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Research Article

Effect of Different Storage Methods on the Proximate Composition and Functional Properties of Cream-Skinned Sweet Potato(*Ipomea batatas* Lam)

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Abstract: In this study, the effect of different storage methods on the proximate composition and functional properties of sweet potato (Ipomoea batatas Lam.) was investigated. The sweet potato tubers were harvested from a local farm in Jukwa, a village within the vicinity of Cape Coast. For the proximate composition, sample from the fresh tubers were thoroughly sorted, washed, peeled and subjected to analysis for moisture, ash, protein, fat, fibre, carbohydrate and reducing sugars. For the functional properties the peeled samples were sliced, sun-dried, milled into flour and subjected to analysis for water absorption, oil absorption, foaming capacity and swelling power. The rest of the tubers were cured and stored in sawdust, wood ash and ambient conditions for six weeks in a storage facility. Samples were taken from various storages every two weeks, processed and subjected to proximate composition and functional properties analysis. Results of the proximate analysis carried on the fresh sweet potato samples showed 59±0.69 % moisture, 2.27±0.17 % ash, 7.85±0.08 % protein, 0.95±0.00 % fat, 0.21±0.00 % fibre, 62.68±8.00 % carbohydrate and 2.41±0.00 % reducing sugars. For the functional properties the results showed 1.95±0.14 ml/g, 1.37±0.26 ml/g, 4.03±0.05 ml/g, and 8.88±0.82 g/g for water absorption capacity, oil absorption capacity, foaming capacity, and swelling power respectively. The results of the analysis of the stored samples showed no significant variations ($p>0.05$) in fibre, and reducing sugar, foaming capacity and swelling power with the storage methods and time but showed that moisture, ash, protein, fat, carbohydrate, foaming capacity and swelling power varied significantly ($p<0.05$) with storage time.
Keywords: proximate composition, functional properties, saw dust, wood ash, ambient condition

INTRODUCTION

Tropical root and tuber crops, of which cassava, sweet potato and cocoyam are important representatives, constitute an under exploited resource of developing countries. Many of the developing world's poorest farmers and food insecure people are highly dependent on root and tuber crops as a contributing to source of food, nutrition and cash income [1]. The principal component of these tropical root and tuber crops is starch, which is increasingly becoming an important raw material for the food and non food industries worldwide. Despite being rich in starch, tropical root and tuber crops have remained underutilized, though starch from these crops could be used in different industrial applications. The current industrial demand for starch is being met by a restricted number of crops mainly corn, potato and wheat [2]. Consequently, the world starch market is dominated by starches from these three crops. In order to increase the competitiveness of starches from tropical root and tuber crops on the world markets, unveiling of the characteristic properties of starches from these crops is required.

Sweet potato (*Ipomoea batatas*Lam) is a creeping dicotyledonous plant belonging to the family of *Convolvulaceae*. It is one of the world's most important food crops with an annual production of about 120 million tons. Sweet potato is ranked as the7th most important food crop worldwide and 5th in the less developed countries. High yield, nutritional value, production geography, length of production cycle and resistance to production stresses like high temperature and water deficit are some of its positive attributes when contrasted with other major staple food crops]3]. Sweet potato is thought to have originated from Central or South America. It is mainly cultivated in developing countries in Asia, Africa and Latin America with China accounting for about 85% of total world production [4].

In Ghana, sweet potato is the second most important root crop after cassava, which supplements maize, the staple crop. It is widely grown throughout the country for its sweet tasting tuberous roots and young leaves, which are important vegetables. Sweet potato is currently being promoted in the country because of its low production costs, ability to do well even on marginal soils and semi-drought conditions, highly flexible planting dates and short growth cycle [5]. Apart from being used as food crop, sweet potato roots have found their way to produce markets in rural, urban and peri-urban centres, thus acting as a source of income for the local people [6].The popularity of formulated convenience foods places greater emphasis on the reliability of functional properties of food ingredients. Carbohydrates sources of food must be functionally reliable if they are to be used in food products. Several potential food carbohydrates such as sweet potato, potato, cocoyam and yam are presently underutilized [7].

Sweet potato (*Ipomoea batatas* Lam) is a nutritive vegetable, being an excellent source of vitamin A precursor, certain other vitamins and minerals, energy, dietary fiber and some protein. Sweet potato consists of about 70% carbohydrates (dry basis) of which a major portion is starch, which can be utilized as a functional ingredient in certain food preparations. For example, controlling the rate of heating during cooking activates endogenous amylolytic enzymes leading to conversion of a portion of starch to dextrins, which as an adhesive material could function as a binding agent in food products. Ghana produces about 100 thousand tons of sweet potato in a year, most of which are consumed fresh. In spite of the fact that it is cheaper than other crops, this abundant resource is, however, still poorly utilized [8].

Processing of sweet potato into flour is perhaps the most satisfactory method of creating a product that is not only functionally adequate, but also remain for an extended period without spoilage. Incorporation of sweet potato flour into various products has been reported. 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 fat frying. Sweet potato flour is used by baking industry and is incorporated in the baking of 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. The dried and ground sweet potato is used as a supplement in puddings, gruel, etc. Starch manufacture is the main industrial utilization of sweet potatoes which has been used in the preparation of noodles, bakery foods, snack foods, confectionery products and for alcohol production and in brewing industries [9]. The functional properties of the flour are provided not only by the starch but also by other flour components. The limited data for flour functional properties are different from those of starch since extra constituents available in flour (non-starch carbohydrates, protein, fat, etc.), restrict access of water into the starch granules. For example, most of the pasting viscosities of flour were not correlated to that of purified starch. In view of the increasing utilization of sweet potato in composite flours for various food formulations, their functional properties are assuming greater significance. Such properties of plant foods are determined by the molecular composition and structure of the individual components and their interactions with one another. 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. Starch-based coatings and adhesives can replace fat or oil in low fat baked snacks, while resistant starch provides high fibre nutritional claims for snack foods[10].

