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Proximate Composition of *Dioscorea dumetorum* (K.) and *Dioscorea bulbifera* (L.) Tubers during Storage

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ABSTRACT

Yam is a staple food of sub-saharan African, consumers have consistently doubted, the actual nutritional compositions of the tubers during storage. There has been continued need to understand the composition of yam tubers at various stages of storage, especially after sprouting. This research determined the proximate composition of *Dioscorea dumetorum* and *Dioscorea bulbifera* during storage. The proximate analysis involved the moisture content, crude protein, fat, carbohydrate, crude fiber and dry matter of the two yam species at storage. Sample obtained from two species were subjected to proximate assay. Analytical methods were used for the nutritional assay. Data from analysis were subjected to ANOVA and means separated using DUNCAN'S Multiple Range Test. Test of significance was based on 5% probability level. Proximate analysis of *Dioscorea dumetorum* revealed that, the tail region of immediately after harvest gave the highest protein content (78.68±0.28) which was significantly higher than that of the tail region of post sprouted stage (77.98±0.18). Carbohydrate content *Dioscorea dumetorum* was highest in the head region of second stage (98.39±0.11) while the least was in the head region of third stage (77.78±0.19) and the *Dioscorea bulbifera*, the head regions of all the storage gave the significantly highest carbohydrate composition value, the tail region showed the lowest or no significant across the column. This study revealed that there is a mobilization and utilization of proximate of tubers of two yam species during storage.

Keywords: Yam storage, *Dioscorea dumetorum*, *Dioscorea bulbifera*, Proximate composition and Nutritional analysis

INTRODUCTION

Yam is a member of the *Dioscorea* genus of the *Dioscoreaceae* family [1]; [2] and a tuberous, herbaceous tropical perennial monocot plant with climbing or trailing vines which can be smooth or prickly within the order *Dioscoreales* and the class *Liliopsida*. It is the second most important root or tuber crop in Africa after cassava with production reaching just under one third the level of cassava [3]. *Dioscorea* is a genus comprises over 600 species of flowering plants [4] and the vast majority of the species are tropical. The most important part of the yam plant is the tuber [5]. The tubers are the only palatable part of the yam, which have a prodigious capacity to store food reserves, broaden the food base and bring food security to millions of people in the low income, food deficit and developing countries of the tropics which can provide them with about 200 Kilocalories per day. The aerial storage organ of *Dioscoreaceae* (*D.* bulbifera) is the bulbil. The benefit consumption and economic importance of yam tubers lies in their utility as a source of carbohydrate, minerals and B – complex group of vitamins (pyridoxine, thiamine, riboflavin, folates, pantothenic, niacin, ascorbic acid and carotenes) in human diet [6]. There have been many reports on the nutritional and anti-inflammatory activities of *Dioscorea* in the past, as well as studies on the treatment of metabolic diseases, such as obesity and diabetes. However, reported reviews on *Dioscorea* have focused on single species, such as *D. alata*, *D. rotundata*, *D. cayenensis*, *D. bulbifera*, or generalized pharmacological nutritional activities [7]; [8]; [9] and there has not been a comprehensive review on mobilization of nutritional compositions of *Dioscorea* at different regions during storage, which is not conducive to relevant studies. This is beneficial for the reader to quickly understand the latest research progress of *Dioscorea* and provides an updated reference for researchers to facilitate the mobilization and changes in composition during consumption of *Dioscorea* in storage. This research was therefore aimed at ascertaining the proximate composition of the tubers of two yam species and the understanding of the constituents in the regions at various stages of storage.

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MATERIALS AND METHODS

Source of Materials

Fresh tubers of *Dioscorea dumetorum* and *Dioscorea bulbifera* used in this study were obtained under special arrangements with a farm in Ogidi, in Idemili North Local Government Area of Anambra State, Nigeria. Immediately after harvest, the tubers were sorted to select the matured, healthy-looking and bruise free ones.

