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Physicochemical and manufacturing cost elements of complementary food formulations from broken fraction of rice cultivars, soybean and sorghum malt

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ABSTRACT

The broken fractions of rice cultivars improved for yield, grain quality, amylose content and tolerance to common production constraints consisting of FARO 44, FARO 52, NERICA L-34, NERICA L-19 and LOCAL RICE. The rice cultivars, Sorghum malt and soybean were processed. Evaluation of the physicochemical properties of these new African rice cultivars together with their products yield and utilization (value addition) were the main objective of this study. The experimental design for these infant food formulations (5x2x2 factorial design) consisted of those 5 rice cultivars, sorghum malt (0, 5%) and soybeans flour (0, 30%). These formulations together with the raw materials were evaluated for their physicochemical properties. Manufacturing cost of formulations with ratios of rice to soybeans 70:30 with malt were selected and quantified. Results of particle size distributions showed significant ($p < 0.05$) difference. However, 98.38 and 94.90% of raw materials and blends respectively, successfully passed through 600 µm sieve aperture. Mesh 300 and 180 µm were found to retain the highest percentage particles. Functional properties of raw materials and blends were within the recommended range. More importantly, pH values of blends were comparable to infants' natural milk drinks. Proximate composition of raw materials and blends contain 4.14 to 9.59% moisture, 0.37 to 5.12% ash, 8.25 to 45.35% protein, 0.41 to 20.00% fat and 26.54 to 82.59% carbohydrate. Blends fiber and energy ranged from 1.27 to 4.33 and 362.95 to 388.71 Kcal (1541.92 to 1643.04 KJ) respectively. Formulations with ratios of rice to soybeans 70:30 with malt and those of rice 100% alone with malt were observed suitable as follow-on formulae and for infant(s) with critical protein related ailments, respectively. Net profit generated is more significant than interest rate that could have been obtained from bank saving system.

Introduction

Broken fractions of rice have generally got low market value and sometimes they are not used for human consumption or even not available in conventional market. In many parts of the world where there is no proper processing technology to obtain whole head rice through milling, farmers and other intermediate business associates end up with low grade rice (broken fractions) which affect the value chain operatives. In the United State of America, rice is marketed according to three main properties: size, colour and condition of damaged kernel. These three properties make up the desired quality of rice (Henry and Kettlewell, 1996; Ndindeng et al., 2014; FAO, 2018). Broken fractions of rice are staple food materials, which occur in different sizes, shapes and texture. However, if reduced or put into desired uniform shaped flour for human consumptions, especially as

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infants formulae, the benefits are numerous. It would no longer be regarded as broken fraction of rice but flour from rice (Earle, 1983; Ojha and Micheal, 2006; Mijinyawa et al.,. 2007; Sahay, 2008). In this regard, mechanically damaged starch during milling is of considerable importance, since damaged starch is reported to absorb much water and is more susceptible to enzymes degradation than intact starch. Uniform particle size distribution of flour is often considered the key role for evaluating flour food quality. It is one of the means of assessing properties of granulated materials and the most important criteria in usage of flour foods. It also enhances effective utilization of flour by enzymes. One of these approaches includes adding power flour into complementary food for viscosity reduction and at the same time increases the energy density of food (Hough 1992, Mosha and Svanberg, 1983; Obradovic et al., 2009; Hossen et al., 2011, Elemo et al., 2011). Similarly, low fiber contents, due to smaller particles of flour generated during milling, are reported to be one of the good attributes for infant feeding formulae and to facilitate infant transition to solid food (Chandra and Shamsher, 2013; Asma et al., 2006, MacDonald et al., 2011). In addition, protein, carbohydrates, facts, ash and moisture are always subject of concern in infant foods. More importantly, metabolic significance of those those classes of food if compared to infants nutrition (European Commission, 2003; Nestle Nutrition Institute, 2005; Kane et al., 2010; MacDonald et al., 2011, CAC, 2015).

Rice is often regarded as number one infant cereal (Danbaba et al., 2016). However, the demand for rice over the years in Nigeria and in many other regions of the world is high due to poor yield in rice production. This necessitates the use of broken fraction of rice to fill annual deficit in rice production. Secondly, the cost of conventional complementary foods is also another challenging issue among less privileged families. For these reasons, product yield from broken fractions of rice, if harnessed properly, would significantly improve economic growth rate of a country.

Therefore, to ascertain the potential food uses for these low - grade rice and up - grade them via processing into vital products, it is important to ascertain their food uses and the successes of the plant breeder by determining the physicochemical properties of these rice and their product yield.

Materials and methods

Raw materials collection

The broken fractions of improved rice cultivars consist of FARO 44, FARO 52, NERICA L-34 and NERICA L-19. They were obtained from National Cereals Research Institute, Badeggi, Bida, Niger State. Indigenous or local rice (*Yar-Mubi*), soybean (*Glycine max-yar Jalingo*) and sorghum (*Sorghum bicolar* L.) (Early maturing sorghum also commonly called *Wata uku-yar Hong*) were procured from agricultural seed stores (Maiduguri Monday market) and further identified by crop breeder in the Department of Crop Science, University of Maiduguri.

Preparation of food materials

Four kilograms (4 kg) of each broken rice fraction from the milling of the rice cultivar were toasted in an open thick aluminum pot at 120 °C for 20 minutes. The temperature of the heating system was regulated by thorough stirring of rice. Constant increase and decrease of heating flame was maintained where there was a need to avoid temperature fluctuation and it was monitored with a thermometer (Foster-Powell et al., 2002; Eshun et al., 2011).

Soybeans were sorted first, then washed and soaked for five hours in clean water of three times their weight until the seed coats were soaked and wet to assist in removal of some soluble anti-nutrients and to facilitate dehulling. The soybeans were further washed, drained and partially sun-dried. The soybeans were then toasted at surface temperature of 180 ± 5 °C for 30 minutes in an open thick aluminum pot (Iwe, 2003; Badau et al., 2006).

