Global Scientific and Academic Research Journal of Multidisciplinary Studies
ISSN: 2583-4088 (Online)
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journals-gsarjms-home/

PRODUCTION AND EVALUATION OF GLYCEMIC INDEX FUFU ANALOGUE PRODUCTS FROM COCONUT RESIDUE.

BY

Ndulaka, Justina, C[1], Obasi, Nneoma, E.[2],Onwuka, Gregory, I.[2]

[1]Department of Chemistry/Biochemistry Abia State Polytechnic, Aba.
[2]Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Abia State.

Received: 09/07/2024
Accepted: 28/07/2024
Published: 30/07/2024

Vol – 3 Issue –7

PP: - 24-30

Abstract

Glycemic index of fufu analogue products from coconut residue were evaluated. Coconut residue was blended with different quantities of food binders (psyllium husk and gelatin) for the production of fufu analogue products. Dietary fibre, glycemic index/load, and sensory attributes of the fufu analogue products were determined using standard methods The total dietary fibre (TDF) ranged from 68.15 to 78.98%, Soluble dietary fibre (SDF) ranged from 0.54 to 0.94% and insoluble dietary fibre ranged from 67.61to 78.05 %. The estimated glycemic index obtained after in vitro enzymatic digestion of the fufu analogue products ranged from 39.93% to 43.18% with glycemic loads from 1.78 to 4.42 (100g of serving). The results revealed that the fufu analogue products made from coconut residue had low glycemic index and low glycemic loads. The sensory results of the fufu analogue products showed that the fufu analogue products made of 5-10g of the psyllium husk rated highest (7.00) in terms of appearance, taste, hand-feel, and overall acceptability. From result it was observed that ten grams (10g) of the binders formed a fufu dough that was accepted by all the panelist. There were no significant different at (p<0.05) in the odour analysis of fufu analogue products. The results showed that all the samples had very good sensory ratings.

Keywords: *Fufu, coconut residue, dietary fibre, glycemic /load, and sensory analysis.*

1. INTRODUCTION

Glycemic index (GI) is the incremental area under the blood glucose response curve of a 50g portion of carbohydrates expressed as a percentage of the response to the same amount of carbohydrates from a standard food consumed by the same subject (Blessing *et al*., 2021). Glycemic load uses the glycemic index to calculate how much an individual intake of carbohydrates affects them, accounting for the quantity of carbohydrates in a serving (Madu *et al*., 2018). Developing new functional foods is a major trend in the food industry due to consumer consideration and preference for healthier food options. Interest in functional foods is being fueled by a number of factors, including the aging population, rising healthcare costs, changes in food laws affecting label and product claims, and the rapid advancements in science and technology. The prevalence of chronic illnesses has been rising globally (Akibode and Maredia, 2011; Li *et al*., 2014), and studies have indicated that glycemic indices of foods play a significant role in both treatment and prevention of chronic diseases (Hoover *et al*., 2010, Guzel and Sayar, 2012). Foods containing carbohydrates have been categorized into four groups according to their glycemic indices: high (> 70), intermediate (56-69), low (20-55), and free (< 20) (Ratnaningsih *et al*., 2016). Experts from FAO (2010) recommended the use of glycemic index concept to categorize foods high in carbohydrates. This would help people to select the best foods to consume for maintaining their health and treatment of various diseases (Simsek and Nehir, 2015).

Lower dietary glycemic index values are associated with a lower risk of developing hyperinsulinemia-related conditions, including diabetes mellitus and cardiovascular disease (Salmeron *et al*., 1997). Foods with a low glycemic index and high dietary fiber have been demonstrated to improve blood glucose and overall lipid concentrations and to decrease postprandial blood glucose and insulin responses in both normal subjects and diabetes mellitus patients (Brand *et al*., 1991). Foods with a high glycemic index cause higher insulin levels and excretion of c-peptide when compared to foods with a low glycemic index (Wolever *et al*., 1991). Over time, efforts to reduce the glycemic index value of foods have focused more on increasing the fiber content of foods (Foster-Powell *et al*., 2002; Du *et al*., 2014).

