

## NUTRIENTS COMPOSITION AND FUNCTIONAL PROPERTIES OF OIL PALM SYRUP, AQUEOUS EXTRACT OF KOLA NUT AND THEIR MIXTURES

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### ABSTRACT

*In this study, oil palm (*Elaeis guineensis*) syrup, aqueous extracts of kola nut (*Cola acuminata*) and their mixtures (decoction of *C. acuminata* in 20 % oil palm syrup solution) were investigated using suitable biochemical procedures. The proximate analysis of oil palm syrup and *C. acuminata* revealed the values of moisture, crude protein, fat, ash, fibre and nitrogen free extract of oil palm syrup were 29.55 %, 0.50 %, 2.34 %, 2.32 %, 0.00 % and 65.29 % while values for the *C. acuminata* were 44.70 %, 17.50 %, 2.45 %, 1.91 %, 8.86 % and 24.58 %. Also, the total carbohydrate constituted 66.29 % when determined by anthrone method. The pH and titratable acidity values were within the acidic range. The syrup, *C. acuminata* and its mixture extracts recorded high reducing power, total phenolic and vitamin C contents. The  $IC_{50}$  values of  $\alpha$ -amylase inhibitory activity for aqueous solutions of palm syrup, aqueous extracts of *C. acuminata* and its mixture extract were 0.51, 4.50 and 12.10 % respectively. The 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity of aqueous solutions of oil palm syrup, aqueous extracts of *C. acuminata* and its mixture extracts revealed  $IC_{50}$  values of 8.44, 3.29 and 6.60 %. The results of this study suggest that the decoction of *C. acuminata* in 20 % syrup solution had synergistic effects with respect to *in vitro* antioxidant properties and alpha amylase inhibitory potential, and further indicates that the studied extracts could elicit potential nutritional and health benefits.*

**Keywords:** Oil palm syrup, *C. acuminata*, antioxidant activity, alpha amylase inhibitory activity

<https://dx.doi.org/10.4314/jafs.v21i1.1>

### INTRODUCTION

Growing risks of hypertension, obesity, diabetes, and cardiovascular disease have now become a serious worry to most people due to poor dietary habits (Chattopadhyay *et al.*, 2014). Evidence from available literature suggests that excess production of reactive oxygen species (ROS), its related oxidative stress and inflammatory responses play a significant role in the pathogenesis of numerous chronic human diseases (Jia *et al.*, 2018). Halting the

progression of oxidative destruction by supplementation of antioxidants becomes an effective therapeutic strategy to minimize the destructive effects of these diseases (Dai *et al.*, 2006). In recent times, plant products that are rich in antioxidant constituents have been explored for the production of nutraceutical products aimed at combating various degenerative diseases that are caused by oxidative stress.

*Cola acuminata* is a plant species belonging to the Sterculiaceae family, which contains around 125 species local to Africa's rainforests (Okwunodulu *et al.*, 2017). Research findings have shown that *C. acuminata* and *C. nitida* are of commercial, social and industrial significance (Okwunodulu *et al.*, 2017). Two species, *C. nitida* and *C. acuminata* are common all through West Africa (Odebunmi *et al.*, 2009). *C. nitida* and *C. acuminata* are the most popular Kola species. *Cola acuminata* is a tree grows up to 20 m tall, typically smaller in cultivation. In Nigeria, the root is believed to possess aphrodisiac properties (Burkill, 2000). *C. nitida* is of commercial importance; it is consumed throughout West Africa. *C. acuminata* is 'gworo' in Hausa, 'evbe' in Edo and 'Ojigbo'). This stimulant (kola nut) is rich in caffeine, kolanin, and theobromine (Jayeola, 2001), and when consumed, could induce a potent condition of euphoria, enhancing attentiveness, improving cerebral circulation, create a feeling of alertness and well-being (Okwunodulu *et al.*, 2017). Kola nuts are chewed for the medicinal purpose of treating mental and physical fatigue, and for easing hunger cramps and stimulating digestion (Atawodi *et al.*, 2007). The other constituents in kola nut include phenolic compounds, catechin, epicatechin, quinic acid, tannic acid and chlorogenic acid (Lee and Jaworski, 1987). *C. acuminata* contains primary and secondary amines (Atawodi *et al.*, 2007). Kola nuts are used to treat health conditions for example, dysentery, diarrhea, and anorexia for the management of diabetes (Atawodi *et al.*, 2007).

Nutrients present in this stimulant (kola nut) include proteins, starch, B vitamins such as (niacin and riboflavin) and water. Significant traces of minerals such as K, Ca, Mg Na, Fe Zn, Mn, and P are present in kola nut (Williams, 1979).

