Comparative Studies on the Estimated Glycemic Indices/ Loads of Fufu-Like Products from Coconut and Maize Chaffs

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ABSTRACT

Comparative studies of the estimated glycemic indices/ loads of fufu-like products made with coconut and maize chaffs were studied. Coconut chaff and maize chaff (100g each) were mixed separately with different quantities (2g, 5g and 10g) of each of the binders (psyllium husk and gelatin) and 10ml of water. The paste was stirred in a cooking pot to form dough at 100^0C for 5 minutes. It was allowed to cool and packaged in transparent polyethylene bag, Hydrolysis indices, glycemic indices and glycemic loads of the fufu-like products were determined using standard methods. Hydrolysis index of the fufu-like products made from coconut chaff were found in the range of 0.41% to 0.86% while products made from maize chaff ranged from 1.08% to 6.32%. Estimated glycemic indices of the fufu-like products made from coconut chaff ranged from 39.93% to 40.18% while that of maize chaff ranged from 40.30% to 43.18%. The glycemic loads of the fufu-like product made from coconut chaff ranged from 1.78 to 4.42 (100g serving) while products made from maize chaff ranged from 6.32 to 10.34 (100g serving). The study revealed that all the fufu like products had low glycemic indices and glycemic loads except fufu-like products made with maize chaff that fell under medium range of glycemic load classifications. Fufu-like product made from coconut chaff with 10g psyllium husk yielded lowest glycemic index and glycemic load which could be used as a functional food.

INTRODUCTION

Glycemic index (GI) is a ranking system for carbohydrates based on their effect on blood glucose levels (Blessing *et al*., 2021). According to Wolever *et al*. (1991), it is also known as 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. 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). The prevalence of chronic illnesses has been rising globally (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 (Guzel and Sayar, 2012, Hoover *et al*., 2010). 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). Eating foods with low glycemic index may help prevent the development of several diseases, including diabetes, obesity, heart disease and even some types of cancer (Du *et al*., 2014).

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. Fresh coconuts are processed by shelling, paring, wet milling and extracting the milk using screw press. This milk can then be used to make coconut oil or dried and powdered into spray-dried coconut milk. After the milk is extracted and dried, the defatted coconut chaff is obtained, which can then be ground into flour (Trinidad *et al*., 2003; Raghavendra *et al*., 2006). Coconut has high dietary fiber, protein, antioxidant and vitamin. Trinidad *et al*. (2006) stated that the residue (chaff) of coconut could be made into flour and used for formulation and development of new food product. It is interesting to note that coconut flour lacks gluten and is a significant source of nutrients, including proteins, fiber and has no trans fats. It also has a low glycemic index (Ramaswamy, 2014).

Zea mays L., commonly known as maize or corn, is a significant annual cereal crop grown worldwide and a member of the *Poaceae* family. The kernels can be extracted and eaten or used to make a variety of foods, such as cereals and flour. The ears can also be cooked and consumed as a vegetable. Maize processing waste (chaff) variously called in Nigeria as *Esususoka* in Igbo, *Dusa* in Hausa and *Eeriogi* in Yoruba is the waste from *akamu* (pap) production (Okafor and Usman, (2015). The waste is relatively available in large quantities both in rural and urban communities in Nigeria. Most of the backyard poultry farmers use it as a source of feed (Iyayi and Aderolu, 2004). In the majority of the world, the only use of these plant wastes produced during the processing of maize and coconut milk is as a source of feed for poultry and livestock. These are biomasses known as lignocelluloses, which are composed of cellulose, hemicelluloses and lignin and have a total dietary fiber content of 90g/100g (Deutschmann and Dekker, 2012).

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). The fufu's high carbohydrate content is consistent with the nutritional profile of cassava roots, where starch makes up 80% of the total carbohydrate content (Purseglove, 1991). 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-like product, coconut chaff, maize chaff and food binders can be used. This study would help in the acquisition of knowledge of the functional benefits of this innovative product, thus enlighten the public and nutritionists on the vast health benefits of this by-product and enable them to make better dietary choices and food formulations. It will also increase their menu varieties.

MATERIALS AND METHODS

Collection of samples

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

Production of coconut chaff: 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 (100ºC.) and poured into a muslin cloth, squeezed to separate its creamy (oily) juice and the chaff was further rinsed with hot water (<70^{0}C) until the filtrate becomes colourless. The defatted coconut chaff was dried (60^{0}C for 3h) in the hot air oven (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.

