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Nutritional composition and consumer acceptability of complementary meal blended from pearl millet, sorghum, chickpea, sesame and moringa oleifera

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ABSTRACT

Childhood malnutrition caused by the consumption of low nutrient density foods is continues to be a major problem in Ethiopia. Complementary foods play a crucial role in facilitating consumption of important nutrients. Therefore, it is better to focus on development of complementary food aimed to reduce such malnutrition. This study was designed to formulate complementary food from the blend of malted sorghum and pearl millet, roasted chickpea and sesame, moringa oleifera flours for vulnerable infants. All samples were cleaned of any impurities. Pearl millet and sorghum samples were malted and dried; chickpea and sesame samples were roasted; and moringa oleifera sample was dried. Then all samples were milled, sieved and packed for further analysis. The proximate composition and anti-nutritional factors and sensory analysis were conducted by standard methods. The result of this study revealed that proximate and anti-nutritional factors composition are significantly affected (P<0.05) by the blend ratio. Moisture, protein, fat, carbohydrate, and energy value content ranged from 4.35 (T4) to 4.77% (T1), 13.51 (T5) to 15.91% (T4), 8.05 (T2) to 12.40% (T4), 61.40 (T4) to 66.79% (T2) and 394.66 (T2) to 420.83 kcal/100g (T4) respectively. Tannin, phytic acid and oxalate content ranged from 4.37(T1) to 11.16% (T5), 0.02(T2) to 0.04% (T1) and 41(T5) to 69.12mg/100g (T1) respectively. The overall sensorial acceptability of complementary food (porridge) ranged from 4.75 (T3) to 5.17 (T4). Therefore, based on the proximate composition and sensory evaluation data, treatment four (T4) of the proportion, 20% sorghum + 40% pearl millet + 20% chickpea + 10% sesame + 10% moringa oleifera complied with codex standards set for complementary food. Therefore, this proportion can be taken as an appropriate complementary food to fulfill the nutritional demand of children either by manufacturing in complementary food processing factories or preparing at household level if ingredients are easily accessible.

1. INTRODUCTION

Childhood malnutrition caused by the consumption of complementary foods having less nutrient density is still a major problem in several low and middle-income countries (Black et al., 2008). Globally, 144 million children under five are stunted, 47 million are wasted, and 38.3 million are overweight (UNICEF et al., 2020). According to this report, Africa accounts for a larger share of these indecencies, with 57.5 million stunted, 12.7 million wasted, and 9.3 million overweight children in this age group. Among 7 billion of the world population, about 2 billion (28.57%) people suffer from micronutrient malnutrition and nearly 800 million people (11.43%) suffer from energy (calorie) deficiency (International Food Policy Research Institute, 2016). Under-nutrition accounts for 45% of all < 5 deaths (Hawkes, 2017). When we look the nutrition situation here in Ethiopia, 38% <5 children are stunted, 10% <5 children are wasted and 24% < children are underweight (CSA and ICF, 2016). In Amhara region, 46% <5 children are stunted, 10% <5 children are wasted and 28% < children are underweight (CSA and ICF, 2016). The density of nutrients in the first 1,000 days, the period from the start of a mother's pregnancy through her child's second birthday, determines the futurity of many children, and in fact, nations. This window period is critical since the brain and body of children are developing rapidly and good nutrition is essential to determine a healthy and productive future. Infant and children development is impacted by the consumption of inappropriate nutrients during this time, which can lead to irreversible stunted growth, poor brain development, decreased academic performance, and higher mortality rates. (Keyata et al., 2021; UNICEF, 2020). Acute and chronic illnesses, reduced physical capacity, increased social service demand are also the effects of child under-nutrition in person as well as the general public.

