Effects of Fermentation Time and Blending Ratio on Functional Properties and Organoleptic Acceptability of Complementary Food

Milkesa Feyera
Melkassa Agricultural Research, P.O.BOX 436, Adama, Ethiopia

Abstract
High bulk and poor in organoleptic acceptability are a major characteristics of most complementary food used in developing countries. Fermentation and blending are afeasible approach to reduce bulkiness and organoleptic acceptability of such complementary foods. Therefore,this study aimed to develop nutritionally adequate and organoleptically acceptable complementary food from composite flour. Three fermentation times (0, 24 and 36 hr) and four blends of composite flour consisting of maize, haricot bean, and cooking banana, respectively, in the proportion of 65:20:15, 60:30:10, 50:35:15, 30:60:10 were used in the formulation with 100% maize as control. Fermentation causes significant ($P<0.05$) reduction in bulk density from 0.90 to 0.59g/ml, dispersibility from 63.59 to 60.72%,and swelling power from 4.55 to 4.38 g/g. On the other hand increment of water solubility index from12.45 to 14.16% and water absorption capacity from 134.38 to 158.40% were recorded as fermentation time increased. Blending ratio significantly ($P<0.05$) influenced some functional properties of composite flour. Bulk density ranged from 0.71 to 0.75 g/mL, water absorption capacity from 136.11 to 165.72%, dispersibility from 47.06 to71.83%, swelling power from 4.28 to 4.57g/g and water solubility index from 9.81 to 17.18%.The sensory acceptability of complementary food prepared in the form of porridge was evaluated by panelists. Among all the proportions, 60, 30 and 10% of maize ,haricot bean and cooking banana blends, respectively, fermented for24h rwas organoleptically highly preferred by panelists. Therefore, fermentation and substitution of maize with haricot bean and cooking banana could be, recommended in the production of nutritious and organoleptically acceptable complementary food for older infants and young children.
Keywords: Blending, Complementary Food, Composite Flour, Cooking Banana, Haricot bean, Fermentation, Maize
DOI: 10.7176/FSQM/104-03
Publication date: January 31st 2021

INTRODUCTION

Most complementary foods used in low-income households are starchy porridges prepared traditionally from locally available cereals (Motuma *et al*., 2016). Such complementary foods are often characterized by low nutrient density, poor protein quality, high bulk, low mineral bioavailability and low energy (Hardwick and Sidnell, 2014). The prospects of blending tubers, roots, and fruits with cereals and legumes are receiving considerable attention worldwide for products promising the nutritive potential of household food products (Nnam, 2002). Complementation of cereals with locally available legume and fruits will enhances the nutrient content, functional properties and sensorial acceptability of composite products.

Haricot beans have relatively high protein content and low carbohydrates, while cooking bananas are an excellent source of vitamins, micronutrients, and good health promoting bioactive compounds. Complementation of maize with haricot beans and cooking banana flours in desired proportion for production of complementary food are expected to meet macronutrients, micronutrients and vitamins requirements for older infants and young children with retaining sensory acceptability.

Different food processing techniques are used to improve functional properties and organoleptic acceptability of such complementary food products. Fermentation, dehulling, drying and milling are economic domestic food processing techniques used at homes to improve and increase nutrient density, acceptability, quality, availability, flavor, aroma and palatability (Hotz and Gibson, 2007). They also reduce bulk density and viscosity of flour (Nnam, 2002).

Fermentation is biological process, which has the potential to improve the nutrient availability in foods. It helps in the introduction of probiotic bacteria so by consuming fermented foods, beneficial bacteria and enzymes are being added to overall intestinal flora for important health benefits (Kalui *et al*., 2010). The breakdown of some of the sugars and starches in food during fermentation has role to makes easy for digestibility, reduce starch content and decreased the bulk density of fermented foods (Michaelsen *et al*., 2000; Oti and Akobundu, 2008). Other advantages of fermentation include the increase in the availability of vitamins and minerals and the removal of some natural compounds that interfere with the absorption of nutrients (Towo *et al*., 2006). Therefore, this study was aimed to develop nutritionally adequate and organoleptically acceptable complementary food from fermented maize, haricot bean and cooking banana flour.

MATERIALS AND METHODS

Experimental Location

The experiment was conducted at Melkassa Agricultural Research Center of Ethiopian Institute of Agricultural Research, Ethiopia. The Center is geographically located at latitude of 8˚24'N, longitude of 39˚21' E and at altitude of 1,550 meters above sea level. It is situated at about 107 km from Finfine, capital city of Ethiopia and 17 km of south east from Adama town of Oromiya Regional state. Raw materials were prepared and processed in Food Science and Postharvest Technology laboratory of Melkassa Agricultural Research Center. Both functional properties and sensory evaluation of complementary food were performed in the Food Science and Postharvest Technology laboratory of Melkassa Agricultural Research Center.

Experimental Materials

Maize (Zea mays L.), Haricot bean (Phaseolus vulgaris L.) and Cooking banana (Musa spp) of known variety were obtained from Melkassa Agricultural Research Center of Ethiopian Institute of Agricultural Research. All raw materials collected were transported to Food Science and Post harvest Technology, laboratory of Melkassa Agricultural Research Center using human labor. Obtained maize and haricot bean grain sample were not treated with post harvest pesticides.Maize (Melkassa -2 variety), Haricot bean (Awash -1 variety) and cooking banana (Matoke variety) were used in the experiment.

Experimental Design and Plan

The experiment was organized in a factorial arrangement consisting of two factors, fermentation time and blending ratio. Three fermentation time and four blending ratio were applied to produce complementary food. The details of treatment combination were performed as indicated below. Fermentation has three levels (0 h, 24 h and 36 h) and blending ratio has five level. In this study 100% maize flour was used as control. The experiment was organized in the total of fifteen treatments as shown in the table below.

Table 1. Experimental plan:

Factor 1 Blending Ratio	Factor 2 Fermentation time		
	F0	F1	F2
B1	B1*F0	B1*F1	B1*F2
B2	B2*F0	B2*F1	B2*F2
B3	B3*F0	B3*F1	B3*F2
B4	B4*F0	B4*F1	B4*F2
B5	B5*F0	B5*F1	B5*F2

Where, h= hour, F0 = Fermentation for 0 h, F1 = Fermentation at room temperature for 24 h, F2 = Fermentation at room temperature for 36 h, B1= 100% Maize flour, B2= 65:20:15, B3 = 60:30:10, B4 = 50:35: 15, B5 = 30:60:10, Maize, Haricot bean and Cooking banana, respectively.

Sample Preparation

Preparation of maize flours

Maize grain about six kilogram was sorted, cleaned and abundantly washed by immersion in cold tap water stirred by hand and screened out of the water to remove impurities. The kernels then sun dried and milled using cyclone milling machine with 30-1060 model into flour using laboratory miller machine to sieve size of 0.5 mm. Finally, the maize flour was packaged and stored at room temperature in glass bottles (container) until used for product formulation and experimental analysis.

