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Nutritional Quality and Sensory Acceptability of Complementary Food from Blend of Sorghum (*Sorghum bicolor* L Monech), Pumpkin (*Cucurbita pepo*) and Pigeon Pea (*Cajanus cajan* L.) in Maale and Benna Tsemay Woreda, Southern Ethiopia

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Abstract

This study assessed the nutrient composition and sensory properties of complementary food prepared from sorghum, pigeon pea and pumpkin flour blends. Four formulations of the composite flours were produced and evaluated. Results showed that moisture contents were <10%. Ash content had ranged from 1.72%-3.62%. Crude fiber content had ranged from 2.14%-11.36%. Protein content had ranged from 10.82%-13.04%. β-carotene contents were varied from 90 µg/100 g-4609 µg/100 g. Iron content varied from 3.867 mg/100 g-4.842 mg/100 g. Zinc content varied from 1.578 mg/100 g-1.710 mg/100 g. Phytate content was between 69.00 mg/100 g-92.40 mg/100 g. Tannin content was between 335.76 mg/100 g and 431.01 mg/100 g. Molar ratio of phytate to zinc varied from 0.404-0.549. Molar ratio of phytate to iron varied from 0.131-0.166. Sensory evaluation results showed that the mean score of overall acceptability ranged, 3.41-4.39. It can be concluded that BF3 (56% SF: 20% PF: 24% PPF) has high protein, β-carotene, iron, zinc and low phytate as compared to control (100% SF). BF1 (100% control) has low iron, vitamin A and β-carotene as compared to other ratios. Formulation BF3 (56% SF: 20% PF: 24% PPF) were highly acceptable by mother-child pairs. Generally, locally available and low cost food ingredients used in the present study have potential to develop complementary foods.

Keywords: Nutritional q uality; Pigeon p ea; Pumpkin; Sensory acceptability; Sorghum

Introduction

The first two years of human life are the critical window of opportunity where one can improve the wellbeing of a child. Adequate nutrient intake, especially of protein and micronutrients, enhances growth of children and decreases susceptibility to disease. Around 6 months of age introduction of complementary foods along with sustained breastfeeding is required as mother's milk solely cannot provide adequate energy.

Complementary food helps in promote growth and provides healthy life, but such foods should be include adequate quantities of animal foods and vitamin A-rich fruits, vegetables every day. Where it is not possible, the use of fortified complementary foods and vitamin, mineral supplements is necessary to ensure nutritional adequacy. Complementary foods in developing countries are mostly comprised of cereals or starchy root crops which are provided in the form of porridge, it results in deficiencies of key micro-(Fe, Zn, Ca, vitamin B2, vitamin A and vitamin C) and macro (protein) nutrients [1].

In Ethiopia, the diet of infants and young children was predominantly cereals and legume-based with limited consumption of nutrient-dense animal source food, fruits and vegetables. Because of the different bioactive anti-nutrient factors such as phytates, oxalates and the forms of the nutrients in plant-based diets, the bioavailability of nutrients like Zinc (Zn) and Iron (Fe) is low. Thus, energy and micronutrient such as vitamin A, C and zinc density in complementary food were inadequate for children aged 6-23 months in Ethiopia. Complementary food feeding practice also not conforms to WHO recommendations. Only 7% of children aged 6-23 months in Ethiopia meet the minimum acceptable dietary standards.

Most children in pastoralist areas mainly fed on cereal-based, less nutritious diets with no fruits or vegetables. According to Ethiopian health and nutrition research institute, reported over 44% of the pastoral communities is severely food insecure. The pastoralists depend mainly on two food groups: Cereal (97%) and dairy products (>50%). IYCF practice is very poor among Ethiopian pastoral communities [2].

