IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 10, Issue 12, December 2023

DOI: 10.17148/IARJSET.2023.101216

Profiling the invitro glycemic index determination of some under utilized tubers flours

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Abstract: Some underutilized tubers:Aerial yam (Dioscorea bulbifera), Cocoyam (Xanthosoma robustum) and Water yam (Dioscorea alata) were analysed for their glycemic indices using Invitro method after they have undergone four pre-processing operations of boiling, sprouting, frying, roasting and a set was left untreated. Boiled Cocoyam (Xanthosoma robustum) was significantly different ($p<0.05$) in terms of glycemic index (40.217)% compared to the other samples while among the processing methods, boiling was significantly different ($p<0.05$) from sprouting, frying and roasting. The untreated samples were the control samples.

Keywords: Underutilized tuber species, Glycemic Index, pre-processing operations, Dioscorea bulbifera Xanthosoma robustum, Dioscorea alata.

I. INTRODUCTION

Diabetes mellitus,cancer, stroke and other cardiovascular diseases has been associated with the consumption of high glycemic foods,[1].Glycemic index is a measurement taken on carbohydrate foods in order to determine their impact on one's blood sugar,[1]

Glycemic Index(GI) showcases the extent to which some class of carbohydrate foods induce our bodies to secret insulin. Glycemic index (GI) is a measurement taken on carbohydrate containing foods to determine their impact on one's blood sugar. It rates food on how they affect blood glucose level, [2] It rates food on the scale of 0-100 based on how fast the carbohydrate content of the food breaks down into glucose and enter the blood stream.[3] According to International glycemic index table, any food rating less than 55 in glycemic index is considered low, 56-69 is seen as medium while 70 or more is considered high,[4] Foods with high glycemic index promotes higher insulin level thus increased risk of one having type 2 diabetes and other related diseases such as obesity, stroke and cardiovascular diseases. Insulin is a pancreas hormone that regulates the level of glucose released in the body,[5]. In the absence of insulin, the body cell would not be able to use the energy released from the body to perform vital body activities. GI ultimately measures starch digestibility through comparison to a reference food; glucose or white bread,[1]

It is therefore important to estimate the glycemic index of some underutilised tuber crops which have medicinal properties of reducing blood sugar levels, reduce excess weight gain by being incorporated in weight management diet and also help to prevent cancer, stroke and other cardiovascular diseases.

In addition, the pro-prandial glycemic response of similar portions of carbohydrates from different plant crops vary immensely depending on their rate of absorption, www.diabetes.org. Research shows that the amount and class of carbohydrate in a particular food consumed can affect blood glucose level, [3] Tuber crops such as aerial yam (*Dioscorea bulbifera*), cocoyam (*Xanthosoma robustum*) and water yam (*Dioscorea alata*) have these potentials and they will be subjected to the following pre-processing operations; boiling, sprouting, frying and roasting, in order to know which process will effectively give a lower estimated glycemic index.

II. MATERIAL AND METHODS

Study Site: The study was carried out in the Department of Food Technology, Akanu Ibiam Federal Polytechnic Unwana, Afikpo in Ebonyi State, and the analyses were done at the Department of Food Technology, Akanu Ibiam Federal Polytechnic Unwana, Laboratory of Food Science and Technology in the University of Agriculture, Umudike and Biochemical Department of the National Root Crops Research Institute (NRCRI) Umudike in Umuahia, Abia state.
The sample collection, preparation and investigation were conducted within three (3) months.

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Raw Materials

Aerial yam (*Dioscorea bulbifera*),cocoyam (*Xanthosoma robustum*)and water yam (*Dioscorea alata*) were purchased in large quantity from Eke market in Afikpo in Ebonyi State.

