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EVALUATION OF COMPLEMENTARY FOODS PRODUCED FROM SORGHUM, SOYBEAN AND IRISH POTATO COMPOSITE FLOURS

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ABSTRACT

The nutritive and ready-to-eat complementary foods were formulated from the blends of malted sorghum, soybean and Irish potato flour and evaluated for proximate, vitamin and sensory properties using standard analytical methods. The protein, fat, ash and crude fibre contents of the samples increased significantly ($p<0.05$) with increased substitution of soybean and Irish potato flours from 9.30±0.02 - 15.15±0.41%, 0.86±0.03 - 2.00±0.14%, 2.45±0.01 – 4.02±0.14% and 2.18±0.03 – 3.66±0.29%, respectively, while the carbohydrate decreased. The control sample (100% malted sorghum flour) had the highest carbohydrate value (77.00+0.72%). The vitamin content of the complementary foods also showed similar increases in ascorbic acid (10.12±0.14 – 22.64±0.11 mg/100g), niacin (2.47±0.01 – 3.18±0.09 mg/100g), thiamine (27.33±1.57 – 41.02±0.78 mg/100g), riboflavin (9.41±0.01 – 10.83±0.08 mg/100g), vitamin A (0.88±0.02 – 10.02±0.14 mg/100g) and folic acid (7.11±0.01 – 10.15±0.09 mg/100g), respectively as the ratios of soybean and Irish potato flours increased in the blends. The colour, taste, mouthfeel and the texture of the control sample were the most acceptable to the judges compared to the samples substituted with soybean and Irish potato flours at different graded levels. Although, it had better consumers' sensory attributes, it was the least in nutrient contents with the exception of carbohydrate. The study, therefore, showed that the macro and micronutrient contents of the gruels can be improved by substituting sorghum-based traditional complementary foods with soybean and Irish potato flours at varying proportions in the preparation of complementary foods.

Keywords: Complementary foods, proximate composition, vitamin content, sensory properties, sorghum flour, soybean flour, Irish potato flour.

INTRODUCTION

The consumption of cereal–based food products from maize *(Zea mays)*, sorghum (*Sorghum bicolor),* millet (*Pennisetum typhoideum),* wheat (*Triticum aestivum),* oat (*Avena sativa)* and rice (*Oryza sativa*) etc. is very common and popular worldwide especially in developing African countries where they constitute a major source of their staple food (Gemah *et al*., 2012*;* Mohammed *et al.,* 2016*).* Due to the prevailing unfavourable economic condition in most developing countries of the world, Africa and Nigeria in particular where over 40% of the population live below poverty line, the incidence of protein – energy malnutrition among different age groups particularly children with an estimated 400 million children being reported to be malnourished worldwide is highly prevalent and on the increase on a daily basis (Nzeagwu and Nwaejike, 2008; Agiriga and Iwe, 2009). Weaning of infants is highly critical in the life of children as breast feeding (4-6 months), which normally precedes the weaning period can no longer meet their nutritional requirements (Kinyua *et al*., 2016). The nutritional qualities of traditional complementary foods in developing countries, particularly in Nigeria, indicate that they are low in protein content and also devoid of vital nutrients that are needed for normal growth and development (FAO, 2004). In Nigeria as in most developing countries, one of the greatest problems affecting millions of people, particularly children is lack of adequate protein intake in terms of quality and quantity. As cereals are generally low in protein, supplementation of cereal with locally available legume that is high in protein will greatly increase the protein content of cereal–legume blends. Complementary foods are used to meet the infant nutritional requirement, when the mother's breast milk is no longer adequate to meet its nutritional requirement after the period of exclusive breast feeding (Agu and Aluya, 2004). Complementary foods are mostly produced from locally available food crops which include cereals such as wheat, sorghum, maize, millet and rice, root and tuber crops such as yam, Irish potato and sweet potato and legumes such as cowpea, soybean, African yam bean and Bambara groundnut etc. The formulation of complementary foods can be made by using either one or a combination of more than one plant product, cereal with legume (Odumodu, 2008). In most developing countries, traditional complementary foods which consist mainly of un-supplemented cereal gruels or porridges made from maize, sorghum and/or millet are grossly inadequate in some macro and micronutrients (Barber *et al.,* 2017). Adequate processing and judicious blending of locally available food crops could result in improved intake of nutrients to prevent the problem of malnutrition. Sorghum (*Sorghum bicolor*), soybean *(Glycine max*) and Irish potato (*Solanum tuberosum*) are foods crop that are readily available in Nigeria. Whole sorghum grain is an important source of complex vitamins and some minerals like phosphorus, magnesium, calcium and iron (Onabanjo *et al*., 2009). The protein content of sorghum is similar to that of wheat and maize, with lysine as the most limiting essential amino acid (FAO, 2009). Soybean is an excellent source of protein (35-40%). It is also rich in calcium, iron, phosphorus and vitamins. It is the only vegetable source of protein that contains all the essential amino acids (Nwakalor and Obi, 2014). Soy protein is limiting in essential sulphur containing amino acids (methionine, cystine etc.) but is rich in lysine (FAO, 1992). Hence, soybean could form a good supplement to sorghum which is low in lysine. Sorghum contains high level of dietary fibre (13.2%) but low in trace minerals and ascorbic acid. Thus, there is need to enrich sorghum diets with both protein and micronutrient rich foods. Legumes also contain substantial amount of minerals and vitamins with cowpea (Vigna unuguiculata), soybean (*Glycine max*) and Bambara groundnut (*Vigna subterrenea*), regarded as good sources of calcium and iron (Enwere, 1998).

