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PHYSIO-BIOCHEMICAL ASSESSMENT OF SOME METABOLITES OF CITRUS FRUITS COMMONLY CONSUMED IN SOUTH-WEST, NIGERIA

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ABSTRACT

Quantities of biochemicals are measures of the nutritional and medicinal potentials of fruits. This study evaluated biochemical constituents in grape, sweet orange, lemon and lime fruits. Nutritional, antinutrient and phytochemical contents in peels and juice of the fruits were determined. Crude protein (8.15 %), crude fibre (7.85 %), fat (3.35 %), ash and (4.72 %) were higher ($p<0.05$) in lemon fruit peels. Sodium (16.16 mg), calcium (6.33 mg), potassium (70.31 mg) and zinc (5.63 mg) were higher in lemon peels. Tannin (0.91 %), phenol (0.76 %) phytate (0.32 %) and oxalate (0.28 %) were also higher in the peels as well as alkaloid (5.23 %) and saponins (1.49 %) in lemon fruit peels. Sweet orange peels contained higher flavonoids (3.24 %) while lime fruit peels contained higher steroids (0.13 %). Also, lemon fruit juice contained higher crude protein (1.42%) and fat (0.33%) while ash (0.13 %) was significantly recorded in lime fruit juice. Sodium (12.89 mg) was higher in the lemon fruit juice, calcium (43.25 mg) in sweet orange juice, potassium (145.86 mg) in grape juice while phosphorus (19.16 mg) was higher in lime fruit juice. Phenol (0.71%) and phylate (0.21 %) were higher in lemon juice. Alkaloid (0.78 %) was higher in sweet orange juice as well as flavonoid (0.32 %) in grape fruit

juice. Lemon fruits contained appreciable quantities of metabolites compared with other oranges.

Keywords: Biochemicals, Fruit peels, Fruit juice, Metabolites, Extraction.

1.0 INTRODUCTION

Citrus fruits are some of the natural beverages consumed majorly to derive valuable nutrients for the maintenance of healthy living and the prevention of diseases. The common examples of such organic beverages are *Citrus sinesis, Citrus limon, Citrus aurantifolia* and *Citrusparadisi.* They are available and affordable types of fruits, that are consumed by the average person in every community of Nigeria.

The nutritional and medicinal benefits of *Citrus* fruits have been attributed to the presence of minerals, phytochemicals and other bioactive compounds in the fruits which are responsible for novelty health benefits (Ani and Abel, 2018). Many studies have been carried out on the biochemical and phytochemical properties of *Citrus* fruit juice with little or no information on the peel possibly because they are regarded as wastes (Ani and Abel, 2018). In Nigeria, peels of oranges are available massively all over the place, constituting both health and environmental challenge due to improper and lack of sustainable usage of the products (Olife et al., 2015). Also, despite high sales and direct consumption of citrus, many consumers do not have adequate information about the nutritional and medicinal potentials of both the juice and peels of the fruits. In addition, there are inadequate processing industries saddled with the conversion of peels or concentrate of *Citrus* fruits into canned fruit or other useable products. The lack of sustainable usage of orange peels constitutes serious waste resulting in environmental pollution. On the other perspective, although the decomposition of fruit peels found in our communities may be used to feed livestock or increase soil fertility yet the benefits have not been fully harnessed due to a lack of adequate assessment of the biochemical constituent of the product. Also, comparative studies of the biochemical contents of juice and commonly tagged waste (peels) of the fruits have not received much scientific attention. These may be justifications for the indiscriminate placement of peels of oranges all over the place. Hence the present study elucidated the quantity and variations of biochemical constituents in juice and peels of four species of *Citrus* commonly consumed in Nigeria.

2.0 Materials and Methods

2.1 Sample collections: Matured fruits *Citrus* species (*Citrus sinesis, Citrus limon, Citrus aurantifolia* and *Citrusparadisi)* were collected from a local farm land located beside the Federal Ministry of Agriculture and Rural Development, Kotopo, Abeokuta, Ogun State. The farm lies latitude 7.18457, **N 7** ^{0}11'4.494 and longitude 3.42816, E 3^{0} 25'41.31, 5CMH +W3F, Kotopo, 110121, Abeokuta, Ogun State, Nigeria and identified at Herbarium unit, Department of Botany, Lagos State University, Ojo, Lagos State, Nigeria.

