

Biochemical Composition and Glucose Syrup Production Potential of Elite Yam Varieties from Benue State, Nigeria

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Abstract

The starchy tubers of five elite white yam (*Dioscorea rotundata*) varieties (Okpani, Hembra, Ogoja, Dorban and Ameh) from Benue State (North – Central, Nigeria) were biochemically assessed as possible raw materials for the production of glucose syrup and yam flour. Glucoamylase enzyme was used in profiling the rate of glucose production. The glucose production was monitored using the glucose oxidase method. Standard phytochemical methods were used to determine the proximate composition and mineral content of the samples. Results showed that the gelatinized starch slurry of Okpani variety gave the highest rate of glucose syrup production (60%) at 24 hours reaction time followed equally by those of Hembra and Ameh (55%) respectively. The five elite yam varieties had a pre-processing proximate composition of 3.01 – 3.81% protein, 0.81 – 1.03% fat, 1.46 – 1.74% crude fibre, 1.29 – 1.31% ash and 47.41 – 48.78% moisture. The calculated caloric values and total carbohydrate were (198.15 – 203.62 Cal/100g) and (43.99 – 45.13%). The mineral analyses showed that the yam varieties had appreciable values for mineral elements such as 0.36 – 0.57mg/100g phosphorus, 0.30 – 0.70mg/100g potassium, 0.07 – 1.20mg/100g calcium, 0.38 – 0.47mg/100g magnesium, 0.02 – 0.05mg/100g iron, 0.05 – 0.07mg/100g sodium and 0.01 – 0.03mg/100g zinc. The futuristic potentials of the obtained values were discussed in the paper.

Keywords: *Dioscorea rotundata*; Glucoamylase; Glucose Syrup; Biochemical Analyses

Introduction

Nigeria is presently the largest producer of edible yam with Benue State producing a substantial quantity of the national output. The indigenes of Benue State are also noted to consume the crop mainly as pounded yam (yam fufu) or boiled yam (to a lesser extent) as well as make

sales. Though the starchy yam tuber is processed and utilized as yam flour (elubo/alubo) largely in South – West and South – East Nigeria, there is no documented research work on the use of Benue yams for yam flour or other analytical products such as starch and/or sugar syrup. Many industrial products such as modified starches, maltodextrins, high fructose syrup (HFS), glucose syrup,

gums, adhesives, bioethanol, etc are made from starch [1]. The industrial processing of starch to sugars can be carried out either by acid or enzyme hydrolysis. Production of glucose syrup by acid hydrolysis however produces variable quality of the syrup due to the difficulty of controlling the reaction [2]. Also the higher dextrose equivalent syrups made by acid hydrolysis tend to have a bitter taste and dark colour due to the production of hydroxymethylfurfural and other products of reversion such as gentiobiose, isomaltose and trehalose which give unacceptable flavors to the syrup [3]. Starch pastes of all types are susceptible to hydrolysis by amylolytic enzymes resulting in shorter polymer chain lengths and sharply reduced viscosities and can easily be hydrolyzed to form syrup containing dextrose, maltose and other oligosaccharides [4]. The production of syrups by enzyme method is amongst the most advanced food technologies characterized by higher yields, wide range of products, higher product quality and energy economy [5,3]. With enzymes it is possible to produce syrups with dextrose equivalent from 28 and up to 98. These biological approaches of using enzymes in glucose syrup production has become economically attractive for biotechnological industries and with the increase in demand for sugar both for nutrition and industries, enzyme technology has thus led to a decrease in the high costs of glucose syrup production [6]. Glucose syrup is a concentrated aqueous solution of glucose maltose and other nutritive saccharides from the hydrolysis of edible starch. Glucose syrup is used in large quantities in fruits, liquors, bakery products, pharmaceuticals and brewery products as well as in cosmetics industries. It is used in food to soften texture, add volume, prevent crystallization of sugar and enhance flavor. Its major uses in commercially prepared foods are as thickener, sweetener and humectants [5]. In the absence of yam product diversification, farmers in Benue State may suffer economically if and when there is a heavy glut in the yam market. This study is therefore aimed at biochemically assessing the potential production of glucose syrup and energy rich yam flour from the elite yam varieties of Benue State of Nigeria.

Materials and Methods

Chemicals: All chemicals were of analytical grade.

Yam Varieties: The yam varieties were originally obtained from Benue State by the yam programme of National Root Crops Research Institute (NRCRI) Umudike, Umuahia. Abia State. Nigeria.

Enzymes: Alpha- amylase was obtained commercially from Sigma Industries Ltd.

Glucoamylase – The production of glucoamylase was carried out by surface culture of *Aspergillus niger*, isolated from the soil using Sabourand agar supplemented with penicillin.

