Investigation of Carbohydrate Content of White Yam (*Dioscorea rotundata*) Tubers Stored in Cold Storage Structure

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ABSTRACT
Background: *Yam tuber (Dioscorea species) is one of the major carbohydrate crops and deteriorates fast after harvesting if not properly stored.*
Objective: *This study investigated the carbohydrate content of yam tubers stored in cold storage.*
Methods: *Cold storage structure developed in 3 replicates was used for the storage of yam tubers, each of the cold storage structures was set at a temperature of 10, 15, and 20 degrees centigrade respectively. 100 kg of yam tubers were stored inside each of the cold storage structures. The carbohydrate content of the yam tubers was evaluated for 6 months using standard methods at the beginning of the experiment and subsequently at an interval of a month (30 days) during the storage period. Data obtained were analyzed with the use of R-software.*
Results: *The results showed that the carbohydrate content of the stored yam tubers varied from 26.15 to 31.01 % while the coefficient of variation for yam tubers stored at 10, 15 and 20 degrees centigrade was 5.25 %, 5.17 %, and 3.26 % respectively indicating that 20 degrees centigrade was the best storage temperature that would prevent deterioration of yam tubers. Yam stored in cold storage at this temperature is capable of having a long shelf life.*
Conclusion: *The study showed that yam tubers could be stored in cold storage for a longer period and still retain its nutrient. Storage of yam in cold storage is recommended.*

Keywords: Carbohydrate, Cold Storage, Preservation, Temperature, Yam.

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INTRODUCTION

Yam is a tropical crop and belongs to the genus Dioscorea which is the largest genus of the family Dioscoreaceae having between three and six hundred species (1, 2). The period from planting to maturity of yam varies from about 6 - 12 months. Single-harvested tubers had better-eaten quality than the double harvested tubers (3). The tuber sizes vary from 2.5 to 5 kg and vine lengths are 10 – 20 meters long (4, 5). Yam belongs to the semi-perishable class of food due to its relatively high moisture content and vulnerability to gradual physiological deterioration after harvesting (6). Yams, unlike cassava, are normally stored fresh (7). Yam stores relatively longer in comparison with other tropical fresh produce and represents stored wealth which can be sold all year round by the farmer or marketer.

In Nigeria, yam is one of the major tuber crops in the economy (5). Most of the World production of yam is from Africa (about 96 %) with Nigeria alone accounting for nearly 75 % of the total

World production (9). Research records show that Nigeria is one of the leading producers of yams in the World (10, 5). The increase in production is mainly due to an increase in the area of production (11, 5).

Yam is an excellent source of carbohydrates, which provides calorific energy (8, 2). The energy needed by man to do work is obtained from the carbohydrate food we eat which must be kept in good condition. The lack of adequate storage structures is responsible for most of the postharvest losses experienced in developing countries. All the traditional structures (barn, underground pit, ground surface platform, delay harvesting) used for storing yam could not maintain its freshness for a long time. A modern storage structure that would maintain the freshness of yam tubers for a longer time to obtain their carbohydrate content was developed. Carbohydrate content was used to determine the quality of yam because yam is regarded as a high carbohydrate food. This study was, therefore, planned to investigate the carbohydrate content of the yam tubers stored inside the cold storage to examine the quality and freshness of the stored yam tubers at their minimal storage temperature.

MATERIALS AND METHODS

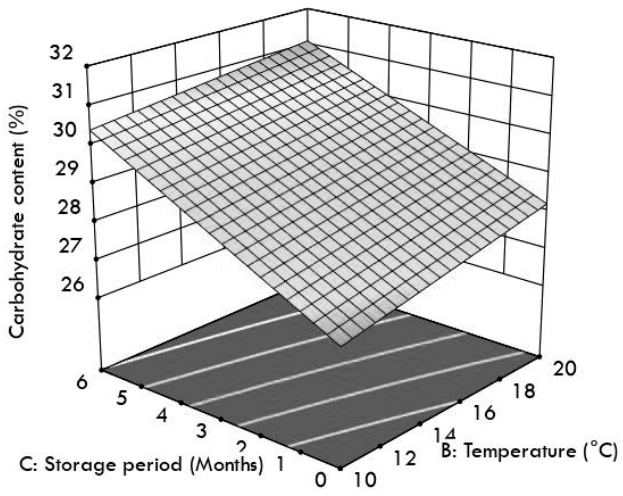
100 kg of early maturing species of white yam tubers cultivated in Ekiti State of Nigeria were used for this experiment that was carried out at the Department of Agricultural and Environmental Engineering, the Federal University of Technology, Akure located in the rainforest zone of the southwestern region of Nigeria within Latitudes 7o 14' and 7o 17' North and Longitudes 5o 08' and 5o 13' East. The factors considered during the design and construction of the cold storage have been reported somewhere before this work.