2.2 Extraction of juice from the sample: Juice was extracted from the four oranges by peeling and cutting the fruits into half and squeezing them with a citrus squeezer. The juice collected was filtered using a muslin cloth and the pulp-free juice was collected in clean stainless containers after which the juice was kept under freezing conditions (0±1^{o}C) until required. The powder form of the peels was prepared and used for the determination of primary and secondary metabolites.

2.3 Determination of proximate composition in the peels of the oranges

2.3.1 Crude fibre: About 2g each of the defatted samples of the four oranges were boiled in 20 mL 1.25 % H_2SO_4, filtered, and boiled again 100 mL 1.25% NaOH for thirty minutes. The contents of spoutless beakers were dried at 932^{o}F-1112^{o}F for 2-4 hours before being weighed after cooling. The following formula was used to get the crude fiber content:

Crudefibre

$$= \frac{weight\ of\ spoutless\ beaker\ containing\ crude\ fibre - weight\ of\ spoutless\ beaker\ and\ crude\ fibre}{Weight\ of\ sample} x100$$

2.3.2 Crude protein: Micro-Kjeldahl was used to determine total nitrogen (Ojewumi and Oyebanji 2020). Protein content (%) was determined as shown below

Protein (%) = $\frac{Titter\ value \times 1.4\ x\ 6.25\ x\ 0.1N\ HCL\ x\ Vol\ (used)}{Weight\ of\ sample \times\ Aliquot\ digested\ sample \times 1000} x100$

2.3.3 Crude fat: Approximately 2g of powdered peels of the oranges were kept using a paper thimble. Then 90 mL of C6H14 was added, and the mixture was refluxed, cooled, and finally weighed. The percentage of crude fat was calculated.

Crude fat (%)) = $\frac{Weight\ of\ flask\ with\ fat - weight\ of\ empty\ flask\ )}{Weight\ of\ original\ sample} x100$

2.3.4 Moisture: Hot air oven method was used to evaluate moisture as illustrated below

Moisture = $\frac{Weight\ of\ sample\ before\ drying - weight\ of\ sample\ after\ drying}{Weight\ of\ sample\ before\ drying} x100$

2.3.5 Ash content: Approximately 10g of the samples were to a known weight crucible, weighed and dried (932^{0}F) for 4hrs. The samples were then made to cool and reweighed and the ash contents were calculated using the following formula:

Ash (%) == $\frac{Weight\ of\ ash}{Weight\ of\ sample} x100$

2.3.6 Carbohydrate: According to AOAC (2000), carbohydrate was determined as illustrated below;

Carbohydrate (%) = 100 - (moisture + crude fat + ash + crude protein) %

2.4 Determination of phytochemicals in *C. sinesis, C. limon, C. aurantifolia* and *C.paradisi fruits* peels

Methods of Harborne (1973) were adopted to determine phytochemicals in the peels of the four oranges.

2.4.1 Alkaloids: The distillation and titrimetric method of Harborne (1973) was modified and used to determine alkaloids in the samples. A sample of finely crushed orange peels from each orange were obtained, 2 grams were taken, along with 20 mL of 80% pure alcohol. A further 250 mL of alcohol was added to the mixture before 1 g of magnesium oxide was stirred in, left to ferment for 2 hours, and then filtered. It took another 30 minutes of digestion once the leftovers were put back into the flask. The mixture was transferred to a 250 mL volumetric flask and then three (3) drops of 10% hydrochloric acid were added. Then, 5 mL of (ZnC4H6O4) solution and 5 mL of (K4[Fe(CN)6]3H2O) solution were added and combined. In a seperation funnel, 10 mL of the filtrate was agitated. The residues were collected, dissolved in 10 mL of hot distilled water, and then transferred to a Kjeldahl tube for further analysis. The amount of nitrogen (N) in the sample was calculated using the Kjeldahl distillation technique after the addition of 0.20 g sucrose, 10 mL concentrated H_2SO4, and 0.02 g selenium. According to Ani and Abel (2018) and Ashok-Kumar *et al*. (2011), the N (percent) were multiplied by a factor of (3.26).

