The Bioscientist Journal Vol. 10 (1): 1-10, January 2022
Available online at https://www.bioscientistjournal.com



OPEN ACCESS

Full Length Research Paper

COMPARATIVE STUDIES ON THE NUTRITIONAL AND PHYTOCHEMICAL COMPOSITIONS AND THE ANTIOXIDANT POTENTIALS OF FERMENTED CASTOR OIL AND SOURSOP SEEDS

[1]Joshua O., [1]Igwilo I.O., [2]Ezeonu C.S., [1]Nworji O.F., [2]Ojochenemi E.Y., [2]Asemave S.S.
[1]Department of Applied Biochemistry, Faculty of Biosciences, NnamdiAzikiwe University, Awka, Anambra State, Nigeria.
[2]Department of Biochemistry, Faculty of Pure and Applied Sciences, Federal University Wukari, Wukari, Taraba State, Nigeria. *Email: onwukajoshua26@gamil.com

ABSTRACT

This work compared the nutritional and phytochemical compositions, antioxidant capacities of fermented castor oil and soursop seeds. The seeds of castor oil and soursop were fermented traditionally and standard methods were applied for the determination of the phytochemical, proximate, vitamins, minerals and *in vitro* antioxidant activity. The phytochemical compositions showed total phenols (11.60±1.52 and 22.17±0.64 mgGAE/100g), flavonoids (3.60±0.11 and 3.37±0.07 mgCE/100g), tannins (4.77±0.13 and 1.33±0.40 mg/100g), alkaloids (0.30±0.03% and not detected), oxalate (0.54±0.00 and 0.68±0.20 mg/g), phytate (0.33±0.02 and 0.09±0.01%) and saponin (0.54±0.62% and not detected) for fermented castor oil andsoursop seeds respectively. Proximate compositions showed crude fibre (0.73±0.11 and 7.25±0.35%), ash (2.29±0.22 and 1.64±0.12%), lipid (17.80±1.13 and 11.55±0.77%), moisture (43.29±0.72 and 38.60±1.81%), carbohydrate (31.25±2.28, 23.84±1.12%) and crude protein (16.75±1.41 and 5.03±0.31%) for fermented castor oil and soursop seeds respectively. The vitamin analysis revealed vitamins A (6.37±0.00 and 16.56±0.00 mg/g), B_1 (3.89±0.00 and 9.44±0.43µg/g), C (5.43±0.31 and 2.39±0.31mg/g), E (5.39±0.04 and 0.52±0.04 mg/g) and folic acid (31.22±1.60 and 42.33±1.60µg/g). The mineral composition showed Ca (180.00±2.52 and 2.72±0.36mg/kg), K (281.63±0.40 and 2.95±0.09mg/kg), P (214.80±6.15 and 214.39±3.80mg/kg) and Zn (0.87±0.06 and 214.39±3.80mg/kg) respectively. The fermented castor oil and soursop seeds significantly ($p<0.05$) increase inhibition of lipid peroxidation and also had a high reducing power capacity.

The result indicated that fermented soursop seeds can serve as a substitute for fermented castor oil seeds especially for individuals with vitamins deficiency.

Keywords: Phytochemicals, Proximate, Vitamins, Mineral, Antioxidants, Castor oil and Soursop seeds