Several basic properties of flours of concern to food processors such as heat, shear and acid stability are improved by starch modification. Either one or combination of these characteristics is required in most food processes where the properties of unmodified starch are insufficient. Flour is prepared by dehydration methods such as drum drying. However, the properties of such flours were not reported to decide their suitability for specific product development. Acetylated starches are used by food industry because of the unique characteristics imparted by acetylation such as low gelatinization temperature, high swelling and solubility, and good cooking and storage stability. Enzyme treated flours though tend to show changes in its properties due to the breakdown of starch as a result of enzyme action, the functional and rheological properties of such flours were not studied earlier. Thus, information on the properties of processed, acetylated and enzymatically modified potato and sweet potato flours is scanty and is mostly related to the starches.

Preserving harvested storage root crops is a major problem to farmers, sellers and consumers of the crop. Though cold storage, that is refrigeration, and other methods have been used to prolong the shelf life of crops in other countries, this method would not be suitable to Ghanaian farmers because most of them have no access to such facilities. These notwithstanding, the unavailability of ready market and storage limitations that cultivators mostly in northern Ghana have to grapple with, poses great challenges. Readily available, traditional methods of storage would be more suitable for Ghanaian farmers.

Sweet potato is a versatile crop grown in almost all parts of the country. The main products of the crop, flour and starch have a wide range of application from dietary needs for humans to industries (food, plastics, cosmetics, pharmaceutical, textile and adhesive). The different application of the crop both at home and in the industry largely depends on the physicochemical, functional and structural properties of the products of the crop. For years, the Ghanaian industry has relied on imported flour and starch of cassava, potato and wheat for use in various applications. This importation has led to loss of large amounts of foreign currency and employment opportunities for the local Ghanaians. Though the demand for flour is increasing, the Ghanaian industry faces problems due to increased costs, supply capacity, availability and late deliveries. There is the need therefore to explore indigenous crops locally grown by subsistence farmers as alternative source of flour and starch. Such attempts have so far focused on cassava. Sweet potato, just like cassava has great potential for this purpose, yet its utilization in diversified forms has been limited due to lack of adequate information on the effect of the storage methods on its characteristic properties. Therefore, evaluation of the effect of different storage methods on the functional, structural and physicochemical properties of sweet potato cultivated by the local Ghanaian farmer is a major step in the positive direction. A detailed knowledge of the storage effect on the functional properties of the crop would facilitate its utilization in industries, enable tailoring the properties by physical and/or chemical modification to specific applications and bringing economic benefit to the local Ghanaian farmers, sellers and consumers of the crop. This investigation is to find out which traditional storage method would best prolong the shelf life of sweet potato, and find out which of the methods would have minimal effects on the nutritional and functional properties of the crop. The aim of this study is to investigate the possible changes in the proximate composition and functional properties of sweet potato during storage in sawdust, wood ash, and ambient conditions over a period of six weeks.

MATERIALS AND METHODS

Study area

Freshly harvested sweet potato tubers were obtained from a farm in Jukwa. Jukwa is *a* town *about* 18 km north of Cape Coast in the Central Region of Ghana which falls within the Coastal Savanna zone of Ghana. Its geographical coordinates are 5°16'0" N and 1°19'60" E (in Degrees/Minutes/Seconds). There are two main seasons in the area; the wet and dry seasons. The major wet season start from May to July while the minor wet season begins from September to November. The main dry season in the area is from December to February. The analysis was carried out at the soil science laboratory of the School of Agriculture, University of Cape Coast from 14thFebruary, 2013 to 28th March, 2013. The sweet potato samples were cured at 29-32°C and a relative humidity of 90% for 7 days to heal harvesting wounds. The cured samples were then divided into three parts for storage.

Sampling and sampling techniques

The experimental design used was randomized complete block design where the various storage methods constituted the treatments and were each replicated three times. The treatments were set up as follows:

Treatment 1

Storage in wood ash (suspected to be from *Cassia siamea*) packed in a wooden box.The purpose of the wood ash was to act as an insecticidal agent, pest repellant and moisture absorbent [11].

Treatment 2

Storage in moist sawdust from a local timber saw mill packed in a wooden box. The saw dust served as insecticidal agent since most indigenous plants are proven to have some insecticidal properties [12].

Treatment 3

Storage in an empty wooden box. The set up in the various storage methods it was monitored for twelve weeks and samples were taken every two weeks for analysis.

The freshly harvested sweet potatoes were analyzed for proximate composition and functional properties before the storage.

Preparation of native flour for the analysis of functional properties

The sweet potatoes were trimmed with knife, sorted to remove defective ones from the lot, graded according to size and carefully cleaned under running tap water and surface dried. The tubers were peeled in an abrasive peeler and hand trimmed with knife, keeping them in water to prevent enzymatic darkening. Slices of 2-3 mm thick were prepared from the peeled tubers with a grater. The slices were dried at 40±2^{0}C to reduce moisture content and to facilitate grinding into flour. The dried slices were milled with attrition mill into powder. The powder was sieved through a mesh sieve of 75 µm to obtain a fine powder. The flour samples were packaged into polyethylene bags making sure it did not absorb moisture from the environment and stored at 12^0 C in refrigerator prior to analysis.

