Evaluation of the Effect of Storage Time and Particle Size on the Physicochemical and Functional Properties of Bambara Nut (*Vigna subterranea*) Flour

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Abstract:- Bambara nut was obtained and cleaned manually, milled to flour and particle size distribution was done using sieve analysis; the flour was classified to 20, 40, 60, 80 and 100 mesh numbers (850, 425, 250, 180 and 150µm). 400g of each of the particle sizes of the flour samples was stored in high density polythene bags at room temperatures (28-32°C) for 24 weeks. The flour was analyzed for bulk density, least gelation capacity, foam capacity and stability, capacities for absorption of oil and water monthly. Results from the study showed that Bambara nut flour bulk density ranges from 0.64 to 0.79 g/ml. The bulk thickness (density) is a sign of the porosity of the Bambara nut. There was a significant decrease in the bulk density (P<0.05) as then period of storage advanced. The result revealed that the least gelation capacity of Bambara nut flour took fix more preferably at higher concentration of protein because of the greater intermolecular connection during heating. There was also a meaningful (P<0.05) reduction in the least gelation capacity of the flour as periods of storage increased with values ranking from 12 – 16% from the 1st week of the flour storage. Subsequently, there was a meaningful distinction (P<0.05) in the flour particle sizes of 850µm, 250µm and 150µm of the foam capacity of Bambara nut flour stored for the period of 24 weeks. Foam stability depicted the capacity of a protein to shape a strong cohesive film around air vacuole, which resists air diffusion from the vacuole. The study confirmed that there was a significant (P<0.05) in the storage time and particle sizes of 850µm and 150µm on the foam capacity of Bambara nut flour. The foam capacity of the flour sample ranges between 45% – 80%.The absorption capacity for oil and water of the flour varied with the particle size and storage period and ranged between 0.53g/ml – 1.67g/ml and 0.8g/ml – 1.8g/ml, respectively. The study revealed that physicochemical and functional properties are important parameters for handling and storage of Bambara nut flour.

Keywords:- *Assessment, Bambara Nut Flour, Storage Duration, Physical And Chemical Properties.*

I. INTRODUCTION

Bambara nut (*Vigna subterranea*) is a leguminous crop cultivated widely in African countries like Nigeria, Ghana, Senegal and Kenya; it is also cultivated in the Sahara to South Africa and Madagascar [1]. Beyond Africa, Bambara nut is tilled in Brazil and is known as "Mandubid Angola'', it is also farmed in southern Thailand and West Java. Some locations in the tropics such as Middle East, Syria and Greece could also grow Bambara nut. State of Florida in the USA successfully carried out trial cultivation of Bambara nut [2]. It is third of the most important legume grain after ground nut and cowpea in Nigeria [3, 4]. Howbeit, Bambara nut is grown excessively in Nigeria, it's one of the under research legumes in the country. In recent years, renewed interest have been developed in the cultivation of Bambara nut in arid savannah zones, this is due to its drought and pests resistance, and also the capacity for reasonable yield when cultivated on poor soils with an advantage of long storage life [3, 4, and 5]. In Nigeria, it is locally called *Okpa* (Ibo), *epiroro* (Yoruba) and *gurjiya* (Hausa). Bambara nut contains 63% carbohydrate, 19% protein and 6.5% fat [6]. The protein content of Bambara nut is described to be large in critical amino acid (methionine) in excess of other legumes. The seeds are prepared and consumed locally in divers' ways. In eastern part of Nigeria, the seeds are prepared into flours and used as a major ingredient for the preparation of Okpa. In the Northern part of Nigeria, the seeds are steamed and consumed with cereals or roasted cereals seasoned with salt and ingested as snacks [7]. It is not different in western Nigeria where the seeds are grinded to powder and utilized for the preparation of fufu. Bambara nut flour is white or creamy in color and is used in the food industry for pasta and confectionery production [8].

