African Journal of Food Science and Technology (ISSN: 2141-5455) Vol. 5(4) pp. 105-113, April, 2014
DOI: http:/dx.doi.org/10.14303/ajfst.2014.031
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Full Length Research Paper

Functional and physico-chemical properties of complementary diets produced from breadfruit (*Artocarpus altilis*)

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ABSTRACTS

Babies are normally breastfed as long as possible, sometimes up to two years. However as the child grows, other foods are introduce as from six months. These foods are complementary to breast milk which is usually inadequate in basic nutrient for the rapid growth and development of the babies. Functional and physicochemical properties of complementary diet formulated from blends of breadfruits(*Artocarpus altilis*), Soybean (*Glycine max*) and groundnut (*Arachis hypogeal*) were investigated in this study and compared with a commercial complementary diet for the suitability of the diets to the growing child in terms of texture , dietary bulk density and caloric density. BRESOG1 was formulated to contain (80% Basal: 10% Soybean: 10% Groundnut); BRESOG2 (80% Basal: 5% Soybean: 15% Groundnut); BRESOG3 (80% Basal: 15% Soybean: 5% Groundnut). The functional properties (Water Absorption Capacity, Oil Absorption Capacity, Gelation Capacity, Swelling and Solubility), Pasting characteristics and physicochemical analysis (Bulk Density and pH) were determined by standard methods. Result showed that the diets BRESOG1, BRESOG2 and BRESOG3 have high gelation end point, low bulk density, swelling capacity, viscosity, and water binding capacity. This implies that it forms low viscous and high caloric density food per unit volume rather than a high viscosity/high volume density.

Keywords: Complentary Diets,Functional Physico-Chemical Properties and Breadfruits

INTRODUCTION

Breastfeeding is acknowledged to be the optimal way of both feeding and caring for young infants. It is the cheapest means of feeding a child during the first six months of life. As the child grows and becomes more active, breast milk alone is insufficient to meet the full psychological needs of the infant. Thus, there is need to introduce soft, easily swallowed foods to supplement the infant's feeding early in life (FMOH, 2005). Complementary foods according to WHO (2001) and Lutter (2001) are products intended to supplement or replace breast milk during the early years of life. Proper complementary foods should supply certain essential elements that cannot be sufficiently supply by breast milk after six months while also providing additional calories (Sajilata et al., 2002). It has been discovered that with the addition of food other than breast milk in developing countries there has been a marked increase in the danger of gastroenteritis as a potentially fatal disease (WHO, 2000). Poor feeding practices as well as lack of suitable complementary foods are responsible for under nutrition with poverty exacerbating the whole issue. The complementary foods are often of low quality and given in insufficient amounts (Brown et al*.,* 1998). Fortified complementary foods are unavailable especially in the rural areas and where available, they are often too expensive and beyond the reach of average mothers (Bentley et al*.,* 1991). Therefore most complementary foods used in Nigeria are locally produced and based on local staple foods, usually cereals that are processed into porridges. Apart from their bulkiness reported as a

