Effect of Processing Methods and Blending Cereal and Legume Grain on Some Mineral and Sensory Qualities of Weaning Foods

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Abstract: The most important nutritional problems in weaning foods consumed by infants in many parts of developing nations including Ethiopia are deficiencies in macronutrients and micronutrients. In view of this, the effect of processing method and blending of teff, finger millet, and sprouted groundnut on mineral contents and sensory acceptability of weaning food gruel was investigated. The treatments consisted of three blends B_1 (20% teff + 40% finger millet + 40% groundnut), B_2 (30% teff + 30% finger millet + 40% groundnut) and B_3 (40% teff + 20% finger millet + 40% groundnut) and six processing condition (roasting, fermentation, three duration of sprouting and unprocessed blend as a control). The experiment was laid out as a Completely Randomized Design (RCD) in a factorial arrangement (3 x 6 = 18 treatments) and replicated three times per treatment. The mineral contents of initial ingredients and blended samples were analyzed using standard methods. Processing condition had significant ($P < 0.05$) effect on mineral and sensory properties of weaning food gruel. On sprouting (groundnut), roasting, and fermentation, zinc content increased. The highest zinc content (3.86 mg/100 g) was obtained in response to sprouting groundnut for 12 hr in blend B_3 and the lowest was (1.91 mg/100 g) in the control weaning food B_1. The highest iron (32.96 mg/100 g) content was recorded for roasted weaning food of B3, while the lowest (14.70 mg/100 g) was obtained in the control blend B1. The highest calcium (304.82 mg/100 g) content was in the roasted weaning food blend B_1 and the lowest (110.63 mg/100 g) was in the control blend B1. Sensory analysis revealed that the most acceptable product was obtained from roasted blends of weaning food (i.e., color, flavor, taste and overall acceptability scores of 5.36, 5.66, 5.84 and 5.75 on 7-point hedonic scale, respectively). Overall, the result showed, roasting or fermentation or sprouting of groundnut (12 to 24 hr and drying the sprout at 50 ^{o}C for 20 hr) and blending level at B_3 have improved the nutrient quality and sensory acceptability of weaning food gruel compared to control sample. In the developing country like Ethiopia factory processed weaning foods are not affordable for majority of the population, such domestic processing conditions can be promoted at each household to improve weaning food gruel quality for child of weaning age.

Keywords: Blending ratio; fermentation; finger millet; groundnut sprouting; teff, mineral contents; roasting, sensory quality

1. Introduction

The growth and survival of infants after the recommended period of exclusive breast feeding of six months depends on the nutritional quality of the weaning food (Ogbeide and Ogbeide, 2000; Dewey and Brown, 2003). Breast milk is a sole and sufficient source of nutrition during the first six months of infant life since it contains all nutrients and immunological factors that infants require to maintain optimal health and growth. However, towards the middle of the first year, breast milk alone is insufficient to support the growing infant. Therefore, nutritious complementary foods are needed to be introduced from six to twenty-four months of age (Mamiro *et al*., 2005). Weaning foods are traditionally processed from staple cereals and legumes either individually or as composite gruel (Huffman and Martin, 1994; Mensah and Tomkins, 2003), and supposed to serve as additional source of energy and nutrients for babies at weaning (Ogbeide and Ogbeide, 2000).

Traditional methods such as roasting, germination/ sprouting, and fermentation of grains are often used separately or in combination during preparation of weaning foods. Roasting is one of the processing steps involved in the nut manufacturing industry to improve the flavor, color, texture and overall acceptability of the product (Ayyildiz *et al*., 2001). The textural characteristic of the whole-kernel is affected by the roasting condition while moisture content is reduced on roasting (Boge *et al*., 2009). Color is an important quality indicator of the roasting process (Cämmerer and Kroh, 2009). Germination/sprouting is a food processing method by which the quality of a cereals and legumes can be improved for both digestibility, nutrient bioavailability and physiological function. During germination, enzymatic activity and bioactive compounds increase within the seed. Germination is induced by rehydration of the seed, which increases both respiration and metabolic activity that allow the mobilization of primary and secondary metabolites. The process of germination comprises three unit