INTRODUCTION

Annona muricata commonly known as soursop is a member of the *Annonacae*family which consists of about 130 genera and 2300 species (Moghadamtousi*et al.,* 2015). Extensive phytochemical evaluations carried out on different parts (leaves, roots, fruits, stem, bark and seeds) of *Annona muricata* have shown the presence of several bioactive compounds such as alkaloids, megastigmanes, flavonoltriglycosides, phenolics, cyclopeptides, essential oils and annonaceousacetogenin compounds. Major minerals such as potassium, calcium, sodium, copper, iron and magnesium have been reported to be present, which makes them ideal dietary sources of electrolytes, essential nutrients and elements which are utilised in various biological processes (Elizabeth *et al.,* 2018). *Annona muricata* has shown to be the most abundant source of the annonaceousacetogenin compounds; which are the main bioactive compounds of the *Annonaceae*family (Errayes*et al.,* 2020). They possess the most beneficial antitumor, cytotoxic, antimalarial and anti-feedant properties. Acetogenins gets interacted with the NADH–ubiquinone oxidoreductase (complex I) in mammalian and in the insect mitochondrial electron transport systems and/or with ubiquinone-linked NAD(P)H oxidase in the cancer cells cytoplasmic membranes (Gajalakshmi*et al.,* 2012). Other mechanism of action of cytotoxicity of *Annona muricata* include; the inhibition of multiple signaling pathways, metastasis, cell cycle arrest and induction of necrosis (Gavamukulya*et al.*, 2017).

Castor oil seeds are one of the oldest cultivated crops and known for their seeds yielding a viscous, pale yellow nonvolatile and nondrying castor oil (Patel *et al.,* 2016). The major constituents of castor oil are mainly fatty acids and neutral lipids (triglycerides). Castor oil seeds constitute other minor bioactive compounds that consist of unsaponifiable fractions such as carotenoids, phenolics, phospholipids, phytochemicals, phytosterols, tocopherols, and tocotrienols are also present in the oil (Yaboah*et al.,* 2020). Castor oil seeds are used in other part of the world for large scale production of consumable and non-consumable oils. But in Nigeria, castor oil seeds are found to be part of our diet when processed by traditional fermentation method. And researchers have revealed countless health benefits of this food condiment. But the castor oil seeds and its derivative (ogiri) as a food condiment are not readily available and affordable in the market. Therefore, other plant seeds with related health benefit and that can serve the same purpose as the fermented castor oil seeds have to be discovered to meet the increasing demand for traditionally fermented food condiments in our country. Therefore, this work is aimed at comparing the nutrients and phytochemical compositions, in vitro antioxidant capacities of fermented castor oil and soursop seeds.

MATERIALS AND METHODS

SAMPLE COLLECTION

Both the castor oil seeds and soursop seeds were collected from Woliwo, Ochanja market, Onitsha L.G.A Anambra State, Nigeria. The plant sampleswere identified

and authenticated by a taxonomist at the Botany laboratory, Department of Botany, NnamdiAzikiwe University Awka and subsequently deposited at the herbarium with Voucher numbers of 10^{A} and 09^{A} respectively.

SAMPLE PREPARATION

The traditional method employed in preparation of the fermented samples is similar to that reported by Okwunodulu*et al.* (2020). The soursop seeds were manually removed from the soursop fruits collected and washed with clean water. 1kg of both the castor oil seeds and soursop seeds were dehaulled and boiled for an hour. The boiled soursop seeds were then soaked in cold water till the next day and then boiled for another 30 minutes to increase its softness. Whereas, the castor oil seeds were boiled only for an hour because the desired softness is easily achieved. Both seeds were then ground and "nngu" was then added to enhance fermentation. The ground seeds were then wrapped with leaves and allowed to ferment.

PHYTOCHEMICAL ANALYSIS

Phytate content was determined by the method of Young and Greaves (1940). Determination of oxalate and cardiac glycosides were by the method of Osagie (1998). Flavonoid and total phenol contents were determined by the method of Barros *et al.,* (2007) and Barros *et al.,* (2008) respectively. Alkaloids were determined by the method of Harborne (1995). Tannin content was determined according to the method of AOAC (1990).

PROXIMATE ANALYSIS

The determination of the moisture content, ash content, lipid content, crude fibre and crude proteins were performed using standard methods of the Association of Official Analytical Chemists (1990) while the carbohydrate content was determined by difference of method as reported by Yerima and Adamu (2011).