Analysis of sweetpotato and its flour

Proximate composition: The moisture contents of the fresh and stored sweet potatoes (*Ipomea batatas* L.) were determined by drying in an oven at 105^{o}C during 24 hours to constant weight [13]. The ash contents were determined by incinerating the dry samples (3g) in a muffle furnace at 550oC for 6 hours, then weighing the residues after cooling to room temperature in desiccators and expressed on dry weight bases [13]. The protein contents were calculated form nitrogen contents (N x 6.25) obtained using the Kjeldahl method [13]. The fat contents were determined by continuous extraction in a Soxhlet apparatus for 8 hours using Petroleum ether (40-60^{o}C) as solvent [13]. The fiber contents were determined according to standard method [13]. The carbohydrate contents were determined by difference that is by deducting the mean values of other parameters that were determined from 100. Therefore % carbohydrate =100-(% moisture + % ash + % protein + % fat + % fibre). The reducing sugar contents were determined using the Lane and Eynon constant volume technique described by Pearson [14].

Water and oil absorptions, foaming capacity and swelling power were determined according to the methods of Appiah *et al*.,[15].

Statistical Analysis

Data collected was analyzed using SPSS version 16 and reported using bar charts. The results were subjected to the analysis of variance (ANOVA) procedure using Tukey's post hoc statistical soft-ware to investigate whether there were statistical differences in the parameters studied.

RESULTS AND DISCUSSION

The results of the study are presented on Table 1 and Figures 1-11.

Table 1: Proximate composition and functional properties of fresh sweetpotato samples

Parameter	Mean ± SD
Moisture (%)	59.32± 0.69
Ash (%)	2.27± 0.17
Fat (%)	0.95 ± 0.00
Protein (%)	7.85± 0.08
Carbohydrate (%)	29.40± 1.03
Fibre (%)	0.21± 0.00
Reducing sugar (%)	2.41± 0.00
Water absorption (mg/g)	1.95±0.14
Oil absorption (mg/g)	1.37±0.26
Foaming capacity (mg/g)	4.03±0.05
Swelling power (g/g)	8.88±0.82

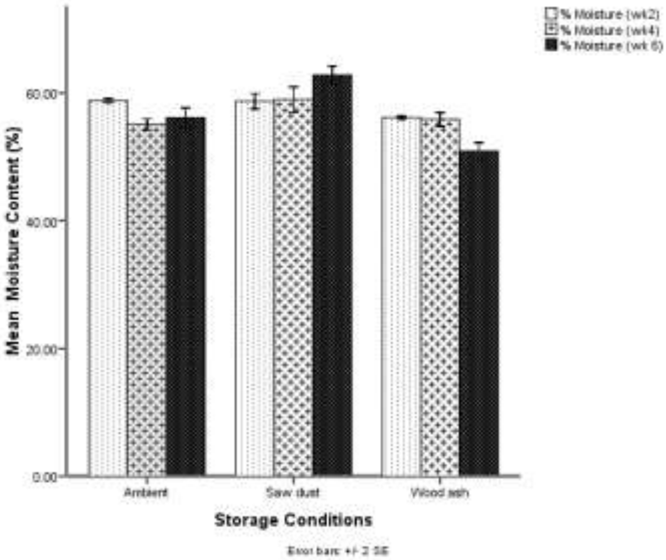

Fig. 1: Moisture content of sweetpotatoes stored for six weeks versus storage methods

Effects of storage methods and storage time on moisture content

Moisture content was 59.32% in freshly harvested sweet potato. At week two of storage under ambient condition, moisture content decreased to 58.79%, then to 55.05% at week four, followed by an increase to 56.15% at week six. For storage in moist sawdust the moisture content decreased to 58.72% in week two, then to 58.97% at week four and finally to 62.80% at week six. There was a steadily reduction in moisture content of sweetpotatoes stored in wood ash from 56.16% to 55.87% then finally to 50.91% at weeks two, four and six respectively (Figure 1). Comparatively, in week two the decrease in moisture content of sweetpotatoes stored under ambient and sawdust was not significantly different ($p>0.05$) whereas that of wood ash was significantly different ($p<0.05$). At week four there was no difference in moisture reduction of storage ambient and wood ash conditions ($p>0.05$), whereas that of sawdust was different ($p<0.05$). At week six, the various storage methods showed significant decreases of moisture content in the sweet potatoes stored in them ($p<0.05$). The differences in the moisture content among the sweetpotato can be attributed to the different storage conditions. Wood ash and saw dust have the ability to absorb water from food materials they make contact with and this may account for reduction in the moisture contents with respect storage of the sweetpotato in these storage materials. This result does not compare favourably with that reported by Odenigbo *et al.*, [16] who reported a moisture content range of 64.76±1.64 – 78.42±1.19%. This deviation may be attributed to varietal differences.

Effects of storage methods and storage time on ash content

The ash content of the fresh sweet potato was 2.27% (Table 1). The ash content among the different storage methods revealed that there was a general increase. Highest content at the end of the storage period was in sweet potatoes stored under ambient condition (2.46%) while the sweet potatoes stored under both sawdust and wood ash increased to 2.40% at the end of the storage period (Figure 2).

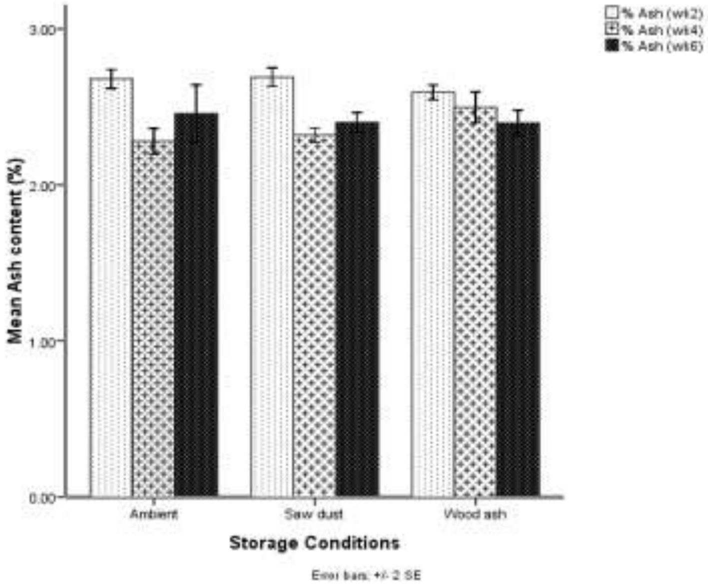

Fig. 2: Ash content of sweet potatoes stored for six weeks versus storage methods

