Available online at www.worldnewsnaturalsciences.com

World News of Natural Sciences

An International Scientific Journal

WNOFNS 47 (2023) 104-114 EISSN 2543-5426

Determination and correlation of physicochemical properties of aqueous extracts from edible portions of common tropical fruits

Ejike Joel Ejiako[1,2], **Verla Evelyn Ngozi**[3], **Muna Stela Ebele**[1], **Verla Andrew Wirnkor**[1,*] and **Fidelis Ehirim**[4]

[1]Group Research in Analytical Chemistry, Environment and Climate Change (GRACE & CC), Department of Chemistry, Imo State University Owerri, P. M. B 2000, Imo State, Nigeria

[2]Department of Pure and Applied Chemistry, University of Calabar, P. M. B. 1115, Calabar, Cross Rivers State, Nigeria

[3]Department of Environmental Technology, Federal University of Technology Owerri, P. M. B. 1526 Owerri, Imo State, Nigeria

[4]Department of Food Science and Technology, Imo State University Owerri, Imo State, Nigeria

*E-mail address: verlaanadreww@gmail.com

ABSTRACT

The quantity and quality of these constituent may not usually be the same under certain conditions, so fruits sold in Owerri where heavy pollutant abound were analysed, three samples of each water melon, Pawpaw, pineapple and orange fruits were bought from Owerri commercial centre and their juices extracted and stored in screw cap bottles prior to analysis. The physiochemical parameters revealed that fruits were of good quality but showed positive and negative significant relationship correlation ships such as pH-FW (0.958), pH-SG (-0.025), TS-MC (-0.999), TA-FW (-0.987). Vitamin C content ranged from 13.14 ± 0.39 mg/100g to 75.46 ±1.72 mg/100g for water melon and orange respectively. In conclusion, fruits studied showed good quality and a good source of vitamin C and mineral content. Such analysis needs to be carried out periodically to ensure quality and create awareness to the public.

Keywords: Antioxidants, Edible portion, Food, Health, Nutrition, Juice, *Citrullus lanatus, Carica papaya, Ananas comosus, Citrus cinesis*

(Received 21 January 2023; Accepted 10 February 2023; Date of Publication 11 February 2023)

1. INTRODUCTION

This study aims at determining physicochemical properties of edible portion of *Citrullus lanatus* (water melon), *Caricca papaya* (paw-paw), *Ananas comosus* (pineapple) and *citrus cinesis* (orange) sold in commercial centre of Owerri, Imo State Nigeria. The fruits were characterized for some of their properties such as weight, edible portion, pH, electrical conductivity, moisture content, ash content, titratable acidity, solid density, viscosity, total solids, specific gravity and vitamin C. The significance of this study lies in the fact that the selected tropical fruits are on high demand and among the mostly consumed fruits in Owerri [1].

Whenever the city inhabitants are returning from their daily activities to their respective homes, they tend to purchase vended edible fruits in a bid to replenish themselves through the consumption of the fruits [2]. Unfortunately, most of the fruits are sold in dilapidated environment, close to major roads, dumpsites and even exposed directly to sunlight. This scenario may affect the quality of the exposed fruits and thus place consumers at risk. While vended edible fruits have been studied elsewhere, data for fruits sold within the commercial center of Owerri is lacking. This study therefore attempts to fill this knowledge gap. In addition there is the need to understand what parameters will have a strong effect on the quality of fruit extracts. In this way the monitoring of physicochemical parameters of fruit juice extracts can be reduced to a few parameters.

2. MATERIALS AND METHODS

2. 1. Collection of the sample

Fully matured ripe fruits of *Citrullus lanatus* (watermelon), *Carica papaya* (paw-paw), *Ananas comosus* (pineapple) and *Citrus cinesis* (orange) (Figure 1) were procured from Relief Market Owerri, Imo State, Nigeria. Collected samples were fresh, matured, well-shaped and free from insect's bites and other organoleptic deterioration. The freshly collected samples were washed with de-ionized water to eliminate visible dirt and removed the water quickly with a blotting paper. They were transported to the Chemistry Laboratory, Imo State University for analysis. The pictures of the studied tropical fruits is presented in Figure 1.

