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Quantitative Determination of Sugars in Three Varieties of Cassava Pulp

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Authors' contributions

This work was carried out in collaboration between all authors. Author MAO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MAO and BO managed the analyses of the study. Authors GKA and AEA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Carbohydrate stands out among the various classes of food synthesized by plants. It has the highest proportion in cassava tuber which is a staple root crop in many developing countries, especially in West Africa. This research is aimed at determining the sugar contents in cassava tuber. In this examination, the sugar contents were further analyzed at the development phases of the tubers.

Study Design: The root tubers of three cultivars which included TMS 98/0581, TMS 98/0505 and TMS 98/0524 from Otukpo Local Government Area, Benue State, Nigeria were investigated. The samples were collected in triplicates. Samples were collected between the month of November to April.

Methodology: The starch and sugar contents were determined by techniques described by A.O.A.C.

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Results: The outcome from this finding uncovers that the Cassava varieties studied had appreciable quantities of sugars and starches. The result shows the following ranges of values amongst the varieties: total sugar (4.02 - 5.58)%, non-reducing sugar (2.74 - 4.24)%, reducing sugar (0.28 – 0.34)%, sucrose (2.60 – 4.03)% and starch (27.98 – 38.34)%. Variations were observed in the sugar content with sucrose and reducing sugar recording a mean value across the varieties of (0.82 – 4.15)% and (0.83 – 2.03)% respectively from November - March.

Conclusion: Reducing sugar and sucrose are important sugars in cassava, which serve as the immediate product of photosynthesis and the fundamental requisite for the synthesis of sucrose. Results from this finding, will be used to enlighten farm extension workers on the requirement for improved photosynthetic process, as a way to build starch yield in cassava tuber. This research will also be used as a pointer in enhancing better awareness on the right season of harvest targeted towards improved nutritional yield in tubers.

Keywords: Sugar; sucrose; starch; cassava; carbohydrate.

1. INTRODUCTION

Cassava (*Mannihot esculenta* Crantz) is a tropical root that has primarily sugars in its composition, for example, starch, glucose, sucrose and fructose [1,2]. Cassava is a major staple root crop grown in over 90 developing countries, particularly in West Africa, with Nigeria being the largest producing country in the world [3,4]. Starch has a special synthetic and physical attributes and nutritious quality, which set it apart from every single other sugar. It occurs naturally as a discrete particles called granules, which are composed of a blend of two polymers – amylose and amylopectin [5,6]. In addition, it has high purity, viscosity and dissolvability, making it to be effortlessly swollen, compared with other starches such as Potato, Rice and Corn [3]. Starch is the major caloric source in an assortment of weight control plans of individuals [3]. Starch assumes a vital part in creating sustenance items, either as a crude material or as a nourishment added substance, for example, a thickener, gelling agent, stabilizer, or surface enhancer [7]. Corn, potato, and cassava are the most well-known source of starch for such enterprises [7,8,9]. Starch are partitioned into the following groups; monosaccharides (simple sugars that are the simplest members of carbohydrates, cannot be subjected to hydrolysis); oligosaccharides (consists of small number of monosaccharides, usually two to ten molecules, with disaccharides being the most common in foods; polysaccharides (consist of large amount of monosaccharides) [10]. They vary in their physical and chemical properties compared to monosaccharides. Most important polysacharides in food are starch, glycogen and cellulose [8,10]. The final products of starch processing in the digestive tract are totally glucose, fructose, and galactose. Since glucose is the main starch that can be oxidized in muscle, a significant part of the fructose and all of galactose are transported to the liver, after assimilation from the intestinal tract, and changed over into glucose [11]. The transformation takes place in the liver at lower rates [10]. Basic monosaccharides, for example, glucose can be specifically consumed by the host. Disaccharides, for example, maltose, lactose and sucrose can be hydrolyzed to their particular monosaccharides, yet the capacity to process complex plant polysaccharides, for example, inulin, pectin and xylan is exceptionally constrained [12,13]. Cassava waste as raw material in ethanol production, not only reduces waste material engendered from starch Industry, but additionally lowers the cost of ethanol engenderment [14]. Other findings have also revealed that cassava peels are rich in carbohydrate. It also contains moderate amounts of minerals [15]. The significance of reducing sugar cannot be overemphasized on the grounds that it is a fundamental raw material for the production of ethanol, a good option as transportation fuel in this era [16]. Ethanol is beneficial to mankind; it can be used as solvent, disinfectant, radiator fluid and intermediate for other natural chemicals [14,16]. It is an inexhaustible biofuel that could be produced from plant biomass and consumed successfully in car motors without emanation of perilous gases into the environment [17]. This research is aimed at determining some simple sugar in cassava tuber as the look for elective vitality has turned out to be central because of anthropogenic emanation of green house gases, which begin from the combustion of non-renewable energy source as coal, oil and gaseous petrol [18].

