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Functional And Pasting Properties Of Weaning Food Formulated From Locally Sourced Food Commodities

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***Abstract:** Weaning is a period of transition for infants during their diet change in term of constituency and sources. Such diet is formulated from maize, millet soybean, sorghum, groundnut, tigernut and plantain. Maize millet, soybean, sorghum, groundnut, tigernut and plantain were processed into semi product using standard methods. The semi products were composited to give 15 samples in different percentage ratio, the composited weaning food were subjected to functional and pasting analysis using standard procedure. Sample L (40% millet:40% groundnut,20% plantain) absorb less water which is desirable to produce thin meal, sample M (100% maize) has the highest oil absorption and swelling capacity. Sample M has significant effect on solubility, sample M has significant effect on solubility, sample I has the highest bulk density which determines food expansion. Peak and trough viscosity increase in sample O (100% millet) sample B (40% sorghum: 40 soybean: 20% tigernut) has the least breakdown viscosity which suggest its stability under hot conditions sample G (40% maize: 40% sorghum: 20% plantain) has the highest final viscosity, sample O (100% millet) has the highest setback which is beneficial in producing meal with les retrogradation. Peak time and pasting temperature weaning food. The research shows that complementary foods with adequate functional and pasting properties can be formulated from the locally available materials used and can compete well with available product in market.*

I. INTRODUCTION

During the first few months of life, breast milk or iron fortified milk alone provides optimal nutrition for the rapidly growing young Infant. As physical and developmental capabilities mature, weaning is starts. Weaning is the developmental process in which semisolid foods are introduced and the composition and consistency of diet are progressively advanced. Ideally by 12 months of age the infant is eating a variety of food from mixed diet but breast milk, or formula is the best source of energy and nutrient (Darling *et al.,* 1995). Pattern of introduction of supplementary foods should be based on the individual infant nutritional needs, physiological maturation and the development of feeding skills (Onofiok, 1998).

The growth of the infant in the first or second years is very rapid and breast feeding alone will not meet the child nutritional requirement. After about four months of age the child needs supplementary feeding (Achinewhu *et al.*, 1987). As a result of many brand of preparatory weaning foods has been developed and marketed in most developing countries including Nigeria (Adeyemi *et al.,* 2008). In these countries, the child is usually weaned into a porridge prepared from cereal flour such as maize which is characterized by bulky, high viscosity and low energy density per unit volume of the food, thus necessitating frequent feedings to meet the daily energy requirements of the child. Apart from energy the food is usually inadequate in other nutrients, leading to wide spread protein energy malnutrition and its complication during the weaning period (Ijarotimi *et al.*, 2009).

Nigeria is no exception, as most children are weaned onto ‘ogi’, a gruel made from fermented corn (Ugwu, 2009). The situation is even more critical as prices of commercial weaning food products are too expensive for many mothers (Njoki *et al.*, 2001). Thus the need to have maximum utilization of commonly available cheap cereals to formulate weaning foods that would be low in viscosity, high in calorific density and with adequate necessary nutrients (Onofiok *et al.*, 1998).

The nutritional adequacy of complementary foods is essential for the prevention and infant morbidity and mortality, including malnutrition and overweight. In Nigeria, traditional complementary foods are usually produced from staple cereals and legumes prepared either individually or as composite gruels (Walker, 1990). Cereal grain are considered to be one of the most important sources of dietary proteins, carbohydrates. However the nutritional quality of cereals and sensorial properties of their products are sometimes inferior or poor in comparison with milk and milk products. This is because cereal is deficient in certain essential amino acids (i.e lysine and trytophan) and additionally is characterized by low starch availability, presence of anti-nutrients (phytic acid, tannins and polyphenols) and the coarse nature of the grains (Vasal, 2001). Combination of common cereals, which are deficient in lysine but have sufficient amount of sulphur-containing amino acids, with inexpensive plant protein sources like legumes that are rich in lysine can be used to improve the nutritive value of a food product.

FAO/WHO/UNICEF (1971) emphasized the use of local foods formulated at home and guided by the principles that it has to be high nutritional value to supplement breastfeeding, acceptable to infants, cost effective and locally available (Dewey and Brown *et al.*, 2003).