Processing of haricot bean flour production

Haricot bean seeds, about seven kilogram were sorted by removing dirt and broken beans. The clean beans were soaked in tap water (1:5 w/v) for 12 h at room temperature (28 ± 2^{o}C). Soaked haricot bean seeds were dehulled manually by rubbing between palms. The dehulled beans were spread on a tray and dried in hot air oven drying with 3010 - 019EN55014/EN55014S/N model at 60^{o}C to a constant weight. The dried haricot bean seeds were subjected to roasting. Haricot bean roasting was carried out following the method described by Oraka and Okoye (2017). The dried beans were then roasted in an open frying pan with constant stirring on a electric stove using a moderate heat (130-140 ^{0}C) for 15 –20 min. The roasted beans were milled into flour, packed in a polythene bag and sealed. The beans flour were kept in the refrigerator before used for food product development and experimental analysis.

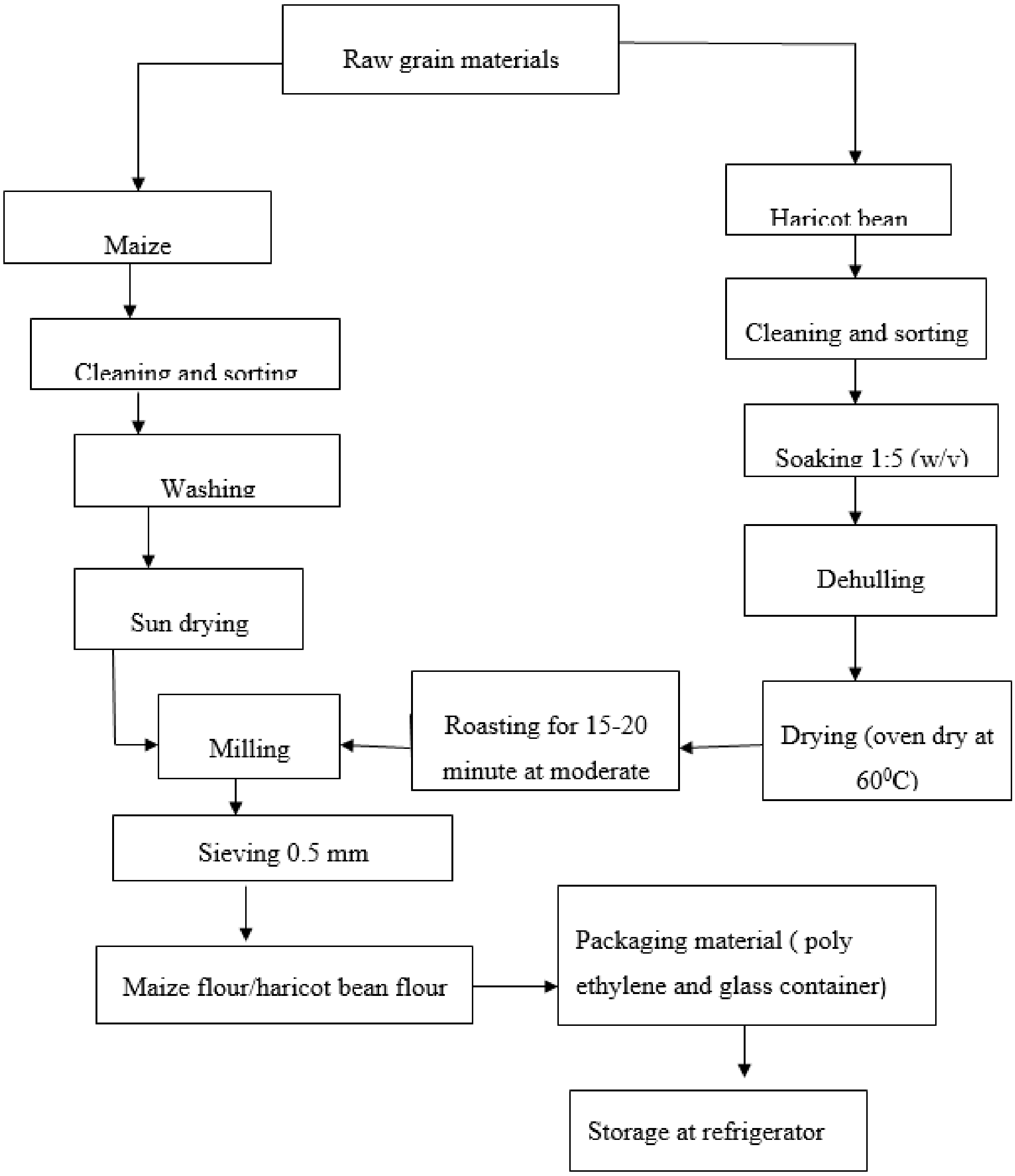

Figure 1. Flow diagram for maize and haricot bean flour processing

Cooking banana flour production

Healthy, clean and well-matured bunch was selected and representative fingers from the middle bunch of the Matoke cooking banana variety were collected. Harvested matured bananas from five bunch were washed using tap water to remove surface contaminants such as soil, dust,debris, and others. Cleaned cooking banana was blanched at 80ºC for five minutes (Ngalani, 1989). Cooking banana flour production procedures such as peeling of the fruits with the hands and cutting the pulp into small pieces were applied. Then small pieces of cooking banana were allowed to dry in a laboratory using oven dry method. Dried cooking banana was milled into sieve size of 0.5 mm flour using laboratory milling machine and placed in polyethylene bag until used for experiments.

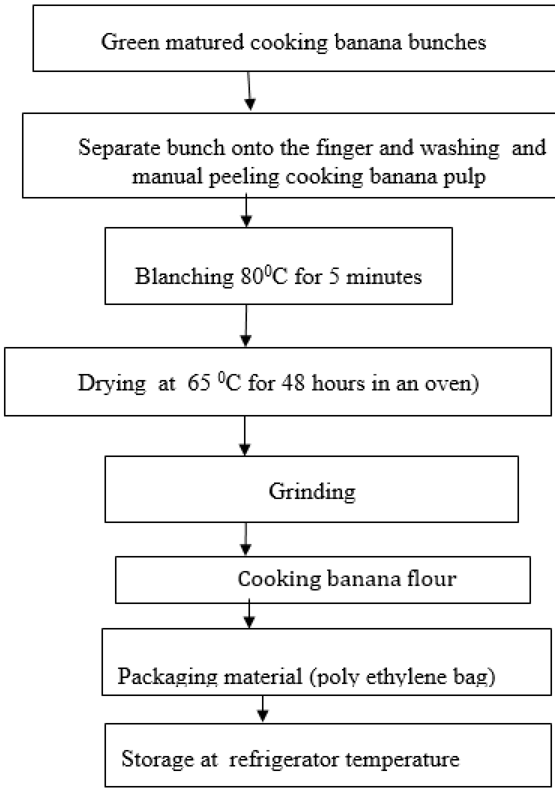

Figure 2. Cooking banana flour production flow chart (Ngalani, 1989)

Fermentation
The fermentation was carried out according to Griffith et al. (1998). Flour obtained from each raw materials were mixed with distilled water independently in the ratio of 1:4 (w/v) to make a dough. It was allowed to ferment in a cleaned plastic container covered with plastic material at room temperature for 24 hr and 36 hr fermentation period. The dough was fermented by adding 5% of ersho, starter culture obtained from previously fermented maize and haricot bean to start the fermentation process. The fermented dough was dried in laboratory oven dry at 70^0C for 16 hr. The dried slurries were milled to a fine powder using a laboratory miller machine to 0.5 mm sieve size and kept at 4 ^{0}C for nutrient composition, anti-nutrient and functional properties analysis (Antony and Chandra, 1998).