2. MATERIALS AND METHODS

2.1 Sample Collection

The root of three varieties of cassava obtained in triplicates from three distinct locations in Otukpo Local Government Area of Benue State were considered. The samples were collected at different maturity stages (November to April). Their exchange characters were validated at the Benue State Agricultural Research and Development Agency (BNARDA), Makurdi, Benue State, Nigeria. The varieties are: (TMS 98/0581), (TMS 98/0505), and (TMS 98/0524).

2.2 Sample Preparation

Cassava samples were gathered and transported to the research facility at the Benue State University laboratory without cutting the stem, while the tubers were covered with black polythene bag. At the laboratory, the samples were cleaned, peeled and washed with consumable water. Samples were cut into minor bits and dried at 60˚C for 48 h in an oven. The dried samples were ground into flour. The flour samples were then bundled into polypropylene sacks and kept at room temperature for analysis.

2.3 Starch Determination

Sedimentation technique was utilized for the extraction of starch [19,20]. The tubers were sorted out and washed with clean water. The tubers were peeled, washed, with clean water to remove all the dirt and ground into pieces. The 300 g of the samples was weighed and processed with 800 ml of water utilizing a blender. The resulting solution formed was filtered through a perfect cheddar material. The solids held by the fabric were further washed with water and filtered through the cheddar material to remove all retained starch filtrate. The solution was kept undisturbed for 15 hours and the fluid decanted and disposed off. The starch was air dried at room temperature and the dried weight reported as percentage fresh weight.

2.4 Determination of Total Sugars

Technique described by A.O.A.C was used for the determination of total sugar [19,20]. Ten grams of the sample were dissolved in 100 ml of distilled water and 10 ml of concentrated HCl was added to the solution and warmed in a water bath for 8 minutes which was then neutralized with NaOH. The solution was diluted further and made up to 200 ml with distilled water and filtered. Thereafter, 25 ml of mixed Fehling's solution was pipetted into a conical flask, followed by the addition of 15 ml of the solution from the burette. The solution was heated and three drops of methylene blue were added when boiling began. Further quantities of the solution were added from the burette (1 ml at a time) at 10 seconds interval to the boiling liquid until the indicator was completely decolourized. The titre values obtained corresponded to the sugar content reported in mg/100 ml.

2.5 Determination of Reducing Sugars, Non-reducing Sugars and Sucrose

Reducing sugars were determined by methods described by A.O.A.C [19,20]. About 10 g of the sample was dissolved in 50 ml of distilled water. The solution was made up to 100 ml with distilled water and filtered. About 25 ml of the mixed Fehling solution was pipetted into a conical flask followed by the addition of 15 ml of the solution from the burette. The solution was heated and on boiling, three drops of methylene blue were added. Few more drops of the solution were added from the burette 1 ml at a time to the boiling liquid until complete decolourization of the indicator was observed. The titre values obtained corresponded to the sugar content reported in mg/100 ml. The non-reducing sugars content was obtained by subtracting the reducing sugars from that of the total sugars. Multiplying the non-reducing sugar content by a factor of 0.95 gives the sucrose content in mg/100 ml.

2.6 Statistical Analysis

Examination of differences among the cassava varieties was conducted at a level of significance of $p<0.05$ using an SPSS programme, version 21.

3. RESULTS AND DISCUSSION

3.1 Sugar and Starch Contents

Table 1 shows the sugar contents of the cassava varieties studied at harvest. Variations were observed in the total sugar content of the cassava varieties which ranged between 4.02% to 5.58%. The variety TMS 98/0581 had the highest value, while TMS 98/0524 recorded the lowest value. Results obtained from these findings fell within the range of 1.58% to 7.50%

reported in another study [21,22]. It was observed that the reducing sugar content of the cassava varieties varied with ranges from 0.28% to 0.48% with TMS 98/0581 recording the highest value and TMS 98/0524 the lowest value.

Result from this research reveals that all varieties had their reducing sugar contents below value of 1.67 g/100g in other examination [23]. Non-reducing sugars varied with ranges from 2.74% to 4.24% with TMS 98/0581 being the highest and TMS 98/0524 the lowest. The result shows that non-reducing sugars formed the major components of the total sugars of the cassava varieties. The results for sucrose content, shows variations amongst the varieties which ranged from 2.60% for TMS 98/0524 to 4.03% for TMS 98/0581. Result from other findings reveals that 17% of the cassava root is made up of sucrose, which is higher that result of sucrose content from this report [24,25]. Reported one way analysis of variance of the total sugars, reducing sugar, non-reducing sugar and sucrose data showed that there were significant differences ($p<0.05$) amongst the cassava varieties, except for TMS 98/0505 and TMS 98/0524 values that were not significantly different within this range for reducing sugar and sucrose content.