The sorghum grains were first screened and washed to remove contaminants and any seemingly dormant grains (i.e. floating grains). The cleaned grains were steeped inside sufficient clean water to cover the surface of the grains completely at room temperature for 12 hours. The steeping process was interrupted after every 6 hours by draining. An "air-rest" period of one hour each for every interruption was provided until the grain reached about 42% moisture content (Hough, 1992; Badau et al., 2005; Badau et al., 2006). The grains were wrapped in a wet piece of cotton cloth and placed in a wet jute bag to provide about 3 to 5 cm depths of the placed grains. The grains were germinated at room temperature for a period of 2 days. During germination, small quantity of water was spread on the germinating grains using manual hand spray. At the end of the germination, the germinated grains were dried to a moisture content of 5.25 ± 0.2 at 30 ± 2 °C for 36 hours. The germinated dried grains were polished using piston and mortar for detachment of roots and rootlets. Later, they were winnowed to remove detached root and rootlets leaving behind kernels, which were further sieved through 0.8 mm mesh size. This was done to obtain polished sorghum malt. All materials were milled into fine flour using hammer miller (Christy Hunt Agricultural Ltd, Foxhills Ind. Est Scunthorpe, Model DE DN15 8QW, South Humbers, Englang) and were let to pass through a 0.8 mm mesh size screen. Flours were then packaged in a plastic container and stored in metal lagged cupboard until when needed for use (Badau et al., 2016; Badau et al., 2006).

The raw processed materials (flours) were formulated. A 5x2x2 factorial in a completely randomize design was used (Gomez and Gomez, 1983; Mead et al., 1993). The composition of the different mixtures were either broken fractions of rice cultivars alone, with and without malt (89.40 g rice + 5.00 g malt or 94.40 g rice) or a ratio of 70:30 rice and soybeans, with and without malt (62.58 g rice + 26.82 g soybeans + 5.00 g malt or 66.08 g rice + 28.32 g soybeans) as described by Almeida-Dominguez et al. (1993) and Badau et al. (2006). All four sets of formulations contained 5.00 g vitamin A fortified sugar and 0.60 g iodide salt per 100 gram. The rice cultivar flours and soybean flours were blended before adding sugar, salt and "power flour." Each formulation was thoroughly blended to obtained uniform particle size distribution (Badau et al., 2006).

Determination of particle size distribution of flours and blends

The particle size distribution of flour was determined by shaking 40 g of flour and let to pass through 600, 425, 300, 180, 150 µm mesh screens and base pan (bottom sieve collection) within 5 minutes. This was done by using laboratory test sieve (Endecotts Ltd. London, England, mounted on a shaker) as described by Nishita and Bean (1982).

Determination of functional properties of flours and blends

Bulk density

Fifty gram (50 g) flour of the developed complementary food was placed into a 100 mL measuring cylinder and tapped to a constant volume. The bulk density (g/cm^3) was determined as the weight of developed complementary food (g) divided by developed complementary food volume (cm^3) as reported by Adejuyitan et al. (2009).

Dispersibility

Dispersibility was measured by placing 10 g of the flour sample in a 100 mL measuring cylinder; water was added gradually until the 100 mL mark was reached. The mixture was vigorously shaken and allowed to stand for 3 hours. The volume of the settled particles was subtracted from the total volume and the difference was expressed as percentage dispersibility (Asma et al., 2006).

Water absorption capacity

Water absorption capacity of the flour sample was determined by placing one gram of flour into 10 mL of water. It was allowed to stand at room temperature for one hour and it was centrifuged at 200 x g for 30 minutes. The volume of water in the sediment was measured. Water absorption capacity was calculated as mL of water absorbed per gram of flour (Adejuyitan et al., 2009).

pH measurement

The pH values of the blends were determined with pH meter (Equip-Tronics, Model 800D, Mumbai) as described by Blanco and Sherbo (1980) and Egan et al. (1988).

Determination of proximate composition of flours and blends

The moisture, protein, fat, fiber and ash contents of the samples were determined as described by AOAC (1990). However, the available percentage of carbohydrates was estimated by difference {i.e. 100% - % (moisture + protein + fat + fiber + ash)} as described by Chibuzo and Ali (1995), AOAC (1990) and Asma et al. (2006). Protein content of flours and blends were determined by using micro-Kjeldahl procedure. A nitrogen conversion factor of 100/16 (N% x 6.25) was used for the protein calculation (AOAC, 1990; Nielsen, 2002).

Energy value of blends

The total caloric value was determined using the Atwater factor (physiological fuel value) of 4 kcal, 4 kcal and 9 kcal per gram of carbohydrates, proteins and fats respectively (Chibuzo and Ali, 1995). The energy value of blends was also calculated as kJ per 100 g of food, using the fuel value of 17 kJ, 17 kJ and 37 kJ per gram of carbohydrates, proteins and fats, respectively, as reported by Onwuka (2005).

Determination of manufacturing cost elements and quantification of blends

Cost are expenses of goods and services consumed or incurred during accounting period, i.e. whether they were identifiable in the finished product of the establishment (food cost), constituted the remuneration of the employees (labour costs), or were incurred for the general purpose of running the establishment as overheads (Kotas and Davis, 1981; Adeniji, 2008).

Statistical analysis

Data obtained were subjected to analysis of variance using Statistical Package for Social Sciences (SPSS) version 16.0 and means were separated by Duncan's multiple range tests at 5% significance level.

Results and discussion

Particle size distribution of rice cultivars, sorghum cultivar, sorghum malts and soybean flours

The result of particle size distribution of rice cultivars, sorghum cultivars, sorghum malt and soybeans flours are shown in Table 1. The sieve aperture used ranged from 600 µm to 150 µm. The Result of the particle size distribution of flours showed significant (p<0.05) difference. The highest percentage particle size was retained on 300 µm and 180 µm mesh sizes. NERICA L-19 had the highest collection of base pan with 32.84% particles, followed by soybean flour (9.28%). NERICA L-19 also had 1.33% particles retained on 600 µm mesh while the remaining rice cultivars had 0.00% each. The result of the particle size distribution of rice cultivars showed better uniformity than the sorghum cultivar, sorghum malt and soybeans flours.

Iwe (2003) reported that a minimum of 99% flour must pass through U.S. standard screen No.6 and a maximum of 60% must pass through U.S. standard screen No.6 for good wetting characteristics. This study agreed with the U.S. standard sieve recommendations. In fact, much better for the rice cultivars (except NERICA L-19) and dehulled soybean flours as compared to whole sorghum, sorghum malt and whole soybean flours retained on 600 µm mesh.

Particle size distribution of complementary food formulations

Table 2 shows the result of particle size distribution of complementary food formulations. The result of the particle size distribution of complementary food formulations showed significant (p<0.05) difference. The highest percentage distributions of particles were also recorded on 300 µm and 180 µm mesh sizes as also occurred in Table 1. Percentage base pan collection of particles of the formulations containing rice 100% alone, with and without malt, were higher than those with the ratio of rice to soybeans 70:30, with and without malt.

