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Nutritional value of green and red *Nymphaea lotus* seeds and their glycemic index

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Abstract
Aims: *The aim of this study is to determine the nutritional value and glycemic index of red and green Nymphaea lotus (N.lotus) seeds. Most of the seeds are exposed to spoilage due to high moisture content and underutilization due to lack of adequate knowledge on its nutritional value.*
Methodology: *Two varieties of N.lotus seeds were used for this study. The N.lotus fruits were obtained from Alau Dam in Jere LGA of Borno State, Nigeria. The fruits were opened to obtain the seeds which were dried to a constant weight and ground to a fine powder. Proximate composition, mineral element composition, vitamin composition and amino acid profile of the N.lotus seeds were determined using standard methods. Eighteen Wister rats of both sexes weighting 150g - 160g were used for the glycemic index determination. The rats were grouped into three groups of six rats each. Group 1 were fed green N.lotus seeds , group two were fed the red N.lotus seeds while the third group fed glucose served as the control. The incremental areas under curves (IUACs) of the blood glucose response curve were used to determine GI. All results obtained are expressed as mean ± standard deviation of three independent determinations. Significance of the results was obtained by one-way analysis of variance (ANOVA). The level of significance of the mean values was accepted at P≤0.05.*
Results: *The nutritional value of the N.lotus seeds were compared with earlier reports of common cereals consumed in northeast Nigeria. The results obtained showed Significant (P≤0.05) differences in the protein and carbohydrate content of green N.lotus (8.78 ± 0.67%), (70.76 ± 0.91%) and red N.lotus (7.22 ± 0.76%),(74.50 ± 0.47%). The protein and carbohydrate contents N.lotus seeds compare favourably with rice, acha (hungry rice), sorghum, maize and wheat. The calcium content of the red N.lotus seeds (61.04 ± 0.76 mg/100g) were significantly(P≤0.05) higher than that of green N.lotus seeds (35.15 ± 0.45 mg/100g). the calcium contents of the two varieties of N.lotus seeds were higher than the values for pearl millet, sorghum, acha and maize. The green N.lotus seeds had significantly(P≤0.05) higher content of thiamin and riboflavin (0.86 ± 0.86 mg/100g, 0.79 ± 0.70 mg/100g) than the red N.lotus seeds (0.38 ± 0.59 mg/100g, 0.41 ± 0.71 mg/100g).The thiamin and riboflavin contents of the two N.lotus seeds were higher than the reported values for pearl millet, acha, sorghum, wheat and maize. There were no significant (p>0.05) differences in the lysine and methionine contents of the green(3.71 ± 0.73 mg/100g, 3.95 ± 0.95 mg/100g) and red (3.63 ± 0.62 mg/100g, 4.00 ± 0.75 mg/100g) N.lotus seeds.The lysine content of the N.lotus seeds is within the same range with the values for wheat and maize.The N.lotus seeds showed higher values of lysine than pearl millet, acha and sorghum.The methionine content of the N.lotus seeds is higher than the values obtained for millet, sorghum, wheat and maize. The two varieties of N.lotus seeds exhibited medium GI(green; 61.09 ± 7.16 %, red 64.42 ± 4.73 %).*
Conclusion: *The findings showed that the green N.lotus seeds has higher protein, fibre, thiamin, and riboflavin than the red N.lotus seeds while the red N.lotus seeds has higher calcium and iron than the green N.lotus seeds. The nutritional value of the two varieties of N. lotus seeds is higher than the common cereals consumed in the north eastern region of Nigeria. Therefore, N.lotus seeds can be used as a source of carbohydrate. The medium glycemic index of the N.lotus seeds indicate that it can be used as a food in the management of obesity and diabetes.*

Keywords: *(N.lotus, seeds, Nutritional value, Glycemic index, Glycemic load)*

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I. Introduction

Nymphaea lotus Linn. (N.lotus) which belongs to the family of Nymphaeaceae is a wild perennial aquatic flowering plant with rhizomes anchored with mud, floating leaves widely distributed in the stream,

rivers and ponds. The common name, shared with some other genera in the same family, is water-lily. It is native to Egypt and grows in various parts of Central Africa, West Africa, and Madagascar (1, 2,3,4,5).

