EFFECT OF INCORPORATING LEGUMES ON NUTRITIVE VALUE OF CASSAVA-BASED COMPLEMENTARY FOODS

ALEXANDER A. KALIMBIRA, BEATRICE M. MTIMUNI AND JOSHUA P. MTIMUNI
University of Malawi, Bunda College of Agriculture, P.O. Box 219, Lilongwe, MALAWI

ABSTRACT

The effect of incorporating different amounts of beans and soybeans, on nutritive value of cassava-based complementary foods in Malawi was studied. The legumes were either germinated beans, germinated soybeans, or non-germinated. Twelve flour mixtures primarily composed of cassava and maize flours were studied. The results showed that Likuni Phala which was composed of 80% whole maize meal and 20% soybean was significantly high (p<0.01) in energy content (430 kcal/100 g), whereas 100% cassava flour had the lowest energy level (356 kcal/100 g). Protein content was significantly high (p<0.01) in the flour mix containing 70% cassava + 30% germinated soybeans (20.4 g/100 g). Crude fat values were significantly high (p<0.01) in Likuni Phala (9.4 g/100 g) and the 70% cassava + 30% soybeans (8.95 g/100 g) flour mix. All the 12 flour mixes were poor sources of ascorbic acid with values ranging from zero in 100% cassava and Likuni Phala, to 2.51 mg/100 g in the 70% cassava + 30% germinated beans sample. It can be concluded that Likuni Phala was superior to cassava-based flour mixtures. However, there is potential in the 70% cassava + 30% soybean flour mixture as an alternative to Likuni Phala in places where cassava is readily available.

Key words: Cassava, complementary foods, Likuni Phala, Malawi, soybeans

INTRODUCTION

Problems associated with child malnutrition have persisted in developing countries despite many years of concerted efforts to alleviate them (Izurieta and Larson-Brown, 1995). As a result, low cognitive development, high child morbidity and mortality, and reduced working capacity among adults are common (Birch, 1972). In Malawi, child malnutrition has been a public health concern for many decades. High child mortality rates (52%) were attributed to inadequate protein and energy intake as long as three decades ago (Musomali, 1969). Lack of knowledge about various nutritious food mixes was recognized as one of the contributing factors to the high mortality rates.

Today, malnutrition continues to be widespread especially among children below the age of 5 years. Almost half (49%) of the country's children under the age of 5 years are stunted, 25.4% are underweight, and 5.5% are wasted (National Statistical Office, 2001). Many factors are associated with these high rates of malnutrition; they include inadequate food and nutrient intake, frequent infections, poor child feeding practices, and inadequate information. Since inadequate food and nutrient intake directly cause under nutrition, the problem is likely to persist in Malawi, especially considering that nearly 60% of Malawian smallholder farmers experience food insecurity even in non-drought years (Pearce, Ngwira and Chiweta, 1996).

One of the efforts to reduce malnutrition has been promotion of f ermented porridges such as Likuni Phala as a complementary food, alongside other locally available foods (Ministry of Health, 1992). Likuni Phala, which was developed in 1966 is currently composed of maize (Zea mays) and soybeans (Glycine max) in the ratio of 8.2. The flour is rich in energy and macronutrients, providing 396 kcal, 16 g protein and 7.7 g fat per 100 g. This surpasses mgaiwa (whole maize meal) or uwa woyera (refined maize meal with 60% extraction), that are commonly used for preparing porridges for young children in Malawi (Ministry of Health, 1992).

Although maize is the main staple food in Malawi, it is not widely grown and consumed in some parts of the country, especially in most areas along the lakeshore. Therefore, it would appear to be difficult for mothers in such areas to prepare Likuni Phala; as a result, its adoption is likely to be low. Alternatively, people in the cassava-eating areas use cassava flour to prepare porridges
as complementary foods. The porridges are predominantly carbohydrate in nature, unless nutritionally enhanced by addition of fish broth or legume flours, whose proportions are not known. Hence, the main objective of the study was to assess the effect of incorporating different amounts of beans and soybeans, on nutritive value of cassava-based complementary foods in Malawi.