One of the advantages of milling grains into small particle size flour as indicated was reported to reduce indigestible materials such as fiber (Chandra and Shamsher, 2013). The smaller the particle sizes of flour, the better the uniform constitution with water (i.e. the better the wetting characteristics) as reported by Iwe (2003), also the better the solubility and interaction of starch molecules by enzymes (Obradovic et al., 2009; Hossen et al., 2011). All formulation results were observed to meet the recommendations that minimum of 99% flour must pass through U.S. standard screen No.6 and maximum of 60% must pass through U.S. standard screen No.6 for good wetting characteristics (Iwe, 2003). But it was also observed that more collections of particles on mesh 600 µm occurred than those shown in Table 1. This may be due to aggregation (agglomeration of flours) effects of thorough blending of the mixtures (Hossen et al. 2011). Hayes et al. (2012) in a similar study reported 89.70 to 99.70% of materials passed through 0.60 mm, 21.80 to 81.60% passed through 0.25 mm, also 9.30 to 52.50% materials passed through 0.15 mm and 100% passed through 3.36 mm sieve size. These values are easily comparable to the particle size distribution of blends found in this study.

Functional properties of rice cultivars, sorghum cultivar, sorghum malt and soybeans flours

Table 3 shows results of the functional properties of rice cultivars, sorghum cultivar, sorghum malt and soybeans flours. The results of the functional properties of these cultivars showed slight variations. Similarly, these slight variations were observed among the rice cultivars, also between sorghum cultivar and sorghum malt, as well as whole soybean and dehulled soybean flours. Their pH ranged from 5.80 to 6.48, bulk density 0.64 to 0.78 g/mL, percentage dispersibility 31.33 to 42.00% and water absorption capacity 1.60 to 2.87 mL/g. Dehulled soybean flour was found to be better in terms of uniform constitution with water than rice and sorghum cultivars. However, it showed less water absorption capacity. pH of sorghum decreased from 6.07 to 5.50 upon malting, while that of soybean increased from 6.14 to 6.48 after processing.

The bulk density, percentage dispersibility and water absorption capacity have got advantages in food operations. High bulk density of flour is a desirable factor in packing; it allows more weight (concentration of food calories) per limited volume of food since large quantities of food are packed in small space. Transportation of materials also becomes easy (Balogun and Olatidoye, 2010; Chandra and Shamsher, 2013). This study showed required values for high energy density per unit volume of food. In addition, high percentage dispersibility of flours indicates good or better constitution with water. The higher the water absorption capacity of flour, the more the flour absorbs water and vice versa.In this study, the pH values of soybeans were observed to be more comparable to other legumes such as pH of velvet beans (5.0-6.64) as reported by Egounlety (2003).

Table 1. Particle size distribution of rice cultivars, sorghum cultivar, sorghum malt and soybean flours

Parameters	600 µm	425 µm	300 µm	180 µm	150 µm	Base pan
FARO 44	0.00 ± 0.00[d]	6.59 ± 0.52[d]	45.13 ± 0.15[a]	37.49 ± 0.50[c]	8.04 ± 0.16[g]	2.76 ± 1.06[cde]
FARO 52	0.00 ± 0.00[d]	6.24 ± 0.36[de]	44.05 ± 0.26[a]	33.17 ± 0.77[d]	12.67 ± 0.67[f]	3.86 ± 0.08[cd]
NERICA L-34	0.00 ± 0.00[d]	6.19 ± 0.44[de]	42.36 ± 0.56[b]	31.46 ± 1.40[e]	18.57 ± 0.51[c]	1.42 ± 1.07[de]
NERICA L-19	1.33 ± 0.49[ab]	3.22 ± 0.23[f]	31.56 ± 0.51[e]	9.31 ± 0.52[f]	21.74 ± 0.65[a]	32.84 ± 0.82[a]
LOCAL RICE	0.00 ± 0.00[d]	2.03 ± 0.25[g]	39.05 ± 1.00[c]	33.51 ± 1.39[d]	20.21 ± 0.34[b]	5.21 ± 2.63[c]
Whole sorghum	1.62 ± 0.28[a]	47.16 ± 1.14[a]	37.52 ± 0.54[d]	7.60 ± 0.34[g]	4.20 ± 0.35[h]	1.90 ± 1.80[de]
Sorghum malt	1.14 ± 0.06[bc]	45.98 ± 0.27[b]	39.29 ± 0.77[c]	8.35 ± 0.53[fg]	4.63 ± 0.55[h]	0.62 ± 0.39[e]
Whole soybean	0.95 ± 0.18[c]	7.83 ± 0.82[c]	26.26 ± 0.90[f]	43.88 ± 0.61[b]	15.72 ± 0.55[d]	5.36 ± 1.82[c]
Dehulled soybean flour	0.00 ± 0.00[d]	5.33 ± 0.49[e]	25.43 ± 0.51[f]	45.37 ± 0.55[a]	14.57 ± 0.51[e]	9.29 ± 1.05[b]

Each value is a mean ± SD of triplicate determinations. Mean values in a column not sharing a common superscript letters are significantly ($p<0.05$) different.