% alkaloids = % N X 3.26

2.4.2 Flavonoids: One gram sample was weighed and 80 mL of ninety-five per cent (95 %) ethanol was added, stirred thoroughly and filtered. Also, 1 mL of the filtrate was pipetted and three drops of con.H_2SO_4hydrochloric acid was added. The mixture was then dyed with a vibrant magenta by adding 0.5 g of magnesium turnings. From a 100 ppm stock solution, a 0-5 ppm standard flavonoid solution was made and subjected to the same HCl and magnesium turnings treatment. Magenta red absorbance at 520 nm was measured using a digital Jenway V6300 Spectrophotometer for both samples and standards. The flavonoid content was determined using the formula:

$$Flavonoids = \frac{Absorbance\ of\ sample\ X\ average\ gradient\ factor\ X\ dilution\ factor}{Weight\ of\ sample\ X\ 10000}$$

2.4.3 Saponins: After weighing 2 g of finely crushed peel from each orange, 100 mL of isobutyl alcohol was added, and the mixture was shaken on a UDY shaker and filtered; 20 mL of a saturated solution of magnesium carbonate was then added. The combination was filtered once more to remove any trace of color. Pipetting two milliliters into a fifty milliliter volumetric flask, two milliliters of 5% Iron (III) chloride solution was added, and the mixture was let to stand for thirty minutes to acquire a blood red color. After that, 2 mL of a 5% Iron (III) chloride solution was added to the standard solution, and the resulting solution ranged from 0 to 10 ppm. After the colors had developed, we measured the absorbance of the sample and reference saponin solutions with a Jenway V6300 Spectrophotometer (380 mm).

$$\% \, Saponin = \frac{Absorbance \; of \; sample \; X \; gradient \; factor \; X \; dilution \; factor}{Weight \;\; of \; sample \; X \; 10000}$$

2.4.4 Steroids: The powder samples were each weighed at 2 grams (g), and then 20 milliliters (mL) of a 2:1 chloroform-methanol mixture was added and filtered. 1 mL of sample residue was treated with 5 mL of KOH and agitated until the mixture was homogenous and devoid of steroids. Next, the mixture was heated between 37 and 40 degrees Celsius for 120 minutes, cooled, and then 10 milliliters of petroleum ether and 5 milliliters of distilled water were added and allowed to evaporate. The absorbance and absorbance of the combination were measured at 620 nm after 6 mL of Liebermann Burchard reagent were added to the residue. The 100 mgmL-1 stock steroid solution was used to create the standard steroid concentrations of 0-4 mg/mL.

$$\% \, Steroids \; = \frac{Absorbance \; of \; sample \; X \; gradient \; X \; dilution \; factor}{Weight \;\; of \; sample \; X \; 10000}$$

2.5 Determination of anti-nutrients in *C. sinesis, C. limon, C. aurantifolia* and *C. paradisi*

2.5.1 Phytic acid: Procedures of Sofowora (1993) was modified and used to determine phytate. Approximately 2g of ground sample of each orange was weighed and 100 mL of 2 % hydrochloric acid was added in a 250 mL conical flask to soak each sample and the mixture was filtered. Sixty (60mL) of the filtrates were diluted with 100 mL water to ensure proper acidity. Then, it was titrated using a standard iron (Ill) chloride solution of 0.00195 g Iron per mL after adding 10 mL of a 0.3% NH4SCM) solution. The final color, a brownish yellow, persisted for around five minutes. The following formula was used to calculate the percentage of phytic acid:

$$\% \, Phytic \; acid \; = \frac{Titre \; value \; x \; 0.00195 \; x \; 1.19 \; x \; 100 \; x \; 3.55}{Weight \; of \; sample}$$

2.5.2 Tannin: About 1 g of finely powdered material from each orange was weighed; 30 mL of 50% methanol was then added; the mixture was then covered with paraffin and heated at 77-80 ^{o}C in a water bath for 1.5 hours while being shook to ensure uniformity. The filtered extract was added to 20 mL of water, 2.5 m; folin Denis reagent, and 10 mL of 1% Na CO_3 in a 100 mL volumetric flask and vigorously shaken. The mixture was brought up to the correct level with water, then let to stand for 20 minutes. The bluish-green hue was achieved at the upper limit of the 0-10 ppm range using the same methodology applied to the 1 mL sample up above. After the samples and standards had been properly colored, the absorbance at 760 nm was read on a 21D spectrophotometer. The percentage of tannin was determined by the formula.