At week two, the general increase in ash content of potatoes across the various storage methods showed no significant differences ($p>0.05$). In week four, there was a general decrease in the ash content as compared to week two, however, only sweet potatoes stored under wood ash showed a significant difference ($p<0.05$) compared to ambient and sawdust ($p>0.05$). At week six, ash content of sweet potatoes stored under ambient and sawdust increased whereas those of wood ash decreased, however, these differences in the ash content were not significant ($p>0.05$). This result was in conformity with that reported by Srivastava *et al.*, [17]

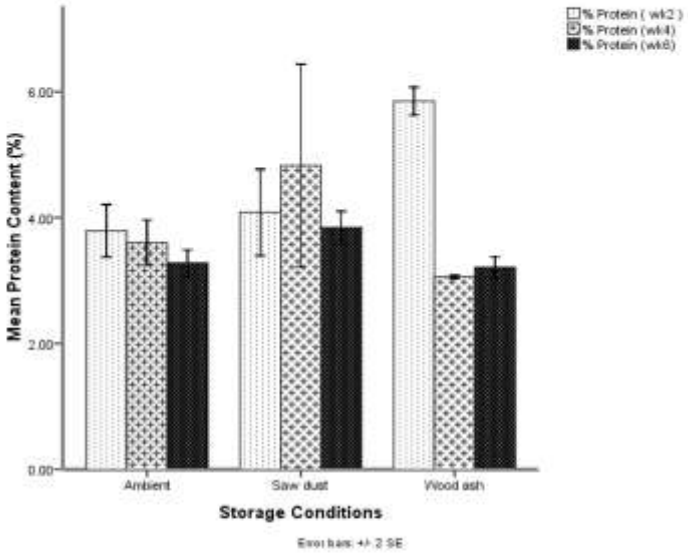

Fig. 3: Protein content of sweet potatoes stored for six weeks versus storage methods

Effects of storage methods and storage time on protein content

The protein content in the freshly harvested sweet potato variety was 7.85 (Table 1). During the storage period, it was seen that the protein content of sweet potato stored under ambient conditions decreased from 3.79% to 3.28% at the end of the storage period. During storage under moist sawdust at week two protein content increased from 4.08% to 4.83% at week four, however, at week six the protein content reduced to 3.84% at week six. Under wood ash storage condition, the protein content decreased from 5.85% in week two to 3.21% at week six. At week two of storage there was a decrease in protein content of sweet potato stored under ambient and sawdust, however, these decreases were not significant ($p>0.05$). The protein content of samples stored under wood ash decreased significantly ($p<0.05$) with storage time. There was a general decrease in protein content from the fresh state to the end of the storage period, however, of the three storage conditions; the sweet potatoes stored under moist saw dust retained the highest protein content. The decrease in protein content from 7.85% in fresh roots to 3.28%, 3.84% and 3.21% in ambient, sawdust and wood ash conditions, respectively could be attributed to the post harvest handling which often leads to loss in quality and quantity of protein in extreme temperature conditions [18].

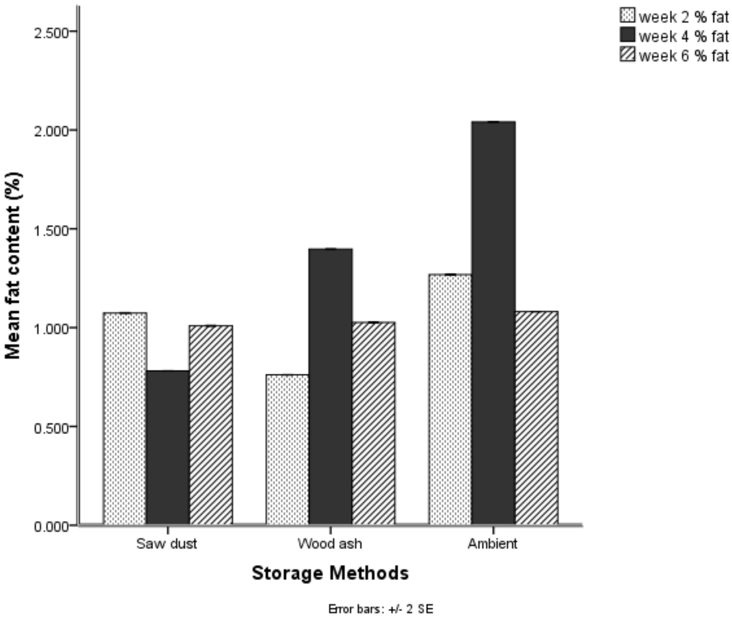

Fig. 4: Fat content of sweet potatoes stored for six weeks versus storage methods

Effect of storage method and storage time on fat content

Fat content had significant differences between the various storage methods, wood ash, ambient and saw dust ($p<0.05$) during the six weeks of storage. Fat obtained for freshly harvested sweet potato was 0.95. At week two under the ambient condition it increased to 1.27 and to 2.04 at week four but decreased to 1.08 in week six. At week two under the moist sawdust crude fat increased to 1.07, decreased to 0.78 in week four then increased again to 1.01 in week six. For the wood ash, crude fat decreased to 0.76 in week two, then increased to 1.40 and to 1.03 in week 6. However, the increases and decreases in the fat content of the stored sweet potato were not significant ($p>0.05$). The result of this study showed a higher fat content of sweet potato than that reported by Srivastava *et al.*, [17]. The difference may due varietal differences.

