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Effect of grain teff, finger millet and peanut blending ratio and processing condition on weaning food quality

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Abstract: This study was conducted to evaluate the effect of grain teff, finger millet and peanut blending ratio and processing condition on weaning food quality with three specific objectives. Therefore, this study was initiated to address the protein-energy malnutrition of weaning foods that are observed in many parts of developing nations. The experiment consisted of a factorial design of two factors, i.e. three blending ratios and six processing conditions in three replicates. Processing condition had significant effect on nutritional and sensory qualities of weaning food products. The proximate analysis results obtained from fermented blend B3 showed significantly higher crude protein, ash and carbohydrate contents (20.81%, 2.90% and 51.77%) respectively. The mean values (for three measurements) of moisture, protein, fat, fiber, ash and carbohydrate were 4.30%, 20.06%, 20.01%, 1.43%, 2.55%, 50.61%, respectively, in fermented weaning foods. Sensory analysis revealed that highly acceptable product was obtained from roasted blends of teff, finger...

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PUBLIC INTEREST STATEMENT

Weaning is the stage when an infant moves from a diet consisting exclusively of breast milk to one which resembles that of an adult in the community. The capacity of a weaning diet to meet the protein-energy requirement of infant depends on its nutritional quality as well as its dietary bulk. This can be achieved through legume supplementation of cereal-based weaning foods. The rapid physical growth as well as physiological, immunological and mental development when nutritional requirements are at their highest during weaning period. For instance, most brain development which protein, cholesterol, zinc and some essential fatty acids are crucial requirements in the first 2 years of birth. Therefore, proper weaning practices coupled with lengthened breastfeeding period of at least 2 years can eliminate or reduce the high incidence of infant mortality and morbidity experienced in developing countries. So, the formulation of weaning food from locally available cereals and legumes has the ability to alleviate the problems of protein-energy malnutrition.
millet and peanut. The color, flavor, taste and overall acceptability scores of roasted blend were 5.36, 5.66, 5.84 and 5.75 (on 7-point hedonic scale), respectively. Among the treatments, fermented weaning food was found to produce acceptable weaning food gruel enriched by protein, ash and carbohydrate contents.

Subjects: Food Chemistry; Carbohydrates; Food Analysis; Nutrition; Food Engineering

Keywords: blending ratio; finger millet; groundnut; teff; processing condition; weaning food composition

1. Introduction

The growth and survival of infants after the recommended period of exclusive breastfeeding for up to 6 months depend on the nutritional quality of the weaning food (Ogbeide & Ogbeide, 2000). Breast milk is a sole and sufficient source of nutrition during the first 6 month of infant life. It contains all the nutrients and immunological factors infant require to maintain optimal health and growth. Towards the middle of the first year, breast milk is insufficient to support the growing infant. Therefore, nutritive complementary foods are needed to be introduced from 6 to 24 months of age (Mamiro et al., 2005). These complementary foods are composed of based on local staple foods mainly produced from cereals and given in liquid gruel for infants (Obatolu, 2002) and they are supposed to serve as the main source of energy and nutrients for babies at weaning (Ogbeide & Ogbeide, 2000). Therefore, the combination of cereals and legume has been found to produce amino acid patterns that adequately promote growth (Ejigni et al., 2007).

Traditional methods employ roasting, germination, and fermentation of grains. These technologies are often used separately or in combination during infant weaning food preparation. The nutritional profiles of a variety of weaning blends prepared by traditional technologies were examined (Dahiya & Kapoor, 1993). Weaning foods are traditionally composed of staple cereals and legumes prepared either individually or as composite gruels (Huffman & Martin, 1994). Peanut (Arachis hypogaea), teff (Eragrostis tef) and finger millet (Eleusine coracana) are major agricultural products grown in many developing nations. Teff (Eragrostis tef) provides over two-thirds of the human nutrition in the country (Uraga & Narasimha, 1997). Therefore, cereals are deficient in lysine but have sufficient sulphur containing amino acids which are limited in legumes (Iqbal, Ateeq, KhalilS, Perveen, & Saleemullah, 2006) whereas legumes are rich in lysine. The effects of the supplementation are highly beneficial, since nutritive value of the product is also improved (Amankwah, Barimah, Nuamah, Oldham, & Nanaji, 2009).