The current scenario of nutritional status of children and adolescence in the country is distributing, necessitating essential remedial measure. One of the most significant reasons for this study was to develop low cost, value added weaning foods which are easy to prepare.

II. MATERIALS

The materials used for this work were obtained locally from markets in Osun State, Nigeria. These materials include soybeans, millet, sorghum, maize, and groundnut which were bought from Iree market in Iree. Osun State, Unripe plantain bought from Ada market in Ada. Osun State. Tiger nut was obtained from Osogbo market in Osogbo, Osun State, Nigeria.

Other materials used include weighing balance sieve spoon, water, oven, tray, plastic containers, knife, polythene bags, cellotape, paper tape which were available in the food workshop of Food Science and Technology Department of Osun State, Polytechnic Iree Osun State Nigeria.

A. PROCESSING OF PLANTAIN INTO SEMI PRODUCT

Unripe Plantain was sorted to removed the damaged or infected ones, it was the peeled with a stainless knife and sliced into smaller forms. It was pre-cooked for few minutes, it was sundried, milled sieved and packaged into polythene bag.

B. PROCESSING OF SORGHUM, MAIZE AND MILLET INTO SEMI PRODUCT

Soybean, maize and millet were sorted to remove foreign matters such as stone, dirts and damaged ones, it was washed with potable water, drained and sundried, it was milled, sieved and then packaged into polythene bag.

C. PROCESSING OF SOYBEAN INTO SEMI PRODUCT

Soybean was sorted to remove extraneous matters such as stone, dirt and damaged seeds, it was washed with portable water, it was drained and sundried, it was roasted and then winnowed, it was sundried again, then it was milled, sieved and packaged into polythene bag.

D. PROCESSING OF TIGER NUT INTO SEMI PRODUCT

Tiger nut was sorted to remove extraneous matters such as stone, dirts and damaged ones, it was washed with portable water, it was milled into slurry, the slurry was sundried and was milled into flour, it was sieved and packaged into polythene bag.

E. PROCESSING OF GROUNDNUT INTO SEMI PRODUCT

Groundnut was sorted to remove damaged ones, it was roasted, cooled then peeled, it was winnowed to remove the peels, it was milled, then heated and its oil was extracted, the cake formed was packaged into polythene bag.

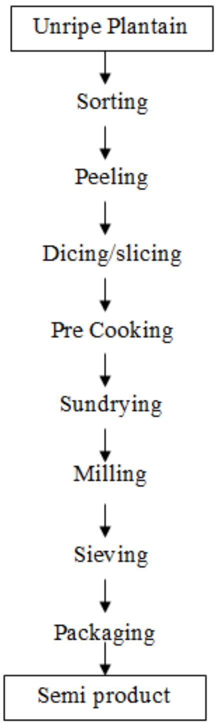

Figure 3.2.1: Flow chart for processing plantain into semi product

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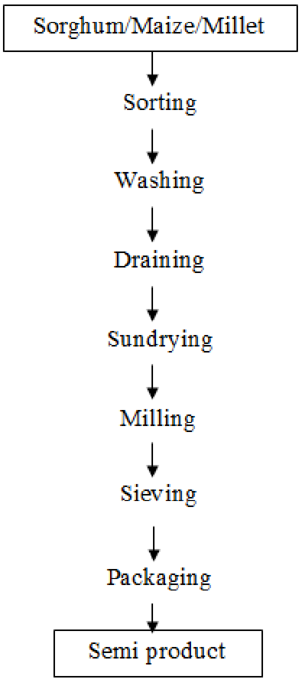