(a) Pinapple (*Ananas comosus*), (b) Pawpaw (*Carica papaya*)

(c) Watermelon, (*Citrullus lanatus*), (d) Oranges, (*Citrus sinensis*)

Figure 1. Photograph of some studied fruit samples

2. 2. Sample preparation

The fruits were washed thoroughly with distilled water and weighed. The outer parts were peeled off and the flesh was separated from the rind and the seeds removed. The fruit pulps were homogenized in a blender and filtered with a muslin cloth. This was done separately for each fruit. The juice was stored in air tight screw cap bottles and refrigerated at 5 °C prior to analysis.

Figure 2. The fruit juice extracts. From left to right: pineapple, pawpaw, watermelon and orange.

2. 3. Analytical procedure

2. 3. 1. Physical and chemical properties analytical procedure

The edible portion of the fruits was determined by subtracting the weight of inedible parts of fruits from the weight of whole fruit. This was done for each fruit. The pH of each fruit was determined using a digital pH meter (Jenway 3510) according to previous reports [3],[4]. 50ml of fruit extract was transferred in a beaker and the pH was determined after the meter had been calibrated using standard buffer solutions of pH (4.0 and 7.0). Sufficient time was allowed for equilibration before reading was taken.This was conducted using HANNA HI8733 EC METER in µS/cm as reported previously[5][6]. The meter was calibrated using potassium chloride and then the EC probe was inserted into the beaker containing juice sample for 60seconds and readings were taken. The procedure was repeated in triplicate for each fruit sample and average obtained was recorded as actual reading. Total Solids (TS) of the fruit samples were determined by evaporating a known weight of juice sample in an oven at 105 °C for 2-3 hours as described by Owerri et al. (2016)[7].

The solid left after evaporation was weighed and used to calculate total solids. The viscosity of the samples was determined using NDJ-5S digital viscometer as described by [6]. The temperature of the fruit samples were maintained at room temperature (28±2 °C) using water bath. Measurements were made on fruit samples at a constant shear rate of 60 rpm. A 600 ml beaker was used for all measurements and 500 ml of sample was added to bring sample level to the immersion groove on the spindle shaft. Triplicate samples were analyzed and the viscosity values were obtained by multiplying dial reading by appropriate factors (supplied by the viscometer manufacturer). Mathematically calculated (equation 1)

$$Viscocity = Dial\ reading\ X\ factor\ (500) \tag{1}$$

The SG was done using a hydrometer test procedure according to the official methods of Analysis of the Association of Official Analytical Chemists[8]. The juice sample was poured into a measuring cylinder. The juices were allowed to stand for five minutes and temperature measured. The hydrometer was then lowered into the measuring cylinder containing juice. The scale was read when hydrometer is stabilized. The moisture contents were determined by gravimetric method as described by the AOAC[9]. A slice of each fruit (2 mm) was weighed in a pre-weighed dish. Then it was placed in the oven to dry at 105 °C for 3 hours until constant weight. The % moisture was then calculated using equation 2 below

$$Moisture = \frac{Initial\ weight - final\ weight}{Initial\ weight} \times 100\% \tag{2}$$

The density of the fruit was determined using simple flotation principle[8]. Equal mass of 10 g of each sample was weighed using an electronic weighing balance. The mass so measured was put into 250 ml measuring cylinder containing 100 ml water (as flotation liquid) and the difference in volume noted. The difference is the volume occupied by the 10 g sample.