Despite the nutritional and economic importance of Bambara nut, there is no industrial use of the crop in Nigeria and most of the African countries. For the use of Bambara nut in the production of flours, the flour needs to be stored properly prior to utilization for its quality maintenance, safety and storage stability. However, there are limited studies on the processing and storage of Bambara nut on the impacts of storage conditions on qualities of reserved flour of Bambara nut. The hypothesis of this study is that Bambara nut flour packed and stored at different storage conditions will show variations in the physiochemical and functional properties.

II. MATERIALS AND METHODS

A. The Research Materials

All the chemicals used were of analytical grade (Distilled water, sulphuric acid, sodium Hydroxide, Selenium tablets, Boric acid, Methyl red, Hydrochloric acid and Refined Vegetable oil). Some were purchased from Nsukka market while others from VEKO Scientific Chemical Shop, Jimeta-Yola.

B. Source of Bambara Nut

The Bambara nuts were purchased from Donga and Wukari local markets, Taraba State. North-Eastern Nigeria. The seeds were carefully selected and manually cleaned to remove debris, immature and broken seeds.

C. Preparation of Experimental Samples

The Bambara seeds were milled into flour using a magnetic sieve grinding machine as described by [9]. The size of particle distribution using sieve analysis was carried out to separate the flour at a range of 20 - 100 mesh numbers (850 - 150µm) as reported by [10]. 400g of 20, 40, 60, 80 and 100 mesh particle sizes, respectively of the powdered samples were packed in low density polythene bag and reserved for period of 6 months in ambient temperature and analyzed for bulk density, Gelatinization temperature, least gelation capacity, foam capacity and stability, oil and water absorption capacities.

D. Determination of the Flour Bulk Density

The determination of the bulk density was carried out by the method described by [11]. The weight of a calibrated centrifuge was determined then flour samples were loaded to level of 5ml by steady tapping till there was no additional change in volume [11]. The proportion was then counterbalanced and from the disparity in weight the sample's bulk density was calculated as follows:

$$\text{Bulk density} = \frac{Weight\ of\ sample\ (g)}{Volume\ of\ sample\ (ml)} = \text{(g/ml)} \tag{1}$$

E. Water and Oil Absorption Capacity Determination

The determination of water and oil adsorption capacity (WAC/FAC) was conducted as described by [11] using 1g of the sample coupled with 10 ml of distilled water or refined vegetable oil (with density of $0.89gml^{-1}$). The determination was one in triplicate at room temperature and the values were expressed as ml of water or oil absorbed by 1g of flour.

F. Determination Foam Capacity and Stability

The determination of the foam capacity and stability was according to the approach of [12]. 2g of flour sample was blended together with distilled water of 100 ml inside a warring blender (with the suspension being switched at 1600 rpm for 5 minutes), the compound was then transfered into a 250 ml gauged cylinder and the volume recorded after 30 seconds [12]. Foam capacity is expressed as percentage increase in volume using the formula of [13].

$$\text{Foam capacity} = \frac{Volume\ after\ whipping - Volume\ before\ whipping}{Volume\ before\ whipping} \times 100 \tag{2}$$

The foam volume was then recorded for a period of time say 20 – 120 minutes as foam stability for the respective periods. Measurements were carried out in triplicate and averaged and foam stability was calculated as given in equation 3.8

$$\text{Foam stability} = \frac{Foam\ volume\ after\ time\ 't'}{Initial\ foam\ volume} \times 100 \tag{3}$$

G. Determination of Gelation Capacity

Gelation capacity was calculated through the methodology of [12]. The samples of the flour were combined in test tubes with distilled water of 5 ml to acquire suspensions of 2 – 20 % (w/v) concentrate. After heating the test tubes for an hour (1 hour) inside a boiling water bath, they (test tubes) were cooled quickly under tap water after which it was cooled further for 2 hours inside a refrigerator at temperature of 4^oC. The gelation capacity was the least gelation concentration determined as the concentration at which the sample from the inverted test tube will not fall or slip.

H. Determination of Gelatinization Temperature

Gelatinization temperature was determined after the method of [11] where about 10% suspension preparation of the sample flour was done in a test tube, and then this aqueous suspension was boiled inside a boiling water bath, with stirring continuously. Then the record was taken of the temperature 3 seconds after gelatinization is visually noticed as the gelatinizing temperature.