Sorghum (*Sorghum bicolor* (L) Moench) is one of the most underutilized crops in the semi-arid tropics of Asia and Africa. It is one of the leading cereal crops that are widely used as human food, poultry, cattle and horse feed, as well as major source of energy, protein, vitamins and minerals. It is the fifth most important cereal after wheat, rice, corn and barley. It is the principal source of energy, protein, vitamins and minerals for millions of the poorest in these regions. Sorghum products are deficient in essential amino acids such as lysine, methionine, tryptophan and the presence of anti-nutritional factors such as tannin and phytate which limit their nutritional value. Sorghum contains 60%-80% starch and thus needs to be enriched with affordable source of other essential nutrients needed by children. As cereals are generally low in protein, supplementation of sorghum with locally available legume that is high in protein increases protein content of cereal-legume blends.

Pumpkins is an amazing source of vitamin A, full of antioxidants, rich in fiber and low in fat, good source of vitamin C, Cu and B vitamins, a great food for people struggling to keep their weight and regulate cholesterol and blood glucose level.

Pigeon pea (*Cajanus cajan* L.) is a nutritionally important legume crop of rain fed agriculture in the semiarid tropics. Pigeon peas are both a food crop (dried peas, flour or green vegetable peas) and a forage/cover crop. It is rich in protein (19%-26%) and minerals. Pigeon pea is a good source of protein, dietary fiber and various vitamins and minerals; thiamin, magnesium, phosphorus, potassium, copper and manganese. The antinutrients in pigeon pea are easily removed by processing. Pigeon pea is cholesterol free and has low saturated fats and sodium content. This makes pigeon pea like other legumes a healthy substitution for meats. In combination 6 with grains, pigeon peas constitute a well-balanced human diet. Pigeon pea contains high levels of protein and important amino acids (methionine, lysine and tryptophan). Pigeon pea is a rich source of lysine but deficient in the sulfur-containing amino acids methionine and cysteine [3].

However, there is a scarcity of evidence on the knowledge of processing and utilization of nutritionally enriched complementary food in pastoralist areas in Ethiopia, particularly Maale and Benna Tsemay Woreda. The main aim of the study is to formulate and introduce sorghum based complementary food enriched with pigeon pea and pumpkin and also determines the proximate composition, vitamin and mineral combinations, anti-nutritional and sensory attributes of the formulated food in Maale and Benna Tsemay Woreda, Southern Ethiopia.

Materials and Methods

Study area

The study was conducted at Benna Tsemay and Maale district in located in South Omo zone, southern nations, nationalities and people's regional state. Benna Tsemay district is situated between 5°01' and 5°73' north latitude and 36°38' and 37°07' east longitude with altitude of 588 meter above sea level. The rainfall distribution of the area is bimodal with main rainy season extends from January to May and the second cropping season, from July to October. It receives annual average rainfall of 876.3 mm and the monthly average minimum and maximum temperatures of 18.2°C and 37.3°C, respectively. All the metrological data a given above are long term averages. According to information gathered from key informants and secondary source almost half of the study population faces poor consumption. The study districts are among the most sorghum, pigeon pea and pumpkin growing areas in Ethiopia [4].

Maale district covers an area of 1405.58 km^2 and 1405558.12 hr. The population density of the district is very sparse with an estimate of 66 persons per km^2. The district has 23 rural kebeles (villages) and 1 urban kebele. The altitude of the district ranges between 600 m.a.s.l-1500 m.a.s.l. The study area is situated between 5.080 N-6.010 N latitudinal and 36.30 E-370 E longitudinally. It had comprised 40% mid-altitude which ranging from 1000 m.a.s.l-1400 m.a.s.l land whereas 60% is lowlands which has been ranging from the 605 m.a.s.l-999 m.a.s.l. The mean annual rainfall is ranging from 800 mm-1200 mm with annual temperature has lain between 18°C-35°C. The agro-pastoral production is the farming system has prevailed in the study area for the last four decades. The dominant crops that are being grown in the area are maize, sorghum, finger millet, teff, sesame and pumpkin.