Table 2. Particle size distribution of complementary food formulations

Formulations	600 µm	425 µm	300 µm	180 µm	150 µm	Base pan
Ratio of rice to soybean 100:0 without malt						
FARO 44	5.100 ± 0.10[a]	2.04 ± 0.05[j]	25.68 ± 0.61[f]	42.04 ± 0.06[klm]	16.12 ± 0.21[bc]	9.02 ± 0.75[fghi]
FARO 52	5.00 ± 0.01[a]	1.04 ± 0.06[k]	30.37 ± 0.55[d]	38.59 ± 0.53[op]	17.72 ± 0.54[a]	7.28 ± 1.34[hij]
NERICA L-34	4.98 ± 0.08[a]	2.00 ± 0.01[j]	18.10 ± 0.11[i]	42.65 ± 0.35[k]	11.05 ± 0.06[f]	21.21 ± 0.50[b]
NERICA L-19	1.14 ± 0.17[f]	2.03 ± 0.03[j]	17.38 ± 0.33[i]	39.02 ± 0.03[nop]	10.76 ± 0.68[f]	29.68 ± 1.09[a]
LOCAL RICE	4.14 ± 0.27[bc]	3.25 ± 0.22[i]	11.03 ± 0.04[j]	52.08 ± 0.92[a]	15.77 ± 0.53[c]	13.74 ± 1.12[d]
Ratio of rice to soybean 100:0 with malt						
FARO 44	3.26 ± 0.28[d]	6.28 ± 0.35[e]	18.13 ± 0.14[i]	45.88 ± 0.75[i]	14.31 ± 0.40[d]	12.15 ± 0.84[def]
FARO 52	2.12 ± 0.19[e]	15.43 ± 0.70[b]	25.72 ± 0.59[f]	34.32 ± 0.39[q]	11.10 ± 0.02[f]	11.30 ± 0.66[defg]
NERICA L-34	3.28 ± 0.52[d]	8.38 ± 0.33[d]	20.73 ± 0.48[h]	40.60 ± 0.43[lmn]	14.21 ± 0.78[d]	12.80 ± 0.78[de]
NERICA L-19	2.56 ± 0.44[e]	10.62 ± 0.43[c]	19.59 ± 0.42[h]	37.95 ± 0.16[p]	11.13 ± 0.02[f]	18.14 ± 1.06[c]
LOCAL RICE	3.37 ± 0.44[d]	6.61 ± 0.43[e]	20.02 ± 0.92[h]	42.36 ± 0.79[kl]	17.24 ± 1.04[ab]	10.73 ± 0.14[defg]
Ratio of rice to soybean 70:30 without malt						
FARO 44	1.29 ± 0.28[f]	5.23 ± 0.55[fg]	30.18 ± 0.90[d]	44.91 ± 0.78[ij]	14.44 ± 0.49[d]	3.94 ± 1.13[kl]
FARO 52	1.46 ± 0.41[f]	3.27 ± 0.40[i]	30.19 ± 0.69[d]	40.38 ± 0.68[mno]	12.76 ± 0.65[e]	11.93 ± 2.01[def]
NERICA L-34	0.00 ± 0.00[g]	4.44 ± 0.52[gh]	26.39 ± 1.39[f]	52.72 ± 4.02[a]	11.78 ± 0.67[ef]	4.67 ± 4.20[jkl]
NERICA L-19	0.99 ± 0.12[f]	5.49 ± 0.59[f]	23.46 ± 0.28[g]	48.96 ± 0.83[h]	11.44 ± 0.49[f]	9.66 ± 1.41[efgh]
LOCAL RICE	4.41 ± 0.64[b]	22.78 ± 0.62[a]	62.73 ± 0.54[a]	3.87 ± 0.31[r]	3.55 ± 0.72[g]	2.66 ± 0.85[l]
Ratio of rice to soybean 70:30 with malt						
FARO 44	1.24 ± 0.37[f]	5.11 ± 0.06[fg]	29.85 ± 1.48[d]	43.91 ± 1.20[kj]	12.95 ± 1.72[e]	6.93 ± 1.35[hijk]
FARO 52	1.32 ± 0.34[f]	3.19 ± 0.52[i]	28.23 ± 0.90[e]	51.10 ± 0.93[ab]	11.74 ± 0.62[ef]	4.43 ± 1.92[jkl]
NERICA L-34	0.00 ± 0.00[g]	4.84 ± 0.67[fgh]	25.29 ± 0.66[f]	49.57 ± 0.61[gh]	11.70 ± 0.52[ef]	8.84 ± 2.53[ghi]
NERICA L-19	2.05 ± 0.13[e]	4.19 ± 0.29[h]	34.22 ± 1.06[c]	39.44 ± 0.65[nop]	10.49 ± 1.20[f]	9.50 ± 3.32[fgh]
LOCAL RICE	3.72 ± 0.60[cd]	23.08 ± 1.02[a]	58.82 ± 1.29[b]	4.59 ± 0.34[r]	3.88 ± 0.28[g]	5.90 ± 2.32[ijk]

Each value is a mean ± SD of triplicate determinations. Mean values in a column not sharing a common superscript letters are significantly ($p<0.05$) different.

Table 3. Functional properties of rice cultivars, sorghum cultivar, sorghum malt and soybeans flours

Samples	pH	Bulk density (g/mL)	Percentage Dispersibility	Water absorption capacity (mL/g)
FARO 44	5.80 ± 0.06[c]	0.74 ± 0.00[c]	38.33 ± 0.58[b]	2.87 ± 0.12[a]
FARO 52	5.80 ± 0.04[c]	0.76 ± 0.00[b]	30.00 ± 0.00[cd]	2.73 ± 0.12[b]
NERICA L-34	5.85 ± 0.10[c]	0.76 ± 0.00[b]	29.33 ± 1.15[d]	2.63 ± 0.06[b]
NERICA L-19	5.73 ± 0.10[cd]	0.78 ± 0.00[a]	31.33 ± 1.15[c]	2.67 ± 0.06[b]
LOCAL RICE	5.60 ± 0.09[de]	0.71 ± 0.00[d]	38.00 ± 0.00[b]	2.70 ± 0.00[b]
Whole sorghum	6.07 ± 0.06[b]	0.78 ± 0.00[a]	24.00 ± 0.00[e]	2.47 ± 0.12[c]
Sorghum malt	5.50 ± 0.02[e]	0.77 ± 0.00[b]	24.00 ± 2.00[e]	2.23 ± 0.06[d]
Whole soybean	6.14 ± 0.15[b]	0.61 ± 0.00[f]	41.00 ± 0.00[a]	1.60 ± 0.00[e]
Dehulled soybean flour	6.48 ± 0.00[a]	0.64 ± 0.00[e]	42.00 ± 0.00[a]	1.63 ± 0.04[e]

Each value is a mean ± SD of triplicate determinations. Mean values in a column not sharing a common superscript letters are significantly ($p<0.05$) different.

But they were found to be slightly lower in bulk density and water absorption capacity than the velvet beans (Balogun and Olatidoye, 2010). On the other hand, the bulk density of all the broken fractions of rice cultivars were observed more comparable to the bulk density of rice flour reported by Chandra and Shamsher (2013).

Functional properties of complementary food formulations

Results of the functional properties of complementary food formulations is indicated in Table 4**.** Results of these formulations showed significant (*p*<0.05) difference. The pH values of all the formulations ranged from 5.66 to 6.42, bulk density 0.68 to 0.81 g/mL, percentage dispersibility 28.80 to 39.33% and water absorption capacity 1.63 to 2.97 mL/g. Addition of sorghum malt and soybean flour had better significant effects on the functional properties of formulations as observed. There was better uniformity of results than those shown in Table 3, especially in terms of pH value.
pH as index of preservation may interfere with the stomach if the food consumed is either at very low or high pH. Bulk density is also an important factor; it measures weight per unit volume of food. High bulk density of food is required for energy density (allows more weight of food per limited volume). Percentage dispersibility and water absorption capacity are food-water constitution factors. All these properties of the blends were observed at moderate level; appropriate for complementary foods (Nkama et al., 2001; Asma et al., 2006; Adebayo-Oyetoro et al., 2011). pH of the formulations were observed to be within safe acceptable level (5.5-6.5), but alternatively, a good indication for microbial proliferation (Egan et al., 1988; Adams and Moss, 1999). Functional properties of all formulations were observed to be slightly comparable to the results obtained for the evaluation of functional properties of Ofada rice (*Oryza sativa* L.) flour blended with bambara groundnut (*Vigna subterranean* L.) investigated by Adebayo-Oyetoro et al. (2011). The work on sorghum supplemented with legumes and oil seeds, conducted by Asma et al. (2006), was found to be more comparable in terms of their functional properties.