Formulation of Complementary Food
Samples were formulated for satisfying specified guideline of Codex Alimentarius Commission and WHO/FAO for complementary food for older infant and young children of age group after six month to five years of old (Codex Alimentarius Commission, 1991;WHO/FAO, 2010). Details of specified requirements used in this infant formulas were described in the earlier published part of this study (Feyera et al., 2020)

Product Development and Sensory Evaluation
The complementary food in form of porridge was prepared from maize, cooking banana, and haricot bean blends and 100% maize flour was used as a control. Measured quantities of each flour was mixed with distilled water of 1:5 (w/v). The slurry was heated in a thermostatically controlled water bath at 75°C (Agomoh *et al*., 2015). It was cooked until desired consistency achieved. Thereafter, it was cooled with the incorporation of granulated table sugar (6%, w/w) and refined vegetable oil (5%, w/w) (FAO, 1985). The vegetable oil was added to increase the fat content of the food to the stipulated minimum level of 6% in a complementary food (WHO/UNU, 1985). Sensory acceptability of produced complementary porridge samples were carried out by a panelist consisting of 30 people selected from mothers and staff members of Melkassa Agricultural Research Center. Panelists evaluated the acceptability of sensory attributes such as color, flavor, texture, aroma, taste and overall acceptability of complementary porridge based on a seven-point hedonic scale. Those hedonic scales were 7= like extremely, 6=like moderately, 5=like slightly, 4= neither like nor dislike,3= dislike slightly, 2=dislike moderately and 1= dislike extremely. The complementary porridge was placed on a cleaned plate, served in a bright and well ventilated room. All evaluation sessions were held at Melkassa Agricultural Research Center in the food Product development room. Sensory evaluation was carried out after product cooled to room temperature. Instruction was provided to panelists on how to use sensory evaluation forms and terminologies of sensory attributes.

Functional Properties
Dispersibility
Flour dispersibility was determined by the standard method of (Kulkarni *et al*., 1991). A sample of 10g was dispersed in distilled water in a 100 mL measuring cylinder and distilled water was added up to 50 mL mark. The mixture was then stirred vigorously and allowed to settle for 3 h at room temperature. The volume of settled particles was recorded and the percentage dispersibility of the flour was calculated as follows:

$$\text{Dispersibility (\%)} = \frac{(50 - volume\ of\ the\ settled\ particle) \times 100}{50} \qquad (14)$$

Bulk density
Bulk density was estimated according to the procedure of the Okako and Potter (1979). About 50 g of flour sample was placed into a 100 mL measuring cylinder and tapped to a constant volume and the bulk density in (g/mL) was calculated using the formula:

$$\text{Bulk density} = \frac{\text{mass}}{\text{volume}}$$

Water absorption capacity
The method described by Adebowale *et al*. (2012) was used for determining the water absorption capacity (WAC). A sample of 1g was weighed into a clean pre-weighed dried centrifuge tube and mixed with 10 mL of distilled water with occasional stirring for 1 h. The dispersion was centrifuged at 3000 rpm for 15 min using universal centrifuge having model (PLC - 012E) manufactured in Taiwan. After centrifuging, the supernatant was decanted and the tube with the sediment was weighed after removal of the adhering drops of water. The weight of water (g) retained in the sample was reported as WAC.

$$\text{Water absorption capacity} = \frac{\text{grams bound by water}}{\text{sample weight}} \times 100$$

Swelling power and solubility index
Swelling power and solubility index were determined according to the method described by Hirsch (2002). About One gram of sample was placed into a pre-weighed graduated centrifuge tube. Then, 10 mL of distilled water was added to the weighed sample in the centrifuge tube and the mixture was stirred and placed in a water bath (with model :YCW-010 manufactured in Taiwan) heated at 75°C temperature for 1 h while shaking the sample gently to ensure that the starch granules remained in suspension until gelatinization occurred. The samples were cooled to room temperature under running water and centrifuged for 15 min at 3000 rpm. After centrifuging, the supernatant was decanted from the sediment into a pre-weighed and dried pellets; the supernatant in the pellet was weighed and dried at 105 °C for 1 h. After 1 h pellet with sediment was removed from oven dry cooled in desecrator to room temperature. Then it was weighed and the reading was recorded.
The flour swelling power and solubility were calculated according to the equations below.

$$Swelling\ power = \frac{weight\ of\ a\ swollen\ sediment}{sample\ weight}$$

$$Solubility\ \text{index} = \frac{weight\ of\ dried\ supernatant}{weight\ of\ sample} \times 100$$

RESULT AND DISCUSSION
Functional Properties of Raw Materials
All raw materials used in this study exhibited a unique value of functional properties. The higher bulk density 0.96 g/mL, water absorption capacity 196.51%, and swelling power 6.34 g/g were recorded for cooking banana flour. This could be attributed by high carbohydrate content and starchy flour samples of cooking banana. The higher value of dispersibility (75.00%) and water solubility index (23.90%) were noted for maize and cooking banana flour, respectively, as presented in Table 2.

Table 2. Functional properties of raw materials

Raw materials	BD (g/mL)	WAC (%)	SP (g/g)	Dispersibility (%)	WSI (%)
Haricot bean	0.85	181.3	4.20	42.12	23.90
Cooking banana	0.96	196.51	6.34	62.5	7.29
Maize	0.92	124.7	4.25	75.00	6.28

BD= Bulk density, WAC= Water absorption capacity, SP= Swelling power, WSI= water solubility index.