Production of maize chaff: The method described and used by John and Osita, (2012) was adopted with slight modifications for the production of *ogi* from which the maize chaff was gotten. White maize grains (10kg) was sorted, cleaned and steeped in clean water at room temperature for 48 h. The water was decanted and the fermented grains were washed with clean water and wet milled using an attrition mill (Model CH178RA). The chaff was removed wet with a muslin cloth and the filtrate was allowed to settle for 24 h to form starchy sediment, which is *ogi*. The wet chaff was rinsed several times and was dewatered in a jute sack. The dewatered chaff was pulverized and dried in a hot air oven (Uniscope Laboratory Model SM9023) (55±5°C), milled using an electric blender (Philip, HR1702), sieved and packaged in air tight container for further use.

Preparation of fufu-like products: Coconut chaff, tiger-nut chaff and maize chaff (100g each) were mixed separately with different quantities (2g, 5g and 10g) of each of the binders (psyllium husk and gelatin) and 10ml 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,

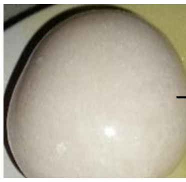
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Plate 1: Fufu-like product made from coconut chaff of 2g gelatin


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Plate 3: Fufu-like product made from coconut chaff of 10g gelatin


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Plate 2: Fufu-like product made from coconut chaff of 5g gelatin


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Plate 4: Fufu-like product made from coconut chaff of 2g psyllium husk

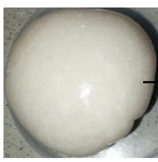
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Plate 5: Fufu-like product made from chaff of 5g psyllium husk


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Plate 6: Fufu-like product made from coconut chaff coconut of 10g psyllium husk .


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Plate 7: Fufu-like product made from maize chaff 2g psyllium husk


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Plate 8: Fufu-like product made from maize chaff of 2g gelatin


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Plate 9: Fufu-like product made from maize chaff of 5g psyllium husk


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Plate 10: Fufu-like product made from maize chaff of 5g gelatin

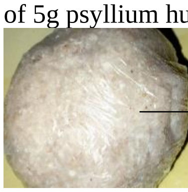
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Plate 11: Fufu-like product made from maize chaff of 10g psyllium husk


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Plate 12: Fufu-like product made from maize chaff 10g gelatin

Determination of the estimated glycemic index (eGI)

Determination of the eGI of fufu-like products was conducted using the method of Nani *et al*. (2017

Calculation of glycemic load (GL)

Glycemic load of the fufu-like products was calculated using the method of Blessing *et al*. (2021).

RESULTS AND DISCUSSION

Hydrolysis index of the glycemic index fufu-like products

Hydrolysis index (HI) of the fufu-like products are shown in (Table 1) which ranged from 0.45 to 0 6.32 % , with the highest hydrolysis index (HI) mean value seen in product made from maize chaff of 2g gelatin (6.32%) and lowest mean value seen in products made from coconut chaff of 10g psyllium husk (0.45%). The smaller the hydrolysis index the lower the glycemic index. Hydrolysis index is one of the most important criteria for differentiation of starch digestibility from the nutritional standpoint. Hydrolysis index represents the proportion of starch digested in food related to the starch digested in reference food. Estimated glycemic index is calculated from hydrolysis index. The Hydrolysis index of the product were significantly different at ($p < 0.05$).

Table 1: Hydrolysis index (HI %) of the fufu-like products

Binder	Quantity (g)	Coconut HI (%)	Maize HI (%)
Gelatin	2	0.72^{ef}±0.01	6.32^{a}± 0.01
Gelatin	5	0.86^{d}±0.01	6.01^{ab}±0.01
Gelatin	10	0.68^{f}±0.01	1.57^{c}±0.00
Psyllium husk	2	0.76^{e}±0.03	6.03^{ab}±0.00
Psyllium husk	5	0.81^{de}±0.07	2.35^{b}±2.83
Psyllium husk	10	0.41^{g}±0.07	1.08^{d}±0.01