Figure 3.2.2: Flow chart for processing sorghum into Semi product

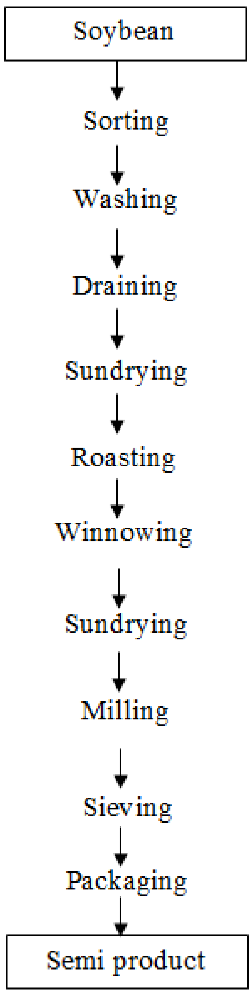

Figure 3.2.3: Flow chart for processing Soybean into Semi product

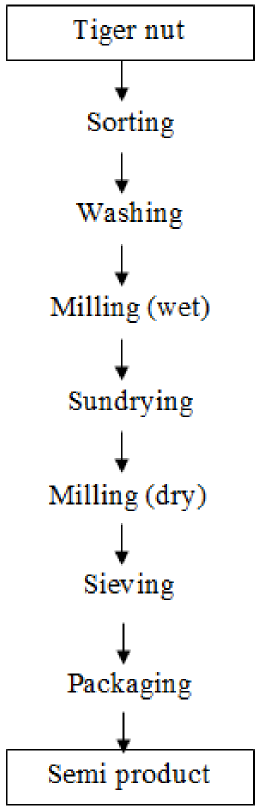

Figure 3.2.4: Flow chart for processing Tiger nut into Semi product

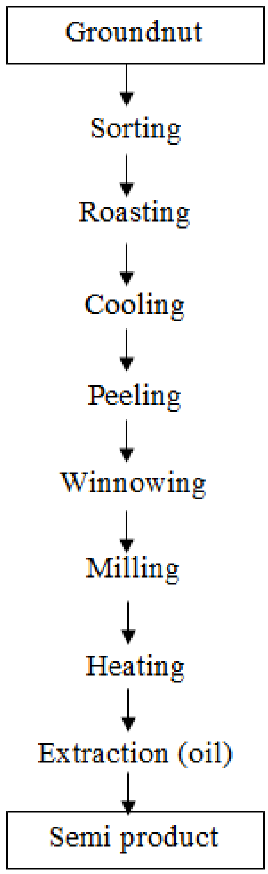

Figure 3.2.5: Flow chart for processing groundnut into flour

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F. FORMATION OF WEANING FOOD

This was done by weighing each semi product i.e maize, millet, groundnut, tigernut, sorghum, soybean and plantain according to some ratio, the sample were weighed and mixed in a clean big bowl, packaged and labeled as below.

Samples codes	Formulation
A	40% Maize: 40% Soybean: 20% Tiger Nut
B	40% Sorghum: 40% Soybean: 20% Tiger Nut
C	40% Millet: 40% Soybean: 20% Tiger Nut
D	40% Maize: 40% Groundnut: 20% Tiger Nut
E	40% Sorghum: 40% Groundnut: 20% Tiger Nut
F	40% Millet: 40% Groundnut: 20% Tiger Nut
G	40% Maize: 40% Sorghum: 20% Plantain
H	40% Sorghum: 40% Soybeans: 20% Plantain
I	40% Millet: 40% Soybeans: 20% Plantain
J	40% Maize: 40% Groundnut: 20% Plantain
K	40% Sorghum: 40% Groundnut: 20% Plantain
L	40% Millet: 40% Groundnut: 20% Plantain
M	100% Maize
N	100% Sorghum
O	100% Millet

G. FUNCTIONAL PROPERTIES OF FORMULATED BULK DENSITY (BD)

The procedure of Narayana and Narasinga (1984) was used with slight modification. A specified amount of the formulated sample was put into an already weighed (w) 25mL measuring cylinder, it was gently tapped and the volume was noted. The new level of sample on measuring cylinder was recorded in ml as (m).

WATER ABSORPTION AND OIL ABSORPTION

The water absorption capacity of each formulated sample was determined using the method of (Sathe *et al.*, 1982). A suspension of 1g of sample in 10ml of distilled water or (10ml of executive chef oil with density of 0.92g/ml. the suspension of 1g of sample in 10ml of distilled water or (10ml of executive chef oil with density of 0.92g/ml). the suspensions were stirred for 5 minutes using magnetic stirrer (Staurt Co ltd 7664) at 1000rpm. The mixture was then transferred into centrifuge (CENCOM SELECTA) for 30 minutes at 3500rpm. The free water or oil absorbed by the formulated sample was calculated as the difference between the initial water/oil used and the volume of the supernatant obtained after centrifuging. The result was expressed as a gram of water or oil absorbed per gram of sample.

