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Formulation and Sensory Evaluation of Complementary Food from Locally Available Ingredients in South Ari Woreda, Southern Ethiopia

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Abstract

Background and objective: Poor feeding practices as well as lack of suitable complementary foods are responsible for under nutrition with poverty exacerbating the whole issue. The present study aim to develop sorghum based complementary foods supplemented with common bean and carrots and to analyze the nutritional and anti-nutritional composition of the formulated CF. In addition to this to determine acceptability of the supplemented foods for use by mothers and their children.

Material and methods: The study was conducted in Debube Ari Woreda, South Omo Zone, Southern Ethiopia. Four versions of porridge which includes 100% SF (control), 50:25:25 (SF: CBF: CF), 55:30:15 (SF: CBF: CF) and 70:20:10 (SF: CBF: CF) was prepared.

Key findings: The moisture contents of the formulated CF were generally low; values were less than 10%. The highest ash content (3.13%) was recorded in product 2, while product 1 had the least ash content. Energy values of the CF ranged between 336.97 and 360.19 kcal/100 g, with product 2 having the least value and 100% sorghum flour having the highest value. CF made with 100% sorghum flour (the control) had higher carbohydrates content. The fat content of the CF were generally low and this is likely to be desired by weight watchers. The fiber contents of all the CF were within the recommended range of not more than 5 g dietary fiber per 100 g dry matter (FAO/WHO, 1994). The protein content for each sorghum based complementary food had ranged from 8.34–12.56%. Vitamin A contents of all of the products were not detected. The iron content of the samples varied from 33.11 to 52.30 mg/kg. The lowest value of iron was contained in product 1 but product 2 had highest in iron content. The zinc content of the products varied from 13.99 to 17.94 mg/kg. Product 3 contained high zinc content whereas product 4 contained the lowest. The phytate content of the products was between 117.22 & 129.36 mg/100 g. The highest value of phytate was contained in product 1 but the least was detected in product 4. The tannin content of the products was between 596.31 & 1894.04 mg/100 g. The highest value of tannin was contained in product 1 but the least was detected in product 2. The molar ratio of phytate to zinc varied from 0.666 to 0.890. The highest molar ratio of phytate to zinc was contained in product 1. Similarly, molar ratio of phytate to iron varied from 0.196 to 0.332. The highest molar ratio of phytate to iron was contained in product 1 and lower phytate was contained product 2.

Summary and conclusion: The formulated CF contained higher protein and lower phytate and tannin contents than Codex recommended level. The use of sorghum, common bean and carrot flour blends in CF can greatly enhance the protein content, without compromising consumer acceptance. This study showed that nutrient dense CF could be produced from sorghum and common bean fortified with carrot flour than using sorghum flour alone.

Keywords: Poor feeding practices • Complementary foods • Anti-nutritional composition • Consumer acceptance

Introduction

The level of under nutrition among children remains unacceptable throughout the world, with large number of children living in developing world [1]. Malnutrition is the cause of the majority of deaths among children under five years in Ethiopia [2]. Ethiopia has one of the highest rates of stunting and wasting in the world. The 2011 Ethiopian Demographic Health Survey reported that 44% of Ethiopian children under five years of age were stunted, which is an indication of chronic malnutrition [3]. Complementary feeding period is the time when malnutrition starts in many infants, contributing significantly to the high prevalence of malnutrition in children less than 5 years of age worldwide [4]. Poor feeding practices as well as lack of suitable complementary foods are responsible for under nutrition with poverty exacerbating the whole issue [5]. The complementary foods are often of low nutritional quality and given in insufficient amounts. When introduced too early or too frequently, they displace breast milk as the main sources of nutrition in infants [6,7]. Fortified nutritious commercial complementary foods are unavailable especially in the rural areas and where available, they are often too expensive and beyond the reach of most of families in Ethiopia [3].

Therefore, most complementary foods used are locally produced and based on local staple foods, usually cereals that are processed into porridges. Apart from their bulkiness reported as a probable factor in the etiology of malnutrition [8], cereal-based gruels are generally low in protein and are limiting in some essential amino acids, particularly lysine and tryptophan [9].

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Supplementation of cereals with locally available legumes rich in protein and lysine, and vegetables rich in vitamins is important [10].

