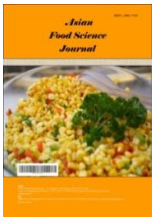

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Environmental Effects on Physicochemical Compositions, Microbial Load and Heavy Metal Content of Retailed Cut Fruits in NsukkaMain Market Enugu, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author ONA designed the study, wrote the first draft of the manuscript. Author UFU edited the work and performed the statistical analysis. Author UNN wrote the protocol and managed the analyses of the study. Author OCS managed the literature searches, collected samples and participated in laboratory analysis. All authors read and approved the final manuscript.

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ABSTRACT

The study evaluated the environmental effects on physico-chemical compositions, microbial load and heavy metal content of cut fruits retailed in Nsukka main market. Whole fruits were procured from fruit vendors in the market. They were washed, peeled (except watermelon) and divided into three portions each and designated as PA0, PA4, PA8; PP0, PP4, PP8 and WM0, WM4, WM8 for pineapple, pawpaw and watermelon collected at 0,4,8 hours respectively. A portion from each fruit was picked at three different times (8 am, 12 noon and 4 pm designated as 0, 4, 8 hour) and were analyzed for physicochemical (proximate, pH, titratable acidity, °Brix value, vitamin content)

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properties, microbial (total viable, mold and coliform count) load and heavy metal (lead, cadmium and nickel) content. The proximate analysis showed that all the fruit collected at 8 am had the highest moisture content (78.83% - 93.29 %) and gradually decreased at 12 noon and 4 pm. There were significant ($p<0.05$) differences only in carbohydrate 25023.content and energy value for proximate parameters. The pH, brix and vitamins all showed significant differences in all fruits and at different collection time. The pH for pawpaw and watermelon increased with increase in exposure time while °Brix value and vitamins significantly ($p<0.05$) decreased. Microbial analysis indicated the presence of microbes in all fruits with total viable count range of $0.83\times 10^3 – 2.9 \times 10^3$ CFU/g. The result of cadmium and nickel detected ranged from 0.015 – 0.08 mg/kg and 0.103 – 0.82 mg/kg respectively. This study showed that cutting and exposing of fruits affected their proximate, pH, °Brix value, vitamins, microbial load and heavy metal accumulation.

Keywords: Environment; fruits; microbial; toxicity; vitamins.

1. INTRODUCTION

Consumption of cut fruit products has been on the increase locally and globally because they are more convenient, easily accessible and affordable [1]. Retailed cut fruits are fruits that have been cut or sliced open, packaged in small white polyethylene bags and carried around by street vendors or hawkers at local markets or streets. Such fruits are eaten immediately, without necessarily having to cut, peel or rinse them. In Nigeria, cut fruits are popularly displayed, completely exposed for sale in shopping malls, market places, busy roads/ major streets with heavy traffic, security check points or at bad spots on the highways where motorists are forced to slow down [2]. Cut fruits commonly sold include pineapple, watermelon and pawpaw, among others. Increased consumption of cut fruits and the disease risk which consumers are exposed to while consuming them should be a great concern to the society. In most cases, one may find it difficult to confirm the hygienic status and sanitary condition of processing by uninformed retailer/vendor who has little or no knowledge of good manufacturing practices and food hygiene. The situation become worse when cut fruits are produced without adequate storage conditions, thereby, exposing the cut fruits to flies, ants, dust and other microbial pathogens [3]. Some of these conditions multiple risk of food-borne diseases caused by pathogens such as bacteria (*Salmonella spp*, *Staphylococcus aureus*, *Enterobacteriaceae*), fungi, viruses and parasites [4]. Such fruits are therefore widely exposed to microbial contamination through contact with soil, dust, air and water and also by inadequate handling practices during harvest or postharvest processing. Pathogenic microorganisms may also enter the fruits through damaged surfaces as a result of punctures, wounds and cuts [5,6].

Also accumulation of heavy metals (such as cadmium, lead, nickel, arsenic and mercury) from the earth's crust and from environmental pollutants with their toxicity poses health challenge with consumption of cut fruits [7,8,9].

The aim of this study is to assess the environmental effects on the physico-chemical composition, microbial load and heavy metal content of retailed cut pineapple, pawpaw and watermelon fruits sold in Nsukka main-market Enugu state, Nigeria.