SWELLING POWER AND STARCH SOLUBILITY

The swelling power and solubility of the samples were determined using the method reported by leach *et al.*, (1959) 1g of the formulated sample was weighed into centrifuge tube and 50ml distilled water was added. These tubes were 1merged in water bath at temperature range from 50 to 90^{0}C at 10^{0}C intervals from 30 minutes, thoroughly and constantly stirred with glass rod during heating period. The tubes were removed, colled to room temperature and centrifuged at 5000rpm for 15 minutes. The supernatant was fully transferred into a conical flask and 5ml was pipette into a weighed petridish, evaporated over a steam bath and dried in the air oven at 105^{0}C for 4 hours. The weight of the pastes were determined and used to calculate the swelling power as gram of sediment paste per gram starch. Percentage solubility was calculated as gram of soluble starch per gram starch.

H. PASTING PROPERTIES OF FORMULATED SAMPLES

It was determined using a Rapid Visco Analyzer (Newport Scientific, RVA Super 3, Switzerland) as described by AACC(2001). 3 grams each (on a dry 100% dry matter basis) of the formulated samples was weighed into the canister. The paddle was placed into the canister and the canister was inserted into the instrument. The measurement cycle was initiated by depressing the motor tower of the instrument when the computer commands "press down the tower". The canister was removed on completion of the test. Flour suspension (9% w/w dry flour basis, 28g total weight) were equilibrated at 3000^{0}C.

III. DISCUSSION

Table 4.1 represents the functional properties of formulated weaning food from maize, millet, sorghum tigernut, soybean, plantain and groundnut. The results obtained in this research work is comparison with the work of Asaam *et al.* (2018) who reported functional and pasting properties of cereals formulated from yellow maize, soya bean and pumpkin pulp. The result of Asaam *et al.* (2018) compare favourably with the current in terms of water absorption capacity, solubility and bulk density but differs in terms of swelling capacity which the current is far less compared to the work of Asaam *et al.*, (2018).

The Water Absorption Capacity (WAC) ranged from 180.00 to 264.67%. Sample H has the highest WAC (264.67%), followed by sample T (251.00%), the sample A (249.67%), followed by sample G (242.00%), then sample B (240.33%), followed by sample C (237.33%), then sample M (230.33%), followed by sample N (211.00%), then sample O (210.00%), followed by sample D (204.00%), then sample J (198.33%), followed by sample E (190.67%), then sample F (186.00%), followed by sample K (185.67%) and the least was found in sample L (180.00%). The result showed that WAC of formulated weaning food increased due to inclusion of 40% soybean and reduced due to inclusion of 40% groundnut. The high WAC of the formulated sample could be attributed to high drying process employed of the product that can prove more protein water interaction during protein denaturation, starch gelatinization and swelling of crude fibre used for processing of the sample into semi product (Narayana *et al.*, 1982). Food with high absorption capacities for water may also contain high hydrophilic constituents such as starches and polar amino acid residue which influence their gelation and hydrophilicity capacity (Kaur *et al.*, 2005). Weaning food with low water absorption produce thin meal which are desirable for infant formulations (Onweluzo and Nwabugwu 2009).

Sample	Water absorption (%)	Oil absorption (%)	Swelling (%)	Solubility (%)	Bulk density (G/ml)
A	249.67±2.31	209.33±7.77	6.85±0.50	20.00±0.00	0.76±0.01
B	240.33±3.21	201.00±5.29	6.81±0.24	17.00±3.00	0.81±0.02
C	237.33±4.04	193.00±8.72	714±0.10	10.33±1.53	0.87±0.00
D	204.00±6.00	188.33±0.58	6.59±0.17	22.33±1.53	0.74±0.03
E	190.67±7.64	167.67±7.23	6.25±0.09	40.33±2.08	0.81±0.02
F	186.00±6.93	174.33±19.40	6.72±0.41	23.33±3.21	0.87±0.00
G	242.00±3.00	211.33±7.51	8.57±0.57	15.67±3.61	0.80±0.00
H	264.67±2.89	217.67±9.07	9.38±0.16	17.33±3.06	0.80±0.00
I	2.51.00±3.61	209.00±7.00	9.48±0.23	14.00±4.00	0.94±0.02
J	198.33±6.11	196.00±9.14	8.85±0.03	29.33±5.03	0.78±0.02
K	185.67±4.73	194.00±11.14	8.45±0.01	24.33±4.93	0.86±0.02
L	180.00±3.00	148.67±23.35	4.60±0.06	25.67±1.53	0.90±0.02
M	230.33±3.06	222.00±7.93	10.86±0.04	6.45±1.40	0.71±0.00
N	211.00±7.81	198.67±8.51	9.41±0.02	8.43±0.76	0.84±0.00
O	210.00±4.00	182.67±9.07	10.36±0.59	8.43±1.40	0.92±0.02

