CHAPTER 5

Objective 4: Determination of the nutritive composition of mixes and biscuits

Introduction

Nutritive composition of grains has been reported to vary due to variety, class, location, crop year and a combination of these factors (Khan et al 1979, Davis et al 1981, Davis et al 1984). Germination has been shown to improve the nutritive quality of the grains by enhancing the contents of nutrients like protein (Opoku et al 1981, Wu 1982, Wu 1983, Opoku et al 1983, Harrison and Vanderstoep 1984), amino acids as lysine and tryptophan (Tsai et al 1975, Dalby and Tsai 1976, Ram et al 1979, Wu and Wall 1980, Wu 1982, Wu 1983), fat (Bates et al 1977, Ranhotra et al 1977, Wu 1982), calcium (Khader 1983, El-Shimi et al 1984), iron (Brandtzaeg et al 1981), thiamine (Hasim and Fields 1979, Geervani and Theophilus 1980, Opoku et al 1981), and riboflavin (Nandi 1960, Hasim and Fields 1979, Hsu et al 1980, Opoku et al 1981, Brandtzaeg et al 1981, Abdullah and Baldwin 1984). In the present study, the nutritive composition of mixes prepared from malted and raw wheat and bengal gram, and biscuits prepared from these mixes with or without colocasia leaf powder was determined. The nutritive composition of biscuits and cookies prepared from different formulations has been reported by many investigators (Prabhavathi et al 1973, Ranhotra 1980, Meimban et al 1982, Hernandez and Sotelo 1984, Dreher and Patek 1984).

Nutritive composition of germinated and malted grains and mixes

Wide variations have been reported in the nutritive composition of grains germinated for same or varied length of time.

Moisture : Khader (1983) had observed that the moisture content of 3 days germinated and subsequently dried soya beans was 4% (9.9 Vs 9.5%) higher than that of the ungerminated beans. In malted grains, however, the moisture content was found to be lower than that of the raw grains. Opoku et al (1981) had observed that the moisture content of 18 h germinated and malted millet was 58% lower than that of the raw millet grain (4.3 Vs 10.2%). Earlier, Singh and Tauro (1977) had reported a 25% decrease in moisture content of 120 h germinated bajra malt (from 9.2 to 6.9%) anda20% decrease in that of 120 h germinated barley malt (from 10.1 to 8.1%) from the moisture contents of their respective raw grains. But Fotedar (1981) had reported that the moisture content of a mix prepared from malted wheat and bengal gram (4:1) was 16% higher than that of the mix prepared from raw grains (15.1 Vs 17.5 g/100 g). The variations in results might be due to the temperature at which kilning was done and the length of the kilning period. Khader (1983) and Fotedar (1981) had oven dried their samples but the kilning time and temperature were not mentioned. Opoku et al (1981) had kilned millet grains at 45°C while Singh and Tauro (1977) had kilned their samples for 24 h at 45°C and then for 8 h at 55°C.

Protein : Dalby and Tsai (1976) had demonstrated that the protein content of wheat germinated for 5 days had increased by 15% from its pre-germination value of about 13%. Somewhat similar results have been reported by Ranhotra et al (1977). They reported that the protein content of flour prepared from 0 to 5 days germinated wheat increased progressively from 13.6 to 15.1% with the increase in germination time. An year earlier, Lemar and Swanson (1976) had germinated wheat for 1 to 3 days and observed increases in protein content of 4 to 7% from the original value of 12.3%. Recently, Singh et al (1983) had demonstrated increases of 10, 8 and 13% over the control value of 14.1% after 3, 5 and 7 days of germination of wheat grains, respectively. Hamad and Fields (1979) determined the crude protein content of wheat, barley, oats and rice germinated for 5 days. They observed that the crude protein content of wheat increased by 4% (from 10.2 to 10.6%), of barley by 6% (from 9.8 to 10.4%) and of rice by 19% (from 7.9 to 9.4%) while of oats exhibited no change (10.8 Vs 10.9%). It appeared from these data that the changes in protein content occurring in a grain in response to germination vary with the grain type. However, the same type of grain germinated for the same time period has also shown varied responses in terms of increases in protein content. For example, the increase in protein content of wheat germinated for 5 days was 4% as reported by Hamad and Fields (1979), 8% as reported by Singh et al (1983), 11% as reported by Ranhotra et al (1977) and 15% as reported by Dalby and Tsai (1976). The increases in grain protein however are considered apparent owing to the loss of dry weight through

173

respiration during the process of germination.

Varietal effects on the changes in grain protein as a result of germination were monitored by Tsai et al (1975). The authors demonstrated a gradual increase in the total protein content from 14.4 to 16.0% in one variety of maize germinated for 1 to 5 days while in another variety no marked variation in protein content was observed (12.1 Vs 12.2%). Ram et al (1979) also evaluated the total protein content of 2 varieties of 1 to 5 days germinated maize. In one variety, a gradual increase in total protein content from 12.5 to 13.4% was observed till the end of the germination period of 5 days. While in another variety, the total protein content increased by 5% over the initial value of 10.9% after 2 days of germination, then decreased following one day of germination and later exhibited an upward trend. Consequently, the total protein content of 5 days germinated maize was 13% higher over its initial value. These data therefore illustrated that the changes in protein content during the process of germination were influenced by the variety of a protein.

Wu (1982) germinated triticale for one to 8 days and observed that the protein content decreased by 3% from the initial value of 15.8% during the first day of germination and then increased gradually to 18.2% until 8 days of germination. Later, Wu (1983) had shown a 17% decrease in protein content of oats after one day of germination from the initial value of 17.8% and thereafter it increased gradually from 14.7 to 19.9% after

8 days of germination. However, Hamad and Fields (1979) had observed no increase in protein content of 5 days germinated oats. The discrepency in results could be attributed to varietal differences and the length of germination period as the former investigator had germinated oats for 8 days and the latter for 5 days.

A somewhat similar observation has been made in sorghum germinated for one to 10 days (Wu and Wall 1980). The protein content of sorghum did not change up to 3 days of germination and then increased from the initial value of 10.1 to 11.1 and 11.9% after 6 and 10 days of germination, respectively. Likewise, Opoku et al (1983) had shown an irregular pattern in the changes in protein content of 0 to 96 h germinated millet. The protein content decreased from 10% to approximately half its value after 18 h of germination and then it increased sharply to 14% after 36 h of germination, thereafter it was almost constant till the end of the germination period of 96 h. Hemanalini et al (1980) had exhibited no change in the protein content of flour made from overnight germinated ragi in comparison to whole ragi flour (7.7 Vs 7.2 g/100 g). Hwang and Bushuk (1973) had reported a small loss in protein content of flour made from wheat soaked for 2 days and germinated for 8 days. The decrease in protein was attributed to the loss of low molecular weight nitrogen compounds during soaking. Thus, it seems that in response to germination the protein content of a grain might increase gradually with the increase in germination time, might show no change or might decrease depending on the type of grain used

and the period for which the grain has been germinated.

The protein content of legumes germinated for various number of days has also been determined. Jaya and Venkataraman (1980) had reported a progressive increase in protein content of bengal gram over a germination period of 72 h. The protein content had increased by about 10% (from 20.2 to 22.3 g/100 g seeds) by the end of the germination period. Hsu et al (1980) determined the effect of germination on protein contents of yellow peas, faba beans and lentils germinated for 24 to 96 h. The content of protein of yellow peas increased from 25.3 to 26.7% after 72 h of germination. With the extension of germination period by 24 h, the protein content tended to remain unchanged. The protein content of faba beans exhibited an upward trend from the initial value of 29.7 to 30.8% after 24 h of germination and remained unchanged until 72 h of germination and then increased to 31.1% after 96 h of germination. In lentils, such variations in protein content in response to 96 h of germination were not observed as the protein content gradually increased from 26.7 to 28.9% with the increase in germination period from 0 to 96 h.

Palmer et al (1973) determined the nitrogen content of 4 or 8 days germinated kidney beans. The initial nitrogen content of 3.9% was found to have increased by 5 and 28% after 4 and 8 days of germination respectively. Kakade and Evans (1966) germinated navy beans for one to 4 days and observed that the protein content of the navy beans increased progressively with increase in germination time. It increased from 23.6 (raw beans value) to

24.9% in one day, and to 26.3% in 4 days germinated beans. It appeared from these data that after 4 days of germination period, the protein content increased by 5% in kidney beans and by 11% in navy beans suggesting that the seed type might influence the protein content in response to germination as has been stated earlier.

Venugopal and Rama Rao (1978) monitored the changes in protein content of black gram (Phaseolus mungo) over a germination period of 66 h. There was no appreciable net change in the protein content of germinated black gram seeds, as it increased by 4% from 23.5 to 24.5 g, until 42 h of germination and then decreased so that after 66 h of germination period the protein content of black gram was comparable to its initial value (23.6 Vs 23.5 g).

Khader (1983) determined the nutritive value of 3 days germinated soya beans and found no change in the protein content of germinated soya beans as compared to that of the raw beans (43.0 Vs 42.0 g/100 g). While Bates et al (1977) had reported an increase of 6% from 39.4 to 41.7% in crude protein content of 4 days germinated soya beans.

The protein content of malted grains has also been determined. Singh and Tauro (1977) had determined the protein contents of bajra and barley malts and observed that as compared to the protein content of unmalted grains that of malted bajra had increased by 14% (from 12.5 to 14.3%) and of barley by 11% (from 8.8 to 9.8%). Opoku et al (1981) have shown an increase of 37% (from 8.6 to 11.8%) in the protein content of malted millet

which had been germinated for 18 h. Fotedar (1981) also had observed an increase of 5% in the protein content of a mix prepared from malted wheat and bengal gram (4:1) in comparison to that of the raw mix (15.4 Vs 14.6 g/100 g). But in 2 varieties of malted corn, no appreciable increases in protein contents over the initial values (9.9 Vs 9.6%; 9.5 Vs 9.2%) were observed by Singh and Bains (1984).

Fat : The changes in fat content of germinated and malted grains have also been observed. Ranhotra et al (1977) had reported that the fat content of 5 days germinated wheat flour was elevated by 15%. Earlier, Lemar and Swanson (1976) had exhibited higher increases of 64 to 67% in one to 3 days germinated wheat over the control value of 0.94%. Likewise, Wu (1982) reported that the fat content of triticale increased from 1.5 to 1.6% after one day of germination and then came back to the original value after 2 days of germination. Thereafter, it increased gradually to 2.3% exhibiting an increase of 53% after 8 days of germination.

The fat content of sorghum did not appreciably change during the first 3 days of germination but increased by 17% after 6 days of germination from the initial value of 3.5%, later it decreased by 20% from 4.1 to 3.3% after 10 days of germination so that the value for fat content after 10 days of germination was 6% lower than the initial value (Wu and Wall 1980).

In contrast, Jaya and Venkataraman (1980) had shown a decrease in fat content of bengal gram over the germination period

of 72 h. The fat content decreased by 14% in the first 24 h from the initial value of 5.5 g/100 g seeds, in the next 24 h there was a further decrease of 15% but the fat content remained unchanged when the germination period was extended from 48 to 72 h. The net decrease in fat content was 38% from the original value (4.0 Vs 5.5 g/100 g seeds) after 72 h of germination period. On the other hand, Bates et al (1977) had demonstrated a 6% increase in fat content from 21.0 to 22.3% in 4 days germinated soya beans. But in the same pulse, germinated for 3 days, Khader (1983) had exhibited a 10% decrease in fat content from 21.8 to 19.6 g/100 g.

Singh and Tauro (1977) had shown an 11% increase from 4.4 to 4.9% in the fat content of bajra malt and an increase of 20% from 2.0 to 2.4%, in that of barley malt. On the contrary, Opoku et al (1981) had demonstrated a reduction of 67% from 7.5 to 2.5%, in the fat content of malted millet grains. A somewhat lower decrease of 41% in the fat content of malted wheat and bengal gram mix (from 3.44 to 2.04 g/100 g) was shown by Fotedar (1981). From these studies it is apparent that both increases and decreases in fat content of a grain in response to germination and malting have been observed.

Carbohydrates : Jaya and Venkataraman (1980) showed no appreciable change in total carbohydrates of bengal gram (from 67.7 to 68.3 g/100 g seeds) over a germination period of 72 h. Fotedar (1981) had also observed no change in the carbohydrate content of malted

wheat bengal gram mix in comparison to that of the raw mix. Opoku et al (1981) had reported a 10% decrease in carbohydrates from 53.9 to 48.5% in malted millet grains. While Lemar and Swanson (1976) had demonstrated a smaller decrease of 2% in the carbohydrate content of flour prepared from one to 3 days germinated wheat. A decrease in carbohydrates is expected due to their oxidation during the process of germination (Dalby and Tsai 1976).