To combat such problems, complementary food should be formulated and served to vulnerable infants. However, the high cost of supplemented infant formulae forcing consumers in low and middle-income countries to depend solely on low nutrient gruel/porridge to complement the infant diet (Abeshu et al., 2016). Complementary foods are nutritious liquids, semi-solid and/or solids foods that are usually given when breast milk is no longer able to meet the recommended nutritional needs of older infants and young children between the ages of 6 and 23 months (Abeshu et al., 2016). Balanced nutrient content, low bulk density, low viscosity and appropriate texture along with a consistency that allows easy consumption are the properties of complementary foods having good quality (Fleischer et al., 2003). When we come to the region, the Amhara region which contributes the second largest agricultural product in the country shows the highest vulnerability of malnutrition. Waghimra zone is one of the zones where severe malnutrition is observed in the region. Stunting, wasting and underweight are most likely to happen due to macronutrient deficiency. To prevent infant and young children (<5) malnutrition and its associated health problems, complementary food should be produced from locally available nutrient dense crops (Bolarinwa et al., 2016). Pearl millet and sorghum, chickpea, sesame and moringa olifera were known to provide the carbohydrate, protein, energy and micronutrient contents respectively. Thus, the aim of this study was to produce complementary food that is nutritionally adequate, readily available and have a consistency that allows easy consumption to infants from pearl millet and sorghum, chickpea, sesame and moringa olifera flours.

1. MATERIALS AND METHODS

1.1. Sampling and sample preparation

Samples of pearl millet and sorghum from Sekota Dry Land Agricultural Research Center; sesame from Gondar Agricultural Research Center and moringa oleifera from Woramit Horticultural Crop Research Sub-center were collected. In addition, chickpea sample was purchased at Bahir dar town open market. All grains were cleaned manually to remove broken kernels, husk, stems, damaged grain, stone, dust, unwanted materials, undersized and immature grains and other extraneous materials.

1.2.Pearl millet sample preparation

Cleaned seeds, about 2.5kg, were washed three times in tap water, soaked for 12h in tap water (1:3 w/v) at room temperature. After soaking, the grains were drained and uniformly spread on wet cotton cloth. The grains were covered with another cotton cloth. Malting was carried out at room temperature for 48h according to the method followed by Inyang and Zakari, (2008). The grains were de-vegetated, moldy seeds were removed by hand and the sprouted seeds washed with tap water before drying with sun drying to about 12% moisture content. The germinated and dried grains were soaked in tap water and de-hulled to remove the bran. The de-hulled and dried grain samples were grounded, sieved and then packed in airtight plastic bags until further analysis.

1.3. Sorghum sample preparation

Three rounds of tap water washing were performed on 2.5 kg of cleaned seeds, followed by a 12-hour soak at room temperature in tap water (1:3 w/v). After soaking, the grains were drained and uniformly spread on a wet cotton cloth. Water was sprayed on top of the grains after they were covered with another cotton cloth. Malting took place at room temperature for 48h according to the method followed by Inyang and Zakari (2008). The grains were de-vegetated, the sprouted seeds were rinsed with tap water after the moldy ones were manually removed, and they were then sun-dried until the moisture content reached about 12%. The bran was removed from the germinated and dried grains by soaking under tap water and de-hulling them. Dried and de-hulled grain samples were grounded, sieved and then packed in airtight plastic bags until further analysis.

1.4. Chickpea sample preparation

After washing to get rid of dust and draining the water, a 2 kg sample of chickpeas was handled. Then, the sample was roasted in hot air oven for 30 minutes at 150°C (Keyata et al., 2018). The cooled sample was decorticated, grounded, sieved and then packed in airtight plastic bags until further analysis.

1.5. Sesame sample preparation

About 2kg of sesame sample was manually sorted to remove stones, metals and other extraneous materials such as dust and fine plant residues, followed by winnowing. Thereafter, the winnowed seeds were washed and soaked for 18 h. After soaking, the grains were de-hulled using mortar and pestle, washed and dried. The dried sample was roasted at 70°C for 30min and was milled. The obtained flour was sieved and packaged in an air tight container for further processing (Fasuan et al., 2017).

Moringa oleifera sample preparation

Moringa oleifera leaf powder was prepared the method followed by Odinakachukwu et al. (2014). Fresh leaves of Moringa oleifera were plucked, washed and drained, shade-dried, pulverized, sieved and packaged in polythene bag for further analysis.