ANALYSIS OF VITAMINS

Vitamins A and E contents were determined by the methods of Rutkoski*et al.,* (2006) and Rutkoski*et al.* (2005) respectively. Vitamin C content was determined by the method of Klein and Perry (1982). Determination of the B vitamins were by the method of Kirk and Sawyer (1991). Folic acid content was determined by the method of Padamarajaiah*et al.* (2002).

MINERAL ANALYSIS

The minerals analyses were carried out using the method ofAOAC (2003).

SAMPLE DIGESTION

Two grams (2g) of each the sample was weighed into a digestion flask and 20ml of acid mixture (650ml conc. HNO_3; 80ml perchloric acid; 20ml conc. H_2SO_4) was added. The flask was heated using a heating mantle until a clear digest was obtained. The digest was diluted with metal-free distilled water to the100ml mark.The minerals in the solution were analyzed using Chemetrics V-3000 Automated Multi-Analyte Photometer.

***IN VITRO* ANTIOXIDANT ANALYSIS**

The free radical scavenging activity was determined using the method of Ebrahimzadem*et al*. (2014) and both the reducing power assay and inhibition of lipid peroxidation was determined using the method of Barros *et al.* (2007).

RESULTS

Phytochemical Compositions of Fermented Castor Oil (Ogiri) and Soursop Seeds

The result obtained from the phytochemical analysis of fermented castor oil and soursop seeds were as shown in Table 1. It revealed that fermented castor oil seeds had higher

flavonoid, tannin, and phytate while fermented soursop seeds had higher phenols than fermented castor oil seeds. Whereas, saponin and alkaloids were detected in fermented castor oil seeds, they were not found in fermented soursop seeds.

Proximate Compositions of Fermented Castor Oil Seeds (Ogiri) and Fermented Soursop seeds

Results obtained from the proximate composition analysis of both fermented castor oil and soursop seeds are presented in Table 2. The result indicated that the crude protein, ash and lipids contents were found higher in fermented castor oil seeds while the fibre, carbohydrate and moisture contents were found higher in fermented soursop seeds than in castor oil seeds.

The Vitamin Compositions of Fermented Castor Oil and Soursop seeds

Results obtained from the proximate composition analysis of both fermented castor oil and soursop seeds are presented in Table 3. The vitamin compositions revealed varying concentrations of vitamins. The result revealed that fermented soursop seeds had higher vitamins A, B1, B2 and folic acid contents than fermented castor oil seeds. While fermented castor oil seeds had higher vitamin C and E contents than fermented soursop seeds.

Mineral Compositions of Fermented Castor Oil (Ogiri) and Soursop Seeds

The result of mineral composition analysis presented varying concentrations of different minerals (Table 4). It revealed that fermented castor oil seeds had higher calcium, potassium, magnesium, sodium and iron contents than fermented soursop seeds. While the phosphorus content of both fermented castor oil and soursop seeds are fairly comparable.

Table 1: Phytochemical Compositions of both Fermented Castor Oil and Soursop Seeds

Parameters	Fermented Castor Oil Seeds Mean ± S.D	Fermented Soursop Mean ± S.D
Total Phenol (mgGAE/100g)	11.60 ± 1.52	22.17 ± 0.64
Flavonoid (mgCE/100g)	3.60 ± 0.11	3.37 ± 0.07
Tannin (mg/100g)	4.77 ± 0.13	1.33 ± 0.40
Alkaloid (%)	0.30 ± 0.03	ND
Oxalate (mg/g)	0.54 ± 0.00	0.68 ± 0.20
Cardiac Glycoside (%)	0.04 ± 0.00	0.07 ± 0.01
Phytate (%)	0.33 ± 0.02	0.09 ± 0.01
Saponin (%)	0.54 ± 0.62	ND

Results are expressed as Mean ± Standard deviation of triplicate determinations

Table 2: Proximate Compositions both Fermented Castor Oil Seeds and Soursop Seeds