The most important nutritional problems in weaning foods consumed by the children in many parts of developing nations are protein-energy malnutrition and deficient in essential macronutrients and micronutrients (Millward & Jackson, 2004). The high cost and inadequacy in the production of protein-rich foods have resulted in increased protein-energy malnutrition among children and other vulnerable groups in the developing world (Otegbayo, Sobande, & Aina, 2002). In view of this weaning food would be made from locally available cereals and legumes. Therefore, this work was initiated to evaluate the effect of grain teff, finger millet and peanut blending ratio and processing condition on weaning food quality with the following specific objectives:

- To determine the nutritional composition of weaning food blends of peanut, finger millet and teff.
- To determine the processing condition with the best potential for improving the nutritional quality of weaning food.
- To evaluate the sensory characteristics of weaning blends processed.
2. Materials and methods

2.1. Experimental materials
Ingredients for the composite blends were acquired from the following sources: 1) Peanut (Werer 962 variety) was obtained from BHURC (Bobila Haramaya University Research Center); 2) Finger millet (Padat variety) and teff (Gemechis variety) were obtained from MARC (Melkassa Agricultural Research Center) that grown 2009/2010 crop years. All grains were stored at room temperature until analyzed.

2.2. Seed cleaning and milling
Finger millet, teff, and groundnut were manually cleaned of debris. Split and discolored seeds were discarded. Groundnut hulls were manually removed using gloved hands, collected and stored in sealed plastic bags. Due to the extremely small seed size and the inability to decorticate, teff was used as whole seed flour. Teff and finger millet grain were milled to flour using a cyclone mill (Model 3010-081P, Colorado, USA). A peanut kernel was ground to paste using a grinding mill (Model Typ A11 basic, China). Peanut paste and milled flours were stored at room temperature in plastic bags until gruel preparation and analysis were done.

2.3. Weaning blend formulation
Weaning blends were formulated in 60% cereals to 40% legume ratios, which yield the highest projected amino acid scores based on infant lysine requirements (FAO/WHO/UNU, 1985). Ingredients were weighed and blends formulated in proportions as follows: B
\textsubscript{1} (20% teff + 40% finger millet + 40% peanut), and B
\textsubscript{2} (30% teff + 30% finger millet + 40% peanut) and B
\textsubscript{3} (40% teff + 20% finger millet + 40% peanut).

2.4. Experimental design
Samples were divided into three weaning blends and six processing conditions. A 3 × 6 factorial design (CRD) giving 18 treatments with three replicates were used for statistical analysis.

2.5. Processing methods

2.5.1. Unprocessed control
All the test samples were cleaned, free from abnormal odors, broken seeds, dust and other foreign materials including living or dead insects before ground to flour. Finger millet and teff were milled in cyclone mill (Model 3010-081P, Colorado, USA) to a fine powder that able to pass through ≤250 μm sieve size. Then, the powder obtained was placed in plastic container and stored at room temperature prior to blend. Peanut seed was ground to paste using grinding mill (Model Typ A11 basic, China). All the three samples were blended in different proportions as follows: B
\textsubscript{1} (20% teff + 40% finger millet + 40% peanut), B
\textsubscript{2} (30% teff + 30% finger millet + 40% peanut) and B
\textsubscript{3} (40% teff + 20% finger millet + 40% peanut). These blends were used as a control.

2.5.2. Natural fermentation
Fermentation was performed using the microorganisms naturally present on the grain. Slurries of the three composite blends (1:4 w/v) were made from unprocessed control ingredients by mixing 200 g of flour with 800 mL of distilled water in a sterile beaker. Slurries were fermented in a temperature-controlled incubator at 30°C for 72 hr (Chavan & Kadam, 1989). After 72 hr fermentation period, the slurries were transferred into aluminum pans, and then oven-dried (Model 10 – 1A, China) at 55°C for 48 hr. Fermented dry blends were further milled into fine flour using a home coffee grinder.