Ash : The ash content did not change in flour prepared from wheat germinated for 3 days but it increased by 10% from 1.9 to 2.1%, after 5 days of germination (Ranhotra et al 1977). A similar pattern of increase in ash content was observed in triticale. The ash content did not change until 3 days of germination of triticale and then increased gradually from 1.8 to 2.5% after 8 days of germination exhibiting an increase of 39% (Wu 1982). Earlier, Lemar and Swanson (1976) had also shown increases in the ash content of one to 3 days germinated wheat flour. This increase in total ash is considered as an apparent and not a true increase in mineral matter. Since the dry matter mainly in the form of carbohydrates is lost during germination due to respiration of the grains, consequently, the percentage of total mineral matter is found to increase (Lorenz 1980).

Wu and Wall (1980) showed that in germinated sorghum, ash content decreased by 12% from 1.7 to 1.5% after one day of germination and then did not change until 3 days of germination. It later increased to the initial value of 1.7% after 6 days of

germination and was 1.8% after 10 days of germination. The net 6% increase in ash content in 10 days germinated sorghum was lower than that of 5 days germinated wheat (10%) and 8 days germinated triticale (39%) indicating that seed type and length of germination period might have influenced the changes observed in ash content.

In bengal gram, Jaya and Venkataraman (1980) had reported that ash content reduced by 14% from 2.8 to 2.4 g/100 g seeds, after 24 h of germination, a further reduction of 12% was observed when the germination period was extended from 24 to 48 h. After 48 h of germination, an increase of 17% in the ash content was observed but the value of 2.4 g/100 g seeds observed after 72 h of germination was 14% lower than the initial value of 2.8 g/100 g seeds. Likewise, Giri et al (1981) had germinated green gram, horse gram (Dolichos biflorus) and red gram (Cajanus cajan) for 24, 48 and 72 h, respectively. The ash content was found to decrease progressively in the 3 legumes with increase in germination time with the result that the values of ash content after 72 h of germination were 5 to 7% lower than the initial values of 3.6% for green gram, 3.0% for horse gram and 3.8% for red gram. The decrease in ash content was attributed by the authors, to leaching of organic and inorganic compounds during germination.

Udayasekhara Rao and Deosthale (1983) found that in pigeon pea (Cajanus cajan), the ash content decreased by 38% from 4.2 to 2.6%, after 24 h of germination followed by a decrease of 4%

after 48 h of germination (from 2.6 to 2.5%). Similar pattern of decreases was observed in 48 h germinated green gram and black gram. The decreases in ash content amounted to 43 and 45% from their initial values of 4.7 and 4.4%. The decreases observed by Udayasekhara Rao and Deosthale (1983) in 48 h germinated pigeon pea, green gram and black gram were of a higher magnitude (40 to 45%) than those (5 to 7%) observed in 72 h germinated green gram, horse gram and red gram by Giri et al (1981). On the other hand, Khader (1983) had reported an increase of 23% (from 4.7 to 5.8 g/100 g) in the ash content of 3 days germinated soya bean.

The ash content of grains has been shown to reduce in response to malting. Opoku et al (1981) reported that ash content decreased by 22% over the initial value in millet malt (from 4.1 to 3.2%). Sankara Rao and Deosthale (1983) had observed that the ash content decreased by 22% from 1.8 to 1.4% in malted pearl millet and by 21% from 2.4 to 1.9% in malted ragi. A similar decrease of 15% in the ash content of malted wheat and bengal gram (4:1) mix (from 1.3 to 1.1 g/100 g) was reported by Potedar (1981).

Fibre : Ranhotra et al (1977) had reported a progressive increase in fibre content of wheat over the germination period of 5 days. The fibre content of flour prepared from 3 days germinated wheat was 34% higher and that of flour prepared from 5 days germinated wheat was 144% higher over the initial value of 2.7%. While in another study, germination of wheat up to 3 days did not produce a significant change in crude fibre content although there was an

apparent slight decrease from 2.24 to 2.07% (Lemar and Swanson 1976).

A progressive decrease in the fibre content of 72 h germinated bengal gram was observed by Jaya and Venkataraman (1980). The fibre content decreased by 10% from the initial value of 4.1 g/100 g seeds in the first 24 h, and by 12% in the next 24 h of germination. But, no further reduction in fibre content was observed with increase in germination period. Consequently, the fibre content of 72 h germinated bengal gram was 24% lower than the initial value of 4.1 g/100 g seeds.

On malting of millet, Opoku et al (1981) had demonstrated that the fibre content increased by 79% from 10.4 to 18.6%. Fotedar (1981) had exhibited a 29% increase in the fibre content of malted wheat and bengal gram mix (from 2.1 to 2.7 g/100 g). Based on these findings it seems that fibre content of a grain increases on malting.

According to Lorenz (1980), the increase in crude fibre has not been explained. Crude fibre determinations measure only cellulose and a certain percentage of lignin and there is no indication that either one of the crude fibre components is formed from carbohydrates degradation products during germination and sprouting.

Changes in mineral contents of grains in response to germination have also been observed.

Calcium : A 3% increase in calcium content over the initial value of 34.9 mg/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. It was 36.0 mg in 100 g flour prepared from 4 days germinated wheat and 39.6 mg in 100 g flour prepared from 5 days germinated wheat. However, in flour prepared from germinated ragi Hemanalini et al (1980) had observed no change in calcium contents (325 Vs 324 mg/100 g).

Likewise, Jaya and Venkataraman (1980) have demonstrated no change (201.8 Vs 199.2 mg/100 g seeds) in the calcium content of bengal gram germinated over a period of 72 h. Similarly, Reddy et al (1978) observed no appreciable difference in the calcium contents of 10 days germinated and raw black gram seeds (1.47 Vs 1.48 mg/g).

On the other hand, Ganesh Kumar et al (1978) showed losses in calcium content of green gram, cowpea and bengal gram germinated for 24 and 72 h. It was observed that from their respective initial values, the calcium content of green gram decreased by 29 and 39%, of cowpea by 13 and 47% and of bengal gram by 7 and 22% after 24 and 72 h of germination respectively. In 72 h germinated bengal gram, Jaya and Venkataraman (1980) had observed no change in calcium content while Ganesh Kumar et al (1978) had shown a decrease of 22%.

Giri et al (1981) had monitored changes in calcium content in green gram, horse gram and red gram over a germination period

of 96 h. The calcium content of green gram decreased by 9% in the first 24 h of germination (from 121.0 to 109.8 mg/100 g) and by 4 and 2% when the germination period was increased from 24 to 48 h and from 48 to 96 h, respectively. The total decrease in calcium content of green gram was 15% while those of horse gram and red gram were between 6 to 7% over the germination period of 96 h.

On the other hand, Khader (1983) had demonstrated an increase of 39% in the calcium content of 3 days germinated soya bean from 180 to 250 mg/100 g. The increase in calcium content was attributed to the net loss of dry weight as a result of oxidative breakdown of stored compounds in the seed.

When millet was malted, Opoku et al (1981) had shown that there was a decrease in the total calcium content by 18% from 20.4 to 16.8%. Sankara Rao and Deosthale (1983) had observed that the calcium contents of malted pearl millet and ragi were 11% (46 Vs 41 mg/100 g) and 48% (398 Vs 207 mg/100 g) lower from those of the whole grains, respectively. Brandtzaeg et al (1981) had also reported a decrease of 39% in the calcium content of a mix (7:3) prepared from malted ragi and green gram (from 199 to 122 mg/100 g).

Phosphorus : Singh et al (1983) had demonstrated decreases of 22% after 3 and of 23% after 5 and 7 days of germination in the total phosphorus content of Triticum dicoccum wheat. The authors had attributed the decreases to loss of solubles during steeping

and respiratory losses of carbohydrates during steeping and germination. A 15% decrease (from 270 to 230 mg/100 g) in phosphorus content was observed in germinated ragi flour by Hemanalini et al (1980).

Jaya and Venkataraman (1980) had observed no change in the phosphorus content of bengal gram germinated over a period of 72 h from the initial value of 314.2 mg/100 g. But earlier Belavady and Banerjee (1953) had reported decreases of 41 (from 124 to 73 mg/100 g) and 55% (from 74 to 33 mg/100 g) in phytate phosphorus of 2 varieties of 5 days germinated bengal gram.

Reddy et al (1978) had monitored the changes in phytate phosphorus of black gram seeds germinated for 10 days. It was observed that the phytate phosphorus decreased from 4.1 to 2.0 mg/g and the non-phytate phosphorus increased from 1.1 to 3.5 mg/g after 10 days of germination period. Consequently, the total phosphorus did not appreciably change. Giri et al (1981) evaluated the effect of germination on the phosphorus and phytin phosphorus contents of green gram, horse gram and red gram germinated for 24, 48 and 72 h. Similar to the results reported by Reddy et al (1978) the total phosphorus content showed no difference on germination of all 3 legumes while the phytin phosphorus decreased markedly. The decrease in phytin phosphorus was attributed to the increase in phytase activity.

No significant changes in total phosphorus contents of black eyed (Vigna sinensis), red kidney, mung and pink beans (Phaseolus

vulgaris) germinated for 24, 48, 72, 96 and 120 h have been reported by Tabekhia and Luh (1980). There were increases ranging from 27 to 68% in inorganic phosphorus which were attributed to formation of orthophosphate from the hydrolysis of phytic acid by the enzyme phytase. In all the 4 varieties of legumes the decrease in phytic acid was slower during the first 48 h of germination than which occurred during the 72 to 120 h of germination period. Thus, the first 48 h of germination represented a latent period during which the phytase activity was not present. After 72 h of germination, the decrease in phytic acid was more rapid and much faster until 96 and 120 h of germination period.

On the other hand, Udayasekhara Rao and Deosthale (1983) observed decreases in the total phosphorus content of germinated pigeon pea, green gram and black gram. The total phosphorus content of 48 h germinated pigeon pea was 20% lower than the original value of 390 mg/100 g and it decreased by 24 and 19% in 48 h germinated green gram and black gram from the initial values of 464 and 415 mg/100 g, respectively. Khader (1983) had also reported a decrease of 15% from 820 to 698 mg/100 g in the phosphorus content of 3 days germinated soya beans.

The decreases in total phosphorus and phytin phosphorus contents were also observed in malted grains. Sankara Rao and Deosthale (1983) had reported that the total phosphorus content had decreased by 25% from 379 to 285 mg/100 g in malted pearl millet and by 18% from 320 to 264 mg/100 g in malted ragi. The

phytin phosphorus had decreased by 60% from 172 to 69 mg/100 g in malted pearl millet and by 33% from 132 to 88 mg/100 g in malted ragi. Likewise, Brandtzaeg et al (1981) had reported decreases of 8% from 293 to 269 mg/100 g in phosphorus and of 12% from 180 to 158 mg/100 g in phytin phosphorus contents of malted ragi and green gram (7:3) mix.

Iron : 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 (Ranhotra et al 1977). 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 ragi.

A decrease of 31% in the iron content of bengal gram from the initial value of 14.17 mg/100 g seeds, in the first 24 h of germination was observed by Jaya and Venkataraman (1980). Thereafter, the iron content tended to increase up to 72 h of germination but remained lower than the initial value (10.00 Vs 14.17 mg/100 g seeds). Udayasekhara Rao and Deosthale (1983) observed increases and decreases in the iron contents of 24 and 48 h germinated pigeon pea, green gram and black gram. The iron content increased by 7% (from 3.0 to 3.2 mg/100 g) and 28% (from 2.9 to 3.7 mg/100 g), respectively, in 24 and 48 h germinated pigeon pea while it decreased by 20% (from 4.0 to 3.2 mg/100 g) and 6% (from 3.2 to 3.0 mg/100 g) in 24 and 48 h germinated

green gram, respectively. In black gram, the iron content decreased by 12% from the initial value of 4.0 mg/100 g after 24 h of germination and further decreased by 6% with the increase in germination period to 48 h, as a result, the iron content of 48 h germinated black gram was 18% lower than that of the raw grain.

On the other hand, in 10 days germinated black gram seeds, Reddy et al (1978) observed no change (0.118 Vs 0.122 mg/g) in the iron contents of raw and germinated seeds. Giri et al (1981) observed no changes in the total iron contents of green gram, horse gram and red gram over the germination period of 72 h and thereby supported the results of Reddy et al (1978).

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 ragi, respectively. On the contrary, Brandtzaeg et al (1981) had demonstrated a 21% increase from 11.6 to 14.0 mg/100 g, in malted ragi and green gram (7:3) mix in comparison to the raw mix.

Bioavailable iron : Singh and Banerjee (1955) studied the effect of germination on the availability of iron in bengal gram, 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 h 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.