$$\% \, Tannin = \frac{Absorbance \; of \; sample \; X \; average \; gradient \; factor \; X \; dilution \; factor}{Weight \; of \; sample \; X \; 10{,}000}$$

2.5.3 Oxalates: In a reflux condenser, 50 m1 of water was used to boil 2 g of the sample for 30 minutes before adding 10 mL of 20% Na CO_3. After obtaining a mixture, it was filtered, and the liquid extract was washed with hot water until the water no longer showed signs of an alkaline reaction. Filtering, cooling, and stirring the combined wash water before adding drops of hydrochloric acid (1:1) caused a heavy precipitate to form, and the extract was then filtered. The Aliquot of this filtrate was diluted with water to 200 m1 in a 400 m1 beaker and made ammoniacal, and reacidified with lactic acid. Also, 10 mL of a 10 % $Cacl_2$ solution was added and mixed thoroughly until CaC□O□ precipitate appeared and was allowed to settle. The clean supernatant liquid was decanted. The precipitate was dissolved in a hydrochloric acid ratio of one to one and $C_2H_2O_4$ was re-precipitated. The mixtures were boiled and allowed to cool. Oxalic acid was estimated using the titration method against 0.05 N Potassium permanganate solution.

$$1mL \; of \; 0.05 \; N \; KMNO_4 \; = \; 0.00225 \; anhydrous \; oxalic \; acid$$

$$= \%\, Oxalic\ Acid$$

$$= \frac{Titre\ value\ x\ 0.00225}{2}\ x \frac{100}{1}$$

$$= T.V\ x\ 0.1125.$$

2.5.4 Phenol: Procedures of Sofowora(1993) was modified and used to determine phenol. Roughly 2 grams of the sample was weighed; then, 20 milliliters of acetone was added, and the mixture was homogenized for 1 hour before being filtered. Then, 20 milliliters of water were added to 1 milliliter of the sample extract. Additionally, 3 mL of phosphomolybdic acid and 5 mL of 23% Sodium carbonate were added separately, agitated, and made up to mark with distilled water, then left to stand for 20 minutes to develop a bluish-green color. Phenol concentration standards (0.1–10.0 mg/ml) prepared from a 100 mg/L phenol stock solution (Sigma-Aldrich chemicals, USA). Using a digital spectrophotometer (at 5l0 nm), we measured the sample and standard amounts of Phenol for absorbance. Phenol content was calculated as follows:

$$\%Phenol = \frac{Absorbance\ of\ sample\ X\ gradient\ factor\ X\ dilution\ factor}{Weight\ of\ sample\ X\ 10{,}000}$$

Mineral analysis of *C. sinesis, C. limon, C. aurantifolia* and *C. paradisi* peels

Three grams of the sample of each orange was digested in $HNO_3/HCl_4O/H_2SO_4$ (9:2:1 v/v,) after which phosphorus, copper, magnesium, calcium, Iron, and Zinc were essay using an atomic absorption spectrophotometer. Potassium, sodium and phosphorus were essayed according to the method described in Ojewumi and Oyebanji (2020) and Okey et al., (2016). The procedures were modified and used for the fruit juice of the oranges.

2.6 Method of data analysis

A statistical analysis system (SAS, 2013) was used to examine the collected data. Duncan's Multiple Range Test at 5% was used to differentiate means determined by analysis of variance.

3.0 Results and Discussion

Sustainable usage of natural resources has been a major focus of several studies in recent times most especially in terms of food crops including fruits. In the present study, proximate compositions of grape, sweet orange, lemon and lime fruit peels are presented in table 1. Higher proportions of **c**rude protein (8.15 %), crude fibre (7.85 %), fat (3.35 %), ash content (4.72 %) and moisture (30.36 %) were determined in lemon fruit peels than peels of other oranges fruits investigated. A Significant quantity of proximate contents recorded in lemon fruit peels may indicate that the fruits are valuable diets of many households as evident by the high food constituents evaluated in the fruits. It was proven from the study that the nutritional indices of the oranges were significantly higher in lemon peels and juice than in the peels and juice of other oranges. This observation may establish the basis for using peels of oranges as non-caloric bulking agents and consumption of juice of the orange as nutritional dietary supplements not only for livestock but also humans (Oikeh et al., 2013). High fibre content recorded in the peels and juice of lemon oranges has its therapeutic relevance in the management of diseases.