Sample Preparation. Samples were prepared at the processing laboratory of the department of Food Technology, Akanu Ibiam Federal Polytechnic Unwana, Afikpo in Ebonyi State and the analytical grade chemicals and Enzymes used in the bench work for the analysis of this research were from the Laboratory of Food Technology, Akanu Ibiam Federal Polytechnic Unwana, Laboratory of Food Science and Technology Department, Michael Okpara University of Agriculture, Umudike, Umuahia and Biochemical Department of the National Root Crops Research Institute (NRCRI) Umudike in Umuahia, Abia state.

RAW MATERIALS PREPARATIONS

The selected tuber crops; water yam, aerial yam and cocoyam were sorted (to remove bad or spoilt ones), washed with the back, peeled and washed again. They were then sliced into 2-3cm thickness, labelled and subjected to four different treatments: boiling, frying, sprouting and roasting.500g of each of the samples were boiled 100^{0}C for 15 minutes for cocoyam and water yam and 100ºC for 20 minutes (for aerial yam).500g of each of the samples were fried till done and oil was drained off. Another 500g of each of the samples were sprouting for 7-21 days at 36^{0}C/room temperature. 500g of each of the samples were oven roasted at 180^{0}C for 20 minutes for all and 30 minutes for aerial yam .A set (500g) was left untreated which served as the control samples The samples were oven dried until a constant weight was achieved for each of the samples showing maximum drying.. Glucose was used as the reference food for the glycemic index evaluation.

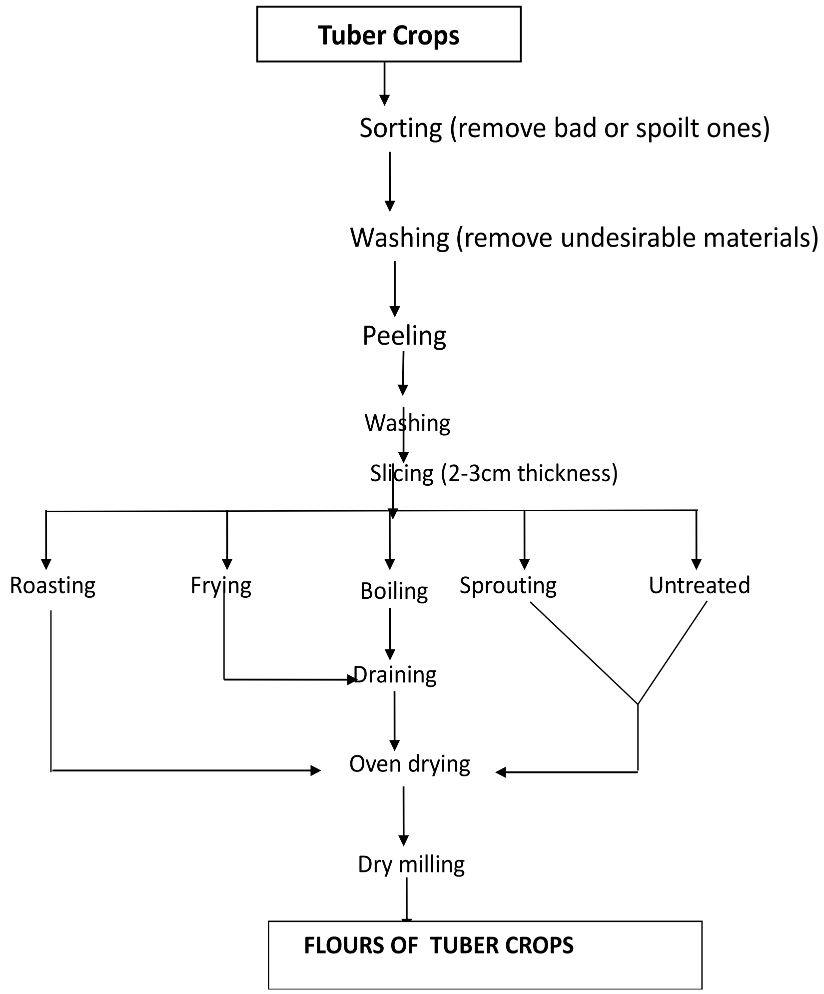

Figure 1: Showing the production of the tuber flours with the different processing methods.
Source: [6] with some modifications.