MATERIALS AND METHODS

Flour mixes

Twelve flour mixes based on cassava (11 flour mixes) and maize (1 flour mix) were used. Two of the flour mixes (100% cassava flour and Likuni Phala) are already in use in Malawi for preparing porridges as complementary foods. Levels of beans and soybeans were based on the existing proportion of soybeans (20%) in Likuni Phala. The present study, therefore, attempted to use the same proportion of legume in the cassava mixes, as well as increase it to 30% in order to observe if there would be any quality benefits associated with the increase. The combinations used were as follows:

1. 100% cassava flour
2. Likuni Phala (80% maize + 20% soybeans)
3. 80% cassava + 20% soybeans
4. 80% cassava + 20% beans
5. 80% cassava + 10% soybeans + 10% beans
6. 70% cassava + 30% soybeans
7. 70% cassava + 30% beans
8. 80% cassava + 20% germinated soybeans
9. 80% cassava + 20% germinated beans
10. 80% cassava + 10% germinated soybeans + 10% germinated beans
11. 70% cassava + 30% germinated soybeans
12. 70% cassava + 30% germinated beans

Germination of legumes

Half of the beans and soybeans were germinated. The beans and soybeans were soaked in plastic basins overnight for 12 hours, then the water was drained. The two legume types were spread in winnowing baskets and covered with banana leaves. After germination, which took 4 days, they were sprayed on mats to dry in the sun, and then stored in woven baskets prior to milling.

Heat processing of soybeans

Dried soybeans were purchased from a local farmer around Bunda College of Agriculture. The beans were processed according to recommendations of the Ministry of Agriculture and Livestock Development (1997).

Maize and beans

The maize used in the experiment was MH 18 and it did not under-go special processing other than milling. The beans (kalima) were purchased from the Bean/Cowpea Collaborative Research Support Project in Malawi. Besides germination of the other portion used in the experiment, the remaining beans were simply milled into flour.

Proximate analysis

Standard methods (AOAC, 1984) were used to determine moisture (oven-drying method), crude protein (macro Kjeldal method using a Kjeltec System 1002 Distilling Unit), crude fat (Soxhlet extraction), energy (direct calorimetric method using a CP 400 Bomb Calorimeter), and crude ash (muffle furnace method).

Ascorbic acid determination

Ascorbic acid content of the flour mixes was analysed using a visual titration procedure with a dye, 2,6-dichlorophenolindophenol solution (Seki, 1990).

Iron determination

Iron was determined from the ashed samples using a Buck Scientific Atomic Absorption Spectrophotometer Model 200A at a wavelength of 248.3 nm (Mugho, 1999). Standard absorbances were plotted into a standard curve, which were then used to calculate the con-
centration of the element.

Data analysis

The experiments were conducted in a Completely Randomised Design using the twelve different flour mixes. MSTAT-C software program was used to statistically analyse the data using the analysis of variance technique. Least significant difference tests were carried out to separate the means.

RESULTS AND DISCUSSION

Nutritive value of the flour mixes

Nutritive values of the flour mixes are presented in Table 1. Significant differences ($p<0.01$) were observed with respect to moisture, energy, crude protein, crude fat, and ash values.

Energy content

There were significant differences ($p<0.01$) in energy content of the flours. *Likuni Phala* had the highest (430 kcal/100 g), whereas 100% cassava flour had the lowest (356 kcal/100 g) energy content. In all cases, flour mixes containing soybeans had higher energy levels than cassava flour to which beans had been added. It was also observed that germination of the legumes decreased the energy content.

*Likuni Phala*, the complementary food recommended during nutrition education lessons, and also used to treat moderate forms of acute malnutrition through nutrition clinics, was superior in terms of caloric value. This was expected because according to Ministry of Health (1992) soybeans are high in energy (407 kcal/100 g), mostly due to high fat and protein content. Furthermore, whole maize meal has more energy (363 kcal/100 g) than cassava flour (342 kcal/100 g), hence the high energy content of *Likuni Phala*. Similarly, it was not surprising that flour mixes containing beans had lower caloric values than those containing soybeans since soybeans are rich in energy because of their high fat content. However, values in this report are consistently higher at the given moisture content than values obtained through calculations using food composition tables. For example, *Likuni Phala* was expected to have 396 kcal/100 g at 4% moisture (Ministry of Health, 1992), while this experiment showed 430 kcal/100 g at 10% moisture. This variation could be attributed to differences in equipment and methods used for moisture and energy determination, differences in varieties of the maize and soybeans, and perhaps experimental errors.