In the peels of lemon fruits, the appreciable quantity of sodium (16.16 %), calcium (6.33 %), potassium (70.31 %) and zinc (5.63 %) were determined (table 2).

A significant quantity of these mineral elements determined in the peels and juice of the lemon may inform that lemon fruits contain an appreciable proportion of the primary metabolites which make both the peels and juice of the orange host diverse nutritional contents. On the other perspective, this observation may imply that lemon peels can potentially provide the mineral elements needed for proper physiological processes of the body. This submission agrees with the findings of Ponnusha et al., (2011), who elucidated that minerals such as magnesium, and calcium among others are important nutrients which control the composition of body fluid and build living cells of the body.

Furthermore, higher tannin (0.91%), phenol (0.76 %), phytate (0.32 %) as well as oxalate (0.28%) were recorded in the peel of lemon fruit (Table 3). Also, alkaloids (5.23 %) and saponins (1.49 %) were relatively higher in lemon fruit peels compared with other fruits. In addition, flavonoids (3.24 %) were significantly higher in peels of sweet orange fruit peels, while lime fruit peels contained a significant amount of steroids (0.16 %) compared with lemon, sweet orange and grapefruit peels (Table 4).

Crude protein (1.42 %) and fat (0.33 %) were higher in lemon fruit juice, ash (0.13 %) and moisture (95.44 %) in lime fruit juice (Table 5). Furthermore, sodium (12.89 mg) was higher in the lemon fruit juice, calcium (43.25 mg) in sweet orange fruit juice and potassium (145.86 mg) in grape juice. The observation was consistent with the quantity of phosphorus (19.16 mg) and iron (0.91 mg) in lime fruit juice (Table 6). Further, these primary metabolites recorded in lemon juice may indicate the prospect of juice of the fruits as a source of food for several people because many people consume orange juice daily with little or no cognizance information about the beneficial effects of their peels for health improvement. However, this study established that both the peel and juice of oranges contain components that make them diets or supplements that can be adopted by livestock farmers (Nelofer et al., 2015). These findings corroborate the findings of Nagy et al. (2007), who found that Citrus fruits are rich in folic acid and a number of other essential nutrients.

Similarly, a higher quantity of phenol (0.71 %) and phytate (0.21%) were recorded in lemon juice as well as oxalate (0.08 %) in sweet orange and lemon fruit juice (Table 7**)**. Alkaloid (1.28 %), was significantly higher in sweet orange juice, flavonoid (0.62 %) in grapefruit while steroid (0.44 %) was significantly higher in lime fruit juice (Table 8).

The appreciable amount of secondary metabolites recorded in lemon peels may indicate that the product is an embodiment of phytochemicals suitable as food additives and as novelty products which have many diverse biological activities (Donatus, 2008; Lawal et al., 2013).

This submission corroborates the findings of Ashok-Kumaret al. (2011), who reported that a range of phytochemicals was detected in the sweet orange peels. Nevertheless, the presence of these phytochemicals especially in the peels of the sweet oranges may make this part an untapped potential source of pharmacologically important materials (Mathew et al., 2012; Donatus, 2008). A Significant concentration of anti-nutrients observed in the peels of lemon compared with other oranges studied suggests possible negative interaction between anti-nutrient and nutritional indices. Some of the antinutrients observed in the present investigation have implications on human diets (Kadiri et al., 2015). Other studies had it that anti-nutrients affect nutritional constants to form indigestible complexes.

