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UTILIZING THE GLYCEMIC INDEXES ADVANTAGES OF SWEET POTATO IN PRODUCTION OF GRANULAR PRODUCT: TOWARDS CREATING ALTERNATIVE DIET FOR DIABETIC PATIENTS

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ABSTRACT

This study determined the importance of utilizing potato in producing granular products as an alternative diet for diabetic patients. The production and sensory evaluation of granular like product made from the yellow variety of sweet potatoes towards health improvement of diabetic patients formed the premise on which this work is based. Experimental research design was adopted to obtain Four (4) samples of cassava and sweet potato granules. The sensory properties of the products were evaluated using sensory analysis method and analysis was done using Analysis of variance (ANOVA).The sensory evaluation results showed that the garri made from cassava and sweet potato in the ratio (50%:50%)) was similarly rated with the garri made from 100 % cassava for all the quality attributes assessed. This result thus implies that sweet potato can traditionally be added to cassava for quality garri production to help diabetes patients reduce unnecessary restrictions in their diets.

Key words: Sweet-Potato, Garri, Diabetes Patients, Glycemic Index, Healthy Living

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INTRODUCTION

Food safety and security is one of the major problems facing African countries especially Nigeria. In order to increase food production and ensure that people are health conscious of the type of food they consume, the use of wholesome and indigenous crops must be encouraged. Unfortunately, some individuals are highly restricted on what they consume owing to different and clinical challenges. The incidence of type 2 diabetes which accounts for more than 90 to 95% of all cases of diabetes mellitus with its attendant economic stress is a typical example in this case. A number of factors that have been attributed to this include: increase in sedentary lifestyle, obesity, lack of physical activity and most importantly the consumption of an energy-rich diet (Al-Jiffri and Abd El-Kader, 2015).

Previously, it was widely held that blood glucose response to different diets is determined mainly by the amount of carbohydrates they contain. This consequently resulted in traditional diabetes diet plans in which the amount of foods allowed were based on their carbohydrate contents. However, the concept of glycemic index (GI) which classifies the blood glucose-raising potential of carbohydrate foods relative to glucose has shown that foods with similar carbohydrate contents did not usually have the same impact on blood glucose levels (Kure, Nwankwo and Nyasu ,2012). Hence, the needs to

develop a diet that can suit the consumption pattern of diabetes patient arise.

One of the major food crops widely utilized for foods in Africa is cassava which is widely utilized in the production of "garri", "foofoo", "Amala", chips and even in pastries. However, because of the high glycemic index of cassava, meals made from it are often forbidden by diabetes patients. The need to satisfy the diet pattern of diabetes patients led to the discovery of sweet potato meals as alternative to cassava meals for diabetes patients. The potential of sweet potato as a source of producing a Garri-like product using the conventional cassava Garri processing Technology have thus been a research focus for many researchers (Adeniji, Adeniyi. Akorede, Balogun, Ega and Ugwu, 2005).

Sweet potato (*Ipomea batatas*) is dicotyledonous leafy plants that belong to the morning glory family (Convolvulaceae), genus (Ipomea) and species (I. batatas). It has a strong dark green to brown colour tracing or twining stems. Like other tubers, it is a thickened underground starch storage organ of the plant. Sweet potato is ranked the 7th in the world production after wheat, maize, rice, Irish potato, Barley and cassava. Sweet potato is mostly grown in the Northern part of Nigeria but can also thrive in other parts of the country. It is one of Nigeria's most popular staple foods reported to contribute up to 60% of total calorie intake of the population being a source of carbohydrate for many Nigerians. According to Ojo and Akande (2013) sweet potato comes in different varieties. The yellow, red, white and orange varieties are very rich in carotenes and vitamin C. It is also worthwhile to note that no toxic compound has been reported in sweet potatoes. Sweet potatoes are commonly sold as a tuber and then converted to suit the consumers need either by boiling, frying, roasting, mashing or baking and consumed immediately (Ojo and Akande ,2013). Sweet potato is rich in nutrients such as carbohydrates (starches and simple sugars), protein, fat and fat-soluble vitamins. Allen, Corbett, Maloney, Butt and Truong (2012) assert that cultivars with a yellow flesh also contain significant amounts of carotenes (a bioactive compound that confirm sweet potato as important health food). Abubakar, Olayiwola, Sanni and Idowu (2010) also affirmed that sweet potato's tubers have anti-diabetic, anti-oxidant and anti-proliferative properties due to the presence of valuable nutritional and mineral components.