Weaning blend formulation

Malted sorghum, pearl millet, roasted chickpea, sesame, and moringa oleifera leaf flour were combined to develop five composite flours in various compositions. These proportions were selected by reviewing various literatures (Onabanjo et al., 2009; Olaitan et al., 2014; Emmanuel Omale, 2019). Ingredients were weighed, and the following ratios of blends were developed:

T1 (65% sorghum + 10% pearl millet+5% chickpea+ 10% sesame+ 10% moringa)

T2 (50% sorghum + 20% pearl millet+10% chickpea+ 10% sesame+ 10% moringa)

T3 (35% sorghum + 30% pearl millet+15% chickpea+ 10% sesame+ 10% moringa)

T4 (20% sorghum + 40% pearl millet+20% chickpea+ 10% sesame+ 10% moringa) and

T5 (5% sorghum + 50% pearl millet+25% chickpea+ 10% sesame+ 10% moringa)

These flour samples were thoroughly mixed, packaged and kept at ambient temperature until needed for analysis.

Experimental design

The experiment consisted of five treatments (blend ratios) each of which had malted sorghum and pearl millet, roasted chickpea and sesame, and dried moringa oleifera flour in different proportions. A complete randomized design was employed for the treatments and except for sensory evaluation test, each was replicated three times.

Proximate composition determination

The experiment flour's proximate composition: moisture, crude fat, crude protein, crude fiber, and total ash were ascertained through the use of the AOAC Official Method 925.09, 4.5.01, 979.09, 962.09, and 923.03, respectively (Horwitz and Latimer, 2000). Carbohydrate was determined by calculated difference method, and the energy value was determined by multiplying the proportion of protein, fat, and carbohydrate by their respective physiological energy values and taking the sum of the products (Farzana and Mohajan, 2015).

Anti-nutritional content determination

Tannin content determination

The tannin content was analyzed using the method followed by Makkar and Goodchild (1996). 10 ml of 70% aqueous acetone was added to a 50 ml sample bottle containing 0.2 g of the sample, which was then properly covered. After shaking the bottle for two hours at 30°C, the solution was centrifuged at 1,000-× g, and the collected supernatant was placed in ice for storage. Subsequently, 0.5 ml of Folin-Ciocalteu reagent (the same quantity of reagent was added to 1 ml of 0.5 mg/ml standard tannic acid solution) was added to 0.2 ml of the solution and 0.8 ml of distilled water. Following the addition of 2.5 ml of 20% Na_2CO_3, the solutions were vortexed and left to incubate for 40 minutes at room temperature. The tannin content was computed as an equivalent of tannic acid by measuring the absorbance of the reaction mixture at 725 nm using a spectrophotometer.

Determination of phytate content

After being soaked for three hours in 100 milliliters of 2% HCl, 4 gram of the powdered sample was passed through No. 1 Whatman filter paper. Next, 25 milliliters of the filtrate and an indicator, 5 milliliter of a 0.3% ammonium thiocyanate solution was mixed. The appropriate acidity was then achieved by adding 53.5 ml of distilled water, and the mixture was titrated against an iron (III) chloride solution containing 1.95 mg of iron per milliliter until a persistent brownish yellow color was observed for five minutes. The obtained titer value was used to calculate the phytate content. This was determined according to Day and Underwood (1986).

Determination of oxalate content

The mixture was passed through a No. 1 Whatman filter paper after being soaked 1 gram of the powdered sample in 75 milliliters of 1.5 N H2SO4 for an hour. 25 milliliters of the filtrate were then titrated at a high temperature (approximately 80–90°C) against 0.1 M KMnO4 until a pink color observed for 15-second. With the titer value acquired, the oxalate content was subsequently computed.

Porridge preparation

Porridge was prepared by the method used by Peninah et al., (2019) with some modification. In order to make the porridge, 150 g of composite flour were added to 400 ml of cold water and then to 450 ml of boiling water. 4g of salt and 30g of sugar were added. After continuously stirring the mixture to a boil, it was left to boil for a further fifteen minutes. The prepared gruel was poured to cups those are ready for serving.

Sensory properties

Fifteen trained staffs from Amhara Agricultural Research Institute (ARARI) were used to conduct sensory evaluation on taste, flavor, color, mouth feel, texture, and overall acceptability of the prepared porridge from the blended samples. The scoring was done based on a 7 point hedonic scale where 7 = like extremely and 1= dislike extremely, with results subjected to analysis of variance at 5% level of significance (Larmond, 1973).