Mathematically, the density of solid is expressed in equation 3

$$Solid\ density = \frac{Mass\ of\ the\ sample}{Volume\ occupied\ by\ the\ sample} \tag{3}$$

For titratable Acidity (TA),10ml of each juice sample was pipetted into a conical flask and 25 mL of distilled water was added as described by the AOAC [10] 200 ml of 0.1M NaOH was poured into a burette and titrated against the sample in the flask using three drops of phenolphthalein as indicator until change in color was observed and the corresponding burette reading taken. Titratable acid percent was calculated from equation 4

$$TA = \frac{mls\ NaOH\ used\ x\ 0.1\ N\ NaOH\ x\ milliequivalent\ factor}{grams\ of\ sample} \times 100\% \qquad (4)$$

Ascorbic Acid (AA) determination was done according to the method described by [11]. About 25 ml of prepared juice was taken in each of six 100 mL conical flasks. 10 ml of 1 M H_2SO_4 was added and titrated with a standard iodine solution. Using 2 mL of starch solution as indicator, it was titrated till the appearance of a blue colour.

Determination of the ash content was done by furnace incineration gravimetric method described by [9][12]. 5g of sample was measured into a previously weighed porcela in crucible. The sample was burned to ashes in a muffle furnace at 550 °C. When completely ashed, it was cooled in a desiccator and weighed. The percent ash content of the edible portion was calculated using equation 5

$$Ash = \frac{Initial\ weight - final\ weight}{Initial\ weight} \times 100\% \qquad (5)$$

2. 4. Data Analysis

All statistical analysis was computed with IBM SPSS statistic 20. The results were expressed as mean and standard deviation, while Person's correlation matrix was used in correlating among the physiochemical parameters in the fruit samples.

3. RESULTS AND DISCUSSIONS

3. 1. Physicochemical characteristics

Table 1. Characteristics properties of the edible portion fruit extracts

Parameters	*Citrus cinensis*	*Ananas comosus*	*Citrullus lanatus*	*Carica papaya*
Fruit weight (kg)	6.45±0.65	7.59±0.01	9.20±0.02	8.45±0.08
Edible portion (%)	63.14±2.39	57.07±2.57	56.13±2.70	65.43±1.62
pH	3.63±0.11	4.31±0.03	5.30±0.48	4.43±0.04
EC (μS/cm)	0.37±0.06	0.31±0.07	0.27±0.01	0.22±0.08
MC (%)	89.6±1.05	85.1±0.11	95.3±4.01	88.2±1.87
SG	1.041±0.09	0.983±0.00	1.032±0.03	0.889±0.01
Total solids (mg/100 g)	10.4±1.11	15.1±0.91	5.1±0.19	12.3±0.18

Viscosity (cps)	1078.67±6.78	1135.20±12.65	728±2.45	1236±9.56
Solid density	1040±0.09	983±0.00	1030±0.03	889±0.01
TA (%)	1.28±0.01	0.76±0.23	0.12±0.11	0.25±0.09
Ash	0.25±0.05	0.57±0.45	0.34±0.17	0.16±0.39
Vitamin C (mg/100 g)	75.46±1.72	16.14±1.39	13.14±0.59	65.90±2.39

*EC-Electrical conductivity, MC-Moisture content, SG-Specific gravity, TA-Titrable acidity
*values represent mean ± standard deviation (n=3).

The results for the physiochemical analysis conducted on the studied tropical fruit extracts obtained are presented in Table 1. In Table 1, edible portion, pH, electrical conductivity, moisture, total solid, titratable acidity, specific gravity, solid density, viscosity, ash and vitamin C values are given. The highest amount of edible portion was observed in *Citrus cinensis* (63.14±2.39%). Among the selected fruits, the lowest amount of edible portion was found in *Ananascomosus* (55.07±2.57%). The value is logical due to thick skin of pineapple.

