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Comparative Study of Storage Stability of Sweet Potato and Yam Flours

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Abstract – The storage stability of sweet potato (*Ipomoea batatas*) and yam (*Discorea alata*) flours was investigated. Sweet potato and yam tubers purchased from Kure Market Minna, Nigeria were processed into sweet potato and yam flours of initial moisture contents of 4.32%, and 4.33% respectively. The processed flours were packaged in plastic containers and stored at 23ºC and 65% RH. Proximate composition and microbial analysis of the flour samples were carried out at one week interval for a period of two weeks. Results showed that the moisture, ash, crude fibre and fat contents of yam flour at the end of two weeks storage period were relatively higher than that of sweet potato flour. The protein and carbohydrate contents of yam flour were slightly lower than those of sweet potato flour. Results also showed that the bacterial count of sweet potato flour ranged between 72 × 10^3 cfu/g and 81 × 10^3 cfu/g while that of yam flour ranged between 61 × 10^3 cfu/g and 141 × 10^3 cfu/g after two weeks of storage. The fungal count of sweet potato flour was relatively higher than that of yam flour after two weeks of storage. Subject to the results of the proximate composition analysis and microbial safety, yam flour would be recommended for the production of pastries by food industries either alone or in combination with other flours for good quality attributes, microbial safety and longer shelf life.

Index Terms – Storage stability, Sweet potato, Yam, Flour, Microbial count, Shelf life.

1. INTRODUCTION

Sweet potato (Ipomoea batatas) contains a significant quantity of the anti-oxidant nutrients β-carotene, vitamin C and vitamin E. Sweet potato flour is a source of vitamin A which has beneficial effects on human health such as improvement on immunity and reduction of degenerative diseases such as muscular, cardiovascular and cancer. The flour of sweet potato can partially replace wheat in production of biscuits, cakes, chin-chin and other products used in school feeding and mother-infant support [1].

Processing of sweet potato into flour is possibly the most satisfactory method of creating an added value product that is not only functionally adequate, but also remains for a longer period without spoilage. Different products can be prepared by incorporating sweet potato flour with other flours using different methods of cooking such as baking, roasting, steaming, boiling and deep frying. When used for baking by incorporating it into bread dough, sweet potato flour helps the bread to retain its freshness. It also imparts a distinctive, pleasing flavour and improves toasting qualities. It can be used advantageously in crackers, pastries, yeast raised doughnuts, cake and cake mixes [2]. In view of the increasing utilisation of sweet potato in composite flours for various food formulations, their functional properties are assuming greater significance. Modified flours in snack foods serve as functional ingredients, contributing to desirable attributes such as increased expansion, improved crispness, reduced oil pickup, and better overall eating quality [2].

Yams (D*iscorea spp.*) are important source of carbohydrate for many people of the Sub-Saharan region, especially in the yam zone of West Africa [3]. Yam plays a significant role in the social, cultural and economic wellbeing of thousands of people in Nigeria and elsewhere in the world. In West Africa, a major proportion of yam is eaten boiled, roasted or as flour. Yam is processed into flour which is a good source of protein, carbohydrate and trace amounts of vitamins and minerals [4]. Yam flour is traditionally processed by peeling, slicing, parboiling in hot water (65°C) for varied time followed by steeping for 13 – 24 hours and sun-drying to give a dry yam product which is milled into flour.

Food preservation includes the action taken to maintain or retain the desired properties or nature of foods within a time frame, so that it remains safe and pleasant to consume. It is the process of treating and handling food to stop or slow down spoilage like loss of quality, edibility or nutritional value. Thus, food preservation allows for longer storage [5]. It is also involves the action taken to maintain the desired properties or nature of foods, within a time frame, so that it remains safe and pleasant to consume.

A staple food product can be developed by applying different processing techniques and by keeping it in an appropriate condition. The quality of both sweet potato and yam flours depends greatly on the variety and processing method used.

The flour produced by these crops is prone to contamination especially when it is processed using unhygienic method and poor storage condition. High moisture content is also a factor that can reduce its storage quality and shelf life. Microbial growth and deteriorative physical, chemical and biochemical changes during processing and storage depend on many factors such as moisture content, food composition, preservatives, pH, and environmental or processing factors such as temperature and pressure [6].