Dietary fibre is made up of remnants of plant cells resistant to hydrolysis by the alimentary enzymes of man. Its components are hemicellulose, cellulose, lignin, oligosaccharides, pectins, gums, and waxes (Manikandan *et al*., 2015). Dietary fiber fibrous structure slows down the release of glucose in the blood, assisting in the appropriate control and management of diabetes mellitus and obesity (Dhingra *et al*., 2012),

Coconut (*Cocos nucifera Lin*.) in the world, is the most widely grown and utilized nut. Long-term research and development on coconuts-based food products have resulted in a diversification of products and byproducts. Coconut has high dietary fibre, protein, antioxidant, and vitamin. Trinidad *et al*. (2006) stated that the residue (residue) of coconut could be made into flour and used for formulation and development of new food products.

Fufu, a fermented wet paste made from cassava (Manihot esculenta Crantz) is a staple food in many tropical regions and West Africa (Etudaiye *et al*., 2012; Deniran *et al*., 2022). Traditionally, cassava is used to make *fufu*, but it can also be made with plantains and cassava, plantains and cocoyam, or just yam (Egyir and Yeboah, 2010). During the preparation of *fufu analogue* product, coconut residue, and low carbohydrate food binders can be used. This study focuses on developing low glycemic index *fufu* analogue products using coconut residue and low carbohydrate food binders, evaluating their glycemic indices, glycemic loads, dietary fibre, and sensory analysis.

2. Materials and methods

2.1 Collection of samples

Fresh and matured coconuts and food binders (psyllium husk and gelatin) were purchased at Umungasi Market Aba, Abia State, Nigeria.

2.2. Production of coconut residue

The method described and used by Sanful (2009) was adopted with slight modifications. Freshly dehusked coconuts (*Cocus nucifera*) 10kg was weighed, cleaned, and cracked to expel the containing coconut water. The coconut flesh (meat) was removed from the shell with the aid of a stainless steel pointed knife. The brown outer colour of the skin was scraped off manually with a knife. The clean coconut flesh was sliced into smaller (5mm) pieces and milled with an attrition mill (Model CH178RA). The slurry was homogenized with hot water (100^{o}C.) and poured into a muslin cloth, squeezed to separate its creamy (oily) juice, and the residue was further rinsed with hot water (<70^{0}C) until the filtrate becomes colorless. The defatted coconut residue was dried (60^{0}C for 3h) in the hot air oven (Uniscope Laboratory Model SM9023), milled using an electric blender (Philip, HR1702), sieved (0.5mm mesh sieve), packaged in a polythene bag, sealed and store at ambient temperature (27± 2^{0}C) for further use.

2.3. Preparation of *fufu* analogue products

Coconut residue (100g each) were mixed separately with different concentrations (2g, 5g, and 10g) of each of the binders (psyllium husk and gelatin) and 10 ml of water. The paste was stirred in a cooking pot to form dough at 100^{0}C for 5 minutes. It was allowed to cool and packaged in transparent polyethylene bag.

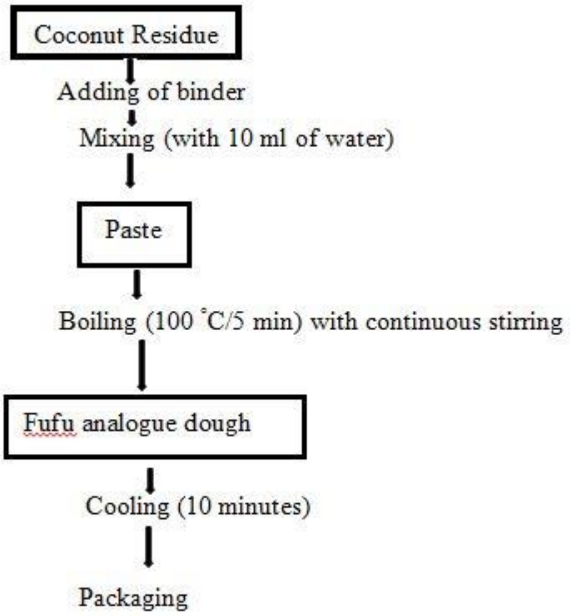

Figure 1: Production of Fufu analogue products

2.4. Formulation of residue blends

A 100g portion of coconut residues was blended separately with different concentrations of psyllium husk and gelatin as shown in Table 1. For each of the sieved samples, a digital weighing balance (Model, CH178RA) and a blender (Philip, HR1702) was used for weighing and mixing the residue blends respectively.