Later, Prabhavathi and Narasinga Rao (1979) also investigated the effect of germination on ionizable iron contents of cereals and legumes using an in vitro method. The results showed that on germination of wheat for 24, 48, 72 and 96 h, the ionizable iron content expressed as percent of total iron, increased from 4.1 (value of raw grain) to 5.7, 6.7, 7.2 and to 7.7%, respectively. The increases in ionizable iron contentswere also observed in germinated bengal gram. On germination for 48 and 72 h, the ionizable iron content of bengal gram expressed as percent of total iron, increased from 1.9 to 3.8 and 4.9%, respectively, while no change was observed until 24 h of germination period. Giri et al (1981) had reported increases of 231, 152 and 586% in available iron contents of green gram, horse gram and red gram respectively, over a germination period of 96 h.

More recently, Annapurni and Murthy (1985) determined the effect of germination on bioavailability of iron in cereals and pulses byamin vitro method. Ragi, jowar and bajra were germinated for 24, 48 and 72 h. It was observed that the total iron content in ragi increased progressively with the increase in germination time while the available iron content as percent of total iron, increased until 48 h and thereafter, it showed a decline. In jowar and bajra, the increase in total iron was observed after 48 h of germination. Similarly, the maximum increase in available

iron occurred at 48 h of germination after which it showed a decline. In bengal gram germinated for 48 h, the available iron content increased from 36.5 to 39.5% of total iron while in 72 h germinated grain a decline was recorded. In green gram germinated for 24, 48 and 72 h the available iron content was found to increase from the initial value of 0.58 to 1.24, 4.82 and 4.86 mg/100 g, respectively. The authors attributed the increase in available iron as a result of germination to (a) increase in phytase activity and decrease in phytate content, (b) increase in relative biological value of protein and (c) decrease in polyphenol content of the grains which makes iron available to the body. Based on these results the authors recommended that cereals and pulses should be germinated for human consumption.

When pearl millet was malted, Sankara Rao and Deosthale (1983) had observed that the ionizable iron, as percent of total iron, had increased 8 fold from 9.0 to 73.5%. Similarly, when ragi was malted, the same authors observed an increase of 12 fold (from 7.4 to 88.3%) in ionizable iron expressed as percent of total iron.

As a result of germination, changes in vitamin contents of a grain have also been observed.

Beta carotene : Chattopadhyay and Banerjee (1951) determined the effect of germination on the carotene contents of cereals; wheat, paddy and corn. The carotene content increased progressively in wheat from 0.45 (initial value) to 4.65 mg/100 g, in paddy from

0.35 (initial value) to 3.95 mg/100 g and similarly in corn from 4.00 (initial value) to 6.15 mg/100 g after 7 days of germination period.

Chattopadhyay and Banerjee (1951) also studied the effect of germination on carotene content of pulses. In four varieties of bengal gram and other pulses gradual increases in carotene contents were observed when the seeds were germinated for one to 4 days.

Similarly, Opoku et al (1981) had found that the beta carotene content had increased from 1.5 (initial value) to 13.3 IU/100 g in millet malt.

Thiamine and riboflavin : In response to germination, thiamine content of various grains had exhibited increases or decreases but riboflavin content of all grains was found to be increased.

As early as in 1943, Burkholder had demonstrated increases in the thiamine (except for corn) and riboflavin contents in 5 or 6 days germinated oats, wheat, barley and corn. The thiamine content had increased by 8% (from 11.3 to 12.2 mcg/g dry matter) in oats, 29% (from 7.0 to 9.0 mcg/g dry matter) in wheat and by 32% (from 6.8 to 9.0 mcg/g dry matter) in barley, while it decreased by 7% (from 5.5 to 5.1 mcg/g dry matter) in corn. The content of riboflavin on the other hand, had shown relatively higher increases as a result of germination. The riboflavin contents of oats increased by 15 fold (from 0.8 to 11.6 mcg/g

dry matter), of wheat by 4 fold (from 1.3 to 5.4 mcg/g dry matter), of barley by 8 fold (from 0.9 to 7.2 mcg/g dry matter) and of corn by 4 fold (from 1.1 to 4.3 mcg/100 g dry matter). The authors had attributed the increase in vitamin content to the loss of dry matter of the seeds. Later, Hasim and Fields (1979) observed that thiamine content of corn increased from 0.17 to 0.20 mcg/100 g in response to 4 days of germination which was in contrast to the decrease in thiamine content of 5 or 6 days germinated corn reported by Burkholder (1943). Although both the authors (Burkholder 1943, Hasim and Fields 1979) had exhibited increases in riboflavin content of corn in response to germination but the increase observed by Burkholder (1943) was 2 fold (391 Vs 170%) of that reported by Hasim and Fields (1979). Lemar and Swanson (1976) had observed increases of 4 to 5% and 36 to 45% in the thiamine and riboflavin contents, respectively, of 3 days germinated wheat flour.

Nandi (1960) had demonstrated that the increase in thiamine content of bengal gram was to the tune of 72% during the first 48 h of germination period and thereafter, the thiamine content decreased by 40% with the increase in germination period to 120 h while riboflavin content of bengal gram was observed to increase progressively from 0.60 to 2.36 mg/100 g seeds during the germination period of 120 h. The elevation in thiamine and riboflavin contents have been noted even when the bengal gram was germinated for 24 h(Geervani and Theophilus 1980). Although the elevation in thiamine content observed in 24 h germinated

193

bengal gram by Geervani and Theophilus (1980) was somewhat higher than that observed (36 Vs 28%) by Nandi (1960) but the increases observed in the riboflavin contents of 24 h germinated bengal gram by Geervani and Theophilus (1980) and Nandi (1960) were comparable (104 Vs 110%).

In soya bean, germinated for 6 to 7 days, Wu and Fenton (1953) recorded no change in their thiamine contents. While Hsu et al (1980) had reported substantial increases over the initial value in the riboflavin contents of 4 days germinated yellow peas (108%), lentils (22%) and faba beans (40%).

No consistent findings have been reported regarding the changes in the thiamine contents of malted grains. Opoku et al (1981) had reported that thiamine content of millet malt was 283% higher than that of the unmalted millet (0.203 Vs 0.053 mg/100 g). While Brandtzaeg et al (1981) had shown a 17% decrease from 2.38 to 1.98 mcg/g in the thiamine content of a mix prepared from malted ragi and green gram (7:3).

As in germinated grains, in malted grains too increases in riboflavin contents were observed. In millet malt, Opoku et al (1981) had shown that the riboflavin content increased by 166% from 0.187 to 0.498 mg/100 g. Brandtzaeg et al (1981) had also observed a 78% increase from 0.68 to 1.21 mcg/g in the riboflavin content of a malted ragi green gram (7:3) mix. These data indicated that as a consequence of germination and malting the riboflavin content of a grain increased more than the thiamine content.

Nutritive composition of baked products

A summary of the nutritive composition of biscuits and cookies (Table 27) revealed that the moisture contents ranged from 0.8 to 7.5%, crude fibre from 0.3 to 2.0%, ash from 1.0 to 3.2%, protein from 7.0 to 16.5% & fat from 11.7 to 36.5%. Regarding the mineral composition of biscuits and cookies, it was observed that the calcium contents varied from 49 to 439 mg/100 g and that of total phosphorus from 187 to 231 mg/100 g. These wide variations in the nutritive composition of the biscuits and cookies were mainly due to the different ingredients used in their preparation.

The effect on nutritive composition of baked products by baking temperature and length of baking period was investigated by El-Samahy and Tsen (1981). The changes in protein, ash and fat contents were not more than 10% when breads were baked for 3.6 min at 327 and 343°C, for 5.0 min at 327 and 343°C and for 6.4 min at 248 and 327°C.

Similar observations were made by Khan and Eggum (1978) in bread preparation. The authors observed no marked changes in protein, fat, available carbohydrates, calcium, sulphur and iron contents while increase of 17% in crude fibre content and decreases of 56% in phosphorus and of 26% in tannin contents were observed on baking of bread at 220 to 230°C for 1.5 to 2.0 min in comparison to the wheat flour.

Table 27. A summary of nutritive composition of biscuits and cookies

Reference	Formulation	Moisture (%)	Protein (%)	Fat (%)	Available carbohydrates (%)	Ash (%)	Crude fibre (%)
Prabhavathi et al (1973)	Biscuits: (1) 3 type of biscuits prepared from protein rich flours, such as, groundnut, soya bean, wheat germ and pea so that for 100 g of wheat flour the proportion of these flours were 20:5:10:0; 20:25:0:0 and 20:24:0:0	4.0 to 7.5	14.4 to 15.8	-	-	3.00 to 3.25	0.50 to 0.52
	(2) Commercial high protein biscuit	3.2	16.5	-	-	2.3	0.45
Meimban et al (1982)	Biscuits: All purpose wheat flour 200 g, shortening 50 g, brown sugar 120 g, baking powder 14 g and cassava leaf protein concentrate at 1 to 5% level (based on flour weight)	2.82 to 3.22	7.23 to 8.51	14.28 to 14.98		1.00 to 1.06	0.43 to 0.63
Ranhotra (1980)	Cookies: Cake flour 100 g, soya flour defatted 50 g, peanut butter (creamy) 40 g, shortening 60 g, sucrose 60 g, dextrose 10 g, honey 10 g, baking soda 2 g, salt 1 g and water 112 g	4.7	15.1	22.4	54.2	2.4	1.5
Hernandez and Sotelo (1984)	Cookies: Wheat flour 60 g, bengal gram 40 g, sucrose 35 g, lard 20 g, baking powder 1.5 g and vanilla extract	0.82	10.10	11.70	73.24	2.04	2.00
Dreher and Patek (1984)	Cookies:						ADF
	(1) Wheat flour alone		7.04	36.52		1.38	0.37
	(2) Wheat flour + 10, 20 or 30% whole navy bean flour		7.52 to 8.68	34.28 to 35.37		1.55 to 1.89	0.32 to 0.70
	(3) Wheat flour + 10, 20 or 30% navy bean high protein flour		7.98 to 9.42	34.22 to 34.99		1.56 to 1.88	0.30 to 0.90

ADF Acid Detergent fibre

196

Bioavailability of iron in baked products : Shackleton and McCance (1936) determined the ionizable iron in foods by alpha dipyridyl method. The authors reported that ionizable iron contents as percent of total iron in 2 types of biscuits were 91 and 100%. In brown wholemeal bread, the ionizable iron as percent of total iron, was 83%. Likewise, Miller (1977) assessed the biological availability of iron in 12 commercial bakery products using the hemoglobin repletion test on anemic rats. Relative biological value (RBV) of iron in most of the products was comparable to that of the ferrous sulphate which was used as the standard.

Ranhotra et al (1979) determined relative biological value of iron from breads with and without fortification with different iron compounds by hemoglobin repletion technique using anemic rats. It was observed that considering the availability of iron from ferrous sulphate as 100, the relative biological value of breads ranged from 35 to 81%. Later in 1982, Schricker and Miller estimated relative availabilities of eight iron sources incorporated into breads. The baking process did not substantially alter the relative availability of non heme iron in breads containing different iron fortification sources.

Lee and Clydesdale (1980) demonstrated that as a result of baking, iron became insoluble regardless whether elemental, complexed or ferrous iron was added to the flour in preparation of biscuits.

197

Ranhotra (1979) determined the availability of iron in high fibre bread. Two sources of fibre, alpha cellulose and micro cystalline cellulose were incorporated into bread at 0, 10, 20 and 30 g per 100 g of flour used. Relative bioavailability of iron in these breads was determined by hemoglobin depletion - repletion technique. The bread diets provided 15 ppm iron. Ferrous sulphate was added to provide 0, 6, 12, 15 and 24 ppm iron to establish a standard hemoglobin repletion curve. Ten commercially produced breads high in fibre were also tested. Results indicated that bioavailability of iron on cellulose free bread was not higher than that observed in bread with cellulose irrespective of the cellulose level. This suggested to the authors that the addition of purified cellulose to iron enriched white bread did not interfere with the availability of iron. However, in the commercial breads, interference in iron bioavailability was observed and was attributed to the fibre type and nutrient interactions.

In order to determine the effect of fibre and phytate on the availability of iron, Reinhold et al (1975) prepared breads from whole meal and dephytinised bran. The authors observed that about 50 to 70% of the ferrous and ferric iron were bound by the whole meal and bran, and that the binding of iron increased following removal of phytate due to increased fibre concentration. The results further indicated that ferrous iron was more strongly adsorbed by bread, bran, or cellulose than the ferric iron.

Since variations have been observed in the nutritive composition of germinated and malted grains and baked products, in this study, malted and raw mixes, and biscuits prepared from malted and raw mixes with or without colocasia leaf powder were analysed for their nutritive composition to ascertain the effects of malting and baking on nutrient composition of mixes and biscuits.