Effect of Fermentation Time and Blending Ratio on Functional Properties of Composite Flour Bulk density
The bulk density is a reflection of the load the flour samples can exert, if allowed to rest directly on one another that could be used to determine the type of packaging material required for the product. The density of processed products dictate the characteristics of its container or package. Product density influences the strength of packaging material, texture or mouth feel (Wilhelm *et al*., 2004). Fermentation time significantly reduced bulk density

(P<0.05) of composite flour. As it increased from 0, 24 and 36 hr, the bulk density gradually decreased, from 0.9, 0.69, and 0.59 g/mL, respectively. Breakdown of starch during fermentation process reduce starch content and decreased the bulk density (Oti and Akobundu, 2008). Low bulk density flour was suitable for infant food formulations (Nelson *et al*., 2007; Ijarotimi *et al*., 2009). This kind complementary food will not be bulky and so it can be taken anytime of the day without adverse effect on the physiological need of an older infants and young children.There were significant difference (P<0.05) among bulk density result of complementary foods as shown in Table 3. The bulk density significantly decreased with increase in the levels of haricot bean flour substitution ranging from 0.75g/mL for 35% haricot bean flour substitution to 0.71g/cm^3 for 60% haricot bean flour substitution. The observed reduction in bulk density with increased in haricot bean flour substitution could be due to low carbohydrate content present in the haricot bean flour. In addition to this, bulk density 0.74 g/mL recorded in the present study, when 20% of haricot bean flour incorporated to 65% maize and 15% of cooking banana flour. This could be possibility of bulkiness effect of high percentage of maize and cooking banana inclusion. The values of the current study were in agreement with those of (0.56 to 0.86 gm/mL and 0.61 to 0.73gm/mL) bulk density reported by Ijarotimi and Oluwalena, (2012); Mishra *et al.* (2012) for popcorn based complementary flour and soya bean and maize flour, respectively.

Table 3. Effect of fermentation time and blending ratio on functional property of composite flour on dry weight basis

Fermentation time (hr)	BD (g/mL)	WAC (%)	Dispersibility (%)	SP (g/g)	WSI (%)
0	0.90^a	134.38^b	63.59^a	4.55^a	12.45^c
24	0.69^b	164.69^a	61.91^b	4.44^{ab}	13.57^b
36	0.59^c	158.4^a	60.72^c	4.38^b	14.16^a
LSD	0.01	8.01	0.72	0.14	0.11
CV	1.87	7.04	1.56	3.59	2.34
Blending Ratio	BD (g/mL)	WAC (%)	Dispersibility (%)	SP (g/g)	WSI (%)
B1	0.73^b	136.11^c	71.83^a	4.28^b	9.81^e
B2	0. 74 ^{a}	150.78^b	67.96^b	4.52^a	12.63^d
B3	0.74^{ab}	153.01^b	63.67^c	4.42^{ab}	13.01^c
B4	0.75^a	156.84^{ab}	59.85^d	4.57^a	14.33^b
B5	0.71^c	165.72^a	47.06^e	4.49^{ab}	17.18^a
LSD	0.01	10.34	0.93	0.22	0.3
CV	1.87	7.04	1.56	3.59	2.34

Means within the same column followed by the same letter are not significantly different (P>0.05), a>b>c>d>e, CV = Coefficient of variance, LSD = Least significant difference, hr = hour, BD = Bulk density, SP = Swelling power, WSI = Water solubility index, WAC = Water absorption capacity,B1=100% maize flour, B2 = 65:20:15, B3 = 60:30:10, B4 = 50:35:15,B5 = 30:60:10 ,maize, haricot bean and cooking banana, respectively.

Water absorption capacity

Water absorption capacity (WAC) indicates the amount of water available for gelatinization. Water absorption capacity results obtained in the present study increased from 134.38 to 164.69% as fermentation time increased from 0 to 24 hr. This indicates that WAC value of the fermented complementary flour is relatively higher than that of unfermented composite flour. The mean value of WAC of composite flour fermented for about 24 and 36 hr were statistically not different (P>0.05) as can be referred from Table 3. The water absorption capacity of the composite flour samples increased with increased in haricot bean flour inclusion and ranged from 150.78 to 165.72%. The high water absorption capacity had been attributed to lose structure of starch polymers, while low value indicated the compactness of molecular structure (Sanni *et al*., 2006). Lower water absorption capacity is desirable in making thinner complementary gruels for older infants. Water absorption capacity results obtained for complementary blends in the present study were in agreement with the 150 to 170 % reported by Abiodun *et al*. (2015) for plantain-cowpea based complementary foods.

Dispersibility

Dispersibility is a measure of reconstitution of flour or starch in water, the higher the dispersibility, the better the sample reconstitutes in water (Adebowale *et al.,* 2008) and gives a fine constituent during mixing (Adebowale *et al*., 2012). Fermentation time significantly decreased the dispersibility of composite flour. The mean value of dispersibility ranged over 63.59% for unfermented sample, 61.91% for 24 hr fermented sample and 60.72% for 36 hr fermented one. As can be seen from (Table 3) maize had the highest mean value while haricot bean flour had the lowest mean value. The lower dispersibility value of the haricot bean flour samples is probably implies that the samples will have lump formation tendency during preparation. The percentage dispersibility of all formulated composite flour were shown in Table 3. The values of percentage dispersibility of the composite flours were significantly (P<0.05) different from 100% maize flour. The lowest percentage (47.06%) of dispersibility recorded for 30:60:10 of maize, haricot bean and cooking banana, respectively,complementary flour and the highest percentage (67.96%) of dispersibility recorded for composite sample formulated from 65:20:15 of maize, haricot bean and cooking banana flour, respectively, were significantly lowered than 71.83% of 100% maize sample. The decrement in the percentage dispersibility of composite flour might have been contributed by the lower reconstitution ability of haricot bean flour.

Swelling power

Swelling power (SP) reflects the capacity of flour for hydration and gelatinization. It is associated with the behavior of starch in flour as it reacts with water, its concentration and temperature. Generally, the starch absorbs very little water at room temperature; hence, it leads to low swelling power. The result of swelling power indicated in the Table 3 showed that there were slight differences in swelling power of 4.28g/g for 100% maize flour, 4.42g/g for 60:30:10 of maize, haricot bean and cooking banana composite flour, respectively,and 4.57g/g for complementary flour produced from 50:35:15 of maize, haricot bean and cooking banana, respectively. This difference could be explained by the high content of starch, low contents of protein and fat in the maize flour contrary to composite flour. According to research finding reported by Wang and Seib (1996), the amount of protein and fat could inhibit swelling capacity of the starch granules. These findings were confirmed by those of Hathaichanock and Masubon (2007), who have shown that the presence of protein in the flour could reduce or inhibit swelling of the starch granules.

Similarly, swelling power of the flour is also affected by the processing methods. Swelling power decreased with increasing the fermentation period. The average values of swelling power for unfermented flour was 4.55 g/g which reduced up to 4.44 to 4.38 g/g after 24 and 36 hours of fermentation, respectively. The decreasing effect of fermentation on swelling power in the present study was consistent with the finding reported by authors Adebowale and Maliki (2011), who reported the reduction of the swelling capacity of pigeon pea flour subjected to different fermentation time.

Water solubility index

Water solubility index (WSI) measures starch degradation and amount of free molecules leached out from the starch granule of the sample including excess water. Lower WSI means there is minor degradation of starch and leads to less numbers of soluble molecules in a food (Hernández-Díaz *et al*., 2007). As results shown in Table 3 water solubility indices of complementary flour fermented for 0, 24 and 36 hr were 12.45, 13.57 and 14.16%, respectively. The obtained water solubility indices of fermented complementary flour significantly increased as fermentation duration increased. Increased WSI observed in all fermented complementary samples showed that degraded molecules of the flour particles by the fermentation process make it more readily available for digestion. As can be indicated in the Table 3, the water solubility index of the complementary blends ranged from 12.63 to 17.18% for 65:20:15 and 30:60:10 proportion consiting of maize, haricot bean and cooking banana flour, respectively, were significantly ($P<0.05$) higher than 9.81% of sample 100% maize flour.

