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Tiger nut (*Cyperus esculentus*): Nutrient profiling using HPLC and UV-spectroscopic techniques

Food insecurity and undernourishment constitute a major challenge in Africa and the world at large. To meet key nutritional targets and tackle the menace of undernourishment, we need to exploit available but underutilised food crops. A common underutilised food crop with the potential to improve daily nutrition is tiger nut. This potential is evidenced in the number of essential amino acids detected, which constitute 74.425% of the entire amino acids detected, in addition to important minerals and vitamins. The nutritional composition of the yellow variety of tiger nut (*Cyperus esculentus*) was determined using the standard methods of high-performance liquid chromatography and UV-spectroscopy. Ten amino acids were identified and quantified, including six essential amino acids, of which valine had the highest concentration (67.59 µg/100 g), followed by leucine (3.019 µg/100 g), phenylalanine (1.767 µg/100 g), lysine (0.946 µg/100 g), histidine (1.048 µg/100 g) and tryptophan (0.055 µg/100 g). The other amino acids were proline (24.124 µg/100 g), cysteine (1.269 µg/100 g), glycine (0.024 µg/100 g), and glutamine (0.022 µg/100 g). Monosaccharides detected were ribose (41.76%), glucose (21.52%), sedoheptulose (17.94%), fructose (4.566%), rhamnose (1.78%) and mannose (1.58%), whilst disaccharides detected were sucrose (87.66%) and maltose (11.39%). Mineral concentrations were K 144.80 ± 1.10 mg/100 g, Ca 94.39 ± 0.02 mg/100 g, Na 83.92 ± 0.04 mg/100 g, Fe 19.36 ± 0.54 mg/100 g, Mg 17.63 ± 0.13 mg/100 g, Cu 13.28 ± 0.05 mg/100 g and Zn 5.18 ± 0.01 mg/100 g. Vitamins A, B₂, C and E were detected and quantified as 53.93 ± 1.03, 7.61 ± 1.20, 31.70 ± 1.25 and 128.75 ± 0.74 µg/100 g, respectively. The chemical and nutritional properties of the yellow variety of tiger nut suggest that it is rich in essential amino acids, minerals, and some vitamins. Hence, it should be recommended to persons with nutritional deficiencies as it is cheap and available all year round.

Significance:

- The nutritional composition of the yellow tiger nut will assist in meeting the recommended daily intake of essential amino acids, monosaccharides, disaccharides, minerals, and vitamins, thus contributing towards solving the challenge of food insecurity and malnutrition, particularly in the African sub-region.
- The rich concentration of these nutrients could be harnessed in the biofortification of food materials known to be deficient in one nutrient or another.
- These important attributes of tiger nut, if harnessed, will add value to this underutilised crop and enhance the economic livelihood of the local farmers.

Introduction

As the global population grows, it is important to improve the food base to avoid food crises and their attendant effects. This improvement could be achieved by developing existing feedstocks that are currently underutilised. Some common underutilised food crops include African yam bean, baobab¹ and tiger nut².

Tiger nut (*Cyperus esculentus* L.) is an edible sweet nut-like tuber that is most common in Spain, Nigeria, Senegal, Ghana, and Chile.³ It has three varieties: yellow, brown and black. The black variety is common in Ghana.⁴ It has many identities, as it is being cultivated both as a livestock food and for human consumption, and is eaten raw or baked.⁵ It is an underutilised crop with high potential for development, which sometimes is considered a weed.⁶ In West Africa, the tubers are an essential part of people's diets, because they are cheap, readily available all year round, and have nutritional benefits.⁷

Tiger nut has been reported to have some medicinal effects, such as activation of blood circulation, and prevention of heart disease and thrombosis.⁸ Other health benefits that have been attributed to tiger nut include reduction in the risk of colon cancer⁷, relief of indigestion due to its fibre content, benefit to diabetics, reduction in cholesterol, and stimulant effects⁵.

Three major products are derived from *C. esculentus*, namely tiger nut oil, tiger nut flour, and tiger nut drink.⁹ The flour is used as a flavouring agent in ice cream and to produce biscuits and other bakery products¹⁰, and the oil is used in making soap¹¹. The main importance of tiger nuts in the food industry is the production of tiger nut milk as a beverage, and a dairy alternative. It is preferred by people with underlying conditions such as lactose intolerance and diabetes mellitus, because of the belief that it does not contain lactose and glucose. Similarly, it is believed to be rich in polyphenolic compounds¹², which are essential antioxidants necessary in the management and treatment of several ailments.

