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THE GLYCEMIC INDICES OF "A*KAMU*" AND "*AGIDI": THE SECOND MEAL* EFFECT

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Abstract

The phenomenon that previous meals can regulate blood glucose response to a subsequent meal is known as the second meal effect. The second meal effect serves as a tool for attenuating glucose levels of high glycemic index foods. We evaluated the second meal effect using two corn pudding meals commonly known as Akamu and Agidi. Servings of corn pudding meals containing fifty grams of carbohydrates were fed to sixteen non-obese healthy subjects as breakfast and midday meal on different days over a 2-week period. Capillary blood samples were collected from the subjects at intervals of thirty minutes and assayed for glucose concentrations. The glycemic indices of akmu and agidi when taken as a breakfast meal was 128.0±3.3 and 105.0±2.8 the glycemic indices reduced to 98.0±3.9 and 89.9±2.2
for akamu and agidi when onsumed as second meals There was a significant ($P<0.05$) difference in glycemic indices of meals. Values of indices were higher in the morning than at noon. However, analyses revealed that both foods are high glycemic indices foods irrespective of the time consumed and meals consumed. This investigation agrees with studies that glycemic indices of foods are higher if determined during morning than midday, however foods were high glycemic index foods irrespective of the time consumed, hence these foods should not be used in dietary plan for management of metabolic disorders such as diabetes and obesity.

INTRODUCTION

Regulating postprandial blood glucose is vital in reducing the risk of metabolic disorders such as diabetes and cardiovascular diseases in healthy populations (Park *et al.,* 2015). The use of the glycemic index was introduced by Jenkins *et al.,* (1981) as a measure of the blood glucose-raising ability of foods. The glycemic index has helped in correcting misconceptions that simple carbohydrates are more quickly absorbed than complex carbohydrates (Jenkins *et al*., 1981). Since the appearance of glycemic index in 1981, the concept has been widely studied and the factors that affect the glycemic index of foods have been elucidated (Wolever, 1990; Akerberg *et al*., 1998; Pi–Sunyer, 2002, Thorsdottir et al., 2005).

Scientific evidence suggests that the glycemic response to the same food or meal is influenced by the time, composition and GI of a previous meal. A prolonged glucose response after a breakfast meal has been demonstrated to improve glucose tolerance at lunch, denoted as the ''second meal effect'' (Ardvisson-Lenner *et al.,* 2004, Park *et al.,* 2015; Mollars et al., 2011). Possible mechanisms for this phenomenon includes, 'attenuation of gastric emptying, early-phase insulin secretion, hepatic glucose output, and muscle glucose uptake' (Gonzalez *et al.*, 2014). There has been increased research in the second meal effect as nutritionists gear towards making dietary plans with this phenomenon in consideration. Chen *et al.,* (2010) reported about 40% reduction of postprandial glucose increment of foods when consuming yoghurt at breakfast.

As current research is geared towards ways of reducing the glycemic index of meals (Meng *et al.,* 2017), there is a need for providing data on glycmic indices on Nigerian foods. One commonly consumed food in Nigeia is maize (Juma, 2010). Maize (also known as corn) is one of the most cultivated food crop in Southern Nigeria. It is utilized for the preparation for various dishes. Due to its abundance, it is used as a staple and snack in Nigeria. Maize can be processed into pap by soaking, milling, filtering and addition of hot water. (Okoh, 1998). There are two popular paps in Nigeria; hot-pap and cold-pap. Hot-pap is known as *eko-gbona* or *ogi* (Yoruba), *akamu* (Ibo), *kamun* (Ibira) while cold-pap is *eko-tutu* (Yoruba), *agidi* (Ibo) and *kaf*a (Hausa).

The purpose of this research is to determine the reduction in glycemic indices of two corn meals akamu and agidi, when consumed as second meals.

MATERIALS AND METHODS

Collection of Food Materials

The raw material used for this study was maize which was purchased at Edjemuoyanre market, Oghara,

Preparation of Food Materials

Maize seeds were sorted and soaked in water for three days. Fermented grains were milled and sieved to remove the pericarp and bran fractions. The main constituent of the filtrate was starch. The starch is placed in a bag to drain out water. Boiling water is added to the starch and stirred until a semi solid paste is formed. In this semi solid state, it is hot and known as *akamu*,

Agidi is prepared by wrapping *akamu* in leaves and allowing it to cool

Serving sizes

Moisture, ash, ether extract, crude protein, crude fiber and carbohydrate contents of the respective diets were determined using AOAC (1995) and Dubois method (1956). Portions that provided 50 grams of carbohydrates were determined and used for the feeding experiment.