Palm sap is a white sugary liquid that is produced by tapping the stalk of the upper stem or the immature inflorescence of palm trees, and/or alternatively, by tapping the felled trees. In Nigeria, palm sap is generally obtained from African oil palm (*Elaeis guineensis*) and raffia

(*Raphia* spp), and is normally allowed to ferment before being drunk as palm wine (fresh, or pasteurized and bottled) or distilled to give a liquor (Francisco-Ortega *et al.*, 2013; Oboh and Imafidon, 2018). The palm syrup contains amino acids (alanine, serine and glutamic acid), organic acids (malic acid, citric acid, tartaric acids, and malic acid), vitamin C and the sugars sucrose, glucose and fructose (Aider *et al.*, 2007). It is becoming popular globally because it is known to be natural and healthy (Oboh *et al.*, 2016). Oil palm sugar has considerable Ca, Fe, and K, and phenolic content (Oboh *et al.*, 2016). A good number of sweeteners are commercially currently available though sucrose derived from sugarcane has been the generally used sugar. Low-calorie sugars for example, acesulfame K, aspartame, neotame, saccharin, sucralose, are of interest with the demand for low-sugar foods. One of the profound health claims is its low glycemic index (GI) (Trinidad *et al.*, 2010; Strikaeo and Tonga, 2015). Low GI foods play a significant function in the dietary management of diabetes and overweight as well as enhancement of sport performance, in addition to the decrease of cardiovascular disease and hypertension risks (Foster-Powell *et al.*, 2002). The intake of foods rich in sugar and beverages could result in a spike in blood glucose level within two hours of post-prandial glucose concentration (Trinidad *et al.*, 2010).  $\alpha$ -Amylase breaks down starch to oligosaccharides and disaccharides that are converted into monosaccharides by  $\alpha$ -glucosidase. Excessive use of added sugar is harmful (Kroger *et al.*, 2006; Sharma *et al.*, 2006), there are demands for healthier sweeteners (ADA, 2018). The control of postprandial hyperglycemia is therefore central to the management of diabetes mellitus, especially type-2 diabetics mellitus and its complications (Trinidad *et al.*, 2010). In Canary Islands, palm syrup derived from the sap of the palm phoenix spp is used flavoring cookies, desserts, fruit coloring and blended drinks (Luis *et al.*, 2012). The high calorie content has also contributed to its growing use as a balanced food supplement for athletes, children and the elderly (Juszczak *et al.*, 2009).

Oil palm syrup (*E. guineensis*) and raffia (*Raphia* spp) is used primarily in Nigeria for beverages, sweet soy sauce, desserts and different traditional food substances. This study is therefore aimed at investigating the chemical, nutritional and functional properties of syrup

derived from the sap of oil palm (*E. guineensis*) tree, aqueous extracts of *C. acuminata* seeds, and their mixtures.

## **MATERIALS AND METHODS**

### **Palm sap**

Oil palm sap was obtained from the palm wine bottling unit of the Nigerian Institute for oil Palm Research (NIFOR), Benin City, Edo state. After tapping, the palm sap was immediately packaged and stored in ice to avoid fermentation.

### **Preparation of palm syrup**

The palm sap was filtered through cheese cloth, and then boiled to a slightly viscous brownish liquid. On cooling, the liquid became more viscous, turning into a thick brownish gel. Different amounts of the oil palm syrup (5, 10, 20, 30 and 40 g) were each dissolved in 100 mL of distilled water.

### **Preparation of *C. acuminata* (Kola nut)**

*C. acuminata* was purchased from New Benin market Benin City, Edo state. The kola nuts were cut into small pieces and dried at 80 °C in a ventilated laboratory oven (Surgifield SM9053, Surgifield Medical, England). The dried pieces were then pounded to smaller bits with the aid of a mortar and pestle. The material was finally dried at 30 °C to a constant weight and reduced to a fine powder using a laboratory blender. Different amounts (0.1, 0.2, 0.3, 0.4, 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 g) of grounded kola nut were each added to 100 mL distilled water, boiled for 20 m, and filtered through Whatman No. 4 filter paper.

### **Proximate Analysis of Oil Palm Syrup**

The proximate composition (namely, moisture, crude lipid, crude fiber, crude protein and nitrogen free extract) of oil palm syrup and *C. acuminata* was determined according to the standard method (AOAC, 2010).

### **Determination of pH**

The calibration of the pH meter (Jenway 3505, Jenway, Bibby Scientific Brand, United Kingdom) was done using standard buffers of pH 4.00 and 7.00. The pH values of different concentrations of oil palm syrup, kola nut aqueous extracts and decoction in sugar solution were determined. The probe of the pH meter was dipped into each of the samples and allowed to stand till a stable/ constant figure appeared on the meter. The reading for each sample was recorded as its pH.

### **Titrateable Acidity**

Titrateable acidity of aqueous extracts of oil palm syrup was determined by titrating 5 mL aliquot with 0.1 N NaOH using phenolphthalein as an indicator to a definite pink end point color. Titrateable acidity was calculated as % lactic acid.

### **Determination of Browning Intensity**

The browning intensity of palm syrup was determined according to the method of Phisut and Jiraporn, (2013). The sugars were mixed (1:25 v/v) with purified water and centrifuged for 15 m at 3000 rpm. The browning intensity was determined using a UV-Vis spectrophotometer at an absorbance of 420 nm.