Analysis of the data

SAS software version 9.0 was used to analyze the data. One-way analysis of variance (ANOVA) and Duncan's multiple range tests were used for the multiple comparison analysis. A test for statistical significance was run at the 0.05 probability level.

2. RESULTS AND DISCUSSION

2.1. Chemical composition of the blended flour

Chemical composition of the developed blended flour from pearl millet, sorghum, chickpea, sesame and moringa olifera flours is given bellow. The mean moisture content value for the tasted blended flours varied significantly (P<0.05) from 4.35 to 4.77% for T4 and T1 (Table 1). Moisture content monitoring in foods and food products is crucial, because high moisture contents can reduce shelf life by increasing microbial degradation activity, resulting in bad odor and unacceptable taste of the product (Olu-Owolabi et al., 2007). In general, the moisture content of all the tested blends was below 5% recommended by the Codex Alimentarius Commission (2007) for infant formula.

The protein content of the blends (Table 1) ranged from 13.51% (T5) to 15.91% (T4) on a dry weight basis with RV 15%. There was significant difference between blends (P<0.05) (Table 1) on protein content. Though T4 (15.91) was significant from the other blends, T3 (15.32%) also higher than the other blends. This observation might result from the mixing of substantial and balanced amount of malted sorghum (20%) and pearl millet (40%) to the second highest amount of chickpea (20%), the ideal protein source for the blends. Blending of cereal-based foods and their processing methods can improve the protein content of the flour (Gibson and Hotz, 2001). The results obtained from this investigation specifically T4 and T3 were higher the protein value (15%) stipulated in the Codex Alimentarius Commission (1991) by 0.91 and % and 0.32% respectively. However, less than the complementary flour made with a blend of peanut, soybean, maize, and powdered moringa oleifera leaf which is 16.04-17.59% reported by Shiriki et al. (2015). The difference may be due to the addition of higher protein content pulses (soybean and peanut).

The total ash content in the blended flours ranged between 2.24% (T1) and 3.04% (T5). There was a significant difference between blends (P<0.05) (Table 1). In the blends, the ash content has increased with increasing the proportion of chickpea. Bojňanská et al. (2012) and Obse et al. (2017) reported similar results when lentil and chickpea are added into cereal-based complementary foods. The ash content obtained for the complementary flour was similar to sorghum, soybean and sesame flour blends reported by Emmanuel Omale (2019) which is 2%. Except T5, the other complementary flours meet the recommendation (<3%) set by Codex Alimentarius Commission (1991).

The fat percentages of the blended flour in this study varied from 8.05 (T2) to 12.40 (T4), with a range of RV 10-25%. There was significant difference between the tested blends (P<0.05). The higher fat content was observed in the fourth treatment, T4 (20% sorghum + 40% pearl millet+20% chickpea+ 10% sesame+ 10% moringa). Similar results with the range between 10.22% and 10.55% were recorded on complementary food blended from Moringa Oleifera and Pearl Millet (Olaitan et al., 2014). The fat content obtained for the complementary flour in this study was much less than 21.5% which is reported by Emmanuel Omale (2019) from sorghum, soybean and sesame flour blends. This difference was probably due to the addition of soybeans that is a source of fat in addition to sesame to the complementary food reported by

Emmanuel Omale (2019). However, similar results observed in the blends of Soybeans, Sorghum and Crayfiah which was reported to be 8.4% by Akapo et al. (1995).

As indicated in Table 1, the mean fiber content of the blends ranged from 3.16% to 4.39% for T3 and T2 respectively. The treatment variations had a significant effect (P<0.05) on the mean fiber value of the final complementary flour. The amounts of fiber found in this study meet the minimum level recommended by the Codex Alimentarius Commission (1991) which is ≤5%. Different researchers reported similar results (3.66-4.11% by Onabanjo et al. (2009); 2.94-4.42% by Shiriki et al. (2015); and 3.56% by Varsha and Sangeeta (2017).