Interaction Effect on Functional Properties of Composite Flour

Combined effect of fermentation time and blending ratio brought significant ($P < 0.05$) difference in bulk density of composite flour as presented in Table 4. The highest bulk density of 0.93 g/mL was recorded for unfermented 100% maize flour and the lowest bulk densities of 0.57 g/mL and 0.59 g/mL with no significant difference between them were noted for 100% maize flour and composite flour of 30, 60 and 10% of maize, haricot bean and cooking banana, level respectively both which fermented for 36 hour.

Significant difference ($P<0.05$) on the water absorption capacity of composite flours observed due to the interaction effect of fermentation time and blending ratio. Statistically, the highest water absorption capacity values ranged from 163.81 to 180.50% for samples fermented for 24 and 36 hr with respective composite flours of various proportions of the components. The majority of the lowest values 129.30 to 134.85% were observed in unfermented samples formulated from various proportions of flours.

Interaction of fermentation time and blending ration cause significant reduction in dispersibility of composite flour. The highest three values 73.73, 71.47 and 70.71% were observed for 100% maize flours of 0, 24 and 36 hr fermentation time, respectively. This showed that maize flour dominated the interaction effect as compared to the other two components. It is also worth noting that blending ratio played a significant role in affecting dispersibility as can be seen in the fall of values as the ratios go from 100% maize flour through 60% incorporation of haricot bean flour within each fermentation period.

Table 4. Interaction effect of fermentation time and blending ratio on functional properties of composite flour on dry weight basis

Treatment Combination	BD (g/mL)	WAC(%)	Dispersibility (%)	SP (g/g)	WSI (%)
F0*B1	0.93[a]	134.85[d]	73.33[a]	4.08[c]	8.62[j]
F0*B2	0.9[b]	131.34[d]	69.75[c]	4.55[abc]	11.34[g]
F0*B3	0.92[ab]	129.30[d]	65.30[e]	4.44[abc]	12.10[f]
F0*B4	0.90[b]	132.11[d]	61.00[gh]	4.80[ab]	13.65[d]
F0*B5	0.87[c]	144.33[cd]	48.567[j]	4.90[a]	16.55[b]
F1*B1	0.68 [ef]	141.07[cd]	71.467[b]	4.28[c]	10.09[i]
F1*B2	0.71[d]	163.81[ab]	67.617[d]	4.54[abc]	12.89[e]
F1*B3	0.70[de]	164.65[ab]	63.55[f]	4.51[abc]	13.20[de]
F1*B4	0.72[d]	173.40[ab]	60.07[hi]	4.52[abc]	14.43 [c]
F1*B5	0.66[f]	180.50[a]	46.85[k]	4.35[bc]	17.24[a]
F2*B1	0.57 i	132.40d	70.71bc	4.48abc	10.73h
F2*B2	0.62[g]	157.18[bc]	66.52[de]	4.47[abc]	13.66[d]
F2*B3	0.59[h]	165.09[ab]	62.16[fg]	4.31[c]	13.72[d]
F2*B4	0.62[g]	165.00[ab]	58.47[i]	4.40[bc]	14.93[c]
F2*B5	0.59[hi]	172.33[ab]	45.76[k]	4.23[c]	17.75[a]
LSD	0.02	17.90	1.61	0.48	0.52
C V	1.87	7.04	1.56	3.59	2.34

Means within the same column followed by the same letter are not significantly different (P>0.05), a>b>c>d>e>f>g>h>i>j>k, CV = Coefficient of variance, LSD = Least Significant Difference, hr = hour, BD = Bulk density, SP = Swelling power, WSI = Water solubility index, WAC = Water absorption capacity, B1=100% Maize flour, B2 = 65:20:15, B3 = 60:30:10, B4 = 50:35:15, B5 = 30:60:10, maize, haricot bean and cooking banana, respectively. F0, F1 and F2 represent 0, 24, and 36 fermentation time in hour, respectively.

As can be seen from Table 4 the highest percentage of dispersibility 73.3% was obtained in unfermented 100% maize flour, while the lowest percentage of dispersibility 45.76 and 46.85% were indicated for 36 and 24 hr fermented composite flours both of which produced from 30, 60 and 10% of maize, haricot bean and cooking banana, respectively.

Significant differences (P < 0.05) were also noted in swelling power of the composite flour due to the two factors. Highest values were recorded for samples consisting of different proportion of components in respective of fermentation time. Among the lowest values are of pure maize regardless of fermentation time, all values ranged from 4.08 to 4.90 g/g.

Fermentation time interaction with blending ratio showed significant difference (P<0.05) on water solubility index of composite flour. The highest water solubility indices 17.75 and 17.24% were recorded for 24 and 36 hr fermented composite sample consisting of 30, 60 and 10% maize, haricot bean and cooking banana, respectively. The next higher value (16.55%) was recorded for unfermented sample with similar proportion of the components. It can be seen from the data that blending ratio played substantial role than fermentation time in this parameter. The lowest (8.62%) water solubility index was recorded for unfermented 100% maize flour.

Effect of Fermentation Time and Blending Ratio on Sensory Evaluation Texture: It is fundamentally important in determining the consumer acceptability of cereal based food (Pareyt and Delcour, 2008). The complementary food made from 100% maize flour had the best score 5.67 for texture acceptability. However, complementary food made by high level of haricot bean addition to maize and cooking banana flour resulted in 4.90 average value of texture. Complementation of haricot bean flour from 30% to 60% showed no significant difference in terms of texture acceptability. The texture of the complementary food made from composite flour fermented for 0 h was preferred by the panelists with the average value of 5.42 (like slightly), where as the complementary food prepared from blend fermented for 24 and 36 hrs were preferred in the second and third rank with the average value of 5.20 and 5.09 (like slightly), respectively.