Effects of storage methods and storage time on carbohydrate content

Freshly harvested sweet potatoes had an initial carbohydrate content of 29.4% (Table 1). At weeks two and four of storage in ambient condition, there was an increase to 34.52% and 55.31% respectively while at week six there was a slight decrease to 37.90%. At week two of storage under moist sawdust the carbohydrate content increased to 34.30%, and then dropped to 33.75% in week four, and further decrease to 30.72% at week six. At week two of storage under wood ash, there was an increase in carbohydrate content to 35.21%, then to 38.38% in week four and finally to 43.34 at week six (Figure 5). Comparatively on fortnight basis of changes in carbohydrate content in the sweet potatoes, weeks two and four showed that the changes in storage in wood ash and under ambient conditions were significantly different ($p<0.05$).

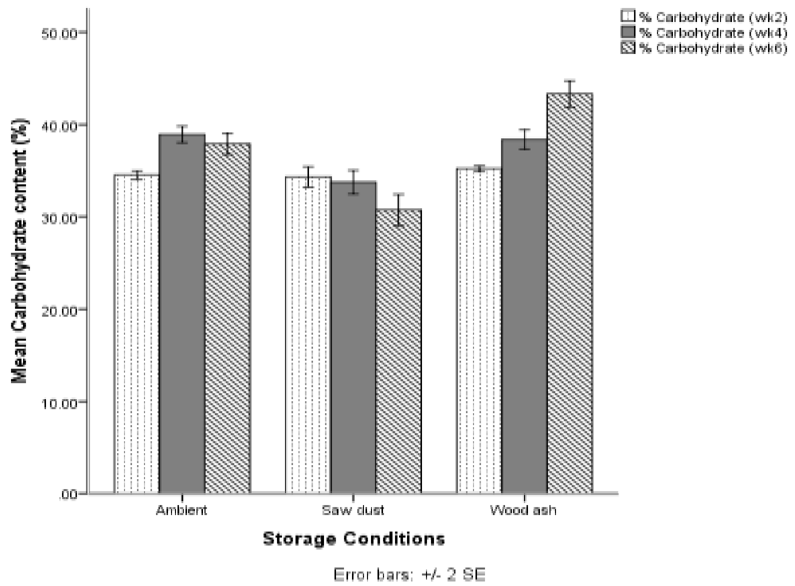

Fig. 5: Carbohydrate content of sweet potatoes stored for six weeks versus storage methods

At week six the changes in carbohydrate content of sweet potatoes stored in sawdust and ambient conditions were not significantly different ($p>0.005$) whereas those of wood ash was significantly different ($p<0.05$) compared to sawdust and ambient. The changes in carbohydrate content of sweet potatoes in all the various storage methods showed no particular trend as the weeks progressed.

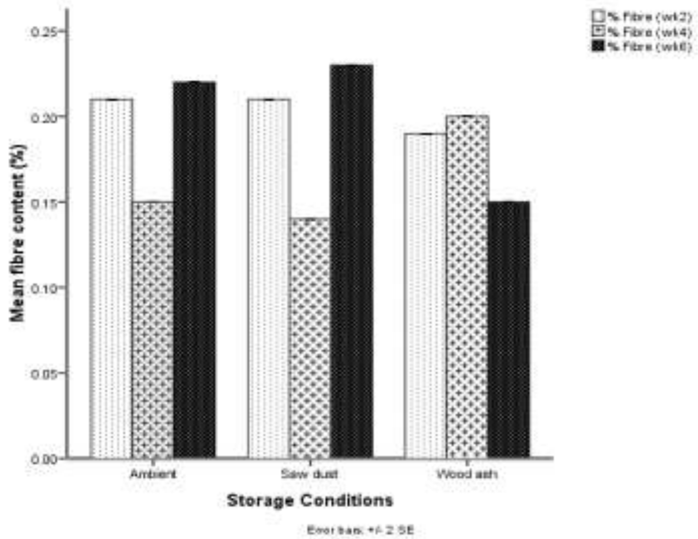

Fig. 6: Fibre content of sweet potatoes stored for six weeks versus storage methods

Effects of storage methods and storage time on fibre content

Pectin, cellulose, hemicelluloses together with lignin are classified as dietary fibre[19]. Dietary fibre has recently gained much importance as it is said to reduce the incidences of colon cancer, diabetes, heart disease and certain digestive diseases. In this study, the initial crude fibre content of freshly harvested sweet potato was 0.21% (Table 1).During week two of storage period, it was seen that the fibre content of sweet potato stored under ambient conditions remained unchanged (0.21%), fibre content however, decreased to 0.15 at week four. At the end of the storage period there was an increase to 0.22%. During storage under moist sawdust at week two, fibre content increased to 0.213%. At week four there was a decrease to 0.15%, then an increase to 0.23% at week six. Under wood ash storage condition, the fibre content decreased to 0.19% at week two, and then increased to 0.20% at the end of the storage period (Figure 4.5). The different storage conditions did not have significant effect ($p>0.05$) on fibre over the storage periods. This was not in conformity with that obtained by Srivastava *et al*., [17.The lower value of fibre in the sweet potato under study may be attributed to varietal differences.

Effects of storage methods and storage time on reducing sugar content

Sucrose is the most abundant sugar in raw sweet potatoes with smaller amounts of glucose and fructose [20]. During storage of the tubers some starch were converted into reducing sugars and subsequently into sucrose [21]. Initial reducing sugar content of fresh sweet potato was 2.41% (Table 1).