2. MATERIALS AND METHODS

2.1 Materials

Average size whole fully ripe pineapple (*Ananas sativa*), pawpaw (*Carica papaya*) and watermelon (*Citrullus lanatus*) fruits ready to be processed into retailed cut products were purchased from a major vendor retailing fruits at Nsukka main market. The fruits were each cut into three portions, peeled (except watermelon) and wrapped with transparent polyethylene bag by the fruit vendor. They were kept in a tray and left exposed under the sun which is the usual practice. A portion of each cut fruit was picked immediately at 8 am (zero hour after cutting) into sterile containers and taken to the laboratory for analysis. After four hours (12 noon) and eight hours (4 pm) respectively, the remaining portions were further picked in sterile containers and transported to the laboratory for analysis.

2.1.1 Proximate composition

The proximate parameters (moisture, crude fibre, ash, fat and proteins) were determined according to AOAC [10]. The carbohydrate was determined by difference while energy value was determined using the method described by Olayinka and Etejere [11]. The energy value was calculated by

multiplying the percentage protein and carbohydrate with 4 and percentage fat with 9.

$$E = (Protein(\%)x4) + (CHO(\%)x4) + (Fat(\%)x9)$$

Where E = energy value (Kcal)
CHO- carbohydrate

2.2 Physical Analysis

2.2.1 pH determination

About 100 g of each fruit sample was blended and then filtered through cheesecloth to obtain the clear juice. The pH of the samples (juices) were determined using the method described by AOAC [10]. A Jenway electronic pH meter was dipped into the juices and the values were recorded afterwards.

2.2.2 Determination of titratable acidity

The method described by AOAC [10] was used. Exactly 10 ml of the fruit juices was measured into a conical flask and three drops of phenolphthalein indicator was added, the solution was titrated with 0.1N sodium hydroxide solution until a pink colour change which lasted for 5 seconds was observed. The titre value was taken and total titratable acidity was calculated using the formula:

$$\% \text{ Total titratable acidity} = \frac{\text{N(NaOH)} \times \text{T} \times 0.09}{\text{Weight of sample}} \times \frac{100}{1}$$

Where T is the titre value, N is the normality of NaOH

2.2.3 Determination of °Brix value

Total soluble solid level was determinedusing Grant refractometer RB62 (HANNA Instruments, Germany) as described by AOAC [10]. The refractometer was first calibrated to 0° Brix value using distilled water and the distilled water wiped off the refractometer using a clean tissue paper. Then, about 1 ml of each sample was dropped on the refractometer and the values read were recorded as °Brix value.

2.3 Vitamin Content Determination

2.3.1 Determination of ascorbic acid content

The ascorbic acid content of each sample was determined using the titrimetric method using 2, 6– dichlorophenol indophenols as described by AOAC [10]. Exactly 5g of each sample was weighed and macerated in 15 ml metaphosphoricglacial acetic acid mixture in a beaker containing 1 g activated charcoal. The resulting mixture was boiled for 10 minutes and thereafter filtered into a conical flask. For complete extraction of the vitamin C, 10 ml of glacial acetic acid was added. Distilled water was added to each conical flask and the volume made up to 100 ml. A blank solution was titrated with 2, 6 – dichlorophenol indophenol dye in a conical flask until a pink colour was obtained. The quantity of 2, 6 - dinitrophenol indophenol dye used to achieve the end point was recorded. The ascorbic acid was calculated as:

$$\text{mg ascorbic acid}/100\text{g sample} = \text{V} \times \text{S} \times \text{D}$$

Where V= volume of dye used to titrate, S= standardization value in mg ascorbic acid and D= dilution factor

2.3.2 Determination of vitamin A

Vitamin A determination was carried out using the method described by Kirk and Sawyer [12]. One gram (1 g) of each sample was weighed in duplicate into 250 ml beakers and petroleum ether was added to the beakers. Petroleum ether was evaporated and 10 ml of distilled water was added to the beaker, stirred and filtered. One milliliter (1 ml) of the various samples was pipette in triplicate into glass test tubes, and 0.2 ml of the chloroform acetic anhydride was added, followed by 2 ml of tetra citric acid and chloroform. The vitamin A content was determined at a wavelength of 450 nm using a UV-VIS spectrophotometer (GS-UV12, General Scientific Ltd., UK). The values were expressed in$\mu g\ \text{Re}/100\ g$.