Of interest, however, is the fact that the energy content of *Likuni Phala* was the same as that of the flour mix containing 70% cassava and 30% soybeans (429 kcal/100 g). Thus, in terms of energy provision for supplementary treatment of moderate protein energy malnutrition (PEM), the latter is a potential substitute for *Likuni Phala*. Addition of some sugar or fats/oils for households that can afford these commodities can further increase the energy content of the porridges.

The Ministry of Health (1992) recommends that a young child aged, for example, 1 - 3 years with a daily energy requirement of 600 kcal should be fed complementary foods five times a day. It further recommends that the food should be fed in 200 ml portions since the child has a small stomach capacity. Therefore, a child who is taking porridge made of 70% cassava and 30% soybeans would meet over 70% of his/her energy requirements by consuming 100 g in a day. Since mothers are advised to continue breast-feeding their children after introducing complementary foods, the deficit in energy can, therefore, be met by breast milk.

Effect of germination on energy content

There was a tendency for the energy content of similar flour mixes to decline whenever the legume used was germinated, even though the level of the germinated or non-germinated legume was the same (Figure 1). The differences were significant ($p<0.01$) in soybean-containing flours as opposed to those containing beans. Since germination is a life process for the sprouting plant, the energy reserves were being used for metabolic activities of the young shoot. Thus, germination has a negative impact on energy content of grains, although the magnitude may not be large enough to warrant concern.

Crude protein content

Flour mixes containing soybeans had significantly higher protein content ($p<0.01$) than those containing beans, at the same rate of substitution. The highest protein content (20.35 g/100 g) was found in the flour mix
containing 30% germinated soybeans. Protein content was not significantly different between Likuni Phala and the 7:3 flour ratio of cassava to soybean. At the same ratio of cassava to legume, flour mixes containing beans had lower protein content than those containing soybeans.

PEM has remained Malawi’s main nutritional problem for a long time and the need for diets that are high in energy and protein for the prevention and treatment of PEM is obvious. Results of this study suggest that in combating PEM, Likuni Phala can be substituted with a cassava-soybean flour mix containing at least 30% soybeans. Ideally, an intake of 100 g of the 7:3 cassava-soybean flour mix in the form of porridge would meet the dietary protein requirement for infants which is estimated to be 12 g per day. The major concern at this level would be the adequacy of amino acids in the flour mix. Although the amino acid composition of the flour mixes was not investigated, it is known that information on the amino acid composition of a foodstuff is crucial in determining protein quality. Among legumes, soybeans have the highest protein content. Soybean protein has high biological value that is between 60 and 99%, compared to egg protein, which is between 95 and 100% (Mebrahtu and Hahn, 1987).

So far, flour mixes containing beans have been inferior to those containing soybeans in terms of energy and protein. This implies that the only feasible means of increasing the protein content of flour mixes containing beans would be to increase the amount of the beans. However, this might be expensive both for the consumers and the government, and/or other stakeholder because it means that more beans would have to be used. Furthermore, beans are already used as a side dish (relish) in many urban and rural households in Malawi. Encouraging the use of high proportions of beans in complementary foods would mean that other household members would be denied an important source of dietary protein and other nutrients. In this regard, soybeans remain a more meaningful substitute since they are not used as a side dish per se. Besides, soybeans yield more protein per unit area than most grain legumes such as beans (Ministry of Agriculture and Livestock Development, 1997b), yet they are easy to cultivate.

Figure 2 shows the effect of germination on the crude protein content of the flour mixes containing cassava and beans and/or soybeans. Germination resulted in a significant increase (p<0.01) in protein content in flour mixes containing the same proportion of beans and soybeans. The increase in protein content is consistent with previous studies which showed that germination results in reduced dietary bulk, hence an increase in nutrient (protein) content (Marero et al., 1988).