Table 1: Proximate contents in grape, sweet orange, lemon and lime peels

Fruit peels	Proximate contents (%)					
	Crude Protein	Crude Fibre	Fat	Ash	Moisture	Carbohydrate
Grape peels	7.73±.01^{d}	6.13±0.07^{d}	3.24±0.01^{b}	4.22±0.01^{d}	22.93±0.01^{d}	67.89±0.01^{a}
Sweet orange peels	7.95±0.06^{b}	6.61±0.05^{b}	3.16±0.01^{c}	4.42±0.01^{b}	28.5±0.06^{b}	61.97±0.09^{c}
Lemon peels	8.15±0.01^{a}	7.85±0.02^{a}	3.35±0.02^{a}	4.72±0.01^{a}	30.36±.05^{a}	59.95±0.03^{d}
Lime fruit	7.83±0.07^{c}	6.25±0.03^{c}	3.233±0.01^{b}	4.26±0.01^{c}	24.2±0.04^{c}	66.49±0.03^{b}
$p < 0.05$	0.02	0.01	0.03	0.01	0.04	0.01

Means ± Standard error in each column with same superscripts are not significantly different at 5% using Duncan's Multiple Range Test.

Table 2: Mineral contents in grape, sweet orange, lemon and lime peels

Fruit peels	Mineral contents (mg 100g-1)						
	Sodium	Calcium	Potassium	Phosphorus	Iron	Zinc	Magnesium
Grape peels	12.83±0.03^{c}	5.25±0.01^{d}	61.31±0.01^{c}	14.85±0.01^{a}	3.63±0.02^{b}	4.69±0.01^{d}	3.98±0.02^{b}

Sweet orange peels	12.63±0.01[d]	5.3±0.03[c]	65.3±0.06[b]	13.94±0.01[c]	3.66±0.01[b]	5.13±0.01[b]	4.28±0.01[c]
lemon peels	16.16±0.05[a]	6.33±0.02[a]	70.31±0.06[a]	14.75±0.02[b]	4.61±0.01[a]	5.63±0.02[a]	4.61±0.01a[b]
Lime peels	14.62±0.01[b]	6.23±0.01[b]	58.34±0.11[d]	13.72±0.01[d]	4.64±0.00[a]	4.91±0.01[c]	4.72±0.01[a]
$p < 0.05$	0.03	0.02	0.01	0.02	0.04	0.01	0.01

Means ± Standard error in each column with same superscripts are not significantly different at 5% using Duncan's Multiple Range Test.

Table 3: Antinutrient contents in grape, sweet orange, lemon and lime peels

Fruit peels	Antinutrient contents (%)			
	Tannin	Phenol	Phytate	Oxalate
Grape peels	0.87±0.98[c]	0.68±0.03[b]	0.22±0.01[c]	0.23±0.01[c]
Sweet orange peels	0.79±0.03[d]	0. 67±0.01[d]	0.22±0.02[c]	0.24±0.01[c]
Lemon peels	0.91±0.01[a]	0.76±0.02[a]	0.32±0.02[a]	0.28±0.02[a]
Lime Peels	0.88±0.02[b]	0.69±0.02[b]	0.27±0.01[b]	0.26±0.02[b]
$p < 0.05$	0.04	0.01	0.01	0.03

Means ± Standard error in each column with same superscripts are not significantly different at 5% using Duncan's Multiple Range Test

Table 4: Phytochemical in grape, orange, lemon and lime fruit peels

Fruit peels	Phytochemical contents (%)			
	Alkaloids	Saponins	Flavonoids	Steroids
Grape peels	5.01±0.02[d]	1.37±0.01[d]	2.66±0.01[d]	0.09±0.01[b]
Sweet orange peels	5.13±0.01[b]	1.46±0.03[c]	3.24±0.05[a]	0.008±0.02[c]

Lemon peels	5.23±0.01[a]	1.49±0.06[a]	3.16±0.08[c]	0.13±0.02[a]
Lime peels	5.07±0.02[c]	1.48±0.02[b]	3.21±0.06[b]	0.16±0.04[a]
P < 0.05	0.02	0.00	0.01	0.02

Means ± Standard error in each column with same superscripts are not significantly different at 5% using Duncan's Multiple Range Test.