Identification of Plant Materials

The yams used in the research were identified at the Department of Botany and was authenticated by Dr. C. A Ezeabara, an Associate professor of Plant Taxonomy at Nnamdi Azikwe University, Awka, Nigeria with Herbarium number: NAU-146A and 30 for *D. dumentorum* and *D. bulbifera* respectively.

Preparation of Plant Materials

At the beginning of the experiment, three fresh yam tubers of each species were randomly selected from the storage section. Each of the three tubers were divided into three regions as Head, Middle and Tail. Analyses were carried out at three different stages of storage [that is, immediately after harvest (at harvest), midway through storage before sprouting (pre-sprouting) and after sprouting (post-sprouting) stages]. The pre-sprouting stage was 6-7 weeks after harvest while post-sprouting stage was one week into sprouting.

Each region was peeled, washed, sliced and dried at 70^0C for 72hours. Thereafter, the different regions were ground into powder using electrical blender NM-8300 and sieved using a 1mm mesh size sieve and each sample was labelled and stored in an air tight container until analysed.

PROXIMATE ASSAY

This was carried out using the method described by the Association of Official Analytical [10]; [11]; [12] and [13].

Determination of Moisture Content

Moisture content was determined by the gravimetric method described by [10]. An empty petri dish was dried in an oven for about 10 minutes and allowed to cool in a desiccator containing calcium chloride for about 20 minutes and then weighed (W_1). A measured weight of each samples 5g was weighed into a previously weighed moisture can. The each samples in the different cans were dried in the oven at 105^0C for 3hours. They were cooled in a desiccators and weighed. The weight was recorded while the sample was retained in the oven for further drying. The drying, cooling and weighing was continued repeatedly until a constant weight was obtained. The moisture content was calculated as shown below.

$$\% \text{ Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where;

W_1 = Weight of empty moisture can

W_2 = Weight of can before drying

W_3 = Weight of can and sample after drying to a constant weight.

% Dry matter = 100 -% moisture

Determination of Protein

This was determined by Kjeldahl method described by [12]. The total N_2 was determined and multiplied with factor 6.25 to obtain the protein content. A measured 0.5g of each sample was mixed with 10mls of concentrated H_2SO_4 in a Kjeldahl digestion flask. A tablet of Selenium catalyst was added to it before it was heated under a fume cupboard until a clear solution was obtained. The acid and other reagent were digested but without sample to form the blank control. All the digests were carefully transferred to a 100ml volume flask using distilled water and made up to a mark in the flask. A 100ml portion of each digest was mixed with equal volume of 45% NaOH solution in Kjeldahl distilling unit. The mixture was distilled and the distillate collected into 10ml of 4% boric acid solution containing three (3 drops mixed indicator cresol green and methyl red). A total of 50 ml distillate was obtained and titrated against 0.02n EDTA from green to a deep red end point. The end point is from the initial green color to a deep red point. The nitrogen content was calculated as shown below.

$$\% \text{ Nitrogen} = \left(\frac{100}{W} X \frac{\text{N X 14}}{100} X \frac{\text{Vf}}{Va}\right) T$$

Crude protein (%) = %Nitrogen x 6.25

Determination of Fat Content

Fat content of the sample was determined by the continuous solvent extraction method using a soxhlex extraction apparatus. The method was described by [13]. A measured 0.5gramms of the sample was wrapped in a porous paper (Whatman No.1 filter paper). The wrapped sample was put in a soxhlex reflux flask containing 200ml of petroleum ether. The upper end of the reflux flask was connected to a condenser. By heating the solvent in the flask through electro thermal heater, it vaporizes and condensed into the reflux flask. The wrapped sample was completely immersed in the solvent and remained in contact with it until the flask filled up and siphoned over thus carrying oil extract from the sample down to the boiling flask. This process was allowed on repeatedly, for about 4 hours before the defatted sample was removed and reserved for crude fibre analysis. The

solvent was recovered and the extracting flask with its oil content was dried in the oven at 60°C for 3 minutes to remove any residual solvent. After cooling in desiccators, the flask was reweighed. By difference, the weight of fat (oil) extraction was determined and expressed as a percentage of the sample weight. It was calculated as

$$\% \text{ fat} = \frac{W_2 - W_1}{\text{Weight of sample}} \times \frac{100}{1}$$