Key: A = 40% Maize: 40% Soybean: 20% Tiger Nut, B = 40% Sorghum: 40% Soybean: 20% Tiger Nut, C = 40% Millet: 40% Soybean: 20% Tiger Nut, D = 40% Maize: 40% Groundnut: 20% Tiger Nut, E = 40% Sorghum: 40% Groundnut: 20% Tiger Nut, F = 40% Millet: 40% Groundnut: 20% Tiger Nut, G = 40% Maize: 40% Sorghum: 20% Plantain, H = 40% Sorghum: 40% Soybeans: 20% Plantain, I = 40% Millet: 40% Soybeans: 20% Plantain, J = 40% Maize: 40% Groundnut: 20% Plantain, K = 40% Sorghum: 40% Groundnut: 20% Plantain, L = 40% Millet: 40% Groundnut: 20% Plantain, M = 100% Maize, N = 100% Sorghum, O = 100% Millet

Table 4.1: Functional properties of formulated weaning food samples

The oil absorption capacity (OAC) ranged from 148.67 to 222.00%. Sample M has the highest OAC (222.00%), followed by sample H (217.67%), then sample G (211.33%), followed by Sample A (209.33%),then Sample I(209.00%) followed by Sample B(201.00%) then Sample N (198.67%),followed by sample J (196.00%),then sample K (194.00%),followed by sample C (193.00%), then sample D (188.38%),followed by sample O (182.67%),then sample F (174.33%),followed by sample E (167.67%) and the least OAC was found in sample L (148.67%). The result showed that OAC is higher in weaning food formulated from 100% maize and also increased due to inclusion of 40% sorghum and soybeans OAC reduced due to inclusion of 40% groundnut. Oil absorption capacity is an important functional property that enhances the mouth feel while retaining the flavor of food products (Adebowale and Lawal 2004). Absorption of oil by food products improves mouth feel and flavor retention and this makes it an important property in weaning food formulations.

The swelling capacity ranged from 4.6 to 10.86%. Sample M has the highest SC (10.86%), followed by sample O (10.36%), then sample I (9.49%) followed by sample N (9.41%),then sample H (9.38%),followed by sample J (8.85%),then sample G (8.57%), followed by sample K (8.45%),then sample C (7.14%)followed by sample A (6.85%), then sample B (6.81%),followed by sample F (6.72%),then sample D (6.85%),followed by sample E (6.25%) and the least SC was found in sample L (4.6%). The result showed that weaning food formulated from 100% maize and millet has high swelling capacity and weaning food formulated with the inclusion of 40% groundnut had low Sc swelling capacity is related to protein and starch contents in food (Woolfe, 1992). It is further related to the amylase-amylopectin ratio of the starch where low amylase content leads to a high swelling capacity (Adewale *et al.*, 2005). Amylopectin is responsible for granule swelling (Tester and Morrison 1990).

The solubility index ranged from 6.43 to 40.33% sample E has the highest solubility index (40.33%) followed by sample J (29.33%),then sample L (25.67%), followed by sample K (24.33%),then sample F (23.33%),followed by sample D (22.33%),then sample A (20.00%),followed by sample H (17.33%),then Sample B (17.00%),followed by sample G (15.67%),then sample I (14.00%),followed by sample C (10.33%), then sample N (8.43%),followed by sample O (8.43%) while sample M (6.43%), having the lest solubility index. Solubility index are influenced by the extent to which water is absorbed and retained within starch granules and the increase in solubility values could be attributed to increase leaching of solubilized amylase molecules from swelled starched granules promoted by destruction of the starches (Pomeranz, 1991). The result showed that swelling capacity of the formulated weaning food increased due to inclusion of 4% millet, maize, groundnut and sorghum while it reduced in weaning food formulated from 100% maize, millet and sorghum. Lower values of solubility indicate the existence of strong bonding forces within the food granules arising from coagulated protein or fat that form complexes with amylase preventing it from leaching from the granules (Sung and stone 2003. Factors capable of influencing the solubility of foods include flour composition and particle size, density and pH, processing conditions and storage conditions (Mirhosseini and Amid 2013).