2.3.3 Determination of vitamin E content

The vitamin E content of each fruit sample was determined using the method described by AOAC [10]. One gram (1g) of sample was weighed into a 250 ml conical flask, 10 ml of absolute alcohol and 20 ml of 1 M alcoholic sulphuric acid was added. The condenser and flask were wrapped in aluminum foil and refluxed for 45 minutes and then cooled for 15 minutes. A volume of 50 ml distilled water was added to the mixture and transferred to a 250 ml separating funnel covered aluminum foil. The unsaponifiable matter in the mixture was extracted with 30 ml of dimethyl ether. The combined extracts were washed free of acid and dry-evaporated at a low temperature. The residues obtained were dissolved in 10 ml of absolute alcohol. Aliquots of

solutions of each sample and standards were transferred into a 20 ml volumetric flask and 5 ml absolute alcohol added, followed by a careful addition of 1 ml concentrated HNO_3. The flask was placed on a water bath and temperature set at 90 °C for 3 minutes. The flask was allowed to cool rapidly under running water and volume was adjusted with absolute alcohol. Absorbance was read at 470 nm against a blank solution containing 5 ml absolute alcohol and 1 ml concentrated HNO_3 treated in a similar manner. The vitamin E content was expressed as:

Vitamin E (µg/ 100 g) =

$$\frac{\text{Absorbance of gradient} \times \text{gradient factor} \times \text{dilution factor}}{\text{Weight of sample}}$$

2.4 Microbiological Analysis

2.4.1 Determination of total viable count

The total viable count was determined using the method described by Precott et al. [13]. One ringer tablet was dissolved in distilled water (500 ml). The clear solution formed was sterilized by autoclaving for 15 minutes at 121°C and 15 Ib pressure. The ringer solution was allowed to cool completely to a temperature of about 28 ±2°C using sample and sterilized quarter strength ringer solution as diluents, I ml of the samples and 9 ml ringer solution was serially diluted. The diluted sample was pipetted into a marked petri dish, swirled to mix and incubated at a temperature of about 37°C for 24 hours. After incubation, the number of colonies was counted using a colony counter and represented as colony forming units per gram (CFU/g).

2.4.2 Mould count determination

Mould count was done using the method described by Prescott et al. [13]. After the serial dilution of the samples, they were inoculated using Saboraud dextrose agar (SDA). Pour plate method was used. The colony count was done after 24 hours on incubation at 37 °C using a colony counter and represented as colony forming units per gram (CFU/g).

2.4.3 Determination of coliform

The method described by Rahman et al., [14] was used. Samples were inoculated onto MacConkey agar media. The isolates were then inoculated in Brilliant Green Lactose Bile (BGLB) broth followed by streaking on Eosine Methylene Blue (EMB) agar plate. After inoculation of the samples, plates were incubated at 37°C and colonies were observed after 24 hours and represented as colony forming unit per gram (CFU/g).

2.5 Determination of heavy metals

2.5.1 Determination of lead,nickel and cadmium

The samples were wet digested according to the method described by AOAC [10]. Exactly 2 g of each of the samples were digested by addition of a mixture of concentrated HNO_3 and concentrated HCl. The solutions were heated,allowed to cool and then filtered. Digests were stored for no longer than 24 hours at temperature of 8°C prior to Atomic Absorption Spectrophotometer (AAS) analysis. Lead, nickel and cadmium metals were determined directly in respective solutions by Flame Atomic Absorption Spectrophotometer AA-7000. Measurements were made using standard hollow cathode lamps for lead, cadmium and nickel. The limit of detection (LOD) of the analytical method for each metal was calculated as being triple the standard deviation of a series of measurements for each solution, the concentration of which is distinctly detectable above the background level. These values were 0.001, 0.001, and 0.002 mg/kg for lead, cadmium, and nickel respectively.

2.6 Statistical Analysis

The study adopted the randomized complete block design (RCBD). Data generated from the study was subjected to two- way analysis of variance (ANOVA) using Statistical Package for Social Solution (SPSS) version 20.0 and the means separated using Duncan's New Multiple Ranged Test and level of statistical significance was set at $p \leq 0.05$.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition

The results of the proximate composition of retailed cut fruits were presented in Table 1. The moisture content for the cut pineapple, pawpaw and watermelon samples ranged from 77.50 - 78.83%; 88.48 – 91.00% and 91.43 – 93.29 % respectively. There were significant ($p<0.05$) decrease in moisture contents for each fruit sample as the exposure durations increased. The moisture content of all cut fruit samples

decreased with increased exposure duration. The highest moisture in all fruits samples was observed at the 0 hour after cutting, which gradually decreased at 4th hour, and the least moisture content observed at the 8th hour after cutting.

The fat, ash, crude fibre and protein contents of each fruit samples were not significant difference ($p>0.05$) at different duration. The ash content of cut pineapples, pawpaw and watermelon ranged from 1.37- 1.60%; 1.34 - 1.55% and 0.90 - 1.05 % respectively. The highest (but not significant ($p>0.05$)) ash content of all the cut fruits samples was observed at the 8th hour samples, while the least ash content was observed at 0 hour samples.