Garri is traditionally fermented gelatinous granular flour obtained from cassava (Mannihot esculentus). It is one of Nigeria's most popular staple foods as it is reported to contribute up to 60% of total calorie intake of the population being a source of carbohydrate for many Nigerians. Garri is widely consumed either in its intact form with sugar, groundnut or transformed into Garri meal (popularly called "Eba" in Yoruba land) eaten with soup of choice. Since garri is a ready-to-eat and easy to prepare food item, its acceptability cuts across all economic and social strata.

Statement of the Problem

Human life and existence have continuously been threatened with a number of preventable diseases. Some of these diseases which include high blood sugar, diabetes mellitus, hypertension, indigestion, and heart related diseases and other gastro-intestinal disorders are nutritional and dietary related. Seeking solutions to these life-threatening diseases have not been easy especially as their medical treatments are very expensive and not generally affordable. Hence, the need to shift attention to nature through seeking remedy from locally available crop plants with inherent medicinal and therapeutic benefits.

One of the important requirements of life is healthy living through consumption of balanced and adequate diet. However, diabetic patients have a number of restrictions attached to their diets because of their clinical conditions. Hence, the production and organoleptic assessment of garri-like product made from the yellow variety of sweet potatoes towards health improvement of diabetic patients form the premise on which this current work is based.

The principal intention of the researchers is the production and organoleptic assessment of garri-like product made from the yellow variety of sweet potato for the purpose of assisting and helping diabetic patients reduce unnecessary

restrictions in their diets. However, the specific objectives of the study included:

i. To evaluate the acceptability of garri samples for taste, sourness, aroma and particle size when soaked in water
ii. To evaluate the garri samples for texture, drawability and molding quality when cooked to make (Eba)

Research Questions

Based on the above specific objectives of the study, the following research questions guided the conduct of the study.

1. What is the acceptability rate in taste, sourness, aroma and particle size of garri made from different composite of sweet potatoes and cassava when soaked in water?

2. What is the level of acceptability of Eba (cooked garri) made from Composite of sweet potatoes and cassava with respect to texture, drawability and molding quality?

Research Hypotheses

The following null hypotheses were tested at 0.5% probability level of significant difference

Ho_1: The differences in the acceptability of "Eba" (made from garri produced from 100% sweet potatoes, 100% cassava, 30% sweet potatoes/70% cassava and 50% sweet potatoes 50% cassava) will not be statistically significantly for texture, drawability and mouldability

Concept of Diabetes Mellitus

Diabetes, often referred to by doctors as diabetes mellitus, describes a group of metabolic diseases in which the person has high blood glucose (blood sugar), either because insulin production is inadequate, or because the body's cells do not respond properly to insulin, or both. International Diabetes Foundation (2011) also defined diabetes mellitus as the condition in which the body does not properly process food for use as energy. Most of the food we eat is turned into glucose, or sugar, for our bodies to use for energy. The pancreas, an organ that lies near the stomach, makes a hormone called insulin to help glucose get into the cells of our bodies. When an individual has diabetes, the body either doesn't make enough insulin or can't use its own insulin as well as it should. This causes sugars to build up in the blood. This is why many people refer to diabetes as "sugar." Diabetes can cause serious health complications including heart disease, blindness, kidney failure, and lower-extremity amputations. People with diabetes according to Chinenye, Oko-Jaja and Young (2013) may experience one or combination of the following symptoms:

- Frequent urination
- Excessive thirst
- Unexplained weight loss
- Extreme hunger
- Sudden vision changes
- Tingling or numbness in hands or feet
- Feeling very tired much of the time
- Very dry skin
- Sores that are slow to heal
- More infections than usual

Unhealthy diet (fast food, excess refined sugar, excess salt, low fibre), overweight/obesity, lack of regular physical exercise, excessive use of alcohol, advancing age and family history are among the risk factors for diabetes identified by Chinenye, Oko-Jaja and Young (2013).