Flour and other materials used in manufacturing food products need to be packaged and stored properly prior to utilization to ensure the quality, safety and storage stability. To realize the full potential of sweet potato and yam flours in food processing, either alone or in combination with other raw materials such as wheat flour, knowledge of their storage stability is important [7].

2. MATERIALS AND METHODS

2.1. Materials

The samples (Plates 1 and 2), processed into potato and yam flours, for determining storage stability were purchased from Kure Market Minna, Nigeria.

Plate 1: Raw sweet potato

Plate 2: Raw yam

2.2. Sample Preparation

The sweet potato and yam tubers were washed and peeled using kitchen knife, washed again and sliced into sizes of 2 – 3 cm thickness. These slices were then soaked in water while peeling to avoid enzymatic browning reaction. The slices were then blanched with hot water at 80ºC for 8 minutes after which they were transferred into the oven (33511-FS, fisher scientific, USA) to dry at 86ºC for 4 hours. The dried sweet potato and yam slices (Plates 3 and 4) were milled using a local milling machine (mortar and pestle) and screened through a 1mm test sieve to obtain the powdery flours. The flours were then packed into a cleaned and closed plastic containers (Plates 5 and 6) and stored under dry conditions at room temperature for further use [8].

Plate 3: Sweet potato slices after oven drying

Plate 4: Yam slices after oven drying

Plate 5: Sweet potato flour

Plate 6: Yam flour

2.3. Methods

The moisture content of the sample was determined using the hot oven method of [9]. The carbohydrate content was determined by the difference between 100 and the sum of fat, crude protein, moisture content, crude fibre and ash content [10]. The ash, crude fibre, fat and crude protein contents were determined according to the method of AOAC [11]. Microbial analysis was done using the method described by [12]. Triplicate determinations of data are presented as mean ± standard deviation and were subjected to analysis of variance (ANOVA) while means were separated using Duncan's Multiple Range Test (DMRT).

3. RESULTS AND DISCUSSION

The results for the determination of changes in proximate compositions of sweet potato and yam flours during storage are presented in Table 1. The variation in total viable bacterial counts and total viable fungal counts for sweet potato and yam flours during storage are presented in Figure 1 and Figure 2, respectively.

Parameters (%)	Sweet potato flour			Yam flour		
	0	1	2	0	1	2
Moisture content	4.32±0.09	5.36±0.04	5.27±0.07	4.33±0.15	4.72±0.92	5.64±0.04
Ash	1.79±0.21	1.66±0.16	2.12±0.12	2.25±0.25	1.68±0.05	2.32±0.32
Crude fibre	2.0 ±0.00	2.17±0.50	2.00±0.00	1.41±0.08	1.55±0.24	2.39±0.28
Fat	1.61±0.11	1.11±0.11	2.57±0.07	2.00±0.00	1.00±0.00	2.92±0.08
Crude protein	9.69±0.47	10.42±0.09	6.36±0.93	10.58±0.10	11.51±0.23	6.23±0.10
Carbohydrate	80.60±0.48	79.28±0.36	81.69±1.18	79.43±0.13	79.88±0.88	80.50±0.10

Values are means of triplicate determinations ± standard deviation

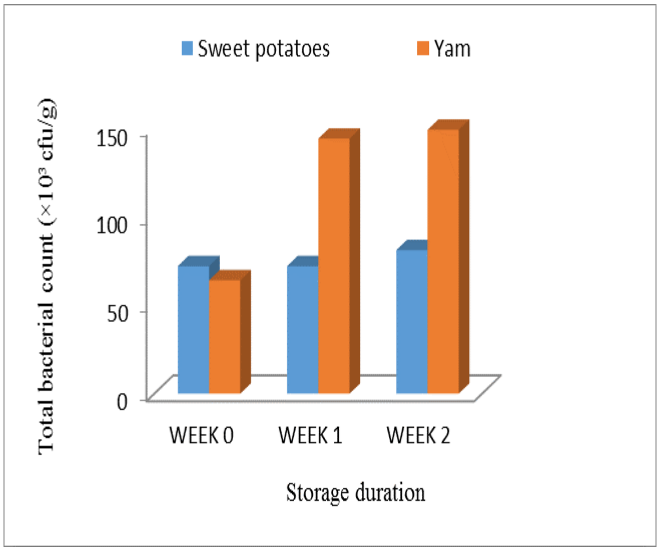

Fig. 1: Variation of total viable bacterial counts for sweet potato and yam flours during storage.