Proximate composition of rice cultivars, sorghum cultivar, sorghum malt and soybean flour

The result of proximate composition of rice cultivars, sorghum cultivar, sorghum malt and soybean flour is indicated in Table 5.

Table 4. Functional properties of complementary food formulations

Formulations	pH	Bulk density (g/mL)	Percentage Dispersibility	Water absorption capacity (mL/g)
Ratio of rice to soybeans 100:0 without malt				
FARO 44	5.89 ± 0.06^{fg}	0.76 ± 0.00^{c}	36.27 ± 0.46^{bc}	2.17 ± 0.06^{ef}
FARO 52	5.89 ± 0.11^{fg}	0.78 ± 0.00^{b}	30.67 ± 1.15^{gh}	2.87 ± 0.06^{ab}
NERICA L-34	6.38 ± 0.17^{ab}	0.78 ± 0.00^{b}	28.80 ± 1.06^{i}	2.73 ± 0.12^{abc}
NERICA L-19	6.12 ± 0.07^{c}	0.81 ± 0.00^{a}	36.00 ± 1.00^{bcd}	2.73 ± 0.12^{abc}
LOCAL RICE	5.79 ± 0.07^{g}	0.74 ± 0.00^{d}	39.33 ± 1.15^{a}	2.97 ± 0.06^{a}
Ratio of rice to soybeans 100:0 with malt				
FARO 44	6.01 ± 0.08^{de}	0.74 ± 0.00^{c}	37.00 ± 1.00^{b}	2.00 ± 0.00^{fg}
FARO 52	6.08 ± 0.09^{de}	0.78 ± 0.00^{b}	34.33 ± 0.58^{ef}	1.83 ± 0.06^{ghi}
NERICA L-34	6.01 ± 0.05^{de}	0.78 ± 0.00^{b}	30.67 ± 1.15^{gh}	1.63 ± 0.06^{i}
NERICA L-19	5.96 ± 0.07^{ef}	0.80 ± 0.02^{a}	36.33 ± 0.58^{bc}	1.70 ± 0.10^{hi}
LOCAL RICE	5.66 ± 0.04^{h}	0.74 ± 0.00^{d}	34.00 ± 0.00^{f}	2.10 ± 0.10^{efg}
Ratio of rice to soybeans 70:30 without malt				
FARO 44	6.34 ± 0.03^{ab}	0.72 ± 0.02^{e}	35.67 ± 0.58^{bcde}	2.53 ± 0.15^{cd}
FARO 52	6.37 ± 0.02^{ab}	0.74 ± 0.00^{d}	35.67 ± 0.58^{bcde}	2.47 ± 0.23^{cd}
NERICA L-34	6.42 ± 0.03^{a}	0.74 ± 0.00^{d}	35.00 ± 0.00^{cdef}	2.00 ± 0.00^{fg}
NERICA L-19	6.40 ± 0.02^{ab}	0.76 ± 0.00^{c}	34.67 ± 0.58^{def}	2.07 ± 0.06^{efg}
LOCAL RICE	6.29 ± 0.02^{b}	0.70 ± 0.01^{g}	36.53 ± 1.36^{bc}	2.33 ± 0.06^{de}
Ratio of rice to soybeans70:30 with malt				
FARO 44	6.29 ± 0.01^{b}	0.72 ± 0.01^{ef}	30.67 ± 1.15^{gh}	2.73 ± 0.31^{abc}
FARO 52	6.32 ± 0.02^{ab}	0.71 ± 0.01^{efg}	31.40 ± 0.53^{g}	2.50 ± 0.10^{cd}
NERICA L-34	6.41 ± 0.02^{a}	0.71 ± 0.01^{fg}	29.47 ± 0.50^{hi}	1.97 ± 0.25^{fgh}
NERICA L-19	6.42 ± 0.01^{a}	0.72 ± 0.00^{e}	31.33 ± 0.58^{bcde}	2.33 ± 0.32^{de}
LOCAL RICE	6.17 ± 0.01^{c}	0.68 ± 0.01^{h}	31.33 ± 1.15^{g}	2.60 ± 0.26^{bcd}

Each value is a mean ± SD of triplicate determinations.Mean values in a column not sharing a common superscript letters are significantly (p<0.05) different.

The result of proximate composition of raw materials showed significant (p<0.05) difference and it contained 4.14 to 8.24% moisture, 0.37 to 5.12% ash, 8.74 to 44.35% protein, 0.42 to 20.00% fat and 25.59 to 82.59% carbohydrates. But there was no significant (p>0.05) difference in ash, protein, fat and carbohydrate contents of the broken fractions of improved rice cultivars, except for slight variation in their moisture contents. The broken fraction of local rice cultivar was observed to be different from the broken fractions of improved rice cultivars in terms of their ash, fat and carbohydrate contents. Sorghum malt showed slight decrease in proximate composition upon malting from sorghum cultivar to sorghum malt, except for fats and carbohydrates. On the other hand, whole soybeans showed slight decrease in proximate composition upon processing into soybean dehulled flour, except in terms of protein and fat. The fat and moisture content of whole sorghum and sorghum malt showed significant (p<0.05) difference, probably the transformation of starch into malt facilitated solvent extraction process resulting in high yield of fat obtained in sorghum malt and not in whole sorghum. Whole soybean and dehulled soybean flour also showed significant (p<0.05) difference for their carbohydrate, protein and fat contents except for ash. This may be due to the seed coat of whole soybean and also some nutrients might have leaked away during long soaking time in water. It can be observed from Table 5 that the protein and ash contents of soybean flour are five times higher than that of rice cultivar. On the other hand, the carbohydrate of rice cultivars is three times higher than that of soybean flour. Therefore, the protein, carbohydrate of rice cultivars is three times higher than that of soybean flour. Therefore, the protein, carbohydrate and ash contents of the two cultivars (i.e. rice and soybeans) is an indication that they can satisfactorily complement each other.