The bulk density ranged from 0.71 to 0.94G/ml. Sample I has the highest bulk density (0.94G/ml), followed by sample O(0.92G/ml),then Sample L (0.90G/ml),followed by Sample F (0.87G/ml) then sample C (0.87G/ml),followed by sample K (0.86G/ml),then sample N (0.84G/ml),followed by sample E (0.81G/ml), then sample B (0.81G/ml),followed by sample G (0.80G/ml),then sample H (0.80G/ml), followed by sample J (0.78G/ml),then sample D (0.74G/ml),followed by sample A (0.76G/ml) and sample M (0.71G/ml) having the lowest bulk density. The result showed that weaning food formulated with 100% millet and inclusion of 40% millet has the highest bulk density and weaning food formulated with 100% maize and inclusion of 40% maize had the lowest bulk density. Bulk density is a determinant of food expansion and an indication of the porosity of food products (Kraithong *et al.*, 2018). Formulation with a higher tapped bulk density will be the densest and those with the lowest tapped bulk densities would be less dense hence would occupy more space per unit weight requiring more packaging material or space. Presence of fibres also contributes to bulkiness in a sample (Akinjayeju and Ajayi 2011). An increase in bulk density offers better packaging advantage since more flour can be kept in a given space (Fagbemi, 1999).

IV. PASTING PROPERTIES OF FORMULATED WEANING FOOD

Table 4.2 shows the result of pasting properties of formulated weaning food from maize, millet, sorghum, tigernut, soybean, plantain and groundnut. The result obtained in this research work is comparison with the work of Asaam *et al.* (2018) who reported functional and posting properties of cereals formulated from yellow maize, soyabean and pumpkin pulp. The result of Asaam *et al.* (2018) compare favorably with the current in terms of breakdown viscosity, setback viscosity, peak time and pasting temperature but differs in terms of peak viscosity, through viscosity and final viscosity.

Peak viscosity (PV) is the ability of starches to swell freely before their physical breakdown and indicates the strength of the pastes formed during gelatinization (Sanni *et al.*, 2004). From the result the peak viscosities of the formulated weaning foods were found to be in the range of 32.00-653.5RVU. Sample O has the highest peak viscosity (653.50ROU) followed by sample G (244.00RVU) then sample I (208.00RVU) followed by sample M (145.50RVU) then sample L (128.00RVU) followed by sample N (116.00RVU) then sample H (92.00RVU) followed by sample C (79.00RVU) then J (74.50RVU) followed by sample K (68.50RVU) then sample F (65.00RVU) followed by B (42.50RVU) then sample E (39.50 RVU) followed by sample A (38.00RVU) while sample D has the least (32.00RVU). The relatively low PV of samples D indicates that the food will not form a very thick paste. Viscosity increased in weaning food formulated with 100% millet an also due to inclusion of 40% maize, sorghum and soybeans. This could be attributed to the high carbohydrate content in the food. (Johnson, 2013). Differences observed in the peak viscosities of the formulated weaning food indicates that there were differences in the rate of water absorption and starch granule swelling during heating (Rogaee and Abdel, 2006).

Sample	Peak Viscosity (RVU)	Trough Viscosity (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Set back Viscosity (RVU)	Peak Time (MIN)	Pasting Temperature (^{0}C)
A	38.00	33.50	4.50	65.00	31.50	6.90	82.60
B	42.50	38.50	4.00	73.50	35.00	6.80	84.60
C	79.00	63.00	6.00	142.00	79.00	6.90	83.40
D	32.00	25.00	7.00	54.00	29.00	7.00	84.90
E	39.50	53.00	4.50	69.50	34.50	6.90	86.10
F	65.00	58.00	7.00	143.50	85.50	7.00	84.20
G	244.00	197.00	47.00	483.50	286.50	7.00	83.70
H	92.00	80.00	12.00	167.50	87.50	7.00	84.80
I	208.00	183.50	24.50	338.50	155.00	7.00	86.20
J	74.50	62.50	12.00	168.50	106.00	7.00	84.20
K	68.50	59.50	9.00	168.00	108.50	7.00	85.00
L	128.00	103.00	19.50	292.00	189.00	7.00	85.10
M	145.50	109.00	36.50	221.50	162.50	7.00	84.60
N	116.00	98.00	18.00	271.50	173.00	7.00	84.40
O	653.50	632.50	21.00	244.50	612.00	7.00	85.90