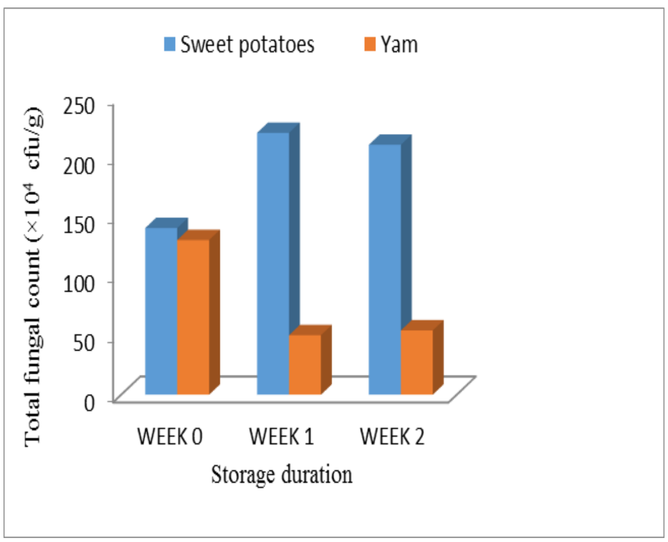

Fig. 2: Variation of total viable fungal counts for sweet potato and yam flours during storage

3.1. Variation in proximate compositions of sweet potato and yam flours during storage

The results of the changes in proximate compositions of sweet potato flour showed that moisture content increased from 4.32% to 5.36% within the first week of storage but decreased to 5.27% at the end of two weeks storage period. This could be attributed to the fact that sweet potato flour lost moisture to the environment during storage. The increase in moisture content during the first week of storage could be as a result of increase in relative humidity of the storage environment. The above values are below the 8.3% reported by [13] for moisture content of sweet potato flour storage. The authors successfully stored sweet potato flour at a moisture content of 8.3%.

It was observed that the ash content of sweet potato flour decreased from 1.79% to 1.66% during the first week of storage the crude fibre content of sweet potato flour increased during the first week of storage from 2.00% to 2.17% and decreased to its original value of 2.00% at the second week of storage. Fat content of sweet potato decreased from about 1.61% to 1.11% after the first week of storage and later increased to 2.57% after two weeks of storage. The variation in fat content of sweet potato flour could be as a result of the lipolytic activities of the corresponding enzymes which probably led to the loss of nutrients during the storage period [7].

The protein content of sweet potato flour increased from 9.69% to 10.42% during the first week of storage but decreased to 6.36% after two weeks of storage. The decrease in protein content of sweet potato flour could be as a result of the effects of moisture content and microbial activities in the flour. The results of this study are in agreement with the previous work of [13] who reported similar trend of variation in protein of maize flour and sweet potato flour.

The carbohydrate content of sweet potato was observed to be approximately stable after two weeks of storage. The slight and then increased to 2.12% in the second week. The variation in ash content could be attributed to the variation in moisture content. This shows that moisture content of sweet potato flour is inversely proportional to the ash content. The decrease in moisture at the end of two weeks storage period led to increased concentration in inorganic minerals present in sweet potato flour and thus, resulted to the increase in ash content.

This is expected since fibre content of roots and tubers correlate positively with moisture content [7].

Variation recorded could be due to microbial activity as storage progressed and as moisture content changed. This is in agreement with the trend reported by [14].

The moisture content of yam flour was observed to increase from 4.33% to 5.64% during the period of storage. This increase in moisture content could be as a result of the hygroscopic nature of yam flour and may be due to the variation of relative humidity and storage temperature. The results of the current study are in agreement with the findings of [15] who suggested that the acceptable limit of moisture content for yam flour during storage should not exceed 10.00%.

Ash content of yam flour decreased from 2.25% to 1.68% during the first week of storage and increased to 2.32% after two weeks of storage. The variation in the ash content of yam flour in this study is an indication that yam flour could be a source of inorganic mineral exhibiting high nutritional importance. The values observed in this work are not in agreement with the findings of [16] who observed different results of 1.40% and 1.60% of ash content in white yam and white cocoyam flour respectively. It was also reported by [16] that ash is a measure of total inorganic minerals content in a biomaterial sample.