Complementary foods in developing countries are often low in fat and essential fatty acids, which are required for growth and development. Non-breast fed children in developing countries are thus often at high risk of inadequate fat intake. Animal source foods such as fish, egg, meat and milk are important for complementary feeding as they provide high quality protein, bioavailable micronutrients and have low levels of anti-nutrients and fibre. However, these are unaffordable for majority of the population in sub-Saharan African countries like Nigeria. Consequently, most mothers use local alternatives to milk such as soybean to complement cereals as such maize, sorghum, millet and rice gruels. Soybean contains about 19% fat. It is low in saturated fat, cholesterol – free and high in many important nutrients such as B-group vitamins, calcium, potassium, magnesium, fibre, isoflavones, iron and vitamin D (USDA, 2007). Irish potato is a very important and cherished food crop all over the world because it serves as vegetable and a good source of starch in the diet of human beings and animals. It is very low in protein and fat. Irish potato has low phytate content which does not interfere with the absorption of minerals and vitamins (Okaka, 2005). The nutritional potentials of the triple mixes (sorghum, soybean and Irish potato) as composites in the preparation of complementary foods can be of immense health benefits especially in the prevention of protein-energy malnutrition and micronutrient deficiencies by providing nutrition security to infants and young children. This study, therefore, was designed to evaluate the proximate, vitamin and sensory properties of sorghum-based complementary foods supplemented with soybean and Irish potato flours.

MATERIALS AND METHODS

The white variety of sorghum (*Sorghum vulgare*), soybean (*Glycine max*) and Irish potato (*Solanum tuberosum*) used for the study were bought from Aria Market, Enugu, Enugu State, Nigeria.

Preparation of Malted Sorghum Flour

The malted sorghum flour was prepared according to the method of Elemo *et al.* (2011). One kilogramme (1kg) of sorghum grains were manually sorted to remove the dirt and other contaminants. The sorted grains were thoroughly cleaned and steeped in 3 litres of potable water in a plastic bowl at room temperature (30 ± 2^0C) for 18 h with a change of water at every 6 h to prevent fermentation. After steeping, the grains were drained, rinsed and immersed in 2% sodium hypochlorite solution for 10 min to sterilize the grains. The grains were rinsed for five consecutive times with excess water and cast on a damped jute bag, covered with a polyethylene bag and left for 24 h to hasten sprouting. The grains were carefully spread on the jute bag and allowed to germinate at room temperature (30 ± 2^0C) and relative humidity of 95% in the germinating chamber for 96 h. During this period, the grains were sprinkled with water at intervals of 12 h to facilitate germination. Non-germinated grains were handpicked and discarded. The germinated grains were collected, spread on the trays and dried in a tray dryer (Model EU 850D, UK) at 50^0C for 24 h with occasional stirring of the grains at intervals of 30 min to ensure uniform drying. After drying, the malted sorghum grains were cleaned and rubbed in-between palms to remove the roots and the sprouts. The dried sorghum malts were milled in a hammer mill and sieved through a 500 micron mesh sieve. The flour produced was packaged in an airtight plastic container, labeled and kept in a refrigerator until needed for further use.