The carbohydrate contents of complementary flours in this study were in the range between 61.40 (T4) to 66.79 % (T2) with RV 41.12-64% (Table 1). The blend ratio variation had a significant effect (P<0.05) on the mean carbohydrate content of the final complementary flour. With respect to the present study, lower result (41.8%) was recorded by Emmanuel Omale (2019) at complementary food made with blends of soybean, sesame, and sorghum flours and 50.06-57.43% by Onabanjo et al. (2009) at complementary foods produced from sorghum, sesame, carrot and crayfish. However, Asma et al. (2006), recorded higher values of carbohydrate (68.7-72.7%) at a weaning food formulated from sorghum supplemented with legumes and oil seeds.

According to Codex Alimentarius Commission (1991), the recommended amount of energy for complementary foods is ranged from 1672 to 1777KJ per 100gm, which is equivalent to 400 to 425kcal per 100gm. The mean energy values (calorie) in this study were ranged from 394.66 to 420.83 kcal per 100gm of the complementary flour for T2 and T4 respectively (Table 1). Except treatment 2 (394.66 kcal/100gm), the other complementary flours can satisfy the minimum energy requirements set by Codex Alimentarius Commission (1991). As indicated in Table 1, the treatment variations had a significant effect (P<0.05) on the mean energy value (calorie) of the final complementary flour. The higher energy value was found in the fourth treatment, T4 (20% sorghum + 40% pearl millet +20% chickpea + 10% sesame + 10% moringa). Similar results (397.48-408.24%) were observed on the complementary flour blended from crayfish, carrot, sesame, and sorghum (Onabanjo et al., 2009). The result of the current research was lower than the result (448.08-472.76%) of complementary flour made with maize, Soybean and Peanut Fortified with Moringa oleifera Leaf Powder (Shiriki et al., 2015). The possible reason for the increment of energy value in the indicated report might be due to higher starch in the maize and higher fat contents which can provide more energy from maize, soybean and peanut.

The tannin contents of complementary flour were found to be in the range between 4.37 (T1) to 11.16 % (T5). The second least value of tannin was recorded in the treatment four (T4) which is 5.86% (Table 2). The blend ratio variation had a significant effect (P<0.05) on the mean tannin content of the final complementary flour. The result of the present study was minimum as compared to 152.50-220.00% recorded from Ogi, millet-based gruel supplemented with treated African oil bean (James et al., 2015). The pretreatment procedures of malting and decortication possible could be the cause of the study's low tannin content in the potential source of tannin (sorghum). However, it was greater than the tannin content reported by Desalegn et al. (2015), 0.004-0.02%, in the complementary food prepared based on quality protein maize (QPM).

As indicated in Table 2, the phytic acid contents of complementary flour in this study were ranged from 0.02 to 0.04 for treatment T2 and T1 respectively. Malting and decorticating of pearl millet might be the reason for the occurrence of minimum amount of phytic acid in the final blended complementary flour. The treatments variations have a significant effect ($P<0.05$) on the mean phytic acid value of the final complementary flour. Similar results (0.02-0.03%) were reported from pearl millet, Irish potato and sesame seed blend by Aande et al. (2020). In addition, almost comparable tannin contents (0.08-0.14%) of tannin were reported (Desalegn et al., 2015). In the contrary, James et al. (2015) reported higher amount (21.71-25.20%) of tannin relative to the current study.

The blend ratio differences as treatments variations have a significant effect ($P<0.05$) on the mean oxalate content of the final complementary flour (Table 2). The oxalate contents of the tested complementary flour were ranged from 41.00 (T5) to 69.12 mg/100g (T1). The anti-nutritional factor reduction methods (malting, decortication and roasting) which were employed for sample preparation might be the cause for minimum amounts of oxalate content in the present study. Lower oxalate content of 0.39-0.78mg/100g was reported from pearl millet, Irish potato and sesame seed blends (Aande et al., 2020). In addition, Onwurafor et al. (2017) reported 1.30-1.59mg/100g of oxalate from sorghum-maize-mungbean malt complementary food. Higher amount of oxalate content (15.96-22.50g/100g) also reported by James et al. (2015) from millet and African oil bean seed flour blend.