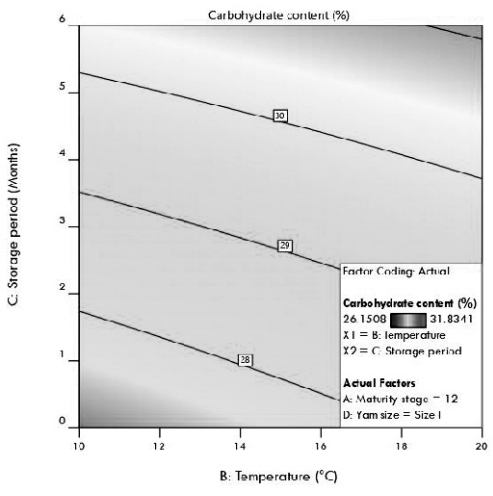
The cold storage structure was developed in 3 replicates and each set at the temperature of 10, 15, and 20 degrees centigrade respectively was used for this experiment. The size of yam was also varied from 1 – 2 kg as small, 2.1 – 3 kg as a medium, and above 3.1 kg as big, stored for 6 months storage duration thereby constituting a 3 x 3 x 3 experimental design.

The matured tubers were harvested 12 months after sowing and cured underground for 6 weeks before putting them inside the cold storage structures. All the tubers were carefully selected to avoid any sign of spoilage like rot and bruise. The carbohydrate content of the yam tubers stored in the cold storage structures was determined at the beginning of the experiment and subsequently at an interval of a month (30 days) during the storage period according to (12) methods of analysis. The results obtained were analyzed with the use of R-software.

RESULTS

The results of the carbohydrate content of the proximate composition are shown in figure 1.