### **Assay of Inhibitory Activity on Alpha Amylase**

The assay of inhibitory activity on  $\alpha$ - amylase was determined using procedure described by kamteter *et al.* (2014). An aliquot (500  $\mu$ L) of each of the sample was incubated with 500  $\mu$ L of  $\alpha$ -amylase solution (enzyme solution (2 units/mL) which was gotten by dissolving 0.001 g of  $\alpha$ -amylase in 100 mL of 0.02 M sodium phosphate buffer pH 6.9 with 6.7 mM sodium chloride) at room temperature (32 °C) for about 10 m. About 500  $\mu$ L of 1 % starch solution (dissolving 1 g of potato starch in 100 mL of purified water with boiling and stirring for 15 m) was mixed after incubation and incubated for around 10 m at room temperature (32 °C). Subsequently, about (1 mL) of 3,5-dinitrosalicylic acid (Coreychem, Zhengzhou, China) was applied to halt the reaction and was incubated for 5 m in hot water bath (85 °C). After 5 m, reaction mixture color changed to orange-red and was removed from water bath and cooled to room temperature. It was diluted up to 5 mL of distilled water. Individual blank was

performed by replacing enzyme with buffer. Control was performed by replacing extract with solvent. Ethanol was used as positive control. Absorbance was measured at 540 nm using UV-visible spectrophotometer (GENESYS 105, Buck Scientific, USA).

### **Total Carbohydrate Content**

The total carbohydrate content was measured using the procedure of Hedge and Hofreiter (1962). About 0.5 g of the oil palm syrup was placed into a boiling tube, which was further hydrolysed by holding it in a boiling water bath with 5.0 mL of 2.5 N HCl for 3 hrs and cooled to room temperature. This was neutralized with solid sodium carbonate till the effervescence took up the quantity to 100 mL. It was then centrifuged, the supernatant was extracted and 0.2 to 1.0 mL taken for analysis. The standards were made by taking working standards from 0.2-1.0 mL. About 1.0 mL of water served as a blank that was made up to a volume 1.0 mL in all the tubes containing purified water, then 4.0 mL of anthrone reagent was included to the mixture which was heated in a boiling water bath for eight minutes. It was further cooled rapidly and green to dark green colour was read at 630 nm. The concentration of glucose in the sample was calculated from the graph by taking the concentration of glucose on X and Y axis (mg/ml) using a spectrophotometer (GENESYS 105, Buck Scientific, USA).

### **Determination of Antioxidant Capacity**

#### **Total Phenolic Content**

Total phenolic content was estimated using the folin ciocalteu method (Singleton *et al.*, 1999; Patel *et al.*, 2010; Bhalodia *et al.*, 2011). About 1 mL aliquots of each sample and standard gallic acid (10, 20, 40, 60, 80, 100 µg/mL) in test tube were added, 5 mL of distilled water and 0.5 mL of Folin Ciocalteu reagent. The mixtures were mixed and shaken. After 5 m, 1.5 mL of 20 % sodium carbonate was added and up to 10 mL with purified water was also added to the volume. On incubation for 2 hrs at ambient temperature, an intense blue colour was developed. The absorbance was determined at 750 nm using spectrophotometer (GENESYS 105, Buck Scientific, USA). Standard gallic acid was used to plot the calibration

curve. The total phenolic content from the calibration graph which was expressed as mg gallic acid equivalent weight (GAE)/L of solution.

### **DPPH Radical Scavenging Activity**

DPPH (2, 2-diphenyl-1-picrylhydrazyl) scavenging activity was determined using the method described by Tamrin (2012). About 0.1 mL of each sample (100 mg/mL) was added by 3.9 mL of 0.15 mM DPPH in ethanol. The solution then was mixed vigorously and allowed to stand in the dark for 30 m at room temperature. The absorbance of the extracts was measured using a spectrophotometer at 517 nm. About 0.1 mL ethanol with 3.9 mL DPPH was used as a control. The DPPH scavenging activity was calculated according to the equations below:

$$\text{DPPH scavenging activity} = \frac{A_{517\text{nm}}^{\text{Control}} - A_{517\text{nm}}^{\text{Sample}}}{A_{517\text{nm}}^{\text{Control}}} \times 100$$

### **Reducing Power**

The reducing power was determined using the method described by Oyaizu, (1986). Aliquot (100  $\mu\text{L}$ ) of each extract was mixed with 250  $\mu\text{L}$ , 200 mM sodium phosphate buffer (pH 6.6) and potassium ferricyanide (250  $\mu\text{L}$ , 1 %). The mixtures were incubated for 20 m at 50 °C. Trichloroacetic acid (250  $\mu\text{L}$  of a 10 % solution) was added to each combination of 250  $\mu\text{L}$  purified water and 0.5 mL, 0.1 %  $\text{FeCl}_3$ . Absorbance was measured at 700 nm. Reducing power was reported as absorbance values.