Crude fat content

Likuni Phala gave significantly higher (p<0.01) crude fat (9.4 g/100 g), than the flour mix containing 80% cassava flour and 20% beans which had the least (0.42 g/100 g) crude fat. Although the latter had the least fat content, no significant differences were observed between it and the flour mixes containing 100% cassava flour, 70% cassava +30% beans, 80% cassava + 20% germinated beans, and 70% cassava + 30% germinated beans. Flour mixes containing soybeans were significantly high in crude fat compared to those containing beans. The crude fat content of the flour mix containing 70% cassava + 30% soybeans had no significant difference with Likuni Phala.

Comparatively, beans contain less fat (1.5g/100 g) than soybeans (20 g/100 g); as such the beans were not expected to significantly contribute to the total fat in the flour mixes. It was, therefore, not surprising for Likuni Phala and the flour mixes containing 30% and 20% soybeans to be high in crude fat. This explains why calorific values were highly significant (p<0.01) for the soybean-containing flours than the bean-containing flours, even when the highest proportion of beans in the flour mix was higher than that of soybeans.

A complementary food that is high in crude fat is essential for child feeding in Malawi partly because of the vitamin A deficiency problem that affects 59.2% of preschool children (Ministry of Health, et al, 2003). Inadequate dietary intake of fat is one of the important factors that leads to vitamin A deficiency due to improper metabolism of the vitamin. Preformed vitamin A and carotenoids are first suspended in fat molecules before they reach the intestinal brush border for absorption. This means that without sufficient dietary fat intake, vitamin A metabolism cannot be efficiently completed. According to the National Research Council (1989), there is marked reduction in absorption of preformed vitamin A and carotenoids when dietary fat intakes are ≤5 g per
TABLE 1. Nutritive values of the flour mixes

<table>
<thead>
<tr>
<th>Flour Mix</th>
<th>Moisture (g/100 g)</th>
<th>Energy (kcal/100 g)</th>
<th>Crude Protein (g/100 g)</th>
<th>Crude fat (g/100 g)</th>
<th>Ash (mg/100 g)</th>
<th>Iron (mg/100 g)</th>
<th>Ascorbic acid (mg/100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% cassava</td>
<td>14.0±0.46</td>
<td>356.0±0.00</td>
<td>1.97±0.22</td>
<td>1.97±0.22</td>
<td>1.58±0.07</td>
<td>0.53±0.21</td>
<td>0.00±0.00</td>
</tr>
<tr>
<td>80% maize + 20%GS</td>
<td>9.7±0.68</td>
<td>430.0±0.00</td>
<td>1.42±0.25</td>
<td>1.42±0.25</td>
<td>1.87±0.14</td>
<td>0.81±0.42</td>
<td>0.00±0.00</td>
</tr>
<tr>
<td>80% cassava + 10%GB + 10%GS</td>
<td>13.5±0.49</td>
<td>383.7±0.58</td>
<td>8.02±0.13</td>
<td>8.02±0.13</td>
<td>8.03±0.14</td>
<td>0.45±0.25</td>
<td>0.80±1.39</td>
</tr>
<tr>
<td>80% cassava + 20%GS</td>
<td>13.2±0.15</td>
<td>406.3±0.58</td>
<td>8.10±0.14</td>
<td>8.10±0.14</td>
<td>1.67±0.12</td>
<td>0.49±0.18</td>
<td>0.94±0.46</td>
</tr>
<tr>
<td>80% cassava + 20%GB</td>
<td>13.9±0.40</td>
<td>369.3±0.58</td>
<td>1.75±0.38</td>
<td>1.75±0.38</td>
<td>2.39±0.06</td>
<td>0.65±0.12</td>
<td>1.61±1.39</td>
</tr>
<tr>
<td>70% cassava + 30%GS</td>
<td>11.6±0.71</td>
<td>429.0±0.00</td>
<td>13.21±1.77</td>
<td>13.21±1.77</td>
<td>1.61±0.12</td>
<td>1.40±1.30</td>
<td>1.82±1.58</td>
</tr>
<tr>
<td>70% cassava + 30%GB</td>
<td>13.4±0.16</td>
<td>374.0±0.00</td>
<td>10.58±0.25</td>
<td>10.58±0.25</td>
<td>2.31±0.06</td>
<td>0.61±0.14</td>
<td>2.09±1.92</td>
</tr>
<tr>
<td>80% cassava + 10%GB + 10%GS</td>
<td>12.7±0.50</td>
<td>382.7±0.58</td>
<td>10.27±1.14</td>
<td>10.27±1.14</td>
<td>1.96±0.06</td>
<td>0.49±0.25</td>
<td>1.94±0.94</td>
</tr>
</tbody>
</table>