Concept of Glycemic Index in Foods

The incidence of type 2 diabetes which accounts for more than 90 to 95% of all cases of diabetes mellitus with its attendant economic stress on the health care system has been alarming (Chinedum, 2016). However, with the knowledge of factors such as increase in sedentary lifestyle, obesity and lack of physical activity as risk factors for diabetes, the role of dietary carbohydrate has been controversial (Omoregie and Osagie, 2008). Little relation has been found between total carbohydrate intake and the risk of type 2 diabetes. Previously, it was widely held that blood glucose response to different diets is determined mainly by the amount of carbohydrates they contain. This consequently resulted in traditional diabetes diet plans in which the amount of foods allowed were based on their carbohydrate contents. However, the concept of

glycemic index (GI) which classifies the blood glucose-raising potential of carbohydrate foods relative to glucose as shown that foods with similar carbohydrate contents did not usually have the same impact on blood glucose levels (Chinedum, 2016).

Nowadays, GI is generally seen as a potentially useful tool in planning diets for diabetic patients and a key player for the prevention and management of diabetes (Chinedum, 2016). With this, an individual can select their food on the basis of whether the food has higher or lower glycemic indices (GIs). The glycemic index (GI) is therefore a tool to measure how individual foods are expected to impact blood sugar levels.

The number is a comparison between individual foods and a sugar called glucose. Glucose is given a value of 100. If the test food is assigned a value below 100, that food is expected to impact your blood sugar less than glucose. If the test food is assigned a value over 100, that food is expected to impact blood sugar more than glucose. People who have diabetes may use GI values as an additional tool for managing blood sugar levels. There is a wide variation in values assigned to the same food. One source may say a russet potato has a GI of 56 and another source may say the GI is 111. GI values can vary depending on the ripeness of the food, the degree of processing, and the cooking method.

Glycemic index values measure the effect of a test food when that food is eaten alone. Most meals contain a variety of foods in combination. The glycemic effect of a food changes when it is combined with other foods. The effect of food on blood sugar can vary from person to person. The glycemic index of sweet potato is 54 which fall under low GI category. Sweet potatoes are known to be high in fibre and have a low glycemic index which result in a less immediate impact on blood glucose level. This according to Corey (2019) can help individuals with diabetes control and manage their blood sugar.

MATERIALS AND METHODS

Methodology

The following unit operations were involved in the production of Garri.

- Washing of cassava and sweet potato tubers to remove sound and other adhering matters that can affect the quality of the final product
- Peeling the tubers (cassava and potato) and washing under running water. The tubers were deep- peeled especially the cassava to help reduce the levels of cyanic acid that is injurious to health. (This is because significant quantity of this acid is found to be concentrated at the peel of the tubers).
- Grating cassava roots into mash to facilitate further hydrolysis of the acid. The grating was done in the following ratio of cassava and sweet potato (100% cassava, 70% cassava/30% sweet potato and 50% cassava/50% sweet potato) to have three different samples.
- De-watering and fermenting the mash into wet cake. Each of the grated samples was separately allowed to de-water inside a neat sack with heavy stone placed on each. These were allowed to ferment for 3 days. (During this fermentation a number of chemistries occurred. For instance, Cornebacterium manihot helped to break down the starch to produce organic acids which decreases the pH and leads to the hydrolysis of linamarin during which gaseous hydrocyanic acid is evolved and Fungus (Geotricum candida) produced aldehydes and esters responsible for the characteristic flavor of garri.
- Sieving the wet and fermented wet cake into fine grits using a sieve with fine mesh size
- Roasting the fine grits into garri. The grits become very dry at this stage. They are thus spread thinly on a clean and stone-free surface to allow them become cool
- Packaging. The four garri sample were packaged differently and labeled accordingly.