2.5.3. Germination/sprouting
Germination was performed in a darkroom following the modified method (Griffith, Castell-Perez, & Griffith, 1998). Peanut seeds were rinsed and soaked in distilled water (1:3 w/v) for 9 h at ambient temperature (23–25°C). Seeds were dried and placed on perforated aluminum pans lined with filter
paper, then placed in a dark, temperature-controlled cabinet at 30°C for 12, 24 and 36 hr germination. Germinating seeds were rinsed twice daily with distilled water to reduce microbial growth and to maintain adequate hydration. Sprouted seed was dried in forced air oven (Model 101-1A, China) at 50°C for 20 hr. Dried sprout peanut was dehulled manually using hand gloves and milled to paste by grinding mill (Model Typ A11 basic, China). Germinated peanut paste was blended with raw milled teff and finger millet flours in the different proportions as follows: B$_1$ (20% teff + 40% finger millet + 40% peanut), B$_2$ (30% teff + 30% finger millet + 40% peanut) and B$_3$ (40% teff + 20% finger millet + 40% peanut).

2.5.4. Roasting
The ingredient was roasted using flat griddle (mittade) until acceptable uniform roast color, aroma and flavor developed and then cooled under room temperature. Medium roasted peanuts were coarsely ground in to paste using grinding mill. Roasted finger millet and teff were milled in cyclone mill (Model 3010-081P, Colorado, USA) to fine powders that able to pass through ≤250 µm sieve sizes. Then, the powder obtained was placed in plastic container and stored at room temperature prior to blending. Then, the flours of roasted finger millet and teff were mixed with peanut paste as follows: B$_1$ (20% teff + 40% finger millet + 40% peanut), B$_2$ (30% teff + 30% finger millet + 40% peanut) and B$_3$ (40% teff + 20% finger millet + 40% peanut).

2.6. Proximate analysis
Proximate composition of initial ingredients and blended samples of weaning food flour were conducted using standard methods. Moisture content, ash, and fiber content of ingredients and weaning blends were determined according to Association of Official Analytical Chemists (AOAC 1990). Protein content was determined by Micro-Kjeldahl method AOAC (1990). Crude fat content was determined according to the standard method AOAC (1990) using soxhlet apparatus and carbohydrate content was calculated as the percentage difference of our proximate compositions (Livesey, 1995).

2.7. Statistical analysis
Analysis of variance (ANOVA) was used to statistically test for significant variations between three blends and processing methods using the statistical analysis system (SAS Institute and Cary, NC). Duncan’s multiple range tests were used to identify significant differences among mean main effects for blend and processing method at p < 0.05.

3. Result and discussions
3.1. Proximate composition of grains (teff, finger millet and peanut) used in the weaning food
The proximate composition of weaning food ingredients used in this experiment is shown in Table 1. The moisture contents were 10.5%, 11.0% and 3.6% for teff, finger millet and peanut, respectively. The protein content of teff was 12.32%, which was appreciably high compared to common cereals like maize, rice and sorghum. This value was higher than 10.7% reported by Kebede (2006) but was in the range (9.4-13.3%) reported by Bultosa and Taylor (2004). Compared to other cereals, teff has higher protein content than maize (8.3%), sorghum (7.1%), barley (9.0%), millet (7.2%) and almost equivalent to wheat (10.3%) (Asrat & Frew, 2001). Proximate compositions of teff (crude fat, ash, crude fiber) found in this work were within the ranges reported by Bultosa and Taylor (2004). The fat content of teff appeared to be lower than maize (4.6%) but higher than wheat, barley and millet and equivalent to sorghum (2.8%). Whereas the ash content was lower than millet and higher than others (Asrat & Frew, 2001). Apparently, the ash content of teff observed in Gemechis variety was higher than finger millet (Padat variety). Carbohydrate contents were 69.0%, 73.1% and 8.8% for teff, finger millet and groundnut, respectively. The carbohydrate content of Gemechies teff variety was in close agreement with National Research Council (1996) content 72%.
Table 1. Proximate composition of grain teff, finger millet and peanut used in the processing of weaning food in (%)

| Ingredient    | Moisture  | Ash       | Crude fiber | Crude fat | Protein   | Carbohydrate |
|---------------|-----------|-----------|-------------|-----------|-----------|--------------|
| Teff          | 10.52 ± 0.02 | 2.77 ± 0.00 | 2.46 ± 0.04 | 2.88 ± 0.00 | 12.32 ± 0.19 | 69.02 ± 0.23 |
| Finger millet | 11.00 ± 0.05 | 1.06 ± 0.07 | 1.80 ± 0.07 | 1.98 ± 0.11 | 11.07 ± 0.11 | 73.05 ± 0.33 |
| Peanut        | 3.58 ± 0.09  | 2.27 ± 0.07 | 4.75 ± 0.04 | 48.68 ± 0.15 | 31.89 ± 0.11 | 8.80 ± 0.24  |