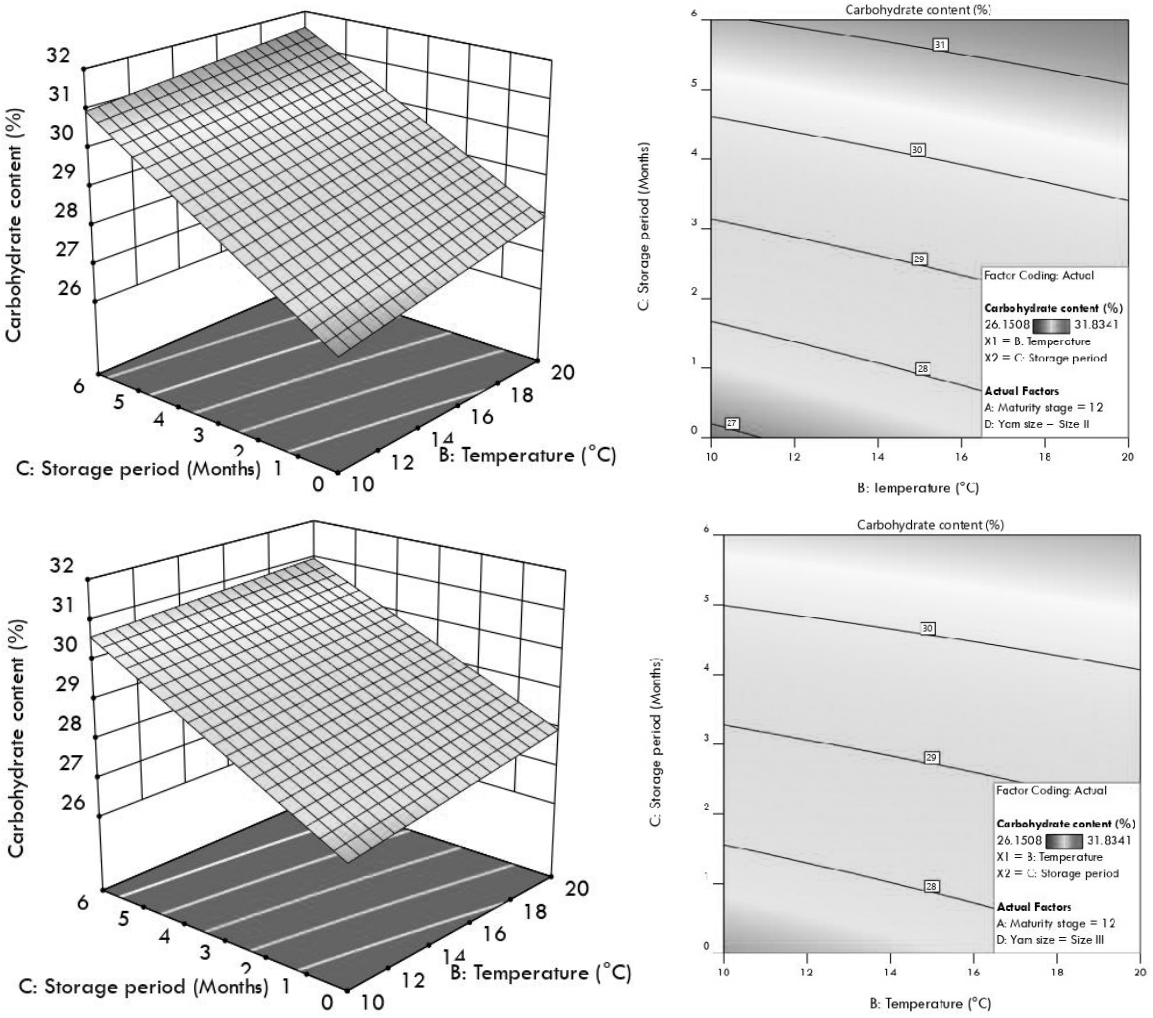


Figure 1: Carbohydrate content of yam stored for 6 months at 12 months maturity stage under the storage period and different yam sizes, and temperature

From the results, it can be observed that the carbohydrate content of the three sample sizes of yam tubers in the storage system ranges from 26.15 % - 31.69 %, 26.16 % - 31.78 %, and 26.26 % - 31.83 % for the yam size small, medium, and big respectively. Tables 1, 2, 3, and 4 show the results of the analysis of variance (ANOVA) of the carbohydrate content of yam tubers in the storage structure. Tables 2, 3, and 4 show the results of the ANOVA of the carbohydrate content of tubers stored under temperatures of 10, 15, and 20 degrees centigrade respectively.

From the tables, it was observed that the results of the carbohydrate content of the stored yam tubers indicate that the physiological, nutritional contents, and freshness of the tubers remain the same throughout the storage time.

DISCUSSION

It can be observed that the values of the carbohydrate content of the yam tubers stored in cold storage structures corroborate with that of (13) who reported 40.61 % of the carbohydrate content of fresh white yam. (14) also reported a similar pattern with higher values and observed that the carbohydrate content of the fresh yam is 66.31 % and 69.76 % during a comparison of the proximate composition of raw and fried yam. The lower value of the carbohydrate content in this study might be due to the varietal difference between the yam tuber and planting regions. It

Table 1: Analysis of variance for the carbohydrate content of the stored yam

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	130.39	14	9.310	15.890	< 0.0001	significant
A-Maturity stage	54.93	1	54.930	93.710	< 0.0001	
B-Temperature	5.93	1	5.930	10.120	0.0021	
C-storage period	33.20	1	33.200	56.650	< 0.0001	
D-Yam size	0.86	2	0.429	0.733	0.4841	
AB	0.92	1	0.921	1.570	0.2138	
AC	19.00	1	19.000	32.410	< 0.0001	
AD	1.53	2	0.765	1.300	0.2774	
BC	0.37	1	0.374	0.637	0.4272	
BD	0.27	2	0.137	0.234	0.7917	
CD	0.88	2	0.441	0.753	0.4745	
Residual	43.96	75	0.586			
Cor Total	174.35	89				

Table 2: Analysis of variance for carbohydrate content at 10°C

	DF	SS	MS	Fc	Pr>Fc
Treatment	2	0.333	0.16674	0.074848	0.92823
Residuals	15	33.416	2.22774		
Total	17	33.750			

CV = 5.25 %

Table 3: Analysis of variance for carbohydrate content at 15°C

	DF	SS	MS	Fc	Pr>Fc
Treatment	2	0.268	0.13392	0.058945	0.94298
Residuals	15	34.081	2.27205		
Total	17	34.349			