Table 1: Factor combinations for the production of *fufu* analogue products from coconut residue

Run	Coconut residue (g)	Sample code	Binder	Quantity (g)
1	100	PH1	Psyllium husk	2
2	100	PH2	Psyllium husk	5
3	100	PH3	Psyllium husk	10
4	100	G1	Gelatin	2
5	100	G2	Gelatin	5
6	100	G3	Gelatin	10

*Corresponding Author: **Ndulaka, Justina, C**

PH1= Psyllium husk (2g), PH2= Psyllium husk (5g), PH3= Psyllium husk (10g), G1= Gelatin (2g),
G2 = Gelatin (5g), G3= Gelatin (10g).

2.5. Dietary fibre analysis

The soluble, insoluble, and total dietary fibre in the *fufu* analogue products was determined using the Enzymatic-Gravimetric method MES-TRIS Buffer (AOAC, 2010).

2.6 Determination of the estimated glycemic index (eGI)

Determination of the eGI of *fufu* analogue products was conducted using the method of Nani *et al*. (2017). Samples (50 mg) and 10 mL of HCl-KCL buffer (pH 1.5) was added to conical tubes and 0.2 ml of pepsin solution in 10 mL of HCl-KCl buffer, pH 1.5) was added to each sample and incubated at 40°C for 1 h in a water bath. The volume was brought to 25 ml with tris-maleate buffer, pH 6.9. Then, 5ml of pancreatic α-amylase solution in tris-maleate buffer containing 2.6 UI was added to each sample and incubated at 37°C in a water bath. Aliquots (0.1 mL) was collected from each sample after every 30 min from 0-180 min and placed in a tube at 100°C and was refrigerated until the end of the incubation time. Sodium acetate buffer (1 mL, 0.4 M, pH 4.75) was added to each aliquot and 30 μL of amyloglucosidase was added to hydrolyze the digested starch into glucose after incubating at 60°C for 45 min in a water bath. The hydrolyzed glucose content was measured using the glucose oxidase-peroxidase reagent. The rate of starch digestion was expressed as the percentage of TS hydrolyzed at different times (0, 30, 60, 90, 120, and 180 min). The total starch hydrolysis (%) of fufu analogue products at different times were calculated as follows:

$$\text{Total starch hydrolysis \%} = \frac{\text{Released glucose weight} \times 0.9}{\text{Total starch weight}} \times 100 \ldots\ldots\ldots (1)$$

The kinetics of **in vitro** starch digestion was calculated using the non-linear model established by Goni *et al*.(1997). The first-order equation is: $C = C_4(1-e^{-kt})\ldots \ldots\ldots\ldots\ldots\ldots\ldots(2)$
where, C is the percentage of starch hydrolyzed at time t (min), C_∞ is the equilibrium percentage of starch hydrolyzed after 180 min and k is the kinetic constant. The parameters C_∞ and k was estimated for each treatment based on data obtained from the in vitro starch digestion. The area under the hydrolysis curve (AUC) was calculated using the following equation:

$$AUC = C_\infty(t_f - t_o) - (C_\infty/K)[1-\exp^{(-k(t_f - t_o))}] \ldots\ldots\ldots\ldots(3)$$

where, C_∞ is the equilibrium percentage of starch hydrolyzed after 180 min, t_f is the final time (180 min), t_0 is the initial time (0 min) and k is the kinetic constant.

The hydrolysis index (HI) represents the rate of starch digestion and the estimated GI indicates the digestibility of the sample in relation to the digestibility of starch.

2.6.1 Calculation of glycemic load (GL)

In calculating glycemic load of the *fufu* analogue products, its glycemic index was multiplied by the number of carbohydrate grams in a serving and then divide by 100 (Blessing *et al*., 2021).

2.7 Sensory evaluation

Sensory evaluation of the formulated *fufu* analogue products was conducted using a fifteen (15) semi-trained panel members (Staff and students of the Department of the Food Science and Technology, Abia State Polytechnic, Aba in Nigeria) who are regular *fufu* consumers. The panelists were asked to score for appearance, odour, taste, mouldability, hand-feel, and overall acceptability using nine point hedonic scale as described by Olapade and Adeyemo (2014) where like extremely = 9, like very much = 8, like moderately = 7, like slight = 6, neither like nor dislike = 5, dislike slightly = 4, dislike moderately = 3, dislike very much = 2 and dislike extremely = 1.