Values are means ± standard deviation
Values with different superscripts are significantly different (p<0.01) from each other.

According to the data presented, the diets of young children must be rich in fat because they are the most vulnerable groups. In addition, a high fat diet ensures proper metabolism of other fat-soluble vitamins D, E and K. Thus, the study has shown that a high fat cassava-based flour mix can be achieved by incorporating soybeans and not beans.

Crude ash content

The results on crude ash analysis showed that there were significant differences (p<0.01) in mineral content among the flour mixes. The un-substituted cassava flour had the lowest mineral content (1.58 g/100 g) while flour mixes containing non-germinated beans had significantly higher ash values than those with non-germinated soybeans. Upon germination, there were no significant differences in ash levels between flour mixes containing beans and those containing soybeans.

The higher ash values observed in non-germinated bean-containing flour mixes compared to those containing non-germinated soybeans suggest that beans are relatively high in overall mineral content. However, the results show that there were no significant differences between flour mixes containing germinated beans and germinated soybeans at the same rate of substitution. It is somewhat difficult to draw meaningful conclusions from such results, although it appears that a higher (30%) proportion of beans or soybeans in a flour mix increased the ash content.

Since the ash values are crude and therefore have little meaning in assessing nutritional adequacy, iron was analysed from the ashed samples.

Iron content

Significant differences were not detected in the iron content of the samples (p>0.05). However, the results show that iron levels were consistently higher (but not significant) in bean-containing samples than those containing soybeans at the same rate of substitution.

Flours containing germinated legumes gave consistently high levels than others. This agrees with Marero et al. (1988) who observed that the micronutrient content of germinated grains and legumes improves due to reduced dietary bulk. H however, according to the present results, the benefit of germination on iron content cannot be fully endorsed because the differences that were observed were not significant. Therefore, germination of beans and soybeans cannot be relied upon to increase dietary iron intakes.

Even Likuni Phala that is widely promoted as a complementary food, and is distributed among moderately acute malnourished children through nutrition clinics, is poor in iron. It is clear that the iron content of Likuni Phala (3.2 mg/100 g) as reported by the Ministry of Health (1992) is several folds higher than the present results (0.81 mg/100 g). The trend is also true for 100% cassava flour, and the calculated iron content of the other flour mixes. Most probably, the variations could be due to differences in analytical methods, varieties, and the edaphic environment in which the cassava, maize, beans and soybeans used in this study were grown.
Adequacy of the dietary iron

The dietary iron requirements for children up to 10 years are shown in Table 2 (FAO, 1997). By assuming that porridges made from the formulated flour mixes are taken without any source of ascorbic acid which enhances non-haem iron absorption, the iron in the porridges would be classified as having low bioavailability. The estimated requirement would be 21 mg/day for children aged 6 to 12 months. Therefore, an intake of porridge containing 100 g flour with 70% cassava and 30% soybeans (Table 2) would meet only about 7% of the iron requirement.

The implication of these results is that neither the newly formulated flour mixes nor the already existing ones (Likuni Phala or 100% cassava flour) should be expected to significantly contribute to the prevention of iron deficiency anaemia in Malawi. Mothers in this country should therefore continue to breastfeed their babies for a continuous supply of iron. Most importantly, the Government and its development partners such as non-governmental organizations should continue to implement the strategies that have been spelled out in the National Plan of Action for the Prevention and Control of Anaemia (Government of Malawi, 1999). The strategies include provision of iron supplements to infants and children, as well as to pregnant and lactating mothers.