Parameters	Fermented Castor Oil seeds (Ogiri) Mean ± S.D	Fermented Soursop seeds Mean ± S.D
Fibre (%)	0.73 ± 0.11	7.25 ± 0.35
Ash (%)	2.29 ± 0.22	1.64 ± 0.12
Lipids (%)	17.80 ± 1.13	11.55 ± 0.77
Carbohydrate (%)	23.84 ± 1.12	31.25 ± 2.28
Moisture (%)	38.60 ± 1.81	43.29 ± 0.72
Crude Protein (%)	16.75 ± 1.41	5.03 ± 0.31

Results are expressed as Mean ± Standard deviation of triplicate determinations

Table 3: The Vitamin Compositions of Fermented Castor Oil and Soursop seeds

Parameters	Fermented Castor Oil Seeds Mean ± S.D	Fermented Soursop Seeds Mean ± S.D
A (mg/g)	6.37 ± 0.00	16.56 ± 0.00
B1 (µg/g)	3.89 ± 0.00	9.44 ± 0.43
B2 (µg/g)	0.02 ± 0.00	0.92 ± 0.03
B3 (µg/g)	0.02 ± 0.00	ND
C (mg/g)	5.43 ± 0.31	2.39 ± 0.31
E (mg/g)	5.39 ± 0.04	0.52 ± 0.04
Folic Acid (µg/g)	31.22 ± 1.60	42.33 ± 1.60

Results are expressed as Mean ± Standard deviation of triplicate determinations

Table 4: Mineral Compositions of both Fermented Castor Oil and Soursop Seeds

Parameters (mg/kg)	Fermented Castor Oil Seeds Mean ± S.D	Fermented Soursop Seeds Mean ± S.D
Ca	180.00 ± 2.52	2.72 ± 0.36
K	281.63 ± 0.40	2.95 ± 0.09
Mg	53.78 ± 0.80	0.84 ± 0.06
Na	25.41 ± 0.43	0.92 ± 0.06
Fe	2.92 ± 0.13	0.92 ± 0.06
P	214.80 ± 6.15	214.39 ± 3.80
Zn	0.87 ± 0.06	214.39 ± 3.80

Results are expressed as Mean ± Standard deviation of triplicate determinations

In vitro Antioxidant Capacity of Fermented Castor Oil (Ogiri) and Soursop Seeds

Lipid Peroxidation Inhibition of Fermented Castor Oil Seeds (Ogiri) and Soursop Seeds

The percentage inhibition of lipid peroxidation of both fermented castor oil seeds (ogiri) and soursop seeds are shown in Figure 1. At a concentration of 10 mg/ml, fermented castor oil seeds and soursop seeds expressed the highest lipid peroxidation inhibitory activity of 92% than the standard synthetic antioxidant, butylated hydroxyanisole (BHA). Nevertheless, BHA showed a higher inhibitory activity (43%) than both fermented castor oil seeds (ogiri) and soursop seeds (29%) at 1.25mg/ml concentration.

Reducing Power Activity of both Fermented Castor Oil Seeds (Ogiri) and Soursop Seeds

Figure 2 shows the *in vitro* reducing power of both fermented castor oil (ogiri) and soursop seeds. The figure shows that the absorbance of both fermented castor oil seeds (ogiri) and soursop seeds increases with an equivalent increase in their concentrations. The various concentrations (0.625mg/ml, 1.25mg/ml, 2.5mg/ml, 5.0mg/ml and 10mg/ml) of both fermented castor oil and soursop seeds showed 92%, 93%, 96%, 98% and 99% reducing power capacity respectively.