Variation was observed in the starch content of the cassava varieties which ranged from 27.94% to 38.34%. TMS 98/0524 had the lowest while TMS 98/0581 had the highest starch content. Results from this finding reveals that the starch content was within the range of 25% and 35% [26,27], but higher than reported value of 3.32% and 23.24% in other study [23]. Significant differences ($p<0.05$) were observed amongst the cassava varieties.

3.2 Monthly Variations in Sugar Content

The reducing sugar is the immediate product of photosynthesis and an essential substance for sucrose synthesis. These sugars are the two fundamental soluble sugars in cassava. During the maturity period (November - February), an increase in the sucrose content was observed. Table 2 shows that a decrease was observed in the month of March (1.98 to 2.24)% which then recorded a slight increase during the period of harvesting (2.80 to 4.03)% as reflected in Table 1. This decrease could be due to weak starch synthesis ability in the tuberous roots as most of the reducing sugar are converted into sucrose which is needed for starch synthesis. This slight increase in sucrose content could account for this assertion as shown in Fig. 1.

The reducing sugar contents decreased slightly across the months in all the varieties with a mean

Table 1. Sugar contents of cassava tuber at harvest

Varieties	*n*	Starch	Total sugar	Reducing sugar	Non-reducing sugar	Sucrose
TMS 90/0581	3	$38.34^{a}\pm0.72$	$5.58^{a}\pm0.01$	$0.34^{b}\pm0.01$	$4.24^{a}\pm0.01$	$4.03^{a}\pm0.01$
TMS 98/0505	3	$34.83^{b}\pm0.11$	$4.54^{b}\pm0.02$	$0.48^{a}\pm0.01$	$2.95^{b}\pm0.02$	$2.80^{b}\pm0.01$
TMS 98/0524	3	$27.94^{c}\pm0.04$	$4.02^{c}\pm0.01$	$0.28^{c}\pm0.02$	$2.74^{c}\pm0.11$	$2.60^{c}\pm0.01$
Mean±SD		33.70±5.29	4.71± 0.79	0.37±0.10	3.31±0.81	3.14±0.77

a, b and c show the variance of the three cultivars, as determined by ANOVA at p < 0.05. n=sample size. SD= Standard deviation

Table 2. Changes in the sucrose content

Varieties	*n*	Months of maturity				
		November	December	January	February	March
TMS 98/0581	3	$0.89^{a}\pm0.10$	$0.92^{a}\pm0.11$	$2.31^{a}\pm0.21$	$4.42^{a}\pm0.00$	$2.24^{a}\pm0.10$
TMS 98/0505	3	$0.75^{c}\pm0.01$	$0.81^{c}\pm0.16$	$1.96^{c}\pm0.17$	$3.92^{c}\pm0.01$	$1.98^{b}\pm0.12$
TMS 98/0524	3	$0.82^{b}\pm0.01$	$0.89^{b}\pm0.12$	$2.08^{b}\pm0.14$	$4.11^{b}\pm0.02$	$1.94^{c}\pm0.01$
Mean±SD		0.82±0.07	0.87±0.06	2.12±0.18	4.15±0.25	2.05±0.16

a, b and c show the variance of the three cultivars, as determined by ANOVA at p < 0.05. n=sample size SD= Standard deviation range of (2.03 to 0.83)% until the harvesting period as shown in Table 3. The decrease in the reducing sugar content could be as a result of the decrease photosynthetic activities toward the mature phase of the tuber development. Previous findings on starch synthesis in plants indicated a possibility of the translocation of reducing sugar over a long distance in the phloem as not feasible, but its presence in the phloem as reported in other findings could be as a result of the degradation of sucrose in the phloem [28]. The result further indicated that towards the maturity stage of the tuber development, the plant produces more sucrose needed for the synthesis of starch in the tuber hence this could account for further decrease in the reducing sugar content as shown in Fig. 2.