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ISSN 1993-8195 (Online), ISSN 1992-0407(Print)

operations: steeping, germination and drying (Lee *et al*., 2007). Germination is a practical, cost-effective, and sustainable process for production of weaning foods with minimum paste viscosity, high energy, and nutrient density (Mensah and Tomkins, 2003). Groundnut (*Arachis hypogaea*), teff *(Eragrostis tef)* and finger millet (*Eleusine coracana*) are major agricultural products grown in many developing nations especially in Ethiopia. Teff (*Eragrostis tef*) provides over two-thirds of the human nutrition in Ethiopia (Uraga and Narasimha, 1997). Both teff (Bultosa, 2016) and finger millet (Chandra *et al.,* 2016) are high in their nutritional quality and research toward desirable weaning food gruel processing from them are important.

The most important nutritional problems in weaning foods consumed by children in many parts of developing nations are protein energy malnutrition, deficiency in micronutrients, presence of anti-nutrients and lack of hygienic processing (Mensah and Tomkins, 2003; Millward and Jackson, 2004; Abrams *et al*., 2013). So, diets that lack animal source of food (meat, poultry, fish, or eggs and milk product) cannot meet the nutritional requirements of children ages 6 to 24 months unless supplementary foods are used. If milk and other animal source foods are not taken in adequate amounts, grain legumes should be consumed daily, preferably within the same meal, to ensure adequate nutrient requirement (Mensah and Tomkins, 2003). Thus, weaning foods made from locally available cereals and legumes are important at weaning age. With appropriate processing and blending of cereal and legume grains that can be easily conducted at household level, there is a possibility to produce quality weaning foods. Therefore, in this work, the effects of processing methods (roasting, fermentation and three duration of groundnut sprouting) and three blending ratio (%) B1 (20:40:40), B2 (30:30:40) and B3 (40:20:40) of teff, finger millet and sprouted groundnut, respectively on Ca, Zn and Fe contents and sensory acceptability of weaning gruel were reported.

2.Materials and Methods

2.1. Description of Study Site

Sample preparation and analysis were conducted at the Department of Food Science and Postharvest Technology, Haramaya University, Ethiopia.

2.2. Experimental Materials

Ingredients for the composite blends were acquired from the following sources: 1) Groundnut (*Werer 962* variety*)* was from Babile, Haramaya University Research Center; 2) Finger millet (*Padat* variety) and teff (*Gemechis* variety) were from MARC (Melkassa Agricultural Research Center). The grains were all obtained from the harvests of 2009/2010 cropping year. All samples were stored at room temperature until being analyzed.

2.3. Experimental procedures

2.3.1. Grains and Nuts Cleaning

Finger millet, teff, and groundnut were manually cleaned of debris. Split and discolored seeds were discarded. Groundnuts were shelled manually using gloved hands, collected and stored in sealed plastic bags.

2.3.2. Weaning Blend Formulations

Weaning blends were formulated at 60% cereal 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 blended on dry matter basis.

2.3.3. Treatments and Experimental Design

Samples were divided into treatment of three blends and six processing methods.

The three blends were: B1 (20% teff + 40% finger millet + 40% groundnut), B2 (30% teff + 30% finger millet + 40% groundnut) and B3 (40% teff + 20% finger millet + 40% groundnut).

The six processing methods were: three duration (12, 24 and 36 hr) of groundnut sprouting, roasting, fermentation and control (unprocessed blended flour). The experiment was laid out as a Completely Randomized Design (RCD) in a factorial arrangement (3 x 6 = 18 treatments) and replicated three times per treatment.

2.3.4. Processing Methods

Unprocessed control: all the samples were cleaned, free from abnormal odors, broken seeds, dust and other foreign materials including live or dead insects before grinding to flour. Finger millet and teff were milled by cyclone mill (Model 3010-081P, Colorado, USA) to particle size of ≤ 250 μm sieve pore size, packed in plastic bottles with screw caps and stored at room temperature prior to blending. Groundnut was shelled and ground to paste using a grinding mill (Model Typ A11 basic, China).