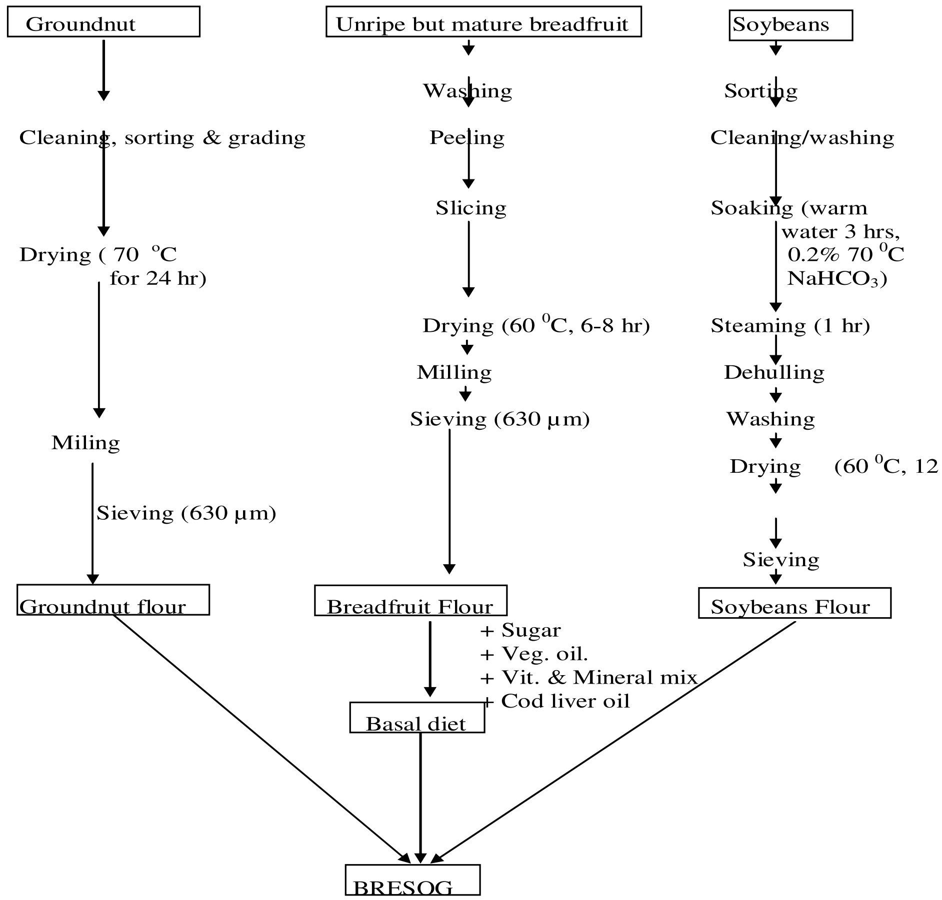

Figure 1. Preparation of the complementary diets

probable factor in the etiology of malnutrition (WHO, 2001), cereals-based gruels are generally low in protein and are limiting in some essential amino acids, particularly lysine and tryptophan. In addition, the demand for the carbohydrate sources (cereals-maize and sorghum) is ever increasing owning to their increased utilization. Furthermore, the population is increasing and the requirement for cereals and cereal-based foods is equally on the rise. In view of the high price of commercial baby foods and low level of locally made complementary foods, the search for locally available, cheap and high carbohydrate sources for complementary food formulation therefore becomes imperative. Breadfruit (*Artocarpus altilis*) is one of the local staples in the developing countries and relatively cheap but neglected (Akanbi et al*,* 2009). It is a tropical fruit and the tree produces fruit twice a year, from March to June and July to September with some fruiting throughout the year (Omobuwajo, 2007). It is one of the principal sources of energy protein, vitamins and minerals. Its value especially carbohydrate, protein, fat and mineral contents is comparable and in some cases superior to some cereals or food grains (Adebowale et al*,* 2008). Breadfruit is of high protein quality unlike most cereals especially maize which is generally recognized as being inherently poor in protein quality (Uvere et al*,* 2002, Omobuwayo, 2007). Therefore, the present study was conducted to investigate the functional and physicochemical properties of complementary diets from breadfruit supplemented with soybeans and groundnut and evaluate the acceptability of the diets for infant feeding.

MATERIALS AND METHODS

Materials

Mature but unripe breadfruit (*Artocarpus altilis*), soybeans (*Glycine max*) and groundnut (*Arachis hypogeal*) were obtained from the Central Market in Ile Ife, Osun State, Nigeria. A commercial complementary food, (CCF) was purchased from Glory 2 Glory Supermart in Ile-Ife, Osun State. The vitamin and mineral mixes were obtained from Pfizer Nig.PLC.