We undertook a comprehensive analysis of the amino acid, monosaccharide, disaccharide, mineral, and vitamin components of the yellow variety of *C. esculentus*.

Materials and methods

Collection of samples

A 2-kg quantity of fresh tiger nut was purchased from a modern market in Nsukka, Enugu State, Nigeria. Defective tubers were discarded, and the healthy ones were washed thoroughly in clean running water and used for the study. The sample was milled using an electric blender to produce a paste-like sample. The sample was stored at 4 °C for further analysis.

Determination of amino acids, monosaccharides and disaccharides

Amino acids, monosaccharides and disaccharides in the sample were quantified using high-performance liquid chromatography with diode-array detection (HPLC-DAD).^{13,14}

Determination of minerals

The concentrations of the essential minerals calcium, magnesium, potassium, sodium, iron, copper, and zinc were determined using the spectrophotometric method of the Association of Official Analytical Chemists.¹⁵

Determination of vitamins

The vitamin A, C and E contents of the sample were determined using the spectrophotometric method described previously.^{16,17}

Statistical analysis

The experiment was carried out in triplicate and results were analysed using Statistical Package for Social Sciences (SPSS) version 20.0; significant difference was established at $p < 0.05$.

Results

Amino acids

The amino acid contents of tiger nut (yellow variety) are shown in Table 1. Ten amino acids were identified and quantified, including six essential amino acids. Of the essential amino acids, valine had the highest concentration (67.59 µg/100 g), followed by leucine (3.019 µg/100 g), phenylalanine (1.767 µg/100 g), histidine (1.048 µg/100 g), lysine (0.946 µg/100 g), and tryptophan (0.055 µg/100 g). The other amino acids detected were proline, cysteine, glycine, and glutamine, with concentrations of 24.124 µg/100 g, 1.269 µg/100 g, 0.024 µg/100 g, and 0.022 µg/100 g, respectively. The essential amino acids constituted 74.425% of the entire amino acids detected, making the yellow variety of tiger nut a good source of amino acids for humans. Thus, the high content of essential amino acids of the yellow variety of tiger nut should be harnessed and utilised for human benefit. The presence of these amino acids suggests why it is used in the production of different types of drinks such as kunu¹⁸, and for fortification of other food products including biscuits, bread, and cookies^{19,20}. Its use in food fortification would in turn improve the market value of the crop.

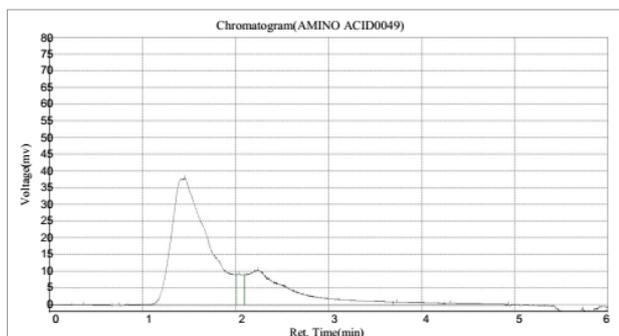


Figure 1: High-performance liquid chromatogram of tiger nut amino acids.

Table 1: Amino acid content of yellow variety of tiger nut

Amino acid	Concentration (µg/100g)
Glycine	0.024
Valine	67.590
Leucine	3.019
Proline	24.124
Phenylalanine	1.767
Cysteine	1.269
Glutamine	0.022
Lysine	0.946
Histidine	1.048
Tryptophan	0.055

Monosaccharides

Ribose was the monosaccharide present in the yellow variety of tiger nut in the highest concentration at 41.76% (Table 2). The concentration of glucose was 21.525%, followed by sedoheptulose, fructose, rhamnose, and mannose at 17.946%, 4.566%, 1.787%, and 1.582%, respectively. These results show that the yellow variety of tiger nut is rich in monosaccharides, which makes it a good source of energy. Although glucose and the other six carbon sugars were present, 41.76% of the monosaccharide content was made up of ribose, an important sugar for the biosynthesis of ATP and other high energy compounds. The low concentrations of the six carbon sugars suggests that tiger nut may not pose a threat or aggravate diabetic-related complications.