The crude fibre content of yam flour was observed to increase from 1.41% to 2.39% at the end of two weeks of storage. This shows a positive correlation with moisture content and is Table 1 shows that fat content of yam flour decreased from 2.00% to 1.00% during the first week of storage and later increased to 2.92% after two weeks of storage. This is an indication that yam flour could be a good source of energy for man. It had been reported that fat serves as energy stored in the body which can be broken down in the body to release glycerol and free fatty acid (FFA). The glycerol can be converted to glucose by the liver and used as source of energy [16].

The protein content of yam flour stored at 23 °C and 65% RH increased from 10.58% to 11.51% during the first week of storage and then decreased drastically to 6.23% at the end of two weeks of storage. This shows that yam flour lost its protein content during storage. This could be attributed to the proteolytic activities of the enzymes present in the flour sample. The carbohydrate content of yam flour was observed to increase from 79.43% to 79.88%, then to 80% during the storage period. The high percentage values observed for the indicative of nutritional stability during storage. It had been reported that the fibre content of red cocoyam and sweet potato flours were 0.50% and 0.75% respectively [17]. It had also been reported that the crude fibre content of *Dioscorea rotundata* and *Colocasia esculenta* were 0.70% and 1.00% respectively [16]. Dietary fibre plays a very important role in the provision of roughages that aid digestion [18] and consumption of dietary fibre also soften stools and lowers plasma cholesterol level in the body [19].

Carbohydrate content showed that yam flour is a very good source of carbohydrate. It was also observed that the carbohydrate content of yam flour during the storage period was relatively stable. This implies that yam flour could be considered nutritionally stable in terms of carbohydrate content during storage. The results observed in this study follow the pattern reported by [17] for red cocoyam and sweet potato flours.

Subject to the results of proximate compositions of sweet potato and yam flours, the moisture content of sweet potato flour was observed to be relatively lower compared to that of yam flour at the end of two weeks of storage. This shows that sweet potato flour maintained relatively stable moisture level at the end of two weeks of storage. Ash and crude fibre content of yam flour were observed to be higher than that of sweet potato flour at the end of two weeks of storage. This is an indication that yam flour could be a better source of inorganic minerals and dietary fibre compared to sweet potato flour. This implies that the quality attributes of yam flour were relatively stable compared to sweet potato flour at the end of two weeks of storage.

The crude protein content of both sweet potato and yam flours decreased after two weeks of storage. This indicates that sweet potato and yam flours lose their protein content during storage.

3.2. Microbial stability of sweet potato and yam flours

The results for the microbial analysis of sweet potato and yam flours (Figures 1 and 2) show that the total viable bacterial count in sweet potato flour ranged between 72×10^3 and 81×10^3 cfu/g while the total viable bacterial count in yam flour ranged between 61×10^3 and 149×10^3 cfu/g. This implies that sweet potato flour exhibits more bacterial stability compared to yam flour. Contrary, the results of the total viable fungal count showed that fungal count in yam flour decreased with storage time from 130×10^4 cfu/g to 54×10^4 cfu/g while fungal count in sweet potato flour increased from 140×10^4 to 210×10^4 cfu/g during the period of storage. The health implications of the high microbial counts reported in this study could be a source of concern for consumers of potato and yam flours after storage and should be further investigated.

4. CONCLUSION

Subject to the results observed in the proximate composition and microbial analysis of sweet potato and yam flours stored the carbohydrate content of sweet potato and yam flours increased with increase in storage duration. The carbohydrate content of sweet potato flour was observed to be relatively higher than that of yam flour at the end of two weeks of storage while fat content of yam flour was observed to be higher than that of sweet potato flour after two weeks of storage. This showed that sweet potato flour better maintained carbohydrate content at the end of two weeks of storage.

Under 23ºC and 65% RH for a period of two weeks, it can be concluded that yam flour showed higher nutritional stability during the period of storage and exhibited better microbial stability. Yam flour should be used for the production of pastries by food industries either alone or in combination with other flours for good quality attributes, microbial stability and longer shelf life.

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