Subjects

Sixteen subjects between the ages of seventeen and thirty (ten males and six females) with average BMI of 22.6 ± 4.2 kg/m^2 were selected from the students of Department of Biochemistry, Western Delta University, Oghara. Criteria for selection were as follows; healthy, non-obese and non-diabetic with no family history of diabetes. Subjects were appraised verbally and they gave their written informed consent. Subjects were invited to partake in the meal studies four times within a fourteen-day period. All subjects for the investigation fasted overnight (10-12 hrs). All protocol for the study done in accordance to the method of Wolever *et al.,* (2003) was approved by the Ethics Committee of Western Delta University, Oghara.

Study Protocol

Sixty subjects were placed in two groups of eight. Each group was fed with *akamu* or a*gidi* and reference food (glucose) providing 50 grams of available carbohydrates, on four different days within a fourteen-day period. Subjects first consumed test sample (*akamu* or a*gidi*) and reference in the morning (first meal investigation) on two occasions while the same foods were consumed in the afternoon (second meal investigation) on two other occasions. Capillary blood samples were collected from the subjects at intervals of 0, 30, 60, 120 and 180 minutes. Samples were assayed for glucose.

Determination of blood glucose concentration

The blood samples were collected via finger prick using a sterilized lancet. Each blood sample was placed on a test strip which was inserted into a calibrated glucometer (Accu-Check). Direct readings were obtained after 45 seconds based on glucose oxidase method (Trinder,1969).

Determination of glycemic index

Glycemic index was determined as described by Wolever *et al*. (2003). The increase in area under the curve (test food) was expressed as a percent of the increase in area under the curve for reference food (Glucose)

Statistical Analysis

Results were expressed as Means ± SEM. T-test was used to test for significant differences between glycemic indices.

RESULTS

Table 1 shows the percentage proximate composition of *akamu* and agidi. The results revealed no significant (P>0.05) difference between *akamu* and agidi in the parameters except for lipid content listed in the table. The lipid content of *akamu* is significantly (P<0.05) higher than agidi. The moisture content of *akamu* (86.00±0.12) is slightly higher than the moisture content of agidi (84.50±0.34).

Table 1 Proximate analysis of *Akamu* and Agidi per 100grams dry weight

Food	**Moisture**	**Ash**	**Crude**	**Lipid**	**Crude**	**Carbohydrates**
Akamu	86.00±0.12[a]	2.80±0.10	5.20±0.42	0.70±0.04	1.62±0.32[a]	89.30±0.12 [a]
Agidi	84.50±0.34[a]	2.90±0.20	5.70±0.39	0.35±0.06	1.75±0.12	89.59±0.4 [a]

Table 2 shows the serving sizes of the food samples. The serving size of *akamu* (357.14g) is more than that of agidi (322.60g). The high moisture of *akamu* resulted in increased the serving size.

Table 2 Serving sizes of Food Samples

Sample	Serving sizes (g)
Agidi	322.60
Akamu	357.14

Table 3 shows the average blood glucose concentration after consumption of reference food (glucose), *akamu* and *agidi* during the first and second meal investigations. All subjects had their peak blood glucose concentration's after 30 minutes of consumption of food. At 180 minutes, blood glucose levels have fallen below baseline values (concentrations at 0 minutes)

Table 3 Average glucose concentration (mg/dl) of subjects during feeding experiment

	0 mins	30 mins	60 mins	120 mins	180 mins
AK	81	135	122	78	75
AK*	85	129	111	92	82
AG	82	128	109	89	81
AG*	92	120	116	97	91
GLU	80	120	100	76	74
GLU*	90	129	110	92	89