The fibre content of cut pineapple, pawpaw and watermelon fruit samples ranged from 2.21 - 2.59%; 0.81 – 0.96% and 1.21 -1.40% respectively. There was no significant difference ($p>0.05$) in the fruits samples with time.

The protein content of cut pineapple, pawpaw and watermelon fruit samples ranged from 0.71- 0.77%; 0.81- 0.96% and 0.58 – 0.60% respectively. There were no significant difference ($p>0.05$) in the protein content in all the cut fruits samples with time.

The carbohydrate content of cut pineapple, pawpaw and watermelon samples ranged from 16.06 -17.50%; 4.51- 6.10% and 3.52 – 5.40 % respectively. There were significant differences ($p<0.05$) in carbohydrate values for each fruit at different durations after cutting. All the cut fruits showed an increasing carbohydrate content with increased exposure duration. Pineapple samples had the highest carbohydrate value indicating that pineapples are rich in carbohydrate.

The energy value of cut pineapple, pawpaw and watermelon samples ranged from 70.35 – 76.93 Kcal; 25.83 Kcal - 32.82 and 19.24 -26.82 Kcal respectively.

3.2 pH, Titratable acidity and °Brix

The pH, titratable acidity and °Brix values of cut fruits retailed samples were presented in Table 2. The pH of pineapple, pawpaw and watermelon samples ranged from 4.1 - 4.3; 5.5 -5.9 and 5.7 - 6.0 respectively. There were significant differences ($p<0.05$) in all the samples. The pH of pineapple samples showed increasing acidity while that of pawpaw and watermelon showed reducing acidity and invariably increasing pH with increase in exposure time.

The titratable acidity of cut pineapple, pawpaw and watermelon samples ranged from 0.72 – 0.73; 0.17 – 0.18; and 0.08 -0.09 respectively. The °Brix value ranged from 18.65 -20.35; 10.65-11.35 and 5.65 -6.55 for pineapple, pawpaw and watermelon samples respectively. This showed a decreasing °Brix value of the cut fruits with increasing time of exposure. Significant difference in °Brix value was observed only at the 8th hour of exposure for all the samples.

3.3 Vitamin Composition

Vitamin compositions of samples were presented in Table 3. The vitamin C content of the samples ranged from 18.40 – 25.20mg/100g; 36.10 - 42.80 mg/100g and 4.80- 7.60 mg/100g for pineapple, pawpaw and watermelon respectively. There were significant differences ($p<0.05$) in all the cut fruits samples. The result of vitamin C in the cut fruits samples showed that sample PP0 had the highest vitamin C value while sample WM8 having the least.

The vitamin A content of fruit samples were significantly different and ranged from 1.83 – 3.25 µg Re/100g; 41.98 - 44.12 µg Re/100g and 25.65 – 25.99 µg Re/100g for pineapple, pawpaw and watermelon respectively. The vitamin E content of cut fruit samples ranged from 0.02 -0.04; 0.42 -0.65; and 0.04 -0.05 µg/100g respectively for pineapple, pawpaw and watermelon. There was no significant difference ($p>0.05$) in vitamin A content of the watermelon samples (WM0, WM4 and WM8) and pawpaw samples (PP0, PP4 and PP8). However, cut pineapple sample PA0 differed significantly ($p<0.05$) from PA4 and PA8.

3.4 Microbial Composition

The microbial composition of those retailed cut fruits were presented in Table 5. The total viable count of cut pineapple, pawpaw and watermelon fruit samples ranged from $0.83 \times 10^3 – 2.1 \times 10^3$ CFU/ g, $1.7 \times 10^3 – 2.9 \times 10^3$ CFU/ g and $1.4 \times 10^3 – 2.7 \times 10^3$ CFU/ g respectively.

Mould was not detected in all fruit samples. Coliform was only detected in sample WM8.

3.5 Heavy Metals

The heavy metals composition of some cut fruits retailed in Nsukka were presented in Table 4. The values obtained showed absence of lead in all the samples.