Table 1: Proximate composition of the blended flour (Mean ± SD)

Formulated foods	Moisture /%/	Fat /%/	Ash /%/	Protein /%/	CHO /%/	Fiber /%/	Energy value /kcal/100g/
T1	4.77 ± 0.04^{a}	10.92 ± 0.10^{b}	2.24 ± 0.26^{d}	13.90 ± 0.18^{c}	64.00 ± 0.08^{b}	4.18 ± 0.29^{a}	409.87 ± 0.50^{cb}
T2	4.49 ± 0.07^{b}	8.05 ± 0.02^{c}	2.52 ± 0.02^{c}	13.77 ± 0.35^{dc}	66.79 ± 0.76^{a}	4.39 ± 0.48^{a}	394.66 ± 1.48^{d}
T3	4.44 ± 0.07^{cb}	10.96 ± 0.08^{b}	2.64 ± 0.08^{cb}	15.32 ± 0.17^{b}	63.49 ± 0.33^{b}	3.16 ± 0.08^{b}	413.87 ± 0.08^{b}
T4	4.35 ± 0.02^{c}	12.40 ± 1.02^{a}	2.78 ± 0.12^{b}	15.91 ± 0.1^{a}	61.40 ± 0.90^{c}	3.17 ± 0.09^{b}	420.83 ± 5.86^{a}
T5	4.57 ± 0.12^{b}	10.61 ± 0.20^{b}	3.04 ± 0.00^{a}	13.51 ± 0.9^{d}	64.44 ± 0.42^{b}	3.84 ± 0.46^{a}	407.25 ± 0.40^{c}
RV	< 5	10-25	< 3	15	41.12-64	≤ 5	400-425

**Means with the same alphabet as superscript within same columns are not significantly different at 5% significance level. RV: indicates reference value*

Table 2: Anti-Nutrient composition of the blended flour (Mean ± SD)

Formulated foods	Tannin/%/	Phytic acid/%/	Oxalate (mg/100g)
T1	4.37 ± 0.35^{e}	0.04 ± 0.01^{a}	69.12 ± 1.70^{a}
T2	9.22 ± 0.23^{b}	0.02 ± 0.00^{b}	47.70 ± 3.92^{cb}
T3	6.55 ± 0.17^{c}	0.03 ± 0.01^{ba}	42.97 ± 7.06^{c}
T4	5.86 ± 0.04^{d}	0.03 ± 0.01^{ba}	53.92 ± 1.11^{b}
T5	11.16 ± 0.24^{a}	0.03 ± 0.01^{ba}	41.00 ± 2.77^{c}

**Means with the same alphabet as superscript within same columns are not significantly different at 5% significance level.*

Sensory evaluation

The result of sensory evaluation is summarized in Table 3. All sensorial attribute of thin porridge was not significantly affected (p>0.05) by different blend ratios. The sensory score of taste, flavor, color, mouth feel, texture and overall acceptability were ranged from 4.42-5.33. Complementary food prepared from treatment four (T4), having the second more pearl millet, was the most accepted in overall acceptability than the other samples. Olaitan et al. (2014) reported that the general acceptability of complementary food from the highest pearl millet blends (97.5%) in the blend of pearl millet and moringa oleifera was the most accepted.

The taste of the porridge was ranged from 5.00 (for T3 and T5) to 5.33 for T2 (Table 3). The porridge from treatment two (T2) gets the highest mean score (5.33) which was prepared from 50% sorghum, 20% pearl millet, 10 chickpea, 10% sesame and 10% moringa oleifera flours. The second higher mean score (5.25) was recorded in T1 and T4. The taste of porridge from the blended flours showed a non-significant difference (p>0.05).

The flavor acceptance of complementary food found in between 4.92 and 5.08. Treatment three (T3) obtained the highest mean score (5.08) which was prepared from 35% sorghum, 30% pearl millet, 15 chickpea, 10% sesame and 10% moringa oleifera flours. The flavor of porridge was not significantly affected (p>0.05) by the blend of the above listed flours (Table 3). The flavor acceptance was increased when the proportion of malted sorghum and pearl millet was about equivalent. This may be because malting effects in the improvement of the flavor. Germination is also known to enhance flavor acceptability of food products (Inyang and Zakari, 2008).