Preparation of Malted Soybean Flour

The malted soybean flour was prepared according to the method of Makinde and Ladipo (2012). One kilogramme (1kg) of soybean seeds were manually sorted to remove the dirt and other extraneous materials. The seeds were thoroughly cleaned and soaked in 3 liters of potable water in a plastic bowl at room temperature (30 ± 2^0C) for 18 h with a change of water at every 6 h to prevent fermentation. The soaked seeds were drained, rinsed and immersed in 2% sodium hypochlorite solution for 10 min to sterilize the seeds. The seeds were rinsed for five consecutive times with excess water and cast on a damped jute bag, covered with a polyethylene bag and left for 24 h to hasten sprouting. The seeds were carefully spread on the jute bag and allowed to germinate at ambient temperature (30 ± 2^0C) and relative humidity of 95% in the germinating chamber for 96 h. During this period, the seeds were sprinkled with water at intervals of 10 h to facilitate germination. Non-germinated seeds were handpicked and discarded. The germinated seeds were collected, spread on the trays and dried in a tray dryer (Model EU 850D, UK) at 50^0C for 24 h with occasional stirring of the seeds at intervals of 30 min to ensure uniform drying. The dried malted soybean seeds were cleaned and rubbed in-between palms to remove the roots and the sprouts along with the hulls. The dehulled soybean malts were milled in a hammer mill and sieved through a 500 micron mesh sieve. The flour produced was packaged in an airtight plastic container, labeled and kept in a refrigerator until needed for further use.

Preparation of Irish Potato Flour

The Irish potato flour was prepared according to the method of Okaka (2005) with slight modifications. One kilogramme (1kg) of Irish potato tubers were sorted to remove the dirt and other contaminants. The sorted potato tubers were cleaned thoroughly with 3.5 liters of potable water and peeled manually with a kitchen knife. The peeled Irish potato tubers were sliced into smaller slices. The potato slices were rinsed, placed into a stainless pot and blanched with 2.5 liters of potable water at 85^0C for 20 min on a hot plate. The blanched potato slices were drained, rinsed, spread on the trays and dried in a tray dryer (Model EU 850D, UK) at 60^0C for 12 h with occasional stirring of the slices at intervals of 30 min to ensure uniform drying. The dried slices were milled in a hammer mill and sieved through a 500 micro mesh sieve. The flour produced was packaged in an airtight plastic container, labeled and kept in a refrigerator until needed for further use.

Preparation of Complementary Food Samples

Sorghum, soybean and Irish potato flours were mixed thoroughly in the ratios of A-100:0:0, B-90:5:5, C-80:15:5, D-70:20:10, E-60:25:15 and F-50:30:20 in a rotary mixer (Philips, type HR 1500/A Holland) to produce homogenous complementary food samples. The complementary foods formulated were packaged separately in airtight plastic containers, labeled and preserved in a refrigerator until needed for analysis. The malted sorghum flour without any substitution (100% malted sorghum flour) was used as control.

Chemical Analysis

The moisture, crude protein, fat, ash and crude fibre contents of the complementary food samples were determined in triplicate according to the standard analytical methods (AOAC, 2006). Carbohydrate was calculated by difference. 100% - (% Moisture + % Crude Protein + % Ash +%Crude Fibre and % Fat). The ascorbic acid, niacin and folic acid contents of the samples were determined by the methods of AOAC (2006). The thiamine, riboflavin and vitamin A contents of the samples were determined according to the flourimetric methods of Onwuka (2005).