### **Estimation of Vitamin C**

Vitamin C was estimated using the method described by Omaye *et al.*(1979). About 0.5 mL of each sample and 1.5 mL of 6 % trichloroacetic acid (TCA) was added and the mixture was centrifuged at 500 g for 20 m. To the supernatant, 0.5 mL of 2, 4-dinitrophenyl hydrazine (DNPH) reagent (2 % DNPH and 4 % thiourea in 9 N sulphuric acid) was added and the mixture was incubated for 3 hrs at room temperature. After incubation, 2.5 mL of 85 % sulphuric acid was added. The standard samples were prepared using known concentrations of ascorbic acid. The absorbance values for the test and of the standard samples were read at 530 nm using UV-visible spectrophotometer (GENESYS 105, Buck Scientific, USA). The vitamin C content (or mg/mL) of the samples were calculated from the calibration graph.

## **Data Analysis**

Experimental data was analysed using Microsoft Excel package. The analysis was carried out in triplicates. The replicates within individual experiments was averaged and presented as mean  $\pm$  Standard Deviation. The IC<sub>50</sub> values were calculated where applicable using linear regression graph.

## **RESULTS AND DISCUSSION**

### **Proximate composition of oil palm syrup and kola nut (*C. acuminata*)**

Table 1 revealed 29.55 % moisture, 2.32 % crude lipid, 2.34 % ash, 0.00 % crude fibre and 0.50 % crude protein content, and total carbohydrate constituted 66.29 % in aqueous solution of oil palm syrup. On the other hand, the moisture, ash, crude lipid, crude fibre, crude protein content and nitrogen free extract of aqueous extracts of *C. acuminata* seed were 44.70 %, 1.91 %, 8.86 %, 17.50 % and 27.03 % respectively. Proximate analysis is a nutritional assessment carried out to evaluate the nutritional constituents and value of food products. Assessing the nutrient constituents is vital to explore health benefits and nutritional status of any product (Omeh *et al.* (2014). The nutritional composition showed that the aqueous solutions of oil palm syrup and aqueous extracts of *C. acuminata* contained considerable amount of nutrients. In this study, both the aqueous solutions of oil palm syrup and *C. acuminata* contained considerable amount of moisture content. The moisture content parameter determines the quality, savor, shelf-life and processing characteristics of the sample (Omeh *et al.*, 2014). It also explains the biochemical and physiological reactions that occur in biological samples. The moisture content values showed that the *C. acuminata* seed and oil palm syrup could be stored for an extensive duration of time with the active components and constituents still intact. The moisture content of *C. acuminata* in this study was higher than the report of Omeh *et al.* (2014). The ash content estimates the inorganic minerals existent in any product. Both the aqueous solutions of palm syrup and aqueous extracts of *C. acuminata* recorded low ash content. Oil palm syrup and *C. acuminata* recorded relatively low lipid contents. Fat is an alternative source through which the body



derives its energy (Wali *et al.*, 2020). However, excess intake of fatty diet may result to cardiovascular disorders (Wali *et al.*, 2020). The lipid content in this study meets the caloric requirement of fat (1 – 2 %) adequate to human beings according to the findings of Kris-Etherton *et al.* (2002).

The protein content of *C. acuminata* was significantly higher than oil palm syrup. Protein serves as a source of amino acids in the diet (Brosnan, 2006). The crude fibre content of *C. acuminata* was high as no fibre was detected in the syrup. *C. acuminata* can therefore be used in treating constipation. Other functions includes, increases bowel motility and slows gastric emptying. Fibre has been reported to decrease the risk of coronary disease (Barber *et al.*, 2020). The nitrogen free extract of oil palm syrup was slightly higher than that of *C. acuminata* seed in this study. The crude fibre content in this study was higher than *Garcinia kola* as reported by Omeh *et al.* (2014). The browning intensity (0.424) and colour (dark brown) were present in aqueous solutions of oil palm syrup. The total carbohydrate content recorded in oil palm syrup was 66.29 %.

The total carbohydrate content of the oil palm syrup in this study was significantly high. This agrees with the findings of Oboh *et al.* (2016). Carbohydrates are the main constituents of oil palm syrup comprising of predominantly monosaccharides such as fructose and glucose (Trinidad *et al.*, 2010; Oboh and Imafidon, 2018). Palm syrup had considerably high browning intensity in this study. The browning of oil palm syrup showed the presence of Maillard reaction generated from the reaction between the amino acids and sugars present in the oil palm sap (Eze and Organ, 1988). An increase in browning intensity indicates a browner colour of oil palm syrup indicating the presence of maillard reaction which occurred during the process of heating. The browning intensity in this study were in agreement with the report of Wong *et al.* (2008). Maillard reaction could be influenced by temperature. Thus, an increase in temperature during the heating process of oil palm sap can upsurge the browning reaction, thereby resulting in a high browning intensity of oil palm syrup. The titratable acidity was observed to increase significantly as the concentration of the aqueous solution of oil palm syrup extract increased. Titratable acidity estimates the amount of organic acids in palm sap. Lactic acid formed by lactic acid bacteria has been described as

the dominant organic acid responsible for the acidic content of palm syrup (Amoa-Awua *et al.*, 2007). The titratable acidity values in this study corroborates with the report of Lasekan *et al.* (2007).