All values are mean ± STDEV on dry basis except moisture (wet basis)
The proximate composition of finger millet used in the weaning food was 11.0% moisture, 1.1% ash, 1.8% crude fiber, 11.1% crude protein, 1.98% crude fat and 73.1% carbohydrate, respectively. Carbohydrate content was high as compared to other common cereals and legumes. This showed the high content of starch in finger millet. Fat content of finger millet was low (1.3%) probably because it has relatively small germ (Serna-Saldivar & Rooney, 1995). The low-fat content of finger millet might be important to bear storage stability due to the low tendency of becoming rancid. The carbohydrate content of finger millet reported as 70–76% of the total weight (Obilana & Manyasa, 2002). The protein content of finger millet reported varies in the range of 4.9–11.3% (McDonough, Rooney, & Serna-Saldivar, 2000). Such variations may be contributed by genotype, water availability, soil fertility, temperature and environmental condition during grain development (Serna-Saldivar & Rooney, 1995).

The proximate composition of peanut was 3.58% moisture, 2.27% ash, and 4.75% crude fiber, and 31.89% crude protein, 48.68% crude fat and 8.80% total carbohydrate (Table 1). So, groundnut provides considerable amounts of mineral elements to supplement the dietary requirements of humans and farm animals. (Asibuo et al., 2008).

3.2. Proximate composition of blended weaning food
The proximate composition of each weaning blend made by six processing method is summarized in Table 2. The moisture content of weaning blend varied significantly (p < 0.05) among processing and blending methods. Moisture content of 12 hr germinated blend had highest (8.11%) as compared to other processing methods. The interaction effect of blend was highest at 12 hr germinated peanut blend B1 (8.36%) and lowest (3.95%) was observed in B3 of fermented weaning food. This was most probably due to dry matter losses. Furthermore, the values obtained for the moisture content and the associated dry matter of the weaning blend were suitable for an increase shelf-life of the food that was formulated from cereal and legumes. High moisture content aids microbial growth and reduce shelf-life of food products. Thus, the reduced moisture content of the weaning food especially the significant drop in the moisture content serves as a positive processing step that will improve the quality of the product (Kikafunda, Abenakyo, & Lukwago, 2006). These also reduce the cost of preservation and processing of the grain for both industrial and domestic uses.

The interaction effect of blending ratio and processing condition on ash content was highest in fermented weaning food blend (B3) (2.90%) and lowest (1.88%) was in B1 of unprocessed control weaning food flour. Shah et al. (2011) found an increase in ash content during the germination of two mung bean varieties and suggested that such an increase was as a result of the reduction in fat and carbohydrate contents. Also in roasted blended weaning food for interaction and processing condition significantly (p < 0.05) increased. These results were in agreement with those indicated by who reported that the ash content of raw peanut increased as a result of roasting process (Abayomi, Isaac, & Ayodele, 2002).

The interaction of blending ratio and processing condition had significant (p < 0.05) effect on crude fiber content of weaning food flour (Table 2). The highest interaction effect on crude fiber content (4.39%) was in B3 of roasted weaning food and lowest (1.30%) was in B1 of fermented weaning food flour. The crude fiber content of germinated peanut blended weaning food significantly decreased as compared to unprocessed control weaning food flour. The decrease crude fiber content of weaning food during germination period was due to, reserve material degradation, commonly used for respiration and synthesis of new cells prior to developing embryo (Vidal-Valverde et al., 2002). The expected decrease in crude fiber content during fermentation could be attributed to the partial solubilization of cellulose and hemicelluloses type of material by microbial enzymes and partly also by leaching. A previous study has reported a significant decrease of crude fiber contents after 4 days of maize fermentation (Ejigui, Savoie, Marin, & Desrosiers, 2005).
### Table 2. Effect of blending and processing condition interaction on proximate composition of weaning food (%)

