 13.0% and PFA 1955 (1985) of 14.0% prescribed as the maximum moisture contents for wheat flour; and it was lower than the critical levels of 15 and 14% moisture for cereal and pulse flours, respectively as suggested by Mahadeviah et al (1977).

Initially, the alcoholic acidity of the malted mix was 0.10% which increased to 0.14% after 28 days of storage under accelerated conditions. Under room conditions, the alcoholic acidity of 28 days stored malted mix was 0.13%. On the other hand, raw mix had an initial alcoholic acidity of 0.04% and it increased to 0.10% under accelerated conditions and to 0.08% under room conditions after 28 days of storage. These values remained markedly below the value of 0.15% specified by PFA 1955 (1985) for whole wheat flour but were higher than the value of 0.10%, the IS specification for wheat flour. The peroxide values of both the malted and raw mixes were below 3 meq/kg fat under both the storage conditions.

The results indicated that the malted and raw mixes can be kept for 28 days and may be longer under both accelerated and room conditions in view of these parameters.

Regarding biscuits, the initial moisture content of MM biscuit was 4.52 g/100 g, of RM biscuit 4.22 g/100 g, of C-MM biscuit 4.54 g/100 g and of C-RM biscuit 4.49 g/100 g. Under accelerated conditions the biscuits were found to be soggy within 14 days of storage but under room conditions they remained crisp even after 28 days of the storage period.

The acidity of extracted fat of all the biscuits was below 0.6% after 21 days of storage under accelerated conditions and after 28 days of storage under room conditions. This value remained below one percent, the IS specification for the acidity of extracted fat for biscuits. The peroxide value of all the biscuits was below one meq/kg fat after 21 days of storage under accelerated conditions and after 28 days of storage under room conditions.

Although with respect to acidity of extracted fat and peroxide value, the biscuits can be kept for 21 days under accelerated conditions, but the increase in moisture content and consequently loss of crispness seemed to limit their keeping quality to less than 14 days under accelerated conditions. However, the biscuits can be kept for 28 days and may be longer under room conditions with respect to crispness, acidity of extracted fat and peroxide value.

Growth promoting ability and protein quality of mixes and biscuits in an animal model

The growth promoting ability and protein quality of malted mix against that of raw mix and casein; and of the MM biscuits with or without colocasia leaf powder against that of corresponding RM biscuits was evaluated. The evaluation was conducted by the methods based on growth rate such as PER, by those based on nitrogen balance such as NPU, BV and DC, by those based on tissue protein levels such as hepatic protein content, serum protein, and serum urea concentrations.

For PER experiment, 24 rats weighing between 35 to 50 g were divided into 3 groups of 8 rats each. They were fed for 28 days, diets containing malted mix or raw mix and casein providing 10% protein. Another group of 56 rats was divided into 7 groups of 8 rats each. They were fed for 28 days, diets containing malted or raw mix or casein ~~and~~ or MM or RM biscuits with or without colocasia leaf powder providing 6% protein. Records were maintained on food intake and weight change. PER values were calculated.

For NPU, BV and DC determinations, 72 rats weighing between 55 to 65 g were divided into 9 groups of 8 rats each. One group was placed on protein free diet and the remaining groups on experimental diets for a period of 10 days. During the last 3 days of the experimental period the rats were placed in metabolic cages for urine and feces collection. The diets were fed ad libitum. Records were maintained for food intake and weight change. The diets, urine and fecal samples were analysed for nitrogen content by micro-Kjeldahl procedure. NPU, BV and DC values of the proteins were calculated. In addition, the mixes and biscuits were analysed for their available lysine contents.

The data on growth rate indicated that there was no difference in the growth rate of rats fed malted and raw mix diets. But the rats fed malted or raw mix diet grew at a significantly slower rate than those fed casein diet. Also the PER values of the malted (2.28) and raw (2.25) mix proteins, did not vary from each other. These findings were attributed to no marked variations between the lysine contents of malted and raw mixes (3.61 Vs 3.42 g/16g N). But the PER values of malted and raw mix proteins were significantly lower than that of casein (3.90) protein.

The NPU and BV values of the malted mix protein were significantly higher than those of the raw mix protein while the values for the DC although tended to be higher did not significantly differ from that of the raw mix protein. Earlier, Geervani and Theophilus (1980) had reported that the PER values of the germinated and raw bengal gram were comparable while the NPU values of the former protein were significantly improved.

Although the PER of the malted mix protein was lower than that of casein protein but the values for NPU and BV of the malted mix and those of casein protein were comparable. The DC of the former protein, however, was significantly lower than that of the latter protein.

The superiority of malted mix protein over that of raw mix protein was not reflected on hepatic and serum protein levels as the hepatic and serum protein levels did not differ between the rats fed malted or raw mix.

When the diets containing biscuits prepared from malted or raw mixes were fed, it was observed that the rats fed MM biscuit diet lost about 6 g while those fed RM biscuit diet about one gram over the experimental period of 28 days but the food intake of the 2 groups was comparable.

Comparing the growth rate of rats fed biscuits and mix diets it was noted that the rats fed biscuit diets lost more weight and ate significantly less than those fed mix diets.

The inclusion of colocasia leaf powder into the biscuits increased the loss of weight in rats by about 3 g suggesting that the biscuits containing colocasia leaf powder were nutritionally not superior to those without them in terms of their growth promoting ability.

Within the colocasia leaf powder containing biscuit diets fed rats, those fed C-MM biscuit diet lost more weight than those fed C-RM biscuit diet. The higher loss of weight perhaps was due to the fact that the C-MM biscuit diet fed rats ate significantly less than those fed C-RM biscuit diet.