Table 5. Effect of fermentation time and blending ratio on organoleptic acceptability of complementary food

Ferm.time (hr)	Texture	Taste	Flavour	Color	Aroma	Overall aceptability
0	5.42^{a}	5.36^{a}	5.00^{a}	5.39^{b}	5.26^{b}	5.58^{a}
24	5.20^{b}	5.07^{ab}	5.20^{a}	5.51^{b}	5.65^{a}	5.55^{a}
36	5.09^{b}	4.95^{b}	5.14^{a}	5.94^{a}	5.34^{b}	5.44^{a}
LSD	0.19	0.30	0.31	0.28	0.30	0.34
CV	5.01	7.87	8.05	6.81	7.52	8.39
Sample code	Texture	Taste	Flavour	Color	Aroma	Overall aceptability
B1	5.67^{a}	5.21^{a}	5.47^{ab}	6.13^{a}	5.98^{a}	6.08^{a}
B2	5.50^{a}	5.51^{a}	4.97^{c}	5.22^{b}	5.33^{b}	5.65^{ab}
B3	5.15^{b}	5.31^{a}	5.52^{a}	5.91^{a}	5.69^{ab}	5.78^{a}
B4	4.99^{b}	5.19^{a}	5.12^{bc}	5.49^{b}	5.44^{b}	5.33^{b}
B5	4.90^{b}	4.41^{b}	4.48^{d}	5.31^{b}	4.63^{c}	4.81^{c}
LSD	0.25	0.39	0.39	0.37	0.39	0.45
CV	5.01	7.87	8.05	6.81	7.52	8.39

Means within the same column followed by the same letter are not significantly different (P>0.05), a>b>c, CV = Coefficient of variance, LSD = Least significant difference, hr = hour, B1=100% maize flour, B2= 65:20:15, B3 = 60:30:10, B4 =50:35:15,B5 = 30:60:10, maize, haricot bean and cooking banana, respectively.

Taste: Taste is the primary factor that determines the acceptability of any food product, which has the highest impact as far as market success of product is concerned. The taste of complementary porridge produced from fermented composite flour were favorably compared with the unfermented complementary food. Fermentation caused significant difference P<0.05 for taste preference by panelists. The result of sensory score shown in Table 5 referred that the highest average taste score of (5.36) for composite complementary porridge fermented for 0 hr was statistically different from the lowest average value of 4.95 for composite complementary food fermented 36 hr. The intermediate average taste sensory score of 5.07 for 24 hr fermented complementary food sample is not statistically different from both values. The average results of taste evaluation by the panelist for the 100% maize flour sample and of the composite blends were statistically not different from each other with exception of composite blends having 60% complementation of haricot bean flour.

Flavour acceptability test was carried out in complementary porridge prepared from composite flour fermented at 0,24 and 36 hr. In this experiment no statistically difference was observed among complementary food prepared from both fermented and unfermented composite flour. The average flavour score of the complementary porridge as affected by blending proportion shown in Table 5 implies that higher flavour score were recorded for complementary porridge produced from 60:30:10 of maize, haricot bean and cooking banana flour, respectively, and for that of 100% maize flour sample. The lowest flavour 4.48 sensory score in this work was recorded for 60% incorporation of haricot bean flour and was significantly (P<0.05) all other samples.

Color: It reflects the suitable raw material used for the preparation and also provides information about the formulation and quality of the product (Mepba *et al.*, 2007). With respect to color, complementary porridge prepared from composite sample fermented for 36 hr had significantly higher color score 5.94 as compared to unfermented and the 24 hr fermented samples with score values of 5.39 and 5.51, respectively. Average color scores of all developed complementary blends showed substantial difference as compared to the control sample. The average result of color evaluation by panelists showed that there were significant difference among developed complementary porridge prepared from different composite flour. Higher color score (5.91) next to control sample (6.13) was observed in developed complementary porridge prepared from 60, 30 and 10% of maize, haricot bean and cooking banana blends, respectively. Complementary porridge produced from maize, haricot bean and cooking banana blends was in acceptable ranges upto 60% haricot bean incorporation levels with respect to color.

Aroma : The acceptability score of the aroma of the products exhibited significant (P<0.005) difference attributed to fermentation time. Samples of 24 hr fermented had higher (5.65) score as compared to those scores 5.26 and 5.34 of the control sample and of that with 36 hr fermentation time, respectively. Aroma scores of the products also varied significantly (P < 0.005) due to blending ratio. The control sample and that of 60:30:10 maize, haricot bean and cooking banana flour, respectively, obtained statistically the highest scores with value of 5.98 and 5.69, respectively, with no statistical difference between them. Statistically, the lowest score (4.63) was recorded for samples with the highest, 60% haricot bean incorporation level.

Overall acceptability: Overall acceptability scores of complementary foods did not show statistical difference attributed to fermentation time with values of 5.58, 5.55 and 5.44 for samples of 0, 24, 36 hours of fermentation, respectively. Blending ratio of components resulted significant difference in overall acceptability scores for some complementary porridge. Samples 100% maize, 65:20:15 and 60:30:10, respectively, of maize, haricot bean and cooking banana complementary porridge showed no significant difference among them with value of 6.08, 5.65 and 5.78, respectively. But all were statistically higher than the scores attained by complementary porridge samples consists 50:35:15 and 30:60:10 of maize, haricot bean and cooking banana proportion, respectively, which achieved score of 5.33 and 4.81, respectively.

The substitution of maize flour and cooking banana with haricot bean flour upto 35% in complementary porridge production generate good results in overall acceptability. Similar, research reports indicated that the overall acceptability of ready to eat complementary food produced from fermented sorghum and cow pea in (2:1) blends was accepted by panelist with like moderately and slightly (Philip, 2015).

Interaction Effects on Organoleptic Acceptability of Complementary Food.

The data that show the interaction of fermentation time and blending ratio on texture score of complementary food are shown Table 6. Statistically, the highest scores, which ranged from 5.36 to 5.78 were recorded for samples with 100% maize flour and 65, 20 and 15% of maize, haricot bean and cooking banana, respectively. Irrespective of fermentation time ingredient proportions played a significant role in acceptability of the texture of the products. As the proportion of maize reduces and those of other components increased the textural acceptability scores decreased regardless of fermentation time. Thus, texture acceptability was more affected by ingredients than by fermentation. The lowest texture scores 4.70 and 4.54 were recorded for blends of 50, 35 and 15% maize, haricot bean and cooking banana fermented for 24 and 36 hour, respectively.

The data showing the interaction of the two factors Table 6, indicated significant ($P<0.01$) differences on average taste scores of complementary food. The values ranged from 4.13 to 6.15 in general with no distinctive trend to show relations.

Table 6. Interaction effect of fermentation time and blending ratio on organoleptic acceptability of complementary food

