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Shelf life, Pasting and Functional Characteristics of composite wheat, African breadfruit and Moringa seed biscuits.

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Abstract:
A*frican breadfruit and Moringa seeds were both processed into flour. Composite blends of wheat, African breadfruit and Moringa flour were formulated in the following ratios(A= WHF 100%:ABF 0: MSF 0; B=WHF 77.5: ABF 20%:MSF2.5%; C=WHF 75%: ABF 20%:MSF 5%; D=WHF 72.5%:ABF 20%:MSF 7.5%; E= WHF 70%: ABF 20%: MSF 10%; F=WHF 90%:ABF 0: MSF 10%; G= WHF 80%: ABF 20%: MSF 0*
The flour were evaluated for their pasting such as peak, Trough, breakdown viscosity, setback viscosity, pasting time and pasting temperature and functional properties examined were water absorption capacity, oil absorption capacity, Solubility, Swelling power, bulk density(pack and loose) Foam capacity.Also the blends were used in the production of biscuits and the shelf life of the biscuits determined. The Shelf life results indicated that samples E and F containing 10% moringa seed flour showed a zero fungal count after 90 days of storage at ambient temperature. Values of peak viscosity and final viscosity ranged from 126.54RVU to 253.94 RVU and 204.71RVU to 285.29RVU respectively

Keywords: shelf life, biscuits, pasting properties, functional properties, African breadfruit flour.

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I. Introduction

Over the years, wheat has been a major source of raw material used in the baking industry in Nigeria, as result of its good visco-elastic properties as well as the presence of appreciable amounts of thiamin and vitamin B (Okpala and Egwu, 2015). However, it has been reported that the importation of wheat constitutes a huge drain on Nigeria's economy with an annual trade bill 635 billion naira. Moreover, wheat have been shown to be low in the essential amino acid lysine (Nwanekezi 2013, Olapade and Oluwole 2013). The huge financial cost has necessitated the sourcing of alternative, cheap and locally available underutilized plant seeds such as moringa seed and African breadfruit seed flour.

Pasting properties are dependent on the rigidity of starch which affects the granule swelling potentials and the amount of amylase leaching out in solution. The starch granule is composed of amylase and amylopectin and this component make up about 98 -99% of the starch dry weight. Amylose is a linear glucose unit joined by alpha (1-4) linkages. Amylopectin is branched with glucose units joined by alpha (1-6) linkages at the branched points and alpha (1 – 4) linkages at the linear points. The other components are lipids, proteins and phosphorus. The lipid content of native starches is related to the amylase content. At the same ratio of starch to water, different starches give different pasting properties (Copeland *et. al*, 2009). The characteristics displayed by starch granules to gelatinization temperature, viscosity and retrogradation depend on the ratio of amylase to amylopectin, molecular structure (size, shape, crystallinity, molecular weight) and the presence of minor components such as lipids, proteins and phosphorus. The size and shape of starch granule depend on the botanical source and processing conditions. However, amylopectin starches tend to be more regular in shape when compared to high amylase starches (Jayakody and Hoover, 2008). The increase in viscosity during heating of starch water system is mainly due to swollen granules and the decrease during further heating at high temperature is caused by weakening, disintegration and disruption of gelatinized granules (Hagenimana and Ding, 2005). Peak viscosity occurs when majority of the granules are fully swollen. The peak viscosity also measures the alpha amylase activity and other contributory factors such as inherent susceptibility of starch to amylase and starch gel strength. Peak viscosities occur at equilibrium between the swelling of the granules (increase in viscosity) and the granule rupture and alignment (reduced viscosity). Starch molecules gelatinizes when heated above 50^{o}c, leading to a marked increase in disintegration of granules. The viscosity of starch paste drops at elevated temperatures (Bakare *et.al*, 2012).