Sensory Analysis

Gruels were prepared from both the control and formulated samples of the complementary food. Sixty (60g) grammes of each sample were dissolved with 150mL of potable water to produce the slurry. Then, 180mL of boiling water was added to each of the slurry with continuous stirring to obtain homogenous gruels. Three grammes (3g) of granulated sugar were added to each sample of the gruel and stirred steadily until well distributed. The sensory test was carried out in sensory evaluation laboratory for attributes of colour, taste, mouthfeel, texture and overall acceptability by a panel of twenty (20) semi-trained judges comprising of nursing mothers, staff and students of the Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria. The samples were randomly coded and served to the assessors in white plastic cups with teaspoons at room temperature (30 ± 2^0C). Clean water was provided to the judges to rinse their mouth in-between testing of the gruels to avoid residual effect. The assessors were instructed to assess and score the samples based on their degree of likeness and acceptance of each of them using a nine-point Hedonic scale with 1 and 9 representing dislike extremely and like extremely, respectively (Iwe, 2007). Expectoration cups with lids were provided for the judges who did not wish to swallow the samples.

Statistical Analysis

The data generated were subjected to one-way analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS, Version 20) software. Means were separated using Turkey's Least Significance Difference (LSD) test at $p<0.05$ and the results were expressed as mean ± standard deviation of triplicate determinations.

RESULTS AND DISCUSSION

Proximate Composition of Complementary Food Samples

The proximate composition of complementary food samples are shown in Table 1. The moisture content of the complementary food samples varied significantly ($p<0.05$) from each other. The moisture content ranged from 8.21 to 10.49% with the control sample (100% malted sorghum flour) having the least moisture content (8.21%), while the sample substituted with 30% soybean and 20% Irish potato flours had the highest value (10.49%). The moisture contents of all the formulated complementary food samples reported in this study were within the recommended moisture contents of dried foods (Ndife *et al.,* 2011; Igyor *et al*., 2011). High moisture content in food has been shown to encourage microbial growth (Sanni and Oladapo, 2008). The values obtained in this study were within the range reported to have no adverse effect on the quality attributes of the product (Yusufu *et al.*, 2013). Bolarinwa *et al*. (2015) reported that the lower the moisture content of a product to be stored, the better the shelf stability of the food product. However, low residual moisture content in food is advantageous in that microbial proliferation is reduced and storage life may be prolonged, if stored in appropriate packaging materials under good environmental conditions. The protein content of the samples ranged from 9.30 to 15.15%. The protein content of the control sample (100% malted sorghum flour) was the lowest (9.30%), while the sample substituted with 30% soybean and 20% Irish potato flours had the highest protein content (15.15%). The protein content of the samples was observed to increase with increase in substitution with soybean flour. The protein contents of all the formulated complementary food products were superior to that of the control (100% malted sorghum flour). The observed increase in protein content could be attributed to the addition of high proportion of soybean flour in the blends and this is in agreement with the report that soybeans are good source of protein (Oti and Akobundu, 2008). The protein content obtained in this study was higher than the protein content of complementary food prepared from sorghum, African yam bean and mango mesocarp flour blends reported by Yusufu *et al*. (2013). Protein is important for tissue replacement, deposition of lean body mass and growth (Okaka *et al.,* 2006). The fat content of the complementary foods ranged from 0.86 to 2.00%. The fat content of 100% malted sorghum (control) was significantly ($p<0.05$) lower than the fat contents of all other formulated samples. There was significant ($p<0.05$) difference in fat content among the samples. The fat content of the formulated complementary food samples was relatively higher than the control (100% malted sorghum flour) but was below the recommended 10% dietary requirement for infants and children. This could be attributed to the inclusion of high levels of sorghum and Irish potato flours which have very low fat contents in the products. FAO/WHO (1998) reported that the high fat content of food meant for infants and children is nutritionally desirable in that it will not only increase the energy density but will also be a transport vehicle for fat soluble vitamins. Fat is also important in the diets of infants and young children as it provides essential fatty acids like Omega-3 and Omega-6 polyunsaturated fatty acids (PUFA's) that are needed in the body for proper neural development (Mariam, 2005). The ash content of the samples increased significantly ($p<0.05$) with increased substitution of soybean and Irish potato flours in the blends. The ash content of a food material could be used as an index for estimating the mineral constituents of the food. The ash content (2.45-4.02%) obtained in this study was lower than the ash content (3.47-4.53%) of complementary food prepared from maize, sesame and crayfish flour blends reported by Fasuan *et al.* (2017). The crude fibre content of the complementary foods ranged from 2.18 to 3.66% with the control (100% malted sorghum flour) and the sample substituted with 30% soybean and 20% Irish potato flours having the least (2.18%) and highest (3.66%) values, respectively. The values obtained in this study were higher than the fibre content (2.38-2.67%) of complementary food produced from sorghum, sesame, carrot and crayfish reported by Onabanjo *et al*. (2009). The crude fibre content of the samples was observed to increase as the level of substitution with soybean flour increased and this is in agreement with the report that soybeans are rich source of dietary fibre (Okoye *et al.*, 2016). Fibre is part of the food that cannot produce energy or be digested and absorbed by humans and other monogastric animals but it plays significant role in the digestion of foods. The carbohydrate content of the samples ranged from 64.68-77.00%. The carbohydrate contents of all the formulated complementary food samples were significantly ($p<0.05$) lower than the control. The increase in carbohydrate content of the control sample could be principally due to the high proportion of sorghum flour used. The levels of carbohydrate in all the complementary food samples are nutritionally adequate as children require energy to carry out their rigorous playing and other activities as growth continues. The values obtained in this study were higher than the carbohydrate content (55.86-70.00%) of complementary food formulated from fermented maize, soybean and carrot flours reported by Barber *et al*. (2017). The substitution of sorghum-based gruels with soybean and Irish potato flours greatly increased the protein, fat, ash and crude fibre contents of the formulations.

