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# GLYCEMIC RESPONSE OF SOME BOILED LEGUMES COMMONLY EATEN IN NIGERIA

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*Key words:* *legumes, cowpeas* (Vigna unguiculata), *pigeon peas* (Cajanus cajan), *African yam beans* (Stenostylis stenocarpa), *groundnut* (Arachis hypogaea), *boiling, glycemic index, glycemic load, postprandial blood glucose, diet for diabetics*

*SUMMARY*

*Glycemic indices (GI) of six commonly consumed legume varieties in Nigeria were investigated. The beans and groundnut were boiled in water until soft. Thereafter, the taste of different bean samples was enhanced with red palm oil and pepper to form cooked beans. A processed legume sample equivalent to 50 g available carbohydrate was fed to 35 healthy volunteers after a 10-12 hour overnight fast. Glucose (50 g in 300 mL) water was fed to control subjects. Glycemic response after 0, 30, 60, 120 and 180 min was calculated. The results revealed the lowest GI for African yam bean (17±6) and highest GI for white cowpea (41±10). Pigeon pea (cream and brown variety) and groundnut (*Arachis hypogaea*) had a value of 24±3, 24±10 and 24±12, respectively. Cowpea (brown and white/black varieties) had a value of 29±9 and 30±11, respectively. The legumes elicit low postprandial rise of blood glucose.*

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## INTRODUCTION

Low postprandial glucose concentration and diets with a low glycemic index are associated with a reduced risk for the development of diabetes mellitus, obesity and cardiovascular disease (1-3). Foods that raise blood sugar slowly and steadily giving continuous energy are low glycemic index foods, while high glycemic index foods induce a sharp rise in blood glucose, which declines within a short time (4).

Glycemic index (GI) is a quantitative assessment of foods based on the postprandial blood glucose response (5). It is usually determined by measuring the effect of 50 g available carbohydrate of a test food on blood glucose when compared with that of a control food, usually glucose or white bread (6). GI of 0-55 has been categorized as low, 56-70 as medium, and >70 as high (7). The concept of GI has been developed to supplement information available on the chemical composition of foods given in food tables. The FAO/WHO has endorsed the inclusion of this concept to guide food choices (8).

Grain legumes, especially cowpeas, are widely consumed in Nigeria (9). Different processing methods (boiling, steaming, frying, soaking, dehulling, grinding) are often combined to produce different products that are eaten as a snack or main meal (10).

However, some prominent underutilized grain legumes, i.e. African yam bean (*Sphenostylis stenocarpa*), pigeon pea (*Cajanus cajan*), lima beans (*Phaseolus lunatus*) and Bambara groundnuts, are readily available in Nigeria (11). Their proximate contents, minerals and antinutritional factors have been reported (12,13). They serve as a cheap source of protein and other nutrients. Generally, Nigerian diabetics consume legumes because of their low GI. It is desirable in the management of diabetes as legumes may reduce postprandial blood glucose levels (14).

The availability of different underutilized varieties of legumes in the southwest agricultural zone of Nigeria, especially in the Esan speaking areas of Edo State, Nigeria, makes the choice of these local legumes useful for the control of postprandial rise of blood glucose. The aim of this study was to determine the GI of some legumes commonly eaten in Nigeria and compare their effects on glycemic values in healthy persons.

## MATERIALS AND METHODS

### Materials

Cowpeas (*Vigna unguiculata*; white, brown and white/black varieties), Pigeon peas (*Cajanus cajan*; brown and cream varieties), African yam beans (*Sternocarpa stenostylis*) and groundnut (*Arachis hypogaea*) were obtained from New Benin market in Benin City, Edo State, Nigeria. They were sorted by picking out the broken and weevil infested seeds. Whole seeds were used for preparation of experimental diets.

### Preparation and production of processed samples

### Boiled beans

Whole seeds (1 kg) were rinsed in tap water and cooked by boiling in 7 L of distilled water for two hours until tender. Seed tenderness was determined by the method of Njoku *et al*. (15). Ten g of salt and 50 mL of hot palm oil was added to cooking legumes.

### Proximate analysis of processed cowpeas

The processed beans were analyzed for moisture content, ash, crude protein, and crude fiber by the AOAC method (16). Carbohydrate was determined by difference.

### Experimental design

The subjects were students recruited from various faculties of the University of Benin. The study protocol was carefully explained to all of them before they signed a written informed consent.

Thirty five volunteers (aged 21-30 years) were offered a single meal each of one of the three test foods. Another ten subjects were administered 50 g glucose in 300 mL distilled water. The serving size was determined by the quantity that will give 50 g carbohydrate when eaten. Blood samples were collected before feeding (0 min) and at 30, 60,120 and 180 min after the test meal intake.