Pasting temperature is an indication of temperature required to cook flour blend beyond its gelatinization point. It corresponds to the temperature where viscosities first increase by at least 2 RVU (rapid viscous unit) over a 20 sec period. Changes that may occur when starch water system is heated include enormous swelling, increased viscosity, translucency and solubility and loss of birefringence (Shimelis*et.al*, 20

Other factors that affect rheology of foods are particle size concentration and particle properties (Augusto *et.al*, 2012).

Singh *et.al*, (2011) reported that non starch constituents such as proteins, lipids and non-starch polysaccharides influence the rheological and visco-elastic properties of flours.

The goal of this research is to produce flour from African breadfruit and Moringa seed, formulate blends of the flour with wheat flour , evaluate the pasting and functional properties

II. Materials And Method

Preparation of African breadfruit flour:

African breadfruit flour was produced in accordance with the method described by Agu et.al (2007). African breadfruit seeds were sorted and boiled in tap water for 30mins at 100^0C. The water decanted and the seeds dried with an electric air oven at 55^0 C for 6hr. The seeds were then milled to pass through a 250µm aperture size and package.

Preparation of Moringa seed flour:

Moringa seed flour was prepared in accordance with the method described by Ogusina et.al (2011). Moringa oleifera seeds were sorted and dehulled. De-bittering process was carried out by soaking in water (3:1 vol : wt) for 7 hrs and decanting the water. The seeds were dried at 55^0C for 5hrs and milled before packaging.

Formulation of Biscuits:

Composite biscuits were formulated using Wheat flour, African breadfruit flour, Moringa seed flour. Other ingredients used were sugar, margarine, salt, baking powder, egg and vanilla. The method of Wabali et.al (2020) was used in the formulation.

Baking of Biscuits:

Baking of biscuits was done according to the procedure of Agu and Okoli (2014). Mixing and creaming of flour blends were carried, followed by kneading , Cutting and Tray greasing. Baking was done at a temperature 180^0C for 25mins.The biscuits were then allowed to cool and packaged.

Shelf Life Determination

Mold Count

All glasswares were sterilized by autoclaving at 121⁰C for 15 minutes before use.

Preparation of media (Agar).

Thirty-nine grams (39 g) of Potato dextrose agar and Sixty-five (65 g) of Sabourand dextrose agar was weighed separately and dissolved in 1000 ml of distilled water in a separate conical flask and mixed to dissolve completely before covered with cotton wool and foil paper. They were then sterilized by autoclaving at 121⁰C for 15 minutes and allowed to cool to 45 to 60⁰C and antibiotic added to inhibit growth of bacteria. These were gently mixed to avoid bubbles and dispensed into sterile petri dishes solidify.

Preparation of Diluent (peptone water).

Fifteen grams (15 g) of peptone was weighed and dissolved in 1000 ml of distilled water in a beaker, stirred vigorously to dissolve completely. Then 9 ml was pipette into each test tube and covered with cotton wool and foil.

Serial Dilution: One gramme (1 g) of each sample was dissolved in 9 ml of diluents one ml was pipetted into a second test tube and the dilution continued till the fifth to provide separate colonies.

0.1 ml of the last diluents was pipetted and inoculated on the prepared plated and evenly spread with a sterile loop and incubated at 30⁰C for 2 to 5 days. Results were collected using the standard plate count method.

Calculation of Colony Forming Units: Colony forming units was calculated per ml and is determined by the total number of colonies on the culture plate after incubation at the required temperature for a period of time, multiplied by the dilution factor and divided by the volume ofinoculum.

$$\text{Cfu / ml} = \frac{(\text{No.ofcolonies} \times \text{Dil. factor})}{\text{Vol. ofcultureplate}}$$

Moisture détermination : Moisture content wasevaluated using the Rapid moisture analyser.