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

Estimated glycemic index (EGI) of the fufu-like products: The estimated glycemic index obtained after the in vitro enzymatic digestion of each fufu-like products are shown in Table 2 and it ranged from 39.93% to 43.18%. The highest mean value was seen in fufu -like product made from maize chaff of 2g gelatin (43.18%), while the lowest mean value (39.93%) was seen in fufu-like product made from coconut chaff of 10g psyllium husk (Table 2). There were significant differences at ($p < 0.05$) in the estimated glycemic index mean values of the fufu-like products. Despite the variations seen in the products, the estimated glycemic indices of the fufu-like products fell within low glycemic index food classification. The low estimated glycemic index values observed in the fufu like products could be attributed to its high content in dietary fibre and it is able to slow down the enzymatic digestion of carbohydrates and reduce the gastrointestinal absorption of glucose. Previous research has 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).

Table 2: Estimated glycemic index (EGI) of the fufu-like products

Binder	Quantity (g)	Coconut EGI (%)	Maize EGI (%)
Gelatin	2	40.11^{e}±0.01	43.18^{a}±0.02
Gelatin	5	40.18^{d}±0.01	43.01^{ab}±0.02
Gelatin	10	40.08^{d}±0.01	40.57^{bc}±0.02
Psyllium husk	2	40.12^{e}±0.01	43.02^{ab}±0.02
Psyllium husk	5	40.15^{df} ±0.01	41.00^{b}±0.05
Psyllium husk	10	39.93^{f}±0.01	40.30^{c}±0.01

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

Glycemic load (GL) of the fufu-like products: The glycemic load was calculated from the results obtained from the glycemic index of the fufu-like products. The glycemic loads of the fufu-like products ranged from 1.38 to 19.34(100g serving) (Table 3). Fufu-like product made with maize chaff of 10g gelatin recorded the highest glycemic load mean value (19.34 /100g serving) while the lowest glycemic load mean value (1.78/100g serving) was seen in product made from coconut chaff 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 after its consumption in an individual. One unit of glycemic load approximates the effect of consuming one gram of glucose (Jia-Yu Zhang, 2019). Glycemic index does not consider the number of carbohydrates in a food, glycemic load is a better indicator of how a carbohydrate food will affect blood glucose. Although the glycemic index can represent a carbohydrate-containing food's effect on blood glucose, the portion size is also an important factor that needs to be taken into consideration for glucose management as well as the management of weight. 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 load is therefore the current way to evaluate the impact of carbohydrate consumption that takes into account the glycemic index but provides a deeper picture than the glycemic index. The Glycemic loads of the foods are classified as low (less than 10%), medium (between 11 – 19%) or high (more than or equal to 20%) (Blessing *et al*., 2021).Food serving sizes have a major effect on the glycemic index of the food, thereby increasing the glycemic load of the food (Christabel, 2022). The United States Department of Agriculture (USDA) and Food and Drugs Administration and Control (Young and Nestle, 2003) have established standard serving sizes that guide Americans to select the right portion sizes of food to eat for sustained and improved health. 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, both the glycemic index and the 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 course 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). The glycemic load of the fufu-like products made with coconut chaff fell under low glycemic loads food range while fufu-like products made with maize chaff fell under medium glycemic load food range except the products of 10g psyllium husk that recorded low glycemic load of maize chaff.

Table 3: Glycemic load (EGL) of the fufu-like products

Binder	Quantity (g)	Coconut EGL	Maize EGI
Gelatin	2	$4.42^{f}\pm0.02$	$12.97^{c}\pm0.02$
Gelatin	5	$3.86^{g}\pm0.02$	$13.29^{b}\pm0.01$
Gelatin	10	$2.50^{i}\pm0.02$	$19.34^{a}\pm0.01$
Psyllium husk	2	$3.68^{gh}\pm0.02$	$12.85^{c}\pm0.01$
Psyllium husk	5	$2.78^{h}\pm0.02$	$10.56^{d}\pm0.01$
Psyllium husk	10	$1.78^{i}\pm0.02$	$6.32^{e}\pm0.01$

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

CONCLUSION

The study attempted to investigate the possibility of using coconut chaff and maize chaff for the production of low glycemic index fufu-like products. The study also revealed that all the fufu like products had low glycemic index and glycemic load except fufu-like product made with maize chaff that fell under intermediate range. It is recommended that food scientists, nutritionists and dieticians can as well recommend fufu-like products made with coconut chaff of 10g psyllium husk 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 affects the blood glucose levels

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