**pH and titratable acidity of aqueous solutions of oil palm syrup, aqueous extracts of *C. acuminata* seed and decoction of *C. acuminata* in 20 % oil palm syrup solution.**

Table 2 revealed the pH values of aqueous solutions of the oil palm syrup were within the acidic range and showed a decrease from 3.63 - 3.53 as the titratable acidity increased from 2.70 - 4.01 g/L with an increase in the amount of syrup. Table 3 indicated that the pH values of aqueous extracts of *C. acuminata* tend towards the acidic range 6.70 - 6.48 as the amounts increased. Also, pH values for decoction of *C. acuminata* in 20 % palm syrup increased from 4.57- 4.83 as the amounts increased as observed in Table 4. pH is a significant physiochemical parameter that determines a good shelf stability and texture of food products. The pH of the various palm syrup concentrations were within the acidic range. The pH values of oil palm syrup in this study agrees with the report of Adebisi *et al.* (2004), Khalil *et al.* (2010), Kayode and Oyeyemi (2014). In this study, the fermentation of sap during the collection process may be responsible for the high titratable acidity and low pH of aqueous solutions of palm syrup. Yeast and other fermenters are found to grow under low pH condition. Therefore, the action and presence of these organisms during the process of fermentation may have direct effect on the pH values. The pH of aqueous extracts of *C. acuminata* seed was slightly acidic as the concentration increased. These findings agree with the report of Oyekunle *et al.* (2012). The decoction of *C. acuminata* in 20 % oil palm syrup showed an increase in the pH values as the concentration increased.

***In vitro* antioxidant capacity and alpha amylase inhibitory activity of aqueous solutions of oil palm syrup, aqueous extracts of *C. acuminata* seed and decoction of *C. acuminata* in 20 % oil palm syrup solution.**

The total phenolic content of the oil palm syrup: 112.7 - 420.6 µg GAE/L, vitamin C: 2.80 - 5.99 mg/L, reducing power: 0.236 – 0.384, DPPH scavenging activity: 88.76 – 93.83 % and

*in vitro*  $\alpha$ -amylase inhibitory activity 73.4 - 89.2% increased as the amounts of extract increased.

The total phenolic content of the aqueous extracts of *C. acuminata* seed: 29.0 – 307.1  $\mu$ g GAE/L, vitamin C: 0.78 – 6.55 mg/L, reducing power: 0.284 – 0.914, DPPH radical scavenging activity: 64.24 – 87.67 % and *in vitro*  $\alpha$ -amylase inhibitory activity: 41.78 - 66.15 % increased as the amounts of extract increased. The results are presented in Table 3.

Table 4 showed the total phenolic content of the decoction of *C. acuminata* in 20 % oil palm syrup solution: 200.0 - 476.9  $\mu$ g GAE/L, vitamin C: 8.45 - 21.1 mg/L, reducing power: 1.042 - 2.047, DPPH scavenging activity: 28.84 - 61.36 % and *in vitro*  $\alpha$ -amylase inhibitory activity: 15.42 - 42.43 % increased as the decoction extract increased.

Phenolic compounds are the most diverse group of natural compounds characterized with a broad range of biological actions such as antioxidant and radical scavenging properties. They possess high antioxidant potentials that enables them act as a reducing agents i.e. hydrogen donors and singlet quenchers. The concentration of phenolic content of the decoction of *C. acuminata* in 20 % palm syrup was significantly high as the concentration increased. Also, the phenolic content of aqueous extracts of *C. acuminata* and aqueous solutions of oil palm syrup singly was considerable high. However, decoction of *C. acuminata* in 20 % oil palm syrup had the highest phenolic content in comparison with aqueous solutions of oil palm syrup and aqueous extracts of *C. acuminata* alone. The decoction of *C. acuminata* in 20 % oil palm syrup solution exhibited better OH<sup>-</sup> scavenging potentials by donating electron than aqueous solutions of oil palm syrup and aqueous extracts of *C. acuminata* alone respectively. The decoction of *C. acuminata* in 20 % oil palm syrup solution exhibited high contents of vitamin C as the concentration increased in relation to aqueous solutions of oil palm syrup and aqueous extracts of *C. acuminata* separately. The presence of significantly high vitamin C content in decocted extract showed its potential of exhibiting antioxidant action by donation of hydrogen atoms to molecular oxygen which counteracts free radical species. Vitamin C performs a vital function in the formation of collagen by inhibiting the oxidation of ferrous iron co-factor of prolyl hydroxylase, thus preventing vitamin C deficiency (scurvy) (Davey, 2012). High consumption of vitamins is linked to series of chronic diseases such as

cancer, cardiovascular disease and cataract. Furthermore, vitamin C may reduce hydrogen peroxide which ultimately protects the cells against reactive species in the body (Davey, 2012).

The reducing power of the decoction of *C. acuminata* in 20 % palm syrup showed to exhibit high chelating abilities compared to aqueous solutions of the oil palm syrup and aqueous extracts *C. acuminata* singly as the concentration increased. Hence, the decocted extract had better ability to reduce  $Fe^{+3}$  to  $Fe^{+2}$ . By implication, an elevated reducing capacity of these extracts may be significant in counteracting free radicals generated in hyperglycemic condition thus delaying the progress of diabetic complications because of the effect of oxidative stress (Sudha *et al.*, 2011). The reducing power result in this study corroborates with the report of Joshua *et al.* (2017).

