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NUTRITIONAL QUALITY OF EXTRUDED PEARL MILLET-SOYBEAN-COWPEAS INSTANT PORRIDGE FLOUR

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ABSTRACT

The aim of this study was to develop and determine the nutritional quality of pearl millet (*Pennisetum glaucum)*-based extruded instant porridge flour for use by children. Two varieties of millet complemented with soybeans (*Glycine max*) and cowpeas (*Vigna unguiculata*) were extruded and proximate and mineral composition, anti-nutrition levels determined. There were significant differences in nutritional composition between flour formulations. Complementation of millet with legumes increased protein content [10.7 g/100g in plain *Shibe* millet to 16.9 g/100g DM in *Shibe*: soybeans: cowpeas, (70:25:5)]. Ash increased with complementation, ranged from 0.9 g/100 g DM [*Shibe*: soybeans: cowpeas (90:5:5) to 2.2 g/100g DM (native pearl millet: soybean: cowpea (70:5:25). Fat increased with soybeans levels [from 2.6 in (70:5:25) native pearl millet: soybean: cowpeas to 7.2 g/100g DM (*Shibe*: soybeans: cowpeas (70:25:5). Crude fibre increased with soybeans (1.3 g/100g in plain millet to 4.5 g/100g DM in 70:25:5). The digestibility of flours ranged from 12.8 to 18.2%; native plain flour had lowest digestibility. The energy content of the flours ranged from 394 to 409.8 Kcal/100g. Phytate increased with soybean level, but native millet contained more phytate. Tannin content increased with level of legumes. This study indicated that extruded instant pearl millet-based flour has potential for use as complementary food.

Keywords: Pearl millets, Instant porridge flour, Antinutritional factors, Nutritional quality.

1. INTRODUCTION

•There were significant differences in nutritional composition between flour formulations
•Some formulations met requirements recommended by Codex Alimentarius commission
•Pearl millet varieties were suitable to develop complimentary foods

Complementary foods provided to children and infants should have excellent nutritional quality for growth and development (Mekuria et al., 2021). Adequate nutrition during infancy and early childhood is essential to ensure growth, health and development, as early nutritional deficits are linked to long-term impairment in growth and health (Black et al., 2013; WHO, 2020). Child under-nutrition is one of the main public health problems in developing countries despite recognition of the importance of proper child nutrition to healthy well-being (Samahegn et al., 2014). Inappropriate complementary feeding practices together with poor nutritional quality of complementary foods are among the causes of malnutrition (Rao, et al., 2011; WHO, 2013). Strategies to improve the availability and access to good quality complementary foods are important in order to improve the nutritional status of children (Mekuria et al., 2021). Protein energy malnutrition (PEM), might cause stunting, poor immunity and poor cognitive ability and

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death in children under five years of age in developing countries (WHO, 2021). Developing complementary food products from locally available, foods could be helpful in reducing malnutrition in poor households in developing countries (Nassanga et al., 2018). Such foods include climate resilient, low-cost, under-utilized plant foods, such as millet. Among the millet species, pearl millet is the widely grown but has poor nutritional quality, but fortification with legumes improves the sensory and nutritional quality (Ali et al, 2009). Some of the problems encountered by the overworked mothers include long duration required and inability to reduce wastage of flour in preparation of complementary foods, such as porridge. The use of extruded instant porridge flour is convenient, saves fuel, as no further cooking is required, only the amount of porridge in demand could be instantly prepared, might offer a solution to these problems. The aim of this study was to develop and assess the suitability of extruded instant pearl millet-based flour for use as complementary food.

2. MATERIALS AND METHODS

2.1 Samples

Two pearl millet varieties (improved variety *Shibe* and native variety) and cowpeas were obtained from Hombolo Agricultural Research Institute in Dodoma, while soybeans were obtained from Morogoro municipality central market, Tanzania.

2.2 Instant flour preparation

Millet and cowpeas were sorted and washed while soybeans were sorted and dehulled before air oven drying at 60°C. The conditioned grains (20% moisture) were extruded using a twin screw extruder (Kneader Model EX 60, Chaoyuan Power Machinery. Co. Ltd, Yantai, China). The extruder zone temperatures were 141 and 105°C in zone I and zone II, respectively; screw and feeder speed were 30.45 and 6-8 rpm, respectively. The extrudates were allowed to cool down at room before milling into flour (sieve size-1mm). The flours were mixed in appropriate composite flour formulations (Table 1, 2 and 3) using Nutrisurvey software (http://www.nutrisurvey.de/) and stored in polyethylene bags for analysis.