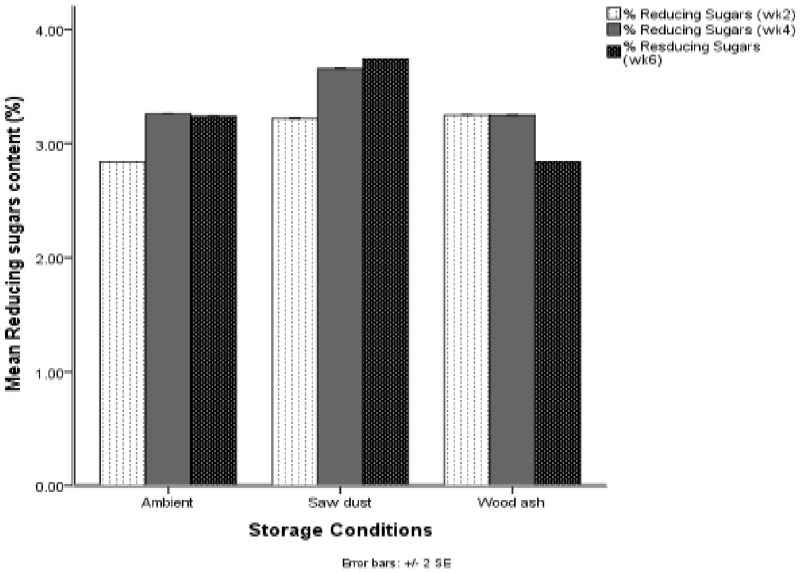

Fig. 7: Reducing sugars content of sweet potatoes stored for six weeks versus storage methods

During the storage period, it was seen that the reducing sugar content of sweet potato stored under ambient conditions increased from 2.84% to 3.24% at the end of the storage period. During storage under moist saw dust, the reducing sugar content increased from 3.22% to 3.74% at the end of the storage period. These increases in reducing sugars may be due to enzymatic breakdown of the starch into smaller sugar units. Reducing sugar content of sweet potatoes stored under wood ash decreased from 3.25% at week two of storage to 2.84% at the end of the storage period (Figure 7). This decrease in reducing sugars in the sweet potatoes stored in wood ash may be due to alkaline nature of the ash which may have affected the action of the enzymes (amylase). The different storage conditions did not have significant effect ($p>0.05$) on reducing sugar over the storage periods. Cultivars from the South Pacific region were found to have total sugars from 0.38% to 5.64% and from 2.9% to 5.5% in American cultivars and the time of harvest had a significant effect on total sugar content [4]. The difference in reducing sugars of the sweet potatoes as compared to that reported by Woolfe, [4] may be attributed to varietal differences.

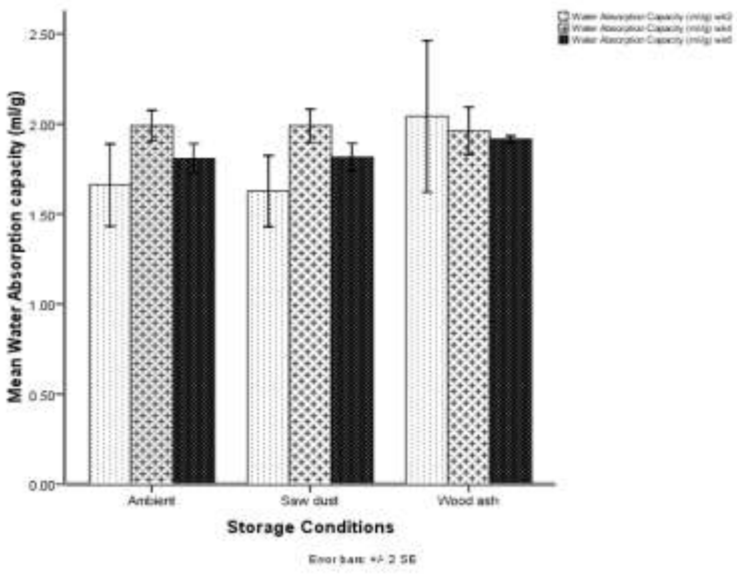

Fig. 8: Water absorption capacities of sweet potato stored in three different conditions

Effects of Storage on Water Absorption Capacity

The results of water absorption capacity of sweet potato determined in the fresh sample and in the stored samples are presented in Table 1 and Figure 8 respectively. The results showed no significant variation ($p>0.05$) in water holding capacity of the sweet potato with storage time and storage methods used in the study. An increase in water absorption was observed between the fresh samples to week 2 while a decrease was observed between week 4 to week 6 with respect to storage in wood ash. A decrease in water holding capacity were also observed from1.95±0.14 ml/g in the fresh sample to 1.66±0.20 ml/g and 1.63±0.17 ml/g in week 2 for both storage in ambient temperature and in sawdust respectively. These values increased between week 2 to values of 1.99±0.07 ml/g and 1.99±0.08 ml/g in week 4 and decreased to 1.81±0.07 ml/g and 1.82±0.07 ml/g in week 6 for both storage in ambient temperature and sawdust respectively. This result was not in conformity with that obtained by Srivastava *et al*., [17]. The difference may be due to varietal differences. Generally, there were no variations in water absorption capacity for the storage in ambient temperature and sawdust over time. This according to Hoover [8]was due to the similar conditions that existed in these storage methods. He explained further that storage of sweet potato in sawdust allows for better aeration, thus creating a similar environment as that of storage in the ambient temperature. This therefore confirms the reason why the two storage methods gave almost same water absorption capacity values over the storage period. A clear trend of decrease in water absorption capacity was observed from week 2 through to week 6 with respect to wood ash. Samples stored in wood ash therefore exhibited higher affinity for water which is informed by its lower moisture content.