Materials and methods

As described in Chapter 3, wheat and bengal gram grains in the ratio of 4:1 by weight were soaked for 12 h and germinated for 48 h at 23°C (15 to 35°C). The germinated grains with rootlets were dried in an oven at 70±5°C for 9 to 11 h and milled. Mixes made from malted and raw wheat and bengal gram were used in the preparation of biscuits with or without colocasia leaf powder (see Chapter 3). Mixes and biscuits were analysed for moisture, crude protein, fat, available carbohydrate, ash, crude fibre, calcium, iron - total, soluble and ionizable, phosphorus, carotenes, thiamine and riboflavin contents.

Analytical procedure

Moisture content : Moisture was estimated by the method of NIN (1983). About 10 g of the ground sample (mixes, and biscuits with or without colocasia leaf powder) was weighed into a weighed petridish and dried in an oven at 100 to 105°C and cooled in a desiccator. The process of heating and cooling was repeated till

199

a constant weight was obtained.

Calculation:

$$\text{Moisture (g/100 g)} = \frac{\text{Initial weight - Final weight}}{\text{Weight of the sample}} \times 100$$

Crude protein content : Protein was determined by the micro-Kjeldahl method (Ranganna 1977) as outlined in Chapter 3.

Fat content : Fat was estimated as crude ether extract of the dried sample (NIN 1983). Approximately 10 g of the dried sample was weighed accurately into a thimble and plugged with cotton. The thimble was then placed in a Soxhlet apparatus and the fat was extracted with petroleum ether (40 to 60°C, boiling point) for about 16 h. The ether extract was filtered into a weighed conical flask. The flask containing the ether extract was washed 4 to 5 times with small quantities of ether and the washings were also transferred. The ether was removed by evaporation and the flask with the residue was dried in an oven at 80 to 100°C, cooled in a desiccator and weighed.

Calculation:

$$\text{Fat content (g/100 g)} = \frac{\text{Weight of ether extract} \times 100}{\text{Weight of the sample (equivalent to fresh sample taken)}}$$

Available carbohydrate content : Starch and sugars present in the sample were estimated as reducing sugars by the method of Lane and Eynon (1923) as described by Ranganna (1977).

Approximately 2 g of the sample was digested with 35 ml of 20% hydrochloric acid in a boiling water bath for 3 h. The contents of the tube were cooled to room temperature and neutralized with 10 N sodium hydroxide. The volume was made up to 60 ml and contents filtered through Whatman No. 1 filter paper. An aliquot of 2 ml from the filtrate was used for the estimation of reducing sugars in the hydrolysed sample and the estimation was done as described in Chapter 3.

Ash content : Ash was determined by the method of NIN (1983). In triplicate, about 5 g of the sample was weighed in a silica crucible which was previously ignited, cooled and weighed. The crucibles with the samples were kept in an oven for 24 h at 100°C. The contents were charred on a direct flame and then ashed in a muffle furnace for about 16 h at 500°C. The crucibles were cooled in a desiccator and dropwise one millilitre of nitric acid was added to the crucible and were kept in an oven at 100°C for 48 h. The contents were again heated in the muffle furnace for 6 h at 500°C. The crucibles were cooled in a desiccator and weighed.

Calculation:

$$\text{Ash (g/100 g)} = \frac{\text{Weight of the ash}}{\text{Weight of the sample taken}} \times 100$$

Crude fibre content : The method of NIN (1983) was used to determine the crude fibre. About 2 g of moisture and fat free sample was weighed into a 500 ml beaker and 200 ml of boiling 0.255 N (1.25% w/v) sulphuric acid was added. The mixture was

boiled for 30 min keeping the volume constant by the addition of water at frequent intervals (a glass rod was inserted in the beaker for smooth boiling). At the end of this period, the mixture was filtered through a muslin cloth and the residue washed with hot water till free from acid. The material was then transferred to the same beaker and 200 ml of boiling 0.313 N (1.25%) sodium hydroxide was added. After boiling for 30 min (keeping the volume constant as before) the mixture was filtered through muslin cloth. The residue was washed with hot water till free from alkali followed by washings with 25 ml alcohol and 25 ml ether. It was then transferred to a crucible, dried overnight at 80 to 100°C and weighed. The crucible was heated in a muffle furnace at 600°C for 2 to 3 h, cooled and weighed again. The differences in weights represented the weight of crude fibre.

Calculation:

$$\text{Crude fibre (g/100 g)} = \frac{100 - \left(\text{g moisture + g fat in } \frac{100 \text{ g sample}}{}\right) \times \text{weight of fibre}}{\text{Weight of sample taken (moisture and fat free)}}$$

Calcium content : Calcium was estimated by the method of Clark and Collip (1925) as given by Pearson (1971). About 5 g of sample was ashed at 550°C for 16 h. The crucibles were cooled in a desiccator and 2 ml of concentrated hydrochloric acid was added to the ash. The hydrochloric acid was evaporated to dryness. Then 10 ml of N hydrochloric acid was added to the crucible and boiled. The contents were filtered through Whatman No. 44 filter paper into 25 ml volumetric flask, the crucibles and the filter paper were washed with more of N acid and volume was made up to

the mark. An aliquot of 5 ml was pipetted into a centrifuge tube. One millilitre of 5% ammonium oxalate solution was added with a drop of methyl red indicator. The solution was made alkaline with strong ammonia. The glacial acetic acid was added until the solution was just pink (pH 5.0). The centrifuge tubes were covered and allowed to stand overnight. Then the contents were centrifuged at 3000 rpm for 15 min. The supernatant liquor was decanted off and the precipitate washed twice with dilute ammonia (2%) by thoroughly mixing the precipitate with the fluid and centrifuging as before after each addition. After the final decantation, 2 ml of dilute sulphuric acid (one volume concentrated acid + 4 volume water) was added. The precipitate was dispersed, heated to 85°C and titrated with 0.01 N potassium permanganate solution (one millilitre = 0.2 mg calcium).

Calculation:

$$\text{Calcium (mg/100 g)} = \text{titre value} \times \frac{0.2 \text{ mg calcium}}{} \times \frac{25 \text{ ml}}{5 \text{ ml}} \times \frac{100 \text{ g}}{\text{g sample taken for analysis}}$$

Phosphorus content : The method of Fiske and Subbarow (1925) was followed to determine the phosphorus content. Phosphorus reacts with molybdic acid to form a phosphomolybdate complex. It is then reduced with aminonaphthol sulphonic acid to the complex molybdnum blue which is measured colorimetrically. The reagents as used for the estimation are given in Appendix 5.

To one millilitre of the ash solution, 5 ml of molybdate reagent was added and the contents were mixed. If necessary the

203

ash solution was diluted. Two millilitres of aminoaphthol sulphonic acid solution was added, mixed and the volume was made up to 50 ml. Similarly, a blank using water in place of the sample was prepared. The solutions were allowed to stand for 10 min and the colour was measured at 650 nm setting the blank to 100% transmission. Standards were carried with each set of estimations.

Calculation:

$$\text{Phosphorus (mg/100 g)} = \frac{SR}{SR_1} \times C \times \frac{V}{V_1} \times \frac{100\ g}{S}$$

where: SR = reading of the sample
SR_1 = reading of the standard
C = concentration of the standard (mg)
V = total volume after digestion (ml)
V_1 = aliquot taken for estimation (ml)
S = weight of the sample taken for analysis (g)

Iron content

Total iron : Total iron was estimated by the method of Wong (1928) as given by Oser (1979). The reagents as used for the estimation are given in Appendix 6.

About 2 to 3 g sample was taken in a Kjeldahl digestion flask. To this, 50 ml of the mixture of concentrated nitric acid and sulphuric acid (5:1 v/v) was added. The mixture was swirled lightly and heated in a digestion chamber until a colourless clear solution was obtained. The flask was then allowed to cool and the contents poured into a 100 ml volumetric flask. The digestion flask was washed 3 to 4 times with double distilled

water, the washings were added to the volumetric flask and the volume was made up to the mark. Aliquots of 10 ml of the sample and of 10 ml of double distilled water were taken in test tubes. To each, 0.5 ml of saturated potassium persulphate was added followed by 2 ml of 3 N potassium thiocyanate. The tubes were mixed by inversion and read within 30 min in Klett Summerson colorimeter at 480 nm after setting the instrument to zero with the blank.

Aliquots of standard iron solution prepared from crystalline ferrous ammonium sulphate, containing 10 to 50 mcg were also run simultaneously throughout the entire procedure.

Calculation:

$$\text{Total iron (mg/100 g)} = \frac{SR}{SR_1} \times C \times \frac{V}{V_1} \times \frac{100\ g}{S} \times \frac{1}{1000}$$

where: SR = reading of the sample
SR_1 = reading of the standard
C = concentration of the standard (mcg)
V = total volume after digestion (ml)
V_1 = aliquot taken for estimation (ml)
S = weight of the sample taken for analysis (g)

Bioavailable iron : Bioavailable iron was estimated using the 'in vitro' method proposed by Narasinga Rao and Prabhavathi (1978).

The reagents as used for the estimation are given in Appendix 7.

About 2 g sample was taken in a 150 ml conical flask and

205

to this 25 ml of pepsin-hydrochloric acid mixture was added. The pH of the solution was adjusted to 1.35 by dropwise addition of 6 N hydrochloric acid. The mixture was incubated exactly for 90 min at 37°C in a mechanical shaker (100 to 120 oscillations/ min). The contents of the flask were then centrifuged at 2000 rpm for 30 min and the supernatant was transferred to a clean 150 ml conical flask. The weight of the flask with the supernatant was recorded. The supernatant was heated in a boiling water bath for 15 min, cooled and reweighed. The loss in weight due to evaporation was made up with double distilled water. The solution was filtered through Whatman No. 44 filter paper. The pH of this solution was adjusted to 7.5 using sodium hydroxide solutions of varying strengths (0.5 to 0.1 N). The mixture was then incubated in a shaking water bath at 37°C for 45 min after which it was filtered through Whatman No. 44 filter paper and the volume of the filtrate was recorded. This filtrate was used for the estimation of soluble iron and ionizable iron.

For estimation of ionizable iron, 7 ml of the filtrate was taken in test tubes in duplicates to which one millilitre of 10% hydroxylamine hydrochloride, 5 ml of acetate buffer (pH 4.2) and then 2 ml of alpha alpha dipyridyl solution were added. The colour intensity was read in a spectrophotometer after 30 min at 540 nm against a reagent blank. Sample blanks, and standards containing 2 to 10 mcg of iron per ml were run with each set of estimations.

206

Calculation:

$$\text{Ionizable iron (mg/100 g)} = \frac{SR}{SR_1} \times C \times \frac{V}{V_1} \times \frac{100\ g}{S} \times \frac{1}{1000}$$

where: SR = reading of the sample
SR_1 = reading of the standard
C = concentration of the standard (mcg)
V = total volume after last filtration (ml)
V_1 = aliquot taken for estimation (ml)
S = weight of the sample taken for analysis (g)

Soluble iron was estimated by the method of Tennat and Greenman (1969). Six millilitres of the final filtrate was taken in a test tube to which 4 ml of acidified potassium permanganate was added. The mixture was shaken and left at room temperature for 15 min after which 2 ml of 20% ascorbic acid was added. After shaking, this mixture was incubated for 120 min at 56°C in an ordinary water bath. The solution was filtered through Whatman No. 44 filter paper and the iron in the supernatant was estimated as described earlier for ionizable iron.

Calculation:

$$\text{Soluble iron (mg/100 g)} = \frac{SR}{SR_1} \times C \times \frac{VE}{V_1} \times \frac{V}{VE_1} \times \frac{100\ g}{S} \times \frac{1}{1000}$$

where: SR = reading of the sample
SR_1 = reading of the standard
C = concentration of the standard (mcg)
V = total volume after last filtration (ml)
VE_1 = aliquot taken for final incubation (ml)
VE = volume before incubation (ml)
V_1 = aliquot taken for estimation (ml)
S = weight of the sample taken for analysis (g)

207

Carotene content : It was determined by the method of AOAC (1970). The method is based upon the separation of the biologically active carotenoid pigments from the total carotenoid pigments in an extract by an adsorbant with varying affinities for the different pigments. The individual pigments exhibit characteristic absorption maxima at which their concentration may be determined. The preparation of column is given in Appendix 8.

About 15 g of the sample was taken in a conical flask to which 30 ml of acetone hexane mixture (3+7) was added. The flask was allowed to stand overnight. The contents were filtered through Whatman No. 1 filter paper and the flask and the filter paper were washed several times and the volume was made up to 100 ml with 9% acetone in hexane. The contents were mixed. Fifteen millilitres of the filtrate was loaded on to the column (activated magnesium oxide and hyflo supercel, 1:1 by weight) which had been previously wetted with hexane. The carotenes were eluted out with the 9% acetone in hexane solvent. The volume of the eluate was made up to 60 to 100 ml. Readings were taken in Spectronic 20 at 450 nm. The instrument was set with 9% acetone in hexane.