Table 5: Proximate contents in grape, sweet orange, lemon and lime juice

Types of fruit juice	Proximate contents (%)					
	Crude protein	Crude Fibre	Fat	Ash	Moisture	Carbohydrate
Grape fruit juice	0.92±0.02[c]	0.72±0.12[c]	0.11±0.01[c]	0.12±0.01[b]	90.27±0.12[d]	12±0.13[a]
Sweet orange fruit juice	0.81±0.01[d]	0.61±0.11[d]	0.11±0.01[c]	0.12±0.01[b]	93.4±0.07[c]	8.97±0.05[b]
Lemon fruit juice	1.42±0.06[a]	1.32±0.04[a]	0.33±0.02[a]	0.12±0.01[b]	92.73±0.35[ab]	7.31±0.35[c]
Lime fruit juice	1.02±0.03[b]	0,6.02±0.01[b]	0..22±0.02[b]	0.13±0.02[a]	95.44±0.76[a]	6.61±0.76[c]
P < 0.05	0.04	0.04	0.03	0.01	0.00	0.03

Means ± Standard error in each column with same superscripts are not significantly different at 5% using Duncan's Multiple Range Test.

Table 6: Mineral contents in grape, sweet orange, lemon and lime juice

Types of fruit juice	Mineral contents (mg 100g-1)						
	Sodium	Calcium	Potassium	Phosphorus	Iron	Zinc	Magnesium
Grape fruit juice	0.63±0.02[d]	15.1±0.06[d]	145.86±0.3[a]	10.82±0.02[d]	0.41±0.02[d]	0.27±0.02[c]	11.04±0.03[b]
Sweet orange fruit juice	0.76±0.01[c]	43.25±0.3[a]	122.85±0.09[c]	14.88±0.01[c]	0.69±0.01[c]	0.24±0.05[d]	2.57±0,01[d]
lemon fruit juice	12.89±0.09[a]	28.24±0.01[c]	142.35±0.14[b]	17.92±0.01[b]	0.87±0.02[b]	0.28±0.01[b]	11.24±0.01[a]
Lime fruit juice	12.61±0.02[b]	33.9±0.05[b]	107.5±0.23[d]	19.16±0.11[a]	0.91±0.01[a]	0.4±0.00[a]	9.26±0.02[c]
$p < 0.05$	0.01	0.03	0.00	0.01	0.03	0.01	0.00

Means ± Standard error in each column with same superscripts are not significantly different at 5% using Duncan's Multiple Range Test

Table 7: Antinutrient contents in grape, sweet orange, lemon and lime juice

Types of fruit juice	Antinutrient contents (%)			
	Tannins	Phenol	Phytate	Oxalate
Grape fruit juice	0.22±0.02[a]	0.62±0.00[b]	0.13±0.01[b]	0.12±0.01[b]
Sweet orange fruit juice	0.23±0.01[a]	0.62±0.00[b]	0.11±0.00[b]	0.18±0.00[a]
Lemon fruit juice	0.24±0.01[a]	0.71±0.01[a]	0.21±0.01[a]	0.18±0.03[a]
Lime fruit juice	0.23±0.00[a]	0.63±0.00[b]	0.12±0.01[b]	0.112±0.00[c]
$p < 0.05$	0.13	0.01	0.00	0.00

Means ± Standard error in each column with same superscripts are not significantly different at 5% using Duncan's Multiple Range Test.

Table 8: Phytochemical contents in grape, sweet orange, lemon and lime juice

Types of fruit juice	Phytochemical contents (%)			
	Alkaloids	Saponins	Flavonoids	Steroids
Grape fruit juice	0.82±0.01[d]	0.33±0.00[a]	0.62±0.01[a]	0.34±0.01[b]
Sweet orange fruit juice	1.28±0.03[a]	0.33±0.01[a]	0.57±0.02[b]	0.35±0.01[b]
lemon fruit juice	1.08±0.02[b]	0.32±0.02[a]	0.54±0.05[b]	0.32±0.01[c]
Lime fruit juice	0.87±0.01[c]	0.34±0.03[a]	0.51±0.02[c]	0.44±0.02a
$P < 0.05$	0.04	0.14	0.00	0.01

Means ± Standard error in each column with same superscripts are not significantly different at 5% using Duncan's Multiple Range Test.

4.0 Conclusions

Results showed that both peels and juice of the oranges are hosts of primary and secondary metabolites yet higher quantities of the metabolites are higher in lemon fruits juices than peel. However, the two parts should be adopted for human and animal consumption.