***Natural fermentation*:** fermentation was performed using the microorganisms naturally associated with the grain. Slurries of the three composite blend levels (1:4 w/v) were made from unprocessed control (raw ingredient blend) by mixing 200 g of the sample 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 and 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 in to fine flour using a coffee grinder.

Sprouting of groundnut: this was performed in a dark room following the modified method of Griffith *et al.* (1998). Groundnut were rinsed and soaked in distilled water (1:3 w/v) for 9 hr at ambient temperature (23-25^{o}C). Seeds were blot dried and placed on perforated aluminum pans lined with filter paper, then placed in a dark, temperature-controlled cabinet at 30^{o}C for 12, 24 and 36 hr for sprouting. Sprouted seeds were rinsed twice daily with distilled water to reduce microbial growth and to maintain adequate hydration. After sprouting, seeds were dried in a forced air oven (Model 101-1A, China) at 50°C for 20 hr. Seed coat of dried sprout groundnut was removed manually using hand gloves and milled to paste by a grinding mill (Model Typ A11 basic, China).

Roasting: the ingredients were roasted using flat griddle until acceptable uniform roast color, aroma and flavor developed and then cooled under room temperature. Medium roasted groundnuts were coarsely ground into paste using a coffee grinder mill. Roasted finger millet and teff were milled by cyclone mill (Model 3010-081P, Colorado, USA) to fine flour (≤ 250 μm sieve pore size), packed in plastic bottles with screw caps and stored at room temperature prior to blending. Then the flours of roasted finger millet and teff were mixed with groundnut paste.

2.4. Mineral Analysis

The mineral (zinc, iron and calcium) contents of initial ingredients and blended samples of the weaning food flour were analyzed using standard methods by Atomic Absorption Spectrophotometer (AACCI, 2000 Method 40-70).

2.5. Sensory Evaluation

Sensory acceptability was evaluated by 50 undergraduate, postgraduate students and staff members of the Department of Food Science and Postharvest Technology, Haramaya University. The weaning food gruels were prepared by mixing 135 g of flour with 900 mL of distilled water (15% w/v). The slurries were cooked in a boiling water until 15 min with regular stirring to prevent lump formation. Just before each test session, orientation was given and the cooled sample (about 45 min) were served on a plate with spoon as three digit codded samples in a random order to judges. Water in a cup was provided to cleanse carryover after each taste. The sensory attributes: taste, visual color, flavor and overall acceptability were evaluated on a seven point hedonic scale (7 = like extremely and 1 = dislike extremely).

2.6. Statistical analysis

A triplicate data were subjected to analysis of variance (ANOVA) using the statistical analysis system (SAS Institute and Cary, NC). Means significant difference were separated by Duncan's multiple range tests at $p < 0.05$.

3. Results and Discussion

3.1. Mineral contents

Mineral contents of teff, finger millet, and groundnut used in the weaning food gruel

The zinc and iron contents were highest in teff, followed by groundnut and finger millet (Table 1). The calcium content was highest in grain teff followed by finger millet and peanut. Almost similar zinc content (2.86 mg/100 g), but lower iron content (36.18 mg/100 g) was reported in grain teff by Abebe *et al.* (2007). The calcium and zinc contents determined in grain teff were almost similar to the value reported previously by Urga *et al.* (1997). In addition to grain teff variety, the variation in mineral composition of the soil on which the teff plant was grown and differences in the postharvest handling practices of grain teff, particularly difference on soil contamination degree during threshing are contributors toward grain teff mineral contents difference.

The zinc content of groundnut seed was in the range 0.0-6.5 mg/100 g reported by Asibuo *et al.* (2008). The finger millet zinc and iron contents found in this study was almost similar to the value reported by Mamiro *et al.* (2001) (i.e., zinc = 2.05 mg/100 g and iron = 5.48 mg/100 g), but were lower than the value reported by Chandra *et al.* (2016) for calcium (344 mg/100 g) and zinc (2.3 mg/100 g). The analysis shows high mineral content to the weaning food blend can be contributed by teff. Also high calcium and iron to then blend are contributed by finger millet and groundnut, respectively.