Raw material collection

Sorghum (melkam variety), pumpkin and pigeon pea samples were directly collected from farming plots of volunteer agro-pastorals and Jinka Agricultural Research Center (JARC). All the raw materials were carefully selected based on the availability in local region and for their best quality and productivity.

Raw material processing

Preparation of sorghum flour**:** Sorghum was manually cleaned by winnowing and removed chaffs, dust and other impurities. After cleaning, ground to flour by miller (heavy-duty cutting mill) and sieved through a 0.5 mm sieve and packed in polyethylene bags.

Preparation of pumpkin flour: Uniform size, matured pumpkin were harvested carefully and brought to the laboratory from field. The pumpkin were washed with potable water; fruits were peeled using vegetable peeler (paring knife) and cut into half in lengthwise carefully, seeds were scooped out with spoon. Uniformly sliced flesh was dried using hot air oven at 60°C for 24 hr. Finally, the dried pumpkin slices were ground into powder by mill (heavy-duty cutting mill, SM2000/695 upm, Germany), sieved through 0.5 mm sieve, packed in amber-colored plastic container and stored in subdued light until further use.

Production of pigeon pea flour: Pigeon pea was cleaned properly using dry cleaning methods to remove foreign materials; cleaned pigeon pea was soaked in excess of potable water for 18 hour at room temperature. The soaked water was drained off and remained pigeon pea seeds were washed with distilled water. Then the pigeon pea seeds were spread in growth cabinet (model: RGX250) and maintained at temperature of 25°C for 48 hr. The germinated pigeon pea seeds were allowed to dry for 24 hour in hot air oven at 50°C. The dried pigeon pea were milled into fine powder using a miller (heavy-duty cutting mill) and sieved through a 0.5 mm sieve and packed in polyethylene bags until further work carried out [5].

Formulation of composite flour

According to the specified guidelines for complementary flour for older infants and young children, the formulation was estimated using the nutrient composition of the raw materials to produce a product that could have an energy level of 400 Kcal/100 g and a protein content of at least 15 g/100 g on a dry matter basis. Additionally, 250 mg of calcium, 5.8 mg of iron and 4.15 mg of zinc were taken into consideration as the necessary micronutrient composition at 50% supply of fortified supplemental food per 100 g. Breast milk was anticipated to provide the remaining 50%. The flours were thoroughly mixed to obtain a homogenous blend.

Experimental design: Total of five treatment combinations were generated which includes 100% SF (control), 63:10:27 (SF:PF:PPF), 56:20:24 (SF:PF:PPF), 50:30:20 (SF:PF:PPF) and 50:35:15 (SF:PF:PPF). These ranges were set based on previously reported studies on complementary foods prepared from grains, legumes, vitamin-rich plant foods and WHO infant feeding guidelines.

Nutrient composition of flour blends

Proximate composition and energy estimation: According to the AOAC method, the composite flour blends moisture, crude protein, crude fat, crude fiber and crude ash contents were examined. Carbohydrate was calculated using the difference method, and energy content was calculated using the Atwater factor (fat values were multiplied by 9 kcal/g, while carbohydrate and protein values were each multiplied by 4 kcal/g).

Determination of mineral content: Mineral content (Fe and Zn) were determined according to the standard method of AOAC using Atomic Absorption Spectrophotometer (AAS) in acid digested ash.

Determination of β-carotene: The β-carotene of the products was determined according to AOAC.

Determination of anti-nutritional factor: The anti-nutritional factors; phytate and tannin were evaluated. Phytate and tannin content of the sample was determined according to AOAC. The phytate determination was done as per the colourimetric method described by vaintraub and lapteva. The condensed tannin determination was conducted according to the method of Maxson and Rooney.