Treatment combination	Texture	Taste	Flavour	Color	Aroma	Overall acceptability
F0*B1	5.71^{a}	5.09^{cd}	5.58^{b}	6.47^{ab}	6.13^{b}	6.43^{ab}
F0*B2	5.48^{abc}	6.03^{a}	4.88^{cedfg}	5.29_{efg}	5.42^{cd}	5.79^{bcde}
F0*B3	5.57^{abc}	5.17^{bcd}	4.79^{defg}	4.92^{g}	4.94^{de}	5.15^{efg}
F0*B4	5.24^{bcd}	5.68^{abc}	5.21^{bcdef}	5.16^{efg}	5.42^{cd}	5.79^{bcde}
F0*B5	5.13^{cde}	4.82^{de}	4.56^{fg}	5.10^{g}	4.37^{e}	4.76^{fg}
F1*B1	5.78^{a}	5.63^{abc}	5.54^{bc}	5.63^{def}	6.11^{b}	5.81^{bcd}
F1*B2	5.36^{abcd}	4.67^{def}	4.95^{bcde}	5.23^{efg}	5.25^{cd}	5.43^{cdef}
F1*B3	5.16^{cd}	6.15^{a}	6.29^{a}	6.75^{a}	6.84^{a}	6.69^{a}
F1*B4	4.70^{ef}	4.64^{def}	4.68^{efg}	4.90^{g}	5.28^{cd}	4.82^{fg}
F1*B5	5.01^{de}	4.27^{ef}	4.54^{fg}	5.08^{fg}	4.76^{de}	5.02^{efg}
F2*B1	5.51^{abc}	4.91^{de}	5.29^{bcde}	6.28^{abc}	5.69^{bc}	5.99^{abc}
F2*B2	5.66^{ab}	5.84^{ab}	$5.10b^{cdef}$	5.16^{efg}	5.31^{cd}	5.74^{bcde}
F2*B3	4.72^{ef}	4.61^{def}	5.49^{bc}	6.08^{bcd}	5.30^{cd}	5.49^{cdef}
F2*B4	5.03^{de}	5.27^{bcd}	5.47^{bcd}	6.42^{ab}	5.62^{bc}	5.34^{cdefg}
F2*B5	4.54^{f}	4.13^{f}	4.34^{g}	5.75^{cde}	4.77^{de}	4.66^{fg}
LSD	0.44	0.67	0.69	0.64	0.68	0.77
C V	5.01	7.87	8.05	6.81	7.52	8.39

Means within the same column followed by the same letter are not significantly different ($P>0.05$), a>b>c>d>e>f>g, CV = Coefficient of variance, LSD = Least significant difference, F0, F1and F2 show 0, 24 and 36 fermentation time in hour, respectively, and B1=100% maize flour, B2= 65:20:15, B3 = 60:30:10, B4 = 50:35:15, B5 = 30:60:10, maize, haricot bean and cooking banana, respectively.

Interaction effect of fermentation and blending ratio resulted considerable difference on average flavor score of complementary porridge. Statistically the highest flavor score 6.29 was of samples with 24 hr fermentation time and composition of 50, 35, 15% maize, haricot bean and cooking banana, respectively. The lowest scores (4.34 to 4.68) belonged to samples having the lowest 30% of maize proportion (B5) regardless of fermentation time.

Fermentation with blending ratio interaction showed significant difference ($P<0.05$) on the colorscore of complementary porridge. The highest average color score 6.75 was observed in 24hr fermented with 60, 30, 10% maize, haricot bean and cooking banana incorporated complementary porridge. The values ranged from 4.90 to 6.75 that varied randomly showing no trend among the data.

The interaction of fermentation time and blending ratio on aroma score of complementary food showed considerable difference. The highest mean score of aroma 6.84 was noted for samples prepared from 24 hr fermented blends of 60, 30, 10% maize, haricot bean and cooking banana. This was followed by 6.13 and 6.11 for 100% maize products fermented for 0 and 24 hr, respectively. The lowest three mean aroma score 4.37, 4.76 and 4.77 were recorded for products having 30, 60 and 10% of maize, haricot bean and cooking banana flour fermented for 0, 24 and 36 hr, respectively.

As can be referred from the Table 6, among all treatment combination the highest 6.69 and 6.4 overall acceptability scores were observed for unfermented 100% maize sample and sample consisting of 60, 30 and 10% of maize, haricot bean and cooking banana fermented for 24hr, respectively. Statistically, the lowest overall acceptability scores ranged between 4.66 and 5.34 were recorded for samples with lower maize contents of 50 and 30%. This showed that maize played important role in overall acceptability of the formulated products.

CONCLUSION

Maize, haricot bean and cooking banana are locally available and affordable raw materials that can be used in development of nutritionally adequate and organoleptically acceptable complementary food. The study showed that fermentation significantly improved some functional properties of developed complementary foods. Correspondently, bulk density and dispersibility of composite flour decreased as fermentation time increased, whereas water absorption capacity and solubility index increased as fermentation duration prolonged. No considerable significant difference was observed on swelling power among all treatments. Unfermented composite flour produced from 60, 30 and 10% of maize, haricot bean and cooking banana achieved the highest (0.92 g/mL) bulk density value. The highest water solubility indices were recorded for samples of lowest 30% maize proportion, whereas high dispersibility 70.71 to 73.33% were recorded for those with 100% maize regardless of fermentation time.

Furthermore, the sensory result showed that the majority of the products earned scores of greater than 5 in the scale of 7 points indicating a positive response. Accordingly, result of organoleptic acceptability score revealed that complementary porridge produced from 24 hr fermented composite flour composed of 60, 30 and 10% maize, haricot bean and cooking banana, respectively, were highly preferred by panelists in terms of all sensory attributes exclusive texture.

ACKONWLEDGEMENT

Firstly, the Authors gratefully Acknowledge the Almighty God, next, Ethiopian Institute of Agricultural Research for it's financial support and finally support offered by Food science and post harvest Technology staff members of Melkassa Agricultural research center and Haramaya University, Ethiopia.

REFERENCE

Abiodun, A., Olapade, Kafaya, A. Babalola, Ogugua, C. and Aworh. 2015. Evaluation of Plantain and Cowpea Blends for complementary foods. *Journal of International Scientific Publications* , 3, pp. 274–288.

Adebowale, A.A., Adegoke, M.T, Sanni, S.A., Adegunwa, M.O. and Fetuga, G.O. 2012. Functional properties and biscuit making potentials of sorghum -wheat flour composite. *Am. J. Food Technol.* 7: 372-379.

Adebowale, A.A., Sanni, L.O and Fadaunsi, E.L. 2008. Functional properties of cassava – sweet potato starch blend. *Proceeding of the 32nd Annual Conference of Nigerian Institute of Food Science and Technology*, pp 304-305.

Adebowale, O.J. and Maliki, K. 2011.'Effect of fermentation period on the chemical composition and functional properties of Pigeon pea (Cajanus cajan) seed flour', 18(4), pp. 1329–1333

Agomoh-Adeoye, Q.C., Ezenwa H.C. and 2015. Evaluation of Blended Cooking Banana (*Musa spp*) and Soybean (*Glycinemax (L.) Merrill*) as Food Complement for Infants. *Science Journal of Business and Management*. Special Issue: Sustainable Entrepreneurial Developments in Agribusiness. Vol. 3, No. 5-1, 2015, pp: 26-29 .

Antony, U. and Chandra, T. S. 1998. Antinutrient reduction and enhancement in protein, starch, and mineral availability in fermented flour of finger millet (Eleusine coracana). *Journal of Agricultural and Food Chemistry*, *46*(7), 2578-2582.

Codex Alimentarius commosion.1991.Guidelines for formulated supplementary food for infant and young children (No. CAC/GL 8).Rome, Italy: Codex Alimentarius commission. Available at http:// Codex Alimentarius.net/Download /standards/298/CXG-008e.pdf.

FAO/WHO/UNU. 1985. Energy and protein requirements Report of a joint expert consultation Federal Agriculture Organisation/World Health Organisation/United Nations Universities. WHO Technical Report series No. 724, Geneva. 206.