Methods

The complementary diets were prepared as shown in Figure 1. BRESOG1 was formulated to contain (80% Basal: 10% Soybean: 10% Groundnut); BRESOG2 (80% Basal: 5% Soybean: 15% Groundnut); BRESOG3 (80%

Table 1. Composition of Basal Diet

Component	g/kg
Protein	-----
Breadfruit flour	800g
Sugar	60g
Vegetable oil	100g
Vitamin and Mineral mix	35g
Cod liver oil	5g

Basal: 15% Soybean: 5% Groundnut). The composition of the Basal diet is shown in Table 1.

Water Absorption Capacity (WAC)

Water absorption capacity was determined by the method of the AACC (1995). A 2g complementary diet was dispersed in 200 ml of distilled water. The contents were mixed for 30 seconds every 10 minutes using a glass rod and after mixing five times, it was centrifuged at 4000 g for 20 min. The supernatant was carefully decanted and then contents of the tube was allowed to drain at a 45^0 angle for 10 min before it was weighed. The water absorption capacity was expressed as percentage increase of the sample weight.

Oil Absorption Capacity (OAC)

Oil absorption capacity was determined by the centrifugal method described by Beuchat (1977) with slight modifications. One gram of complementary diet was mixed with 10 ml of pure gino oil for 60 sec, the mixture was allowed to stand for 10 min at room temperature, centrifuged at 4000 g for 30 min and the oil that separated was carefully decanted and the tubes was allowed to drain at a 45^0 angle for 10 min and then weighed. Oil absorption was expressed as percentage increase of the sample weight.

Solubility Index

Solubility index of the complementary diets was determined in triplicates by the method of Leach *et al.* (1959) as modified by Okoli (1998).One gram sample was suspended in 50 ml distilled water in a clean dry beaker. The suspension was mechanically stirred at a rate sufficient to keep the sample completely suspended. The beaker was placed in a thermostatic water bath with the temperature set at 60 ^oC for 30 min with gentle stirring. The stirrer was subsequently removed and rinsed with distilled water to bring the total water content to 60 ml. The mixture was then centrifuged at 4000 g. The supernatant was decanted into tarred evaporating dish. It was thereafter evaporating to dryness at 120 ^oC. The percentage of soluble extract from the sample was calculated on dry weight basis.

Least Gelation Concentration (LGC)

Least gelation concentration was determined by the method of Sathe and Salunkhe (1981). Sample suspensions 1-19 % (W/V) were prepared in 5 ml distilled water and the test tubes were heated in a boiling water bath for 1 hr followed by rapid cooling under running cold tap water. The test tubes were further cooled for 2 hrs at 4 ^0C. Least gelling concentration was determined as that concentration when the sample from the inverted test tube did not fall down or slip.

Swelling Capacity (SC)

Swelling capacity was determined by the method described by Takashi and Sieb (1988). 3-5g complementary diets were weighed into tarred 50 ml centrifuge tube. About 30 ml distilled water was added and mixed gently. The slurry was heated in a water bath at 95 ^0C for 30 min. During heating, the slurry was stirred gently to prevent clumping of the sample. On completion of the 30 min, the tube containing the paste was centrifuged at 3000 g for 10 minutes. The supernatant was decanted immediately after centrifugation. The tubes were dried at 50 ^0C for 30 minutes, cooled and then weighed (W_2). Centrifuge tubes containing sample alone were weighed prior to adding distilled water (W_1).

Swelling capacity was calculated as follows:

$$\frac{W_2\,(g) - W_1\,(g)}{\text{Weight of Sample (g)}}$$

Bulk Density

The bulk density was determined by the method of Okezie and Bello (1988). A 10 ml graduated cylinder, previously tarred, was gently filled with the complementary diet. The bottom of the cylinder was gently tapped on a laboratory bench several times until there was no further diminution of the sample level after filling to the 10 ml mark. Bulk density was calculated as weight of sample per unit volume of sample (g/ml).