The simple flow chart showing the various unit operations for the processing of garri is shown in Figure 1

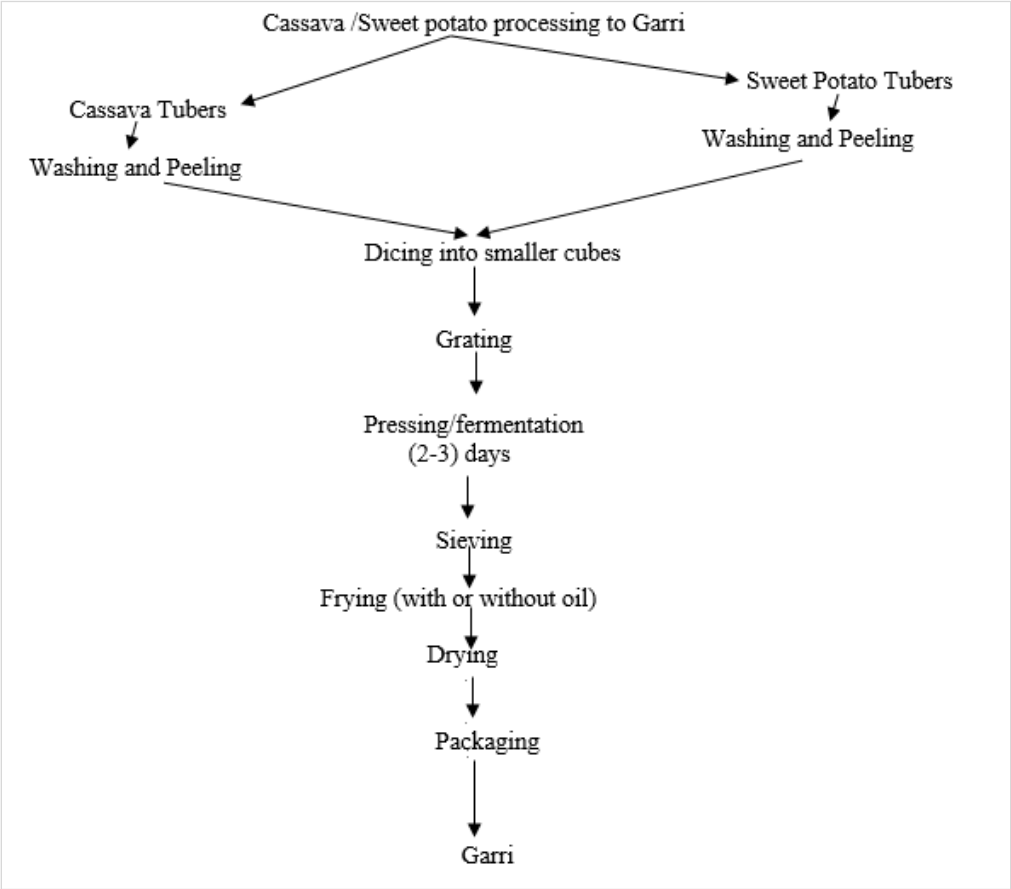

Figure 1. Processing Cassava and Sweet Potato to Garri

The Coded Garri Samples

Sample CG = Garri produced from 100% Cassava

Sample CSPG1 = Garri produced from 30% sweet potatoes and 70% cassava

Sample CSPG2 = Garri made from 50% sweet potatoes and 50% cassava

Sensory Evaluation Procedures

i. The sensory panelists were initially briefed and inducted on the essence of the exercise. They were also made to realize the importance of objectivity in their assessment.

ii. The sensory Evaluation room (Home-Economics Class room) was prepared as conducive as possible such that each sensory panelist is given enough space interval to avoid any form of interaction which could affect the credibility of their individual judgment

iii. Coded garri samples were presented to the panelists with cup, spoon and water for soaking the garri

iv. The cooked samples of the garri samples (Eba) with soup (Vegetable) were also served to the panelists for assessment.

v. Each of the panelists was given a copy of the Sensory Evaluation sheet to complete based on their assessment of the garri samples.

vi. Soaked garri samples were evaluated for colour, taste, sourness, and particle size while the cooked samples (Eba) served with vegetable soup were evaluated for texture, drawability and molding quality when eaten.