Regarding the protein quality of the biscuits it was observed that the available lysine contents of the MM biscuits with or without colocasia leaf powder tended to be lower than that of the corresponding RM biscuits (1.52 Vs 1.72 g/16g N; 1.51 Vs 1.56 g/16g N).

No differences were observed in the NPU, BV and DC values of the protein of MM and RM biscuits. Incorporation of colocasia leaf powder into MM and RM biscuits improved the BV of the biscuit proteins. But the NPU values of C-MM and C-RM biscuit proteins tended to be lower than those of the MM and RM biscuit proteins. Likewise, the DC values were significantly reduced when colocasia leaf powder was incorporated into MM and RM biscuits.

The hepatic protein contents of the rats fed MM biscuit diets tended to be higher than those of the RM biscuit diet fed rats. Between the biscuits and mixes diet fed rats, the hepatic protein contents of those fed biscuit diets were not markedly different from those fed diets containing mixes. Addition of colocasia leaf powder into the MM and RM biscuits exerted a beneficial effect on hepatic protein over those without colocasia leaf powder as the hepatic protein contents of rats fed C-MM and C-RM biscuit diets were higher than those fed MM and RM biscuit diets.

When the hepatic protein contents of the rats fed biscuit and casein diets were compared it was observed that the hepatic protein content of rats fed MM, RM or C-RM biscuits diets were comparable to that of the casein fed rats and that of C-MM biscuit diet fed rats was significantly elevated.

The serum protein contents of the biscuit diets fed rats ranged from 5.01 to 5.20 g/dl. The comparisons made within the biscuit diets fed rats exhibited no significant differences between the serum protein levels of the rats fed diets containing these biscuits. Likewise no significant differences were observed when the serum protein levels of the biscuits diets fed rats were compared with those of the mixes diets fed rats. The serum protein contents of the biscuit diets fed groups were significantly lower than that of the casein diet fed group.

Scrutiny of the serum urea levels which are also indicative of protein quality revealed that there were no significant variations in the serum urea levels whether the rats were fed MM, RM, C-MM or C-RM biscuits.

Since the rats fed C-MM and C-RM biscuit diets lost about 3 g more weight than those fed MM and RM biscuit diets, another experiment was planned to investigate whether the ill effects on growth were caused by some toxic component that was present in colocasia leaf powder. The colocasia leaf powder was incorporated into the biscuits at 7.5% level. It was observed that the rats fed C-malted mix and C-raw mix diets lost significantly more weight and ate significantly less than those fed malted and raw mix diets. These data indicated that perhaps colocasia leaf powder has some appetite depressor which ultimately leads to decreased food intake and consequently reduced weight gain.

Table 72 presents the highlights of the results of these experiments that (a) the optimal time for soaking and germination for wheat and bengal gram appeared to be 12 and 48 h, respectively, (b) biscuits prepared from malted and raw mix with or without colocasia leaf powder were equally acceptable to 3 to 6 year old children, (c) malting of grains did not appreciably alter the nutritive composition of the raw mix; addition of colocasia leaf powder to biscuits markedly enhanced the contents of protein, minerals and vitamins, (d) the malted and raw mixes can be stored for 28 days or more under accelerated and room conditions while the biscuits can be kept only for 14 days under accelerated conditions but for 28 days or may be more under room conditions and (e) malting of grains although did not alter the growth promoting ability but significantly improved the quality of protein in terms of NPU and BV; heat treatment to malted mix in biscuit preparation lowered the growth promoting ability of the biscuit but the protein quality as shown by NPU, BV and DC values was comparable with that of the raw mix biscuits; addition of colocasia leaf powder did not improve the growth promoting ability and protein quality of biscuits.

Table 72. Highlights of the findings of the study

Objectives:					
1. Determination of the optimal soaking and germination time for wheat and bengal gram grains as indicated by the germinative capacity of the grains	2. Changes in carbohydrate profile and protein content of wheat and bengal gram in response to the process of germination	3. Preparation of biscuits from malted wheat and bengal gram mix with or without green leafy powder and to determine acceptability of the biscuits in comparison to that of biscuits prepared from raw mix	4. Determination of the nutritive composition of mixes and biscuits	5. Determination of the keeping quality of mixes and biscuits	6. Evaluation of growth promoting ability and protein quality of mixes and biscuits in an animal model
Findings:					
The percentage of germinated grains and those having sprout length more than 0.2 cm was maximum in 12 h soaked and 48 h germinated wheat and bengal gram	The content of total and reducing sugars was maximum in 48 h germinated wheat and bengal gram	Biscuits were prepared using malted and raw mixes with or without 7.5% colocasia leaf powder. Biscuits were found to be equally acceptable by 3 to 6 year old children. Biscuits with colocasia leaf powder were liked by their mothers	There were no appreciable differences in the nutritive composition of of the mixes, and the biscuits. Addition of colocasia leaf powder markedly enhanced the protein, calcium, phosphorus, iron-total soluble and ionizable, carotene, thiamine and riboflavin contents of the biscuits	The malted and raw mixes can be kept for 28 days and may be more under accelerated and room conditions with respect to moisture contents, alcoholic acidity and peroxide value. The biscuits can be stored for less than 14 days under accelerated conditions and for 28 days or more with regards to their moisture contents under room conditions	The PER value of the malted mix was comparable to that of the raw mix but the NPU and BV values of the former were significantly improved. The MM biscuits exhibited inferior growth promoting ability than that of the RM biscuits but the protein quality was comparable, Addition of colocasia leaf powder did not improve the growth promoting ability and protein quality of the biscuits

Suggestions for further research

1. The reason why biscuits containing colocasia leaf powder led to relatively greater growth arrest needs further investigation.
2. The profile of available amino acids of unbaked and baked biscuits needs to be determined.