Calculation :

$$\text{Carotene (mcg/100 g)} = \frac{SR}{SR_1} \times C \times VE \times \frac{V}{VE_1} \times \frac{100\ g}{S}$$

where:
- SR = reading of the sample
- SR_1 = reading of the standard
- C = concentration of the standard (mcg)
- VE = total volume of the eluate (ml)
- VE_1 = aliquot loaded on the adsorption tube (ml)
- V = total volume after extraction (ml)
- S = weight of the sample taken for analysis (g)

208

Thiamine content : It was determined by the method of AACC (1983). The reagents as used for the estimation are given in Appendix 9.

About 10 g of the sample was taken in a 100 ml volumetric flask. Fifty millilitres of 0.1 N sulphuric acid was added and the contents of flask were heated in a boiling water bath for 10 min. The flasks were cooled to room temperature and 5 ml of enzyme suspension was added. The contents were incubated at 37 to 40°C for 4 h and diluted to 100 ml. The digested sample extract was mixed thoroughly and filtered through Whatman No. 41 filter paper. Twentyfive millilitres of the filtrate was loaded on to the adsorption tube while decalso was still wet from the washings. The column was washed with 3 successive 5 ml portions of hot water to ensure proper distribution of thiamine on the column. The adsorbed thiamine was eluted from the base exchange silicate with boiling 5% potassium chloride. The eluate was collected in 25 ml volumetric flask and the volume made up to the mark. The eluate was mixed well and 5 ml was pipetted into glass stoppered separating funnel. Another 5 ml aliquot was pipetted into second glass stoppered separating funnel to be used as a blank. The funnels were numbered one and 2. To first funnel 3 ml alkaline ferricyanide solution and to the second funnel 3 ml of 15% solution of sodium hydroxide was added. The contents were mixed gently for about 30 sec and then each received 15 ml isobutanol. The funnels were shaken rigorously for 60 sec. Then one millilitre of 95% ethanol was added and the contents were

209

mixed well. The acqueous layer was drawn off with a micro-pipette into a tube. Ten millilitres of isobutanol was used to set the instrument to zero. Quinine sulphate was used to set the instrument to 100% transmission. Readings of the sample and the blank were taken. Five millilitres of the standard solution containing one microgram thiamine was treated in a similar manner.

Calculation:

$$\text{Thiamine (mg/100 g)} = \frac{SR - SBR}{SR_1 - SBR_1} \times \frac{VE}{V_1} \times \frac{V}{VE_1} \times \frac{100\ g}{S} \times \frac{1}{1000}$$

where: SR = reading of the sample
SBR = reading of the sample blank
SR_1 = reading of the standard
SBR_1 = reading of the standard blank
V = total volume after extraction (ml)
VE_1 = aliquot loaded on the adsorption tube (ml)
VE = total eluate after eluting the sample (ml)
V_1 = aliquot taken for estimation (ml)
S = weight of the sample taken for analysis (g)

Riboflavin content : Riboflavin was estimated by the method of AACC (1983). The reagents as used for the estimation are given in Appendix 10.

About 5 g sample was taken into a 100 ml volumetric flask. Seventyfive millilitres of 0.1 N sulphuric acid was added and the contents were mixed well. The flasks were immersed in boiling water bath for 30 min, with shaking the flasks every 5 min. After cooling the contents, 5 ml of 2.5 M sodium acetate solution was

added and the contents were mixed well. The solution was allowed to stand for one hour. The volume was made up to 100 ml and the contents filtered through Whatman No. 41 filter paper. Oxidation was conducted in two test tubes marked A and B. In tube A, 10 ml of sample solution, one millilitre of standard solution and one millilitre of water, and in tube B, 10 ml sample solution and 2 ml water were taken. Then 0.5 ml of 4% potassium permanganate solution was added. After 2 min, 0.5 ml of 3% hydrogen peroxide solution was added to each tube and the contents were stirred after addition of permanganate and hydrogen peroxide solution until foaming was negligible. Fluorometer was set to 100% transmission with sodium fluorescein solution. The fluorescence of solutions A and B were determined with not more than 10 sec of exposure in the fluorometer. To solution B in cuvette, about 20 mg of sodium hydrosulfite was added, the contents were stirred and the blank fluorescence (C) was determined.

Calculation:

$$\text{Riboflavin (mg/100 g)} = \frac{B - C}{A - B} \times \frac{100 \text{ ml}}{10 \text{ ml}} \times \frac{100 \text{ g}}{\text{g sample taken for estimation}} \times \frac{1}{1000}$$

Statistical analysis

Differences among the means were tested at 5% of significance level by student's 't' test (Snedecor and Cochran 1968).

Results and discussion

The nutritive composition of mixes and biscuits was determined in terms of moisture, protein, fat, available

carbohydrate, ash, fibre, calcium, phosphorus, iron - total soluble and ionizable, carotene, thiamine and riboflavin contents.

For the sake of clarity and brevity henceforth the following symbols for mixes and biscuits will be used throughout the text:

	Mixes and biscuits	Symbol
1	Mix prepared from malted wheat and bengal (4:1)	MM (malted mix)
2	Mix prepared from raw wheat and bengal gram (4:1)	RM (raw mix)
3	Biscuits prepared from malted mix	MM biscuits
4	Biscuits prepared from raw mix	RM biscuits
5	Biscuits prepared from malted mix with colocasia leaf powder	C-MM biscuits
6	Biscuits prepared from raw mix with colocasia leaf powder	C-RM biscuits

Nutritive composition of mixes

Moisture : The mean moisture contents of the mixes prepared from malted and raw wheat and bengal gram were 5.78 and 8.88 g/100 g, respectively (Table 28). Between the malted and raw mixes, the mean moisture content of the latter was significantly ~~lower~~ higher than that of the former mix. The decrease in moisture content of the malted mix was attributed to the process of drying of the germinated grains. The germinated grains were dried at 70±5°C for 9 to 11 h in order to obtain an optimally dried malt. These results were in line with those reported by Opoku et al (1981)

Table 28. Moisture, protein and fat contents of malted and raw mixes

Nutrients (g/100 g)	Malted mix	Raw mix	't' values Malted Vs raw mix
	Mean ± SE		
Moisture	5.78±0.029	8.88±0.009	103.33***
Protein			
as observed	15.21±0.210	14.61±0.130	2.429 NS
on moisture free basis	16.14±0.220	16.04±0.145	0.380 NS
Fat			
as observed	2.36±0.027	2.48±0.017	3.750*
on moisture free basis	2.51±0.030	2.72±0.017	6.000**

NS = Non Significant

* = Difference between means significant at 5% level of significance

** = Difference between means significant at 1% level of significance

*** = Difference between means significant at 0.1% level of significance

and Singh and Tauro (1977). Opoku et al (1981) had observed that the moisture content of the millet malt was 58% lower than that of the raw millet. Relatively smaller decreases in moisture contents of malted bajra and barley grains have been demonstrated by Singh and Tauro (1977). The authors observed that in response to malting, the decrease in moisture content was 25% in bajra malt and to the tune of 20% in barley malt from their respective original moisture contents of 9.2 and 10.1%. In the present study, the moisture content of the malted mix was 54% lower than that of the raw mix.

On the other hand, Fotedar (1981) had reported a 16% increase (from 15.1 to 17.5 g/100 g) over the initial value in the moisture content of a mix prepared from malted wheat and bengal gram (4:1). Since Fotedar (1981) had not mentioned the temperature and duration of heat treatment given to the germinated grains, it is possible that the variations in temperature and duration of drying between her study and present study caused differences observed between the moisture contents of the mixes.

The moisture content of the malted mix observed in the present study was comparable with that reported by Pandya (1982) for a similar mix (5.78 Vs 5.16%). But it was lower than the values of 15.07 and 9.2% reported by Fotedar (1981) and Inamdar (1980) respectively for similar malted wheat bengal gram mixes. The high moisture contents reported by the latter authors could be due to inadequate drying of the germinated grains as stated earlier.

Protein : The mean protein content of the malted mix tended to be higher than that of the raw mix (Table 28). The small increase (4%) in the protein content of the malted mix could be due to its low moisture content. Because when the values of protein content were expressed on 'moisture free' basis, the small elevation disappeared as the mean protein content of the malted mix was 16.14 g/100 g and that of the raw mix, 16.04 g/100 g (Table 28).

An apparent increase of 5% in protein content of a mix prepared from malted wheat and bengal gram was observed by Fotedar (1981). In 2 days germinated wheat, Dalby and Tsai (1976) had demonstrated an increase of less than 4%; Lemar and Swanson (1976) and Ranhotra et al (1977) had shown that in 3 days germinated wheat the protein content had increased by 5 to 7%. Likewise, Hamad and Fields (1979) exhibited an increase of 4% in the protein content of 5 days germinated wheat. In 2 days germinated bengal gram, Jaya and Venkataraman (1980) had shown an 8% increase in protein content.

In 2 varieties of malted corn, Singh and Bains (1984) had demonstrated a small increase of 3% in their protein contents. However, appreciable increases in protein content have been reported as a result of malting of grains. Singh and Tauro (1977) had demonstrated an increase of 14% in the protein content of bajra malt and of 11% in that of barley malt from their respective initial values of 12.5 and 8.8%. Opoku et al (1981) had observed a 37% increase in protein content of malted millet grain from the

initial value of 8.6%. The increases in protein content have been attributed to loss of dry matter during germination.

Fat : Table 28 shows that the mean fat content of the malted mix was 5% lower than that of the raw mix (2.36 Vs 2.48 g/100 g). When the same data were expressed on 'moisture free' basis, the mean fat content of malted mix was found to be 8% lower than that of the raw mix (2.51 Vs 2.72 g/100 g) and this difference happened to be statistically significant probably because of the homogenity in the data. Fotedar (1981) had observed a 40% decrease in fat content of malted mix as compared to that of the raw mix (2.07 Vs 3.44 g/100 g). Similarly, Opoku et al (1981) had observed a 67% decrease (from 7.5 to 2.5%) in the fat content of 18 h germinated millet malt. The decreases in fat contents in the malted grains have been attributed to the utilization of lipid reserves of a grain during germination (Opoku et al 1981). In contrast, increases in fat content over the initial value, in response to germination have also been reported. Singh and Tauro (1977) had observed increases in fat contents of 11% (from 4.4 to 4.9%) in 120 h germinated bajra malt and of 20% (from 2.0 to 2.4%) in 120 h germinated barley malt.

Available carbohydrates : The mean available carbohydrate contents of the malted and the raw mixes were found to be comparable (Table 29). When the same data were expressed on 'moisture free' basis, the mean available carbohydrate content of the malted mix (Table 29) was about 3% lower than that of the raw mix

Table 29. Available carbohydrates, ash and fibre contents of malted and raw mixes

Nutrients (g/100 g)	Malted mix	Raw mix	't' values Malted Vs raw mix
	Mean ± SE		
Available carbohydrates			
as observed	60.91±0.547	60.68±1.796	0.122 NS
on moisture free basis	64.64±0.582	66.60±1.972	0.953 NS
Ash			
as observed	1.55±0.044	1.54±0.009	0.222 NS
on moisture free basis	1.64±0.046	1.69±0.009	1.064 NS
Fibre			
as observed	2.41±0.034	2.38±0.103	0.275 NS
on moisture free basis	2.55±0.037	2.61±0.114	0.500 NS

NS = Non Significant

217

(64.64 Vs 66.60 g/100 g). Although, Potedar (1981) had observed a decrease of similar magnitude in the carbohydrate content of a similar malted wheat and bengal gram mix, a higher decrease of 10% (from 53.9 to 48.5%) in the carbohydrate content of malted millet was observed by Opoku et al (1981). Decreases in carbohydrate contents are expected due to oxidation of carbohydrates during respiration in the process of germination (Dalby and Tsai 1976).

However, in 2 days germinated bengal gram, Jaya and Venkataraman (1980) had observed no change in the carbohydrate contents from that of the ungerminated seeds (67.7 to 68.2 g/100 g seeds).

Unavailable carbohydrates comprise of noncellulosic polysaccharides, cellulose and lignin. Spillar et al (1978) had reported that whole wheat meal contained 9.51 g/100 g of total dietary fibre constituting of 6.25 g noncellulosic polysaccharides, 2.46 g of cellulose and 0.80 g of lignin. Later in 1980, Kamath and Belavady had reported that the total unavailable carbohydrates in wheat were 17.22 g comprising of 10.59 g of noncellulosic polysaccharides, 5.47 g of cellulose and 1.16 g of lignin. And in bengal gram they were 25.62 g constituting of 9.06 g of noncellulosic polysaccharides, 13.70 g of cellulose and 2.87 g of lignin. Hence in the present study, a deficit of 9 to 12 g in the proximate composition was due to the presence of noncellulosic polysaccharides.