Functional Properties

Foam Capacity and Stability:

The foam capacity and stability were determined using the method described by Coffman and Garcia (1977). Two grams of each flour blend was whipped with 10ml distilled water for 5 minutes in a blender (model at a high speed. This was then poured into a 250 ml graduated cylinder. The volume of foam was read at 30 seconds after whipping and expressed as foam capacity. Further, the volume of foam over 10 – 120 mins interval was taken as foam stability and results obtained calculated as stated below.

$$\text{Foam capacity} = \frac{\text{Volafterwhipping} - \text{Vol.beforewhipping}}{\text{Vol. beforewhipping}} \times 100$$

$$\text{Foam stability} = \frac{\text{Foamvolumeaftertime "t}}{\text{Initialfoamvolume}} \times 100$$

Water Absorption Capacity

The water absorption capacity was determined using the method of Sosulski et.al, (1976). One gram of sample was added to 15 ml of distilled water in a pre-weighed centrifuge tube. The centrifuge tube was agitated and centrifuged (L 600) for 30 minutes at 3000 rpm, the clear supernatant was discarded and the volume taken. The water absorbed was then weighed. The amount of water retained was calculated as water absorbed per gram of sample.

$$\text{Water absorption capacity (g/ml)} = \frac{\text{initial vol. water added} - \text{vol. of water}}{\text{Sample weight}}$$

Bulk Density

The bulk density of the flour was determined using the method of Narayana and Narasinga Rao (1984).

The sample was poured into a calibrated sample tube to get to the 5 ml mark and the weight taken. The tube was then shaken and tapped slightly to make allowance for further addition of more samples to reach the 5 ml mark and a new weight recorded as the final weight.
Calculation of bulk density:

$$= \frac{\text{samplewt after tapping} - \text{sample wt before tapping}}{\text{vol before tapping}}$$

Swelling Power and Solubility.

The determination of Swelling power and Solubility of the flour was carried out using the method of Takashi and Sieb (1988).

One gram of sample was weighed into a conical flask and 15 ml of distilled water added and shaken vigorously. This was transferred to a water bath at a temperature of 100°C for one hour. Cooling was done under running water and the content transferred to a previously dried and weighed centrifuge tube. The content was centrifuged (L 600) at 2000 rpm for 30 minutes and the swollen volume read directly from the tube. The clear portion was poured into a dry metal can of known weight, oven (Gallenkamp Hot box) dried at 105°C for one hour then cooled in a dessicator and weighed.

$$\text{Calculation : Solubility} = \frac{\text{Wt of dried supernatant}}{\text{Wt of sample}} \times 100$$

$$\text{Sweling power} = \frac{wtofwetsediment}{wtofsample} \times 100$$

Pasting properties

Pasting properties of the flour and the blends were characterised using Rapid ViscoAnalyser (RVA Model 3c, Newport Scientific PTY Ltd, Sydney). Five grams of sample and 25 ml of distilled water was used. Sample was dispersed into a test canister with a paddle placed inside, with the paddle blade joggled up and down through the sample ten times or more until there are no more lumps on the water surface. The paddle was placed inside the canister and both were inserted firmly into the paddle coupling so that the paddle could be properly centred. The measurement cycle was initiated by depressing the motor of the instrument. The test was allowed to proceed and terminated automatically.

Peak viscosity, peak time, peak temperature, trough, pasting temperature and final viscosities were read on the instrument, while breakdown and set back viscosities were calculated from the amylogram.

Peak viscosity**:** This is the maximum viscosity developed during or soon after the heating portion of the pasting test; which is an indication of the water binding capacity of starch.

Peak time**:** The time at which peak viscosity occurred (in minutes).

Peak temperature: The temperature at which peak viscosity occurred (°C).
Pasting temperature: Temperature where viscosity first increased by at least 25 RVU over a period of 20 seconds; below this temperature the starch is essentially insoluble in water.
Breakdown: Peak viscosity minus trough. This is a period when the test sample was subjected to constant temperature and it measures the ability of the paste to withstand breakdown during cooling.
Final viscosity: Viscosity at the end of test (RVU).
Set back viscosity: Final viscosity minus peak viscosity (RVU).