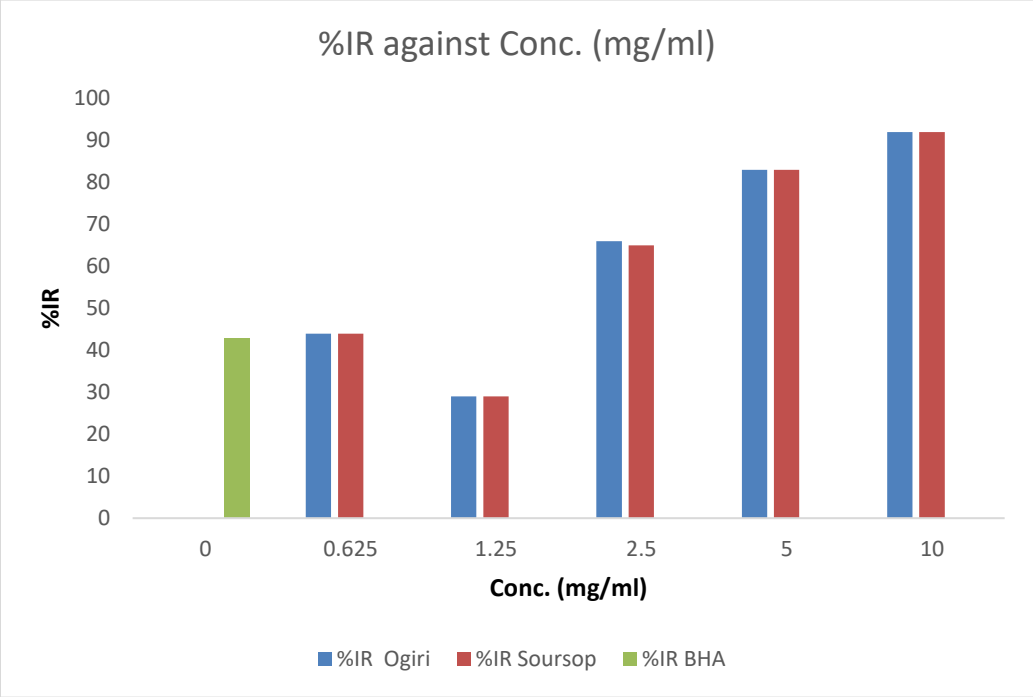


Fig 1: The % Lipid Peroxidation Inhibition Activities of fermented castor oil and soursop seeds

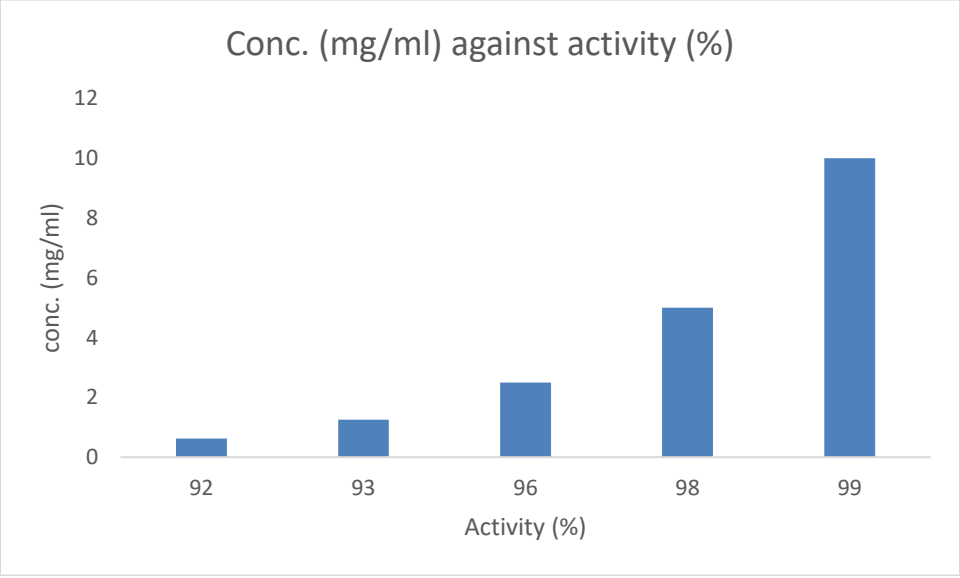


Fig 2*:* The Reducing Power activities of fermented castor oil (ogiri) and soursop seeds