3. 2. pH

The pH measures the acidity or alkalinity of a fruit juice commonly measured on a scale of 0 to 14[13]. The lower the pH the more acidic the solution is and the higher the more alkaline (or base) the solution is. The pH value among the tropical fruits was found to vary (3.63±0.11 to 5.30±0.48). The highest and lowest amount of pH was observed in watermelon (*Citrullus lanatus*) (5.30±0.48) and orange (*Citrus cinensis*) (3.63±0.11) respectively. Ranking the pH values; Watermelon >Pawpaw > Pineapple > Orange. The high acidity of orange may be related to its concentration of ascorbic acid or vitamin C, as it is more commonly known. The current study recorded lower pH for papaya when compared to the pH 5.5 reported in India [14]. The lower pH value for orange indicates that it has sour taste.

3. 3.. Electrical Conductivity

Electric current is the flow of electrons through a material, and electrical conductivity is the ability of electric current to flow through a material[15]. The EC measurement explains or gives an indication of free ions/electrons present in the fruit samples. The EC ranged from 0.22±0.08 to 0.37±0.06 µS/cm. The highest EC was recorded in orange (*Citrus cinensis*) and lowest recorded in pawpaw (*Carica, papaya*). The electrical conductivity in food materials or agricultural produce is gaining attraction in due to ohmic heating and pulsed electric field processing[16] as a result, many researchers have reported EC in food such as fruits and vegitables.[17-19]

3. 4. Ash

Ash provides information on the total amount of minerals within a food. The ash content recorded in the study is shown in Table 1. The ash content ranged from 0.16±0.39 to 0.57±0.45 %. The highest value was observed in pineapple while the least was recorded in pawpaw. The ash content of pawpaw recorded in the current study is in compliance with the value reported by Purseglove [20] which reported that papaya contains about 0.6% ash. Generally, the studied fruits showed lower value of 3.13 % recorded for African Star Apple by Dauda[21].

3. 5. Moisture content

The solid content of food products is related to their food values. The greater the solid content (low moisture content) of the fruits, the greater its nutritional value. The moisture content is of profound importance in the determination of shelf-life of unprocessed and processed fruit since it affects physicochemical properties, microbiological spoilage and enzymatic change. From Table 1, the moisture content determined was all higher than 60%. The high moisture content of the fruits makes them suitable for spoilage organisms and agents to grow and multiply. Therefore, all the fruit can be classified as highly perishable and can be preserved by refrigeration or freezing. However, the highest moisture content was recorded by watermelon (95.3±4.01 %) and lowest by pineapple (85.1±0.11 %). The results obtained in terms of moisture were slightly higher than the ones previously reported which ranged from 80.3 % to 87.1 % for *Ecballium elaterium* fruit juice[22][23].

3. 6. Titratable Acidity

Titratable acidity (TA) measures total acid content in a fruit, which provides information on the maturity or ripeness of the fruit and related to the overall quality. High acid content suggests that the fruits are not yet riped or matured. The TA (%) recorded in this study ranged from 0.12 ± 0.11 to 1.28 ± 0.01 % shown in Table 1. The highest TA was recorded in the orange which could be due to the low pH/high acidity of orange. The lowest TA was recorded in watermelon. The order of TA of the fruit samples were *Citrulluslanatus<carica papaya <Ananascomosus<Citrus cinensis*.

3. 7. Total solids and Viscosity

The apparent viscosity of the fruit samples is shown in Table 1. The viscosity values of the fruit ranged from 728±2.45 to 1236±9.56 cps. From Table 1, it was observed that pawpaw had the highest (1236±9.56 cps) apparent viscosity value followed by pineapple (1135.20±12.65 cps) while watermelon had the least apparent viscosity value (728±2.45 cps). The viscosity of the samples decreased with increase in moisture (Table 1).The observed increase in viscosity could be attributed to solubility and the quantity of total solids recorded in this study for the fruit samples. The total solid ranged from 5.1±0.19 to 15.1±0.91 %. This result is supported by some researchers Ikegwu and Ekwu (2009) and Synder and Kwon (1987), who reported that the more material there is in solution the higher the viscosity.Asafa (1998) reported 15.6% and 17.2% respectively for total soluble solids of African Star Apple and 18.4% and 21.5% respectively for total solids[6][24]. The sweetness level of the type of African Star Apple fruits was depicted by the values obtained for the soluble solids.