Where;
W_1 = Weight of empty extraction flask
W_2 = Weight of flask and oil extract

Determination of Crude Fibre

The crude fibre was determined using the gravimetric methods of [11]. Two grams of the defatted sample obtained during fat determination was air dried and transferred into a 250ml conical flask. Two hundred milliliter (200ml) of 1.25% sulphuric acid was added and heated gently for 30 minutes. The flask was rotated every few minutes, in order to mix the content and remove particles from the side. At the end of the 30 minutes boiling period, the acid mixture was allowed to stand for one minute and then filtered using a filter paper. The filtration was so fast and was completed within 2minuties. The insoluble matter was washed with boiling distilled water until the filtrates is free from acid. The insoluble matter was washed back into the flask by means of wash bottle containing 1.25% NaOH and boiled for 30minutes with the same precaution as those used in the early acid treatment. At the end of the 30minutes boiling, the mixture was allowed to stand for one minute and then filtered immediately using a filter paper. The insoluble matter was washed with 1% HCl and finally with boiling water until free from acid, it was then washed twice with alcohol and three times with ether. The insoluble matter was transferred into a dried weighed crucible and then oven dried at 100°C to constant weight. The crucible and its content was ash and the weight of insoluble matter gave the weight of the crude fiber.

$$\text{Crude fibre \%} = \frac{\text{weight of dried insoluble matter} - \text{weight of ash}}{\text{weight of sample before defatting}} \times 100$$

Determination of Total Ash

Ash represents the inorganic remains after the organic carbonaceous portion and other volatile components have been oxidized and evaporated away. This was done using the incineration gravimetric method [10]. A measured weight (5g) of sample was put in a previous weighed porcelain crucible. The sample in crucible was put in a muffle furnace and set at 550°C and allowed to burn for 2-3 hours (until the sample become a grey ash). The sample in crucible was carefully removed from the furnace and cooled in a desiccator. It was reweighed by difference, the weight of ash was obtained and in percentage. It was given by the formula,

$$\% \text{ Ash} = \frac{W_2 - W_1}{W_0}$$

Where;
W_1 = Weight of crucible
W_2 = Weight of empty crucible + Ash
W_0 = Weight of sample used

Determination of Dry Matter

Percent dry matter was estimated as a differences of percent of protein moisture content in 100% as described by [11].

Determination of Carbohydrate

The carbohydrate content was calculated by difference as the nitrogen free extractive (NFE), a method described by [11]. The NFE was calculated by using the formula below;
% NFE = 100 – (% MC + % ASH +% CF + % EE + % CF).

Statistical Analysis

Data collected were Analysed using Analysis of Variance (ANOVA) and test of significance were processed using Duncan's Multiple Range Test (Duncan, 1955) at 5% level of probability.

RESULTS

Percentage Proximate Composition of *D. dumetorum* tubers during storage.

Result of the percentage proximate compositions of *D. dumetorum* tubers during different stages of storage showed that Protein composition was highest (6.94±0.10 %) in the head region of post sprouted stage, followed by the head region of initial stage (6.77±0.10 %), while the least was in tail region of initial harvest (6.19±0.10 %). Interestingly the difference among them were significant. The highest composition of fat was the value of 0.65±0.01 % which occurred both in the tail region of initial harvest and middle region of post sprouted tubers respectively, the least also occurred in the head regions of both the pre sprouting and post sprouted stages of the tubers (0.43±0.01 %) (Table 3). Carbohydrate content was highest in the head region of second stage (98.39±0.11 %) while the least was in the head region of third stage (77.78±0.19 %). Certainly the differences were significant among the samples (Fig 1).