The plant has wide round leaves that float flat on the water surface. They are greenish in colour thus able to carry out photosynthesis. They produce bulbs that develop from the matured flowers. The bulbs look like the onion bulbs though greenish in colour and contain numerous little seeds inside them unlike the onion bulbs. The bulb is described to be tasteless and slimy like okra. The bulbs easily deteriorate when harvested from its environment and exposed to different environmental condition without following necessary preservation precaution. This may be due to high microbial activities occurring either on the bulb or inside the bulb from the aquatic environment (6)

N.lotus is one of the foremost aquatic macrophytes that have been identified in Nigerian fresh water bodies (7). In Nigeria, it is called 'Bado' in Hausa , 'Iyeye' in Yoruba and 'Ijikara' in Ibo (8). The roots are cooked and eaten as green or dried and ground into powder for use as thickening agent or flour (9).

It has been known that both the amount of carbohydrates consumed and its source have different effects on postprandial blood glucose and insulin responses in healthy and diabetic subjects depending on the rate of digestion (10, 11 and 12) and the rate at which food is passed through the digestive tract or may be slowing the rate of nutrient absorption following ingestion of the diet (13). The adoption of Glycemic Index (GI) and Glycemic Load (GL) concepts allows the control of postprandial glycemia through dietary measures. Controlling postprandial glycemia is an important target in maintaining health and preventing diseases. For this reason, there is a growing interest in the promotion of diets that evaluate not only the absolute amount of energy or nutrient to be ingested, but are also focused on the postprandial response (14).

. The present study was to examine the nutritional value and GI and GL of the two varieties of N.lotus from Jere LGA of Borno State and advocate for the utilization of N. lotus seeds as most of the seeds end up being spoiled due to lack of knowledge on its nutritional value.

II. Material and Methods

2.1 MATERIALS

2.1.1 Source of Materials

One hundred matured nymphaea lotus fruits of both green and red varieties were obtained from alau dam in Jere LGA, Maiduguri, Borno State, Nigeria. The fruits were identified and authenticated by a botanist in the Department of Biological Science, University of Maiduguri., Nigeria.

2.1.2 Preparation of Sample

The fruits were washed with water to remove dirt and sand. The pods were opened manually to separate the pods and seeds which were then sundried for three days to obtain a constant weight. The dried seeds were ground using a mortar and pestle and sieved using a 1mm pore sieve to obtain a five powder which were stored in air tight containers.

2.2 METHODS

2.2.1 Proximate Composition

Proximate compositions of the two varieties of Nymphaea lotus were determined by the standard methods of AOAC (15).

2.2.1.1 Determination of moisture content

Two grammes (2 g) of the sample was weighed into Petri dishes of known weight and dried to a constant weight at 105^{O}C for 5 hours in an oven. The dried sample was weighed. The difference in weight of the sample before and after drying gives the moisture content.

$$\% \text{ moisture} = \frac{\text{Loss in weight of dried sample}}{\text{Initial weight of sample}} \times 100$$

2.2.1.2 Determination of ash

The ash content was determined by incinerating 2 g of the sample at 600^{O}C for 2 hours and noting the loss in weight. The procedure allows organic matter to be burnt off without allowing appreciable decomposition of ash constituents.

$$\% \text{ ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

2.2.1.3. Determination of protein (Micro Kjedahl method)

Digestion

Two grams (2 g) of the sample was weighed into 50 ml Kjedahl digestion flask, one digestion tablet was added followed by 20 ml of concentrated sulphuric acid. The mixture was heated gently until frothing ceased and the heat was increased to digest until the solution became clear. After cooling, the digested sample was transferred into 100 ml standard volumetric flasks and made up to 100 ml with distilled water.