Data Collection and Analysis

All completed Sensory Evaluation Sheet were retrieved immediately after the sensory evaluation. The data obtained were subjected to SPSS package for Analysis of Variance

(ANOVA) statistics. Chart was used to represent the percentage general acceptability of the products (when soaked in water)

RESULTS

Data were obtained through the hedonic scale rating. A total of 50 sensory evaluation forms were distributed to 50 taste panelists. All were retrieved showing 100% return rate. The percentage panelist's acceptance for Garri samples when soaked in water with respect to colour, taste, sourness and particle size is represented in Table 1 and Fig. 2. The ANOVA tables for the texture, drawability and molding quality of the garri when cooked to make "Eba" is shown in Tables 2a. 2b, 3a, 3b, 4a and 4b respectively.

Table 1: Percentage Score on Comparative Sensory Evaluation of Garri Samples

Samples	Colour	Taste	Sourness	Particle size
CG	91	96	94	98
CPG1	88	86	70	75
CPG2	89	87	80	79

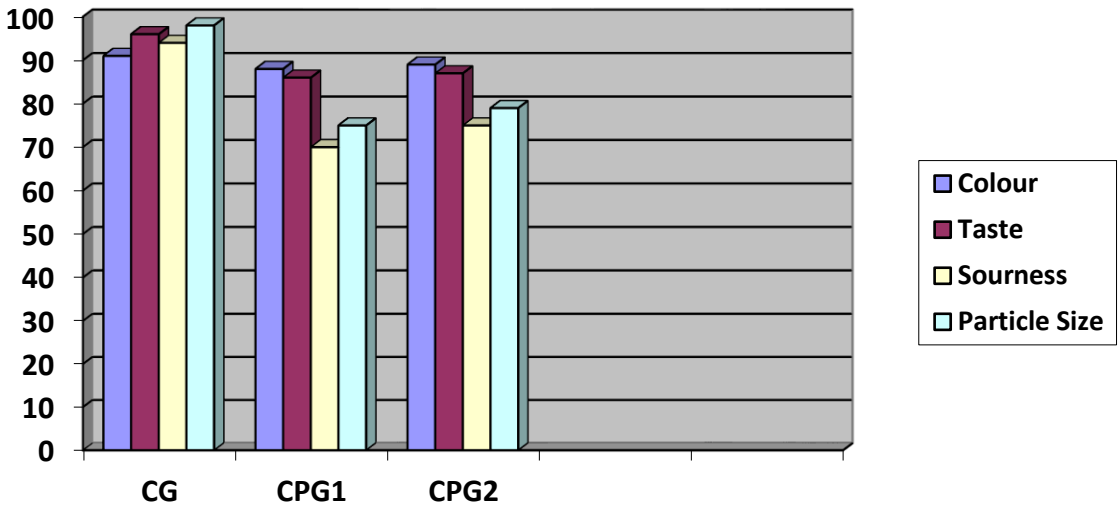

Fig. 2. Percentage Acceptance of Garri products for Quality Attributes

Table 2a: ANOVA Table for Texture of Cooked Garri Samples

	Sum of Squares	Df	Mean square	F	P-Value	Remark
Between Group	2.400	2	0.6000	0.388	0.816	Hypothesis Accepted
Within Group	69.600	45	1.547			
Total	72.000	47				

Level of Significance (p) = 0.05

The F –value of 0.388 in Table 2a is not significant at 0.05 probability levels. This is because the calculated F-value is less than he P-value (from table). Hence, the differences in the acceptance of the judges in the texture of the cooked Garri samples (served with vegetable soup) do not vary significantly across the different samples. Therefore, the respondents' acceptance of the texture of the 3 samples is not statistically significant at ($P<0.05$).