Table 1. The mineral contents of grains used for processing of weaning food.

Grain	Zn (mg/100 g)	Fe (mg/100 g)	Ca (mg/100 g)
Teff	3.10 ± 0.03	21.13 ± 0.38	152.91 ± 3.44
Finger millet	1.58 ± 0.03	7.24 ± 0.40	139.20 ± 3.12
Groundnut	2.79 ± 0.00	19.16 ± 0.37	78.51 ± 3.12

Note: All values are mean ± sd on dry matter basis

3.2. Effect of Blending Ratio and Processing Method Interaction on Mineral Contents of Weaning Food

The interaction effect of blending ratio and processing method significantly ($P < 0.05$) influenced Zn contents of the blended weaning food flour (Table 2). The highest Zn content (3.86 mg/100 g) was recorded for 12 hr sprouted groundnut blend (B_3) and lowest (1.91 mg/100 g) was in B_1 of unprocessed control weaning food flour. The increase in mineral contents of the weaning food in response to processing of the grains can be attributed to the destruction of anti-nutrient (phytic acid and condensed tannin) factors that chelates mineral elements and make them not bio-unavailable. Germination enhances bioavailability of Zn, Fe and Ca and improve protein quality in maize, legumes, groundnuts, pumpkin and millet seeds (Sandstrom, 2001). Also germination and malting induce hydrolysis of phytate and hence increase Zn, Fe, Ca and magnesium absorption (Sandström, 2001; Gharibzahedi and Jafari, 2017). The net effect on the nutrient bioavailability depends on the balance between factors that either inhibit or enhance nutrient absorption and/or utilization in the whole diet (Sandström, 2001; Gharibzahedi and Jafari, 2017). Some inherent anti-nutritional factors such as protease inhibitors, phytate, tannins and other phenolic compounds, oxalic acid and saponins are plant constituents which play an important role in biological functions of plants. These compounds, in humans, reduce the digestibility of nutrients and the absorption of minerals (Dicko *et al.,* 2005). Due to the various processing methods (germination/sprouting and fermentation) phytates can be hydrolyzed by phytase enzymes and such processing leads to improved mineral absorption in cereals/legumes food products.

Table 2. Effect of blending ratio and processing method interaction on mineral contents of weaning food.

Blend	Zn (mg/100 g)	Fe (mg/100 g)	Ca (mg/100 g)
Unprocessed control			
B_1	1.91 ± 0.03^{o}	14.70 ± 0.39^{k}	110.63 ± 3.64k
B_2	2.34 ± 0.03^{m}	16.24 ± 0.00^{i}	112.39 ± 3.39^{kj}
B_3	2.07 ± 0.03^{n}	17.59 ± 0.00^{g}	118.25 ± 3.46^{j}
Roasted			
B_1	2.55 ± 0.03^{kl}	19.79 ± 0.00^{d}	304.82 ± 5.86^{a}
B_2	2.71 ± 0.03^{j}	26.45 ± 0.02^{b}	264.51 ± 5.80^{C}
B_3	2.86 ± 0.02^{i}	32.96 ± 0.00^{a}	293.14 ± 5.87^{b}
Fermented			
B_1	3.19 ± 0.03^{h}	19.51 ± 0.01^{e}	138.77 ± 5.59^{i}
B_2	3.21 ± 0.03^{h}	26.23 ± 0.00^{b}	151.37 ± 5.90^{fg}
B_3	3.32 ± 0.02^{g}	18.76 ± 0.00^{f}	115.47 ± 5.77^{kj}
12 hr sprouted groundnut blend			
B_1	3.66 ± 0.02^{d}	15.44 ± 0.38^{j}	139.01 ± 5.89^{i}
B_2	3.71 ± 0.03^{c}	16.06 ± 0.39^{i}	142.68 ± 3.46^{hi}
B_3	3.86 ± 0.03^{a}	17.61 ± 0.00^{g}	146.47 ± 3.48^{gh}
24 hr sprouted groundnut blend			
B_1	3.43 ± 0.03^{f}	16.71 ± 0.38^{h}	150.61 ± 0.04^{fg}
B_2	3.50 ± 0.01^{e}	17.98 ± 0.38^{g}	157.68 ± 3.40^{ef}
B_3	3.77 ± 0.00^{b}	19.11 ± 0.38^{ef}	162.07 ± 0.04^{de}
36 hr sprouted groundnut blend			
B_1	2.53 ± 0.02^{l}	15.40 ± 0.38^{j}	156.95 ± 0.10^{ef}
B_2	2.58 ± 0.03^{k}	19.22 ± 0.39^{e}	162.69 ± 0.09^{de}
B_3	2.72 ± 0.03^{j}	20.31 ± 0.00^{c}	166.17 ± 3.14^{d}
Mean	3.00	19.59	166.31
CV	0.93	1.32	2.53