2.8 Statistical analysis

The result (data) obtained was analysed using one way analysis of variance (ANOVA) to test for significant difference at 5% level of significance (p <0.05). Statistical Package for Social Science (SPSS, version 20) was used for the statistical analysis.

3. RESULTS AND DISCUSSION

Plate 1: *Fufu* analogue product made from Plate 3: Fufu analogue product made from coconut residue coconut residue of 2g gelatin of 10g gelatin

Plate 2: *Fufu* analogue product made from Plate 4: *Fufu* analogue product made from coconut coconut residue of 5g gelatin residue of 2g psyllium husk

Plate 5: *Fufu* analogue product made from Plate 6: *Fufu* analogue product made from coconut residue coconut residue of 5g psyllium husk of 10g psyllium husk .

Table 2: Dietary fibre of *fufu* analogue products.

Binder	Quantity (g)	(IDF (%)	SDF (%)	TDF (%)
Gelatin	2	$67.61^{d} \pm 0.03$	$0.54^{f} \pm 0.01$	$68.15^{e} \pm 0.02$
Gelatin	5	$70.69^{cd} \pm 0.01$	$0.58^{d} \pm 0.02$	$71.27^{d} \pm 0.03$
Gelatin	10	$72.76^{b} \pm 0.07$	$0.68^{c} \pm 0.00$	$73.46^{b} \pm 0.05$
Psyllium husk	2	$70.73^{cd} \pm 0.01$	$0.57^{d} \pm 0.02$	$71.29^{d} \pm 0.03$
Psyllium husk	5	$70.92^{c} \pm 0.05$	$0.72^{b} \pm 0.01$	$71.59^{c} \pm 0.01$

*Corresponding Author: **Ndulaka, Justina, C**

Psyllium husk	10	$78.05^{a}\pm 0.01$	$0.94^{a}\pm0.02$	$78.98^{a}\pm0.03$

Values are mean ± SD of duplicate determinations. Mean values with different superscripts in a column are significantly ($p<0.05$) different.
Key: IDF= Insoluble dietary fibre, SDF= Soluble dietary fibre, TDF = Total dietary fibre.

Table 3: Estimated glycemic index (EGI) and glycemic load (EGL) of the *fufu* analogue products

Binder	Quantity (g)	EGI (%)	EGL (100g/serving)
Gelatin	2	$40.11^{b}\pm0.01$	$4.42^{a}\pm0.02$
Gelatin	5	$40.18^{a}\pm0.01$	$3.86^{b}\pm0.02$
Gelatin	10	$40.08^{c}\pm0.01$	$2.50^{d}\pm0.02$
Psyllium husk	2	$40.12^{b}\pm0.01$	$3.68^{bc}\pm0.02$
Psyllium husk	5	$40.15^{ab}\pm0.01$	$2.78^{c}\pm0.02$
Psyllium husk	10	$39.93^{d}\pm0.01$	$1.78^{e}\pm0.02$

Values are mean ± SD of duplicate determinations. Mean values with different superscripts in a column are significantly ($p<0.05$) different.

3.1. Total dietary fibre (TDF).

The total dietary fibre (TDF) of the fufu analogue products ranged from 68.15 to 78.98% (Table 2), the highest ($p<0.05$) total dietary fibre mean value was seen in the *fufu* analogue product made with 10g psyllium husk (78.98%) and the lowest was seen in product made with 2g gelatin (68.15 %) at ($p<0.05$). It was observed that dietary fibre of the fufu analogue products increased with increase in the quantities of the binders. According to (Edima-Nyah *et al*.,2019), a food can be referred to as high in fibre provided that the food contains at least 6g/100g or 3g/100Kcal of dietary fibre. Fibre is important for the removal of waste from the body thereby preventing constipation and many health disorders. It also enhances glucose tolerance and increases insulin sensitivity (Sobota *et al*., 2010). Numerous studies found that dietary fibre can increase satiety and decrease appetite, hence indirectly reducing energy intake.

3.2 Soluble dietary fibre (SDF)

The Soluble dietary fibre (SDF) of the fufu analogue product ranged from 0.54 to 0.94% (Table 2). The highest ($p<0.05$) soluble dietary fibre mean value was seen in fufu analogue products made with 10g psyllium husk and the lowest ($p<0.05$) soluble dietary fibre mean value was seen in product made with 2g gelatin. Soluble dietary fibre include pectin, oligosaccharides, guar gum, most of which are dietary and healthy additives (Dhingra *et al*., 2012).