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Plate 1: Water yam
(Dioscorea alata)

Plate 2: Sprouted Wateryam

Plate 3: Aerial yam
(*Dioscorea bulbifera)*

Plate 4: Sprouted Aerial yam

Plate 5: Cocoyam
(*Xanthosoma robustum)*

Plate 6: Sprouted cocoyam

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IN VITRO GLYCEMIC DETERMINATION OF THE SELECTED TUBER FLOURS.

In vitro Starch digestion as described by [7] was used. Fifty (50) mg of the flour sample was weighed into large test tube, labelled and incubated with a solution containing 20 mg pepsin enzyme at 40 ^{o}C for 60 min to remove protein and the volume was made up to 25 mL with a 0.2M tris-maleate buffer. Five (5) mL of the prepared mixture containing 3.3 µL of α-amylase was incubated at 37 ^{0}C for 3h to hydrolyse the digestible starch (Ds), in a shaking water bath. Aliquots of 1 mL was taken from the test tube every 30 min from 0-180 min and placed in a boiling water bath for 5 min to inactivate α-amylase enzyme .Then 60 µl of amyloglucosidase from *Aspergillus niger* was added to the test tubes to hydrolyze the digested starch into glucose concentration at 60 ^{0}C for 45 mins. After centrifugation at 4500 g for 15 min, the glucose content in the supernatant was measured using a glucose oxidase peroxidase kit and the digestible starch was calculated as mg of glucose x 0.9.The rate of digestion was expressed in terms of the glucose released per 100 g of sample hydrolysed at different times (0,30,60,90,120,150,180).

The digestible starch was calculated as shown below:

$$D_{t}(\%) \text{ of digested Starch} = \frac{[0.9 \times CG \times (1/1000)}{Ws/100}$$

Where CG = glucose concentration (µg/ml)

0.9 = stoichiometric constant of glucose content conversion into starch

$\frac{1}{1000}$ = Conversion from µg to mg

Ws = weight of sample (mg)

HYDROLYSIS INDEX (HI)

The percentage of starch hydrolysis over a 3h period was plotted (i.e % hydrolysis versus time ('t'). The area under the curve (AUC) is calculated thus:

HI (hydrolysis index) is given by

$$HI = \frac{\text{AUC of test food}}{\text{AUC of standard (pure glucose)}} \times \frac{100}{1}$$

GLYCEMIC INDEX (GI)

Glycemic Index (GI) is given by the equation below:

GsI = 39.71 + 0.549HI

Table 1: Similar research works using invitro glycemic index determination and the effects of processing methods on the glycemic index and/ chemical contents of tuber crops /flours.

Foods	Authors
Two Bitter yam(*Dioscorea dumetorum*) spp	[8]
Water yam,pigeon pea and carrot pomace blends	[9]
Water yam,cocoyam,sweet potato and cassava	[10]
Yams(*Dioscorea spp*) and cocoyam(*Xanthosoma maffa scoth*)	[11]
Wild yam species	[12]

Table 2: Profiling the *in vitro* estimated glycemic index (%) of the selected underutilised tuber flours.

Processing Methods	Species: Aerial yam (*Dioscorea bulbifera*)	Cocoyam (*Xanthosoma robustum)*	Water yam (*Dioscorea alata*)
Untreated	41.218^{b}±0.002	40.215^{a}±0.001	41.218^{b}±0.001
` **Boiled**	41.218^{b}±0.001	40.217^{a}±0.002	40.214^{a}±0.001

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Roasted	$43.217^{b}\pm0.001$	$41.218^{a}\pm0.001$	$42.217^{b}\pm0.001$
Fried	$43.216^{b}\pm0.001$	$40.216^{a}\pm0.001$	$44.217^{b}\pm0.001$
Sprouted	$44.218^{c}\pm0.001$	$40.216^{a}\pm0.0001$	$42.218^{b}\pm0.001$

Values are mean ± standard deviation of duplicate determinations. Mean on the same column with the same superscript are not significantly different at p>0.05%.