Distillation

Five milliliters (5 ml) of the digested sample was pippeted into a distillation flask and 10 ml of 40% sodium hydroxide was added into the distillation flask. The flask was placed at the heating end of the distillation unit. Ten milliliters (10 ml) of 2 % boric acid was pippeted into a 100 ml conical flask and 2-3 drops of mixed indicator was added. The conical flask containing the borate and a mixed indicator was placed at the extended tube (outlet) of the distillation unit. Ammonia was distilled into the boric acid solution until no ammonia evolved.

Titration

The boric acid distillate was titrated with 0.1M HCl using 2-3 drops of mixed indicator to pink end point. A blank was also used for the determination using distilled water. The percentage protein in the sample was calculated using the following formulae:

$$\% \text{ Protein} = \frac{\text{Sample titre - Blank titre x A x 14.007 x F}}{\text{Weight of sample x B}} \times 100$$

Where

A = Volume to which digest is made up with distilled water.
B = Aliquot taken for distillation.
F = Factor 6.25

2.2.1.4 Determination of fat

Fat was determined by soxhlet extraction method. Three grammes (3 g) of sample was weighed into fat extraction thimbles and plugged (40o- 60o) with cotton wool to prevent splashing of the sample during extraction. The extraction unit (Tecator Soxhlet 1046) was setup and extraction was carried out using petroleum ether.

$$\% \text{ extractable fat} = \frac{W3 - W2}{W1} \times 100$$

Where

W1 = weight of sample before extraction.
W2 = weight of flask without fat.
W3 = weight of flask with fat.

2.2.1.5.Determination of crude fibre

Two grammes (2 g) of the sample was weighed and transferred into 250 ml quick conical flask.100 ml of the digestion mixture was added and refluxed with occasional shaking for 45 minutes. The mixture was filtered through ashless filter paper using gentle suction. This was washed with 100ml of boiling water and then with 50ml of alcohol followed by 50ml petroleum ether. The filter paper with the sample was dried at $100^{O}C$ to constant weight. The filter paper was weighed to obtain the weight of the residue. The residue was placed in a crucible which was already weighed and ashed at $600^{O}C$ for 4 hours. The crucible was then removed and placed in a desiccator to cool after which it was weighed again.

Calculation

$$\% \text{ Crude Fibre} = C - F \times 100$$

Where

b = weight of paper + residue.
a = weight of paper alone.
C = b – a = weight of residue.
e = weight of dish + ash.
d = weight of dish alone.
F = e- d = weight of ash.
C- F = weight of crude fibre.

2.2.1.6.Determination of carbohydrate

The carbohydrate content of the samples was determined by difference (16) according to this formula:

% carbohydrate = 100 – (% moisture + % ash + % protein + % fat + % crude fibre).

2.2.1.7.Determination of energy

The matabolisable energy was calculated by the Atwater conversion factors (17).

1 g of carbohydrate = 4Kcal.
1 g of fat = 9 Kcal.
1 g of protein = 4 Kcal.

2.2.2 Determination of Mineral Elements

Atomic absorption Spectrophotometer (AAS) AA series (6800 series Shimazo Corp) was used for determination of Ca, P, Fe and Mg. Two grammes (2 g) of sample was weighed into a crucible and incinerated at 600^{O}C for 2 hours. The ashed sample was transferred into 100 ml volumetric flask and 100 ml of distilled water was added into it and readings were taken on the AAS. The appropriate lamps and correct wavelength for each element were specified in the instruction manual.

2.2.3 Determination of Vitamins

The vitamin composition of the two varieties of N.lotus were determined using AOAC (15). To 5mL of samples hexane-extract add KOH and saponify for 30 minutes and add an antioxidant. Transfer to a separate or funnel extract by adding water and 11. 5 volume of hexane. Wash extracts several times with water and filter through a filter paper containing 5g anhydrous sodium sulfate into a flask, rinsed with hexane and make up to volume. USP vitamin reference standards were used to prepare standard dilutions. Prepare as blanking solution in a similar manner (5mL water in place of sample extract).Read the absorbances of samples, standards after zeroing with blank solution at 620nm with UV/ V spectrophotometer .Vitamins concentrations were calculated using a five point calibration curve.