| B              | Moisture | Ash     | Crude fiber | Crude fat | Crude protein | Carbohydrate |
|----------------|----------|---------|-------------|-----------|---------------|--------------|
| **Unprocessed control** |          |         |             |           |               |              |
| B₁           | 8.13 ± 0.10<sup>a</sup> | 1.88 ± 0.02<sup>a</sup> | 3.14 ± 0.04<sup>b</sup> | 20.99 ± 0.00<sup>e</sup> | 16.51 ± 0.10<sup>d</sup> | 48.83 ± 0.67<sup>c</sup> |
| B₂           | 7.91 ± 0.06<sup>cd</sup> | 1.97 ± 0.02<sup>cd</sup> | 3.21 ± 0.05<sup>de</sup> | 21.48 ± 0.46<sup>f</sup> | 17.04 ± 0.21<sup>de</sup> | 48.86 ± 0.33<sup>c</sup> |
| B₃           | 7.89 ± 0.01<sup>cd</sup> | 2.10 ± 0.02<sup>g</sup> | 3.27 ± 0.05<sup>cd</sup> | 22.00 ± 0.13<sup>d</sup> | 17.60 ± 0.29<sup>de</sup> | 47.10 ± 0.32<sup>d</sup> |
| **Roasted**  |          |         |             |           |               |              |
| B₁           | 5.53 ± 0.09<sup>f</sup> | 2.31 ± 0.08<sup>g</sup> | 3.31 ± 0.02<sup>c</sup> | 20.90 ± 0.16<sup>i</sup> | 16.61 ± 0.24<sup>c</sup> | 51.31 ± 0.11<sup>a</sup> |
| B₂           | 5.61 ± 0.01<sup>g</sup> | 2.48 ± 0.01<sup>g</sup> | 3.93 ± 0.09<sup>b</sup> | 22.76 ± 0.46<sup>b</sup> | 17.42 ± 0.18<sup>e</sup> | 47.77 ± 0.58<sup>e</sup> |
| B₃           | 5.30 ± 0.01<sup>g</sup> | 2.78 ± 0.02<sup>g</sup> | 4.39 ± 0.07<sup>a</sup> | 20.88 ± 0.04<sup>i</sup> | 18.66 ± 0.18<sup>f</sup> | 47.96 ± 0.17<sup>e</sup> |
| **Fermented** |          |         |             |           |               |              |
| B₁           | 4.13 ± 0.06<sup>i</sup> | 2.31 ± 0.05<sup>g</sup> | 1.30 ± 0.01<sup>mi</sup> | 20.72 ± 0.00<sup>k</sup> | 19.59 ± 0.10<sup>b</sup> | 51.77 ± 0.19<sup>a</sup> |
| B₂           | 4.82 ± 0.03<sup>g</sup> | 2.44 ± 0.04<sup>c</sup> | 1.51 ± 0.09<sup>b</sup> | 20.72 ± 0.00<sup>i</sup> | 19.79 ± 0.10<sup>e</sup> | 50.68 ± 0.25<sup>b</sup> |
| B₃           | 3.95 ± 0.04<sup>g</sup> | 2.90 ± 0.04<sup>g</sup> | 1.48 ± 0.06<sup>mi</sup> | 21.45 ± 0.01<sup>g</sup> | 20.81 ± 0.10<sup>i</sup> | 49.38 ± 0.19<sup>c</sup> |
| **12 hr germinated peanut blend** |          |         |             |           |               |              |
| B₁           | 8.36 ± 0.08<sup>bc</sup> | 1.93 ± 0.01<sup>k</sup> | 1.89 ± 0.05<sup>b</sup> | 22.12 ± 0.14<sup>cd</sup> | 16.36 ± 0.11<sup>c</sup> | 49.32 ± 0.26<sup>c</sup> |
| B₂           | 8.10 ± 0.01<sup>bc</sup> | 1.98 ± 0.01<sup>i</sup> | 2.15 ± 0.02<sup>cd</sup> | 22.46 ± 0.08<sup>bc</sup> | 17.57 ± 0.19<sup>g</sup> | 48.72 ± 0.31<sup>c</sup> |
| B₃           | 7.89 ± 0.08<sup>bc</sup> | 2.21 ± 0.03<sup>bc</sup> | 1.89 ± 0.05<sup>b</sup> | 22.23 ± 0.28<sup>cd</sup> | 17.54 ± 0.10<sup>g</sup> | 47.63 ± 0.23<sup>c</sup> |
| **24 hr germinated peanut blend** |          |         |             |           |               |              |
| B₁           | 8.00 ± 0.09<sup>bc</sup> | 1.83 ± 0.04<sup>k</sup> | 1.92 ± 0.03<sup>k</sup> | 22.37 ± 0.25<sup>cd</sup> | 16.48 ± 0.10<sup>h</sup> | 49.38 ± 0.11<sup>c</sup> |
| B₂           | 7.51 ± 0.06<sup>bc</sup> | 2.02 ± 0.05<sup>bc</sup> | 2.22 ± 0.02<sup>cd</sup> | 22.82 ± 0.63<sup>d</sup> | 17.40 ± 0.18<sup>i</sup> | 47.79 ± 0.89<sup>e</sup> |
| B₃           | 7.57 ± 0.08<sup>bc</sup> | 2.11 ± 0.04<sup>bc</sup> | 1.97 ± 0.02<sup>k</sup> | 22.40 ± 0.07<sup>cd</sup> | 17.73 ± 0.10<sup>h</sup> | 48.19 ± 0.09<sup>bc</sup> |
| **36 hr germinated peanut blend** |          |         |             |           |               |              |
| B₁           | 8.11 ± 0.10<sup>b</sup> | 1.82 ± 0.02<sup>k</sup> | 2.03 ± 0.09<sup>cd</sup> | 24.02 ± 0.02<sup>cd</sup> | 17.84 ± 0.10<sup>h</sup> | 46.15 ± 0.22<sup>g</sup> |
| B₂           | 8.05 ± 0.13<sup>b</sup> | 2.09 ± 0.02<sup>bc</sup> | 2.09 ± 0.05<sup>cd</sup> | 23.94 ± 0.00<sup>k</sup> | 18.12 ± 0.12<sup>k</sup> | 45.67 ± 0.19<sup>bc</sup> |
| B₃           | 7.79 ± 0.07<sup>d</sup> | 2.17 ± 0.03<sup>de</sup> | 2.26 ± 0.04<sup>cd</sup> | 23.90 ± 0.06<sup>bc</sup> | 18.37 ± 0.10<sup>cd</sup> | 45.50 ± 0.08<sup>bc</sup> |
| **Mean**     | 6.93     | 2.18    | 2.64        | 22.13     | 17.80         | 48.46        |
| **CV**       | 1.13     | 1.85    | 2.30        | 1.12      | 0.90          | 0.74         |