3.3 Insoluble dietary fibre (IDF)

The insoluble dietary fibre of the fufu analogue products ranged from 67.61 to 78.05 % (Table 2), with the highest ($p<0.05$) seen in the fufu analogue products made with 10g psyllium husk (78.05%) while the lowest was seen in *fufu* analogue product with 2g gelatin. The insoluble dietary fibre of samples were significantly different at $p<0.05$. This result (67.61% - 78.05%) is line with the result reported by Piotr *et al*., (2019) on effect of whole meal oat flour storage on content of dietary fibre and rheological properties. Insoluble dietary fibre mainly consist of hemicellulose, cellulose, and lignin and cannot be degraded by enzymes in the human body or dissolved in water.

3.4 Estimated glycemic index (EGI) of *fufu* analogue products

The estimated glycemic index obtained after the in vitro enzymatic digestion of each fufu analogue products are shown in Table 3 and it ranged from 39.93% to 43.18%. The highest mean value was ($p <0.05$) seen in fufu -like product made with 2g gelatin (40.18%), while the lowest mean value (39.93%) was seen in fufu analogue product made with 10g psyllium husk. There were significant difference ($p <0.05$) in the estimated glycemic index mean values of the *fufu* analogue products. Despite the variations seen in the products, the estimated glycemic indices of the *fufu* analogue products fell within low glycemic index food classification. The low estimated glycemic index values observed in the *fufu* analogue products could be attributed to its high content of dietary fibre. Previous research illustrated the potential of lowering glycemic response to foods by incorporating different fibre fractions, especially soluble fibre (Blessing *et al*., 2021). Low glycemic index foods are important in the management of hyperglycemia and hyperinsulinemia because they have a high satiety effect and therefore can reduce the likelihood of excessive consumption of calories. Research has shown that food with low glycemic index is known to have a positive health benefit when compared to foods with higher glycemic index (Miao *et al*., 2015).

3.5 Glycemic load (GL) of *fufu* analogue products

The glycemic load was calculated from the results obtained from the glycemic index of the *fufu* analogue products. The glycemic load of the *fufu* analogue products ranged from 1.78 to 4.42 (Table 3). *Fufu* analogue product made with 2g gelatin recorded the highest glycemic load mean value (4.42) while the lowest glycemic load mean value (1.78) was seen in product made of 10g psyllium husk. There were significant differences at ($p<0.05$) in the glycemic loads of the samples.

The glycemic load of food, is a number that estimates how much a food will raise the blood glucose level in individual. One unit of glycemic load approximates the effect of consuming one gram of glucose (Jia-Yu Zhang, 2019). According to Christabel. (2022) Both the quality and quantity of carbohydrate in a food determine an individual's glucose response to the food. The glycemic loads of the foods are classified as low (less than 10 of 100g/serving), medium (between 11 – 19 of 100g/serving) or high (more than or equal to 20 of 100g/serving) (Blessing *et al*., 2021).

Food servings have a major effect on the glycemic index of the food, thereby increasing the glycemic load of the food (Christabel, 2022). Foods that have high glycemic load are linked to an increased risk of certain chronic diseases whiles low glycemic load foods are seen to reduce the risk of acquiring these diseases. In a collection of studies, high glycemic index and high glycemic load of the total food have been associated with a greater risk of type 2 diabetes in both men and women (Kettleborough *et al*., 2013). Since diabetes is primarily a condition of disordered glucose metabolism, it is important to bear in mind the type of dietary carbohydrate that can influence the risk and cause of this disease (American Diabetes Association, 2015).

Food that produces higher blood glucose concentration and greater demand for insulin would increase the risk of type 2 diabetes (Sanusi and Olurin, 2012).