2.2.4 Determination of Amino Acid Profile

The amino acid profile in the samples was determined using methods described by 18. The sample was defatted, hydrolysed ,evaporated in a rotary evaporator and then loaded into the Technicon Sequential Multi Amino Acid Analyzer (TSM).

2.2.4.1.Defatting of sample

Five grammes (5 g) of the dried sample was put into extraction thimble and the fat was extracted with chloroform/methanol (2:1mixture) using Soxhlet extraction apparatus as described by AOAC (15).The extraction lasted for 15 hours.

2.2.4.2 Hydrolysis of sample

Five grammes (5 g) of the sample was put in glass ampoule.7ml of 6NHCl was added and nitrogen was passed into the ampoule to expel oxygen. This was to avoid possible oxidation of some amino acids (methionine and cysteine) during hydrolysis. The glass ampoule was sealed with Bunsen burner flame and put in an oven preset at 105^{O}C ± 5^{O}C for 22hours. The ampoule was allowed to cool before it was broken, opened at the tip and the content was filtered through a non-absorbent cotton wool.

The filtrate was evaporated to dryness at 40^{O}C under vacuum in a rotary evaporator. The residue was dissolved with 5ml of acetate buffer (pH 2.0) and stored in plastic specimen bottles which were kept in the freezer.

2.2.4.3 Loading of the hydrolysate into the TSM analyzer

The amount loaded was between 5 to 10 microlitre. This was dispensed into the cartridge of the analyzer. The TSM analyzer is designed to separate and analyze free, acidic, neutral and basic amino acids of the hydrolysate. Each analysis lasted for 76 minutes.

2.2.5 Blood Glucose Determination

Eighteen Wister rats of both sexes weighting 150g - 160g were housed in suspended mesh bottom and front stainless-steel cages at room temperature. Food and water were offered ad libitum. After two days of acclimatization, the rats were weighed and divided into 3 groups of six rats each, The Wister rats were fasted for 18hours after which 2g N.lotus diluted in 9ml of distilled water was given to group 1(green N.lotus) and 2 (red N.lotus). Group 3 was given glucose (standard) which served as control. Blood samples were collected at 0min, 30 mins,60 mins,90 mins and 120 mins from the tail of the rats using a sharp blade to cut the end of the tail. Blood glucose was determined by using glucose tester Device made by Johnson and Johnson Co., Lifescon, USA.

2.2.5.1 Determination of glycemic index

The blood glucose concentrations of the rats were used to plot blood glucose response curve graph, which was used to calculate the GI. The method of Wolever et al. (1991) was used to calculate the GI of the two varieties of N.lotus seeds . The incremental areas under curves (IUACs) of the N.lotus seeds which were used to determine GI was obtained by summing up the surface triangles and rectangles under the blood glucose response curve graph

The GI for each food was calculated using the formula:

GI= IAUC standard X 100
IAUC test

2.2.5.2 Determination of glycemic load
Calculation of Glycemic Load (GL):
GL= GI X available carbohydrate (50g)
100

2.2.6 Statistical Analysis

All results obtained are expressed as mean ± standard deviation of three independent determinations. The statistical significance of the results was obtained by subjecting the results to one-way analysis of variance (ANOVA) along with the least significant difference (LSD) test. The level of significance of the mean values was accepted at $P \leq 0.05$.