REFERENCES

1. Ani PN, Abel HC (2018) Nutrient, phytochemical, and antinutrient composition of *Citrus maxima* fruit juice and peel extract. Food Sci Nutr 6:653–658.
2. AOAC, (2000) Official methods of Analysis of A.O.A.C International, 17 Edition, Volume 11 Gaithenburf, MD, USA, Official methods 920-957.
3. Ashok-Kumar K, Narayani M, Subanthini A, Jayakumar M (2011) Antimicrobial Activity and Phytochemical Analysis of Citrus Fruit Peels -Utilization of Fruit Waste. International Journal Engineering Science and Technology 3(6): 5414 – 5421.
4. Donatus EO (2008) Citrus fruits: a rich source of phytochemicals and their roles in human health. International Journal of Chemistry Science 6(2): 451-471.
5. Harborne JB (1973) Photochemical Methods: A Guide to Modern Techniques of Plant Analysis. Chapman A. and Hall, London, 279.
6. Kadiri M, Ojewumi AW, Bada, IO (2015). Ethnotherapeutic evaluation and anti-nutrient content of common plants used for management of kidney and liver disorders in odeda communities, Ogun state, Nigeria. Journal of Drug Delivery and Therapeutics 5(3):24-32.
7. Lawal D, Bala JA, Aliyu SY, Huguma MA (2013) Phytochemical screening and in vitro anti-bacterial studies of the ethanolic extract of *Citrus Sinensis* (Linn.) peel against some clinical bacterial isolates. International Journal of Innovation and Applied Studies 2(2): 138 -145.
8. Mathew B, Jatawa SK, Tiwaari A (2012) Phytochemical analysis of *Citrus limonum*pulp and peel. International Journal of Pharmacy and Pharmaceutical Sciences 4(2): 269-371.
9. Nagy V, Szabo Z, Mark L, Deli J (2007) Comparative Study on the Carotenoid Citrus. Innovative Food Science and Emerging Technologies 8:390 – 394.
10. Nelofer J, Rukhsana J, Muzaffar K, Musarat R, Tayyiba N, Aqsa K, Noor US, Sadaf AG, Uzma J, Ahmed B, Ayesha M, Sabeena R, Shagufta F (2015) Quantitative Assessment of Juice Content, Citric Acid and Sugar Content in Oranges, Sweet Lime, Lemon and Grapes Available in Fresh Fruit Market of Quetta City. International Journal of Basic and Applied Sciences 15: 21-24.
11. Oikeh EI, Oriakhi K, Omoregie ES (2013) Proximate Analysis and Phytochemical Screening of *Citrus sinensis* Fruit Wastes. *The Bioscientist* 1(2): 164-170.
12. Ojewumi AW, Oyebanji EO (2020) Ethnopharmacological survey and physiological evaluation of nutritional and phytochemical contents of indigenous plants used for treatment of toothache and mouth odour in Ijebu Ode Local Government Area, Ogun state, Nigeria. Nigerian Journal of Pure and Applied Sciences 33 (1): 3559-3576.
13. Ojewumi AW, Sanusi JF (2020) Evaluation of proximate, mineral anti-nutrients and phytochemical constituents of indigenous beans sold in Ibadan north local government area, Oyo state. Tropical Journal of Natural Product Research 4(10):838-843.
14. Okey FO, Sunday LE, Chidinma OE (2016) Evaluation of Air Oven Moisture Content Determination Procedures for Pearl Millet (*Pennisetum glaucum* L.). Int J Food Prop. 19(2):454-466
15. Olife IC, Ibeagha OA, Onwualu AP (2015) Citrus Fruits Value Chain Development in Nigeria. Journal of Biology, Agriculture and Healthcare 5 (4): 37-46

16. Ponnusha BS, Subramaniyam S, Pasupathi P, Subramaniyam B, Virumandy R (2011) Antioxidant and Antimicrobial properties of Glycine Max-A review. International Journal of Current Biological and Medical Science 1(2): 49 – 62.
17. Sofowora A (1993) Medicinal Plants and Traditional Medicines in Africa. John Wiley and Sons, New York. Chichester 97-145.