Note: Mean ± sd within a column with the same letter are not significantly different (P>0.05); CV=Coefficient of Variation; B_1=20% teff + 40% finger millet + 40% groundnut; B_2=30% teff + 30% finger millet + 40% groundnut; B_3= 40% teff + 20% finger millet + 40% groundnut.

Iron content varied significantly ($P < 0.05$) among the blends and processing methods (Table 2). The highest value of iron (32.96 mg/100 g) was recorded for roasted weaning food samples of blend (B_3) where teff content in the blend was high, while the lowest value (14.70 mg/100 g) was recorded for B_1 of unprocessed control flour (i.e., where teff content in the blend was low).

The interaction of blending ratio and processing condition had a significant effect ($P < 0.05$) on calcium content of blended weaning food sample (Table 2). The highest calcium content was recorded for B_1 of roasted weaning food sample (304.82 mg/100 g) and the lowest (110.63 mg/100 g) was recorded for B_1 of control weaning food sample. With roasting an increase in zinc, iron and calcium contents were observed and similar was reported in other works (Ayoola and Adeyeye, 2010) which was implicated because of the loss of volatile components on roasting. Sprouted groundnut blended food significantly ($P < 0.05$) affected calcium content as compared to control sample. The calcium contents of sprouted groundnut blended weaning food sample at 12, 24, and 36 hr were 142.72, 156.08 and 161.93 mg/100 g, respectively (Table 3). This result showed that there was a significant improvement in the mineral contents of the blended weaning foods as compared to the control weaning food sample.

3.3. Effect of Main Factors of Blending Ratio and Processing Condition on Mineral Contents of Weaning Food

Processing condition and blending ratio had a significant ($P < 0.05$) effect on mineral contents of weaning food sample (Table 3). The highest value of Zn (3.86 mg/100 g) was recorded for 12 hr sprouted groundnut blended weaning food (B3) and the lowest (1.91 mg/100 g) was recorded for B1 of control weaning food sample. Increasing teff proportion had increased zinc content of blend from 2.88 mg/100 g in B1 to 3.10 mg/100 g for B_3 blends. This shows sprouting groundnut and blending proportion had a significant effect on mineral contents of weaning food sample. Combination of cooking and fermentation were known to improve the nutrient quality and to reduce the content of anti-nutritional factors to safe levels in comparison to other methods of processing (Obizoba and Atii, 1991).

The work showed that Ca, Zn, and Fe contents were significantly highest ($P < 0.05$) in the processed samples as compared to the control weaning food sample. During sprouting, roasting and fermentation, zinc content was increased. Germination has been an effective treatment to remove anti-nutritional factors from legumes (e. g., phytates and galactosides) and in mobilizing secondary metabolites (Uebersax, 2006). Such domestic processing are cheap and more effective in improving the nutritional value of grains and legumes, and, therefore, hoped that this can contribute to nutrition improvement for infants.