Plant cells depend on sucrose, a highly soluble disaccharide as a source of energy. Results from this findings shows that there was a positive correlation between the sucrose content and the starch as described in Fig. 3. In other literature, starch has been reported to be synthesized in

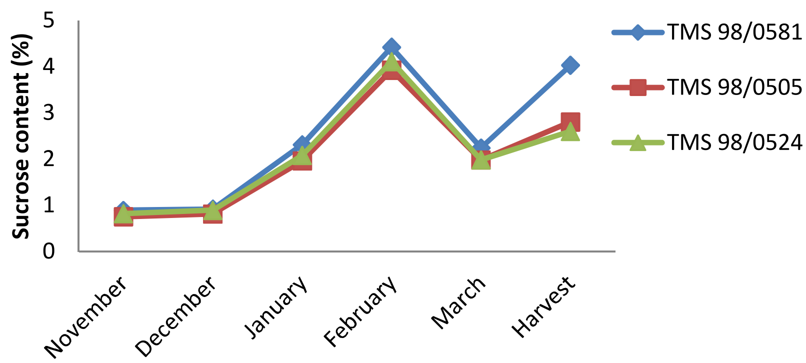

Fig. 1. Variation of sucrose content with month of maturity

Table 3. Changes in the reducing sugar content

Varieties	*n*	Months of maturity				
		November	December	January	February	March
TMS 98/0581	3	2.12^a±0.12	1.32^b±0.24	1.24^a±0.04	0.96^a±0.00	0.95^a±0.21
TMS 98/0505	3	1.94^c±0.17	1.29^c±0.11	0.98^c±0.01	0.72^c±0.22	0.72^c±0.13
TMS 98/0524	3	2.03^b±0.18	1.43^a±0.17	1.02^b±0.03	0.84^b±0.01	0.83^b±0.18
Mean±SD		2.03±0.09	1.35±0.07	1.08±0.14	0.84±0.12	0.83±0.07

a, b and c show the variance of the three cultivars, as determined by ANOVA at $p < 0.05$. n=sample size. SD= Standard deviation

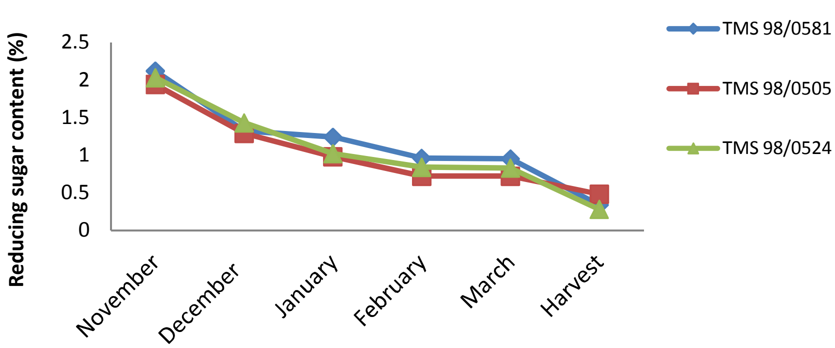

Fig. 2. Variation of reducing sugar content with month of maturity

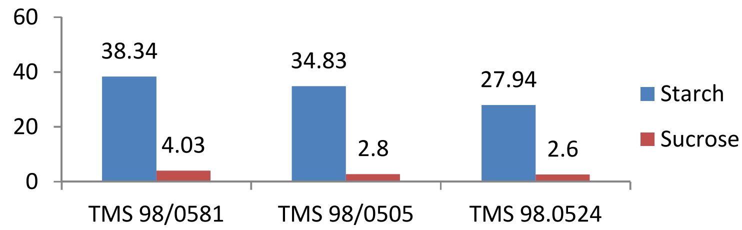

Fig. 3. Composition of starch and sucrose content

the leaves with sucrose as one of the important sugar source during the day, then degraded for energy metabolism requirements at night [29,30]. The result from this finding is a clear pointer that, keeping up a ceaseless sucrose supply is essential for high starch amassing in the roots.

4. CONCLUSION

Cassava varieties studied had appreciable quantities of sugars and starch. These values were significantly different amongst the cassava varieties. TMS 98/0581 varieties recorded higher sugar and starch levels of 5.58% and 38.34% respectively as compared to the other varieties which had relatively lower concentrations. This research reveals that TMS 98/0581 has a high score impact, suitable for fermentation, and could be successfully used as raw material for industrial production of ethanol used as biofuel, and as an adhesive in paper making. In conclusion, farm extension workers should be enlightened on the importance of seasonal impact on sugar variation, as the decrease in sucrose content can be enhanced by improving photosynthetic process, which is reflected to be highest (4.14%) at the early part of the year with relatively high sunshine for photosynthesis, which can also serve as a better approach to expand starch yield in the underlying foundations of cassava. Furthermore, the result from this finding, opens up the need for more enquiries on whether the high starch accumulation in the tuber, correlates with the transport capacity of the stems.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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