III. Results And Discussion:

The shelf life (moisture parameter) of biscuit samples produced from Wheat flour (WHF), African breadfruit flour (ABF), and Moringa seed flour blends are shown in Table 1. The moisture content of the control sample ranged from 5.5% after the first month of storage to 7.6% in the third month, sample B had a value of between 6.6% - 7.4%, sample C 4.99% - 6.9%, sample D 6.53% to 7.0% , and sample E 6.28% - 7.6%, sample F 5.63% - 5.83% and sample G 6.5% - 7.7% . On a month by month basis, product sample F which contains 10% moringa seed flour and wheat flour had the least moisture content of 5.63% to 5.83%.

TABLE 1 Shelf life (Moisture content) of biscuit samples produced from wheat flour (WHF), African breadfruit flour (ABF), and Moringa seed flour (MSF) blends.(%)

SAMPLE	MONTH 0	MONTH 1	MONTH 2	MONTH 3
A	4.72	5.50	6.40	7.60
B	6.07	6.60	7.70	7.40
C	4.99	5.70	6.50	6.90
D	6.53	6.00	6.60	7.0
E	6.28	6.40	7.10	7.60
F	5.63	5.69	5.73	5.83
G	6.58	6.60	7.3	7.70

KEY

Sample	WHF	ABF	MSF
	(blend ratio)		
A	100	0	0
B	77.5	20	2.5
C	75	20	5
D	72.5	20	7.5
E	70	20	10
F	90	0	10
G	80	20	0

Table :2 Fungal count on biscuit samples produced from wheat flour(WHF),African breadfruit flour(ABF), and Moringa seed flour(MSF) blends.(cfu/ml)

SAMPLE	MONTH 0	MONTH 1	MONTH 2	MONTH 3
A	Nil	1.20 x10	$1.3x10^3$	$1.5x10^3$
B	Nil	1.0 x 10	1.4×10^3	3.0×10^3
C	Nil	Nil	1.0×10^3	2.0×10^3
D	Nil	Nil	Nil	1.4×10^3
E	Nil	Nil	Nil	Nil
F	Nil	Nil	Nil	Nil
G	Nil	1.8 x 10	1.9×10^3	3.8×10^3

Sample	WHF : ABF : MSF (blend ratio)		
A	100 :	0 :	0
B	77.5	20	2.5
C	75	20	5
D	72.5	20	7.5
E	70	20	10
F	90	0	10
G	80	20	0

TABLE 3: Pasting properties of wheat flour(WHF),African breadfruit flour(ABF) and Moringa seed flour(MSF) blends(RVU).

Blends	Peak 1	Trough 1	Breakdown	Final Visc.	Setback	Peak Time(min)	Pasting Temp ^{0} c
A	253.94 ± 0.84^{a}	181.33 ± 1.36^{a}	75.40 ± 0.14^{b}	261.46 ± 1.66^{b}	103.51 ± 0.16^{f}	4.96 ± 0.01^{c}	62.78 ± 0.06^{a}
B	162.00 ± 5.0^{d}	87.58 ± 3.25^{d}	74.42 ± 1.75^{b}	285.29 ± 4.04^{a}	197.71 ± 0.79^{a}	5.96 ± 0.03^{b}	52.63± 0.02c
C	163.45 ± 1.12^{d}	87.29 ± 1.71^{d}	76.16 ± 2.83^{b}	279.71 ± 1.96^{a}	192.42 ± 3.66^{b}	5.87 ± 0.0^{b}	50.77^{c} ± 0.22^{d}
D	126.54 ± 1.71^{e}	67.00 ± 2.83^{e}	59.55 ± 1.12^{d}	207.46 ± 3.46^{d}	140.46 ± 6.29c	5.76 ± 0.03^{b}	50.57±0.37^{d}
E	126.58 ± 0.83^{e}	64.58 ± 0.83^{e}	62.00^{c} ± 0.00^{c}	204.71±2.54^{d}	140.13 ± 1.71^{c}	5.76 ± 0.03^{b}	50.98±0.03^{d}
F	176.88±1.56^{c}	103.26±1.12^{c}	58.92±0.26^{d}	199.30±0.86^{e}	125.10±0.74^{d}	5.39±0.01^{c}	54.90± 0.11^{b}
G	218.62±1.62^{b}	117.00±2.92^{b}	101.62±1.29^{a}	227.0 ±0.33^{c}	110.0±2.58^{e}	6.06±0.13^{a}	51.57±1.12^{c}