Ash : Table 29 shows that the values for mean ash contents of the malted and raw mixes did not markedly differ from each other whether expressed on 'as observed' (1.55 Vs 1.54 g/100 g) or on 'moisture free' basis (1.64 Vs 1.69 g/100 g). However, decreases in ash contents of grains in response to malting have been reported. Potedar (1981) had observed a 15% decrease in the ash content of a similar malted mix as compared to raw mix. Somewhat higher decreases in malted pearl millet (22%) and in malted ragi (21%) have been demonstrated by Sankara Rao and Deosthale (1983).

On the other hand, Ranhotra et al (1977) had observed no change in the ash content of flour obtained from 3 days germinated wheat as against that of the ungerminated wheat flour (1.90 Vs 1.89%). While Jaya and Venkataraman (1980) had demonstrated a decrease of 15% from 2.83 to 2.41% in the ash content of 2 days germinated bengal gram.

Fibre : The mean fibre content (Table 29) of the malted mix did not significantly differ from that of the raw mix whether expressed on 'as observed' (2.41 Vs 2.38 g/100 g) or on 'moisture free basis' (2.55 Vs 2.61 g/100 g). However, Ranhotra et al (1977) had demonstrated a 34% increase in the fibre content of flour prepared from 3 days germinated wheat, from that of the flour from ungerminated wheat (2.7%). On the other hand, Jaya and Venkataraman (1980) had shown that the fibre content of 2 days germinated bengal gram was 22% lower than that of the ungerminated bengal gram, the decrease was from 4.09 to 3.21 g/100 g seeds. Probably, the increase observed in the fibre content of wheat

(Ranhotra et al 1977) was counterbalanced by a decrease in the fibre content of the bengal gram (Jaya and Venkataraman 1980) and therefore, in the present study, no appreciable difference was observed in the fibre content of the malted mix versus that of the raw mix.

Calcium : No difference was observed between the mean calcium contents of malted and raw mixes (Table 30). But when expressed on 'moisture free' basis (Table 30), the calcium content of the malted mix was found to be significantly lower than that of the raw mix (78.78 Vs 82.15 mg/100 g). Earlier, decreases in calcium content of grains as a result of malting have been observed. Opoku et al (1981) observed a decrease of 18% from the initial value of 20.4%, in the calcium content of malted millet. Likewise, Sankara Rao and Deosthale (1983) had observed that the calcium contents of malted pearl millet had decreased by 11% (from the initial value of 46 to 41 mg/100 g) and that of malted ragi by 48% (from the initial value of 398 to 207 mg/100 g). Brandtzaeg et al (1981) had reported that malted ragi and green gram mix (7:3) contained 39% less calcium than that of the unmalted mix.

On the other hand, in flour prepared from germinated wheat (Ranhotra et al 1977), and in bengal gram (Jaya and Venktaraman 1980) no changes were recorded in the calcium contents in comparison to that of the ungerminated grains.

Phosphorus : The mean phosphorus content of the malted mix was significantly higher than that of the raw mix (Table 30).

Table 30. Calcium and phosphorus contents of malted and raw mixes

Nutrients (mg/100 g)	Malted mix	Raw mix	't' values Malted Vs raw mix
	Mean ± SE		
Calcium			
as observed	74.23±0.272	74.86±0.664	0.877 NS
on moisture free basis	78.78±0.290	82.15±0.728	4.298*
Phosphorus			
as observed	262.39±1.161	249.24±1.990	5.707**
on moisture free basis	278.48±1.233	273.53±2.184	1.974 NS

See Table 28 for foot note

But when the same data were expressed on 'moisture free' basis (Table 30) the observed elevation in phosphorus content of the malted over that of the raw mix disappeared as the phosphorus content of malted mix was 278.48 mg/100 g which did not differ markedly from that of the raw mix, 273.50 mg/100 g. These findings are supported by those of Jaya and Venkataraman (1980) who had observed no change in the phosphorus content of 2 days germinated bengal gram.

In contrast, increases in phosphorus contents in response to germination have been observed in 3 days germinated soya bean and mung bean (Abdullah and Baldwin 1984) and in 4 days germinated fenugreek seeds (El-Mahdy and El-Sebaiy 1982). El-Mahdy and El-Sebaiy (1982) had suggested that the apparent increase in total phosphorus was mainly due to decrease in dry weight. But decreases in the phosphorus contents on malting of grains has also been reported. Brandtzaeg et al (1981) had reported a decrease in the total phosphorus from 293 to 269 mg/100 g in malted ragi green gram mix. Likewise, Sankara Rao and Deosthale (1983) had reported decreases of 25% and 18% in the phosphorus contents of malted pearl millet and malted ragi, respectively, from their respective initial values of 379 and 320 mg/100 g.

Iron : There was no significant difference between the mean total iron contents of malted and raw mixes on 'as observed' or on 'moisture free' basis (Table 31). No changes in the iron contents of germinated seeds in comparison to those of the raw seeds have

Table 31. Total soluble and ionizable iron contents of malted and raw mixes

Nutrients (mg/100 g)	Malted mix	Raw mix	't' values Malted Vs raw mix
	Mean ± SE		
Total iron			
as observed	5.55±0.331	5.44±0.191	0.288 NS
on moisture free basis	5.89±0.352	5.96±0.209	0.171 NS
Soluble iron			
as observed	1.49±0.255	1.04±0.215	1.351 NS
% total iron	26.8	19.1	
on moisture free basis	1.60±0.275	1.14±0.220	1.307 NS
% total iron	27.2	19.1	
Ionizable iron			
as observed	0.94±0.010	0.58±0.015	21.176***
% total iron	16.9	10.7	
on moisture free basis	1.00±0.010	0.64±0.020	16.364***
% total iron	17.0	10.7	

See Table 28 for foot note

223

been demonstrated by Reddy et al (1978) and Giri et al (1981). While both increases and decreases in the iron contents of cereals and pulses as a result of germination and malting have also been reported by many investigators (Ranhotra et al 1977, Jaya and Venkataraman 1980, Brandtzaeg et al 1981, Udayasekhara Rao and Deosthale 1983, Sankara Rao and Deosthale 1983, Pawar et al 1986).

But malting of grains brought about 43% increase in the mean soluble iron content as the mean soluble iron content of the malted mix was 1.49 mg/100 g and that of the raw mix 1.04 mg/100 g however the difference between the two means was statistically not significant (Table 31). The soluble iron as percent of the total iron had also shown an increase from 19.1 to 26.8%. In response to malting, the mean ionizable iron content of malted mix had increased significantly in comparison to that of the raw mix (0.94 Vs 0.58 mg/100 g) and when expressed as percent of total iron, it had increased from 10.5 to 16.9%. These results were in line with those reported by Singh and Banerjee (1955), Prabhavathi and Narasinga Rao (1979), Giri et al (1981), Sankara Rao and Deosthale (1983) and Annapurni and Murthy (1985). Singh and Banerjee (1955) had reported that the available iron content had increased from 0.86 (value of raw bengal gram) to 0.92 mg/100 g after 48 h of germination. Prabhavathi and Narasinga Rao (1979) had shown that as percent of total iron, the soluble iron content of wheat germinated for 48 h had increased from 10.4 (value of raw wheat) to 14.5% and the ionizable iron content from 4.1 (raw value) to 6.7%. The same authors had also demonstrated that in

bengal gram germinated for 48 h, as percent of the total iron, the soluble iron content had increased from 11.2 (raw) to 16.8% and the ionizable iron content from 1.9 (raw) to 3.8%. Annapurni and Murthy (1985) had observed that the available iron content of 48 h germinated bengal gram had increased from 3.77 to 4.50 mg/100 g. However, Sankara Rao and Deosthale (1983) had exhibited 8 fold (from 9.0 to 73.5%) and 12 fold (from 7.4 to 88.3%) increases in ionizable iron content expressed as percent of total iron in malted pearl millet and ragi, respectively. The increases observed in ionizable iron content in response to germination have been attributed to (a) 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 concomitant increase in the protein free iron values (Singh and Banerjee 1955, Giri et al 1981), (b) increase in phytase activity and decrease in phytate content, (c) increase in relative biological value of protein and (d) decrease in polyphenol contents (Annapurni and Murthy 1985).

Thiamine : The mean thiamine contents of the malted mix and the raw mix were found to be comparable (Table 32) but when expressed on 'moisture free' basis (Table 32) the thiamine content of the malted mix was 6% lower than that of the raw mix (0.48 Vs 0.51 mg/100 g). In 6 to 7 days germinated soya bean, Wu and Fenton (1953) had recorded no change in their thiamine contents. Brandtzaeg et al (1981) also found that the thiamine content of malted ragi green gram mix was 19% lower than that of the

225

Table 32. Thiamine and riboflavin contents of malted and raw mixes

Nutrients (mg/100 g)	Malted mix	Raw mix	't' values Malted Vs raw mix
	Mean ± SE		
Thiamine			
as observed	0.45±0.003	0.47±0.009	2.222 NS
on moisture free basis	0.48±0.003	0.51±0.012	2.500 NS
Riboflavin			
as observed	0.38±0.015	0.16±0.005	13.750***
on moisture free basis	0.40±0.015	0.17±0.010	12.778***

See Table 28 for foot note

226

unmalted mix (2.38 Vs 1.93 mcg/g). Opoku et al (1981) had reported that the thiamine content of millet malt was 283% higher than that of the raw grain (0.053 mg/100 g).

Riboflavin : Table 32 shows that the mean riboflavin content of the malted mix whether expressed on 'as observed' (0.38 Vs 0.16 mg/100 g) or on 'moisture free' basis (0.40 Vs 0.17 mg/100 g) was significantly higher than that of the raw mix. These findings were in accordance with those reported by Geervani and Theophilus (1980), Brandtzaeg et al (1981) and Opoku et al (1981). These authors had reported increases ranging from 78 to 166%. In the present study, an increase of about 138% was observed in the riboflavin content of malted wheat bengal gram mix.

The nutritive analysis of malted and raw mixes showed that the process of malting did not appreciably alter the nutritive composition of the raw mix other than that the fat content of the malted mix was significantly lower and that the ionizable iron and riboflavin contents were significantly higher than those of the raw mix.

Nutritive composition of biscuits

Moisture : The mean moisture content of MM biscuit (Table 33) was 4.61 g/100 g and that of RM biscuit, 4.21 g/100 g. Likewise, the mean moisture contents (Table 33) of C-MM and C-RM biscuits were comparable (Table 34).

Table 33. Moisture, protein and fat contents of biscuits

Nutrients (g/100 g)	MM biscuit	RM biscuit	C-MM biscuit	C-RM biscuit
	Mean ± SE			
Moisture	4.61±0.277	4.21±0.139	3.79±0.190	3.89±0.076
Protein				
as observed	6.72±0.036	6.53±0.041	7.45±0.045	7.25±0.048
on moisture free basis	7.03±0.048	6.81±0.044	7.74±0.047	7.54±0.048
Fat				
as observed	20.42±0.145	20.69±0.037	21.42±0.353	21.95±0.065
on moisture free basis	21.41±0.154	21.60±0.037	22.26±0.365	22.83±0.067

Table 34. 't' values for the variables of Table

Nutrients	Comparisons			
	MM Vs RM biscuits	C-MM Vs C-RM biscuits	MM Vs C-MM biscuits	RM Vs C-RM biscuits
Moisture	1.290 NS	0.488 NS	2.440*	2.025 NS
Protein				
as observed	3.454*	3.030*	12.807***	11.428***
on moisture free basis	3.385*	2.985*	10.597***	11.231***
Fat				
as observed	1.800 NS	1.476 NS	2.618*	16.800***
on moisture free basis	1.202 NS	1.536 NS	2.146 NS	15.974***

See Table 28 for foot note

Inclusion of colocasia powder into MM or RM biscuits reduced their moisture contents. It was significantly reduced in C-MM and non-significantly reduced in C-RM biscuits (Table 34).

The reported values for moisture content of biscuits and cookies vary widely from 0.82 to 7.5% (Prabhavathi et al 1973, Ranhotra 1980, Meimban et al 1982, Hernandez and Sotelo 1984). It appears that the basic ingredients, water used in dough preparation, baking temperature and time determine the moisture content of baked product. The data presented in Table 35 supports such relationship.

Protein : The mean protein content of the MM biscuit whether expressed on 'as observed' or on 'moisture free' basis was 3% higher than that of the RM biscuit (Table 33). This was not surprising because the mean protein content of malted mix was 4% higher than that of the raw mix (Table 28).