III. Results and Discussion

3.1 Proximate Composition

The mineral element composition of the two varieties of *N.lotus* seeds is presented in table 2.Significant ($P \leq 0.05$) differences were observed in the levels of calcium, iron, magnesium and phosphorus in the two varieties of *N.lotus* seeds. The red *N.lotus* seeds showed higher values of calcium (61.04 ± 0.76 mg/100g) and iron (4.05 ± 0.36 mg/100g) than the green *N.lotus* seeds. The levels of magnesium (61.25 ± 0.26 mg.100g) and phosphorus 981.15 ± 0.15 mg/100g)

The *N.lotus* seeds exhibited low moisture content. The low moisture of the *N.lotus* seeds imply could the seeds can be stored for a reasonable long period. Moisture content of food samples is the main determinant of food spoilage. Low moisture content of food samples reduce the activities of microorganisms, and thereby increase the shelf life of the food products. (19). The protein content of the *N. lotus* seeds is comparable to that of rice (7.07 %) (20), acha (6.96 %) (21) and sorghum (9.28 %) (22) The carbohydrate content of the N. lotus seeds is similar to the results of Ihekoronye and Ngoddy, (20), 70.1 % for wheat (23),74.3 % for maize. This indicates that the N; lotus seeds can be a major source of carbohydrate just like cereals.

Table 1: Proximate composition of two varieties of *N.lotus* seeds

Parameters	Green	Red
Moisture (%)	5.55 ± 0.45^a	6.00 ± 0.23^b
Ash (%)	5.34 ± 0.75^a	5.74 ± 0.49^b
Fibre (%)	5.62 ± 0.49^a	4.54 ± 0.91^b
Fat (%)	3.95 ± 0.39^a	2.00 ± 0.48^b
Protein (%)	8.78 ± 0.67^a	7.22 ± 0.76^b
Carbohydrate (%)	70.76 ± 0.91^a	74.50 ± 0.47^b
Energy (kcal/100g)	353.71 ± 0.32^a	344.88 ± 0.56^b

Values are recorded as mean ± SD of three replications. Means in the same row with different superscripts are significantly different ($P \leq 0.05$).

3.2 Mineral Element Composition

The mineral element composition of the two varieties of *N.lotus* seeds is presented in table 2.Significant ($P \leq 0.05$) differences were observed in the levels of calcium, iron, magnesium and phosphorus in the two varieties of *N.lotus* seeds. The red *N.lotus* seeds showed higher values of calcium (61.04 ± 0.76 mg/100g) and iron (4.05 ± 0.36 mg/100g) than the green *N.lotus* seeds. The levels of magnesium (61.25 ± 0.26 mg.100g) and phosphorus 981.15 ± 0.15 mg/100g)

Calcium is an essential nutrient that is necessary for many functions in human health (24). It is vital for strengthening of teeth and bones, important for the regulation of muscle and heart funcions and transmission of nervous system. The calcium content of the *N.lotus* seeds are higher than that of pearl millet (3.2 mg/100g), sorghum (22.3 mg/100g), acha (19.6 mg/100g) and maize (19.5 mg/100g) as reported by Varriano-Marston and Hoseney (25), Kowieska *et al.* (26), Anuonye *et al*. (27), Mamudu *et al*. (28). The iron contents of the *N.lotus* seeds is higher than that of acha (2.9 %) (Anuonye et al., (27), Mamudu et al., (28) .

Table 2: Mineral Element Composition of Two Varieties of *N.lotus* Seeds (mg/100g)

Mineral elements	Green	Red
Calcium	35.15 ± 0.45^a	61.04 ± 0.76^b
Iron	3.47 ± 0.48^a	4.05 ± 0.36^b
Magnesium	61.25 ± 0.26^a	47.15 ± 0.16^b
Phosphorus	81.15 ± 0.15^a	69.05 ± 0.05^b

Values are recorded as mean ± SD of three replications. Means in the same row with different superscripts are significantly different (P≤0.05).

3.3 Vitamin Composition

Table 3 presents the vitamin composition of the two varieties of *N.lotus* . The vitamin composition of the two varieties of *N.lotus* showed significant (P≤0.05). differences. The green *N.lotus* seeds showed higher values of thiamin and riboflavin (0.86 ± 0.86 mg/100g), (0.79 ± 0.70 mg/100g) than the red *N.lotus* seeds (thiamin, 0.38 ± 0.59 mg/100g: riboflavin, 0.41 ± 0.71mg/100g).