Table 3. Effect of the main factors processing methods and blending ratio on mineral contents of weaning foods.

Factor			
Processing method	Zinc (mg/100 g)	Iron (mg/100 g)	Calcium (mg/100g)
C	2.11 ± 0.19^{f}	16.17 ± 1.26^{e}	113.76 ± 4.59^{f}
R	2.71 ± 0.13^{d}	26.40 ± 5.70^{a}	287.49 ± 18.66^{a}
F	3.24 ± 0.06^{c}	21.50 ± 3.56^{b}	135.20 ± 16.54^{e}
SD_1	3.74 ± 0.09^{a}	16.37 ± 1.00^{e}	142.72 ± 5.65^{d}
SD_2	3.57 ± 0.15^{b}	17.94 ± 1.09^{d}	156.08 ± 5.28^{c}
SD_3	2.61 ± 0.08^{e}	19.14 ± 1.08^{c}	161.93 ± 4.32^{b}
CV (%)	2.94	12.16	6.72
Blending ratio			
B_1	2.88 ± 0.61^{c}	17.34 ± 1.98^{b}	165.55 ± 65.34^{a}
B_2	3.01 ± 0.51^{b}	20.36 ± 4.49^{a}	166.80 ± 48.64^{a}
B_3	3.10 ± 0.64^{a}	21.06 ± 5.56^{a}	166.93 ± 61.53^{a}
CV (%)	2.94	12.16	6.72

Note: values are means ± sd. Values followed by different letters with in a column indicate significant difference (P < 0.05): Note: CV=Coefficient of variation, C=Unprocessed control, R=Roasted, F=Fermented, SD_1, SD_2, SD_3 (sprouted groundnut blend at 12, 24, and 36 hr, respectively); B_1=20% teff + 40% finger millet + 40% groundnut; B_2=30% teff + 30% finger millet + 40% groundnut; B_3=40% teff + 20% finger millet+ 40% groundnut.

There was a significant (P < 0.05) effect on the iron content of weaning food samples due to blending ratio and processing method (Table 3). As compared to the control blend, the iron content has significantly increased with roasting, fermentation, duration of groundnut sprouting and with an increase in the proportion of teff in the blend. The highest (26.40 mg/100 g) iron content was obtained for roasted weaning food blend and the lowest (16.70 mg/100 g Fe) was recorded for the unprocessed control weaning food blends. Iron content of the blends was increased from 17.34 mg/100 g for blend B_1 to 21.06 mg/100 g for blend B_3. Also during germination, iron content of blended weaning food significantly (P < 0.05) increased as compared to the control samples. Similar to this an increase in iron and phosphorus contents in response to germination of various cereals/legumes was earlier reported by Sulieman *et al.* (2007). In addition to reduction of phytic acid and condensed tannins, fermentation can result into lower proportion of dry matter in the food leading to an increase in the mineral bioavailability (Adams, 1990; Mohite *et al.* 2013).

The calcium content of blended weaning food significantly (P < 0.05) increased in roasted, fermented and on sprouting of groundnut processing conditions, but were not due to blending ratio of three blends (B_1, B_2 and B_3) (Table 3). The highest calcium content (287.49 mg/100 g) was recorded for the roasted weaning foods and the lowest (113.76 mg/100 g) was recorded for the control weaning food sample. This shows that processing significantly increases the calcium content of weaning food flours. During germination, calcium content increased with germination time, possibly due to degradation/hydrolyses of anti-nutrients factors. Malting can improve safety of foods by degradation of toxic and anti-nutritional substances such as phytates, lectin and haemagglutinins thereby can improve the bioavailability of essential minerals (iron, calcium, zinc, phosphorus) (Chung *et al.*, 2009; Li *et al.*, 2014). Consistent with the results, improvements in calcium bioavailability was observed after germination and fermentation of legume samples, which was attributed to simultaneous reduction of phytic acid, tannin, and dietary fibers (Ghanem and Hussein, 1999). Mensah *et al.* (1991) also reported that long period of fermentation hydrolyzed phytates and increased minerals. Thus this study conquer that processing methods at household levels such as soaking, fermentation, germination and roasting of cereal staples and legumes can be manipulated to enhance the content of micronutrients and/or alter the levels of absorption modifiers to improve micronutrients bioavailability (Hotz and Gibson, 2001; Mensah and Tomkins, 2003).