Sorghum (*Sorghum bicolor*), common bean (*Phaseolus vulgaris*) and carrot (*Daucus carota*) are food materials that readily available in Ethiopia and they have nutritional attributes. Whole sorghum grain is an important source of complex vitamins and some minerals like phosphorus, magnesium, calcium and iron [11]. The protein content of sorghum is similar to that of wheat and maize, with lysine as the most limiting amino acid [2]. Carrot is an herbaceous plant containing about 87% water, rich in mineral salts and vitamins (B, C, D, and E) [12]. Raw carrots are excellent source of pro-vitamin A and potassium; they contain vitamin C, vitamin B6, thiamine, folic acid, and magnesium [12]. Common bean is most important grain legume in human diets. It provides protein, complex carbohydrates and valuable micronutrients for more than 300 million people in the tropics. In many areas, common beans are the second most important source of calories after maize.

The nutrient potentials of the multimixes (Sorghum, common bean and Carrot) as composite for use as complementary food can be of relevance in nutrition security of young children. Therefore, the present study aimed to develop sorghum based complementary foods supplemented with common bean and carrots and to analyze the nutritional and anti-nutritional composition of the formulated CF. This study also determined the sensory acceptability of the supplemented foods for use by mothers and their children.

Materials and Methods

Description of study areas

The study was conducted in Debube Ari Woreda, South Omo Zone, and Southern Ethiopia. The Woreda lies between 6.08 to 6.27' N latitude and 36.54 to 36.75' E longitude. The elevation of the areas ranges from 501 to 3500 meter above sea level. The annual average rainfall of the district ranges between 1401-1600 mm with minimum and maximum annual temperature of 10.1°C and 25°C (CSA, 2007). 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 maize, common bean and carrot growing areas in Ethiopia.

Site and farmer selection

The experiment was conducted in major maize, common bean and carrot growing areas in South Omo Zone. For demonstration site selection was conducted considering relative land area allocated for maize, common bean and carrot growing, number of maize, common bean and carrot growers, accessibility and engagement in other research projects. Based on the above criteria, 10 Kebles from Debube Ari woreda was selected. Following the site identification, selecting the participating farmers at all sites was done. Selection of the farmers was done based primarily on farmer land covered with maize, common bean and carrot, production status and willingness to participate in the research.

Sample collection

The samples are collected from directly from farming plots of volunteer farmers and Jinka agricultural research center. The red Sorghum grains (*Sorghum bicolor*), carrot (*Daucus carota*) and common bean (*Phaseolus vulgaris*) were purchased from local market.

Sample preparation

Preparation of sorghum flour: Sorghum grain were separately washed and cleaned with distilled water and air-dried for 12 hours. The grains were then milled into flours with a hammer mill.

Preparation of carrot flour: Carrot powder was obtained by washing carrot roots with water and then slicing and sun drying for three days, and milling them into flour with a stainless steel milling machine. The flour was then sieved and packaged in air tight polyethylene plastic bags and stored in a cool place.

Preparation of common bean flour: Common beans were washed and soaked in clean tap water for 12 hours. After draining, the beans were germinated at room temperature for 24 hours, rinsed, dried in the sun and roasted using an oven to further reduce anti-nutritive factors and improve the flavor of the final product [13]. The roasted common beans were milled into flour. All milled samples were packed in airtight polyethylene plastic bags and stored at room temperature until needed. Lastly, the processed foods were analyzed for their proximate composition, anti-nutritional factors and mineral contents.

Formulating the complementary food

Four versions of porridge which includes 100% SF (control), 50:25:25 (SF: CBF: CF), 55:30:15 (SF: CBF: CF) and 70:20:10 (SF: CBF: CF) was prepared. Porridges were prepared as follows: 100 g of prepared flour added to 300 ml of boiled water of four separated pan. Two tea spoon of table salt was added and allowed to cook for 15 minutes.

Experimental design

Total of four treatment combinations were generated which includes 100% SF (control), 50:25:25 (SF: CBF: CF), 55:30:15 (SF: CBF: CF) and 70:20:10 (SF: CBF: CF). 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 [14-16].

It is recommended that in developing countries, where social and economic constraints are vast, the raw materials used in supplementary foods should come from locally available ingredients wherever possible [17]. Legumes such as peas, common bean, chick peas, mung beans, green gram and kidney beans are known to be sources of appropriate protein that ranges between 20-40% [14]. The addition of legumes to cereals is one way of improving the protein quality of complementary foods of cereal staples [14,17].

The combined use of cereals and pulses takes advantage of fact that cereals (except rice) are relatively deficient in lysine while pulses have high lysine content. It is also recommended that tentatively, the ratio of cereals to pulses should be in the range of 3:1 or 4:1 in order to obtain the best mutual lysine complementation [17]. The amount of legumes incorporated for present study will be determined on the basis of the scientific fact explained above. Accordingly, 25%, 15% and 10% addition of legume, which is in this case common bean, will be employed for formulation of composite flours.