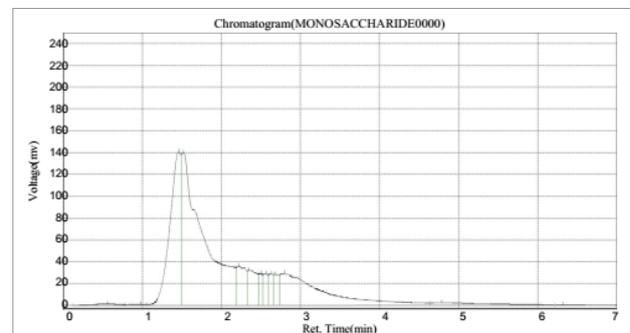


Figure 2: High-performance liquid chromatogram of yellow variety of tiger nut monosaccharide.

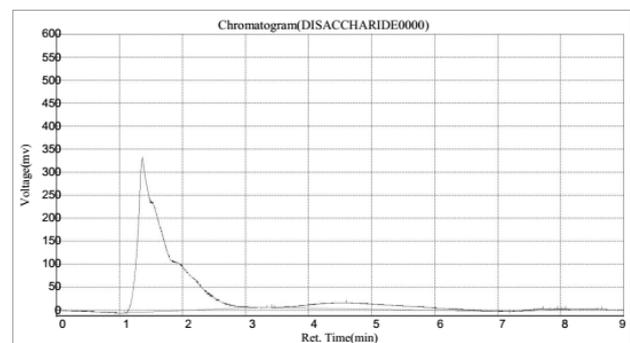


Figure 3: High-performance liquid chromatogram of yellow variety of tiger nut disaccharide.

Table 2: Monosaccharide content of yellow variety of tiger nut

Monosaccharide	Concentration (%)
Glucose	21.525
Ribose	41.764
Fructose	4.566
Mannose	1.582
Rhamnose	1.787
Sedoheptulose	17.946

Table 3: Disaccharide content of yellow variety of tiger nut

Disaccharide	Concentration (%)
Sucrose	87.66
Maltose	11.39

Disaccharides

The disaccharides detected were sucrose (87.66%) and maltose (11.39%). This makes the yellow variety of tiger nut a good source of energy and of precursors for other important biochemical molecules. Sanchez-Zapata et al.²¹ reported a sucrose concentration of 13.03%, which is low when compared to the 87.66% obtained in this study. Conversely, a concentration of 130.4 g/kg of sucrose was obtained by Oguike et al.²² for the yellow variety of tiger nut.

Minerals

The mineral contents of tiger nut are reported in Table 4. The concentration of K was 144.80 ± 1.10 mg/100 g, Ca was 94.39 ± 0.02 mg/100 g, and Na was 83.92 ± 0.04 mg/100 g. Fe, Mg, Cu and Zn were detected at concentrations of 19.36 ± 0.54 mg/100 g, 17.63 ± 0.13 mg/100 g, 13.28 ± 0.05 mg/100 g and 5.18 ± 0.01 mg/100 g, respectively. Micronutrients are an essential part of human nutrition, as they support and strengthen body tissues and organs. These elements also aid or are important for biochemical reactions in the body. Thus, tiger nut could provide the daily requirements of these minerals. They could be sourced from different origins at different concentrations. Among the minerals studied, K and Ca concentrations were highest, and Zn was the lowest (Table 4). Reports from previous researchers show high concentrations of K (110.70, 194 and 216 mg/100 g) and C (185, 152 and 84 mg/100 g) in the yellow variety of tiger nut.²³⁻²⁵ The concentration of K obtained (144.80 mg/100 g) is high compared to the 110.70 mg/100 g reported by Nina et al.²³ This difference could be attributed to the many factors that influence the plant, such as site of cultivation, period of cultivation and system of cultivation. Tiger nut is an ideal food for pregnant women to consume as it will supplement the K requirement for both the mother and the developing baby.