2.3 Chemical analyses

The proximate composition of was determined by using AOAC (1999) methods. Mineral composition was determined by AOAC (1999) procedure by atomic absorption spectrophotometer (UNICAM, Cambridge, United Kingdom). Protein digestibility was determined by using a procedure described by Sabah El-Kheir and Murwa (2010).The anti-nutritional factors, phytic acid and tannins, were determined by using a procedure described by Lukas and Markakas (1975) and Pearson (1991), respectively.

2.4 Data analysis

One way-Analysis of variance (ANOVA) was used for statistical analysis and Duncan's Multiple Range Test for significant difference between means ($P < 0.05$).

3. RESULTS AND DISCUSSION

Crude protein

The crude protein content ranged from 10.7 g/100g DM in *Shibe*: soybeans: cowpeas (100:0:0) to 16.9 g/100g DM in *Shibe*: soybeans: cowpeas (70:25:5). Complementation of pearl millet with legumes (soybeans and cowpeas) improved crude protein content. The crude protein increased with amount of legume and was highest in the formulation with highest amount of soybeans (25%). The increase in protein content with legumes addition implied an increase in amino acids, essential for promotion of growth, development and overall well-being of infants and children. Various researchers reported increase in crude protein in samples of complementary foods with addition of soybeans (Ali, et al., 2009; Laswai et al., 2010).

Three formulations of *Shibe*:soybeans:cowpeas (70:25:5), native pearl millet:soybean:cowpea (80:5:15) and native pearl millet:soybean:cowpeas (70:5:25) contained 16.9, 15.5 and 15.4, respectively and complied with CXS 74-1981 requirements for protein content for cereal-based foods for infants minimum of 14%, thus, might be recommended for alleviation of malnutrition in children.

Ash

The ash content in the flours ranged from 0.9 g/100g DM (*Shibe:* soybean: cowpeas (90:5:5**)** to 2.2 g/100g DM (native pearl millet: soybean: cowpea (70:5:25). The ash content increased with complementation of pearl millet with legumes because they are rich in minerals thus suitable for consumption by infants and young children. The ash content increased with cowpeas. The results corresponded with those reported by Okafor et al. (2017) that the addition of legumes (pigeon pea) to maize in the production of Ogi yielded fortified products with improved mineral composition, which was related to the increased ash content. However, all the flour formulations met the requirements for the ash content of 5% as stipulated by CXS 74-1981s for cereal-based complementary foods.

Crude fat

The crude fat content of the flours ranged from 2.6 to7.2 g/100g DM in (70:5:25) native pearl millet: soybean: cowpeas to (70:25:5) *Shibe:* soybeans: cowpeas. The crude fat increased as the amount of soybeans in the formulations was increased. The increase in fat content indicated the increase in fatty acids which are essential for cell and tissue metabolism, function and responsiveness to hormonal and other signals. The results correspond to those reported by Laswai et al. (2010). All the flour formulations complemented and non-complemented with legumes met the necessary crude fat content requirements for cereal-based infant foods stipulated by CXS 74-1981.

The crude fibre of the flour formulations ranged from 1.3 g/100g DM (100:0:0) to 4.5 g/100g DM (70:25:5). Crude fibre content increased with addition of soybeans. Similar results were reported by Ali et al. (2009) and Ogundele et al. (2014). In this study, all flour samples met the requirements for crude fibre as required by CXS 74-1981, that the maximum dietary fibre content of food for children should be 5% by mass. Fibre has many health benefits including reducing the risk of chronic diseases such as diabetes, obesity and cardiovascular diseases and cancer.