Table 1. Proximate composition(%)and energy value (Kcal)of some retailed cut fruits

Samples	Moisture	Fat	Ash	Crude Fibre	Protein	Carbohydrate	Energy value (Kcal)
Pineapple							
PA0	78.83^{a}± 0.01	0.43^{a} ± 0.05	1.37^{a}± 0.24	2.59^{a}± 0.26	0.71^{a}± 0.06	16.06^{c}± 0.07	70.56^{c}± 0.25
PA4	78.07^{b}± 0.25	0.43^{a} ± 0.06	1.39^{a}± 0.14	2.48^{a}± 0.11	0.75^{a}± 0.08	16.87^{b}± 0.03	74.37^{b}± 0.28
PA8	77.50^{c}± 0.08	0.43^{a} ± 0.04	1.60^{a}± 0.19	2.21^{a} ± 0.13	0.77^{a}± 0.04	17.50^{a}± 0.16	76.93± 1.17
Pawpaw							
PP0	91.00^{a}± 0.15	0.51± 0.02	1.34^{a}± 0.12	2.74^{a}± 0.13	0.81^{a}± 0.18	4.51^{c}± 0.25	25.83^{c}± 0.48
PP4	89.22^{b}± 0.03	0.51^{a} ± 0.10	1.45^{a}± 0.16	2.53^{a} ± 0.19	0.94^{a}± 0.07	5.36^{b}± 0.02	30.69^{b}± 0.66
PP8	88.48^{c}± 0.13	0.51^{a} ± 0.07	1.55^{a}± 0.11	2.40^{a} ± 0.25	0.96^{a}± 0.37	6.10^{a}± 0.30	32.82^{a}± 0.69
Watermelon							
WM0	93.29^{a}± 0.02	0.32^{a} ±0.04	0.90^{a}± 0.15	1.40^{a}± 0.14	0.58^{a}± 0.30	3.52^{b}± 0.27	19.24^{c}± 0.20
WM4	92.57^{b}± 0.01	0.32^{a} ±	0.91^{a} ±	1.31^{a}± 0.03	0.59^{a}± 0.24	4.32^{b}± 0.04	22.44^{b}± 0.32
WM8	91.43^{c}± 0.04	0.32^{a} ± 0.08	1.05^{a}± 0.09	1.21^{a} ± 0.14	0.60^{a}± 0.27	5.40^{a}± 0.45	26.82^{a}± 0.00

Result are mean of two duplicate ± standard deviation. Values having different superscripts for each fruit in the same column are significantly ($p \leq 0.05$) different. Key: PA0-cut pineapple at 0 hour; PA4- cut pineapple at 4thhour; PA8- cut pineapple at 8^{t}hour; PP0-cut pawpaw at 0 hour; PP4- cut pawpaw at 4th hour; PP8- cut pawpaw at 8th hour; WM0 – cut watermelon at 0 hour; WM4- cut watermelon at 4th hour; WM8- cut watermelon at 8th hour

Table 2.pH, titratable acidity and °Brix value of some retailed cut fruits

Samples	pH	Titratable acidity	°Brix
Pineapple			
PA0	$4.3^{a} \pm 0.00$	$0.72^{a} \pm 0.00$	$20.35^{a} \pm 0.71$
PA4	$4.1^{b} \pm 0.00$	$0.72^{a} \pm 0.00$	$19.15^{b} \pm 0.71$
PA8	$4.1^{b} \pm 0.00$	$0.73^{a} \pm 0.00$	$18.65^{c} \pm 0.71$
Pawpaw			
PP0	$5.5^{c} \pm 0.00$	$0.18^{a} \pm 0.00$	$11.35^{a} \pm 0.71$
PP4	$5.7^{b} \pm 0.00$	$0.17^{a} \pm 0.01$	$11.35^{a} \pm 0.71$
PP8	$5.9^{a} \pm 0.00$	$0.17^{a} \pm 0.00$	$10.65^{b} \pm 0.71$
Watermelon			
WM0	$5.7^{c} \pm 0.00$	$0.09^{a} \pm 0.00$	$6.55^{a} \pm 0.71$
WM4	$5.9^{b} \pm 0.00$	$0.09^{a} \pm 0.00$	$5.85^{b} \pm 0.71$
WM8	$6.0^{a} \pm 0.00$	$0.08^{a} \pm 0.00$	$5.65^{b} \pm 0.71$

Results are means of two duplicates ± standard deviation. Values having different superscripts for each fruit in the same column are significantly ($p \leq 0.05$) different. Key: PA0-cut pineapple at 0 hour; PA4- cut pineapple at 4th hour; PA8- cut pineapple at 8th hour; PP0-cut pawpaw at 0 hour; PP4- cut pawpaw at 4th hour; PP8- cut pawpaw at 8th hour; WM0 – cut watermelon at 0 hour; WM4- cut watermelon at 4th hour; WM8- cut watermelon at 8th hour