Key: A = 40% Maize: 40% Soybean: 20% Tiger Nut, B = 40% Sorghum: 40% Soybean: 20% Tiger Nut, C = 40% Millet: 40% Soybean: 20% Tiger Nut, D = 40% Maize: 40% Groundnut: 20% Tiger Nut, E = 40% Sorghum: 40% Groundnut: 20% Tiger Nut, F = 40% Millet: 40% Groundnut: 20% Tiger Nut, G = 40% Maize: 40% Sorghum: 20% Plantain, H = 40% Sorghum: 40% Soybeans: 20% Plantain, I = 40% Millet: 40% Soybeans: 20% Plantain, J = 40% Maize: 40% Groundnut: 20% Plantain, K = 40% Sorghum: 40% Groundnut: 20% Plantain, L = 40% Millet: 40% Groundnut: 20% Plantain, M = 100% Maize, N = 100% Sorghum, O = 100% Millet

Table 4.2: Pasting Properties of Formulated Weaning

The trough viscosity value ranged from 25.00 to 632.50RVU. Sample O has the highest through viscosity (632.50RVU) followed by sample G (197.00RVU) then sample I (183.50RVU) followed by sample M (109.00RVN) then sample L (103.00RVU) followed by sample N (98.00RVU) then sample H (80.00RVU) followed by C sample (63.00RVU) then sample J (62.50RVU) followed by Sample K (59.50RVU)then Sample F(58.00RVU) followed by sample E (53.00RVU) then sample B (38.50RVU) followed by sample A (33.50RUV) and the least in sample D (25.00RVU) trough viscosity (TV) is the minimum viscosity value in the constant temperature phase of the RVA profile measuring the ability of paste to withstand breakdown during cooling (Tharise *et al.*, 2014). The result indicates that samples formulated with 100% millet, 40% maize, sorghum and soybean can withstand high heat treatment during processing than samples formulated with 40% maize. High trough values may represent low cooking losses and superior eating quality (Zee *et al.*, 1999).

The breakdown viscosity value ranged from 4.00 to 47.00RVU. Sample G has the highest breakdown viscosity (47.00RVU) followed by sample M (36.50RVU) then sample I (24.50RVU) followed by sample O (21.00RVU) followed by Sample L (19.50RVU) then Sample N (18.00RVU) followed by Sample J (12.00RVU) then sample H (12.00RVU) followed by sample N (18.00RVU) then sample J (12.00RVU) followed by sample H (12.00RVU) then sample K (9.00RVU) then sample E (4.50RVU) followed by sample A (4.50RVU) while sample B has the least value (4.00RVU). The breakdown viscosity is regarded as a measure of the degree of disintegration of starch granules or its paste stability during heating (Dengate, 1984). A higher breakdown viscosity value indicates a lower ability or sample to withstand heating and shear stress during cooking (Adebowale *et al.*, 2005). Thus sample G formulated with 40% and 100% of maize which the highest break down viscosity is less resistant to heat and shearing during heating. Lower breakdown viscosities suggest that pastes are more stable under hot conditions resulting from lower concentrations of starch in a sample (Ayernor, 1985).

From table 4.2 the final viscosity of formulations ranged from 54.00 to 483.50RVU. Sample G has the highest (483.50RVU). Final viscosity, followed by sample I (338.50RVU) then sample L (292.00RVU) followed by N (271.00RVU) then sample O (244.50RVU) followed by sample M (221.50RVU) then sample J (168.50RUV) followed by K (168.00RVU) then sample H (167.50RVU) followed by sample F (143.50RVU) then sample C (142.00RVU) followed by sample B (73.50RVU) then ample E (69.50RVU) followed by sample A (65.00RVU) and sample D has the least (54.00RVU). A high value of final viscosity has been attributed to the aggregation of amylase and a low final viscosity indicates the resistance of the paste to shear stress during stirring. A less starch paste is commonly accompanied with high values of breakdown and could indirectly give a clue of how resistant starch is formed via retrogradation of starch (Liu, 1997).