The proportions of carrot flour will be determined on the basis of recommended daily intake (RDI) for vitamin A for young children [16] and the guide line for fortification of complementary foods [14]. The RDI for vitamin A was established to be 400 μg RE/day for young children [16]. The Codex alimentarius suggests that when a food supplemented with one or more nutrient, the total amount of the added vitamin(s) or mineral(s) contained in 100 g of the food on a dry matter basis should be at least 2/3 of the reference daily requirements. Accordingly, the level of carrot in the composite flour mix (% on dry weight basis) will be made to 25%, 20% and 15%.

Incorporation of adequate amount of fat and /or oil is important to increase the energy density of products. It is also recommended that addition of not more than 10 g of fat per 100 g of product would be optimal to attain the desirable energy density and palatability [17]. For the resent study, however, the amount of vegetable oil added to the formulated porridge sample will be limited to only 5g due to low socioeconomic status of most mothers in Ethiopia.

Nutrient analysis

The proximate compositions of the sample were determined using AOAC (2006) methods [18]. Moisture content of the jam was determined gravimetrically. The protein content was determined by micro- Kjeldahl method, using 6.25 as the nitrogen conversion factor. The fat content was determined by Soxhlet extraction method using petroleum ether. The ash content was determined by incinerating the samples at 600°C in a muffle furnace. Carbohydrate was obtained by difference, while gross energy (KJ and Kcal per 100 g) was calculated based on the formula [19]. Gross energy (Kcal per 100 g dry matter) = (crude protein × 17) + (crude lipid × 37) + (crude carbohydrate × 17) for protein, carbohydrate and lipid, respectively. Mineral elements were determined using wet-acid digestion method for multiple nutrients determination as described by the method of AOAC (2006). The β-carotene of the products was determined according to AOAC (2006) [18]. Phytate and tannin content of the sample was determined according to AOAC (2005) [20].

Acceptability testing

Acceptance testing was conducted with 30 mother-child pairs at South Ari District. A 5-point Likert-like scale questionnaire was created containing the sensory elements to be asked: appearance, flavor, taste, color and consistency/ mouth-feel. Each mother-child pair was given a measured sample (30 g) of each of the four porridges. Mothers gave answers on behalf of their children based on each child's reaction (facial expression and general reaction) to the food offered, and these are the responses that are reported here in. Scores were averaged to obtain overall acceptability.

Results and Discussion

Proximate composition of Sorghum based complementary food

Four formulations were produced and they were evaluated for their proximate and anti-nutritional factors. The 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. The highest ash content (3.13%) was recorded in product 2, while product 1 had the least ash content. Energy values of the CF ranged between 336.97 and 360.19 kcal/100 g, with product 2 having the least value and 100% sorghum flour having the highest value. CF made with 100% sorghum flour (the control) had higher carbohydrates content. The fat content of the CF were generally low and this is likely to be desired by weight watchers. The fiber contents of all the CF were within the recommended range of not more than 5 g dietary fiber per 100 g dry matter [21].

Crude protein content

The protein content for each sorghum based complementary food had ranged from 8.34–12.56%. The highest protein content was recorded in blend of 50% sorghum flour +25% common bean flour +25% carrot flour blend ratio and the least was found in 100% sorghum flour only. Protein content was increased with increasing the proportion of common bean flour and decreased with increasing the proportion of sorghum flour only (Table 1). The difference could be due to the difference in blending ratio and crop types used during the formulation. According to a study, blending of cereal-based foods and their processing methods can improve the protein content of the flour [22]. The required daily allowance for protein contents in the complementary foods is ≥ 15% [16]. However, in our finding, this result can be satisfied when the proportion of common bean in the blend is greater than 25%. This suggests that increasing of the common bean can improve the protein content of sorghum based complementary processed foods.

Vitamin A and mineral content of Sorghum based CF

Vitamin A contents of all of the products were not detected. Two possible reasons could be mentioned; first the carrot flour was over sundried and during this time vitamin A content might be degraded and lost in the final product. The second major reason is the insolubility of vitamin A in water, thus vitamin A does not dissolve in water but slightly soluble in alcohol, fat, oil and soluble in organic solvents like ether. The iron content of the samples varied from 33.11 to 52.30 mg/kg. The lowest value of iron was contained in product 1 but product 2 had highest in iron content. The zinc content of the products varied

Table 1. Proximate composition of Sorghum based complementary food.