Estimated Invitro Glycemic Index Discussion

The range of samples' *in vitro* estimated glycemic index (40.217-44.218%) were within the range of what [13] reported as the *in vitro* estimated glycemic index of white yam flour (36.55%) ,white yam paste(37.32%) ,water yam flour (35.14%) and water yam paste(32.34%) but the range were lower compared to what [10] reported on the *in vitro* estimated glycemic index for water yam (53.57%) and cocoyam (63.79%).

[14] also reported *in vitro* estimated glycemic index for water yam varieties to range from (35.56-41.31%). Glycemic index measures the effect of carbohydrate in foods on blood glucose levels. According to International glycemic table, any food rating less than 55 in its glycemic index is considered low,56-69 middle and above 70 is high, [3] Low glycemic foods produce a more gradual rise in blood sugar and are associated with reduced risk of diabetes, cardiovascular diseases and cancer, [5].

Boiled cocoyam with estimated in vitro glycemic index of (40.217%) was significantly (p<0.05) different from all the samples. Boiling is believed to induce gelatinization, thereby permanently disrupting the amylase-amylopectin structure of the starch complex, thus making it more readily accessible by digestive enzymes. This effect of boiling on the glycemic index of boiled cocoyam buttresses what [8] reported on effect of processing methods on glycemic index. They reported that food processing methods influence the glycemic index of some foods especially carbohydrate-rich foods.

Moreso, boiled Cocoyam with with *in vitro* estimated glycemic index of (40.217%) implies a lower glycemic index and thus better therapeutic value than others. According to [15] who made the first nutritional report on *Xanthosoma robustum*, an isolated *Xathosoma robustum* starch was characterized by high nutritional status. This was justified by the report given by the work of [11] on the Proximate compositions of *Xanthosoma robustum, Dioscorea alata and Dioscorea bulbifera* where *Xanthosoma robustum* showed the best properties among them all. [16] also reported that digestion rate increases with longer amylase branches in food materials and this is an important characteristics of this cocoyam.

In addition, Revised International Table for Glycemic Index and Glycemic Load table of some Nigerian foods,[17](listed boiled yam (New Zealand) to have glycemic index of (35+5%) which has a close range with the *in vitro* estimated values (40.217-44.218%)of the tubers used in this research, yam(Nigeria) peeled, boiled with or without 4.24g salt for 30 minutes (74%),yam peeled and cocoyam(*Xanthosoma spp*) Jamaica(61+5%).
However, boiling as a process was significantly different (p<0.05) from the other processes as seen in the predicted low glycemic index of boiled cocoyam (40.217).

Furthermore, the estimated glycemic index of all the samples(40.217 —44.218%) were below 55, which according to the International Tables of glycemic index and glycemic load values [18] is within the accepted range for low glycemic foods, so could be recommended for diabetic, obsessed and generally sick persons.

III. CONCLUSION

This work was done to profile the *in vitro* glycemic index of some underutilised tuber flours: aerial yam(*Dioscorea bulbifera*), cocoyam(*Xanthosoma robustum)* and water yam(*Dioscorea alata*) subjected to some pre-processing operations of boiling,sprouting,frying and roasting and a set left untreated.

Boiled cocoyam was different from the other samples in terms of glycemic index and boiling as processing method gave a low glycemic index value in cocoyam followed wateryam, when compared to the other processing methods. Conclusively, this research will help increase the utilization of these tuber crops and also enlighten the public on their their glycemic indices and the best processing method to use in processing or reconstituting them.

ACKNOWLEDGEMENT.

I acknowledge the sole sponsorship of this work- Tertiary Education Trust Fund (TETFUND) towards the successful completion of this research. I am also thankful to my Institution; Akanu Ibiam Federal Polytechnic Unwana and the Institution Based Research Committee for giving me this opportunity to conduct this research.

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