Table 2b. Multiple Comparison of the Texture of the Samples

Sample (I)	Sample (J)	Mean Difference (I-J)	P-Value
CG	CSPG 1	0.000	1.000
	CSPG 2	-0.400	0.971
CSPG 1	CG	0.000	1.000
	CSPG 2	-0.400	0.971
CSPG 2	CSPG 1	0.400	0.971
	CG	0.400	0.971

The respondents' acceptance of the texture of the 3 samples is not statistically significant at ($P<0.05$) as shown in Table 2a. Hence, further attempt was made to locate the differences with the aid of Scheffe Post-hoc analysis shown in Table 2b. The mean comparison showed that the difference in texture of the samples do not vary significantly in all the pairs. The implication of this result is that the respondents generally accepted the texture of the 3 samples even at 30% and 50% inclusion of sweet potato in cassava for making garri.

Table 3a: ANOVA Table for Drawability of Cooked Garri Samples

	Sum of Squares	Df	Mean square	F	P-Value	Remark
Between Group	10.480	2	2.620	4.335	0.005	Hypothesis Rejected
Within Group	27.200	45	0.604			
Total	37.680	47				

Level of Significance (p) = 0.05

The F –value of 4.335 in Table 3a is significant at 0.05 probability levels. This is because the calculated F-value is greater than he P-value (from table). Hence, the differences in the acceptance of the judges in the drawability of the cooked Garri samples (served with vegetable soup) vary significantly across the different samples. Scheffe Post-hoc analysis was therefore used to determine the extent of this variation in the 3 samples shown in Table 3b.

Table 3b. Multiple Comparison of the Drawability of the Samples

Sample (I)	Sample (J)	Mean Difference (I-J)	P-Value
CG	CSPG 1	0.000	1.000
	CSPG 2	-0.700	0.411
CSPG 1	CSPG 2	0.000	1.000
	CG	-0.800	0.276
CSPG 2	CG	0.700	0.411
	CSPG 1	0.700	0.411

Based on the mean score, "Eba" made from garri (100% cassava) draws better when eaten. Meanwhile, the "Eba" made from garri (Composite of cassava and Sweet potatoes at 30% and 50%) compared favorably with respect to drawerbility quality when eaten.

Table 4a: ANOVA Table for Mouldability of Cooked Garri Samples

	Sum of Squares	Df	Mean square	F	P-Value	Remark
Between Group	3.600	2	0.900	0.592	0.670	Hypothesis Accepted
Within Group	68.400	45	1.520			
Total	72.000	47				

Level of Significance (p) = 0.05

The F-value of 0.592 in Table 4a is not statistically significant at 0.05 level of significance, implying that the difference in the respondent's acceptance of the molding quality do not vary significantly across the 3 samples.

Table 4b. Multiple Comparison of the Molding quality of the Samples

Sample (I)	Sample (J)	Mean Difference (I-J)	P-Value
CG	CSPG 1	0.700	0.805
	CSPG 2	0.700	0.990
CSPG 1	CSPG 2	-0.700	0.805
	CG	-0.400	0.970
CSPG 2	CSPG 1	0.000	0.990
	CG	-0.300	0.970

A further attempt was also made to locate the differences with the aid of Scheffe Post-hoc analysis as shown in Table 4b. The mean comparison showed that the differences in the acceptance of the molding quality of the samples do not vary significantly in all the pairs. This implied that the respondents generally accepted the molding quality of the samples of "Eba" (cooked garri).