The activities of human pancreatic amylase (HPA) in the gut have been linked to a spike in post-prandial glucose levels. Hence, the regulation of alpha amylase inhibitory activity is an effective strategy in the treatment and management of type-2 diabetes (Sudha *et al.*, 2011). Different natural sources have been explored in suppressing glucose production from carbohydrates in the gut or glucose absorption from the intestine. The  $\alpha$ -amylase inhibitory activity values showed that aqueous solutions of the oil palm syrup extract had a low  $\alpha$ -amylase inhibitory activity than aqueous extracts of *C. acuminata* and the decoction of *C. acuminata* in 20 % in oil palm syrup solution. The Inhibition concentration  $IC_{50}$  values of the oil palm syrup was significantly low when compared to the values of aqueous extracts of *C. acuminata* and the decoction of *C. acuminata* in 20 % oil palm syrup. Hence, these findings showed the potency of aqueous solutions of oil palm syrup and the decoction of *C. acuminata* aqueous extract in 20 % oil palm syrup solution to inhibit the activity of  $\alpha$ - alpha amylase in the digestive tract of humans. The inhibitory property of this extracts can be explored and adopted in the management of type 2- diabetes based on the findings of Bhadari *et al.* (2008). The aqueous extracts of *C. acuminata* were observed to be potent and hence could be useful in performing similar function. The value obtained for the decoction of *C. acuminata* aqueous extracts in 20 % oil palm syrup solution was close to that of acarbose (18.63  $\mu$ g/mL) which is used as an anti-diabetic drug.

DPPH (2,2-diphenyl-1-picrylhydrazyl) is a stable free radical. Thus, antioxidants use their scavenging property through donation of hydrogen atoms (Sharma and Bhat, 2009). The IC<sub>50</sub> for the decoction of *C. acuminata* aqueous extracts in 20 % oil palm syrup solution was low. The *C. acuminata* extract exhibited better abilities to quench DPPH radical. Owing to their antioxidant properties, palm sugar and *C. acuminata* seeds could possess potential health benefits for its usage as a sweetener and flavorings in functional food and beverage formulations (Oboh and Imafidon, 2018). The decoction of *C. acuminata* aqueous extracts in 20 % oil palm syrup solution demonstrated antioxidant potentials because of its ability to scavenge 2, 2-diphenyl-1-picrylhydrazyl radical (DPPH).

## CONCLUSION

The results of this study has shown that oil palm syrup (*E. guineensis*) is a rich source of antioxidant with a high  $\alpha$ - amylase inhibitory activity and may be applied in food industries as sweeteners, thereby creating new flavour in food and beverages. The *in vitro* studies carried out on *C. acuminata* clearly showed that the studied extract has high ability to scavenge free radicals, serve as a stimulant and could be used in combination with other extracts to produce healthy products of nutritional importance. The decoction of *C. acuminata* in 20 % palm syrup solution resulted in synergistic effects with respect to *in vitro* antioxidant properties and  $\alpha$ - amylase inhibitory potential, relative to when the oil palm syrup and *C. acuminata* were used separately. This study suggest that the combination of both studied extracts could be used in the production of nutraceuticals based on their antioxidant, nutritional and alpha amylase inhibitory properties.

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**APPENDICES**

**Table 1: Proximate composition of oil palm syrup and *C. acuminata***

Parameters	Oil palm Syrup	<i>C. acuminata</i>
Protein (N x 6.25 %)	0.50 ± 0.03 <sup>a</sup>	17.50 ± 0.03 <sup>b</sup>
Ash (%)	2.32 ± 0.03 <sup>c</sup>	1.91 ± 0.02 <sup>d</sup>
Lipids (%)	2.34 ± 0.03 <sup>c</sup>	2.45 ± 0.02 <sup>c</sup>
Moisture (%)	29.55 ± 0.03 <sup>f</sup>	44.70 ± 0.03 <sup>g</sup>
Fibre (%)	0.00 ± 0.00 <sup>a</sup>	8.86 ± 0.01 <sup>h</sup>
Nitrogen free extract	65.29 ± 0.00 <sup>i</sup>	24.58 ± 0.00 <sup>j</sup>
Total carbohydrate content	66.27 ± 0.03 <sup>b</sup>	
Browning intensity	0.424 ± 0.01 <sup>a</sup>	
Colour (visual)	Dark brown	

Values are means of triplicate analysis and standard deviation. Means with the same letter(s) in each column are not significantly different at  $p < 0.05$

**Table 2: Chemical characteristics, *in vitro* antioxidant capacity and  $\alpha$ -amylase inhibitory activity for aqueous solutions of oil palm syrup**