Table 4:

Residue sample (100g)	Binder	Quantity (g)	Appearance	Odour	Taste	Mouldability	Hand feel	General acceptability
Coconut	Gelatin	2	$5.00^{b}\pm0.02$	$6.00^{a}\pm0.02$	$5.00^{b}\pm0.01$	$5.00^{c}\pm0.01$	$5.00^{c}\pm0.01$	$5.00^{c}\pm 0.01$
Coconut	Gelatin	5	$6.50^{ab}\pm0.01$	$6.00^{a}\pm0.02$	$7.00^{a}\pm0.01$	$6.00^{b}\pm0.01$	$6.00^{b}\pm0.01$	$6.00^{b}\pm0.01$
Coconut	Gelatin	10	$6.50^{ab}\pm0.01$	$6.00^{a}\pm0.02$	$7.00^{a}\pm0.01$	$7.00^{ab}\pm0.02$	$7.00^{a}\pm0.01$	$6.50^{ab}\pm0.01$
Coconut	Psyllium husk	2	$6.00^{b}\pm0.02$	$6.00^{a}\pm0.02$	$7.00^{a}\pm0.01$	$6.00^{b}\pm0.04$	$5.00^{c}\pm0.01$	$5.00^{c}\pm0.02$
Coconut	Psyllium husk	5	$7.00^{a}\pm0.01$	$6.00^{a}\pm0.02$	$7.00^{a}\pm0.01$	$7.00^{ab}\pm0.01$	$6.50^{ab}\pm0.01$	$6.50^{ab}\pm0.01$
Coconut	Psyllium husk	10	$7.50^{a}\pm0.01$	$6.00^{a}\pm0.02$	$7.00^{a}\pm0.01$	$7.50^{a}\pm0.01$	$7.00^{a}\pm0.01$	$7.00^{a}\pm0.01$

Sensory evaluation of glycemic index *fufu* analogue products.

Values are mean ± SD of duplicate determinations. Mean values with different superscripts in a column are significantly ($p<0.05$) different

3.6 Sensory evaluation of *fufu* analogue products.

The results of the sensory evaluation of the low glycemic index *fufu* analogue products are presented in Table 4 above**.** Appearance is an important sensory attribute of any food, because of its influence on acceptability among consumers (Agugo *et al*., 2020). The old adage that the eye accepts the food before the mouth is very true. The sensory results of the *fufu* analogue products are presented in Plates 1- 6 above. The *fufu* analogue products made with 5-10g of all the binders rated highest ($p<0.05$) (7.00) in terms of appearance, taste, hand feel, while fufu analogue products made with 10g of the binders rated highest ($p<0.05$) in terms of mouldability. There were no significantly different at ($p<0.05$) in odour profile of fufu analogue products.

Overall acceptability mean values of the fufu analogue products ranged from 5.0 to 7.00 (Table 4). The highest score ($p<0.05$) was seen in products made with 10 g of the binders. *Fufu* analogue Products made with 2g of the binders rated the lowest (5.00). Acceptance of food varies with standards of living and cultural background, whereas preference refers to selection when presented with choice (Deniran *et al*., 2022). It was interesting to notice that the use of residues to produce the *fufu* analogue products did not make negative impact concerning the overall acceptability of the new product by consumer-oriented panelists. The results show that all the samples had good sensory ratings for appearance, odour, taste, hand-feel, mouldability, and overall acceptability.

3.7. CONCLUSION

The study attempted to investigate the possibility of using coconut residue for the production of *fufu* analogue products. Findings of the research work revealed that the *fufu* analogue products have low glycemic indices, low glycemic loads, high dietary fibre, and all the samples had good sensory ratings**.** It is recommended that food scientists, nutritionists and dieticians can as well recommend *fufu* analogue products made from coconut residue as a functional food. It is also recommended that greater attention should be placed on researching into the glycemic indices and glycemic loads of our local foods as to provide a comprehensive information about the carbohydrate contents and how much in a food consumed in a serving will affect the blood glucose levels.