III. RESULTS AND DISCUSSION

The results of both properties i.e. physicochemical and functional of the Bambara nut flour with respect to three particle sizes are presented in Table 1 – 5.

Table 1 contains the result of the storage period effect on the bulk density of Bambara nut flour. The Bulk Density ranged from 0.64 to 0.79 g/ml in the 0 - 4 week of storage and 0.6 to 0.7 g/ml in the 20 – 24^{th} week of storage. Size particle affects the bulk density of the flour and also varied with storage period given that size of particle is inversely proportional to bulk density as displayed on table 1. There was meaningful disparity ($P<0.05$) in the bulk density of the Bambara nut samples flour within the periods

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of storage with values ranging from 0.60 – 0.704 in the last month of storage. There was also suggestive reduction in bulk density ($P<0.05$) with progress in storage period.

Bulk density differential is an intimation of the porosity of that product. The bulk density reduction of the flour as storage period progressed was the result of the difference in particle sizes of the flour. This result is in agreement with [14] for mucuna beans flour and [15] for cowpea flour.

Similarly, observation of meaningful reduction was made ($P<0.05$) in the least gelation capacity of Bambara nut flour as storage periods advanced with values ranged from 12 – 16% from the 1st week to the 24th week storage as shown on table 2.

The least gelation capacity of Bambara nut flour occurs more easily at increased protein concentration due to the higher intermolecular contacts that occurs during heating. Since Bambara nut contain high amount of protein and carbohydrate, the least gelation of flours is impacted by physical matchup for water between protein gelation and starch gelatinization. The gelling capacity of the Bambara nut flour has been ascribed to aggregation and thermal downgrade of starch. The low gelation capacity observed from this study during the storage of sample with 150µm (100 mesh) particle size at week 5-24 could be due to weevil infestation of the Bambara nut samples which has affected the starch granules.

Furthermore, differences of significant magnitude was observed ($P<0.05$) in the particle sizes of 850µm (20 mesh) of the foam capacity of Bambara nut flour stored for the period of 24 weeks and those of the particle sizes 250µm (60 mesh) and 150µm (100 mesh) stored for the same period of 24 weeks with values ranging from 14 – 16% for the control and 12 – 14% for the samples of particle sizes 150, 250 and 850µm from the 1st week to the 24th week of storage as presented on table 3.

The foam capacity of Bambara nut flour sample ranges between 45% – 80%. This is consistent with the report of [16, 17]. Foaming capacity showed no meaningful difference ($p>0.05$) of the flour sample from week 4 - 19 of the storage period in week 24 as the values of the foam capacity fluctuate between 50 and 60. From week 20 – 24 of storage, the foam capacity increased to 80%. This could be as a result of reduction of the surface tension of the air/water interface brought about by molecules adsorption. [11] Reported that there could be amplification of surface tension by oil which could lead to an eventual depletion of the foaming capacity of a product. Foam stability depicts the capacity of the formation of protein's strong cohesive film around air vacuole, which results in resistance of air diffusion from the vacuole. The result of the foam stability (Table 3) was in agreement with the result reported by [18] for Bambara nut flour and kersting groundnut flour.

The result of the oil capacity of Bambara nut flour as presented in table 4 showed that there were significant ($p<0.05$) differences on the particle size and storage duration of Bambara nut flour.

The oil absorption capacity of Bambara nut flour varied with the particle size and storage period but was all within the range 0.53g/ml – 1.67g/ml as reported by [16] and is also similar to those reported [12]. This result implies that there is no change in the Bambara nut's flour protein content. The oil absorption mechanism concerns the physical entraping of oil by food constituent and affinity of nonpolar protein side chains for lipids [19]. The OAC of flours is very vital in new food products development as well as their stability during storage, particularly for the development of oxidative rancidity. The oil and water capacity of Bambara nut flour is very important for the determination of the texture of its dough which translates to the acceptability and their economic value of the consumers especially diabetic patients. The low OAC of these samples are exceedingly attractive as far as it deals with flour products like Bambara nut. This functional property determines the measure of flour to make good dough. These findings is in agreement with [14] who reported that liquid retention is an index of the ability of proteins to absorb and retain oil/water which is in turn influences the texture and mouth feel characteristics of foods and food products.