DISCUSSION

Phytochemicals are secondary metabolites produced by plants. Phytochemicals are of different types. Some are beneficial to man as antioxidant while some are poisonous or act as anti-nutrients. This study presented that both fermented castor oil and soursop seeds contained different phytochemicals in varying concentrations; total phenol with highest concentration than other phytochemicals. The result revealed the highest concentration of total phenol in fermented soursop seeds than in fermented castor oil seeds. Hence, fermented soursop seeds may have more health benefits in preventing oxidative damage that can induce cancer, modulate the activity of anumber of enzymes and cell receptors when consumed by man than fermented castor oil seeds as reported by Bhuyan and Basu (2017).

Results of the proximate composition of both fermented castor oil and soursop seeds indicated that fermented castor oil seeds had higher ash, lipids and crude protein contents than fermented soursop seeds while fermented soursop seeds had higher fibre, moisture and carbohydrate contents than fermented castor oil seeds. The higher lipids and crude protein contents of fermented castor oil seeds indicate in repair of cells and worn-out tissues(Ibrahim *et al*., 2017); its higher lipid contentsmay also be responsible for its importance as: components of cell membranes, facilitator of transport of fat-soluble vitamins, physiological precursors to biological hormones biosynthesis, insulator and protector of internal tissues and ultimately provider of adequate energy for metabolic processes (Ibrahim *et al*., 2017). Nonetheless, fermented soursop seeds can still be consumed by man due to its higher fibre content which biochemically may contribute to the reduction in the incidence of certain diseases like colon cancer, coronary heart diseases diabetes, high blood pressure, obesity and other digestive disorders, increases faecal bulk and rate of intestinal transit and may result in prebiotic effects as reported by Igboh *et al*. (2009).

Vitamins are organic compounds (or related set of molecules) which are essential micronutrients that organisms including humans require in minute quantities, usually within micrograms (millionths of a gram) to milligrams (thousandths of a gram), for proper functioning of their metabolism. Essential nutrients cannot be made or synthesized in the human body (organism), either at all or in insufficient amounts, and therefore must be obtained by the diet, just as some beneficial phytochemicals are not synthesized in the body. The results of this study revealed that fermented soursop seeds had higher concentrations of vitamins A, B_1, B_2 and folic acids than fermented castor oil seeds. The vitamin A functions as regulators of cells, tissue growth, differentiation and also a precursor of the protein rhodopsin that aids in vision while the B vitamins function as coenzymes and enzymes cofactors or their precursors;this makes fermented soursop seeds a better source of vitamins for human consumption than fermented castor oil seeds as reported by Awuchi*et al.* (2020).

Minerals serve as cofactors of important enzymes in the body. Their presence further suggests both fermented castor oil seeds (ogiri) and soursop seeds to be a viable source of mineral nutrients for the body's various metabolic and physiologic processes, including maintaining muscle tone, body's electrolytes, acting as enzyme's cofactors, thus attesting to the nutritional value of the fruit plant (Gabriel *et al*., 2018). This study revealed varying concentrations of minerals. The result indicated that fermented castor oil seeds had higher concentrations of calcium, potassium, magnesium, sodium and iron than fermented soursop seeds but the concentration of

phosphorus is fairly compared between the fermented seeds. Calcium is needed for heart, muscle, and digestive system health, builds bone, supports synthesis and function of blood cells. Iron required for many enzymes and proteins, notably the hemoglobin to prevent anemia. Sodium acts as a systemic electrolyte and is also essential in co-regulating ATP with potassium. This suggests that fermented castor oil seeds are a better source of minerals than fermented soursop seeds. Nonetheless, fermented soursop seeds can serve as a good substitute for fermented castor oil seeds in the provision of phosphorus especially in individuals that require high phosphorus intake for bone and cell formation, in energy processing, in DNA and ATP (as phosphate) and various other functions as reported by Awuchi*et al.* (2020).