Isolation of glucoamylase enzyme: Organism, culture and enzyme production.

Aspergillus niger was isolated from the soil sample and identified according to the method of Polakovic and Bryjak, [7] with slight modifications. One gram (1g) of soil sample taken from the top 20cm of the soil was dissolved in 10ml of distilled water and serial dilutions were transferred to petridishes containing Sabourand agar (glucose 4%, peptone 1%, CuSO_4 0.001% and agar 1.5%) and supplemented with 500mg/l of penicillin. After inoculating the soil sample, the culture plates were incubated for 7days at 30°C. Then after growth, the fungal species were further isolated by dilution plate and single pore culture method and then subjected to taxonomic studies according to Polakovic and Bryjak [7]. The spores (10^7ml^{-1}) were transferred to 500ml of liquid medium consisting of yeast extract 1%, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ 1%, FeSO_4 , 0.01%, $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$, 0.01%, KH_2PO_4 , 0.02%, $(\text{NH}_2)\text{SO}_4$, 0.125% and starch 1%. After incubation under constant shaking (150rpm) for 48 hours at 32°C, the culture supernatant was collected by filtration through Whatman no. 4 filter paper and kept at 120°C until use.

Yam processing

Yam flour: The production of yam flour was carried out using the procedure of Ukpabi and Uti, [8] with slight modification. Yam flour when properly processed and well packaged can be stored for a period of six months and above.

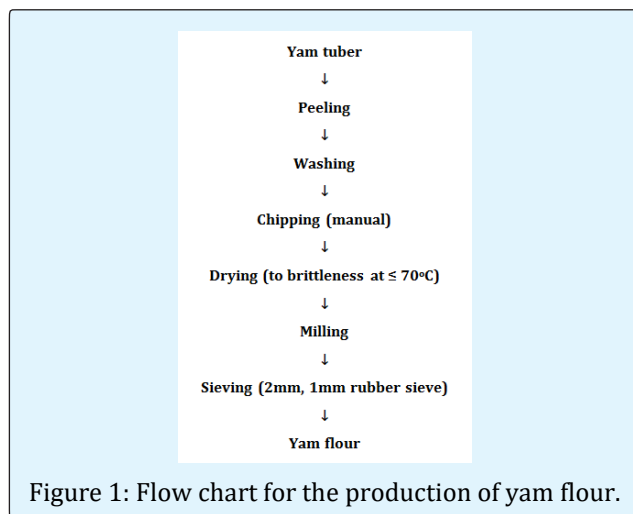
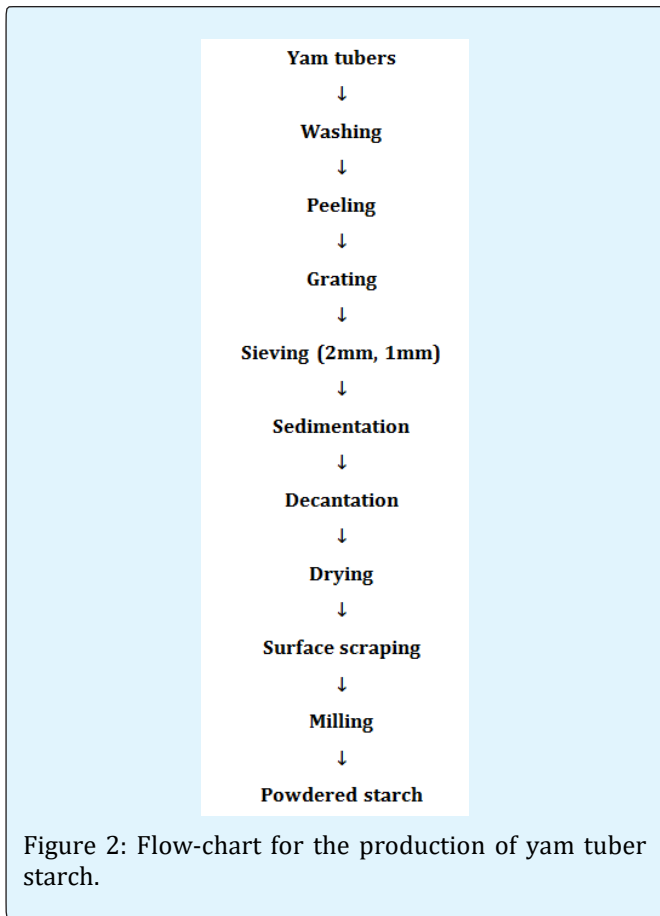


Figure 1: Flow chart for the production of yam flour.