The observed differences in the water absorption capacity were due to factors such as particle size, amylose/amylopectin ratio and molecular structure. The larger the granular size, the greater the water absorption capacity while the higher the amylose levels, the lower the water binding capacity of the flour of the sweet potato [22]. The variation in the water absorption capacity also indicate differences in the degree of engagement to form hydrogen and covalent bonds between starch chains and the degree of availability of water binding sites among the starches in the flours [23]. Earlier works have shown that sweet potato starches have higher amylase content and larger granular size when stored in environment that allows for sprouting. Thus, differences in water binding capacity of sweet potato starches could largely be due to molecular structures of the starches. However, higher water holding capacity of samples stored in wood ash compared to sawdust and ambient temperature suggests the presence of weaker intermolecular hydrogen bonds and/or more water binding sites resulting in lower water absorption capacity.

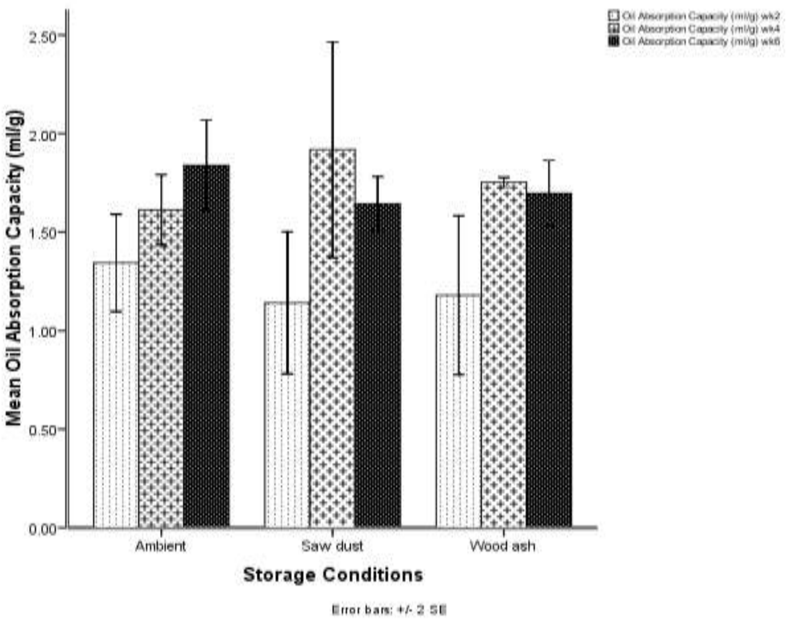

Fig. 9: Oil absorption capacities of sweet potato stored in three different conditions

Effects of Storage on Oil Absorption Capacity

The oil absorption capacity of the fresh sweet potato was determined as 1.37±0.26 ml/g as indicated in Table 1. There was a general decrease in oil absorption capacity in the first two weeks of storage in all the storage methods while high increases in oil absorption capacity were recorded between week 2 to week 4 for all the storage methods used (Figure 9). The oil absorption capacity of samples in the last week (6) of storage showed a decrease in sawdust and wood ash while samples from the ambient storage method showed an increase in oil absorption between week 4 to week 6.A clear trend of increase in oil absorption capacity was observed in samples stored in ambient temperature from week 2 through to week 6. Similar trends occurred between sawdust and wood ash from week 2 to week 6.The mechanism of oil absorption is attributed mainly to the physical entrapment of oil and the binding of fat to the apolar chain of protein [24]. This according to his work can be attributed to the little amount of protein content in sweet potato. This therefore makes it difficult for the conditions created by the various storage methods to disrupt the apolar chains of the protein. In general there was no significant variation (p>0.05) in oil absorption capacity of the samples over both storage period and storage methods used.