DISCUSSION

The essential idea behind this study is exploration into the glycemic advantages of sweet potato in the formulation of suitable diet for diabetic patients. Hence, the study involved the production of garri-like product using the composite of cassava and sweet potato and assessing the sensory properties of the products. The study intended to justify the use of sweet potatoes as diabetic food and to help people living with diabetic to live a normal life from their regimented life of not eating a wide variety of carbohydrate foods. The study generally found that Garri with quality attributes can be produced from a composite of cassava and Sweet potatoes especially with 30% and 50% inclusion of sweet potato. The variations in quality attributes of the Garri samples may be due to lack of adequate starch from sweet potatoes as compared to cassava.

James, Okechuku, Abass, Famoh, Mazuya-Dixon, Sanni, Osei-Sarfoh, Fombs and Lukomba (2012) have earlier established the superiority of cassava as the best and traditional tuber for Garri processing because of its excellent starch quality. However, the incorporation of sweet potatoes into cassava to produce Garri has been supported by many researchers as better alternative to help improve the diets of people living with diabetes. Padmaja, Jaffer and Moothandassery (2012) believe that sweet potato is next to cassava in acreage, widespread cultivation; diversified uses etc., among the tuber crops in the world and that sweet potato tuber with their low glycemic index have additional value as a food for diabetics.

The appearance or colour of Garri refers to the level of visual appeal of the products obtained after fermentation and frying. It is evident that based on the judgment of the panel, sample CG which is Garri from 100% cassava had the best visual appeal followed by Garri made from composite of cassava and sweet potato, the respondents generally accepted sample CSPG 1 and CSPG 2 with respect to colour. This result

corroborated the findings of James et, al (2012) who believes that when cassava is perfectly blended with sweet potatoes, Garri with superior quality attributes can be commercially produced. The sourness of the Garri expresses the level of astringency produced as a result of the activities of "*Cornebacterium manihot*" (a bacterium that helps to break down the starch in cassava to produce organic acids which decreases the PH and leads to the hydrolysis of hydrocyanic acid present naturally in cassava tuber. (Bibek, 2010). The results on sourness for the Garri samples indicated that although sample CG was better rated, the samples CSPG1 and CSPG2 were also well rated in terms of sourness. Garri made from 100% cassava and composite of cassava/sweet potatoes produced excellent quality attributes.

The texture, drawability and molding quality of the cooked garri (Eba) samples when eating with soup showed general acceptability on the part of the respondents. Samples CG, CSPG1 and CSPG2 were similarly rated for texture and molding quality except for the drawability where sample CG was superiorly rated

CONCLUSION

Garri is routinely enjoyed when soaked in water and taken with or without (sugar, groundnut, milk, and fish etc.) depending on the individuals. From the comparison made of the sensory attributes (Colour, taste, sourness and particle size) of the three Garri samples when soaked in watter, the result showed that at 30% and 50% inclusion of sweet potato in the formulation, acceptable products can be achieved. Similarly, when these garri samples are cooked to make "Eba" and eaten with soup of choice, each can generally be enjoyed especially with respect to texture, drawability and molding quality. The health implication of this result is that diabetic patients can now take advantage of the glycemic index of sweet potato to enjoy normal diets.

Recommendations

Based on the conclusion of the study, the researchers recommended the following for policy implementations and further research.

1. The nutritional and medicinal benefits of sweet potatoes beyond their glycemic index advantage should be properly documented so that the individuals and family members can tap these benefits in order to improve their nutrient intake.
2. Sweet potatoes are easy to cultivate and required less amount of energy to process into foods, hence individuals and families should explore the use of sweet potatoes in wide varieties of dishes for improved nutrient intake.
3. The possibility of replacing part of the wheat flour with sweet potato flour for making baked foods should be further investigated in products such as cakes, biscuits, muffins, etc. This will help to improve the consumption of varieties of nutritious foods and help to guarantee food security.
4. Government should encourage massive cultivation of sweet potatoes by empowering the local farmers since it has been established that it can grow and mature on any types of soil and even on those consider very poor for the cultivation of other crops. This will generally help to boost food production in Nigeria
5. Agricultural engineers should synergize actively with food manufacturing industries to fabricate simple and automated machine that can process sweet potato and other useful tubers into varieties of food products.

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