Vitamin Composition of Complementary Food Samples

The vitamin composition of complementary food samples are shown in Table 2. The ascorbic acid, niacin, thiamine, riboflavin, vitamin A and folic acid contents of the complementary food samples increased significantly ($p<0.05$) with increase in substitution with soybean and Irish potato flours. The increase in the vitamin content of the formulated samples confirms the beneficial effect of supplementation (Lutter and Dewey, 2003). The ascorbic content of the complementary food samples ranged from 10.12 to 22.64 mg/100g. The control sample (100% malted sorghum flour) had the least value (10.12mg/100g), while the sample supplemented with 30% soybean and 20% Irish potato flours had the highest ascorbic acid content (22.64mg/100g). The ascorbic acid content of the formulated food blends was observed to increase as the level of substitution with soybean flour increased and this is an indication that soybeans are excellent source of ascorbic acid (Ojinnaka *et al*. 2013). Ascorbic acid is important in the prevention of scurvy. It also helps in the development of healthy immune system in infants and young children (Ibironke *et al*., 2012). The niacin content of the samples varied significantly ($p<0.05$) from each other. The niacin content ranged from 2.47-3.18mg/100g with the control sample having the least value (2.47mg/100g), while the sample substituted with 30% soybean and 20% Irish potato flours had the highest niacin content (3.18mg/100g). The niacin content of the complementary foods formulated in this study was higher than the niacin content (2.28-3.02mg/100) of fermented maize meal fortified with Bambara groundnut flour reported by Mbata *et al.* (2005). Niacin is a component of the respiratory co-enzyme (NAD) that is responsible for tissue oxidation in the body (Berdanier and Zempleni, 2009). The thiamine content of the complementary foods ranged from 27.33 to 41.02mg/100g. The thiamine content of the samples was observed to increase with increase in the proportion of soybean flour in the blends and this is in agreement with the report that soybeans are rich source of thiamine (Mohammed *et al*., 2013). Thiamine helps in the treatment of beriberi and in the maintenance of healthy attitude in humans (Okaka *et al.*, 2006). The riboflavin content of the samples increased significantly ($p<0.05$) with increase in substitution with soybean and Irish potato flours. Similar increase in riboflavin content with increase in substitution with Bambara groundnut and sweet potato flours has been reported by Nnam (2001) for porridges prepared from sorghum, Bambara groundnut and sweet potato flour blends. Riboflavin is essential for growth and development in infants and young children (Lutter and Rivera, 2003). The vitamin A content of the formulations which ranged from 0.88 to 10.02mg/100g increased significantly ($p<0.05$) with increase in substitution with soybean flour. The vitamin A content of the samples was observed to increase with increase in substitution with soybean flour in the blends. The values obtained in this study were close to the vitamin A content (0.79-10.08mg/100g) of weaning foods developed from maize supplemented with legumes and oilseeds reported by Asma *et al.* (2006). Vitamin A helps in the prevention of xerophthalmia and keratomalacia of the eyes (Solomon, 2005). The folic acid content of the samples also increased significantly ($p<0.05$) from 7.11mg/100g in the control sample (100% malted sorghum flour) to 10.15mg/100g for the sample substituted with 30% soybean and 20% Irish potato flours. The folic acid content of the samples was observed to increase with increase in soybean flour substitution in the blends and this is an indication that soybeans are good source of folic acid (Muhimbula *et al*., 2011). Folic acid functions as a co-enzyme in the body. The substitution of sorghum-based gruels with soybean and Irish potato flours generally enhanced the vitamin content of the products.