3. 8. Solid density and Specific Gravity

The result for SG and density of the fruits is presented in Table 1. The SG ranges from 0.889±0.01 for pawpaw (*Carica papaya*) to 1.041 ±0.09 for Orange (*Citrus sinensis*) while solid density ranges from 889±0.01 for pawpaw (*Carica papaya*) to 1041 ±0.09 for Orange (*Citrus sinensis*). The highest and lowest value was recorded for pawpaw and orange for SG and solid densities. There is a relationship between SG and solid density (Kato, 1996).The results obtained are in agreement with results of some researchers for some tropical fruits in Nigeria (Nwanekezi and Ukagu, 1999; Ikegwu and Ekwu, 2009)[6][25]. Data on solid density and specific gravity of fruits provide insight on the fruit quality based on the starch composition and structure.High density is generally undesirable and may indicate poor quality of fruits.

3. 9. Vitamin C

In present study we observed that, orange contain highest amount of vitamin C (75.46±1.72 mg/100g) and watermelon contain lowest amount of vitamin C (13.14±0.39 mg/100g). This result is in agreement with 9.01 to 210.47 mg/100gprovided in the Nutrient database by USDA [26]. Furthermore, it is comparable to that of some other fruits; 47.6 mg/100g for “Agbalumo” pulp 48 mg/100g for papaya)[27], 62 mg/100g for freshly squeezed orange juice[28], while 40.6 mg/100 ml for Florida citrus (freshly squeezed and unpasteurized) [29]. Type of fruit and environmental factor may influence vitamin C composition in tropical fruits.

3. 10. Correlation matrix between physicochemical parameters

The inter-relationship or association between the determined physicochemical properties was tested using the Pearson’s correlation model at 5% significance level and the results presented in Table 2. The model provides information on how the different parameter influences one another either positively or negatively.

Table 2. Pearson’s Correlation matrix between physicochemical parameters in fruit samples

	FW	EP	pH	EC	MC	SG	TS	ViS	Sd	TA	Ash	VC
FW	1											
EP	-0.355	1										
pH	0.958	-0.588	1									
EC	-0.831	-0.132	-0.641	1								
MC	0.531	-0.281	0.626	-0.130	1							
SG	-0.293	-0.551	-0.025	0.770	0.461	1						
TS	-0.490	0.286	-0.595	0.079	-0.999	-0.502	1					
ViS	-0.490	0.699	-0.690	-0.060	-0.877	-0.683	0.883	1				
Sd	-0.301	-0.550	-0.032	0.775	0.453	0.999	-0.494	-0.677	1			
TA	-0.987	0.224	-0.900	0.910	-0.437	0.441	0.392	0.350	0.448	1		
Ash	-0.062	-0.797	0.121	0.301	-0.348	0.322	0.338	-0.143	0.326	0.138	1	
VC	-0.562	0.946	-0.726	0.170	-0.195	-0.254	0.184	0.579	-0.252	0.465	-0.768	1

Numbers in bold are significant at 5%, FW: fruit weight, EP: edible portion, ViS; viscosity, Sd; solid density

The fruit weight showed positive association with pH (0.958), moisture content (MC) (0.531) while negatively associated with electrical conductivity (EC) (-0.831), titratable acidity (TA) (-0.987), vitamin C (-0.562), total solids and viscosity (-0.495). Edible portion showed positive association with viscosity (0.699) and vitamin C (0.946) while associated negatively with pH (-0.588), specific gravity (SG) (-0.551), solid density (-0.550) and ash (-0.797) respectively. EC showed positive association with SG, solid density and TA with correlation coefficient of 0.770, 0.775 and 0.910 respectively. The pH associated negatively with EC (-0.699), total solids (-0.595), viscosity (-0.690), vitamin C (-0.726) and TA (-0.900) while positively associated with MC (0.626). Moisture content relates positively with SG (0.461) and solid density (0.453) while negatively with total solids (-0.999) and viscosity (-0.877) respectively. Solid density related negatively with total solids (-0.494) while positively with TA (0.448) and SG (0.999). Total solids were positive with viscosity (0.883) and negative with SG (-0.502). Vitamin C showed positive association with viscosity (0.579) and TA (0.465) while negatively with ash (-0.768). Significant positive relationship/association between some physicochemical parameters has been observed in some tropic fruits in India (Athmaselvi et. al., 2014).