Sensory evaluation

Five formulated complementary porridge samples were prepared and subjected to sensory evaluation. The evaluation was carried out based on appearance, aroma, taste, mouth feel and overall acceptability using a 5-point hedonic scale, where 1 corresponding to disliked and 5 corresponding to liked. Total of 40 untrained panelists (mothers who have babies age between 6 and 24 months) were randomly selected from Asheker keble from Maale Woreda and Goldya keble from Benna Tsemay Woreda. The consumer panelists were informed about the five-point hedonic scale and its use prior to assessment. Freshly prepared porridge was served on white plate, arranged and coded randomly. During the evaluation, panelists were instructed to palate clean with water between each sample testing [6].

Data analysis

The data was entered and analyzed using spss ver 20. Mean and standard deviations were computed.

Results and Discussion

Proximate composition and energy content

The proximate composition and energy content presented in Table 1. The moisture content ranged from 9.99% in BF3 to 10.70% in BF1. The obtained moisture contents of the formulated CF were generally low; values were less than 10% and as such, moisture in the CF is unlikely to cause any adverse effect on the quality attributes of the product. Hence, the lower the moisture content, the better the keeping quality. Thus the items may not be stored for a long period of time.

The total ash content represents the total mineral contents in a food sample. In this study, ash values were found in the range of 1.72%-3.62% in the porridge. The highest ash content (3.62%) was recorded in product 56:20:24 (SF:PF:PPF), while 100% SF (control) had the least ash content. All the complementary foods processed in this study meets the recommended ash content by WHO/FAO in the complementary food (<5 g/100 g).

Fat is an important source of energy for infants and young children. Dietary fats function in the increase of palatability of food by absorbing and retaining flavors. Fat is important in the diets of infants and young children because it provides essential fatty acids, facilitates absorption of fat soluble vitamins and enhances dietary energy density and sensory qualities. The crude fat of the formulated porridge ranged from 1.77%-2.98% (Table 1). The fat content of the porridge were generally low and this is likely to be desired by weight watchers. In addition, our result is less than the daily recommended fat content in complementary foods range from 10% to 25%. This is may be due to the differences in crop types used and the processing methods employed during the formulation of the flour [7].

Crude fiber is one of the non-energy yielding nutrients; it helps to increase the nitrogen utilization and absorption of some micronutrients. The crude fibers of the formulated porridges varied from 2.14% to 11.36%. It was raised with an increase in the levels of Pumpkin Flour (PF) supplementation. The highest crude fiber content (11.36%) was determined in porridge from BF5 (SF 50%, PF 35% and PPF 15%) whereas the lowest is identified in the porridge from BF1 (SF 100%). The fiber contents of BF2 and BF3 blend samples were within the recommended range of not more than 5 g dietary fiber per 100 g dry matter. Foods used for complementary feeding should not in general contain as much fiber as the adult diet, because fiber can displace the energy-rich foods that children under two years of age need for growth.

Utilizable carbohydrates are important dietary energy sources for infants and young children. The utilizable carbohydrate of formulated porridges ranged from 62.22% to 70.37%. The highest amount of carbohydrate content (70.37%) determined in BF1 (100% sorghum flour) and the lowest determined from the BF5 (SF 50%, PF 35%, and PPF 15%) (Table 1). All the blended samples in this work meet the recommended carbohydrate content by WHO/FAO in the complementary food (≥ 65 g/100 g).

The formulated complementary porridge gross energy varied from 310.07 kcal/100 g to 356.66 kcal/100 g (Table 1). The highest gross energy of the porridge prepared from BF1 (SF 100%), while the lowest was identified in the BF5 (SF 50%, PF 35% and PPF 15%). However, the result is less than the recommended energy content by WHO/FAO in the complementary foods (400 kcal/100 g-425 kcal/100 g). This may be due to the less fat content of the raw materials used in the formulation of the food. The formulated complementary foods energy value (310.07 kcal/100 g-356.66 kcal/100 g) is greater than the recommendation of FAO/WHO/UN, for an infant complementary food (under 1 year) in developing countries, is ranged from 200 kcal/day to 300 kcal/day. The energy needs from complementary foods for infants with average breast milk intake in developing countries are approximately 200 kcal per day at 6-8 months of age, 300 kcal/day at age of 9-11 months and 550 kcal per day at 12-23 months of age [8].