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Table 1: Percentage Proximate Composition of *D. dumetorum* tubers during storage.

Composition / Samples	Moisture Content	Crude Protein	Fat	Crude Fibre	Ash Content	Dry Matter
TLY H_1	58.56±0.09^{c}	6.77±0.10^{b}	0.52±0.04^{e}	1.36±0.04^{a}	1.73±0.02^{c}	8.99±0.10^{c}
TLT M_1	62.25±0.29^{b}	6.54±0.10^{cd}	0.61±0.02^{bc}	0.91±0.04^{b}	3.45±0.01^{d}	9.17±0.04^{ab}
TLY T_1	65.25±0.29^{a}	6.19±0.10^{e}	0.65±0.01^{a}	0.69±0.03^{c}	3.41±0.03^{d}	9.15±0.02^{ab}
TLY H_2	50.25±0.84^{g}	6.71±0.10^{bc}	0.43±0.01^{f}	1.41±0.03^{a}	3.76±0.04^{c}	9.24±0.02^{a}
TLT M_2	53.42±0.41^{e}	6.54±0.10^{cd}	0.59±0.01^{c}	0.89±0.08^{b}	3.45±0.02^{d}	9.24±0.04^{a}
TLY T_2	55.42±0.42^{d}	6.40±0.00^{d}	0.63±0.01^{ab}	0.71±0.01^{c}	3.41±0.05^{d}	9.25±0.01^{a}
TLY H_3	47.08±0.10^{h}	6.94±0.10^{a}	0.43±0.01^{f}	1.43±0.04^{a}	4.39±0.03^{a}	9.04±0.02^{c}
TLY M_3	51.89±0.02^{f}	6.54±0.10^{cd}	6.94±0.10^{a}	0.95±0.01^{b}	4.21±0.08^{b}	9.09±0.08^{bc}
TLY T_3	52.96±0.11^{e}	6.54±0.10^{cd}	6.54±0.10^{cd}	0.73±0.02^{c}	4.35±0.01^{a}	9.10±0.09^{bc}

Values are means of triplicate analysis ± standard deviation.
Mean ± SD followed by different superscripts in the column are significantly different ($P<0.05$).
TLY = Trifoliate Yam
H_1, H_2 and H_3 = Head region at Harvest time, mid-way into storage and Sprouting time respectively. Similarly M_1, M_2 and M_3 as well as T_1, T_2 and T_3 refers to the Middle and Tail regions respectively.