Proximate composition of rice cultivars, sorghum cultivars, sorghum malt and soybean flours shown in Table 5 are within the range as reported by many researchers (Moore and McCreath, 1973; Houston, 1992; Iwe, 2003; FAO, 2012). The result of proximate composition of these cereal grains and soybeans shown in Table 5 is an indication that they can satisfactorily complement each other as described by Onofiok and Nnanyelugo (2003). Variation in composition of cereals and legumes, as shown in Table 5, has been reported and may be due to the nature of soil where the crop was cultivated and due to the type of cultivar (Houston, 1992; Iwe, 2003). This may be an advantage for selecting rice over sorghum, where rice cultivars have higher carbohydrate and low protein content compared to sorghum. These rice cultivars were also reported to have higher moisture contents than in sorghum cultivar, sorghum malt and soybeans flours. This may be due to the differences in their composition and so resulted in moisture absorption, since all were equilibrated at same time before moisture determination. High moisture grain or ability to absorb moisture faster is an indication of rapid rate of deterioration (Deman, 1990; Ndindeng et al., 2014). High fat content of grain if not properly stored is prone to deterioration due to rancidity, especially if coupled with high moisture level above 10% (Deman, 1990; Houston, 1992; Ndindeng et al., 2014). However, all the grains shown in Table 5 indicated moderate moisture level for good storage stability.

Proximate composition of complementary food formulations

Results of the proximate composition of complementary food formulations are shown in Table 6. The resulst showed significant (p<0.05) difference. However, there was only slight variation between formulations containing rice 100% alone, with and without malt and those with the ratio of rice to soybeans 70:30, with and without malt. The proximate composition of formulations containing rice 100%, with and without malt contain 7.07 to 7.72% moisture, 0.70 to 1.44% ash, 8.25 to 9.81% protein, 0.50 to 1.99% fat, 1.17 to 2.17 fiber, 78.43 to 81.07% carbohydrates and energy value 362.95 to367.10 kcal (1541.92 to 1557.81 kJ). Addition of sorghum malt had significant effects on the composition of these formulations. This is because the composition of the sorghum malt shown in Table 5 is slightly higher than those rice cultivars. Similarly, the proximate composition of formulations containing the ratios of rice to soybeans 70:30, with and without malt contain 6.89 to 7.96% moisture, 2.15 to 2.75% ash, 16.51 to 20.13% protein, 6.32 to 8.08% fat, 1.17 to 4.33% fiber, 58.87 to 63.78% carbohydrates and energy value of 378.68 to 388.71 kcal (1541.92 to 1557.81 kJ). Addition of sorghum malt and soybeans had significant increase of ash, protein, fat, fiber, and energy value of these formulations. The proximate composition of these complementary food formulations were further characterized and categorized best on the target group of infants having different nutritional requirement as advocated by many researchers (European Commission, 2003; Nestle Nutrition Institute, 2005; Kane et al., 2010; MacDonald et al., 2011; CAC, 2015).

Table 5. Proximate composition (%) of raw materials

Samples	Moisture	Ash	Protein	Fat	Carbohydrates
FARO 44	8.24 ± 0.46^{b}	0.42 ± 0.01^{c}	8.98 ± 0.28^{d}	1.01 ± 0.10^{d}	81.35 ± 0.73^{a}
FARO 52	7.67±0.45^{bc}	0.37 ± 0.03^{c}	9.07 ± 0.00^{d}	0.68 ± 0.09^{d}	82.19 ± 0.41^{a}
NERICA L-34	6.57±0.06^{d}	0.41 ± 0.03^{c}	9.72 ± 0.93^{d}	0.71 ± 0.18^{d}	82.59 ± 0.99^{a}
NERICA L-19	7.40±0.17^{c}	0.46 ± 0.13^{c}	9.48 ± 0.70^{d}	0.42 ± 0.28^{d}	82.24 ± 0.42^{a}
LOCAL RICE	9.57±0.25^{a}	1.08 ± 0.13^{b}	8.74 ± 0.28^{d}	1.93 ± 0.11^{c}	78.68 ± 0.46^{b}
Whole sorghum	6.73±0.46^{d}	1.14 ± 0.10^{b}	12.17 ± 0.14^{c}	0.86 ± 0.05^{d}	79.10 ± 0.36^{b}
Sorghum malt	5.25±0.20^{e}	0.88 ± 0.05^{b}	11.52 ± 0.00^{c}	2.55 ± 0.54^{c}	79.81 ± 0.57^{b}
Whole soybean	5.64±0.57^{e}	5.12 ± 0.64^{a}	44.35 ± 0.00^{b}	13.90±1.02^{b}	29.99 ± 1.38^{c}
Dehulled soybean flour	4.14±0.00^{f}	4.92 ± 0.20^{a}	45.32 ± 0.80^{a}	20.00±0.11^{a}	25.59 ± 0.25^{d}

Each value is a mean ± SD of triplicate determinations. Mean values in a column not sharing a common superscript letters are significantly ($p<0.05$) different.