4. CONCLUSION

The physicochemical analysis revealed the studied tropical fruits are of good quality. Physicochemical parameters compared well with standards elsewhere and showed that fruits were of good quality. This study will help the people to maintain their dietary requirements through consumption of tropical fruits. Regular intake of tropical fruits may alleviate the prevalence of nutrient deficiency problem from Owerri metropolis. Due to the richness in minerals and the physicochemical quality of the studied fruits, it is recommended that inhabitants of Owerri metropolis should consume more these fruits. Other tropical fruits not covered here should also be analyzed for physical and chemical composition.

References

[1] Ezeibekwe, I. O. (2011). Study of citrus disease prevalence on four citrus varieties at the National Institute of Horticultural Research (NIHORT) Mbato, Okigwe, Imo State, Nigeria. *African Journal of Plant Science*, 5(6), 360-364

[2] Oloko, M., & Ekpo, R. (2021). Effects of the COVID-19 lockdown on the livelihood and food security of street food vendors and consumers in Nigeria. *Journal of African Studies and Development*, 13(4), 106-114.

[3] Verla Andrew Wirnkor, Verla Evelyn Ngozi, Njoku Victor Obinna and Njoku Camilita Chinonso (2017). Speciation of metals and risk assessment in Selected Food Crop Samples Grown in Ohaji/Egbema LGA, Imo State, Nigeria. *Journal of Environmental Analytical Chemistry*, 4: 3. https://10.4172/2380-2391.1000216

[4] Enyoh Christian Ebere, Verla Andrew Wirnkor, Enyoh Emmanuel Chinedu Verla Evelyn Ngozi (2018) A Review on the Quality of Palm Oil (*Elaeisguineensis*) Produced Locally in Imo State, Nigeria. *Sustainable Food Production Submitted* 4, 40-50

[5] Enyoh, C.E, Verla A.W, Ihionu, E.A., and Ebosie, N.P. (2017). Physicochemical Properties of Palm Oil and Soil from Ihube Community, Okigwe, Imo State, Nigeria. *International Letters of Natural Science,* Volume 62, 35-49

[6] Ikegwu, O.J and Ekwu, F.C. (2009). Thermal and Physical Properties of Some Tropical fruits and Juices in Nigeria. *Journal of Food Technology* 7(2): 38-42

[7] Andinet Abera Hailu and Getachew Addis (2016). The Content and Bioavailability of Mineral Nutrients of Selected Wild and Traditional Edible Plants as Affected by Household Preparation Methods Practiced by Local Community in BenishangulGumuz Regional State, Ethiopia. *International Journal of Food Science* Volume 2016, Article ID 7615853, https://doi.org/10.1155/2016/7615853

[8] AOAC (1995). Official Methods of Analysis of the Association of Official Analytical Chemists, 16th edition.

[9] AOAC (1990). Official Methods of Analysis of the Association of Official Analytical Chemists, 15th edition.

[10] AOAC (2012). Official Methods of Analysis of the Association of Official Analytical Chemists, 20th edition.

[11] Nangbes, J.G., Lawam, D.T., Zukdimma, N.A. and Dawam, N.N (2014). Titrimetric Determination of Ascorbic Acid levels in some citrus fruits of kurgwi, Plateau State. Journal of Applied Chemistry. 22(7)1-3.

[12] James, C.J. (1995). The Analytical Chemistry of Foods. Chapman and Hall Press, New York. Pp 86.