All values are expressed as Mean ± STDV of % dry basis except moisture (% wet basis). Values in a column with the same letter are not significantly different (p < 0.05). Note: B = Blending, CV = coefficient of variation in (%); B₁ = 20% teff + 40% finger millet + 40% peanut; B₂ = 30% teff + 30% finger millet + 40% peanut; B₃ = 40% teff + 20% finger millet + 40% peanut.
Crude fat content for all blends varied significantly (p < 0.05) resulting from differences among individual ingredients and processing conditions. The highest crude fat content (23.96%) was recorded in germinated blend and lowest (21.49%) was for unprocessed control blends. Interaction effects of blend on crude fat content were highest (24.02%) in 36 h germinated peanut blend (B1) and lowest (20.72%) was in fermented weaning food flour at B1. Weaning blend formulation of peanut increases fat provided more concentrated calorie source rich in the essential fatty acid, linoleic acid. In reality desirable and more expensive oils are often consumed by household members other than the targeted child (Huffman & Martin, 1994). During the process of germination, significant changes in the biochemical, nutritional, and sensory characteristics of cereals occur due to degradation of reserve materials as used for respiration and synthesis of new cell constituents for developing embryo in the seed (Sharma, Saxena, & Riar, 2016). As compared to un-germinated seed, germinated seeds contain high protein, low unsaturated fatty acids, low carbohydrate, and mineral content (Sharma et al., 2016).