Table 1. Proximate composition of millet-soybean-cowpeas instant porridge flour (on dry weight basis) and digestibility (%)

Sample	Ash (g/100g)	Crude fat (g/100g)	Crude fibre (g/100g)	Crude protein (g/100g)	Carbohydrate (g/100g)	Energy (Kcal)	Digestibility (%)
Shibe pearl millet	1.1±0.75[k]	3.6±0.00[a]	1.3±0.01[ab]	10.7±0.007[a]	83.3±0.003[l]	407.9±0.021[a]	14.4±0.007[a]
Shibe-soybean-cowpea(90:5:5)	0.9±0.68[k]	3.8±0.01[b]	2.5±0.00[bc]	12.2±0.001[b]	80.6±0.002[m]	405.4±0.014[b]	13.9±0.007[b]
Shibe-soy-cowpea(80:15:5)	1.8±0.03[k]	5.3±0.007[c]	3.2±0.0[cd]	13.1±0.00[c]	76.7±0.024[n]	406.8±0.014[c]	14.8±0.014[c]
Shibe-soy-cowpea (70:25:5)	2.1±0.05[k]	7.2±0.00[d]	4.5±0.02[bd]	16.9±0.004[d]	69.4±0.013[o]	409.8±0.007[d]	18.2±0.007[d]
Native pearl millet	1.5±0.121[k]	4.5±007[e]	2.4±0.0[bcd]	12.7±0.0018[e]	78.9±0.014[p]	406.8±0.014[e]	12.8±0.000[ac]
Native-soy-cowpea(90:5:5)	1.7±0.11[k]	2.9±0.00[f]	1.7±0.02[ad]	12.5±0.001[f]	81.2±0.014[q]	400.9±0.00[f]	15.3±0.014[ad]
Native-soy-cowpea(80:5:15)	1.9±0.18[k]	3.3±0.00[g]	2.5±0.0[ef]	15.5±0.000[g]	76.7±0.000[r]	398.7±0.009[g]	14.6±0.000[ab]
Native-soy-cowpea(70:5:25)	2.2±0.05[k]	2.6±0.01[h]	2.3±0.02[def]	15.4±0.000[h]	77.5±0.007[s]	394.8±0.008[h]	14.9±2.114[cd]

Values are means and standard deviation (±) of two replications (n=2). Means with different super script letters along the same column are significantly different at p≤0.05.

Digestibility

The protein digestibility of the flour formulations ranged from 12.8 to18.2%. There was a significant difference (p≤0.05) in digestibility of instant porridge flour formulations from the two varieties of pearl millet when mixed with soybeans and cowpeas at different proportions. The lowest digestibility was observed in native variety plain flour and the highest digestibility was observed in *Shibe*: soybeans: cowpeas (70:25:5). Cooking of pearl millet supplemented with soybean flour was reported to increase the protein digestibility and availability (Ali et al., 2009).

Carbohydrates

The carbohydrate content ranged from 69.4 83.3g/100g DM and was higher improved variety than native pearl millet variety. The carbohydrate content in formulations decreased as the amount pearl millet was reduced. All the formulated complementary porridge flours complied with the minimum carbohydrate content for complementary flour of 60% stipulated by CX 74-1981.

Energy

The energy content of the formulated complementary flour ranged from 394 to 409.8 Kcal/100g. All formulated complementary diets contained adequate energy recommended by CXS 74-1981. There was significant difference (p≤0.05) in energy content between the flours. More energy was observed in improved pearl millet-based formulations.

Mineral composition

Table 3: Mineral compositions of millet-soybean-cowpeas instant porridge flour (mg/ 100g on dry weight basis)

Sample	Zinc (mg/100g)	Calcium (mg/100g)	Iron (mg/100g)	Magnesium (mg/100g)
Shibe pearl millet	3.5±0.004[bc]	6.6±0.00[a]	14.±0.014[ab]	135.1±0.007[bcd]
Shibe-soybean-cowpeas (90:5:5)	3.5±0.007[cd]	9.4±0.007[b]	10.3±0.007[ac]	154.8±0.007[bc]
Shibe-soybean-cowpeas (80:15:5)	3.5±0.014[bc]	14.4±0.007[c]	8.4±0.007[ad]	145.7±0.007[bef]
Shibe-soybean-cowpeas (70:25:5)	3.5±0.00[bc]	2.5±0.007[d]	8.6±0.021[bd]	140.2±0.007[abc]
Native pearl millet	4.1±0.014[bcd]	0.7±0.007[e]	11.7±0.007[bc]	130.6±0.007[aef]
Native pearl millet-soybean-cowpea(90:5:5)	4.2±0.007[efd]	1.0±0.007[f]	13.3±0.00[cd]	134.3±0.014[adb]
Native pearl millet-soybean-cowpea (80:5:15)	4.1±0.021[abc]	1.4±0.00[g]	11.7±0.007[bcd]	149±0.007[ac]
Native pearl millet-soybean-cowpea (70:5:25)	3.1±0.014[bef]	1.3±0.007[h]	9±0.007[efd]	114.3±0.007[ef]

Values are expressed as mean± standard deviation of duplicate replications (n=2) on dry basis. Means with different super scripts are significantly different at p≤0.05.