[13] Addy, K., Green, L., & Herron, E. (2004). pH and Alkalinity. University of Rhode Island, Kingston.

[14] Haque, M. M., Hasan, M., Islam, M. S., & Ali, M. E. (2009). Physico-mechanical properties of chemically treated palm and coir fiber reinforced polypropylene composites. *Bioresource Technology,* 100(20), 4903-4906

[15] DiSalvo, F. J. (1999). Thermoelectric cooling and power generation. *Science,* 285(5428), 703-706

[16] Misgana Banti. Review on Electrical Conductivity in Food, the Case in Fruits and Vegetables, *World Journal of Food Science and Technology*. Volume 4, Issue 4, December 2020 , pp. 80-89. doi: 10.11648/j.wjfst.20200404.11

[17] Sarang, S., Sastry, S. K., & Knipe, L. (2008). Electrical conductivity of fruits and meats during ohmic heating. *Journal of Food Engineering*, 87(3), 351-356

[18] Buddhi Prasad Lamsal, Vinod Kumar Jindal. Variation in Electrical Conductivity of Selected Fruit Juices During Continuous Ohmic Heating. *KMUTNB: IJAST*, Vol.7, No.1, pp. 47-56, 2014

[19] Juansah, J., Budiastra, I. W., Dahlan, K., & Seminar, K. B. (2012). Electrical behavior of garut citrus fruits during ripening changes in resistance and capacitance models of internal fruits. *IJET-IJENS*, 12(4), 1-8

[20] Purseglove, J.W. (1968) Tropical Crops: Dicotyledons, Longman Scientific and Technical. John Wiley and Sons Inc., New York.

[21] Dauda, A. O. (2014).Physico-Chemical Properties of Nigerian Typed African Star Apple Fruit. *International Journal of Research in Agriculture and Food Sciences,* 2(1): 1-6

[22] Greige-Gerges, H., Khalil, R. A., Mansour, E. A., Magdalou, J., Chahine, R. and Ouaini, N. (2007). Cucurbitacins from *Ecballium elaterium* Juice Increase the Binding of Bilirubin and Ibuprofen to Albumin in Human Plasma. *Chemico-Biological Interactions,* 169(1), 53-62

[23] Samir, F., Hafedah, H., Marwa, N., Sana, B., Naourez, K., Mongi, S., Néji, G. and Adel, K. (2016). Nutritional, Phytochemical and Antioxidant Evaluation and FT-IR Analysis of Freeze Dried Extracts of Ecballium elaterium Fruit Juice From Three Localities. *Food Science and Technology Campinas,* 36(4) pp 1-9. https://doi.org/10.1590/1678-457X.12916

[24] Synder, H.E and Kwon T.W. (1987). Soybean Utilization. AVI Connecticut New York, pp: 163-184.

[25] Nwanekezi E.C and Ukagu J.C (1999). Determination of Engineering properties of some Nigerian Fruits and Vegetable. *Nigerian Food Journal* 17: 55-60

[26] USDA (2010), National Nutrient Database for Standard Reference, Release 23 (2010).

[27] Taylor, O.A. (1987). Preservation of Fruits and Vegetables. Paper Presentation of National Home Economics Workshop at Ahmadu Bello University, Zaria, Nigeria.

[28] Kennedy, J.F., Rivera, Z.S, Lloyd, L.L., Warner, F.P. andJumel,.K (1990). Studies on Nonenzymatic Browning in orange juice using a model system based on freshly squeezed orange juice. *J. Sci. Food Agric.* 52: 85-95

[29] Lee, H.S. and Coates, G.A. (1999). Vitamin C in frozen, freshly squeezed, unpasteurized, polyethylene bottled orange juice: a Storage study. *J. of Food Chem*. 65: 165-168

[30] Athmaselvi, K.A., Pandian, J.,Pavithra, C. and Ishita Roy (2014). Physical and biochemical properties of selected tropical fruits Int. *Agrophys.* 28, 383-388