Table 6. Proximate composition (%) of complementary food formulations

Formulations	Moisture	Ash	Protein	Fat	Fiber	Carbohydrate	Kcal	kJ
Ratio of rice to soybeans 100:0 without malt								
FARO 44	7.07 ±0.06^{gh}	0.76±0.01^{h}	8.49 ±0.28^{g}	0.99 ±0.11^{cde}	1.67±0.58^{ef}	81.01 ± 0.88^{a}	366.99±2.07^{c}	1558.24±9.12^{c}
FARO 52	7.59±0.25^{bcd}	0.70±0.04^{h}	8.58± 0.00^{fg}	0.66 ± 0.09^{de}	1.17 ±0.29^{f}	81.07 ± 0.40^{a}	364.58±2.16^{c}	1548.65 ± 9.08^{c}
NERICA L-34	7.32±0.26^{cdefg}	0.75±0.03^{h}	9.23±0.93^{efg}	0.71 ± 0.17^{de}	1.27 ±0.55^{f}	80.72 ± 1.73^{a}	366.18±3.13^{c}	1555.36±13.26^{c}
NERICA L-19	7.70 ± 0.09^{ab}	0.80±0.13^{h}	8.99±0.70^{efg}	0.41 ± 0.22^{e}	1.27 ±0.55^{f}	80.84 ± 0.41^{a}	362.98±3.74^{c}	1542.16±15.71^{c}
LOCALRICE	7.55± 0.13^{bcd}	1.42±0.13^{g}	8.25 ± 0.28^{g}	1.90 ± 0.10^{cd}	1.63±0.55^{ef}	79.24 ±0.61^{ab}	367.10±1.30^{c}	1557.81 ± 5.57^{c}
Ratio of rice to soybeans 100:0 with malt								
FARO 44	7.15 ± 0.16^{fgh}	0.79±0.01^{h}	9.07±0.28^{efg}	1.09± 0.11^{cde}	2.17±0.29^{ef}	79.73± 0.09^{ab}	365.01±1.18^{c}	1549.92 ± 4.90^{c}
FARO 52	7.60 ± 0.23^{bc}	0.73±0.03^{h}	9.16±0.00^{efg}	0.73 ± 0.10^{de}	1.60±0.52^{ef}	80.52 ± 0.84^{a}	365.25±2.55^{c}	1551.39±10.93^{c}
NERICA L-34	7.33±0.27^{cdefg}	0.78±0.04^{h}	9.81 ± 0.93^{e}	0.80± 0.17^{cde}	1.30± 0.52^{f}	79.96± 1.69^{ab}	366.36±3.04^{c}	1556.03±12.88^{c}
NERICA L-19	7.72 ± 0.12^{ab}	0.83±0.14^{h}	9.57± 0.70^{ef}	0.50 ± 0.22^{e}	1.30± 0.29^{f}	80.05± 0.15^{ab}	362.95±2.28^{c}	1541.92 ± 9.56^{c}
LOCAL RICE	7.63 ± 0.08^{bc}	1.44±0.13^{g}	8.84±0.29^{efg}	1.99 ± 0.10^{c}	1.67±0.58^{ef}	78.43 ± 0.71^{b}	367.01±1.51^{c}	1557.29 ± 6.48^{c}
Ratio of rice to soybeans 70:30 without malt								
FARO 44	7.05 ± 0.16^{gh}	2.52±0.08^{bc}	19.15±0.57^{b}	8.08 ± 0.94^{a}	4.33± 0.58^{a}	58.87 ± 1.37^{f}	384.80±5.61^{ab}	1625.30±22.78^{ab}
FARO 52	7.52 ± 0.17^{bcd}	2.36± 0.07^{d}	20.12±0.14^{a}	7.61 ± 0.99^{a}	3.33±0.58^{bc}	59.05 ± 1.16^{f}	385.17±5.83^{ab}	1627.45±23.69^{ab}
NERICA L-34	7.26± 0.15^{defg}	2.40±0.02^{cd}	18.17±0.57^{c}	6.88 ± 0.41^{ab}	3.27±0.64^{bc}	62.03±0.31^{cde}	382.68±3.71^{ab}	1617.78±15.40^{ab}
NERICA L-19	7.50±0.38^{bcde}	2.40±0.04^{cd}	20.13±0.57^{a}	6.32 ± 1.16^{b}	3.33±0.58^{bc}	60.32± 1.43^{ef}	378.68± 6.72^{b}	1601.49± 27.14^{b}
LOCAL RICE	7.57 ± 0.08^{bcd}	2.75± 0.02^{a}	19.37±0.58^{ab}	7.40 ± 0.67^{ab}	2.67±0.58^{bcd}	60.24±0.65^{ef3}	385.04±4.05^{ab}	1627.16±16.50^{ab}
Ratio of rice to soybeans 70:30 with malt								
FARO 44	6.89 ± 0.06^{h}	2.30±0.08^{de}	17.49± 0.57^{c}	7.76 ± 0.62^{a}	3.67± 0.58^{ab}	61.89±1.03^{cde}	387.32± 5.45^{a}	1636.40± 22.44^{a}
FARO 52	7.46±0.10^{bcdef}	2.15± 0.07^{f}	18.46±0.14^{bc}	7.17 ± 1.09^{ab}	3.30± 0.61^{bc}	61.46± 1.25^{de}	384.18±6.20^{ab}	1623.81±25.11^{ab}
NERICA L-34	7.18± 0.08^{efgh}	2.19±0.02^{ef}	16.51± 0.57^{d}	7.14 ± 0.82^{ab}	3.20± 0.72^{bc}	63.78 ± 0.43^{c}	385.39±5.44^{ab}	1628.98±22.24^{ab}
NERICA L19	7.96 ± 0.21^{a}	2.19±0.04^{ef}	18.47±0.57^{bc}	7.19 ± 1.13^{ab}	1.67± 0.29^{ef}	62.53± 1.64^{cd}	388.71± 4.92^{a}	1643.04± 19.49^{a}
LOCAL RICE	7.58 ± 0.16^{bcd}	2.54± 0.02^{b}	17.57± 0.70^{c}	7.67 ± 1.22^{a}	2.53±0.50^{cde}	62.11±1.35^{cde}	387.75 ±7.82^{a}	1638.35± 31.78^{a}

Each value is a mean ± SD of triplicate determinations. Mean values in a column not sharing a common superscript letters are significantly ($p<0.05$) different.

The formulations with rice 100% alone, with and without malt are within the safe range of protein level of 8-12% (European Commission, 2003; Nestle Nutrition Institute, 2005; Kane et al., 2010; CAC, 2015). These formulations are observed to be suitable for phenylketonuria (PKU) that only tolerates small amount of natural protein (less than 10 g per day) and requires supplementation with phenylalanine – free protein substitute as reported by MacDonald et al. (2011). It was also observed that these formulations are suitable for infants recovering from severe malnutrition and are within the range prescribed as infants formulae (European Commission, 2003; Nestle Nutrition Institute, 2005; Kane et al., 2010; CAC, 2015). Nonetheless, formulations containing malt are preferable because it was reported that malts are rich in enzymes and so have concomitant impact factor in viscosity reduction and increase in energy density of gruel (Hough, 1992; Almeidda- Dominguez et al, 1993; Elemo et al., 2011). Similarly, formulations with ratios of rice to soybeans 70:30, with and without malt, were observed to be suitable for infants follow – on formulae (10 to 18% protein). However, most of conventional complementary foods and those recommended by most researchers had maximum limit of 16% protein apart from the 15% Codex standard limit (CAC, 1991, European Commission, 2003; Nestle Nutrition Institute, 2005; Elemo et al., 2011; CAC, 2015). Toxicological risk of excess protein may cause metabolic effects in infants and hence increase later risk of obesity (European Commission, 2003; Nestle Nutrition Institute, 2005; Kane et al., 2010). However, some of these infants formulae may have protein as high as 22% (Lactogen) (Onofiok and Nnanyelugo, 2003; Kane et al., 2010; Garcia-Martinez et al., 2010).