Vitamins are compounds needed in very small amounts in the diet to help regulate and support chemical reactions in the body. Vitamins are classified into fat soluble and water-soluble vitamins. Water soluble vitamins include B group of vitamins. All B vitamins form coenzymes and participate in energy metabolism. Examples of B group of vitamins are thiamin, riboflavin, niacin, folic acid. (29). The green *N.lotus* seeds have higher content of thiamin and riboflavin than pearl millet (0.38mg/100g, 0.21 mg/100g), acha (0.10 mg/100g, 0.05 mg/100g), sorghum (0.31 mg/100g,0.15 mg/100g), wheat (0.42 mg/100g,0.10 mg/100g) and maize (0.38 mg/100g, 0.20 mg/100g) as reported by Hulse et al.(30), Okafor (31), Koehler and Wieser (232).

Table 3: Vitamin Composition of Two Varieties of *N.lotus* Seeds (mg/100g)

Vitamins	Green	Red
Thiamin	0.86 ± 0.86^{a}	0.38 ± 0.59^{b}
Riboflavin	0.79 ± 0.70^{a}	0.41 ± 0.71^{b}

Values are recorded as mean ± SD of three replications. Means in the same row with different superscripts are significantly different (P≤0.05).

3.4 Amino Acid Profile

The amino acid profile of the two varieties of *N.lotus* is presented in table 4. The level of essential amino acid lysine, did not show any significant (p>0.05) difference between the two varieties of *N.lotus* (green *N.lotus* 3.71 ± 0.73 g/100g, red *N.lotus* 3.63 ± 0.62 g/100g). The methionine content of the two varieties *N.lotus* also did not show any significant (p>0.05) difference (green *N.lotus* 3.95 ± 0.95g/100g. red *N.lotus* 4.00 ± 0.75 g/100g).

Amino acids are protein building blocks used to build body proteins. They are classified into essential and non-essential amino acids. The non-essential amino acids can be synthesised in the body using other amino acids consumed while the essential amino acids cannot be synthesised by the body they must be obtained from foods. Cereals are low in the essential amino acid lysine and rich in methionine (29). The essential amino acids lysine and methionine are higher in *N.lotus* than the common cereals consumed in North east Nigeria. The lysine content of the *N.lotus* seeds is within the same range with the values for wheat (3.5 mg/100g) and maize (3.4 mg/100g) as reported by Kowieska et al.(26), Ketema (33). The *N.lotus* seeds showed higher values of lysine than pearl millet (2.0 %), acha (2.5 %)and sorghum (2.0 %) (Obilana and Manyasa, (34), Bultosa, (35). The methionine content of the *N.lotus* seeds is higher than the values obtained for millet (1.2 mg/100g), sorghum (1.0 mg/100g), wheat (1.3 mg/100g) and maize (1.9 mg/100g) in the report of Kowieska et al.(26), Ketema (33) (Obilana and Manyasa, (34), Bultosa, (35).

Table 4: Amino Acid Profile of Two Varieties of *N.lotus* Seeds (g/100g)

Amino acids	**Green**	**Red**
Tryptophan	2.45 ± 0.45^{a}	2.17 ± 0.18^{a}
Histidine	1.38 ± 0.39^{a}	1.21 ± 0.22^{a}
Leucine	1.82 ± 0.83^{a}	1.83 ± 0.85^{a}
Isoleucine	6.33 ± 0.33^{a}	5.84 ± 0.86^{b}
Phenylalanine	5.18 ± 0.19^{a}	6.00 ± 0.60^{b}
Valine	3.88 ± 0.80^{a}	3.86 ± 0.88^{a}
Lysine	3.71 ± 0.73^{a}	3.63 ± 0.62^{a}
Methionine	3.95 ± 0.95^{a}	4.00 ± 0.75^{a}
Threonine	1.75 ± 0.75^{a}	2.00 ± 0.06^{a}
Asparagine	3.86 ± 0.88^{a}	3.61 ± 0.61^{a}
Arginine	4.15 ± 0.17^{a}	3.71 ± 0.79^{b}