Values are Mean ± SEM of duplicate determination.
Means with different superscripts within a column are significantly different ($p \leq 0.05$).
KEY

Sample WHF : ABF : MSF
(blend ratio)
A 100 : 0 : 0F 90 : 0 : 10
B 77.5 20 2.5G 80 : 20 : 0
C 75 20 5
D 72.5 20 7.5
E 70 20 10

TABLE 4: Functional properties of wheat flour (WHF), African breadfruit flour (ABF) and Moringa seed flour (MSF) blends.

Blends	Water Absorption	Oil Absorption	Solubility	Swelling Power	Swelling Volume	Bulk Density		Foam Capacity	
	g/ml	g/ml	%	(g/g)	(ml)	Pack Density g/ml	Loose Density g/ml	Foam Capacity (%)	Foam Stability (Time)
A	0.75 ± 0.01^{d}	0.71±0.00^{d}	9.76± 0.12^{c}	7.15 ± 0.01^{a}	6.50 ±0.0^{a}	0.34 ±0.00^{c}	0.32±0.01^{b}	19.31±0.6^{c}	5.0+0.00^{d}
B	0.95± 00^{b}	0.98±0.00^{c}	7.26 ±0.49^{d}	6.48±0.38^{c}	5.79±0.25^{b}	0.40±0.02^{b}	0.40 ±0.01^{a}	23.0±3.0^{b}	4.0±0.00^{d}
C	0.98± 00^{a}	0.99±0.0^{c}	7.37 ±0.59^{d}	6.10±0.21^{d}	5.5±0.00^{c}	0.40±0.00^{b}	0.40 ± 00^{a}	26.0±0.00^{a}	6.0±0.00^{c}
D	1.00±0.00^{a}	0.99±0.0^{c}	11.46±0.48^{b}	6.71± 0.20^{b}	6.25±0.25^{b}	0.41± 0.01^{b}	0.38 ± 0.01^{a}	19.0±1.00^{c}	8.0±0.00^{a}
E	0.98±0.01^{a}	0.99±0.0^{c}	11.56±0.72^{b}	6.34 ±0.22^{d}	6.0±0.00^{b}	0.40±0.00^{b}	0.39 ± 0.00^{a}	23.0±1.0^{b}	7.0±1.00^{b}
F	0.87±0.00^{c}	1.03±0.01^{b}	11.77 ±0.10^{b}	6.65±0.19c	5.80±0.02^{b}	0.60±0.00^{a}	0.49 ±0.03^{a}	23.6±0.5^{b}	7.0±0.00^{b}
G	0.99±0.00^{a}	1.30±0.01^{a}	12.50±0.07^{a}	6.93 ±0.02^{b}	6.50 ±0.00^{a}	0.44 ± 0.00^{b}	0.32±0.01^{b}	22.5±0.5^{b}	8.0±0.00^{a}

Values are Mean ± SEM of duplicate determination.
Means with different superscripts within a column are significantly different ($p \geq 0.05$).
KEY

Sample WHF : ABF : MSF WHF : ABF : MSF
(blend ratio)
A 100 : 0 : 0E 70 20 10
B 77.5 20 2.5F 90 0 10
C 75 20 5G 80 20 0

D	72.5	20	7.5

The results of biscuit samples produced from wheat flour, African breadfruit flour and moringa seed flour blends (Table 2) indicated the absence of molds at month zero. The mold counts recorded for samples A and B were 1.2 x 10 and 1.0 x 10 cfu/ml after one month of storage, with samples C, D, E, and F having a zero count. The results showed that sample E which contained 10% moringa seed flour and 20% African breadfruit flour, as well as sample F which contained only 10% moringa seed as substitute did not show any mold count after 3 months of storage under normal conditions.