3.4. Sensory Evaluation of Weaning Food

The scores obtained for sensory attributes: aroma, taste, color and overall acceptability demonstrated significant (P < 0.05) differences among the formulated weaning foods tasted (Table 4). The interaction of processing condition and blending ratio had significant (P < 0.05) effect on weaning food flavor. The highest value of gruel flavor (5.72) was recorded for the roasted weaning food gruel of B_3 (liked very much) and the lowest (4.50) was for fermented weaning food gruel blend of B_3 (liked slightly). The flavor in fermented gruel blend appeared low probably because of lactic acid. Whereas in roasted weaning gruel the flavor were high because of flavor release by Maillard and caramelization reactions on roasting. Similar to this, roasting of legumes were reported to result in a significant improvement in the flavor of the formulations (Karen *et al.*, 1984). Among sprouting duration, 12 hr sprouted peanut scored high flavor. Processing method and blending ratio had significant effect on taste of the weaning food gruels. The highest taste value (6.04) was in roasted weaning food blend (B_3) and the lowest (4.66) was in B_2 of fermented weaning food gruel. The roasting weaning food gruel was preferred very much as compared to the other processing methods. The highest weaning food (gruel) color (5.88) was observed in B_2 of control (liked very much) and least (5.08) were obtained in B_2 (liked slightly) of roasted weaning food gruel. The color of food gruel made from sprouted groundnut blended sample was most preferred (liked very much), while those prepared from roasted and fermented flour was least preferred for color (liked slightly). Sprouting can lead to production of more reducing sugars from starch and free amino acids from proteins and this probably helped to release color compounds on Maillard and caramelization reactions during sprouted groundnut drying at 50 ^oC for 20 hr that influenced color acceptance. Germination is known to improve the consistency, mouth feel, and taste of the product (Helland *et al.*, 2002) and in other works panelists have highly rated for formulations from germinated grains for all the sensory parameters investigated (Inyang and Zakari, 2008). Overall acceptability of weaning food gruel was significantly ($P < 0.05$) affected by processing condition and blending ratio.

Table 4. Effect of blending ratio and processing condition interaction on sensory quality of weaning food.