Feyera, M., Abera, S. and Temesgen, M. 2020. Effect of Fermentation time and Blending ratio on Nutrients and some anti-nutrient composition of complementary flour. European Journal of Food Science and Technology 8 (3) , 1-12

Griffith, L.D., Castell, M.E. and Griffith, M.E. 1998. Effects of Blend and Processing method on the Nutritional Quality of Weaning Foods Made from Select Cereals and Legumes, published by the American Association of Cereal Chem., Inc, Vol. 75, No. 1,p.p 105–112

Hardwick, J. and Sidnell, A. 2014. Infant nutrition diet between 6 and 24 months, implications for paediatric growth, overweight and obesity. Nutrition Bulletin, 39(4): 354–363.

Hathaichanock, C. and Masubon, T. 2007. The chemical and physico-chemical properties of sorghum starch and flour. *Kasetsart Journal of National Science,* 41: 342-349.

Hernández-Díaz, J.R., Quintero-Ramos, A., Barnard, J. and Balandrán-Quintana, R.R. 2007. Functional Properties of Extrudates Prepared with Blends of Wheat Flour/Pinto Bean Meal with Added Wheat Bran. Food Science and Techno International 13(4): 301-308.

Hirsch, J.B. and Kokini, J.L. 2002. Understanding the mechanism of cross- linking agents through swelling behavior and pasting properties of cross-linked waxy maize starches, *Cereal Chemistry*, 79: 102-107.

Hotz, C. and Gibson, R. S. 2007. Traditional food. processing and preparation practices to enhance the bioavailability of micro-nutrients in plant –based diets. Journal of Nutrition 137: 1097-1100.

Ijarotimi, O.S., Oluwalana, I.B. and Ogunedojutimi, M.O. 2012. Nutrient Composition, Functional, Sensory and Microbial Status of Popcorn-Based (*Zea may everta*) Complementary Foods Enriched with Cashew Nut (*Anacardium occidentale L.*) flour. *African Journal of Food, Nutrition and Development,* 12 (5):1-23.

Kalui, C.M., Mathara, J.M. and Kutima, P.M. 2010. Probiotic potential of spontaneously fermented cereal based foods. A review, *African Journal of Biotechnology*, 9(17): 2490-2498.

Kulkarni, K.D, Kulkarni, D. and Ingle, U.M. 1991. Sorghum malt-based weaning formulations: preparation, functional properties and nutritive value. *Food and Nutrition Bulletin.,* 13 (4): 322-327.

Mepba, H.D., Eboh, L. and Nwaojigwa, S.U. 2007. Chemical composition, functional and baking properties of wheat-plantain composite flours. *African Journal of Food Agriculture Nutrition and Development,* 7(1): 1–22

Michaelsen, K.F., Weaver, L., Branca, F. and Robertson, A. 2000. Feeding and nutrition of infants and young children Guidelines for the WHO European Region, with emphasis on the former Soviet countries, WHO Regional Publications, European Series, 87: 45-80.

Mishra V., Puranik V.,Akhtar N. and Rai G.K. 2012. Development and Compositional Analysis of Protein Rich Soya bean-Maize Flour Blended Cookies. *Journal of Food Processing and Technol*ogy.3 (9):1-5.

Motuma Adimasu, Azeb Lelisa and Bekesho Geleta. 2016. Complementary feeding: Review of Recommendations, Feeding Practices, and Adequacy of Homemade Complementary Food Preparations in Developing Countries, Lessons from Ethiopia. Frontiers in Nutrition, 3(41): 1–9.

Nelson-Quartey, F. C., Amagloh, F. K., Oduro, I., and Ellis, W. O. 2007. Formulation of an infant food based on breadfruit (Artocarpusaltilis) and breadnut (Artocarpuscamansi). *Acta Horticulturae (ISHS)*, *757*, 212–224

Ngalani, J.A. 1989. Valorisation du plantain: étude del'obtention, de la caractérisation et de l'utilisation des farines –Conservation en frais. Thèse de Doctorat d'Etat, p. 159, Université des Sciences et Techniques du Languedoc, France.

Nnam, N. M. 2002. Evaluation of complementary foods based on maize, ground nut, pawpaw and mango flour blend. Nigerian Journal of. Nutritional Sciences 23:1-4.

Ojokoh, Fayemi, Ocloo and Nwokolo, F. I. 2015. Effect of fermentation on proximate composition, physicochemical and microbial characteristics of pearl millet (Pennisetum glaucum (L.) R. Br.) and Acha (Digitaria exilis (Kippist) Stapf) flour blends. *Journal of Agricultural Biotechnology and Sustainable Development*, Vol. 7(1), pp. 1-8.

Oraka, C.O. and Okoye, J.I. 2017. Effect of heat processing treatments on the chemical composition and functional properties of lima bean (Phaseolus lunatus) Flour. *American Journal of Food Science and Nutrition*, 1(1):14 –24.

Oti, E. and Akobundu, E.N. 2008. Potentials of cocoyam-soybean- crayfish mixtures in complementary feeding. *Nigeria Agricultural Journal*, *39*, 137–145.

Pareyt, B. and Delcour, J.A. 2008. The Role of Wheat Flour Constituents, Sugar, and Fat in Low Moisture Cereal Based Products: A Review on Sugar-Snap Cookies. *Critical Reviews in Food Science and Nutrition,* 48 (9): 824-839.

Philip Kinyua .2015. Nutritional and Anti-nutritional Evaluation of Selected Sorghum Varieties and Sorghum – Pigeon Pea Flour Blends for Ready to Eat Complementary Food Product Development A Thesis submitted in partial fulfillment for the Degree of Master of Science in Food Science and Nutrition in the Jomo Kenyatta University of Agriculture and Technology.

Sanni, S.A, Adebowale, A.A. and Yusuf, A.S. 2006. 'Physical, proximate and cooking properties of selected Nigerian cowpea varieties' *Nigerian. Food Journal, vol.* 24, no. 1, pp. 34-41.

Towo, E., Matuschek, E. and Svanberg, U. 2006. Fermentation and enzyme treatment of tannin sorghum gruels: effects on phenolic compounds, phytate and in vitro accessible iron. *Food Chemistry*, 94(3), 369-376.https://doi.org/10.1016/j.foodchem.2004.11.027.

Wang, L. and Seib, P. A. 1996. Australian salt-noodle flours and their starches compared to US wheat flours and their starches. *Cereal chemistry*, *73*(2), 167-175.

WHO/FAO (World Health Organization) (Food and Agriculture Organization). 2010. Codex Committee on Nutrition and Foods for special dietary uses. *Thirty second session. Santiago, chile.*

Wilhelm, L.R., Dwayna, A.S. and Gerand, H.B. 2004. Introduction to problem solving skills In: Food and Process Engineering Technology. ASAE yellow maize (Zea *mays*). *Journal of Biological Sciences*, **5**, 590-596.