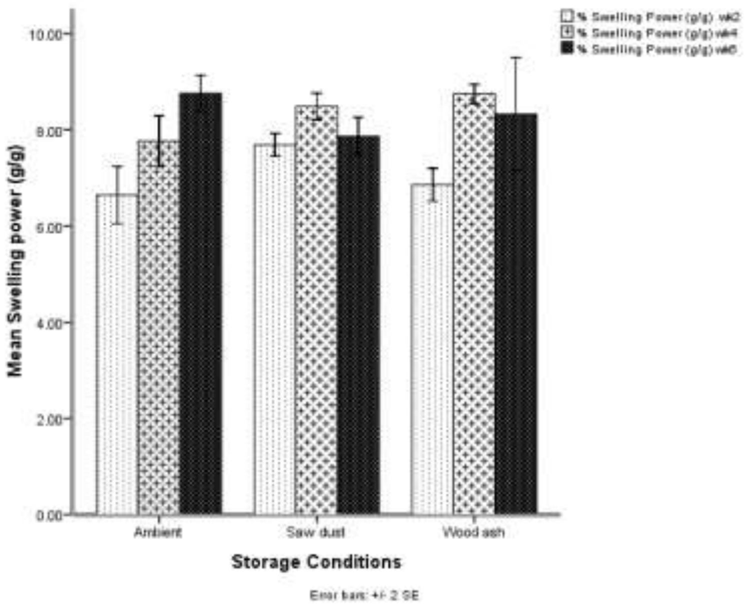

Fig. 10: Swelling power of sweet potato stored in three different conditions

Effects of Storage on Swelling Power

The swelling power of the fresh sample was determined as 8.88±0.82 g/g and presented in Table 1. The result of swelling power of the sweet potato flour from the various storage methods are presented in Figure 10. The swelling power of the flour of the sweet potato decreased in the first two weeks of storage. It however increased between week 2 to week 4 in all the storage methods. While this trend continued in week 6 in ambient conditions, a decline week 4 in all the storage methods. While this trend continued in week 6 in ambient conditions, a decline was observed in week 4 to week 6 for sawdust and wood ash. The swelling power of the flours of the sweet potato at weeks 2, 4, and 6 are 6.64±0.51, 7.76±0.46, and 8.75±0.33 g/g respectively for ambient, 6.69±0.20, 8.48±0.24, and 7.81±0.34 g/g respectively for sawdust and 6.86±0.30, 8.74±0.17, and 8.33±0.38 g/g respectively for wood ash. The swelling power of the sweet potato varied significantly (p<0.05) over the storage period in the storage methods used. The highest swelling powers were observed in week 6 under ambient conditions followed by wood ash in week 4. Week 2 recorded the lowest swelling power with values of 6.64±0.51, 6.86±0.30 and 7.69±0.20 g/g for ambient, wood ash and sawdust respectively. The swelling power of sweet potato flour depends on the capacity of its starch molecules to hold water through hydrogen bonding. After gelatinization these hydrogen bonds between the starch molecules are broken and replaced by hydrogen bonds of water. Thus, rapid swelling of the starch due to the breaking of the intermolecular hydrogen bonds in the amorphous areas occurred in week 6 where the swelling power under ambient conditions recorded a value 8.75±0.33 g/g. The differences in the extent of swelling also indicate structural differences among starches. Swelling power is influenced by a strong bonded micellar network, amylopectin molecular structure and amylose content [25]. Crystallite formation by the association between long amylopectin chains increases granular stability, thereby reducing the extent of granular swelling [9]. Swelling power also increases with increasing long chains of amylopectin and decreasing amylose content [26]. Thus, the differences in amylose content explain the differences in the swelling power between the various storage methods with progressing storage.

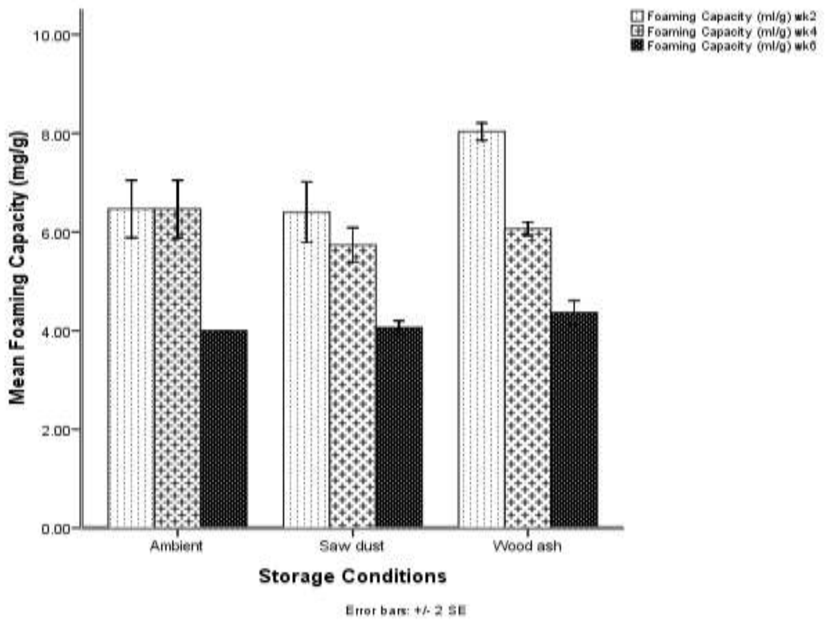

Fig. 11: Foaming capacities of sweet potato stored in three indifferent conditions

Effects of Storage on Foaming Capacity

The results obtained for foaming capacity in the fresh sample and the stored samples are presented in Table 1 and Figure 11 respectively. The results showed an increase in foaming capacity during the first two weeks of the storage in all the three storage methods used. Nevertheless, there was a general decrease in the foaming capacity in all three storage methods per storage time between week 2 through to week 6. It was observed that different storage methods did not have significant effect ($p>0.05$) on the foaming capacity within weeks 4 and 6. In week 2, however, wood ash samples showed a high foaming capacity of 8.03±0.15 ml/g as compared to foaming capacity values of 6.47±0.05 ml/g and 6.40±0.53 ml/g for ambient conditions and sawdust respectively. The foaming capacity varied significantly with storage time ($p<0.05$) as values increased in the first two weeks and decreased in the subsequent weeks. However, there was no general trend in the foaming capacity from week 2 through to week 6 as indicated by figure 11. This trend of increase in foaming capacity in the first two weeks may due to high levels of foaming agents in the samples. The subsequent reduction in foaming capacity between week 2 to week 6 was also may due to the gradual reduction in the foaming agents in the samples [27]. Foaming agents are materials that facilitate foaming. The term refers to either surfactants which when present in small amounts, reduce surface tension of a liquid and reduces the work needed to create the foam or increase its colloidal stability by inhibiting coalescence of bubbles or a blowing agent which is the gas that forms the gaseous part of the foam [8]. The results of the study therefore showed that foaming agents decreased with storage time, hence the increase in the foaming capacity.

CONCLUSION

The results of the study indicates that apart from fat, fibre, reducing sugars, oil and water absorption capacities, the cream-skinned sweet potatoes cultivated in the Cape Coast and its environs in Ghana showed high amounts of moisture, ash, protein, carbohydrate, swelling power and foaming capacity. The results of the analysis of the stored samples showed no significant variations ($p>0.05$) in fibre, and reducing sugar, foaming capacity and swelling power with the storage methods and time but showed that moisture, ash, protein, fat, carbohydrate, foaming capacity and swelling power varied significantly ($p<0.05$) with storage time. The differences observed in the storage saw dust and ambient conditions with respect to moisture, ash, protein, etc. are attributed to the fact that these storage methods did not give adequate protection to the sweet potato as they were prone to attack from sweet potato weevils and sprouting which also predisposed the potato to microbial attack [28]. However, the application of flour in the food industry where water absorption capacity, oil absorption capacity, swelling power and foaming capacity are desired functionalities, sweet potato flours in which the storage is done with the methods used in this study would be suitable. The high values of swelling power and foaming capacity coupled with low values of water and oil absorption capacities of sweet potato are desirable forits application in frozen food products such as ice creams.

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