Incorporation of colocasia leaf powder added 11% protein to the MM and RM biscuits as a result the protein content of C-MM biscuit was significantly higher than that of MM biscuit (7.45 Vs 6.72 g/100 g) and that of C-RM biscuit was significantly higher than that of RM biscuit (7.25 Vs 6.53 g/100 g). Earlier Meimban et al (1982) had reported that the protein content of biscuit without cassava leaf protein concentrate was 7.23% and addition of 1 to 5% leaf protein concentrate (based on flour weight) increased the protein content to 7.61 to 8.51%.

Table 35. Moisture contents of biscuits

Reference	Ingredients	Water (ml/100 g raw ingredients)	Baking temperature (°F)	Baking time (min)	Moisture content of the biscuits (%)
Prabhavathi et al (1973)	Wheat flour, groundnut, soya bean, wheat germ, pea, shortening, starch	not given	500 to 550	8 to 10	4.0 to 7.5
Ranhotra (1980)	Cake flour, soya flour, peanut butter, shortening, sucrose, dextrose, honey, baking soda, salt	34	375	11	4.7
Meimban et al (1982)	Flour - all purpose, shortening, brown sugar, baking powder, vanilla, cocoa, emplex, leaf protein concentrate	17	350	10	2.82 to 3.22
Hernandez and Sotelo (1984)	Wheat flour, bengal gram flour, sucrose, lard, baking powder, vanilla extract	not given	180 to 190	10 to 15	0.82
Present study	Mix, shortening, jaggery, colocasia leaf powder, baking powder	4 to 8	350	15	3.79 to 4.61

230

231

However, within the colocasia containing biscuits, the protein content of C-MM biscuit was 3% higher than that of C-RM biscuit whether expressed on 'as observed' or on 'moisture free' basis (Table 33).

Many investigators have attempted to enhance the protein content of biscuits and cookies by varying the proportion of wheat and bengal gram or by adding protein rich flours. Hernandez and Sotelo (1984) used 60:40 ratio (by weight) of wheat and bengal gram at 64% of the total raw ingredients in the preparation of cookies so that the protein content of their cookies was 10.1 g/100 g. In the present study, wheat and bengal gram mix was of 80:20 ratio (by weight) and was used at 40% level in the preparation of biscuits. Therefore, the protein content of the biscuits was 6.5 g/100 g.

Fat : Table 33 also includes the mean values of fat content of biscuits. The fat content of MM and RM biscuits did not vary from each other whether expressed on 'as observed' or on 'moisture free' basis.

Inclusion of colocasia leaf powder led to moderate increases in fat content of biscuits as the fat contents (Table 33) of the C-MM and C-RM biscuits were higher than those of the MM and RM biscuits. However, there was no significant difference (Table 34) in the fat contents of C-MM and C-RM biscuits expressed on 'as observed' (21.42 Vs 21.95 g/100 g) or on 'moisture free' basis (22.26 Vs 22.83 g/100 g).

232

In the present study, the fat contents of the biscuits were between 20.4 and 22.0 g/100 g (Table 33). A similar value of 22.4 g for the fat content of cookies has been reported by Ranhotra (1980). Higher lipid contents of cookies ranging from 34.1 to 36.5% have also been reported (Dreher and Patek 1984). On the other hand, lower fat contents of 11.7 g/100 g (Hernandez and Sotelo 1984) and 14.3 to 15.0% (Meimban et al 1982) in cookies and biscuits have been reported. The fat content of cookies and biscuits depends on the amount of fat used in dough preparation and also on the basic ingredients.

Available carbohydrates : The mean available carbohydrate contents (Table 36) of MM and RM biscuits did not vary from each other whether expressed on 'as observed' or on 'moisture free' basis. Incorporation of colocasia leaf powder into MM and RM biscuits lowered the available carbohydrate contents. These small decreases were attributed to low available carbohydrate content of colocasia leaf powder. Within the colocasia containing biscuits, the mean available carbohydrate contents of the C-MM and C-RM biscuits did not differ from each other whether expressed on 'as observed' or on 'moisture free' basis (Tables 36, 37).

Ash : No difference was observed in the mean ash contents (Table 36) of MM and RM biscuits whether expressed on 'as observed' (0.89 Vs 0.89 g/100 g) or on 'moisture free' basis (0.93 Vs 0.93 g/100 g).

Table 36. Available carbohydrates, ash and fibre contents of biscuits

Nutrients (g/100 g)	MM biscuit	RM biscuit	C-MM biscuit	C-RM biscuit
		Mean ± SE		
Available carbohydrates				
as observed	62.36±0.218	62.27±0.719	60.43±0.177	60.35±0.583
on moisture free basis	65.38±0.230	65.01±0.748	62.81±0.183	62.80±0.606
Ash				
as observed	0.89±0.013	0.89±0.050	1.59±0.010	1.60±0.021
on moisture free basis	0.93±0.013	0.93±0.033	1.65±0.010	1.66±0.024
Fibre				
as observed	0.99±0.045	0.97±0.084	1.49±0.082	1.47±0.039
on moisture free basis	1.04±0.048	1.02±0.087	1.55±0.085	1.53±0.039

Table 37. 't' values for the variables of Table 36

	Comparisons			
	MM Vs RM biscuit	MM Vs C-RM biscuit	C-MM Vs MM biscuit	C-RM Vs RM biscuit
Available carbohydrates				
as observed	0.120 NS	0.131 NS	6.868**	2.073 NS
on moisture free basis	0.473 NS	0.016 NS	8.741***	2.295 NS
Ash				
as observed	Nil	0.454 NS	41.176***	13.148***
on moisture free basis	Nil	0.385 NS	42.353***	17.805***
Fibre				
as observed	0.210 NS	0.220 NS	5.376*	5.435*
on moisture free basis	0.202 NS	0.215 NS	5.204**	5.368**

See Table 28 for foot note

234

Inclusion of colocasia leaf powder to the biscuits significantly increased (Table 37) the ash contents of the C-MM and C-RM biscuits which was attributed to the high mineral contents of colocasia leaf powder (Gopalan et al 1985). But no difference was observed between the mean ash contents (Table 36) of C-MM and C-RM biscuits expressed on 'as observed' (1.59 Vs 1.60 g/100 g) or on 'moisture free' basis (1.65 Vs 1.66 g/100 g).

In the present study, the ash contents of the biscuits ranged from 1.19 to 1.60%. Dreher and Patek (1984) had observed that the ash contents of the cookies prepared from whole purpose wheat flour with or without whole navy bean flour and navy bean high protein flour, ranged from 1.38 to 1.89%. These values are close to those observed in the present study. Somewhat lower values of 1.00 to 1.06% for the ash contents of biscuits have been reported by Meimban et al (1982). On the other hand, higher values for ash contents of 2.04% (Hernandez and Sotelo 1984), 2.4% (Ranhotra 1980) and 3.00 to 3.25% (Prabhavathi et al 1973) of cookies and biscuits have also been reported. The variations in ash content seemed to relate to the basic ingredients used in biscuit preparation.

Fibre : The mean fibre contents (Table 36) of the MM and RM biscuits did not differ from each other (Table 37) on 'as observed' (0.99 Vs 0.97 g/100 g) or on 'moisture free' basis (1.04 Vs 1.02 g/100 g).

236

Inclusion of colocasia leaf powder into the MM or RM biscuits increased the fibre contents by 50% (1.49 Vs 0.99 g/100 g; 1.47 Vs 0.97 g/100 g). This can again be attributed to the high fibre content of colocasia leaf powder (Gopalan et al 1985). But no significant difference (Table 37) was observed between the mean fibre contents of C-MM and C-RM biscuits on both 'as observed' (1.49 Vs 1.47 g/100 g) and on 'moisture free' basis (1.55 Vs 1.53 g/100 g).

In the present study, the fibre contents of the biscuits ranged from 0.97 to 1.49%. Ranhotra (1980) has reported a value of 1.5% for the fibre content of cookies. Hernandez and Sotelo (1984) had reported that the cookies prepared by them contained 2.0% fibre. However, lower fibre contents of 0.37% (Dreher and Patek 1984), 0.43 to 0.62% (Meimban et al 1982) and 0.50 to 0.52% (Prabhavathi et al 1973) in cookies and biscuits have also been reported.

Calcium : The mean calcium contents (Table 38) of the MM and RM biscuits did not vary from each other whether expressed on 'as observed' or on 'moisture free' basis (Table 39).

Incorporation of colocasia leaf powder doubled the calcium contents of MM and RM biscuits; 67.54 to 148.66 mg/100 g of MM and 67.66 to 148.33 mg/100 g of RM biscuits (Table 38).

Between the colocasia containing biscuits the calcium contents of C-MM and C-RM biscuits did not vary from each other.

Table 38. Calcium and phosphorus contents of biscuits

Nutrients (mg/100 g)	MM biscuit	RM biscuit	C-MM biscuit	C-RM biscuit
	Mean ± SE			
Calcium				
as observed	67.54±0.171	67.66±6.822	148.66±18.066	148.33±11.112
on moisture free basis	70.81±0.180	70.64±7.122	154.51±18.776	154.33±11.562
Phosphorus				
as observed	126.71±1.765	124.24±1.427	136.49±1.606	131.00±0.640
on moisture free basis	132.83±1.852	129.70±1.487	141.86±1.669	136.30±0.666

237

Table 39. 't' values for the variables of Table 38

Nutrients	Comparisons			
	MM Vs RM biscuit	C-MM Vs C-RM biscuit	MM Vs C-MM biscuit	RM Vs C-RM biscuit
Calcium				
as observed	0.018 NS	0.016 NS	4.490**	6.187**
on moisture free basis	0.024 NS	0.008 NS	4.458*	6.163**
Phosphorus				
as observed	1.088 NS	3.175*	4.099*	4.322**
on moisture free basis	1.318 NS	3.094*	3.622*	4.052*

See Table 28 for foot note

238

239

In the present study, the calcium contents of the biscuits with and without colocasia leaf powder were between 67.5 and 148.3 mg/100 g. Ranhotra (1980) had reported that the calcium content of their cookies was 49.1 mg/100 g. On the other hand, Prabhavathi et al (1973) had exhibited a very high calcium content ranging from 427 to 439 mg/100 g in the high protein biscuits prepared from groundnuts, soya bean, wheat germ and pea flours. This was due to the fortification of biscuits with 1.0 g of calcium carbonate per 100 g unbaked blends of biscuits.

Phosphorus : The mean phosphorus contents (Table 38) of the MM and RM biscuits did not differ significantly from each other (Table 39). While the mean phosphorus contents (Table 38) of the C-MM and C-RM biscuits were significantly higher than those of the MM and RM biscuits (Table 39). Likewise, the mean phosphorus content of C-MM biscuit was significantly higher than that of the C-RM biscuit (Table 39).

In the present study, the phosphorus contents of the biscuits ranged from 124.2 to 136.5 mg/100 g. Somewhat higher values of 182 mg/100 g (Ranhotra 1980) and 228 to 231 mg/100 g (Prabhavathi et al 1973) in biscuits have been reported earlier. However, the content of nutrients in biscuits and cookies depends on the ingredients used.

Iron : The mean total iron contents (Table 40) of the MM biscuit and RM biscuit did not differ significantly from each other (Table 41). Similarly, there were no significant differences

Table 40. Total, soluble and ionizable iron contents of biscuits

Nutrients (mg/100 g)	MM biscuit	RM biscuit	C-MM biscuit	C-RM biscuit
	Mean ± SE			
Total iron				
as observed	4.38±0.060	4.36±0.125	5.72±0.161	5.39±0.107
on moisture free basis	4.59±0.060	4.55±0.130	5.95±0.189	5.61±0.112
Soluble iron				
as observed	1.45±0.150	1.32±0.025	2.25±0.200	2.04±0.220
% total iron	33.1	30.3	39.3	37.8
on moisture free basis	1.52±0.160	1.38±0.025	2.34±0.250	2.12±0.225
% total iron	33.1	30.3	39.3	37.8
Ionizable iron				
as observed	1.15±0.151	0.93±0.002	1.80±0.075	1.60±0.130
% total iron	26.2	21.3	31.5	29.7
on moisture free basis	1.20±0.155	0.96±0.005	1.86±0.075	1.66±0.135
% total iron	26.1	21.1	31.3	29.6

Table 41. 't' values for the variables of Table 40

Nutrients (mg/100 g)	Comparisons			
	MM Vs RM biscuit	C-MM Vs C-RM biscuit	MM Vs C-MM biscuit	RM Vs C-RM biscuit
Total iron				
as observed	0.145 NS	1.710 NS	7.791**	6.280**
on moisture free basis	0.280 NS	0.426 NS	6.869**	6.199**
Soluble iron				
as observed	0.855 NS	0.707 NS	3.200*	3.258*
on moisture free basis	0.864 NS	0.655 NS	2.761 NS	3.274*
Ionizable iron				
as observed	1.457 NS	1.333 NS	3.869*	5.154**
on moisture free basis	1.548 NS	0.263 NS	3.837*	5.185**

See Table 28 for foot note

between the mean soluble and ionizable iron contents of MM and RM biscuits (Table 41). When expressed as percent of total iron, the mean soluble and ionisable iron contents of the MM biscuit tended to be higher than those of the RM biscuit (Table 40).