Antioxidants are compounds which can scavenge the free radicals produced due to various biochemical processes in the human body and prevent the damage induced by them. They can effectively reduce oxidative damage of human body from reactive oxygen species (ROS) by neutralizing the free radicals before they can attack the cells and prevent damage to lipids, proteins and enzymes, carbohydrates and DNA (Fang *et al*., 2002). The reduction potency of DPPH was determined by the decrease in its absorbance at 700nm, which is induced by antioxidants. Free radical attack on membrane polyunsaturated fatty acids initiates lipid peroxidation, leading to their transformation and fragmentation to alkanes and reactive aldehyde compounds.The capacity of these fermented seeds to inhibit the process of lipid peroxidation maybe due to the presence of flavonoids, phenols and tannins found in their phytochemical screening as reported by Okpala*et al.*, (2021).

CONCLUSION

. This study revealed that fermented soursop seeds can be explored and utilized as a food condiment in place of the non-readily available and affordable fermented castor oil seeds (ogiri) because of its nutritional and health value. Fermented soursop seeds can therefore, be a good substitute for fermented castor oil seeds (ogiri) as a result of its comparable nutritional and medicinal properties as revealed in the present study.

REFERENCES

AOAC. (1990). Association of Analytical Chemistry. Methods for phytochemical analysis.: 2318-2391.

Awuchi, C.G. (2020). Health Benefits of Micronutrients (Vitamins and Minerals) and their Associated Deficiency Diseases: A Systemic Review. *International Journal of Food Sciences*; **3**(1): 1-32.

Barros, L., Ferreira,M.J., Queiros, B., Ferreira, I. C. F. R and Batista, P., (2007).Total phenols,ascorbic acid, á-carotene and lycopene in portuguese wild edible mushrooms and their antioxidant activities, *Food Chemistry*.**103:**1314-419.

Barros, L., Soraia, F., Baptista, P., Cristina, F., Miguel, V.B., Isabel, C.F. and Ferreira, R. (2008). Antioxidant activity of Agaricus specie mushrooms by Chemical, biochemical and electrochemical assays. *Food chemistry*. **111:** 61-66.

Elizabeth, O.O., Nonso, I.F., Adebola, N.I. and John, O.J. (2018). Comparative Study on Chemical Composition and Antioxidant Activity of *Annona muricata* Plant Parts Cultivated in Covenant University Ota, Ogun State, Nigeria. *Current Research in Nutrition and Food Science*; **6** (3): 807-815.

Errayes, A.O., Abdulsalam-Mohammed, W. and Darwish, M.O. (2019). Review of Phytochemical and Medical

Applications of *Annona muricata* Fruits. *Journal of Chemical Reviews*; **2** (1): 70-79.

Fang, Y., Yang, S. and Wu, G. (2002). Free radicals, antioxidants and nutrition. *Nutrition*. **18(10):**872–879.

Gabriel, A. F., Murana, O. O., Sadam, A. A., and Babalola, S.A. (2018). Proximate and Heavy Metal Studies of *ChryosophyllumAlbidum* seed Cotyledons as a Possible Animal Feed. *Direct Research Journal of Biology and Biotechnology*. **4(2):** 22-26.

Gajalakshmi, S., Vijayalakshmi, S. and Devi, R.V. (2012). Phytochemical and Pharmacological Properties of Annona muricata: A Review. *International Journal of Pharmagnosy and Pharmaceutical Sciences;***4** (2): 3-6.

Gavamukulya,Y., Fred, W. and El-Shemy, H.A. (2017). *Annona muricata*: Is the Natural Therapy to Most Disease Conditions Including Cancer Growing in our Backyard? A Systematic Review of Its Research History and Future Prospects. *Asian Pacific Journal of Tropical Medicine*; **10** (9), 835-848.

Harborne, J.B. (1995). Phytochemical Methods. A Guide to Modern Techniques of Plant Analysis (Third Edition). Chapman and Hall, New York. **Pp**:674-681.