* indicates blood glucose for second meal investigation

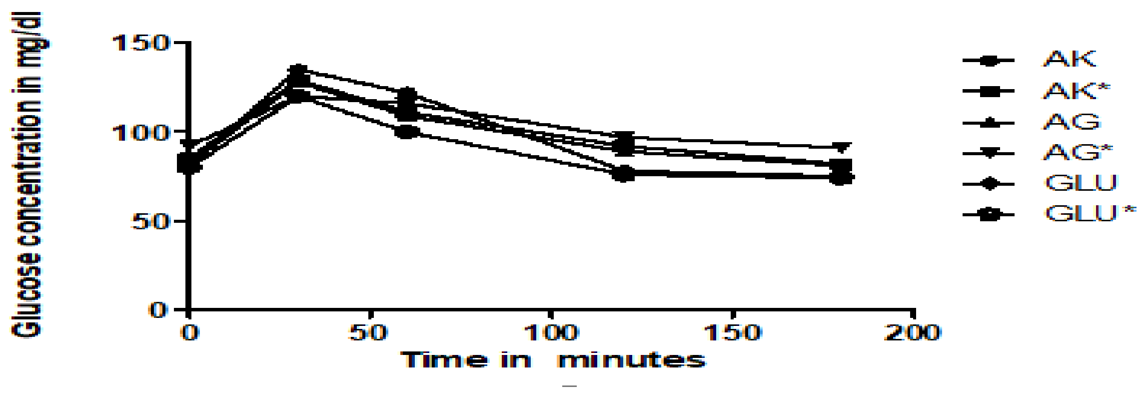

Fig. 1: Average glucose concentration during the feeding experiment

Table 4 shows the glycemic indices of *akamu* and agidi during the first and second meal investigations. Glycemic indices at first the first meal investigations were higher than that of the second meal investigations.

Table 4: Glycemic Indices of *akamu* and *agidi* after first and second meal investigation

	Increase in Area Under the Curve	Glycemic Index (GI)
Glucose (first meal	1450	100
Glucose (second meal	1212.5	100
***Akamu* (First meal**	1930.6	128
***Akamu* (second meal**	1187.5	98
Agidi (First meal	1532.5	105.7
Agidi (second meal	1090	89.9

DISCUSSION

Analyses of food samples showed that *Akamu* and Agidi had similar carbohydrate, protein, fibre and ash content as both foods are made from the same food crop and have similar processing method. It was also observed that the foods have low fibre, protein and high carbohydrate content. Reports have shown that a low fibre, high carbohydrate foods is not consumed by obese and diabetic individuals as studies has associated it with increased risk of the development of insulin resistance and diabetes (Reynolds *et al.,* 2020). To make up or the nutrient deficiency *akamu* and agidi is consumed with foods rich in protein such as *akara* (fried bean cakes) and *moi-moi* (steamed bean cakes). Furthermore, consumption of mixed meals has been shown to reduce glycemic indices of foods (Isio and Isiosio, 2017).

The results of the glycemic indices revealed that both foods are high glycemic index foods. This is not surprising as meals contain high moisture and gelatinized carbohydrate content (Table 1). According to Manullang *et al.,* (2020) high moisture content, low fat and protein content facilitates easy digestibility. Furthermore, reports have also shown that alterations in carbohydrate structure of food through gelatinization make it more susceptible to amylase digestion which results in increased glycemic index; (Jimoh *et al*., 2008). High GI foods elicit higher calorie, insulin levels and c-peptide excretion than low GI foods (Haber *et al*., 1997; Jenkins *et al*., 1987; Wolever and Bolognesi, 1996).

The glycemic indices of the second meal investigation are lower than that of the first meal investigation, is in accordance to reports by Ardvission-Lenner *et al (*2004) and Chen *et al.,* (2010). The possible mechanism of action is that the glycemic indices of foods in the second meal investigation reduced as a result of increased insulin concentrations present in the blood in response to increased glucose concentrations in the first meal especially with consumption rich in proteins (Park *et* al., 2015). In contrast, Jovanovic *et al.* (2009) further observed that the second-meal phenomenon was associated with increased rates of storage of lunchtime carbohydrate in muscle glycogen in normal subjects thereby stimulating better glycemic control.

The purpose of determining the second meal effect is to have lower postprandial glucose levels not only after the consuming the meal but also subsequently after meals later in the day or even on the following day (Higgins, 2012). Though there was a reduction in glycemic indices when foods were consumed after the second meal, food samples were still in the high glycemic index food range. This prevents their use in regulating blood glucose in diabetic patients (Reynolds *et al.*, 2020).

Reports have also shown that some grains and legumes have the ability to reduce glucose not only at a single meal but also influence postprandial glucose at subsequent meals (Higgins, 2012). It is advisable that such foods are eaten prior (breakfast) to consumption of *akamu* or *agidi* with the aim of regulating blood glucose levels for the whole day. However, in disease conditions such hypoglycemia, *akamu* and *agidi* are recommended because of their glucose raising ability.

CONCLUSION

Akamu and *agidi* had lower glycemic indices when consumed as second meals, however, both foods were high glycemic index foods irrespective of time consumed. More research is needed to determine other methods of reducing he glycemic indices of these foods. Further studies should include the implication of consumption of different legumes prior to having *akamu* and *agidi* as second meal of the day.

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