The texture of the porridge was ranged from 4.83 to 5.17 (Table 3). Treatment one (T1), which was prepared from 65% sorghum, 10% pearl millet, 5 chickpea, 10% sesame and 10% moringa oleifera flours, obtained the highest mean score (5.17). The texture of porridge was not significantly affected (p>0.05) by blends of the flours. Odinakachukwu et al. (2014) reported a comparable result in porridges made with maize, soybean, and Moringa oleifera leaves.

The color acceptance of complementary food in this study was found in range of 4.42–4.92. The highest color acceptance was recorded in the fourth treatment, 20% sorghum + 40% pearl millet + 20% chickpea + 10% sesame + 10% moringa oleifera (Table 3). The color acceptance of porridge was not significantly affected (p>0.05) by blends of the flours.

Overall acceptability

The overall acceptability of porridge was not significantly affected (p>0.05) by blends of the flours. The 5 treatments of complementary food samples had ranged from 4.75 to 5.17. The highest score had recorded in fourth treatment of the proportion, 20% sorghum + 40% pearl millet+20% chickpea+ 10% sesame+ 10% moringa oleifera. At the second higher percentage of roasted chickpea, the porridge's overall sensory acceptability increased. This result was in agreement with the investigations of Fikiru et al. (2017) who reported high overall acceptability of complementary processed food formulated from maize, roasted pea, and malted barley blended ratio.

Table 3: Mean ± SD of sensory attributes

Sample code	Sensorial attributes				
	Taste	Flavor	Color	Texture	Overall acceptability
T1	5.25±1.29 [a]	4.92 ±1.24 [a]	4.75 ±0.96 [a]	5.17 ±0.83 [a]	5.08 ±1.00 [a]
T2	5.33 ±0.79[a]	5.00 ±1.04 [a]	4.67 ±0.65 [a]	5.08 ±0.51 [a]	5.00 ±0.43 [a]
T3	5.00 ±1.35[a]	5.08 ±1.44 [a]	4.58 ±0.90 [a]	5.00 ±0.74 [a]	4.75 ±1.14 [a]
T4	5.25 ±1.29[a]	5.00 ±1.04 [a]	4.92 ±0.67 [a]	5.00 ±0.85 [a]	5.17 ±0.83 [a]
T5	5.00 ±1.13[a]	4.92 ±1.00 [a]	4.42 ±0.90 [a]	4.83 ±0.94 [a]	4.92 ±0.90 [a]

[*] *Means with the same letter within the same column are not significantly different*

3. CONCLUSION

Complementary foods allow the consumption of important nutrients that can reduce the observed childhood malnutrition, which continues to be a major problem in Ethiopia. Thus, to alleviate such problem, complementary food was developed from pearl millet, sorghum, chickpea, sesame and moringa oleifera and its nutritional composition and consumer acceptability were assessed. Based on the physicochemical and sensory evaluation results, the developed complementary food with the proportion of 20% sorghum + 40% pearl millet + 20% chickpea+ 10% sesame+ 10% moringa oleifera was better than the other blends tested in the current study. It consists 4.35% moisture, 12.40% fat, 2.78% ash, 15.91% protein, 61.40% carbohydrate, 3.17% fiber, and 420.83 kcal/100g energy value in which all fulfills the codex standards for complementary food. In addition, the highest sensorial overall acceptability score (5.17) had recorded on the complementary food prepared from this proportion. Therefore, it can be taken as an appropriate complementary food to fulfill the nutritional demand of children in Waghimra zone, Amhara region, Ethiopia. This could also play a great role in alleviating the protein energy malnutrition of children in other locations those can grow or access the blended crops in Ethiopia. This complementary food primarily supposed to be manufactured in complementary food processing factories. However, it is possible to prepare at household level if ingredients are easily accessible.

DATA AVAILABILITY

The proximate composition (moisture content (%), Ash (%), Fat (%), Protein (%), Carbohydrate (%), Fiber (%), Energy value (kcal/100g)); Anti nutritional factors (Tannin (%), Phytic acid (%) and Oxalate (mg/100g)); and Sensorial attributes (Taste, Flavor, Color, Texture and Overall acceptability) data's those employed to bolster the results of this investigation are included within the article.

CONFLICT OF INTEREST

The authors state that they have no competing interests.

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