### Determination of blood glucose

Capillary blood samples (8-10 drops) were collected by fingerprick and gentle pressure of the index finger, at 8.00-9.00 a.m. after >12-h overnight fast. Blood glucose was determined by use of One Touch Basic Lifescan Blood Glucose Monitoring System, Johnson & Johnson Company, Ca, USA. The one-touch glucometer measures the amount of glucose in whole blood on the glucose test strip. Analyses were done in duplicate.

Table 1. **Proximate analysis of processed legume samples in dry weight percent**

| Sample (g) | Lipid | Ash | Fiber | Crude protein | Carbohydrate | Moisture |
|---|---|---|---|---|---|---|
| Cowpea (white variety) | 17.50±0.00 | 4.0±0.02 | 1.5±0.01 | 20.30±0.05 | 56.70±1.15 | 51.10±0.02 |
| Cowpea (white and black variety) | 18.15±0.05 | 4.5±0.02 | 1.5±0.01 | 19.95±0.05 | 55.90±0.10 | 50.80±0.06 |
| Cowpea (brown variety) | 15.50±0.02 | 4.5±0.01 | 1.5±0.01 | 20.66±0.01 | 57.84±0.76 | 50.45±0.03 |
| Pigeon pea (cream variety) | 18.85±0.02 | 4.0±0.10 | 4.5±0.01 | 21.35±0.11 | 51.30±0.45 | 50.65±0.01 |
| Pigeon pea (brown variety) | 15.85±0.01 | 4.5±0.01 | 5.0±0.01 | 21.53±0.02 | 53.12±0.67 | 50.60±0.30 |
| African yam bean | 17.45±0.04 | 3.5±0.02 | 3.0±0.02 | 21.00±0.05 | 55.05±2.10 | 50.85±0.30 |
| Groundnut | 38.50±0.10 | 3.0±0.01 | 4.0±0.01 | 10.68±0.02 | 43.82±0.83 | 40.70±0.03 |

Values are means ± standard errors of means (SEM) of four (4) determinations.

Table 2. **Available carbohydrate in 100 g of processed food and serving sizes used on glycemic index determination**

| Sample | Available carbohydrate in 100 g of processed food (g) | Serving size of processed food (g) |
|---|---|---|
| Cowpea (white variety) | 27.73[a] | 180[b] |
| Cowpea (white and black variety) | 27.50[a] | 182[b] |
| Cowpea (brown variety) | 28.66[a] | 175[b] |
| Pigeon pea (cream variety) | 25.32[a] | 198[c] |
| Pigeon pea (brown variety) | 26.33[a] | 190[b] |
| African yam bean | 27.06[a] | 185[b] |
| Groundnut | 26.99[a] | 192[b] |

Values are means ± standard errors of means of five individuals *per* group; means with different superscript are significantly different at ($P \leq 0.05$).

## GI calculation

Blood glucose curves were constructed from blood glucose values for each individual at 0-180 min for the control and test foods of each group. The incremental areas under the blood glucose response curve (IAUC) for a 50 g carbohydrate portion of each test food and control food (glucose) was calculated by the trapezoidal rule (17). The GI values were calculated by the method of Jenkins *et al*. (18). Values were expressed as mean and standard error.

## Statistical analysis

Data were expressed as mean ± standard error of the means. Data were analyzed using ANOVA. SPSS version 16 was used as a statistical software. A *P* value of <0.05 was considered to be statistically significant.

# RESULTS

The proximate composition of processed legumes is presented in Table 1. The cowpeas, pigeon pea and African yam bean had moisture of about 50%, and groundnut of 40%. The carbohydrate content in legumes was generally in the range of 43%-57%. Crude protein was highest in pigeon pea (brown variety) and lowest in groundnut. However, groundnut had the highest lipid content (38%), while in other legumes it ranged from 15.50% in cowpea (brown variety) to 18.80% in pigeon pea (cream variety). Crude fiber was highest in pigeon pea brown variety, while groundnut had the lowest content (10%). Ash ranged from 3% in groundnut to 4.5% in cowpea.

The available carbohydrate in 100 g of processed food and serving sizes of the legumes containing 50 g available carbohydrate portions are presented in Table 2. There were no significant differences in 100 g of different processed legumes. The serving sizes of the legumes containing 50 g available carbohydrate portions were not significantly different. Pigeon pea (cream variety) gave a significantly higher value.