Sensory Properties of Complementary Food Samples

The sensory properties of complementary food samples are shown in Table 3. The sensory scores of the gruels prepared from both the control and formulated samples of complementary food showed significant ($p<0.05$) differences in colour, taste, mouthfeel, texture and overall acceptability. The control sample (100% malted sorghum flour) had significantly ($p<0.05$) the highest scores for colour, taste, mouthfeel, texture and overall acceptability compared to the test samples, while the sample substituted with 30% soybean and 20% Irish potato flours had the lowest scores. The gruels prepared from 100% malted sorghum flour and those made from the formulated samples of complementary food supplemented with 5–30% soybean and 5–20% Irish potato flours were generally acceptable. The increase in substitution resulted in decrease in acceptability of the gruels as indicated by the relatively low scores for the sample substituted with 30% soybean and 20% Irish potato flours. The variation in colour observed could be due to increased substitution of the formulations with soybean and Irish potato flours. The sample substituted with 30% soybean and 20% Irish potato flours was also reported to have crumbly texture and a beany flavour, attributable to increased substitution and the beany flavour of soybean. However, the gruel made from the sample substituted with 5% soybean and 5% Irish potato flours was described by the panelists as having the best taste, mouthfeel and overall acceptability compared to the other test samples. The taste and mouthfeel are important parameters while testing the acceptability of formulated foods. Muhimbula *et al.* (2011) reported that the sensory qualities of complementary food formulations which are closely related to food preferences for infants and young children are of the greatest importance in addition to their energy density. This showed that sensory evaluation should be given adequate attention in the formulation and evaluation of quality attributes of home-made complementary food formulations.

Conclusion

The study showed that the low-cost and ready-to-eat complementary food products formulated from blends of sorghum, soybean and Irish potato flour can meet the micro and macro nutrient needs of infants and young children. The high protein, energy and vitamin contents of the traditionally prepared complementary food samples is an indication that the products could be used to substitute the more expensive proprietary infant formula such as Cerelac because of their high nutrient density and affordability. The complementary foods formulated in this study could be used by mothers to feed their infants and children during the complementary feeding period. The feeding of infants and children with the complementary food products developed from nutrient dense and locally available food materials in this study could also help to prevent the problem of protein-energy malnutrition that is prevalent among infants and children in Nigeria and other developing countries of the world.

Table 1: Proximate composition (%) of complementary food samples

Sample ID	% Substitution SF:SBF:IPF	Moisture	Protein (Nx6.25)	Fat	Ash	Fibre	Carbohydrate
A	100: 0: 0	$8.21^{f}\pm0.02$	$9.30^{f}\pm0.02$	$0.86^{f}\pm0.03$	$2.45^{f}\pm0.01$	$2.18^{f}\pm0.03$	$77.00^{a}\pm0.72$
B	90: 5: 5	$8.31^{e}\pm0.01$	$10.97^{e}\pm0.01$	$0.99^{e}\pm0.04$	$2.92^{e}\pm0.14$	$2.39^{e}\pm0.09$	$74.42^{b}\pm0.21$
C	80: 15: 5	$8.49^{d}\pm0.04$	$11.74^{d}\pm0.17$	$1.44^{d}\pm0.03$	$3.15^{d}\pm0.04$	$2.72^{d}\pm0.14$	$72.23^{c}\pm0.29$
D	70: 20: 10	$8.67^{c}\pm0.07$	$12.72^{c}\pm0.21$	$1.57^{c}\pm0.07$	$3.27^{c}\pm0.14$	$3.00^{c}\pm0.04$	$70.77^{d}\pm0.10$
E	60: 25: 15	$9.28^{b}\pm0.09$	$13.97^{b}\pm0.49$	$1.75^{b}\pm0.09$	$4.72^{b}\pm0.11$	$3.27^{b}\pm0.08$	$67.01^{e}\pm0.83$
F	50: 30: 20	$10.49^{a}\pm0.21$	$15.15^{a}\pm0.41$	$2.00^{a}\pm0.14$	$4.02^{a}\pm0.14$	$3.66^{a}\pm0.29$	$64.68^{f}\pm0.89$

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different letters are significantly different ($p<0.05$).
SF – Malted sorghum flour, SBF – Malted soybean flour, IPF – Irish potato flour.