Table 1: Proximate composition of sorghum based CF enriched with pigeon pea and pumpkin.

Blend formulations	Blend proportion (%)			Moisture (%) w/w	Fat (%) w/w	Protein (%)	Ash (%) w/w	CHO (%)	Crude fiber (%) w/w	Energy (kcal/100 g
	SF	PF	PPF							
BF1:	100	-	-	10.7	2.98	12.09	1.72	70.37	2.14	356.66
BF2	63	10	27	10.14	2.33	13.04	2.64	67.92	3.95	344.81
BF3	56	20	24	9.99	2.19	13.02	3.62	68.1	3.08	344.19
BF4	50	30	20	10.47	1.77	11.38	3.29	67.19	5.9	330.21
BF5	50	35	15	10.22	1.99	10.82	3.39	62.22	11.36	310.07

Crude protein content

The protein content had ranged from 10.82%-13.04% (Table 1). BF2 63:10:27 (SF:PF:PPF) had the highest protein content of 13.04%. The high-protein content of these flour samples is because pigeon pea has been reported to be high in protein. The required daily allowance for protein contents in the complementary foods is ≥ 15%. From our result we concluded that the recommend amount of protein was attained when the proportion of pigeon pea in the blend is greater than 25%. This suggests that increasing of the pigeon pea can improve the protein content of sorghum based complementary processed foods. In fact, legumes are rich sources of proteins ranged from 20% to 50%.

Anti-nutritional content

The phytate content of the products ranged from 69.000 mg/100 g-92.40 mg/100 g. The highest value of phytate was recorded in BF4 50:30:20 (SF:PF:PPF) sample, whereas the least was detected in BF3 56:20:24 (SF:PF:PPF) sample. Phytates bind to minerals like Ca, Fe, Mg, and Zn make them unavailable for bioabsorption. Phytate is said to chelate mineral cations and proteins, forming insoluble precipitates, which lead to reduced bioavailability of trace mineral cations and reduced digestibility of proteins. Phytate binds trace elements and macro-elements such as zinc, calcium, magnesium and iron, in the gastrointestinal tract and making the dietary minerals unavailable for absorption and utilization by the body. The foods with low phytate content are recommended for infants and all consumers. Therefore, the phytate content of the current products is very low when compared with the recommended daily intake of phytate from complementary foods (300 mg/day-500 mg/day) [9].

The tannin content of blended samples was in between 335.76 mg/100 g and 431.01 mg/100 g (Table 2). The highest value of tannin was recorded in BF5 (SF 50%, PF 35% and PPF 15%) samples, whereas the least was detected in BF1 (SF 100%). The tannin content of all blended samples in the present study could be considered safe because the values were found to be lower than the recommended daily intake for man (560 mg/100 g).

Table 2: Anti-nutritional content of sorghum based CF enriched with pigeon pea and pumpkin.

Blend formulation	Blend proportion (%)			Phytate (mg/100 g)	Tannin (mg/100 g)
	SF	PF	PPF		
BF1:	100 (control)	-	-	75.88	335.76
BF2	63	10	27	71.95	352.71

BF3	56	20	24	69	341.27
BF4	50	30	20	92.4	380.77
BF5	50	35	15	82.09	431.01

Vitamin A, β-carotene and mineral content of sorghum based CF

β-carotene content: The β-carotene contents of all of the products were varied from 90 µg/100 g-4609 µg/100 g (Table 3). The highest β-carotene content observed in porridge prepared with BF5 (SF 50%, PF 35% and PPF 15%), while lowest in BF1 (SF 100%). The β-carotene content of porridge sample increased parallel with an increase in the blending ratio of pumpkin flour. The recommended daily allowance for beta carotene for children under the age of five is 400 g RAE of vitamin A, according to WHO/FAO/UNICEF. The beta carotene content of the samples in this study meet the recommended amount except the control samples which is 90 µg/100 g. Utilizing pumpkin flour in the preparation of complementary foods might be considered a potential technique to address the issue of vitamin A deficiency, which affects infants and young children at a high rate.