Table 3. Vitamins composition of some cut fruits retailed in Ogige market

Samples	Vitamin C (mg/100g)	Vitamin A (µg Re/100g)	Vitamin E (µg/100g)
Pineapple			
PA0	$25.20^{a} \pm 0.31$	$3.25^{a} \pm 0.01$	$0.04^{a} \pm 0.01$
PA4	$21.80^{b} \pm 0.12$	$2.57^{b} \pm 0.01$	$0.03^{b} \pm 0.00$
PA8	$18.40^{c} \pm 0.31$	$1.83^{c} \pm 0.00$	$0.02^{b} \pm 0.00$
Pawpaw			
PP0	42.80 ± 0.14	$44.12^{a} \pm 0.00$	$0.65^{a} \pm 0.00$
PP4	$39.40^{b} \pm 0.13$	$43.04^{b} \pm 0.00$	$0.53^{a} \pm 0.01$
PP8	$36.10^{c} \pm 0.16$	$41.98^{c} \pm 0.01$	$0.42^{a} \pm 0.01$
Watermelon			
WM0	$7.60^{a} \pm 0.21$	$25.99^{a} \pm 0.01$	$0.05^{a} \pm 0.01$
WM4	$6.20^{b} \pm 0.24$	$25.83^{b} \pm 0.01$	$0.05^{a} \pm 0.01$
WM8	$4.80^{a} \pm 0.11$	$25.65^{c} \pm 0.01$	$0.04^{a} \pm 0.01$

Results are means of two duplicates ± standard deviation. Values having different superscripts for each fruit in the same column are significantly ($p \leq 0.05$) different. Key: PA0-cut pineapple at 0 hour; PA4- cut pineapple at 4th hour; PA8- cut pineapple at 8th hour; PP0-cut pawpaw at 0 hour; PP4- cut pawpaw at 4th hour; PP8- cut pawpaw at 8th hour; WM0 – cut watermelon at 0 hour; WM4- cut watermelon at 4th hour; WM8- cut watermelon at 8th hour

Cadmium concentration in cut pineapple, pawpaw and watermelon samples ranged from 0.05 – 0.06; 0.02 –0.06 and 0.07 –0.08 mg/kg respectively. There was significant ($p<0.05$) difference in all the cut fruit samples with time of exposure. Sample WM8 had the highest cadmium content of 0.08 mg/kg while sample PP0 had the least cadmium content of 0.02 mg/kg.

Nickel concentration in cut pineapple, pawpaw and watermelon samples ranged from 0.20 - 0.72; 0.10 – 0.82 and 0.51 – 0.82 mg/kg respectively. There was significant difference ($p<0.05$) in all the fruit samples.

3.6 Discussion

This gradual loss in moisture content could be attributed to leakage of cellular fluids during processing operations such as peeling, slicing and cutting and during storage [15]. The fat content of the watermelon samples was within the range of the value (0.21%) reported for the same fruit by Olayinka and Etejere [11]. This low fat content of all the cut fruits could be attributed to naturally low fats content in most fruits which imply low energy value. Non-significant difference in ash content result indicated no change in the inorganic content which is a reflection of the mineral content. Little increase

observed in ash content could be attributed to the reduction in moisture and/or to the increasing heavy metal contamination in all the cut fruits. Retailer's preliminary processing and exposure did not significantly ($p<0.05$) affect total crude fibre of fruits which ordinarily can be altered by physical, chemical, enzymatic and thermal treatments directly or indirectly [16]. Proteins is low in fruits but are essential component of diet needed for survival of animals and human beings. Their basic function is to supply adequate amounts of required amino acids for nutrition [17]. The low fat and protein contents of the fruits samples is normal for most fruits. The carbohydrate content of pawpaw samples was lower than the value (18.26 %) reported by Ekpete et al. [18] for whole pawpaw fruit. Udeme et al. [19] also reported 6.76 % and 6.66 % for whole pineapple and pawpaw fruits respectively. Carbohydrate increased as a result of reduction in moisture and crude fibre since it was calculated by difference. Fruit carbohydrates could be used as a better supplement for cereals [20]. Carbohydrate increase affected the energy value as fat and protein did not change. The increasing energy value could be attributed to the fact that fruit energy value is inversely proportional to moisture content [20].