Likewise, no significant differences were observed (Table 41) between the mean total iron, soluble iron and ionizable iron contents of the C-MM and C-RM biscuits although the values of the former tended to be higher than those of the latter (Table 40). Addition of colocasia leaf powder to the MM and RM biscuits brought about a significant increases in total, soluble and ionizable iron contents (Table 41).

Prabhavathi and Narasinga Rao (1979) had reported that when whole wheat flour containing 5.9% soluble iron and 4.3% ionizable iron (of the total) was baked into bread, the soluble iron content (of the total iron) had increased about 3 fold from 5.9 to 20.3%, and ionizable iron 2 fold from 4.30 to 9.72%. Since the authors had observed a 50% reduction in phytate phosphorus in bread and in fermented dough while an increase in ionizable iron was seen only in baked bread, this increase was not attributed to the reduction in phytin phosphorus through baking.

Shackleton and McCance (1936) had reported that ionizable iron contents (expressed as percent of total iron) of two types of biscuits were 91 and 100%. Ranhotra et al (1979) reported that RBV of iron in bread with and without fortification with different iron compounds was between 35 and 81% taking ferrous

sulphate as standard. The ionizable iron contents, as percent of the total, of the biscuits, in the present study, were between 21 and 32%.

Narasinga Rao and Prabhavathi (1978) have reported that the ionizable iron (as percent of total iron) contents of amaranth and spinach were 5.0 and 4.4% respectively. Zhang et al (1985) had reported that the iron from spinach was utilized 51% as efficiently for hemoglobin synthesis as ferrous sulphate in anemic rats. While, Ifon and Bassir (1978) had reported that in 8 green leafy vegetables, the utilisation of iron ranged from 7.7 to 36.2% while that from ferrous sulphate was 42.7% for hemoglobin synthesis in anemic rats. Oyejola and Bassir (1973-75) had observed that the relative physiological availability of the iron of the green leafy vegetable ranged from 25 to 90% taking iron from ferrous sulphate as 100% available. Thus the increase in total and ionizable iron contents of the biscuits observed in the present study can be attributed to the incorporation of colocasia leaf powder.

Carotenes : The mean carotene contents of the C-MM and C-MM biscuits were 835 and 768 mcg/100 g, respectively (Table 42). Inclusion of colocasia leaf powder increased the carotene contents of the MM and RM biscuits by 8 fold. The colocasia leaf powder was found to contain 38,184 mcg carotene/100 g. Inclusion of 7.5 g of colocasia leaf powder into 100 g of biscuit ingredients would have provided 2,864 mcg carotene. But the biscuits were found to contain 768 and 835 mcg carotene/ 100 g biscuits. These values (Table 43) were found to be com-

Table 42. Carotenes, thiamine and riboflavin contents of biscuits

Nutrients (mg/100 g)	MM biscuit	RM biscuit	C-MM biscuit	C-RM biscuit
			Mean ± SE	
Carotenes[a]				
as observed	103[b]	103[b]	835±18.230	768±72.764
on moisture free basis	108	108	868±19.100	799±75.724
Thiamine				
as observed	0.14±0.005	0.14±0.005	0.17±0.001	0.18±0.005
on moisture free basis	0.14±0.005	0.14±0.005	0.18±0.001	0.18±0.005
Riboflavin				
as observed	0.11±0.020	0.06±0.005	0.18±0.010	0.15±0.015
on moisture free basis	0.12±0.025	0.06±0.005	0.20±0.015	0.16±0.015

[a] mcg/100 g

[b] Gopalan et al (1985)

Table 43. 't' values for the variables of Table 42

Nutrients	Comparisons			
	MM Vs RM biscuit	C-MM Vs C-RM biscuit	MM Vs C-MM biscuit	RM Vs C-RM biscuit
Carotene				
as observed	-	0.893 NS	-	-
on moisture free basis	-	0.884 NS	-	-
Thiamine				
as observed	Nil	2.000 NS	6.000***	5.174**
on moisture free basis	Nil	Nil	8.000**	5.714**
Riboflavin				
as observed	2.381 NS	1.667 NS	3.182*	5.625***
on moisture free basis	2.400 NS	1.905 NS	2.759 NS	6.250**

See Table 28 for foot note

-parable. The loss in carotene content was attributed to its destruction at the baking temperature of 200°C. Sehgal et al (1975) had exhibited losses of 48.0 to 89.8% in the carotene contents of 3 green leafy vegetables, mustard, raya (Brassica juncea) and fenugreek on sundrying (23 to 25°C). Swaminathan (1979) had stated that carotenes are stable to heat in the absence of oxygen but are rapidly oxidised in the presence of oxygen and light.

Thiamine : The mean thiamine contents (Table 42) of MM and RM biscuits did not vary from each other on 'as observed' (0.14 Vs 0.14 mg/100 g) and on 'moisture free' basis (0.14 Vs 0.14 mg/100 g).

Inclusion of colocasia leaf powder to the MM and RM biscuits improved their mean thiamine contents significantly (Table 43). As the thiamine contents of the C-MM and C-RM biscuits were higher than those of the corresponding non-colocasia biscuits (Table 42). The mean thiamine contents of C-MM and C-RM biscuits were comparable (0.17 Vs 0.18 mg/100 g).

Ranhotra (1980) had reported a value of 0.02 mg/100 g as the thiamine content of the cookies. The thiamine content of biscuits observed in the present study were 7 to 9 times higher than that reported by Ranhotra (1980). It could be because the mixes used in biscuit preparation were obtained from whole meal (100% extraction) of wheat and bengal gram. Whereas Ranhotra had used refined cake flour and soya flour in cookie preparation.

Augustin et al (1982) determined the thiamine contents of baked products and reported that whole wheat bread contained 0.42 mg/100 g thiamine, and cheese and peanut crackers contained 0.52 mg/100 g thiamine. These values were much higher than those (0.13 to 0.18 mg/100 g) observed in the present study for biscuits. The discrepency in results could be due to the use of only whole wheat flour in bread preparation, and fortification of cookies with vitamins by Augustin et al (1982).

Riboflavin : The mean riboflavin content (Table 42) of the MM biscuit was almost twice than that of the RM biscuits (0.11 Vs 0.06 mg/100 g). Increases in the riboflavin contents of germinated and malted grains have been demonstrated by many authors (Nandi 1960, Geervani and Theophilus 1980, Brandtzaeg et al 1981, Opoku et al 1981). But the riboflavin content of MM biscuits although was higher than that of the RM biscuits (0.11 Vs 0.06 mg/100 g) but the magnitude of the difference was smaller than that observed between the malted and raw mixes (Table 32). This could be attributed to higher losses of riboflavin during baking.

Incorporation of colocasia leaf powder increased the mean riboflavin contents (Table 42) of the biscuits significantly (Table 43). As in the case of MM and RM biscuits, no significant difference was observed between the mean riboflavin contents of C-MM and C-RM biscuits (Table 43).

In the present study, the riboflavin content of the biscuits ranged from 0.08 to 0.18 mg/100 g which was lower than those

reported by Ranhotra (1980) and Augustin et al (1982). The discrepency in results could be due to product variations. Ranhotra (1980) had reported that the riboflavin content of the high protein biscuit was 0.23 mg/100 g, while Augustin et al (1982) found that the bread contained 0.24 mg/100 g riboflavin, and cheese and peanut crackers 0.22 mg/100 g riboflavin.

The results, therefore, indicated that the nutritive value of biscuits prepared from malted mix or raw mix with or without colocasia leaf powder was comparable. But the addition of colocasia leaf powder to the biscuits markedly increased the contents of protein, calcium, phosphorus, iron - total, soluble and ionizable, carotenes, thiamine and riboflavin.

Cost evaluation of biscuits

The cost (Table 44) of one kilogram of MM and RM biscuits was Rs.14.00/kg. The nutritive composition of MM and RM biscuits (Tables 28 to 32) was also found to be comparable thereby indicating that use of malted mix in biscuit preparation did not appreciably improve the nutritive composition of the biscuits. Hence it would be advisable to use raw mix in biscuit preparation as the price of MM biscuits might go up if malting labour charges are to be included without any nutritional benefits.

Similarly, the cost of one kilogram of C-MM biscuits and that of one kilogram of C-RM biscuits did not differ from each

Table 44. Cost of one kilogram of MM and RM biscuits

Sr. No.	Raw ingredients	Cost Rs./Kg	MM biscuit		RM biscuit	
			Amounts	Cost Rs./Kg	Amounts	Cost Rs./Kg
1	Malted mix	4.54	400	1.95	-	-
2	Raw mix	4.18	-	-	400	1.80
3	Jaggery	6.00	400	2.58	400	2.58
4	Vanaspati	22.50	200	4.84	200	4.84
5	Baking powder	7.75	5	0.39	5	0.39
6	Baking charges	4.00	-	4.00	-	4.00
7	Polythene bags (LDPE) 200 gauge	30.00	One	0.30	One	0.30
				14.06		13.91

Cost estimates are inclusive of milling, malting and baking losses

One US dollar = Twelve rupees and fifty five paisa

Table 45. Cost[a] of one kilogram of C-MM and C-RM biscuits

Sr. No.	Raw ingredients	Cost Rs./Kg	C-MM biscuit		C-RM biscuit	
			Amounts	Cost Rs./Kg	Amounts	Cost Rs./Kg
1	Malted mix[b]	4.54	325	1.59	-	-
2	Raw mix[c]	4.18	-	-	325	1.46
3	Jaggery	6.00	400	2.58	400	2.58
4	Vanaspati	22.50	200	4.84	200	4.84
5	Colocasia leaf powder	25.00	75	2.02	75	2.02
6	Baking powder	7.75	5	0.39	5	0.39
7	Baking charges	4.00	-	4.00	-	4.00
8	Polythene bags (LDPE) 200 gauge	30.00	One	0.30	One	0.30
				15.72		15.59

See Table 44 for foot note

other (Table 45). The nutritive composition of the colocasia containing biscuits was also found to be comparable (Tables 33 to 43).

Inclusion of colocasia leaf powder at an additional cost of about 17 paisa per 100 g, provided significantly higher amounts of protein, calcium, phosphorus, iron - total and ionisable, carotenes, thiamine and riboflavin in comparison to MM and RM biscuits. Hence from a nutritional point of view addition of colocasia leaf powder into biscuits at an additional cost of only 17 paisa/100 g biscuits is advisable.

The cost of commercially available Windsor glucose biscuits is Rs 7.50/500 g. The cost of biscuits prepared in the present study is quite comparable to the prevailing cost of glucose biscuits available in the market and hence mass production of these biscuits with colocasia leaf powder can be advocated for nutritional benefits.

Nutritive composition of biscuits and RDA of 4 to 6 year old child

After the biscuits have been analysed for different nutrients it would be worthwhile to determine their contribution to the RDA of a 4 to 6 year old child. It was noticed that an intake of 100 g of MM and RM biscuits (Table 46) would meet one-third of the energy, protein and iron requirements while an intake of 100 g of C-MM and C-RM biscuits (Table 46) would in addition meet one-third

Table 46. Nutritive composition of biscuits and RDA of 4 to 6 year old child

	Energy (Kcal)	Protein (g)	Calcium (mg)	Iron (mg)	Beta carotene (mcg)	Thiamine (mg)	Riboflavin (mg)
Biscuits (per 100 g)							
MM biscuit	508[a] (34)	6.72 (30)	67.54 (17)	4.38 (29)	103[a] (9)	0.13 (16)	0.11 (14)
RM biscuit	508[a] (34)	6.53 (30)	67.66 (17)	4.36 (29)	103[a] (9)	0.14 (18)	0.06 (8)
C-MM biscuit	505[a] (34)	7.45 (34)	148.66 (37)	5.72 (38)	835 (70)	0.17 (21)	0.18 (22)
C-RM biscuit	505[a] (34)	7.25 (33)	148.33 (37)	5.39 (36)	768 (64)	0.18 (22)	0.15 (19)
RDA[a]							
4 to 6 year old child	1500	22	400 to 500	15 to 20	1200	0.80	0.80

[a]Gopalan et al (1985)

Figures in parenthesis denote percent RDA

253

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 into biscuits.