Pasting Properties:

The pasting properties of flours are parameters used in determining the suitability of its application as functional ingredient in food and other industrial products. The peak viscosity values ranged from 126.54RVU to 253.94RVU for the various samples (Table 3). There was no significant difference between sample B and Sample C; and between sample D and Sample E. The values obtained were higher than those reported by Offia-Olua (2014) for Julglansregia walnut as 45.51RVU. The least peak viscosity was recorded for sample D 126.54RVU while sample A had the highest peak viscosity of 253.94RVU. Peak viscosity is the maximum viscosity reached during or after the heating phase of the paste evaluation and it indicates the water binding capacity of starch. It is indicative of the strength of the paste which is formed as a result of gelatinization of starch granules. This reflects the extent of granule swelling and is indicative of the viscous load to be encountered during mixing. The peak viscosity of the flour depends on solubility and water holding capacity as well as the structure of components in a food system (Leszek 2011). Investigations have revealed that flours with low peak viscosity have lower thickening power than flours with high viscosity. The low peak viscosity of the blends could be attributed to protein and fat interaction.

The results also showed that the trough values of the flours ranged from 64.58RVU for sample E which is lowest to 181.33RVU for sample A (control). The trough or hold period sometimes referred to as shear thinning, holding strength or hot paste viscosity is a period when the samples are subjected to constant temperature and mechanical shear stress. The holding strength indicated the ability of the starch granules to maintain their gelatinized structure when the paste is held at 95^0c for 2mins 30sec. under mechanical sheer stress.

Breakdown viscosity of the different flour blends ranged from 58.92RVU to 101.62RVU. The results indicated that sample G had the highest breakdown viscosity value of 101.62RVU and sample F had the lowest value of 58.92RVU. Although there was no significant difference between samples D and F and between samples B and C. The results showed that increasing the levels of substitution with moringa seed flour lowered the breakdown viscosity of the flours. The breakdown viscosity is an indication of the stability of the starch gel during cooking (Ragace*et. al,* 2006). The higher the breakdown viscosity the lower the ability of the sample to withstand heating and shears stress during cooking (Adebowale *et. al*, 2005).

Breakdown viscosity value is a measure of ease with which the swollen granules can be disintegrated and hence an indicator of the stability of the flour product (Kaur and Singh 2005)

Final viscosity: The final viscosity value of wheat flour, African breadfruit flour and moringa seed flour blends ranged from 199.30RVU to 285.29RVU for sample B. These results can be compared with Bakare *et.al,* (2016) who obtained a final viscosity value 316RVU for whole breadfruit flour. The result showed that substitution of the flour with moringa seed flour beyond 2.5% led to a reduction in the final viscosity of the flour blends. Sample F had the lowest value of 199.30RVU. Shimel*et .al* (2006) reported that the final viscosity of a flour depends on the capacity of the starch to form paste and gel as they undergo cooking and cooling process. There is a direct proportionality between the amylose content of a flour and the final viscosity. The flour with high amylose content gives a higher viscosity.