Recipe name	Blend proportion (SF:CBF:CF)	Moisture (%) w/w	Fat (%) w/w	Protein (%)	Ash (%) w/w	CHO (%)	Crude fiber (%) w/w	Energy (kcal/100 g)
Porridge 1	100	9.63	3.11	8.34	1.51	74.71	2.7	360.19
Porridge 2	50:25:25	11.3	2.49	12.56	3.13	66.08	4.44	336.97
Porridge 3	55:30:15	9.59	2.49	12.52	2.73	69.41	3.26	350.13
Porridge 4	70:20:10	9.27	3.13	11.54	2.21	71.26	2.59	359.37

SF: Sorghum Flour, CBF: Common Bean Flour, CF: Carrot Flour

Table 2. Vitamin A and mineral content of Sorghum based CF.

Recipe name	Blend proportion (SF:CBF:CF)	Iron (mg/kg)	Zinc (mg/kg)	Vitamin A (mg/kg)
Porridge 1	100	33.11	14.4	ND
Porridge 2	50:25:25	52.3	14.45	ND
Porridge 3	55:30:15	49.24	17.94	ND
Porridge 4	70:20:10	38.58	13.99	ND

SF: Sorghum Flour, CBF: Common Bean Flour, CF: Carrot Flour

Table 3. Anti-nutritional content of Sorghum based CF.

Recipe name	Blend proportion (SF:CBF:CF)	Phytate (mg/100g)	Tannin (mg/100g)
Porridge 1	100	129.36	1894.04
Porridge 2	50:25:25	121.27	596.31
Porridge 3	55:30:15	122.06	735.69
Porridge 4	70:20:10	117.22	1029.74

SF: Sorghum Flour, CBF: Common Bean Flour, CF: Carrot Flour

Table 4. Phytate and bioavailability of Iron and Zinc.

Recipe name	Blend proportion (SF:CBF:CF)	Iron (g/mol)	Zinc (g/mol)	Phytate (g/mol)	Molar ratio phytate/Fe	Molar ratio phytate/Zn
Porridge 1	100	0.59	0.22	0.196	0.332	0.89
Porridge 2	50:25:25	0.93	0.22	0.183	0.196	0.831
Porridge 3	55:30:15	0.87	0.276	0.184	0.211	0.666
Porridge 4	70:20:10	0.68	0.21	0.177	0.26	0.842

SF: Sorghum Flour, CBF: Common Bean Flour, CF: Carrot Flour from 13.99 to 17.94 mg/kg. Product 3 contained high zinc content whereas product 4 contained the lowest (Table 2).

Anti-nutritional content of Sorghum based CF

The phytate content of the products was between 117.22 & 129.36 mg/100 g. The highest value of phytate was contained in product 1 but the least was detected in product 4. The tannin content of the products was between 596.31 & 1894.04 mg/100 g. The highest value of tannin was contained in product 1 but the least was detected in product 2. Phytate is good metal chelator and prevents absorption minerals by the intestine, which has negative nutritional impact on metals necessary for good health especially iron and calcium (Table 3).

Phytate and bioavailability of Iron and Zinc

The molar ratio of phytate to zinc varied from 0.666 to 0.890. The highest molar ratio of phytate to zinc was contained in product 1. According to Norhaizan, the suggested critical molar ratio of phytate to zinc must be greater than 15. So that molar ratio of phytate to zinc for the entire product greater than the critical value. Therefore the amount of phytate present in these products is none significant to hinder bioavailability of zinc in the products. Similarly, molar ratio of phytate to iron varied from 0.196 to 0.332. The highest molar ratio of phytate to iron was contained in product 1 and lower phytate was contained product 2. According to Norhaizan, critical value for phytate to iron must be greater than 1 (phytate/iron>1). However, calculated phytate to iron molar ratio of product for all of the products are too small compared to the critical value. Therefore, the available phytate is not significant to hinder the absorption of iron too (Table 4).

Conclusion

The study evaluated the nutritional and anti-nutritional attributes of CF from flour blends of sorghum, common bean and carrot flour. The formulated CF contained higher protein and lower phytate and tannin contents than Codex recommended level. The use of sorghum, common bean and carrot flour blends in CF can greatly enhance the protein content, without compromising consumer acceptance. This study showed that nutrient dense CF could be produced from sorghum and common bean fortified with carrot flour than using sorghum flour alone.

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