Extraction of starch from yam samples:

Percentage starch yield = Dry weight of starch recovered from extraction/Dry weight (5g) of yam sample X 100

Proximate composition: Proximate composition (moisture, ash, crude fibre, crude protein and crude fat) of fresh yam samples were determined using the standard method of AOAC, 1990 [9]. Crude protein was expressed as % nitrogen x 6.25, while carbohydrate content was determined by difference.

Caloric value: The caloric values of the elite yam varieties were obtained using the method of Onyeike, et al. [10]. The crude fat, protein and carbohydrate contents were multiplied by 9, 4 and 4 (Atwater factors) respectively. The caloric values were then calculated as the sum of the products and expressed as calories.

Mineral analysis: The mineral composition was determined according to the method described by

Shahidi, et al. [11]. Phosphorus content of the digest was determined colorimetrically according to the method described by Obadoni and Ochuko, 2001[12].

Production of Glucose Syrup

Glucose syrup production from various starch samples of the elite yam varieties was carried out by the method reported by Ji, et al. [13] with slight modifications. A suspension of 30% (w/v) of previously extracted yam starch was prepared. The suspension pH was adjusted using 0.2M pH 6.0 phosphate buffer. This suspension was maintained under heating, increasing the temperature in 1°C/minute, until the starch was completely solubilized. After it was cooled down, the solution was incubated in water bath at 50°C with 10ml of commercial α -amylase Sigma[®] (1mg/ml) for 2hours for total liquefaction.

For saccharification, this resulting maltodextrin syrup had its pH adjusted to 4.2 with 0.2M of acetate buffer. Then 100ml of previously produced and characterized glucoamylase solution was added and incubated at 60°C for 48 hours under constant agitation. The glucose production was monitored using the glucose oxidase method [14]. The resulting syrup was purified by ion exchange chromatography and concentrated by evaporation under reduced pressure.

Statistical analysis: Statistics Analysis System (SAS)/PC software was used for mean separations and standard deviations of data.

Results and Discussions

The results of the hydrolysis of the gelatinized yam starches with glucoamylase from *Aspergillus niger* are presented in Figure 3. All selected yam varieties investigated showed optimum starch hydrolysis (glucose syrup production) at 24 hours reaction time. Results showed that the gelatinized starch slurry of Okpani variety gave the highest rate of glucose syrup production (60%) at 24 hours reaction time followed equally by Hembra and Ameh (55%) respectively. The glucose concentration increased remarkably at 24 hours reaction time compared to the values obtained at 4 - 12 hours. The results also revealed that after the maximum production of glucose syrup at 24 hours reaction time, there was no remarkable increase in glucose syrup production observed at 36 - 48 hours reaction time. This report is in line with the finding of Zainab, et al. [15] that after the optimum production of glucose syrup using starches from selected cereals, the production of glucose syrup did not

increase significantly with increase in reaction time. Okpani which is highly affected by browning reaction and often not the choice variety for consumption was found in this investigation to be good in the production of glucose syrup and rich in nutrient composition thus may be recommended for glucose syrup production to avoid waste and also improve economy.

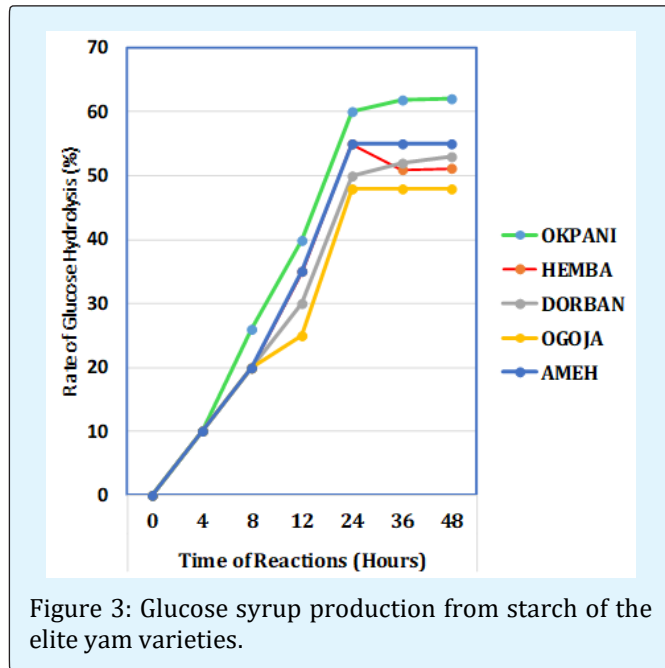


Figure 3: Glucose syrup production from starch of the elite yam varieties.