Alanine	2.42 ± 0.44^{a}	2.52 ± 0.52^{a}
Aspartate	5.45 ± 0.47^{a}	5.14 ± 0.19^{a}
Glutamate	2.51 ± 0.53^{a}	2.41 ± 0.44^{a}
Glycine	9.15 ± 0.15^{a}	9.00 ± 0.45^{a}
Tyrosine	8.22 ± 0.22^{a}	8.55 ± 0.56^{a}
Cysteine	3.11 ± 0.13^{a}	3.12 ± 0.14^{a}
Proline	2.74 ± 0.73^{a}	1.86 ± 0.83^{b}
Serine	2.95 ± 0.95^{a}	2.80 ± 0.87^{a}

Values are recorded as mean ± SD of three replications. Means in the same row with different superscripts are significantly different ($P \leq 0.05$).

3.5 Glycemic index and Glycemic load

The GI and GL of the two varieties of *N.lotus* is presented in table 5. Significant differences were observed in the GI and GL of the two varieties of *N.lotus* . The red *N.lotus* had higher GI (64.42 ± 4.73 %) and GL (32.21 ± 3.48 %) than the green *N.lotus* (GI : 61.09 ± 7.16 % , GL : 30.56 ± 4.75). The values of IAUCs of the *N. lotus seeds* yielded corresponding respective medium GI values. The glucose tolerance curve of rats after consuming *N. lotus* seeds is presented in figure 1. The results obtained showed a sharp increase in blood glucose response for glucose as standard at 30 minutes (9.57 mmol/L) The highest postprandial glucose peak was observed at 30 minutes. Red *N.lotus* had higher postprandial glucose peak at 30 minutes(5.09mmol/L) than green *N.lotus* (4.76 mmol/L). The blood glucose response was observed at 120 minutes with red *N.lotus* having 4.07 mmol/L and green *N.lotus* having 4.02 mmol/L.

The glycemic index is defined as the incremental area under the blood glucose response curve of a 50g carbohydrate portion of a test food expressed as a percent of the response to the same amount of carbohydrate from a standard food taken by the same subject. The concept of glycemic load was developed to simultaneously describe the quality and quantity of carbohydrate in a food serving, meal or diet. GI is widely recognized as a reliable, physiologically based classification of foods according to their postprandial glycemic effect. Glucose occupies the number 100 on the GI. Each food is given a number that shows a rise in blood sugar levels compared with glucose. Foods with high GI (greater than 70) cause a faster rise in blood sugar levels. Foods with medium GI (56 -69) cause a moderate rise in blood sugar. Foods with lower GI (less than 55) cause a slower rise in blood sugar levels (36). The health benefits of low glycemic index and glycemic load of foods is to produce a lesser increase in the plasma glucose concentration as a result of slower rates of gastric emptying and digestion of carbohydrate in the intestinal lumen and subsequently, a slower rate of absorption of glucose into the portal and systemic circulation (12; 37). The GI concept has clinical important benefits for preventing, managing and treating a number of chronic diseases such as diabetes, cardiovascular disease (CVD) and some forms of cancers and obesity (38)

GI and GL are directly proportional to IAUC, which in turn is dependent on postprandial glucose peaks (39). The two varieties of *N.lotus* exhibited medium GI and GL. The medium GI and GL exhibited by green N. lotus seeds could be as a result of the fibre, protein and fat contents of the *N. lotus* seeds. Milan et al. (40) reported that internal factors such as amylose, fat, protein, fibre phytic acid and resistant starch have been correlated with lower GI value.It was reported by Anderson (41) that fiber decreases postprandial glucose and insulin concentration in diabetic and non-diabetic individuals.