Ascorbic acid content

Ascorbic acid was not detected in 100% cassava flour and in Likuni Phala, while the flour mix containing 30% germinated beans had the highest level (2.51 mg/100 g) of ascorbic acid. The only important observation made was that ascorbic acid could not be detected in 100% cassava flour and Likuni Phala. This was expected especially considering that the flour mixes were exposed to the sun during drying, which took a couple of days, hence rendering them deficient in the vitamin which is lost through such factors.

These results show that neither Likuni Phala nor the cassava-based complementary foods should be relied upon as sources of ascorbic acid. Although the flour mix containing 70% cassava and 30% germinated beans had the highest ascorbic acid content (2.51 mg/100 g), the vitamin is likely to be destroyed by heat during cooking since ascorbic acid is readily oxidised by heat (National Research Council, 1989).

Germination has been reported to increase the ascorbic acid content of grain legumes (Deosthale, 1981), but this was not evident in the present study. Perhaps germination of the beans and soybeans actually resulted in an increase in ascorbic acid; however heat and oxygen might have destroyed the vitamin during drying. The low ascorbic acid content implies that the porridges prepared from these flour mixes would have low iron bioavailability. Mothers and child caretakers should be aware that it is essential to include iron-rich foods such as fruits and fruit juices in the diets of infants and young children to enhance dietary ascorbic acid intake, which in turn improves iron absorption.

Further, it is necessary for growing children to take adequate amounts of ascorbic acid in order to continue synthesising collagen, which is vital in the formation of several body components such as tendons, ligaments, teeth and bones (Whitney, Cataldo and Rolfes, 1994).

### TABLE 2. Estimated dietary iron requirements for children up to 10 years

<table>
<thead>
<tr>
<th>Age</th>
<th>Dietary iron bioavailability (mg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>6-12 months</td>
<td>7</td>
</tr>
<tr>
<td>1-3 years</td>
<td>5</td>
</tr>
<tr>
<td>3-5 years</td>
<td>5</td>
</tr>
<tr>
<td>5-7 years</td>
<td>7</td>
</tr>
<tr>
<td>7-10 years</td>
<td>8</td>
</tr>
</tbody>
</table>

Source: FAO (1997)
**B=beans; S=soybeans; GB=germinated beans; GS=germinated soybeans**

**Fig. 1 Effect of germination and type of legume on energy content of flour mixes**

Therefore, as the supply of ascorbic acid from breast milk continually becomes inadequate after the age of 6 months (Jacob, 1994), the diet for young children should supply sufficient amounts of the vitamin to cater for the aforementioned, and other functions.

**CONCLUSION**

Cassava-based flour mixes composed of 70% cassava flour and 30% germinated or non-germinated soybean flour were formulated for preparing porridges that would be used as complementary foods in Malawi. The flour mixes were similar to *Likuni Phala* with respect to energy, protein, fat, ash and iron content. The sample containing 30% germinated soybeans was significantly high in protein. The recommended ratio of 8:2 for cassava to soybean flour (Ministry of Agricul-

**Fig. 2 Effect of germination and type of legume on crude protein content**
ture and Livestock Development, 1997) is, therefore, being challenged.

The cassava-based flour mixes investigated in this study were poor sources of ascorbic acid, even after germinating the beans and soybeans. Therefore, other foods such as fruits that are rich in ascorbic acid should be included in the diets of infants and young children in order to enhance and maintain high dietary intakes of the vitamin.

The results of the study have shown that the flour mix containing 70% cassava flour and 30% non-germinated soybeans has the potential of being used in preparing porridges for feeding young children. This implies that a household that does not have enough maize in stock can prepare a fairly nutritious and acceptable porridge using cassava and soybeans in a ratio of 7:3.

ACKNOWLEDGEMENTS

This work was funded through a research grant from the Norwegian Agency for Development Cooperation (NORAD Project at Bunda College of Agriculture.

REFERENCES


Nairobi: Jomo Kenyatta College of Agriculture and Technology. p 49.