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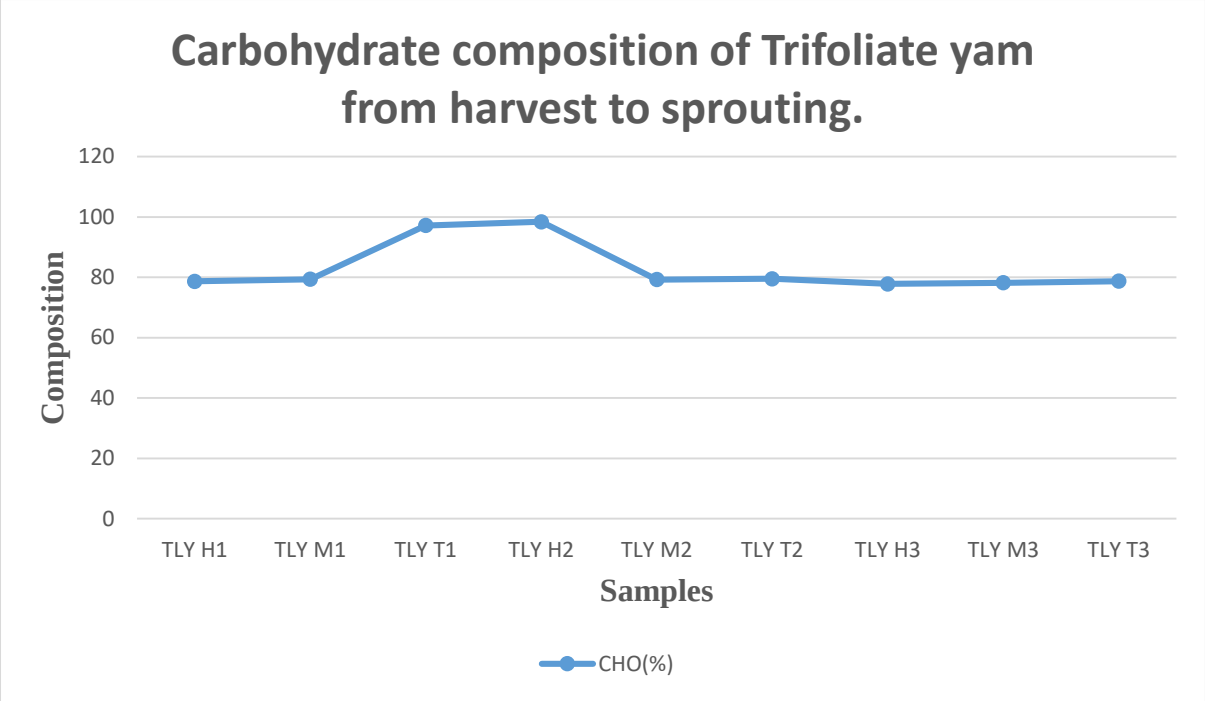

Fig 1. Carbohydrate composition of trifoliate yam from harvest to sprouting.

Percentage Proximate Compositions of *Dioscorea bulbifera* tubers during storage

Result of proximate composition of fresh *D. bulbifera* tubers at three stages during storage showed that moisture content of the tail region immediately after harvest was highest (53.35±0.41%), followed by (52.17±0.50%) of the mid region of the same initial stage. The least was in head region of post sprouted stage (40.07±0.38%). However, the differences among them were significant (Table 4). The highest crude fiber composition was in the head region of the post sprouted stage (1.85±0.01%) while the least was in tail region of initial stage (1.32±0.01%). Ash content composition was highest in head region of third stage (3.49±0.06%), followed by the mid region of post sprouted stage (3.33±0.05%), while the least was in mid region of initial stage (3.10±0.12%) (Table 4). However, the head regions of all the storage gave the significantly highest carbohydrate composition value, the tail region showed the lowest (Fig 2.).

Table 2: Percentage Proximate Compositions of *Dioscorea bulbifera* tubers during storage.

Composition / Samples	Moisture Content	Crude protein	Fat	Crude fibre	Ash Content	Dry Matter
AY H_1	49.67±1.26^{c}	7.41±0.10^{b}	0.73±0.04^{c}	1.71±0.02^{b}	3.15±0.15^{cd}	8.83±0.07^{d}
AY M_1	52.17±0.20^{b}	7.24±0.10^{bc}	0.79±0.03^{ab}	1.49±0.03^{d}	3.10±0.12^{d}	8.90±0.02^{abc}
AY T_1	53.35±0.41^{a}	7.06±0.20^{c}	0.83±0.01^{a}	1.32±0.03^{f}	3.13±0.01^{d}	8.95±0.01^{b}
AY H_2	43.52±0.49^{e}	7.64±0.10^{a}	0.69±0.03^{cd}	1.83±0.01^{a}	3.27±0.02^{bc}	8.93±0.01^{bc}
AY M_2	45.05±0.15^{d}	7.47±0.10^{ab}	0.79±0.01^{ab}	1.60±0.05^{c}	3.15±0.03^{cd}	9.05±0.01^{a}
AY T_2	46.12±0.35^{d}	7.35±0.18^{b}	0.79±0.02^{ab}	1.39±0.02^{e}	3.15±0.01^{cd}	9.11±0.08^{a}
AY H_3	40.07±0.38^{g}	7.70±0.00^{a}	0.67±0.00^{d}	1.85±0.01^{a}	3.49±0.06^{a}	8.85±0.01^{cd}
AY M_3	40.60±0.07^{fg}	7.74±0.10^{ab}	0.78±0.04^{b}	0.65±0.01^{c}	3.33±0.05^{b}	8.91±0.02^{bc}
AY T_3	41.60±1.11^{f}	7.74±0.10^{ab}	0.79±0.01^{ab}	1.47±0.04^{d}	3.33±0.06^{b}	8.95±0.01^{b}