REFERENCES

1. Agugo, U., Agatha, A. A., Olivia,C., Iwueke, A. Vivien, O. B. Joseph, I., Geraldine, O. and Dike, O. (2020). Nutrition Composition and Sensory Properties of Bread and Fufu produced from Cassava (Manihot esculenta) and Mungbean (Vignaradiata) Flour Blends. *Journal of Nutrition and Dietetics*.3:231-235..
2. Akibode, S. and Maredia, M. (2011). Global and regional trends in production, trade, and consumption of food legume crops. Michigan State University, Michigan.
3. AOAC. (2005). Association of Official Analytical Chemists. 15th ed., pp.1045-1047.
4. American Diabetes Association. (2015). Factors affecting blood glucose. Retrieved from http://www.diabetes.org>treatment-and care. Accessed 13/16/2022.
5. Brand, J. C., Calagiuri, S., Crossman, S., Allan, A., Roberts, D. C. K. and Truswel, A.S. (1991). Low glycemic index foods improve long-term glycemic control in NIDDM. Diabetes Care, 14, 95−101.
6. Blessing, M.M., Simeon, A. A., Basil, B. and Terry, T. G. (2021). Effect of cassava on proximate composition, insulin index, glycemic profile, load, and index in healthy individuals: a cross-sectional study. *Functional Foods in Health and Disease* 2021; 11(1): 1-10.
7. Chau, C.F. and Huang, Y.L. (2003). Comparison of the chemical composition and physicochemical properties of different fibres prepared from peel of the Citrus sinensis L. Cv. Liucheng. *Journal Agriculture Food Chemistry*. 51:2615–2618.
8. Christabel A. A.G. (2022). An Evaluation of Glycemic Load in the Assortments of Fufu in Ghana Universal *Journal of Food Science and Technology* 10: 31586.
9. Deniran, I. A., Oyelere,O.E., Oyegbade, S.A., Akinduro, W. O.and Adelaja, O. A. (2022). Comparison of Functional Properties of Fufu Powder and Sensory Evaluation of the Dough Produced from TME 419,TME 693 and IBAO 11371 Cassava Varieties. *Journal of Food and Nutrition Sciences*.10 (6): 178-184.
10. Dhingra, D., M. Michael, H. Rajput, and R. T. Patil. (2012). Dietary fibre in foods: A review. *Journal of Food Science and Technology* 49 (3):255–66.
11. Du, S.K., Jiang, H., Ai, Y. and Jane, J. L. (2014). Physicochemical properties and digestibility of common bean (*Phaseolus vulgaris* L.) starches. *Carbohydrate. Polymers,* 108: 200-205.
12. Edima-Nyah, A. P., Ojimelukwe, P. C. and Nwabueze, T. U. (2019). In Vitro Nutrient Analysis of High Fibre Snack Bars Produced From Blends of African Breadfruit, Maize and Coconut. *Journal of Environmental Science, Toxicology and Food Technology:*1 3: 2319-2399.
13. Egyir, I. S. and Yeboah, B. A. (2010). Fufu flour processing in Ghana: Costs, returns and institutional support expected to encourage young entrepreneurs.*Ghana Journal Agricultural. Science*. 42, 157-168.
14. Etudaiye, A. H, Nwabueze, T and Sanni, O. L. (2012). Nutritional Quality and Preference of fufu processed from selected Cassava Mosaic Disease (CMD) Resistant Cultivars. Pelagia Research Library; 3(5):2687-2692.
15. FAO (2010). Report on Functional Foods, Food Quality and Standards Service (AGNS)..
16. Foster-Powell, K., Holt, S.H.A. and Brand-Miller, J.C. (2002). International table of glycemic index and glycemic load values. *American Journal Clinical Nutrition.* 76: 5-56.
17. Guzel, D. and Sayar, S. (2012). Effect of cooking methods on selected physicochemical and nutritional properties of barlotto bean, chickpea, faba bean and white kidney bean. *Journal Food Science Technology*, 49: 89-95.
18. Jia-Yu Zhang., Yu-Ting Jiang., Ya-Shu Liu., Qing-Chang, Y-Hz. and Q-J.W. (2019).The association between glycemic index, glycemic load, and metabolic syndrome: a systematic review and dose–response meta-analysis of observational studies. *European Journal Nutrition*. 59:451–463.
19. Hoover, R., Hughes, T., Chung, H.J. and Liu, Q. (2010). Composition, molecular structure, properties and modification of pulse starches: A review. *Food Res. International*., 43: 399-413.
20. Kettleborough, R. N., Busch-Nentwich, E. M., Harvey, S. A., Dooley, C. M., De Bruijn, E., Van Eeden, F. and Stemple, D. L. (2013). A systematic genome-wide analysis of zebrafish protein-coding gene function. *Nature*, *496*(7446), 494-497.
21. Li, W., Xiao, X.,Guo, S., Ouyang, S., Luo, Q., Zheng J. and Zhang, G. (2014). Proximate composition of triangular pea, white pea, spotted colored pea and small white kidney bean and their starch properties. *Food Bioprocess Technology*, 7: 1078-1087.