It was reported by Hätönen *et al*. (43) that high levels of protein produce greater gastric inhibitory peptides (GIP) and insulin responses resulting in a lower postprandial glucose peak and reduced glycemic response. Higher levels of fat content have the potential to delay gastric emptying thereby slowing down digestion and absorption of glucose (44)

Table 5: Glycemic Index and Glycemic Load of two varieties of *N.lotus* seeds

Groups	IAUC	G I	GL
Glucose	1271.55 ± 6.43	100	50
Green *N.lotus*	776.85 ± 5.95^{a}	61.09 ± 7.16^{a}	30.56 ± 4.75^{a}
Red *N.lotus*	819.15 ± 6.76^{b}	64.42 ± 4.73^{b}	32.21 ± 3.48^{b}

Values are recorded as mean ± SD of six replications. Means in the same column with different superscripts are significantly different ($P \leq 0.05$).

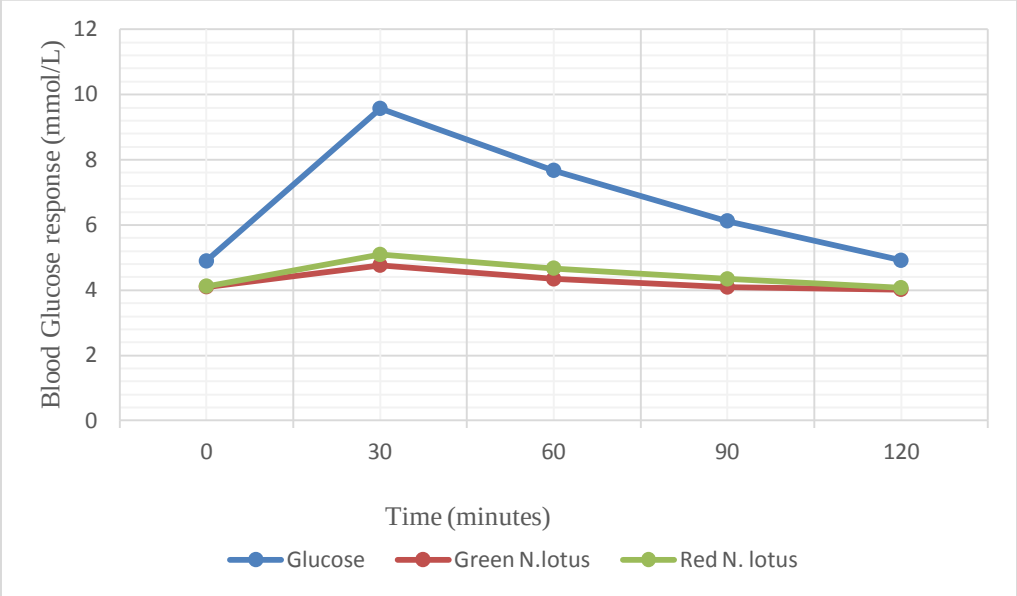

Fig. 1. Glucose tolerance curve of rats after consuming *N.lotus* seeds
Mean ± SD of six experiments significant from normal control P≤0.05

IV. Conclusion

The study reported on the nutritional value of two Varieties of *N.lotus* seeds. The findings showed that the green *N.lotus* seeds has higher protein, fibre, thiamin, and riboflavin than the red *N.lotus* seeds while the red *N.lotus* seeds has higher calcium and iron than the green *N.lotus* seeds. The nutritional value of the two varieties of *N. lotus* seeds is higher than the common cereals consumed in the north eastern region of Nigeria. Therefore, the varieties of *N.lotus* seeds can be used as a source of carbohydrate. The medium glycemic index of the *N.lotus* seeds indicate that it can be used as a food in the management of obesity and diabetes.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

'Hauwa Hajjagana Laminu' designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. 'Rabiu Shehu Sa'ad and Ali Abdullahi Damasak' managed the analyses of the study. All the authors managed the literature searches. All authors read and approved the final manuscript."

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