The interaction of blending and processing condition had significant (p < 0.05) effect on protein contents (Table 2). The highest protein content (20.81%) was observed in fermented weaning food blend (B3) and lowest (17.04%) was in unprocessed control blend (B3). The protein content of weaning blend was increased probably due to a reduction of phytic acid which might have contributed to the improved digestibility observed in germinated, roasted and fermented blends. Protein digestibility during germination reported that improved and while improvements in in-vitro protein digestibility with fermentation were associated with proteolytic enzyme production by micro-organisms (Khetarpaul & Chauhan, 1990). The observed increment in protein content after fermentation was probably due to shift in dry matter content through depletion during fermentation by action of the fermenting microorganisms (Abdelhaleem, El Tinay, Mustafa, & Babiker, 2008). However, cells of the fermenting microorganisms could have contributed to the protein, therefore, fermentation of weaning blend results in an observable increase in crude protein content. In most human diets, the protein is more limiting than others. Therefore, application of the fermentation process that appears to increase the protein content even at the expense of other nutrients may be advantageous nutritionally (Abdelhaleem et al., 2008). Improvements in protein quality have also been documented after fermenting blended mixtures of plant-based complementary foods based on maize and legumes, groundnut and millet and cereal and soybean blends (Gibson, Perlas, & Hotz, 2006). The improvement in protein digestibility after germination, dry heating could be attributed to the reduction of anti-nutrients such as phytic acid, tannins and polyphenols, which are known to interact with proteins to form complexes. Heat processing has been reported to increase the digestibility of proteins by destroying protease inhibitors (Abbey & Berezi, 1988).

Carbohydrate content was determined by difference. The interaction of blending ratio and processing condition had significant (p < 0.05) effect on carbohydrate content (Table 2). The highest (51.77%) was recorded for fermented weaning food blend (B1) and lowest (45.50%) was observed in 36 hr germinated peanut blends of weaning food (B3). The processing methods significantly increased carbohydrate content of weaning food, the highest carbohydrate content of weaning food during processing (50.61%) when it was fermented and lowest (45.77%) in 36 hr germinated peanut blends. Moreover, fermentation and roasting treatments increased significantly the carbohydrate contents. The increase in the total carbohydrates content of legumes after roasting and fermenting would be attributed to the retro-gradiation of starch after gelatinization (Wang, Hatcher, & Gawalko, 2008).

### 3.3. Sensory evaluation of weaning food

The interaction effect of blending ratio and processing condition had significant (p < 0.05) effect in the color of weaning food (gruel). The color of the thin porridge made from germinated peanut-blended flour was most preferred (like very much) by the panelists, while the thin porridge prepared from roasted and fermented flour were least preferred for color (like slightly). The highest weaning food gruel color (5.88) was observed in B2 of unprocessed control (like very much) and least (5.08) were obtained in B2 (like slightly) of roasted weaning food gruel.
The interaction of processing condition and blending ratio was significant (p < 0.05) on weaning food flavor (Table 3). The highest value of gruel flavor (5.72) was recorded in roasted weaning food gruel of B3 (like very much) and lowest 4.78 was recorded in B2 of fermented weaning food gruel (like slightly). Also, interaction effect of processing condition and blending ratio had significant effect on taste of weaning food gruels. The highest value (6.04) was in roasted blend (B3) and lowest (4.66) was in B2 of fermented weaning food gruel. During roasting, the taste of weaning food gruel was preferred very much as compared to other processing conditions. The panelists, however, noted that color, taste and overall acceptability of the gruel prepared were highly acceptable.

Overall acceptability of weaning food (gruel) was significantly (p < 0.05) affected by processing condition and blending ratio (Table 3). The highest processing mean 5.75 (like very much) was recorded in roasted and lowest 5.12 (like slightly) was obtained in fermented weaning food gruels. The highest (6.04) overall acceptability of weaning food was observed in roasted sample blended at B3 and the lowest (5.04) was observed in the fermented sample of blended at B3. Roasting of samples done for the legumes had an important improvement on the flavor of the formulations.

Table 3. Effect of blending and processing condition interaction on sensory quality of weaning food