Table 7. Manufacturing cost elements and quantification for complementary food formulations in one accounting period

		₦	
i. Total capital for investment		10,000,000.00	
ii. Equipment:		₦	
Machinery		40,000.00	
Cooking/Kitchen Utensils		8,330.00	
		48,330.00	
iii. Materials:		₦	
Rice (856.32 kg)		96,307.20	
Soybeans(366.72 kg)		52,804.80	
Sorghum malt (68.64 kg)		3,009.60	
Dangote sugar(68.64 kg)		27,360.00	
Dangote salt(8.16 kg)		820.80	
		180,302.40	
iv. Labour Cost:		₦	
Salary		216,000.00	
Wages		12,000.00	
Staff Meal		12,000.00	
		240,000.00	
v. Overheads:		₦	
Purchasing/Travelling expenses		3,200.00	
Rent and rates		14,400.00	
Tax and vat		29,654.02	
Printing and stationary (packaging/Labeling)		273,600.00	
Certification (NAFDAC)		15,000.00	
Feasibility report		20,000.00	
Company incorporation (with Coperate Affairs Commission)		25,000.00	
Insurance(fire cover of 0.25% of property value)		120.83	
Utilities(Electricity, Water, Fuel)		58,166.40	
Maintenance		2,000.00	
Postage and telephone		1,000.00	
Sundary expenses		600.00	
Advert		30,000.00	
		472,741.25	
		₦	
vi. Sales (4560 units and each is ₦330)		1,504,800.00	(100.00%)
Less Equipment		48,330.00	
Materials		180,302.40	(15.19%)
Gross profit		1,276,167.60	(84.81%)
	₦	₦	
vii. Sales		1,504,800.00	(100.00%)
Less Equipment	48,330.00		
Materials	180,302.40		
Labour costs	240,000.00	468,632.40	(31.14%)
Net margin		1,036,167.60	(68.86%)
	₦	₦	
viii. Sales		1,504,800.00	(100%)
Less Equipment	48,330.00		
Materials	180,302.40		
Labour cost	240,000,00		
Overheads	573,327.23	941,373.65	(62.56%)
Net profit		563,426.35	(37.44%)

Nevertheless, this only agreed with 1971 PAG standard minimum protein limit of 20% (Elemo et al., 2011). Therefore, formulations containing ratio of rice to soybeans 70:30, with malt, were found to be better in terms of the presence of malt and slightly lower in levels of protein than those with ratio of rice to soybeans 70:30, without malt. More importantly, benefits of malt in those formulations are critical and suitable for infants feeding (Elemo et al., 2011). Besides this, it was also observed that formulation containing NERICA L – 34 had protein level of 16.51% and this agreed with many manufacturer specifications on conventional complementary foods. Many researchers (European Commission, 2003; Nestle Nutrition Institute, 2005; Elemo et al., 2011; CAC, 2015) also recommended the same protein level. The moisture levels of all the formulations are less than 10% of the recommended maximum limit for complementary foods (CAC, 1991, European Commission, 2003; Nestle Nutrition Institute, 2005; CAC, 2015). It was reported that food with 5 to 15% moisture content would have a great storage stability for more than a year (Deman, 1990). Therefore, all formulations have indicated properties required for long time storage stability. High ash content in formulations with ratio of rice to soybeans 70:30, with and without malt, showed an indication of mineral richness as reported by Adejuyitan et al. (2009). This is more than in formulations with rice 100% alone, with and without malt. The fiber content of all formulations is lower than the maximum level of 5% advocated for infants and pre-school children (CAC, 1991, Asma et al., 2006; Elemo et al., 2011). High fiber content in infant food was reported that it might expose infant to dietary bulk and low caloric density. In addition, it may cause irritation of the gut mucosa and adverse effects on the efficiency of absorption of various nutrients of significance in diets with marginal nutrients content. The formulations, which contain soybeans, are found to be higher in fat contents, but are all below the maximum level of 10% fat recommended in complementary foods (CAC, 1991, Elemo et al., 2011). This is evident from the proximate composition of soybeans flour which had the highest amount of fat, followed by sorghum malt.

Fat is the major contributor to high energy value in these formulations since oxidation of 1 g of fat was reported to yield about 38 kJ (9 kcal) of energy (European Commission, 2003). In formulations with ratio of 100% rice, with and without malt, the carbohydrate contents are higher than in most conventional complementary foods and low in caloric value when compared to those that had soybeans. However, it can be an added benefit where low energy – dense foods are required for body weight management (European Commission, 2003). Nonetheless, the energy values of all blends were within the recommended level of 350-400 kcal per 100 g (Elemo et al., 2011).

Manufacturing Cost Elements and Quantification of Complementary Food Formulations

Table 7 indicated elements of cost of manufacturing complementary food. Ten million naira indicates capital budget, which was in line with Youth Enterprise with Innovation in Nigeria (YEIN, 2013). The Federal Government of Nigeria for small-scale enterprise in its youth empowerment agenda proposed this. The attempt was made to find out operations and practices of small-scale industries directly from government agencies. The operations and expenses were calculated based on the work of one individual, since it was done by one person. The work that lasted for actual one week was further multiplied to give one accounting period. The cost incurred in producing 4,560 units was ₦ 941,373.67 K, meaning that cost of one unit with a net weight of 300 g was ₦ 330.00 K. The unit price of blends was compared with conventional rice-based complementary food (one third of Friso Gold). This was also compared by many women (during sensory session) to give much allowance for any future improvements for additional desired quality, expected to be within affordable price.

It was observed that if ₦941,373.65 K, used for this study deposited in bank saving system, it would only generate an interest of ₦28, 241.21 K per year. The remaining ₦9, 058,626.36 K out of the ten million naira proposed for full scale operations will only give an interest of ₦271, 758.79 K per year. An anticipated sale price of the business (company) at the end of one-year accounting was observed to be ₦114, 285.83 K. Therefore, the net profit and anticipated sale price of the business at the end of the one-year accounting period will amount to ₦677, 712.80 K. The figures in brackets are also elements of cost and each was expressed as a percentage of sales.

Conclusion

The result obtained from complementary foods has yielded different sets of formulations with the uniform result. However, each group of formulations, which contains malt or soybeans and malt, was observed to be fitted and suitable for a particular category of infants. Slightly higher percentage of particle sizes of flours for formulations containing rice and soybean in the ratio of 70:30 with and without sorghum malt passed through U.S. standard screen No. 6 compared to others. Formulations with a ratio of rice to soybean

70:30 with sorghum malt had moderate levels of proteins as compared to many conventional complementary foods such as Friso Gold (rice based complementary food). Addition of sorghum malt and soybeans did not considerably affect uniform particle size distributions of formulations, because 94% of flours passed through 600 μm sieve. On the other hand, it has increased the ash, protein, fat, fiber, and energy contents of the formulations. Functional properties, especially bulk density as well as pH, were also improved. Unit cost of formulations (rice to soybean 70:30 with sorghum malt) with same weight level with Friso Gold was observed to be three times lower in price. Formulations with higher levels of protein, the quantity of soybean used in the mixing ratios may still be reduced for safe protein level best on the requirement of Codex –standard and European Commission.

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