Palm syrup (g/100 mL) distilled H <sub>2</sub> O	pH	Titrateable Acidity	Total phenolic content ( $\mu$ g GAE/L Solution)	Vitamin C (mg/L)	Reducing power ( $A_{700nm \pm SD}$ )	DPPH Scavenging activity (%)	<i>In vitro</i> $\alpha$ -amylase inhibitory activity (%)
5	3.63 <sup>a</sup>	2.70 <sup>f</sup>	112.7 <sup>a</sup> ± 0.00	2.80 <sup>b</sup> ± 0.00	0.236 <sup>a</sup> ± 0.00	88.76 <sup>a</sup> ± 0.00	73.5 <sup>d</sup> ± 0.07
10	3.59 <sup>b</sup>	2.91 <sup>g</sup>	237.1 <sup>b</sup> ± 0.03	3.47 <sup>j</sup> ± 0.00	0.265 <sup>b</sup> ± 0.06	89.52 <sup>b</sup> ± 0.03	78.9 <sup>e</sup> ± 0.03
25	3.57 <sup>c</sup>	3.27 <sup>h</sup>	262.7 <sup>n</sup> ± 0.00	4.00 <sup>o</sup> ± 0.00	0.273 <sup>c</sup> ± 0.09	91.09 <sup>c</sup> ± 0.03	84.9 <sup>f</sup> ± 0.02
30	3.55 <sup>d</sup>	3.60 <sup>i</sup>	88.8 <sup>d</sup> ± 0.00	5.17 <sup>m</sup> ± 0.00	0.338 <sup>d</sup> ± 0.04	92.46 <sup>d</sup> ± 0.03	87.3 <sup>g</sup> ± 0.01
40	3.53 <sup>e</sup>	4.01 <sup>j</sup>	420.6 <sup>p</sup> ± 0.00	5.99 <sup>s</sup> ± 0.04	0.384 <sup>f</sup> ± 0.00	93.83 <sup>c</sup> ± 0.04	89.2 <sup>u</sup> ± 0.02
Inhibition Concentration IC <sub>50</sub> (%)						28.44	0.51

All values are expressed as mean ± SD of triplicate determinations. Means with different superscripts down the column are significantly ( $p < 0.05$ ) different.

**Table 3: Chemical characteristics, *in vitro* antioxidant capacity and  $\alpha$ -amylase inhibitory activity for aqueous extracts of *C. acuminata* seed.**

<i>Cola acuminata</i> (g/100 mL) distilled H <sub>2</sub> O	pH	Total phenolic content ( $\mu$ g GAE/L Solution)	Vitamin C (mg/L)	Reducing power (A <sub>700nm</sub> $\pm$ SD)	DPPH Scavenging activity (%)	<i>In vitro</i> $\alpha$ -amylase inhibitory activity (%)
0.1	6.70 <sup>a</sup>	129.0 <sup>f</sup> $\pm$ 0.02	0.78 <sup>t</sup> $\pm$ 0.06	0.284 <sup>a</sup> $\pm$ 0.01	64.24 <sup>a</sup> $\pm$ 0.05	41.78 <sup>e</sup> $\pm$ 0.09
0.2	6.68 <sup>b</sup>	152.7 <sup>h</sup> $\pm$ 0.04	1.06 <sup>t</sup> $\pm$ 0.13	0.438 <sup>c</sup> $\pm$ 0.07	65.34 <sup>b</sup> $\pm$ 0.02	44.87 <sup>f</sup> $\pm$ 0.03
0.3	6.66 <sup>c</sup>	175.2 <sup>j</sup> $\pm$ 0.03	1.45 <sup>e</sup> $\pm$ 0.05	0.488 <sup>v</sup> $\pm$ 0.06	66.78 <sup>c</sup> $\pm$ 0.02	46.03 <sup>g</sup> $\pm$ 0.07
0.4	6.64 <sup>d</sup>	189.0 <sup>b</sup> $\pm$ 0.03	2.08 <sup>d</sup> $\pm$ 0.06	0.567 <sup>f</sup> $\pm$ 0.06	68.49 <sup>d</sup> $\pm$ 0.03	48.90 <sup>h</sup> $\pm$ 0.07
0.5	6.61 <sup>e</sup>	214.0 <sup>w</sup> $\pm$ 0.02	2.50 <sup>x</sup> $\pm$ 0.01	0.612 <sup>j</sup> $\pm$ 0.05	70.05 <sup>e</sup> $\pm$ 0.03	51.01 <sup>i</sup> $\pm$ 0.00
1.0	6.58 <sup>f</sup>	231.5 <sup>n</sup> $\pm$ 0.03	2.86 <sup>k</sup> $\pm$ 0.05	0.659 <sup>u</sup> $\pm$ 0.05	71.19 <sup>f</sup> $\pm$ 0.02	53.90 <sup>j</sup> $\pm$ 0.00
1.5	6.56 <sup>g</sup>	257.1 <sup>m</sup> $\pm$ 0.03	3.84 <sup>u</sup> $\pm$ 0.04	0.732 <sup>v</sup> $\pm$ 0.06	74.93 <sup>x</sup> $\pm$ 0.03	55.79 <sup>q</sup> $\pm$ 0.03
2.0	6.54 <sup>h</sup>	275.2 <sup>o</sup> $\pm$ 0.03	4.54 <sup>y</sup> $\pm$ 0.02	0.789 <sup>x</sup> $\pm$ 0.06	81.84 <sup>p</sup> $\pm$ 0.02	56.66 <sup>o</sup> $\pm$ 0.00
2.5	6.52 <sup>i</sup>	293.3 <sup>p</sup> $\pm$ 0.02	5.47 <sup>l</sup> $\pm$ 0.05	0.900 <sup>a</sup> $\pm$ 0.06	84.50 <sup>m</sup> $\pm$ 0.03	61.18 <sup>t</sup> $\pm$ 0.00
3.0	6.48 <sup>k</sup>	307.1 <sup>r</sup> $\pm$ 0.02	6.55 <sup>h</sup> $\pm$ 0.07	0.914 <sup>w</sup> $\pm$ 0.08	87.67 <sup>q</sup> $\pm$ 0.03	66.15 <sup>y</sup> $\pm$ 0.05
Inhibition Concentration IC <sub>50</sub> (%)					3.29	4.50