Table 2. Chemical Composition of Complementary Diets

Parameter	COMMERCIAL	BRESOG 1	BRESOG 2	BRESOG 3	BASAL
Moisture (%)	2.37^{a} ± 0.24	7.83^{d} ± 0.34	6.76^{cd} ± 0.67	5.53^{bc} ± 0.89	5.19^{b} ± 0.72
Protein (%)	15.18^{bc} ± 0.87	16.88^{c}± 1.02	15.22^{bc}± 0.54	15.72^{bc}± 0.11	2.06^{a}± 0.31
Fat (%)	9.05^{b} ± 0.87	10.43^{bc} ± 0.56	11.43^{cd} ± 0.53	9.80^{bc} ± 0.69	0.22^{a} ± 0.11
Crude fibre (%)	5.17^{c} ± 0.50	4.66^{c} ± 0.63	2.85^{ab} ± 0.36	3.31^{ab} ± 0.64	2.08^{a} ± 0.07
Ash (%)	5.10^{d} ± 0.90	4.75^{d} ± 1.05	2.40^{ab} ± 0.08	3.24^{bc} ± 0.25	1.63^{a} ± 0.21
Carbohydrate	62.75^{a} ± 0.51	55.48^{a} ± 1.40	61.94^{a} ± 1.64	62.40^{a} ± 1.12	88.82^{c} ± 1.56
Gross Energy	394.69^{a} ± 1.70	383.04^{a} ± 1.16	409.11^{a} ± 1.67	400.68^{a} ± 2.52	365.50^{a} ± 1.36
Sodium (mg/kg)	210.67^{c} ± 1.16	87.07^{b} ± 0.12	34.63^{a} ± 0.15	41.13^{a} ± 0.99	34.10^{a} ± 0.17
Potassium(mg/kg)	573.50^{a} ± 3.04	1742.23^{c}± 1.15	1020.01^{b}±2.15	1040.32^{b}±2.02	492.03^{a}±4.17
Calcium(mg/kg)	395.00^{b}±1.02	684.60^{d}±2.01	480.60^{bc}±1.25	438.54^{bc}±1.05	17.80^{a}±1.56
Phosphorus(mg/kg)	264.50^{b} ±0.50	874.67^{d}±0.12	608.03^{c}±0.06	520.57^{c}±0.08	33.10^{a}±0.30
Magnesium (mg/kg)	----	490.73^{f}±3.05	243.57^{cd}±1.25	206.99^{b}±1.05	107.40a±0.05
Iron (mg/kg)	10.17^{b}±0.61	22.77^{e}±0.10	15.49^{cd}±1.50	11.37^{bc}±1.02	0.56^{a}±0.12
Zinc (mg/kg)	6.00^{bc}±0.87	6.46^{c}±0.76	5.49^{bc}±1.35	4.97^{b}±0.10	0.46^{a}±0.18

Values are means and standard deviation of three determinations (n=3)
Means followed by the same letter within the same rows are not significantly (P<0.05) different according to LSD test.
Note: BRESOG 1 (Basal 80% + Soybean 10% + Groundnut 10%); BRESOG 2 (Basal 80% + Soybean 5% + Groundnut 15%); BRESOG 3 (Basal 80% + Soybean 15% + Groundnut 5%); Basal (Composition as shown in Table 1), Commercial complementary food / control

pH

The pH was determined by making a 10% w/v suspension of the sample in distilled water. The suspension was mixed thoroughly in a Sorex blender and the pH was measured with a Hanna checker pH meter (Model HI 1270).