Blend	Flavor/aroma	Taste	Color	Overall acceptability
Unprocessed control				
B_1	5.34 ± 1.09^{cde}	5.74 ± 0.94^{abc}	5.52 ± 1.07^{bcd}	5.66 ± 0.89^{abc}
B_2	5.28 ± 0.92^{cde}	5.40 ± 1.03^{bc}	$5.88 \pm 1 .04^{a}$	5.68 ± 0.89^{abc}
B_3	5.18 ± 0.84^{cde}	5.58 ± 0.94^{bc}	5.24 ± 0.65^{cd}	5.38 ± 0.77^{def}
Roasted				
B_1	5.62 ± 1.06^{abc}	5.82 ± 0.98^{ab}	5.30 ± 1.01^{cd}	5.52 ± 0.83^{cde}
B_2	5.66 ± 1.06^{ab}	5.68 ± 1.09^{abc}	5.08 ± 1.19^{d}	5.70 ± 1.12^{abc}
B_3	5.72 ± 1.05^{a}	6.04 ± 0.69^{a}	5.70 ± 0.95^{abc}	6.04 ± 0.87^{a}
Fermented				
B_1	4.98 ± 0.99^{de}	4.92 ± 1.00^{d}	5.10 ± 1.14^{d}	5.20 ± 0.67^{def}
B_2	4.88 ± 1.17^{ef}	4.66 ± 0.96^{d}	5.26 ± 1.10^{cd}	5.14 ± 0.98^{ef}
B_3	4.50 ± 1.01^{f}	4.64 ± 1.24^{d}	5.38 ± 1.19^{bcd}	5.04 ± 1.04^{f}
12 hr sprouted groundnut blend				
B_1	5.38 ± 0.98^{bcd}	5.50 ± 1.01^{bc}	5.50 ± 0.88^{bcd}	5.76 ± 0.62^{abc}
B_2	5.34 ± 0.79^{cde}	5.44 ± 0.86^{bc}	5.82 ± 0.71^{ab}	5.89 ± 0.77^{ab}
B_3	5.16 ± 0.93^{cde}	5.52 ± 0.99^{bc}	5.62 ± 0.92^{abc}	5.42 ± 0.88^{def}
24 hr sprouted groundnut blend				
B_1	5.22 ± 0.93^{cde}	5.46 ± 0.73^{bc}	5.46 ± 0.95^{bcd}	5.38 ± 0.85^{def}
B_2	5.30 ± 0.83^{cde}	5.50 ± 1.07^{bc}	5.58 ± 0.78^{abc}	5.68 ± 0.84^{abc}
B_3	5.04 ± 1.08^{de}	5.42 ± 0.97^{bc}	5.36 ± 1.00^{cd}	5.46 ± 0.83^{cde}
36 hr sprouted groundnut blend				
B_1	5.28 ± 0.80^{ecd}	5.34 ± 0.84^{c}	5.58 ± 0.73^{abc}	5.38 ± 0.85^{def}
B_2	5.34 ± 0.93^{cde}	5.52 ± 0.97^{bc}	5.30 ± 0.99^{cd}	5.68 ± 0.84^{abc}
B_3	5.18 ± 1.10^{cde}	5.46 ± 1.01^{bc}	5.52 ± 0.99^{bcd}	5.46 ± 0.83^{cde}
Mean	5.24	5.42	5.45	5.54
CV (%)	18.82	17.95	17.91	15.57

Note: Values followed by different letters within a column indicate significant difference ($P < 0.05$) using DMRT. * = Mean ± sd, CV= coefficient of variation, B_1=20% teff + 40% finger millet + 40% groundnut, B_2=30% teff + 30% finger millet + 40% groundnut, B_3=40% teff + 20% finger millet + 40% groundnut.

The highest (6.04, liked very much) overall acceptability was recorded in roasted of blend B3 and the lowest (5.12, liked slightly) was recorded for the fermented weaning food gruel. The highest (6.04) overall acceptability of weaning food was observed in the roasted sample blended at B_3 and the lowest (5.04) was observed in the fermented sample of blended at B_3.

Over all the panelists have noted that flavor, taste, color and overall acceptability of the weaning food gruel prepared were highly acceptable in roasted and sprouted groundnut processed weaning gruel. The work showed domestic processing conditions such as sprouting, roasting and fermentation have high potential for processing acceptable and nutrients improved food gruels.

4. Conclusions

The results of this study have demonstrated that blending cereal and legume grains as well as processing them significantly enhanced the mineral contents (zinc, iron and calcium) of the weaning food samples. Processing (roasting, fermentation or groundnut sprouting) improved the mineral contents and sensory quality attributes of the weaning food sample. Overall, the result showed, roasting or fermentation or sprouting of groundnut (12 to 24 hr and drying the sprout at 50 °C for 20 hr) and blending level at B3 (40% teff + 20% finger millet + 40% groundnut) have improved the nutrient quality and sensory acceptability of weaning food gruel compared to control sample. Blend formulation showed the strongest impact on mineral contents i.e. zinc, iron and calcium and should receive attention in the design and development of weaning foods.

5. Acknowledgments

The authors thanks the Ministry of Education for granting the first author the financial required to do this research in connection with his MSc study. The authors also thanks Melkassa Agricultural Research Center for providing teff and finger millet samples; Babile, Haramaya University Research Center for providing groundnut; Center of Research on Grain Quality, Processing and Technology Transfer at Food Science and Postharvest Technology Department of Haramaya University for supporting with facilities.

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