Mineral contents (iron and zinc): Iron (Fe) supplementation in infants diets is essential for mental health and lowering anemia prevalence. The iron content of the samples varied from 3.867 mg/100 g to 4.842 mg/100 g. The highest Fe content (4.842 mg/100 g) found in BF5 (SF 50%, PF 35% and PPF 15%) whereas lowest Fe content (3.867 mg/100 g) found in BF1 (SF 100%). The amount of iron in all samples does not meet the Recommended Daily Allowance (RDA), which is 16 mg/100 g for children under the age of five. Therefore, to alleviate iron deficiency anemia, it's crucial to supplement the samples with flour rich in iron [10].

The zinc content of the products ranged from 1.578 mg/100 g to 1.710 mg/100 g. The highest Zn content found in the porridge prepared from BF2 63:10:27 (SF:PF:PPF) while the lowest found in BF5 (SF 50%, PF 35% and PPF 15%). For infants aged 6 to 8 months, 9 to 11 months, and 12 to 23 months, the recommended daily intake of zinc is 2, 3 and 3 mg/day, respectively. In this study, it was discovered that the Zn concentrations in all prepared complementary flour blends were below the recommended daily intake for infants between the ages of 6 and 23 months. Therefore, supplementation of the blended sample with zinc rich food product is very important [11].

Table 3: Vitamin A, β-carotene and mineral content of sorghum based CF.

Blend formulations	Blend proportion (%)			Iron (mg/100 g)	Zinc (mg/100 g)	Vitamin A (µg/100 g)	β-carotene (µg/100 g)
	SF	PF	PPF				
BF1:	100 (control)			3.867	1.645	1	90
BF2	63	10	27	4.642	1.71	1	1625
BF3	56	20	24	4.217	1.675	1	2756
BF4	50	30	20	4.707	1.662	2	4363
BF5	50	35	15	4.842	1.578	4	4609

Phytate and bioavailability of iron and zinc

The significance of foods as dietary sources of zinc relies on both the overall zinc content and the proportion of other food factors that have an impact on zinc bioavailability. Phytate may reduce the bioavailability of dietary zinc. As a result, the Phy:Zn molar ratio is thought to be a more accurate indicator of zinc bioavailability than just total dietary phytate levels. The molar ratio of phytate to zinc varied from 0.404 to 0.549 (Table 4). The highest molar ratio of phytate to zinc was contained in BF4 sample. According to Brown et al., zinc bioavailability is high when the phytate:Zn molar ratio is less than 5 and it is low when it is greater than 15. The values of all formulated complementary diets were lower than the critical molar ratios of Phytate:Zn, which indicates the high bioavailability of zinc [12].

Similarly, molar ratio of phytate to iron varied from 0.131 to 0.166 (Table 4). The highest molar ratio of phytate to iron was contained in BF4 and lower was contained in BF2 sample. According to Hurrell, the iron absorption is increased only if the phytate to iron molar ratio is reduced to <1 or preferably <0.4. All of the samples had phytate/iron molar ratios below 1, which is considered to be favorable for iron absorption. Gibson, et al. found that adding animal-sourced foodstuffs to complementary foods or using processing techniques including roasting, germination and fermentation improved the molar ratio between phytate and mineral [13,14].

Table 4: Phytate and bioavailability of iron and zinc.