Finger millet is claimed to have thrice the amount of calcium as milk which is critical for women and babies (Feyera et al., 2021). The calcium content in flours ranged from 0.7 to 14.4 mg/100g DM. Improved millet variety contained more calcium. . The iron content of the flours ranged from 8.4 to 14 mg/100g. The improved variety of pearl millet (*Shibe*) contained more iron than the native variety and (9 to 13.3 mg/100g). The amount of iron decreased with decrease in pearl millet content and inclusion of legumes (cowpeas and soybeans) in all formulations. This observation might be due to the fact that pearl millet contained more iron than legumes. The minimum CXS 74-1981 requirement for iron content is 10 mg/100g CXS 74-1981.

Zinc content ranged from 3.1 to 4.2 mg/100g DM. The amount of Zinc was higher in native pearl millet but it decreased with decrease in pearl millet and increased with soybeans and cowpeas were increased. Magnesium content ranged from 114.3 to 154.8 mg/100g. Improved pearl millet variety contained more magnesium (154.8 mg/100g). The inclusion of legumes increased the amount of magnesium, although there was a variation between legumes. The levels of magnesium in the flours increased with cowpeas.

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Antinutritional factors composition

Table 4: Anti-nutritional factor composition (g/100g Dry weight basis)

Sample	Phytic acid (g/100g)	Tannins (g/100g)
Shibe pearl millet	2.1±0.007[a]	13.4±0.007[bc]
Shibe-soybean-cowpeas (90:5:5)	1.4±0.000[b]	17.6±0.014[ab]
Shibe-soybean-cowpeas (80:15:5)	1.4±0.007[c]	18.5±0.007[ac]
Shibe-soybean-cowpeas (70:25:5)	1.3±0.004[d]	15.9±0.014[ad]
Native pearl millet	1.5±0.000[e]	16.2±0.021[abc]
Native pearl millet-soybean-cowpea(90:5:5)	1.3±0.007[f]	17.9±0.007[ade]
Native pearl millet-soybean-cowpea (80:5:15)	1.5±0.000[g]	18.4±0.000[edf]
Native pearl millet-soybean-cowpea (70:5:25)	1.5±0.007[h]	21.8±0.007[aef]

Values are expressed as mean± standard deviation of two replications (n=2) on dry basis. Means with different super scripts are significantly different at $p \leq 0.05$.

The phytate content ranged from 1.3 g/100g (Shibe: soybeans: cowpeas (70:25:5)) to 2.1 g/100g plain Shibe pearl millet. The improved variety of pearl millet contained more phytic acid than the native variety. The phytate content increased as content of soybeans increased, while cowpeas remained constant in the improved variety and decreased as pearl millet level decreased. This might be due to the phytic acid content in soybeans and millets. . The native millet had more phytic content that increased with cowpeas that contained higher levels of phytate; as also was observed by Ileke (2014) According to Gupta et al. (2015), phytate is normally present in foods generally ranging from 0.1-6% by mass.

The levels of tannins were almost similar in the improved millet variety (13.4 -18.5 g/100g) and in native millet (14.2 - 21.8 g/100g). It was observed that in all the formulations, tannin content increased with the inclusion of legumes. The results in this study corresponded with those reported by Gwer et al. (2020) that the addition of soybean flour (legume) in blends of millet flour increased the tannin content. It has been reported that cooking significantly reduces the amount of anti-nutrients both in cowpea and complementary porridge Syeunda et al. (2019).

4. CONCLUSIONS

This study indicated that complementation of pearl millet with soybeans and cowpeas improved the nutritional quality of the instant pearl millet-based porridge flour. The instant porridge flour, that is convenient for preparation of porridge, anywhere, anytime, without further heating would be suitable for promotion of growth and alleviation of malnutrition in children in developing countries with access to pearl millet.

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