Pasting Viscosity

The pasting characteristics of the diets were determined using a Rapid Visco Analyzer (Newport scientific PTY.LTD) connected to a computer (PC) with window operating system via a UBS port. The moisture content of the complementary diet was first determined to obtain the correct sample weight and amount of water required for the test. An aqueous suspension of sample was then made and spun at 75 rpm. The temperature time conditions included a heating step from 50 ^{0}C to 95 ^{0}C at 6 ^{0}C / min (after an equilibrium-time of 1 min at 50 ^{0}C), a holding phase at 95 ^{0}C for 5 min, a cooling step from 95 ^{0}C to 50 ^{0}C for 2 min. Readings were displayed on the monitor in a numerical and graphical form. Viscosities were expressed in rapid viscosity units (RVU).

RESULTS AND DISCUSSION

The chemical compositions of the complementary diets were presented in Table 2. The result showed that the inclusion of soybeans and groundnut to breadfruit flour (Basal diet) improved the crude protein, crude fat, ash, crude fibre and mineral contents and the gross energy of the complementary blends. The protein content of BRESOG1 was significantly higher than that of control (commercial) diet, while protein contents of BRESOG 2 and 3 diets compared favourably with that of commercial diet. The crude fat contents were significantly (P>0.05) higher than that of basal diet but compared favorably with that of commercial diet.

The inclusion of protein and oil rich legumes (soybeans and groundnut) at higher proportions may have accounted for the high levels of protein and oil in the formulated diets.

The crude fibre and ash contents of commercial diet were however higher than those of the formulated diets as well as basal diet. The moisture contents varied betwee

Table 3. Gelation Properties of the Formulated Diets

Cone % Sample	BRESOG 1 Gelation Appearance		BRESOG 2 Gelation Appearance		BRESOG 3 Gelation Appearance		BASAL Gelation Appearance		COMMERCIAL Gelation Appearance	
1	-	Liq	-	Liq	-	Liq	-	Liq	-	Liq
3	-	Liq	-	Liq	-	Liq	-	Liq	-	Liq
5	-	Liq	-	Liq	-	Liq	-	Liq	-	Liq
7	-	Liq	-	Liq	-	Liq	±	viscous	-	Liq
9	±	viscous	±	viscous	±	viscous	±	viscous	-	Liq
11	±	viscous	±	viscous	±	viscous	+	Firm gel	+	Firm gel
13	±	viscous	±	viscous	±	viscous	+	Firm gel	+	Firm gel
15	+	Firm gel	+	Firm gel	+	Firm gel	+	Firm gel	+	Firm gel
17	+	Firm gel	+	Firm gel	+	Firm gel	+	Firm gel	+	Firm gel
19	+	Firm gel	+	Firm gel	+	Firm gel	+	Firm gel	+	Firm gel

2.37% and 7.83% with commercial diet exhibiting the lowest moisture content and BRESOG 1 the highest. The values obtained for moisture contents in this study showed that the formulated diets were likely to be shelf stable.

The results of the proximate composition of the formulated diets BRESOG1, 2 and 3 show that the protein, fat, ash and crude fibre contents were within the recommended values for complementary diets (PAG, (1972); FAO, (1985). The formulated diets contained higher levels of Na, K, Ca, P, Mg and Fe than the control diet (commercial) except for Zn. The recommended intakes for these mineral elements are 400, 270, 75, 275, 4 and 11 mg/d for Na, Ca, Mg, P, Zn, and Fe respectively.

Gelation properties of the complementary diets; BRESOG1, 2 and 3 are shown in Table 3. The results showed that the formulated diets formed stable gel at higher concentration (15%) compared to Commercial complementary food and Basal diet at 11% and 9% respectively.