Na is an important physiological electrolyte that controls responses to stimuli. Na was detected in high concentration (83.92 mg/100 g) (Table 4). Nina et al.²³ reported a higher concentration (100.5 mg/100 g) of Na than that obtained in this study. Obasi and Ugwu²⁴ obtained a higher concentration of Na than the 83.92 mg/100 g obtained in this study.

The concentration of Cu in the yellow variety of tiger nut was 13.28 mg/100 g; this concentration is high when compared to the concentration reported by previous researchers.^{23,25,26} The concentration of Zn was 5.18 mg/100 g (Table 4), which is higher than the 0.01 mg/100 g reported by Oladele and Aina²⁵. Similarly, Bado et al.²⁶ reported a Zn concentration of 2.34 mg/100 g in the yellow variety of tiger nut, which is lower than the 5.18 mg/100 g obtained in this study. Contrarily, Chukwu et al.²⁷ obtained a higher concentration of Zn (34.77 mg/100 g) in their work on tiger nut. This suggests that the

yellow variety of tiger nut contains varying concentrations of Zn. The variations in the concentration of Zn could be attributed to the source of tiger nut harvest.

It is evident that tiger nut is rich in minerals, making it an important nutritional supplement to augment products deficient in these minerals. Also, due to its natural form, it could be recommended for individuals with mineral deficiency diseases and people with special needs for minerals, such as pregnant women and older persons. It is also a very cheap source of these minerals and is available all year round.

Table 4: Mineral content of yellow variety of tiger nut

Mineral	Concentration (mg/100g)
Calcium (Ca)	94.39 ± 0.02
Magnesium (Mg)	17.63 ± 0.13
Potassium (K)	144.80 ± 1.10
Sodium (Na)	83.92 ± 0.04
Iron (Fe)	19.36 ± 0.54
Copper (Cu)	13.28 ± 0.05
Zinc (Zn)	5.18 ± 0.01

Table 5: Vitamin content of yellow variety of tiger nut

Vitamin	Concentration (μ g/100g)
Vitamin A	53.93 ± 1.03
Vitamin B ₂	7.61 ± 1.20
Vitamin C	31.70 ± 1.25
Vitamin E	128.75 ± 0.74

Vitamins

Vitamins C, A, E, and B₂ were detected in the yellow variety of tiger nut in the concentrations of 128.75 μ g/100 g, 53.93 μ g/100 g, 31.70 μ g/100 g, and 7.61 μ g/100 g, respectively. Vitamins are important components of our diets. They are essential for the proper functioning of the tissues, organs, and systems. The presence of vitamin E suggests that the consumption of tiger nut could support healthy skin, retard aging and improve fertility. The presence of vitamin A in the sample suggests that the consumption of tiger nut would support sight as well as increase the dietary antioxidant quotient. Suleiman et al.²⁸ also reported vitamins A and C in the yellow variety of tiger nut at concentrations of 0.87 mg/100 g and 30.70 mg/100 g, respectively. The consumption of tiger nut could assist in meeting the recommended daily intake of vitamin C in children.²⁹ The presence of vitamin C, as an antioxidant, would aid in the prevention or retrogression of diseases caused by pro-oxidants such as cancer.³⁰

Conclusion

We studied the nutritional composition of the yellow variety of tiger nut, that is, the amino acid, monosaccharide, disaccharide, mineral, and vitamin contents. The data obtained show the presence of ten amino acids including six essential amino acids, as well as the monosaccharides glucose, ribose, fructose, mannose, rhamnose and sedoheptulose. The yellow variety of tiger nut is also rich in minerals such as K, Ca, Na and vitamins A, C and E, which are important for the proper growth and development of the body. The rich concentration of these nutrients should be harnessed in the biofortification of food materials known to be deficient in one nutrient or another. Similarly,

these important attributes of tiger nut, if harnessed, will add value to this underutilised crop, improve the nutritional status of consumers, provide food security and enhance livelihoods of the population.

Competing interests

We have no competing interests to declare.

Authors' contributions

K.O.O.: Conceptualisation and resources, project administration, writing – original draft, supervision. J.N.O. Methodology, data curation. B.O.E.: Formal analysis, investigation, writing – review, editing. S.O.O.E.: Conceptualisation and resources, supervision, writing – review, editing. All authors read and approved the final version of the manuscript.

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