The GI of the processed legumes is shown in Table 3. The GI ranged from 17 to 41. African yam bean gave the significantly lowest GI value of 17, while cowpea (white variety) gave the highest value of 41. The cowpea (white and black variety and brown variety) gave a value of 30 and 29, respectively, while pigeon pea (cream and brown variety) and groundnut yielded a value of 24. However, the values were not significantly different.

Table 3. **Glycemic indices (GI) of different legumes**

| Sample | GI |
|---|---|
| Cowpea (white variety) | $41^a \pm 10$ |
| Cowpea (white and black variety) | $30^a \pm 11$ |
| Cowpea (brown variety) | $29^a \pm 9$ |
| Pigeon pea (cream variety) | $24^a \pm 3$ |
| Pigeon pea (brown variety) | $24^a \pm 10$ |
| African yam bean | $17^b \pm 6$ |
| Groundnut | $24^a \pm 12$ |

Values are means ± standard errors of means of five individuals *per* group; means with different superscript are significantly different at (P≤0.05).

Figure 1. **The mean blood glucose curve of the group (5 individuals) after consumption of *Vigna unguiculata* (white variety) which contains 50g carbohydrate and the control curve of the group that consumed 50g of glucose drink**

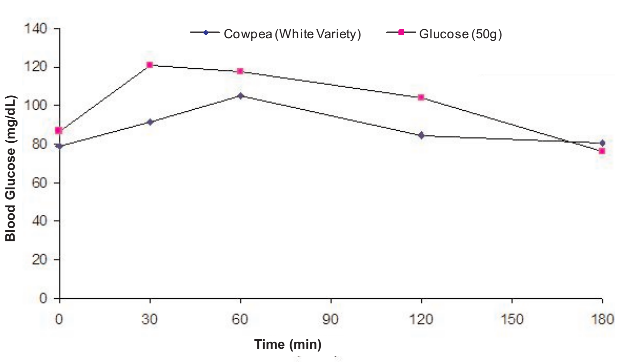



Figure 2. **The mean blood glucose curve of the group (5 individuals) after consumption of *Vigna unguiculata* (white and black variety) which contains 50g carbohydrate and the control curve of the group that consumed 50g of glucose drink**

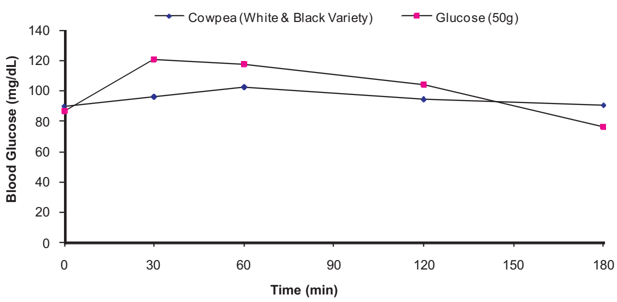



Figure 3. **The mean blood glucose curve of the group (5 individuals) after consumption of *Vigna unguiculata* (brown variety) which contains 50g carbohydrate and the control curve of the group that consumed 50g of glucose drink**

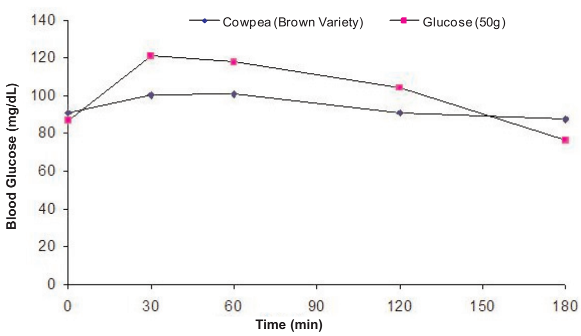
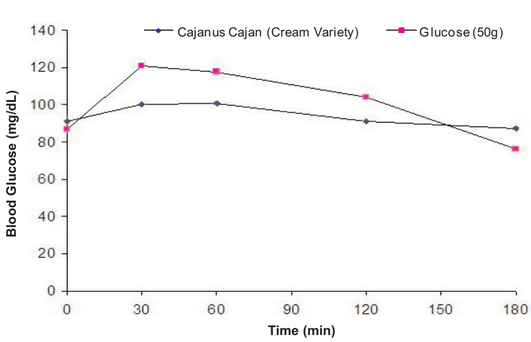



Figure 4. **The mean blood glucose curve of the group (5 individuals) after consumption of *Cajanus cajan* (cream variety) which contains 50g carbohydrate and the control curve of the group that consumed 50g of glucose drink**



## DISCUSSION

Legumes are commonly boiled in water until tender. Thereafter, they are mixed with spices and red palm oil to form cooked beans. Pigeon pea and African yam bean are relatively underutilized in Nigeria but are mainly consumed in the villages because of their hard-to-cook defects, which require the use of scarce energy resources for cooking (19). Legumes produce relatively low glycemic responses in both healthy individuals and in diabetics (20,21). The components present in legumes, particularly the soluble dietary fiber (22), and the nature of the starch (23) can influence the rate by which glucose is released from starch and consequently absorbed from the small intestine. This makes it suitable for use in controlling postprandial rise of blood glucose levels.