The water adsorption capacity of Bambara nut flour as presented in table 5 ranges between 0.8g/ml – 1.8g/ml. This result is corresponding to the reported range by [14, 15] for mucuna bean flour and cowpea flour, respectively. Water adsorption in flour correlates positively with the analyzed content and also particle size of the Bambara nut flour. Water adsorption capacity is a pointer to the extent at which protein can be absorbed into food formulation. Boosting of water adsorption capacity indicates high digestibility of the starch. The water characteristics represent the capability of a product to associate with water under condition where water is limiting in order to improve its handling characteristics and dough making potential [11]. The variation in water capacity within the storage periods could be as result of the variation in relative humidity within the storage environment.

IV. CONCLUSION

This research analyzed the effect of storage time and particle size on the physicochemical and functional properties of Bambara nut flour in an ambient storage condition. It was observed from the analysis that the Bulk Density ranged from 0.64 to 0.79 g/ml. The foam capacity of Bambara nut flour sample ranges between 45% – 80%. The oil and water adsorption of the flour correlates positively with the analyzed content and also particle size of the Bambara nut flour. The oil and water absorption capacities of the flour ranged between 0.53g/ml – 1.67g/ml and 0.8g/ml – 1.8g/ml, respectively. The study revealed that physicochemical and functional properties are important parameters for handling and storage of Bambara nut flour. However, evaluation of the quality attributes of Bambara nut flour in future research would be desirable.

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Sample	Control	Week 0 - 4	Week 5 - 9	Week 10 - 14	Week 15 - 19	Week 20 - 24
Parameter						
Size(µm)						
850	0.794	0.758	0.676	0.714	0.704	0.704
250	0.680	0.676	0.694	0.658	0.714	0.610
150	0.641	0.633	0.625	0.658	0.641	0.600

Table 1:- Bulk Density (g/ml) of Bambara Nut Flour Stored for a Period of 24 Weeks

Sample	Control	Week 0 - 4	Week 5 - 9	Week 10 - 14	Week 15 - 19	Week 20 - 24
Parameter						
Size (µm)						
850	16	12	12	12	14	14
250	12	10	12	14	12	12
150	14	14	12	12	12	12

Table 2:- Least Gelation Capacity (%) of Bambara Nut Flour Stored for a Period of 24 Weeks in an Ambient Temperature

Sample	Control	Week 0 – 4	Week 5 – 9	Week 10 – 14	Week 15 – 19	Week 20 – 24
Parameter						
Size (µm)						
850	55	60	50	50	60	40
250	45	50	60	60	60	70
150	50	60	60	65	60	80

Table 3:- Percentage Foam Capacity of Bambara Nut Flour Stored for a Period of 24 Weeks

Sample	Control	Week 0 – 4	Week 5 – 9	Week 10 – 14	Week 15 – 19	Week 20 – 24
Parameter	**(g/ml)**	**(g/ml)**	**(g/ml)**	**(g/ml)**	**(g/ml)**	**(g/ml)**
Size (µm)						
850	1.67	1.14	1.23	0.89	0.62	0.70
250	1.49	1.14	1.06	0.97	0.53	0.88
150	1.49	1.14	1.23	1.14	0.70	0.53

Table 4:- Oil Adsorption Capacity of Bambara Nut Flour Stored for a Period of 24 Weeks

Sample	Control	Week 0 – 4	Week 5 – 9	Week 10 – 14	Week 15 – 19	Week 20 – 24
Parameter	**(g/ml)**	**(g/ml)**	**(g/ml)**	**(g/ml)**	**(g/ml)**	**(g/ml)**
Size (μm)						
850	1.0	1.0	1.7	1.8	1.1	0.8
250	0.8	1.0	1.5	1.7	1.3	0.8
150	0.8	0.8	2.0	1.7	1.3	0.8

Table 5:- Water Adsorption Capacity of Bambara Nut Flour Stored for a Period of 24 Weeks

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