At concentrations between 1 and 7%, all the diets appeared liquid while at concentration above 7% absorption of water and subsequent swelling of the molecules resulted in increased viscosity. The lower the least gelation capacity (LGC), the better the gelation ability of the food. The ability of the diets to form a less viscous paste rather than thick gel at a lower concentration is a good

Table 4. Functional Properties of the Complementary Diets

PARAMETER	BRESOG 1	BRESOG 2	BRESOG 3	BASAL	COMMERCIAL
BD	$0.40^{cd} \pm 0.01$	$0.31^{a} \pm 0.04$	$0.38^{bc} \pm 0.02$	$0.35^{ab} \pm 0.02$	$0.37^{bc} \pm 0.03$bc
LPD	$0.67^{c} \pm 0.01$	$0.60^{a} \pm 0.01$	$0.63^{b} \pm 0.01$	$0.61^{a} \pm 0.01$	$0.63^{b} \pm 0.01$
WAC	$165.33^{c} \pm 0.40$	$146.33^{c} \pm 0.50$	$124.67^{a} \pm 0.20$	$138.67^{b} \pm 0.66$	$152.33^{a} \pm 0.51$
OAC	$80.53^{a} \pm 0.30$	$95.68^{cd} \pm 0.40$	$99.40^{a} \pm 0.24$	$93.61^{c} \pm 0.44$	$86.25^{b} \pm 0.36$
SP	$15.33^{a} \pm 0.67$	$16.20^{b} \pm 0.10$	$18.67^{bc} \pm 0.34$	$20.67^{d} \pm 0.50$	$36.67^{c} \pm 0.30$
SI	$4.9^{d} \pm 0.26$	$3.63^{c} \pm 0.49$	$3.27^{b} \pm 0.45$	$3.41^{b} \pm 0.44$	$2.27^{a} \pm 0.31$
pH	$6.47^{c} \pm 0.07$	$6.08^{a} \pm 0.02$	$6.09^{ab} \pm 0.01$	$6.09^{ab} \pm 0.01$	$6.69^{d} \pm 0.07$

BD – Bulk density; LPD – Passed Density; WDC – Water Absorption Capacity; OAC – Oil Absorption Capacity; SP – Swelling Power; SI – Solubility Index.
Values are means and standard deviation of three determinations (n=3)
Means followed by the same letter within the same rows are not significantly ($P<0.05$) different according to LSD test.
Note: BRESOG 1 (Basal 80% + Soybean 10% + Groundnut 10%); BRESOG 2 (Basal 80% + Soybean 5% + Groundnut 15%); BRESOG 3 (Basal 80% + Soybean 15% + Groundnut 5%); Basal (Composition as shown in Table 1), Commercial complementary food / control

functional property for a complementary diet. The implication of a thick gel to a complementary diet is that it can affect the gastric system of the child since they have limited gastric capacity to metabolize thick or viscous foods (Omueti et al., 2008). The importance of high LGC to the complementary diet is however that the diet will have reduced viscosity, plasticity and elasticity hence low dietary bulk which is highly desirable for a good complementary diet. The difference in gelling concentration of the formulated diets may be attributed to the relative ratios of different constituents such as protein, carbohydrates and fats that make up the diets and the interactions between such components (Sathe et al, 1982).

Table 4 shows the results of the functional properties of the complementary diets. The formulated diets had significantly lower bulk density than the Commercial product. This indicates that the gruel made from the formulated diets will have a lower dietary bulk. This is important in complementary foods because high bulk density limits, the caloric and commercial diet in take per feed per child and infants are sometimes unable to consume enough to satisfy their energy and commercial diet requirements (Omueti et al., 2009).

Apart from dietary bulk, bulk density (BD) is also important in the packaging requirement and material handling of the complementary diet (Karuna et al. 1996). The loose pack density (LPD) is related to BD; the higher the LPD, the higher the BD. This is because LPD indicates the free space between the foods when packed. A large free space is undesirable in packaging of foods because it constitutes a large oxygen reservoir whereas a low LPD and lower bulk density result in greater oxygen transmission in the packed food.