The setback viscosity is a measure of the retrogradation of starch, and it is related to the amylose content. The setback viscosity results showed a range of 103.51RVU for sample A to 197.71RVU for sample B. The setback viscosity value for the control sample was the least. Subsequent increase in the proportion of moringa seed flour led to a significant reduction in the setback viscosity of the flour. Set back viscosity is the phase of the pasting curve after cooling the starches to 50^0c. This stage involves re-association, retrogradation or re-ordering of starch molecules. The result showed that 2.5% moringa seed substitution levels had significantly higher values of setback viscosity than other formulation. The pasting temperature gives an indication of the temperature required to cook the flour beyond its gelatinization point. It corresponds to the temperature where viscosities first increase by at least 2RVU over a 20sec period (Bemiller 2011). The results showed that sample B containing 2.5% moringa seed flour required a higher pasting temperature to cook than other formulations. There was no significant difference between the other formations.

The pasting time of the different blends of African breadfruit flour showed a range of 4.96mins to 6.06mins. The sample G had a value of 6.06min while sample E had a value of 5.76mins. The pasting time of the different formulation decreased as the level of substitution of the flour increased. Samples B, C, D and E were not significantly ($p \geq 0.05$) different.

Functional properties:

The water absorption capacity of wheat flour (WHF), African breadfruit flour (ABF) and Moringa seed flour blends shows that there was no significant difference in blends of samples B, C, D, E and G which had values ranging from 0.95 g/ml to 1.00g/ml. Sliwinski*et. al* (2004) reported that an optimum amount of water is needed to provide cohesive viscoelastic dough with optimum gluten strength. Optimum water levels differ from flour to flour depending on protein and other dense particles. Protein content has been shown to be an important determinant of the extent to which wheat flour could absorb water during mixing. Water absorption is the amount of water required to develop dough to the point of greatest torque. The water absorption capacity of African breadfruit and moringa seed flour could be attributed to the presence of hydrophilic proteins and polar amino acids in the flour components (Butts and Batool, 2010). However, the control sample A had a lower water absorption capacitiy 0.75g/ml, showing that the addition of both moringa seed flour and African breadfruit flour improved the water absorption capacity of the blends. The oil absorption capacity of the wheat flour (WHF) African breadfruit flour and Moringa seed flour blends ranged from 0.71g/ml. to 1.30g/ml, and the values of sample G were significantly ($p \leq 0.05$) different from other samples.The oil absorption values are in agreement with Oloyede*et. al*, (2016) who had values of 0.87 to 1.91 g/ml. for moringa seed flour. The oil absorption capacity of flour serves as an indication of the utility of the flour in food preparations that involve oil mixing such as in bakery products.

The solubility percentage, swelling power and swelling volume of the various blends indicated the solubility percentage of the flours ranged 7.37% to 12.5%, the values for the swelling power ranged 6.10g/g to 7.15g/g, with sample A which is the control being significantly different and the swelling volume of the blends 5.50ml to 6.50ml.

The swelling power of the flour depends on size of particles, types of variety and the types of processing method. Wilhelm *et. al*, 2004 reported that the bulk density of a flour sample influences the amount and strength of packaging material; texture and mouth feel. Therefore, low value of bulk density makes the sample desirable for packaging. The bulk density of the flour blends ranged 0.34 g/m sample A to 0.60 g/ml sample F for packed density and 0.32 g/ml to 0.49 g/ml for loose density. This result shows that the higher the bulk density the denser the flour. The results show that there was no significant difference in the pack density of samples B, C, D, E, and G. However, the blend (F) containing moringa seed flour only was significantly different from other samples.

The foam capacity and the foam stability of the African breadfruit flour blends ranged from19.1% to 26%while the foam stability had values of 4 to 8%.

Akubor and Chukwu (1999) reported that the foaming capacity improve the texture consistency and appearance of food. Furthermore, foam formation and stability one dependent on pH, viscosity surface tension and processing methods. It has been reported by Mepha*et.al*, (2007) that the foam stability of a product is related to the rate of decrease of the surface tension of air/water interface caused by the absorption of protein molecules.

IV. Conclusion:

Biscuits containing 10% moringa seed flour showed no fungal count after 3 months of storage with moisture content below 8%. Further, substitution of flour led to higher bulk density of the flour and improved water absorption capacity of the flour.

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