Table 4. Microbial composition of some cut fruits retailed in Ogige market

Samples	Total viable count (CFU/g)	Mould count (CFU/g)	Coliform count (CFU/g)
Pineapple			
PA0	0.83×10^3	0.0× 10	0.0× 10
PA4	1.6×10^3	0.0× 10	0.0× 10
PA8	2.1×10^3	0.0× 10	0.0× 10
Pawpaw			
PP0	1.7×10^3	0.0× 10	0.0× 10
PP4	2.6×10^3	0.0× 10	0.0× 10
PP8	2.9×10^3	0.0× 10	0.0× 10
Watermelon			
WM0	1.4×10^3	0.0× 10	0.0× 10
WM4	2.0×10^3	0.0× 10	0.0× 10
WM8	22.7×10^3	0.0× 10	1.0 × 10

Results are means of two duplicates ± standard deviation. Values having different superscripts for each fruit in the same column are significantly ($p \leq 0.05$) different. Key: PA0-cut pineapple at 0 hour; PA4- cut pineapple at 4^{th} hour; PA8- cut pineapple at 8^{th} hour; PP0-cut pawpaw at 0 hour; PP4- cut pawpaw at 4^{th} hour; PP8- cut pawpaw at 8^{th} hour; WM0 – cut watermelon at 0 hour; WM4- cut watermelon at 4^{th} hour; WM8- cut watermelon at 8^{th} hour

Table 5. Heavy metal compositions of some cut fruits retailed in Ogige market

Samples	Lead (mg/kg)	Cadmium (mg/kg)	Nickel (mg/kg)
Pineapple			
PA0	ND	$0.05^{c} \pm 0.00$	$0.20^{c} \pm 0.01$
PA4	ND	$0.05^{b} \pm 0.01$	$0.51^{b} \pm 0.02$
PA8	ND	$0.06^{a} \pm 0.01$	$0.72^{a} \pm 0.09$
Pawpaw			
PP0	ND	$0.02^{c} \pm 0.00$	$0.10^{c} \pm 0.21$
PP4	ND	$0.03^{b} \pm 0.00$	$0.50^{b} \pm 0.1$
PP8	ND	$0.06^{a} \pm 0.00$	$0.82^{a} \pm 0.1$
Watermelon			
WM0	ND	$0.07^{b} \pm 0.00$	$0.51^{c} \pm 0.03$
WM4	ND	$0.08^{ab} \pm 0.00$	$0.70^{b} \pm 0.11$
WM8	ND	$0.08^{a} \pm 0.00$	$0.82^{a} \pm 0.03$

Results are means of two duplicates ± standard deviation. Values having different superscripts for each fruit in the same column are significantly ($p \leq 0.05$) different. Key: PA0-cut pineapple at 0 hour; PA4- cut pineapple at 4^{th} hour; PA8- cut pineapple at 8^{th} hour; PP0-cut pawpaw at 0 hour; PP4- cut pawpaw at 4^{th} hour; PP8- cut pawpaw at 8^{th} hour; WM0 – cut watermelon at 0 hour; WM4- cut watermelon at 4^{th} hour; WM8- cut watermelon at 8^{th} hour

The increasing pH of cut pawpaw and watermelon samples is associated with high rate of respiration by accelerated acid metabolism and accumulated cations [21]. The pH values obtained also reflected a significant extent to the microbial stability of the various cut fruits samples. Also titratable acidity reflects organic acid content of fruits- which is able to affect fruit quality in terms of flavor [22]. Citric acid and malic acid are two organic acids present in the fruits. The high pH values and low titratable acidity values of the cut fruits at 0 hour (8 am) sample indicated that the fruit used were mature ripped fruits.

The decreasing °Brix value with time could be attributed to the steep rise in respiration rate of cut fruits, causing accelerated consumption of sugars (mostly fructose, glucose and sucrose), lipids and organic acids [23]. The decreasing °Brix value will lead to decrease in sweetness and increase in sourness.

The variation in vitamin C among the fruits is in agreement with previous studies stated by Szeto et al. [24]. The consistent decreasing vitamin C content with time indicates that it is highly susceptible to oxidation, either directly or through the enzyme ascorbate oxidase catalyzing the oxidation of ascorbic acid to dehydroascorbic acid, with the concomitant reduction of molecular oxygen to water [25]. The retention of vitamin C is also greatly affected by storage and processing [26]. Processing operations such as washing peeling and cutting, lead to rapid loss of vitamins C since it is water soluble and lost through leaching.

The vitamin C value (25.20 mg/100 g) obtained for pineapple at 0 hour exposure was in the same range with the value (25 mg/100g) reported by Kaziiet al., [27] for the same fruit.