Ibrahim, H. O., Osilesi, O., Adebawo, O. O., Onajobi, F. D., Karigidi, K. O. and Muhammad, L. B. (2017). Nutrients Compositions and Phytochemical Contents of Edible Parts of *Chrysophyllumalbidum* Fruit. *Journal of Nutrition & Food Sciences*, **7(2):** 1-9.

Igboh, M. N., Ikewuchi, C. J. and Ikewuchi, C. C. (2009). Chemical profile of *Chomolaena odoratal*. *Pakistan. Journal of. Nutrition.***8(5):** 521 – 524.

Kirk, R. and Sawyer, R. (1991). Perason's composition and analysis of foods, 9th edition. Longman Scientific and Technical, **pp:** 647-648.

Klein B.P. and Perry A.K. (1982). Ascorbic acid and vitamin A activity in selected vegetables from different geographical areas of the United States. *Journal of Food Science*; **47**: 941- 945

Moghadamtousi, S.Z., Fadaeinasab, M., Nikzad, S., Mohan, G., Ali, H.M. and AbdulKadir, H. (2015). *Anonnamuricata* (Annonaceae): A Review of Its Traditional Uses, Isolated Acetogenins and Biological Activities. *International Journal of Molecular Sciences*,**16**; 15625-15658.

Okpala, C.O., Igwilo, I.O. and Eze, F. (2021). Antioxidant Potential of *Vitexdoniana* Ethanol Leaf Extract in Triton X-100 Induced HyperlipidemicWistar Albino Rats. *The Bioscientist*. **9** (1): 9-23.

Okwunodulu, I.N., Onwuzuruike, U.A. and Agha, E.F. (2020). Nutritional Properties of Indigenous Fermented Condiment (Ogiri) Produced from Partial Substitution of Castor Oil Bean (*Ricinuscommunis*) with Soybean (*Glycine max*) Seeds. *Nigeria Journal of Biotechnology*; **37** (2): 32-46.

Osagie, A. U. (1998). Antinutritional Factors in Nutritional Quality of Plant Foods. Ambik press Ltd, Benin City, Nigeria. **1** (40); 221-244.

Padmarajaiah N., Ramanathapura A.V. and Hemmige S.Y. (2002). Spectrophotometric Determination of Folic Acid in Pharmaceutical Preparations by Coupling Reactions with Iminodibenzyl or 3-Aminophenol or Sodium Molybdate-pyrocatechol. *Analytical Biochemistry* **307**(2):316-321

Patel, V.R., Oumancas, G.G., Viswanath, L.C.K., Maples, R. and Subong, B.J. (2016). Castor Oil: Properties, Uses and Optimization of Processing Parameters in

Commercial Production. *Lipid Insights*, 9; 1-12.

Rutkowski M., Grzegorczyk K. and Paradowski M.T. (2005). Kolorymetrycznametoda oznaczania całkowitejwitaminy E w osoczukrwi – modyfikacjawłasnametodyTsena [Colorimetric method of blood plasma total vitamin E determination – the own modification of Tsen method*]*. *Diagn. Lab.***41**: 375

Rutkowski M., Grzegorczyk K., Gendek E. and Kedziora J. (2006). Laboratory convenient modification of Bessey method for vitamin A determination in blood plasma *J. Physiol. Pharm.***57** (2):221

Yeboah, A., Ying, S., Lu, J., Xie, Y., Amoanimaa-dede, H., Boateng, K.G.A., Chen, M. and Yin, X. (2020). Castor Oil (*Ricinuscommunis*): A Review on the Chemical Composition and Physiochemical Properties. *Food Science and Technology*, 1-15.

Yerima, B. I. and Adamu, H. M. (2011). Proximate chemical analysis of nutritive contents of jujube (Ziziphusmauritiana) seds. *International Journal of Physical Sciences.***6**(36): 8079-8082.

Young, S. M. and Greaves, J. E. (1940). Influenced of Variety and treatment of phytic acid content of wheat. *Food Research*. **5:** 103-105.