Setback viscosity is an index of retrogradation tendency of a paste prepared from a starchy food (Sandhu *et al.*, 2006). Tasle 4.2 showed that setback viscosity ranged from 29.00 to 612.00RVU. Sample O has the highest setback viscosity (612.00RVU) followed by sample G (286.50RVU) then sample L (189.00RVU) followed by sample N (173.00RVU) then sample M (162.50RUV) followed by I (155.00RVU) then sample K (108.50RVU) followed by J (106.00RVU) then sample H (87.50RVU) followed by sample F (85.50RVU) then sample C (79.00RVU) followed by sample B (35.00RVU) then sample E (34.50RVU) followed by sample A (31.50RVU) while sample D has the least (29.00RVU). samples with high setback values would produce meals with less retrogradation, which is beneficial since retrogradation will produce adverse effect on the properties of food products, especially the sensory properties.

Peak time represents the total time taken by each formulations to attain its respective peak viscosity. The highest peak time recorded was 7min and the lowest 6.8min. Thus the formulated weaning food would require approximately the same cooking time.

Pasting temperature gives an indication of the minimum temperature required to cook or gelatinize food and it is also important in managing energy cost and other food components stability in a product (Kaur and Singh, 2005). The results showed that pasting temperatures of the various formulated weaning foods ranged from 82.6 to 86.2^{0}C. Sample I has the highest value (86.20^{0}C) followed by sample E (86.10^{0}C) then sample O (85.00^{0}C) followed by sample L (85.10^{0}C) then sample K (85.00^{0}C) followed by sample D (84.90^{0}C) then sample H (84.80^{0}C) followed by sample M (84.60^{0}C) then sample B (84.60^{0}C) followed by sample N (84.40^{0}C) then sample J (84.20^{0}C) followed by sample F (84.20^{0}C) then sample G (83.70^{0}C) followed by sample C (83.40^{0}C) and sample A with the lowest value (82.60^{0}C). The pasting temperature of the cooked weaning foods were lower than the boiling temperature of water, hence it can form a paste in hot water below boiling point. The samples will also have the same cooking time since pasting temperature depicts on set of rise in viscosity and gelatinization temperature of the sample (Otegbayo *et al.*, 2013).

V. CONCLUSION

This study revealed the functional and pasting properties variation that exist in samples formulated from maize, millet, sorghum, soybean, groundnut, tigernut and plantain.

Weaning food with sample L (40% millet: 40% groundnut: 20% plantain) has the lowest water absorption which indicated thin meal which are desirable for infant formulation. Sample M (100% Maize) has the highest oil absorption capacity which improve mouth feel and flavor retention of food meal product sample M (100% maize) has the highest solubility, swelling capacity, it also has the lowest solubility which indicates the existence of strong bonding forces within the food granules arising from coagulated protein or fat that form complex with amylase preventing it from leaching from the granules. Sample I (40% millet: 40% soybean: 20% plantain) has the highest bulk density which is a determinant of food expansion. Sample O (100% millet) has the highest trough and peak viscosity, high trough value may represent low cooking losses and superior eating quality low cooking losses and superior eating quality. Peak viscosity indicates the ability of starch to swell freely before their physical breakdown and also indicates the strength of the paste formed during gelatinization. Sample B (40% sorghum: 40% soybean, 20% tigernut) has the least breakdown viscosity which suggest that it is more stable under not conditions resulting from lower concentration of starch in a sample. Sample G (40% maize: 40% sorghum: 20% plantain) has the highest final viscosity which attributed to the aggregation of amylase. Sample O (100% millet) has the highest setback viscosity which is beneficial in producing meal with less retrogradation. Peak time and pasting temperature is approximately same for all samples.

VI. RECOMMENDATION

The outcome of this research work shows that weaning food formulated from millet, sorghum, soybean, tigernut, plantain and groundnut could be recommended for nursing mothers to introduce to wean their babies after six months of breast feeding.

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