The Water Absorption Capacities (WAC) of the formulated complementary diets were lower than that of the Commercial diet and ranged between 124.67% and146.33% with BRESOG 1 exhibiting the highest. According to Omueti et al. (2009), WAC is the ability of a product to associate with water under a condition where water is limiting. However the higher WAC of commercial diet compared with other diets may be attributed to the proportion of hydrophilic and hydrophobic amino acids in the protein and relative amount of carbohydrates. The more hydrophilic amino acids and the polysaccharide constituents, the more water make the diet absorb and bind (Otegbayo et al. 2000). The lower WAC of BRESOG 1, BRESOG 2, and BRESOG 3 compared to commercial diet and Basal diet is not unexpected since they contain higher fat contents and since fat is hydrophobic in nature can restrict swelling and form amylose-lipid complex with the polysaccharide in the diet thus decreasing the amount of water absorbed. The significance of low WAC in the complementary diets BRESOG 1, BRESOG 2 and BRESOG 3 compared to commercial diet and Basal diet is that it is desirable for making thinner gruels with high Caloric density per unit volume.

The result of the Oil Absorption Capacity (OAC) showed that BRESOG 2 had the highest OAC while there is no significant difference between OAC of BRESOG 1 and BRESOG 3 respectively. OAC indicates the ability of a flour to retain flavor and improve mouth feel

Table 5. Pasting Properties of the Formulated Diets (RVU**)**

Samples	Peak Visc	Breakdown Visc	Find Visc	Setback Visc	Peak Time	Pasting Temp
COMMERCIAL	$3.81^{a} \pm 050$	$9.63^{d} \pm 0.29$	$10.55^{b} \pm 0.53$	$6.00^{a} \pm 0.81$	$8.21^{d} \pm 0.25$	$61.58^{a} \pm 0.04$
BRESOG 1	$6.84^{c} \pm 0.18$	$0.88^{a} \pm 0.66$	$9.46^{ab} \pm 0.06$	$6.04^{a} \pm 0.06$	$4.29^{a} \pm 0.06$	$61.88^{a} \pm 0.32$
BRESOG 2	$4.40^{b} \pm 2.31$	$4.17^{b} \pm 1.06$	$8.04^{a} \pm 0.76$	$6.05^{a} \pm 0.53$	$6.17^{c} \pm 0.83$	$61.88^{a} \pm 0.32$
BRESOG 3	$6.89^{d} \pm 0.07$	$1.38^{a} \pm 0.18$	$14.54^{c} \pm 0.76$	$10.13^{b} \pm 0.41$	$5.80^{b} \pm 0.53$	$61.80^{a} \pm 0.42$
BASAL	$6.96^{e} \pm 0.02$	$5.50^{bc} \pm 1.17$	$141.00^{d} \pm 0.82$	$68.79^{c} \pm 0.76$	$77.71^{c} \pm 1.24$	$61.70^{a} \pm 0.20$

Values are means and standard deviation of three determinations (n=3)
Means followed by the same letter within the same rows are not significantly (P<0.05) different according to LSD test.
Note: BRESOG 1 (Basal 80% + Soybean 10% + Groundnut 10%); BRESOG 2 (Basal 80% + Soybean 5% + Groundnut 15%); BRESOG 3 (Basal 80% + Soybean 15% + Groundnut 5%); Basal (Composition as shown in Table 1), Commercial complementary food / control

(Kinsella, 1976). According to Omueti et al. (2009). OAC has been attributed to be due to physical entrapment of oil and the binding of fat to the polar chains of proteins. Kinsella (1976) reported that more hydrophobic proteins show superior binding of lipids, this implies that non-polar amino acids side chains bind the paraffin chains of fats. Based on this report the lower OAC of the commercial and Basal diets may be due to the fact that the formulated diets (BRESOG 1, BRESOG 2, and BRESOG 3 (with higher OAC) had more available non-polar side chains in their protein molecules than commercial and Basal diets. This implies that the formulated diets will be able to retain more flavour and probably have better month feel compared to commercial and Basal diet.