All values are expressed as mean  $\pm$  SD of triplicate determinations. Means with different superscripts down the column are significantly different at (p<0.05)

**Table 4: Chemical characteristics for the decoction of *C. acuminata* in 20 % oil palm syrup solution.**

Decoction of <i>C. acuminata</i> / 50 mL 20 % syrup solution)	pH	Total phenolic content ( $\mu\text{g}$ GAE/L Solution)	Vitamin C (mg/L)	Reducing power $A_{700\text{nm}} \pm \text{SD}$	DPPH Radical scavenging activity (%)	<i>In vitro</i> $\alpha$ -amylase inhibitory activity (%)
0.1	4.57 <sup>a</sup>	200.0 <sup>b</sup> $\pm$ 0.03	8.45 <sup>e</sup> $\pm$ 0.10	1.042 <sup>f</sup> $\pm$ 0.09	28.84 <sup>d</sup> $\pm$ 0.04	15.42 <sup>a</sup> $\pm$ 0.00
0.2	4.61 <sup>b</sup>	216.9 <sup>c</sup> $\pm$ 0.05	9.83 <sup>f</sup> $\pm$ 0.00	1.145 <sup>s</sup> $\pm$ 0.01	33.14 <sup>a</sup> $\pm$ 0.04	18.47 <sup>b</sup> $\pm$ 0.00
0.3	4.63 <sup>c</sup>	238.1 <sup>d</sup> $\pm$ 0.04	10.6 <sup>g</sup> $\pm$ 0.00	1.258 <sup>e</sup> $\pm$ 0.11	36.71 <sup>b</sup> $\pm$ 0.02	22.37 <sup>c</sup> $\pm$ 0.10
0.4	4.66 <sup>d</sup>	253.8 <sup>r</sup> $\pm$ 0.06	11.4 <sup>h</sup> $\pm$ 0.01	1.400 <sup>g</sup> $\pm$ 0.01	40.68 <sup>c</sup> $\pm$ 0.00	26.34 <sup>d</sup> $\pm$ 0.00
0.5	4.68 <sup>e</sup>	271.2 <sup>t</sup> $\pm$ 0.06	12.6 <sup>i</sup> $\pm$ 0.01	1.487 <sup>m</sup> $\pm$ 0.06	45.34 <sup>d</sup> $\pm$ 0.03	28.47 <sup>q</sup> $\pm$ 0.03
1.0	4.71 <sup>f</sup>	295.0 <sup>s</sup> $\pm$ 0.00	14.3 <sup>k</sup> $\pm$ 0.00	1.670 <sup>b</sup> $\pm$ 0.00	47.67 <sup>e</sup> $\pm$ 0.00	30.48 <sup>r</sup> $\pm$ 0.00
1.5	4.74 <sup>g</sup>	308.1 <sup>w</sup> $\pm$ 0.00	15.71 <sup>d</sup> $\pm$ 0.07	1.873 <sup>l</sup> $\pm$ 0.00	52.27 <sup>h</sup> $\pm$ 0.00	34.02 <sup>v</sup> $\pm$ 0.09
2.0	4.77 <sup>h</sup>	357.5 <sup>y</sup> $\pm$ 0.05	17.1 <sup>m</sup> $\pm$ 0.01	1.979 <sup>h</sup> $\pm$ 0.00	55.47 <sup>g</sup> $\pm$ 0.07	38.80 <sup>s</sup> $\pm$ 0.04
2.5	4.80 <sup>i</sup>	432.5 <sup>i</sup> $\pm$ 0.03	19.3 <sup>n</sup> $\pm$ 0.02	2.217 <sup>r</sup> $\pm$ 0.00	58.28 <sup>x</sup> $\pm$ 0.04	40.97 <sup>t</sup> $\pm$ 0.03
3.0	4.83 <sup>j</sup>	476.9 <sup>o</sup> $\pm$ 0.00	21.1 <sup>o</sup> $\pm$ 0.01	2.407 <sup>x</sup> $\pm$ 0.08	61.36 <sup>v</sup> $\pm$ 0.00	42.43 <sup>u</sup> $\pm$ 0.09
Inhibition Concentration IC <sub>50</sub> (%)					6.60	12.10

All values are expressed as mean  $\pm$  SD of triplicate determinations. Means with different superscripts down the column are significantly different at ( $p < 0.05$ )