*Corresponding Author: **Ndulaka, Justina, C**

22. Madu, A. N. 1,. Njoku, M. I. and Oluwatosin, I. (2018). Determination of Glycemic Indices (GI), Glycemic Load (GI) and Proximate Analysis of unripe Plantain (*Musa paradisiaca*) and Cocoyam (*Colocasia esculenta*). *International Journal of Scientific Research in Chemistry* 3: 2456-8457.
23. Manikandan, A., Meera, R. and Kannan, E. (2015). Formulation and storage stability of coconut flour and dietary fibre isolate. *International Journal of Pharmacy and Pharmaceutical Sciences*; 17:3. 0975-1491
24. Mathews, M. J., Liebenberg, L. and Mathews, E. H. (2015). How do high glycaemic load diets influence coronary heart disease? *Nutrition and metabolism, 12*(1), 6.
25. Miao, M., Jiang, B., Cui, S. W., Zhang, T. and Jin, Z. (2015). Slowly Digestible Starch- A Review. *Critical Reviews in Food Science and Nutrition*, 55(12): 1642-1657.
26. Nani. R., Suparmo, E. and Marsono, Y. (2017). Invitro starch digestibility and estimated glycemic index of Indonesian cowpea starch (Vigna unguiculata) *Parkistan Journal Nutrition;* 16:1-8.
27. Olapade, A. A. and Adeyemo, A. M. (2014). Evaluation of cookies produced from blends of wheat, cassava and cowpea ours 3: 175-185.
28. Peter, I. A. (2019). Evaluation of the quality of Instant fufu Flour prepared from Corn, cassava and soybean flour blends.South Asian J. Food Technol. Environ., 5(1):785-790.
29. Piotr, Z., Emilia S.D., Aldona S. and Anna, W. (2019). Effect of wholemeal oat flour storage on content of dietary fibre and rheological properties technologia 1 (118), 67 – 78.
30. Ratnaningsih, N., Suparmo. Harmayani, E. and Marsono, Y. (2016). Composition, microstructure and physicochemical properties of starches from Indonesian cowpea (*Vigna unguiculata*) varieties. *International Food Res. Journal*, 23: 2041-2049.
31. Salmeron, J., Ascherio, A. and Rimm, E.B. (1997). Dietary Fiber, Glycemic Load and Risk of NIDDM in Men. Diabetes Care, 20, 545-550.
32. Sanful, R. E. (2009). Promotion of Coconut Fibre in the Production of Yoghurt. *African Journal Food Science* 3(5): 147 - 149.
33. Sanusi, R. A. and Olurin, A. (2012). Portion and serving sizes of commonly consumed foods, in Ibadan, Southwestern Nigeria. *African Journal of Biomedical Research*, *15*(3), 149-158.
34. Simsek, S. and S. Nehir El, 2015. *In vitro* starch digestibility, estimated glycemic index and antioxidant potential of taro (*Colocasia esculenta* L. Schott) corm. *Food Chemistry*; 168: 257-261.
35. Sobota, A., Sykut-Domanska, E. and Rzedzicki, Z. (2010). Effect of Extrusion-cooking process on the chemical composition of corn-wheat extrudates, with particular emphasis on dietary fibre fractions. Polish Journal of Food and Nutrition Sciences, 60(3): 251 – 259.
36. Trinidad, T.P., Mallillin ,A.C., Valdez, D.H., Loyola, A.S., Askali-Mercado, F.C., Castillo, J.C., Encabo, R.R., Masa,D.B., Maglaya, A.S.and Chua, M.T. (2006). Dietary fiber from coconut flour: A functional food. Innovative *Food Science and Emerging Technologies* 7:309-317.
37. Wolever, T.M.S., Jenkins, D.J.A. Jenkins, A.L. and Josse, R.G. (1991). The glycemic index: Methodology and Clinical implications. *American Journal Clinical Nutrition*.54: 846-854.
38. Zhang, Z., Smith, C. and Li, W. (2014). Extraction and Modification Technology of Arabinoxylans from Cereal By-products: A Critical Review *Food Reserve International. 65*, 423–436

*Corresponding Author: **Ndulaka, Justina, C**