The proximate analysis is a set of methods used to get information about the nutritional value of food. Thus knowledge of carbohydrate, protein, lipid, fibre and ash

content of the food is fundamental to the assessment of its nutritive quality [16]. The results of the analyses of the proximate composition of the selected elite yam varieties are shown in Table 1. The high moisture content of the fresh samples studied is an indication that the yam varieties are prone to microbial attack in the course of storage and at such may not be stored favourably over a long period of time [17]. Low moisture content is desirable for good shelf life, as water in addition to participating in chemical and biochemical reactions involving hydrolysis also serve as a modifier of a catalytic activity of some other substances in foods [18]. Crude protein was moderately high in all samples with Ameh having the highest value. Proteins are polymers of amino acids and are required for the building and repair of damaged tissues [19]. The high fibre content in all samples studied showed that the selected elite yam varieties could be useful as sources of fibre and may play a useful role in providing roughage that aids digestion [20]. Results of previous studies have shown that increase in consumption of fibre has contributed to the reduction in the incidence of certain diseases such as colon cancer and various other disorders [21]. The results of the investigation showed that ash content of all samples were moderately high. The high ash content of the elite yam varieties is an indication of a rich mineral composition, though with wide variations in their elemental mineral constituents [22,23]. Ash is a measure of total mineral content in a sample, a pointer that the samples could be of nutritional importance. All samples had high content of carbohydrate as well as high caloric values, and thus could be used as rich sources of energy [24].

Yam Species	Crude Fat	Crude Protein	Crude Fibre	Ash	Moisture	Carbohydrate	Caloric Values (Cal/100g)
Okpani	1.03 ± 0.002	3.64 ± 0.02	1.50 ± 0.02	1.34 ± 0.004	47.47 ± 0.02	44.69 ± 0.02	202.53 ± 0.02
Hemba	0.89 ± 0.04	3.76 ± 0.02	1.47 ± 0.01	1.37 ± 0.003	47.41 ± 0.03	45.14 ± 0.01	203.62 ± 0.02
Ogoja	0.91 ± 0.02	3.53 ± 0.03	1.46 ± 0.01	1.34 ± 0.001	48.77 ± 0.03	43.97 ± 0.05	198.15 ± 0.05
Dorban	0.90 ± 0.04	3.01 ± 0.01	1.55 ± 0.01	1.29 ± 0.01	48.68 ± 0.03	44.58 ± 0.02	198.46 ± 0.02
Ameh	0.81 ± 0.01	3.81 ± 0.02	1.74 ± 0.001	1.36 ± 0.002	47.78 ± 0.02	44.52 ± 0.03	200.47 ± 0.02

Table 1: Proximate composition of yam samples (% composition) Mean of five determinations ± standard deviation

The results of the mineral composition of the elite yam varieties are shown in Table 2. All samples had high values of potassium, phosphorus, calcium and magnesium. Sodium was not high in all samples studied. Iron and Zinc had relatively appreciable values. The ratio

of sodium to potassium (Na/K) in the body is of great concern for prevention of high blood pressure [25]. Na/K ratio less than one is recommended [26]. The ratio of Na/K was less than one (Na/K < 1) in all samples studied, thus the elite yam varieties studied would not promote

high blood pressure. These mineral elements are essential for proper cells and when properly combined together

regulate blood pressure.

Yam Species	Phosphorous(P)	Potassium(K)	Calcium (Ca)	Magnesium (Mg)	Iron (Fe)	Zinc (Zn)	Sodium (Na)
Okpani	0.55 ± 0.029	0.70 ± 0.02	1.20 ± 0.02	0.47 ± 0.016	0.05 ± 0.01	0.03 ± 0.008	0.07 ± 0.008
Hemba	0.53 ± 0.02	0.60 ± 0.02	1.10 ± 0.02	0.40 ± 0.016	0.03 ± 0.01	0.02 ± 0.008	0.06 ± 0.003
Ogoja	0.48 ± 0.01	0.42 ± 0.01	1.15 ± 0.02	0.40 ± 0.016	0.03 ± 0.01	0.01 ± 0.007	0.06 ± 0.002
Dorban	0.53 ± 0.01	0.59 ± 0.02	1.10 ± 0.01	0.43 ± 0.01	0.04 ± 0.01	0.02 ± 0.003	0.20 ± 0.399
Ameh	0.36 ± 0.01	0.30 ± 0.02	0.07 ± 0.012	0.38 ± 0.012	0.02 ± 0.01	0.01 ± 0.007	0.05 ± 0.002

Table 2: Mineral Composition Of The Yam Flour (Mg/100g Dry Matter). Mean of five determinations ± standard deviation

Conclusion and Recommendation

The technology used for glucose production using the starches from the selected elite yam varieties and enzymes produced by the microorganism *Aspergillus niger* was successful and can be up-scaled for industrial purposes. There is need for a future study that will involve agricultural economists, agronomists and rural sociologists/extensionists.

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