The results show that the processed legumes have low GI. White cowpeas had the maximum GI of 41 and African yam bean minimum GI of 17. This result obtained for cowpea varieties is in agreement with that reported for some other cowpea varieties (24). The results obtained by proximate analysis (Table 1) showed that the legumes contained 1.5%-5.0% of fiber. The fibers could be responsible for decreasing postprandial glucose by increasing viscosity of the digestate and reduce gastric emptying time. Other factors like the raffinose oligosaccharide components (25), which are not digested in the gastrointestinal tract, and the structure of starch and fiber present in the seeds after processing could be responsible for the low GI. The interactions of other constituents in the grain legume can bind starch and affect blood glucose levels.

Low glycemic index diets 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 (26). This leads to a reduction of the likelihood to become obese and type 2 diabetic (27).

Figure 5. **The mean blood glucose curve of the group (5 individuals) after consumption of *Cajanus cajan* (brown variety) which contains 50g carbohydrate and the control curve of the group that consumed 50g of glucose drink**

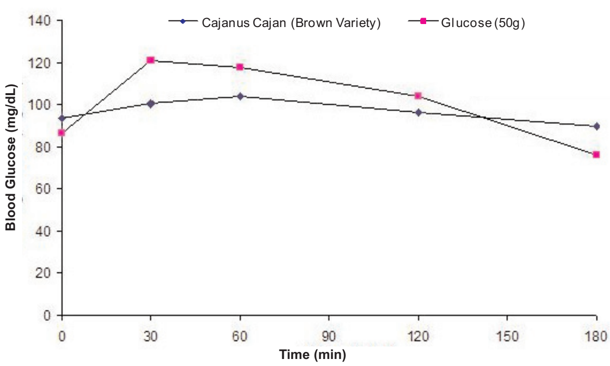



Figure 6. **The mean blood glucose curve of the group (5 individuals) after consumption of *Stenostylis stenocarpa* (African Yam Bean) which contains 50g carbohydrate and the control curve of the group that consumed 50g of glucose drink**

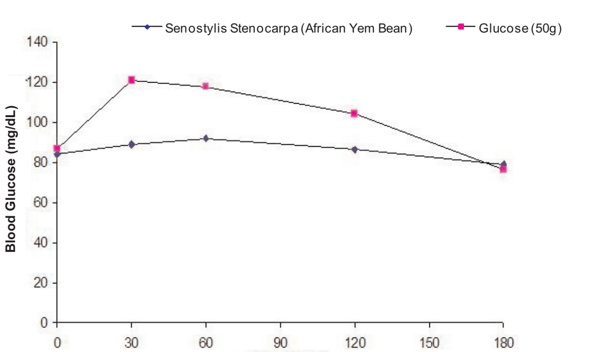
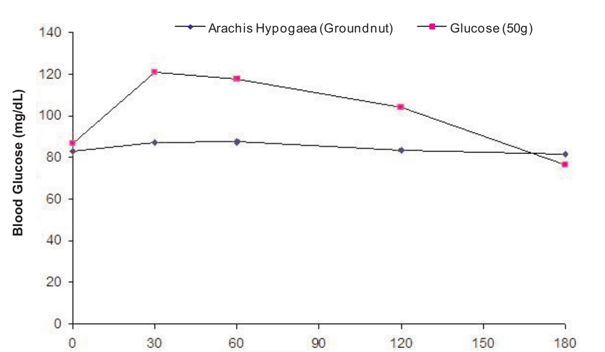



Figure 7. **The mean blood glucose curve of the group (5 individuals) after consumption of *Arachis hypogaea* (groundnut) which contains 50g carbohydrate and the control curve of the group that consumed 50g of glucose drink**



This present study shows that the boiling of beans as is often done in Nigeria leads to a low GI product. Although the GI values obtained were low, further characterization of legume starch and dietary fiber would give an insight into the factors responsible for these low GI values obtained. A similar study would be necessary in diabetics. This would provide insights into the GI and response of different processed legumes in diabetic persons.

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