| Blend                      | Flavor/aroma | Taste | Color      | Overall acceptability |
|----------------------------|--------------|-------|------------|------------------------|
| Unprocessed control        |              |       |            |                        |
| B1                         | 5.34 ± 1.09BC| 5.74 ± 0.94BC| 5.52 ± 1.07BC| 5.66 ± 0.89ABC         |
| B2                         | 5.28 ± 0.92BC| 5.40 ± 1.03BC| 5.88 ± 1.04a  | 5.68 ± 0.89ABC         |
| B3                         | 5.18 ± 0.84BC| 5.58 ± 0.94BC| 5.24 ± 0.65CD | 5.38 ± 0.77DEF         |
| Roasted                    |              |       |            |                        |
| B1                         | 5.62 ± 1.06AB| 5.82 ± 0.98AB| 5.30 ± 1.01CD | 5.52 ± 0.83CDE         |
| B2                         | 5.66 ± 1.06AB| 5.68 ± 1.09AB| 5.08 ± 1.19d  | 5.70 ± 1.12ABC         |
| B3                         | 5.72 ± 1.05a | 6.04 ± 0.69a | 5.70 ± 0.95abc | 6.04 ± 0.87a           |
| Fermented                  |              |       |            |                        |
| B1                         | 4.98 ± 0.99DE| 4.92 ± 1.00DE| 5.10 ± 1.14a  | 5.20 ± 0.67DEF         |
| B2                         | 4.88 ± 1.17ef| 4.66 ± 0.96ef| 5.26 ± 1.10cd | 5.14 ± 0.98ef          |
| B3                         | 4.50 ± 1.01f | 4.64 ± 1.24f | 5.38 ± 1.19bfc| 5.04 ± 1.06f           |
| 12 hr germinated peanut blend |          |       |            |                        |
| B1                         | 5.38 ± 0.98bcd| 5.50 ± 1.01bc| 5.50 ± 0.88bcd | 5.76 ± 0.62abc         |
| B2                         | 5.34 ± 0.79bcd| 5.44 ± 0.86bc | 5.82 ± 0.71ab  | 5.89 ± 0.77ab          |
| B3                         | 5.16 ± 0.93bcd| 5.52 ± 0.99bc | 5.62 ± 0.92abc | 5.42 ± 0.88def         |
| 24 hr germinated peanut blend |        |       |            |                        |
| B1                         | 5.22 ± 0.93bcd| 5.46 ± 0.73bc | 5.46 ± 0.95bcd | 5.38 ± 0.85def         |
| B2                         | 5.30 ± 0.83bcd| 5.50 ± 1.07bc | 5.58 ± 0.78abc | 5.68 ± 0.84abc         |
| B3                         | 5.04 ± 1.08bc | 5.42 ± 0.97bc | 5.36 ± 1.00cd | 5.46 ± 0.83cde         |
| 36 hr germinated peanut blend |      |       |            |                        |
| B1                         | 5.28 ± 0.81bcd| 5.34 ± 0.84bc | 5.58 ± 0.73abc | 5.38 ± 0.85def         |
| B2                         | 5.34 ± 0.93bcd| 5.52 ± 0.97bc | 5.30 ± 0.99cd | 5.68 ± 0.84abc         |
| B3                         | 5.18 ± 1.10bcd| 5.46 ± 1.01bc | 5.52 ± 0.99bcd | 5.46 ± 0.83cde         |
| Mean                       | 5.24         | 5.42   | 5.45       | 5.54                   |
| CV (%)                     | 18.82        | 17.95  | 17.91      | 15.57                  |

Values followed by different letters within a column indicate significant difference (p < 0.05) using DMRT. * = Mean ± SD, CV = coefficient of variation, B1 = 20% teff + 40% finger millet + 40% peanut, B2 = 30% teff + 30% finger millet + 40% peanut, B3 = 40% teff + 20% finger millet + 40% peanut.
(Mitzner et al., 1984). Generally, sugar is by far the most important addition to complementary foods and is commonly added to improve the flavor and to encourage infants to eat while fat acts as flavor retainer and increases the mouth feel of foods (Walker & Pavitt, 2007). Oil also improves the taste/flavor of the product and reduces the bulkiness of starchy food in the mixture (Walker & Pavitt, 2007). Germination also improves the consistency, mouth feel and taste of the product (Helland, Wicklund, & Narvhus, 2002). Sensory panelists are highly rated for formulations from germinated grains for all the sensory parameters investigated (Inyang & Zakari, 2008).

4. Conclusions

The results of this study have demonstrated that blending cereal and legume grains as well as processing them significantly enhanced the nutrient density and sensory quality of the weaning food samples. An infant weaning food of high nutrient density could be formulated and prepared from a combination of teff, finger millet and peanut. Blend formulation showed the strongest impact on nutritional quality and should receive attention in the design and development of an infant weaning food. This study showed that blending ratio and processing condition significantly influenced the proximate composition of blended weaning food flour.

Processing conditions (roasting, fermentation and sprouting) were improved the proximate composition and sensory quality of weaning food blends but crude fiber content was significantly reduced during fermentation and peanut-sprouted blend. Generally, the present result suggests that blending ratio and processing condition significantly improved the nutrient density of weaning foods.

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Competing interests

The authors declare that there are no competing interests regarding the publication of this paper.

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