Table 2: Vitamin composition (mg/100g) of complementary food samples

Sample ID	% Substitution SF:SBF:IPF	Ascorbic Acid	Niacin	Thiamine	Riboflavin	Vitamin A	Folic Acid
A	100: 0: 0	$10.12^{f}\pm0.14$	$2.47^{f}\pm0.01$	$27.33^{f}\pm1.57$	$9.41^{f}\pm0.01$	$0.88^{f}\pm0.02$	$7.11^{f}\pm0.01$
B	90: 5: 5	$12.35^{e}\pm0.09$	$2.53^{e}\pm0.04$	$33.07^{e}\pm0.21$	$9.59^{e}\pm0.09$	$2.03^{e}\pm0.04$	$8.31^{e}\pm0.07$
C	80: 15: 5	$14.70^{d}\pm0.11$	$2.74^{d}\pm0.03$	$34.47^{d}\pm0.36$	$9.94^{d}\pm0.11$	$4.17^{d}\pm0.08$	$8.48^{d}\pm0.11$
D	70: 20: 10	$16.01^{c}\pm0.27$	$2.87^{c}\pm0.08$	$36.02^{c}\pm0.29$	$10.22^{c}\pm0.01$	$6.39^{c}\pm0.09$	$9.40^{c}\pm0.39$
E	60: 25: 15	$18.36^{b}\pm0.03$	$3.04^{b}\pm0.03$	$39.08^{b}\pm0.23$	$10.49^{b}\pm0.25$	$8.72^{b}\pm0.14$	$9.88^{b}\pm0.06$
F	50: 30: 20	$22.64^{a}\pm0.11$	$3.18^{a}\pm0.09$	$41.02^{a}\pm0.78$	$10.83^{a}\pm0.08$	$10.02^{a}\pm0.12$	$10.15^{a}\pm0.09$

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different letters are significantly different ($p<0.05$).
SF – Malted sorghum flour, SBF – Malted soybean flour, IPF – Irish potato flour

Table 3: Sensory properties of complementary food samples

Sample ID	% Substitution MF:SBF:IPF	Colour	Taste	Mouthfeel	Texture	Overall Acceptability
A	100: 0: 0	$8.10^{a}\pm0.14$	$6.86^{a}\pm0.08$	$7.50^{a}\pm0.08$	$7.70^{a}\pm0.14$	$8.40^{a}\pm0.11$
B	90: 5: 5	$7.85^{b}\pm0.08$	$6.74^{b}\pm0.07$	$7.10^{b}\pm0.10$	$7.00^{b}\pm0.29$	$7.70^{b}\pm0.14$
C	80: 15: 5	$7.60^{c}\pm0.19$	$6.55^{c}\pm0.09$	$6.85^{c}\pm0.06$	$6.90^{b}\pm0.19$	$7.10^{c}\pm0.10$
D	70: 20: 10	$7.05^{d}\pm0.08$	$6.40^{d}\pm0.11$	$6.45^{d}\pm0.09$	$6.35^{c}\pm0.08$	$6.75^{d}\pm0.07$
E	60: 25: 15	$6.45^{e}\pm0.09$	$6.25^{e}\pm0.05$	$6.30^{e}\pm0.07$	$6.25^{d}\pm0.05$	$6.55^{e}\pm0.09$
F	50: 30: 20	$6.25^{f}\pm0.05$	$6.10^{f}\pm0.13$	$6.15^{f}\pm0.08$	$6.05^{e}\pm0.21$	$6.35^{f}\pm0.08$

Values are mean ± standard deviation of twenty (20) semi-trained judges. Means in the same column with different letters are significantly different ($p<0.05$).

SF – Malted sorghum flour, SBF – Malted soybean flour, IPF – Irish potato flour.

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