CV = 5.17 %

Table 4: Analysis of variance for carbohydrate content at 20°C

	DF	SS	MS	Fc	Pr>Fc
Treatment	2	0.218	0.10902	0.11963	0.88808
Residuals	15	13.670	0.91131		
Total	17	13.888			

CV = 3.26 %

was observed that the yam tuber has the minimum carbohydrate content before it was stored in the storage system, the recorded values were 26.15 %, 26.16 %, and 26.26 % for the small, medium, and big yam sizes respectively. The highest carbohydrate content in this study is slightly lower than the range of values (36.02 ± 0.22 % - 50.60 ± 0.01 %) reported by (15) during comparative studies on the proximate composition of three tubers of *Dioscorea* species.

A unit increase in the temperature resulted in an average increase in the carbohydrate content of yam in the storage system by 0.08 %, 0.07 %, and 0.04 %, for the small, medium, and big yam sizes respectively, while 0.27 % 0.39 % and 0.29 % increase in the carbohydrate content was observed for the yam size small, medium and big respectively. The relationship between the maturity stage, temperature, storage period, and carbohydrate content of yam is shown in Equation 1 – 3 for the yam size small, medium, and big respectively. The model determination coefficient (R^2) is 0.7479 and this shows that the equation can significantly ($P<0.05$) predict about 74.79 % change in the carbohydrate content of yam as a function of the yam size, maturity stage, temperature, and storage period

The CV for the carbohydrate content of the three tuber sample sizes stored in cold storage set at 10, 15 and 20 degrees centigrade was 5.25 %, 5.17 %, and 3.26 % as presented in tables 2, 3, and 4 respectively. It indicated that the storage temperature of 20 degrees centigrade is the best followed by 15 degrees centigrade. The results obtained from the nutritional composition compared well with the findings of 15 – 40.61 % carbohydrate content present in white yam reported by (16). This finding was in agreement with the result reported by (17) that yam tubers could be preserved at temperatures ranging between 15 and 17 degrees centigrade. Also, (18) and (19) reported that yam tubers could be stored at 15 and 16 degrees centigrade respectively. The temperature value in this study might be due to the cultivar and planting region of the tubers. Also, the results indicate that size of the tubers has no significant difference in the carbohydrate content and the freshness of the tubers stored inside these structures.

CONCLUSION AND RECOMMENDATIONS

This study evaluated the carbohydrate content as a parameter to investigate the quality and freshness of yam tubers stored in the cold storage

$$CC_1 = 39.41 - 1.13MS - 0.08T - 1.26SP + 0.02MST + 0.16MSSP - 8.15x10^{-3}TSP \quad (1)$$

$$CC_{11} = 40.12 - 1.2MS - 0.09T - 1.14SP + 0.02MST + 0.16MSSP - 8.15x10^{-3}TSP \quad (2)$$

$$CC_{111} = 42.36 - 1.34MS - 0.12T - 1.24SP + 0.02MST + 0.16MSSP - 8.15x10^{-3}TS \quad (3)$$

where CC1 is the carbohydrate content of the small yam size,
CC11 is the carbohydrate content of the medium yam size,
CC111 is the carbohydrate content of the big yam size, MS is maturity stage (months),
T is the temperature (°C) and SP is storage period (months)

The results from the experiment predict that tubers stored under the temperature of 10, 15, and 20 degrees centigrade has a Coefficient of Variation (CV) of 5.25 %, 5.17 %, and 3.26 % as shown in tables 2, 3, and 4 respectively. These indicate that tubers stored under the temperature of 20 degrees centigrade which was the temperature of the cold storage structure with the least CV were the best storage temperature for this research work followed by 15 degrees centigrade.

structure. The developed cold storage structure naturally eliminated the tubers freezing or chilling injury. The study showed that the best storage temperature was 20 degrees centigrade followed by 15 degrees centigrade. The findings of this study revealed that yam could be stored for a longer period in cold storage and still retain its nutrient. This will serve as a benchmark for future similar research on the cold storage of yam tubers. Storage of yam in cold storage structure at 20 degrees centigrade storage temperature by

farmers is recommended. In addition, the full performance evaluation of the cold storage system with other yam tuber sample species should be done.

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