Values are means of triplicate analysis ± standard deviation. Mean ± SD followed by different superscripts in the column are significantly different ($P<0.05$).

AY = Aerial Yam

H_1, H_2 and H_3 = Head region at Harvest time, mid-way into storage and Sprouting time respectively. Similarly M_1, M_2 and M_3 as well as T_1, T_2 and T_3 refers to the Middle and Tail regions respectively.

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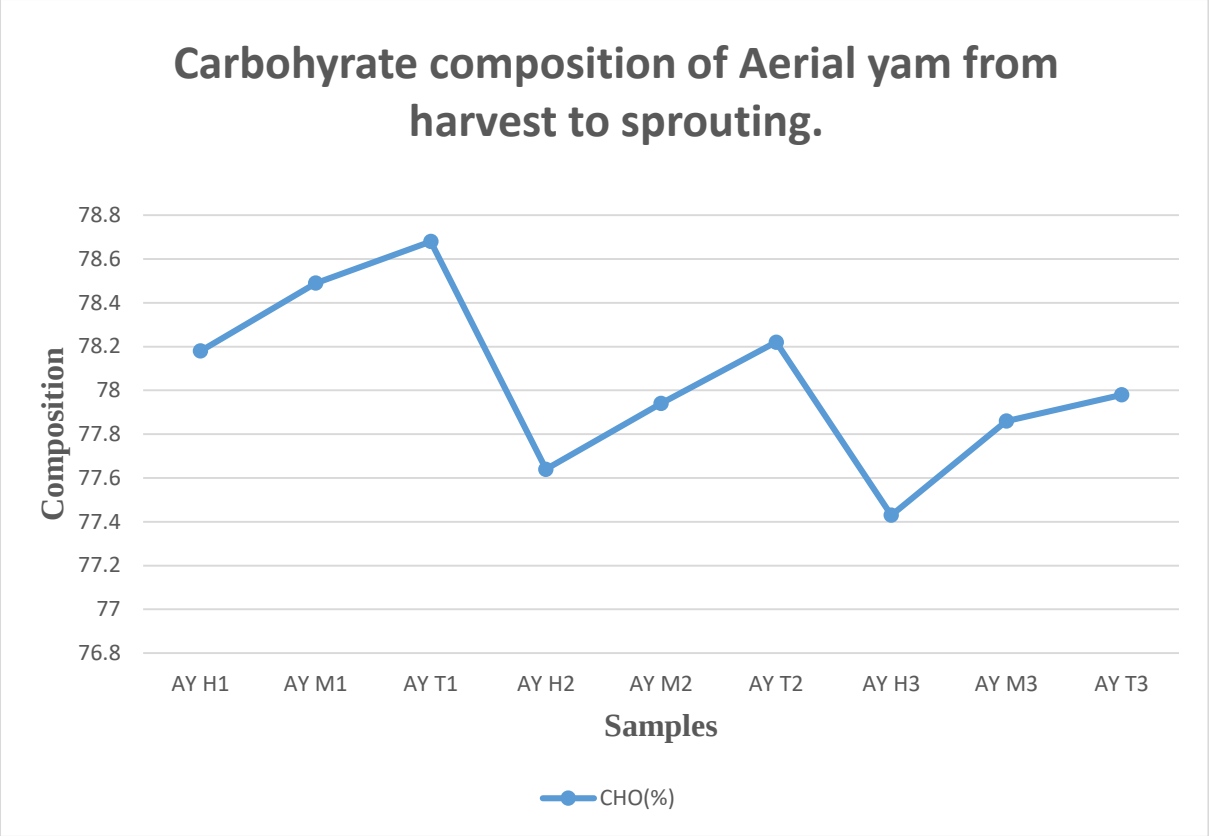

Fig 2. Carbohydrate composition of Aerial yam from harvest to sprouting.