Blend formulations	Blend proportion (%)			Iron (g/mol)	Zinc (g/mol)	Phytate (g/mol)	Molar ratio phytate/Fe	Molar ratio phytate/Zn
	SF	PF	PPF					
BF1:	100 (control)	-	-	0.69	0.253	0.114	0.165	0.45
BF2	63	10	27	0.828	0.263	0.109	0.131	0.414
BF3	56	20	24	0.753	0.257	0.104	0.138	0.404
BF4	50	30	20	0.84	0.255	0.14	0.166	0.549
BF5	50	35	15	0.864	0.242	0.124	0.143	0.512

Sensory acceptability of complementary food

The mean score of sensory acceptability of porridge samples was presented in Table 5. The values ranged from 3.20-4.40, 3.24-4.52, 3.24-4.12, 3.88-4.72 and 3.41-4.39 for appearance, color, taste, mouth feel and over all acceptability, respectively. The sensory acceptability scores of all products were remained above 3 in the scale of 5-point which indicated acceptability levels near and above the moderate degree of liking. From all prepared samples BF2 and BF3 formulated samples scores the highest value for most sensory attributes.

Table 5: Sensory acceptability of complementary food blended from sorghum, pumpkin and pigeon pea.

Blend formulations	Blend proportion (%)			Sensory attributes					
	SF	PF	PPF	Flavor	Taste	Color	Appearance	Mouth feel	Overall acceptability
BF1:	100 (control)	-	-	3.48 ± 1.00	3.24 ± 1.05	3.24 ± 1.30	3.20 ± 1.44	3.88 ± 1.05	3.41 ± 0.84
BF2	63	10	27	4.08 ± 0.95	4.04 ± 0.89	4.04 ± 0.89	3.96 ± 1.02	4.68 ± 0.48	4.16 ± 0.63
BF3	56	20	24	4.16 ± 0.85	4.12 ± 0.93	4.5 2± 0.05	4.40 ± 0.4	4.76 ± 0.52	4.39 ± 0.71
BF4	50	30	20	3.24 ± 1.13	3.24 ± 1.23	3.40 ± 1.15	3.60 ± 1.32	4.32 ± 0.69	3.56 ± 0.91
BF5	50	35	15	3.36 ± 1.25	3.48 ± 1.16	3.56 ± 1.39	3.72 ± 1.46	4.32 ± 0.85	3.69 ± 1.06
CV				28.6	29.26	31.15	33.67	17.08	22.02
LSD				0.5868	0.5939	0.6545	0.712	0.4201	0.4736

Conclusion

From the findings, it can be concluded that the nutrient composition BF3 (56% SF: 20% PF: 24% PPF) has high protein content, β-carotene, selected minerals (iron and zinc) and low anti-nutritional factors (phytate) as compared to control (100% SF). BF1 (100% control) has low iron, vitamin A and β-carotene content as compared to different blended ratio. The formulated CF contained higher protein and lower phytate and tannin contents than codex recommended level. Although, many formulations were found to be organoleptically acceptable recording moderately to extremely like scores, generally formulation BF3 (56% SF: 20% PF: 24% PPF) were highly acceptable by mother-child pairs in terms of different sensory attributes (flavor, taste, color, appearance, mouth feel) and scored significantly ($P<0.05$) higher than the other formulated complementary foods.

Recommendations

Generally, we recommend that locally available and low cost food ingredients used in the present study have good potential to develop complementary foods with enhanced nutritional value and sensorial acceptability for resource-poor households if some enhancement made by including studied amount of milk and milk products and other micronutrient dense foodstuffs. The authors recommend continuous nutrition education in consumption of diversified foods that include pulse and other legumes in order to enhance daily protein supplies.

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Conflict of Interest

We declared that this manuscript is our original work and not published elsewhere and no competing claims among us.

Ethical Clearance

Permission was obtained from South Omo zone and Woreda health offices. Informed consent was obtained from the mother and father of study participating child. Data obtained from each study participant was kept confidential. Nutritional advice was also given for those mothers/caregivers on child feeding.

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