The values obtained signify that pawpaw and watermelon fruits are rich sources of vitamin A. The amount of β-carotene (vitamin A precursor) varies according to cultivar type and environmental factors [28]. Olayinka and Etejere[11] reported 2.81 mg/100g for watermelon pulp while Kim et al. [29] reported β-carotene content of fresh watermelon flesh to be 4.82 mg/g. Vitamin A has the ability to exhibit both antioxidant activity and pro-oxidant properties [30]. The decreasing vitamin A content of all the cut fruits samples with exposure time could be explained by its susceptibility to oxygen, heat and light, resulting from its chemical structure (comprising conjugated double bond system), which causes oxidative cleavage and isomerization.

These Vitamin E values obtained indicates that the fruits are poor sources of vitamin E. In general, vitamin E levels are more abundant in oily seeds, olives, nuts, peanuts, avocados and almonds. Egharevbaet al. [31] had reported the same vitamin E value (0.00 mg/kg) for whole watermelon fruit while Unaegbuet al. [32] also reported the same value for pineapple and watermelon fruits.

The total microbial count values obtained for pineapple and watermelon samples were lower than the value (3.7×10^3 CFU/ g) of ready-to-eat reported by Orji et al. [4] for the same fruits while the values obtained for pawpaw samples were lower than the value (3.7×10^3CFU/g) reported by Daniel et al. [33] for sliced pawpaw. The values indicated that all the fruits were contaminated. However, the microbial load of the fruits varied with the fruit samples. The increasing microbial contamination observed in the fruits may be a reflection of environmental conditions and how long these fruits were exposed before analysis. Peeling and cutting of fruits removes the protective epidermal layer, thus exposing the product to air and possible contamination by bacteria and fungi. Bacteria on the fruit may multiply over time depending on the processing and environmental conditions. Bacteria on processing utensils may be transfer to samples and cross- contamination between produce is probable, particularly where produce are pre-washed with the same wash water by the vendor.

Lead was not detected in all the cut fruits which is in agreement with some previous reportsbut Ogunkunle et al. [34] recorded 1.760 mg/kg and 0.074 mg/kg of lead for watermelon and pawpaw fruits respectively.

Unaegbu et al. [32] had earlier reported non-detectable cadmium values for watermelon and pineapple fruits respectively while Ogunkunleet al. [34] had a value of 0.077 mg/kg for pawpaw fruit. These values of accumulation factors indicate that the source of accumulation of cadmium originates mainly from anthropogenic contributions. The major sources of cadmium are motor oil, car tyres and cadmium compound which may explain its increasing accumulation value on the cut fruits procured along major roads. The values obtained for cadmium in all the

fruits samples were below the Joint FAO/ WHO [35] permissible level of 0.2 mg/kg.

Ogunkunle et al. [34] reported Nickel content of 0.139 mg/kg and 0.113 mg/kg for watermelon and pawpaw fruits respectively. Unaegbuet al [32] reported a non-detectable Nickel value for pineapple fruit. The values obtained for all the samples with the exception of sample PA0 and PP0 were higher than the Joint FAO/ WHO [35] permissible level of < 0.5mg/kg.

The implication of these high values indicates pollution and thereby rendering exposed retailed cut fruits unsafe for consumption. Nickel is one of a few heavy metals whose state remains contradictory to whether it is useful or harmful to the body. Though they have been considered to be essential in animals, microorganisms and plants, they have also been noted to have delirious effects to man.

4. CONCLUSION

This study revealed that exposure of cut pineapple, pawpaw and watermelon fruits retailed in Nsukka resulted in significant loss of moisture, increased carbohydrate and energy contents of all the cut fruits. The pH of pawpaw and watermelon increased with duration of exposure of the cut fruits which invariably may have encouraged the proliferation of microorganisms. The °Brix value of the cut fruits decreased with rise in respiration rate of the cut fruits. Vitamins C and A most especially suffered loss through leaching and oxidation processes. This study also revealed that increased exposure of cut pineapple, pawpaw and watermelon fruits increased their microbial load and toxic metal (nickel and cadmium) contamination which could be as a result of unhygienic processing and retailing environment these fruits were exposed to.

5. RECOMMENDATIONS

It is therefore recommended that cut fruits should be processed in hygienic environment using clean processing utensils and properly packaged to avoid contamination. Cut fruit retailers should undergo training and be advised to cut fruits in quantities sellable within a short period and to used adequate short term storage facilities after cutting so as to salvage nutrients and avoid microbial infestation. On the other hand consumers should be mindful of the areas and hygienic level of retailers they purchase cut fruits from to avoid the risk of food poisoning. Food regulation agencies should look into this aspect of food vendor to produce a guiding rules for cut fruit retailing.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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