Swelling Power (SP) connotes the expansion accompanying spontaneous uptake of solvent while solubility index (SI) is the amount of water soluble solids per unit weight of the sample. The basal diet had the highest SP followed by BRESOG 3, BRESOG 2 and BRESOG 1 with commercial diet being the lowest. Kinsella (1976) reported that swelling causes changes in hydrodynamic properties of the food thus impacting characteristics such as body, thickening and increase viscosity to foods. This thus implies that among the formulated complementary diets basal with the highest swelling power will produce a thick viscous gruel compared to BRESOG 1, BRESOG 2, BRESOG 3 and commercial diet. This is probably due to higher carbohydrate content than the other diets which has been substituted with soybeans and groundnut. Appropriate complementary diet is one which produce a gruel that is neither too thick (when it is too thick, it will be difficult for the infant to ingest and digest because of limited gastric capacity) for the infant to consume nor so thin that energy and Commercial diet density are reduced (WHO, 2003).

Commercial diet had the highest solubility index followed by BRESOG 1, BRESOG 3 and BRESOG 2 while Basal diet had the lowest. Solubility is an index of protein functionality such as denaturation and its potential applications. The higher the solubility, the higher the functionality of the protein in a food. The higher solubility of commercial diet, BRESOG 1, BRESOG 2, and BRESOG 3 compared to the Basal diet may be due to the fact that they have higher protein content due to inclusion of protein components such as soybeans and groundnut and also may indicate that the protein component of these diets are still functional.

Table 5 showed the result of the pasting properties of the complementary diets. All the diets had low peak viscosity, final, setback and peak time when compared to the basal diet. Pasting is the result of a combination of processes that follows gelatinization from granule rapture to subsequent polymer alignment due to mechanical shear during the heating and cooling of starches. High Peak viscosity is an indication of high starch content (Osungbaro, 1990). It is related to the water binding capacity of starch (Adebowale et al. 2005). The low peak viscosity and final viscosity of the diets implies that the complementary diets will forma a low viscous paste rather than a thick gel on cooking and cooling (Omueti et al. 2009). It thus indicates that the gruel will be a high caloric density food per unit volume (Otegbayo et al. 2006) rather than a dietary bulk (high volume viscosity) (Ikujenlola and Fasakin, 2005). The relatively high peak viscosity of basal diet might be related to the proportion of starch in the diet, the ratio of amylose to amylopectin and the resistance of the starch granules to swelling. The presence of other non-starchy constituents in the other diets may be contributing factor to the peak viscosity.

Set back viscosity of starch-based foods has been correlated with texture of various food products. The low setback value of the complementary diets indicates that the diets on cooking will not be cohesive gruels. It has also been reported that low set back is an indication that the starch has a low tendency to retrograde or undergo syneresis during freeze thaw cycles (Ikujenlola and Fashakin, 2005), this means that the diets can be stored at low temperature with low tendency to retrograde.

The pasting temperature provides an indication of the minimum temperature required to cook a given sample and also indicates energy costs. From the table above, the complementary diets had low gelatinization temperature hence a shorter cooking time. The pasting temperatures of the diets were lower than the gelatinization temperature of 70.5 ^{0}C reported for Ogi (fermented corn) flour by Oluwamukomi et al. (2005); 66.7 ^{0}C and 67.2 ^{0}C for white and red sweet potato flours reported by Osundahunsi et al. (2003).

CONCLUSION

It can be deduced from the results of the study that appropriate complementary diet in term of texture, dietary bulk and caloric density can be formulated from breadfruit (*Artocarpus altilis*) which is an underutilized food crop. The technologies for the production of these diets is simple and the ingredients are available and cheap hence can be affordable. It can therefore be recommended as an alternative to commercial product (which is more expensive).

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How to cite this article: Adepeju A. B., Gbadamosi S.O., Omobuwajo T.O. and Abiodun O.A. (2014). Functional and physico-chemical properties of complementary diets produced from breadfruit (*Artocarpus altilis*). Afr. J. Food Sci. Technol. 5(4):105-113