DISCUSSION

Result of the proximate composition revealed that the moisture content was highest immediately after harvest but decrease to the lowest after sprouting. This observation was true for both trifoliate and aerial yams. This result is in line with the report of [9] who stated that in trifoliate yam, the moisture content decreased from very high level immediately after harvest to a low content during and post sprouting stages. The decrease in the moisture content might be as a result of respiratory activities of the tubers. [14], had stated that respiration rates are high at harvest and falls rapidly during curing and remain slow during dormancy of yam tubers. The result of protein content of trifoliate and aerial yams showed a continuous increase in the protein content of the tubers during storage. This result is in line with the report of [15] who reported that proteinase activities increased in *Dioscorea dumetorum* during storage up till post sprouting stage (leave flush). The proteinase may have been increased because of the substrate for its activities must have also increase. [16] and [17] had maintained that in tubers, crude protein level continued increasing until a maximum level was reached, after which it declined. [18], explained this situation as a pattern of changes resulting from some sprouting inhibitory proteins that were synthesised continuously until dormancy was broken when the ratio of sprout promoting to sprout inhibiting protein becomes high. Result of carbohydrate composition of trifoliate and aerial yams displayed interesting feature that gave the tail region in each case the highest carbohydrate composition. For the aerial yam at the three stages of measurement during storage, the carbohydrate content of the tuber proved to be highest at the tail region and lowest in the head at each stage of storage. However, for the carbohydrate content of trifoliate yam, the tail region retained the highest carbohydrate content prior to sprouting, but showed no significant differences at the post sprouted stage. This result may be supported by the fact that during storage (immediately after harvest), the carbohydrate transformation enzymes such as amylases increase in activities, thereby converting the starch to sugars which are subsequently utilized by the tuber during sprouting. It is known that the sugars in various forms such as glucose are used in respiration as source of energy for the survival and sprouting of the tubers [15]. With the mobilization and utilization of carbohydrate especially at head and middle regions where primary sprouting due occur, the carbohydrate constituent are bond to decrease while the carbohydrate content of the tail region would remain highest. For the trifoliate yam, non-significant differences among the carbohydrate content of the head, middle and tail regions from pre sprouting stage, is an indication that distribution of carbohydrate in the tuber is non directional. This result is in line with the work of [19] who reported that in *D. cayenensis*, the distribution of enyzme activities, (amylases) was essentially same in both the head, middle and tail portions of the tubers. [20] had found in potato tubers that the change in sugar in all regions (head, middle and trail) occur simultaneously without significant differences among them. Result of the experiment showed increase in the dry matter of the tubers during storage. This is in line with the apparent reaction of plant which shows that with reduction in moisture content (during increase in respiration) the dry

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matter composition increases [21], [22] and [23] and decrease respiratory rate for storage processes do lead to increased dry matter. Furthermore, [24] concluded that decrease respiratory rate during storage processes lead to dry matter gain.

CONCLUSION

This study revealed that there is mobilization and utilization of proximates in *Dioscorea dumetorum* and *Dioscorea bulbifera* during storage. The results showed that the mobilized nutrients were utilized at different regions during storage (head, middle and tail). Deterioration of tubers in storage may be as a result of the activities of some enzymes which metabolize the tuber constituents for mobilization and subsequent utilization. Reduced carbohydrate in tubers during storage confirmed its use in catabolic activities including increased respiration and elevated energy generation towards sprouting. Therefore, these changes lead to a decline in the nutritional value of the tubers except for protein, fat and ash contents.

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