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A Comparative Study of the Nutritional Quality of Freshly Extracted Juices from Organic Versus Conventional Orange and Apple Fruits

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Abstract

Freshly extracted juices obtained from organically and conventionally produced orange and apple fruits were assayed in terms of their nutritional quality. Total and individual sugars were detected using HPLC while brix concentrations were measured through a hand-held optical refractometer. Enzyme immunoassay method was used for vitamin analysis while both flame photometer and AAS were used for the minerals. It was observed from this study that the total soluble solids of juices obtained from conventionally grown fruits are slightly higher than their organic counterparts. However, apple juices revealed more percent soluble solids (12.8 - 13.56°Brix) than juices obtained from orange (10.78 – 11.6°Brix). The highest soluble sugar concentration detected was sucrose (4.21 – 5.66 g/100 mL) and conventional apple juices had the highest amount. Maltose was not detected in all the analyzed samples. Glucose concentrations were reportedly slightly higher (2.83 – 3.11 g/100 mL) in conventionally grown fruits than their organic counterparts (2.59 - 2.79 g/100 mL). Both organic and conventional orange fruit juices were observed to contain higher amounts of potassium, sodium, calcium, copper and zinc than their counterparts from apple. Concentrations of ascorbic acid were highest (480 mg/ L) in organic orange juice and the lowest was detected in conventional apple juice (190 mg/ L). For folic acid, organic apple juice had the lowest amount (61.29 µg/ L) while juice from conventionally grown oranges contained the highest mean amount (84.23 µg/ L). Additional research on other nutritional aspects such as amino acid profile, antioxidant activity, phenolic and organic acid composition may be necessary in order to provide more information for better comparison.

Keywords: *Fresh Juice; Orange; Apple; Organic; Non organic; Nutritional Quality*

Introduction

Globally, the production and consumption of both local and imported fruit juices respectively have witnessed an increasing trend over the past few decades [1,2]. This upward trend can be attributed to an increase in the awareness provided by various studies that have been conducted to define the benefits associated with the consumption of fruits and fruit products [2]. Freshly extracted juices provide the fastest and most suitable means for humans to enjoy the intrinsic nutritional and health benefits of various fruits [3,4]. They provide many beneficial qualities to human health in that they contain ample quantities of diverse nutrients such as vitamins, minerals and carbohydrates [3].

Fruit products such as juices have been considered to be one of the healthiest foods in human diet and by implication, an important food resource in maintaining good health. Water is the predominant component of fruit juice followed by soluble sugars, including sucrose, fructose and glucose and the total soluble solid concentrations of various fruit juices usually fall between 7 and 26°Brix [3]. Juices from fruits are expected to contain little or no fat or cholesterol and most usually may contain small amounts of proteins. The fiber composition of various fruit juices can also be viewed to be insignificant unless part of the pulp is included during processing.

Fruit juices are consumed on a daily basis and they serve as desserts in the diet of many people across the globe. This is because fresh juices are capable of meeting the high demand for minerals and vitamins in the human body [4]. In Europe, for example, the most widely-consumed fruit product is orange juice and this is followed by apple juice [5]. Orange and apple juices are highly-consumed fruit products because they possess strong health-promoting properties. In addition to containing high amounts of ascorbic acid and potassium, orange fruits and their constituents serve as important dietary source of biologically active compounds which when consumed are capable of exerting health beneficial effects in the body [6].

In a report released by Mintel., *et al*. [7], cold-pressed 'raw' fruit juices have seen more activity in recent times and are positioned as being more nutritious as compared to standard products due to not having being passed through some form of heat in the during processing. According to this report, some recent launches have explored this mechanism due to the claim that it maintains the fresh and natural characteristics of the juice. A second method which can be adopted in fruit juice processing is the heat-pressing technique but this been identified as resulting to fruit products of lower nutritional value than that from cold-pressing since some of the nutrients are believed to be lost during the heat treatment process.

Whichever method to be adopted for the processing of juice from fruits, adequate knowledge of the original characteristics of the fruit and extracted juices is paramount. Such information would assist juice processors in preserving important properties that promote the quality of fruit juices. Also, an assessment of the juice quality of fruits is of great benefit to consumers of fruit products. The nutritional quality and health related characteristics of fruits and fruit juices depend not only on the concentration of nutrients and phytochemicals but also on the daily intake as well as bioavailability [8,9].

Apples are one of the most widely consumed fruits worldwide and earlier studies have shown that it not only has a higher fiber content than other fresh fruits (cellulose, hemicelluloses, pectin and lignin content) but also that its consumption have a statistically significant impact on weight reduction and hence widely used as part of diet in controlling obesity [9-10]. Furthermore, the consumption of apple juices mainly for their antioxidant properties with contributions from ascorbic acid reduce outset of cardiac diseases, cancer, ageing processes, and interferes with the oxidation of lipoproteins of low density [12-15]. Studies conducted by Tsao., *et al*. [16] and Feliciano., *et al*. [9] have showed that the presence of antioxidants such as ascorbic acid effect some contribution to the biochemical efficiency of apples and corresponding fruit products. However, it was concluded that vitamin C only account for a small percent of the total antioxidant activity of apple juices and that polyphenols are higher in terms of contributions to the overall total antioxidant activity [9,16].

The chemical characteristics of apple juice are well balanced and may vary depending on variety, production region and production system adopted [17]. Juices obtained from apples provide a good composition in terms of sugar and acid content, presenting a taste that is mostly appreciated by consumers. With respect to calorie intake, they are moderately energetic. Feliciano., *et al*. [9] reported that the water composition of apple fruits is over 85% and this is where minerals such as potassium, magnesium, calcium and sodium as well as some trace elements are dissolved in. The most abundant vitamins in apple juices are the water-soluble vitamins, although it is evident that a large diversity of vitamin activity is present [9].

Citrus juices are rich sources of soluble sugars, ascorbic acid, folic acid, minerals, as well as phytochemicals [6,18,19]. Sugars have been identified to be the major constituents of the nutrient composition of orange juices [20]. The sugar composition of orange juice is synonymous with its content of soluble solids. Sucrose, a disaccharide, provides the highest contribution to the total sugar concentration of juices from orange which has been observed to vary according to species, varieties, climate, mode of processing and farming systems [20].

The use of organic farming systems in the cultivation of food crops has been seen as one of the fastest growing sub-sectors in the agricultural industry. Pacini., *et al*. [21] reported that organic farming can be considered as "a holistic view of agriculture that aims to reflect the profound interrelationship that exists between farm biota, its production and the overall environment". The main focus of organic farming therefore is to direct the food production cycle towards ensuring social, health, economic and ecological sustainability. This is opposed to conventional farming practices which permit the wide application of chemicals such as herbicides, fertilizers and pesticides with or without the incorporation of natural products such as plant residues, manures and composts in the food production cycle [6].

The demand for organic food produce as well as products so obtained (including fruit juices) has continued to increase rapidly, especially in developed countries. Many consumers of fruit products are thus willing to pay even higher prices for products from organic sources with the claim that they are more nutritious, healthy and better-tasting [22]. It is thought that due to the lack of pesticide use under the organic farming system, plants could exhibit higher activity as a result of improved synthesis of biologically active compounds produced in defense against stress [6].

A number of reviews contrasting organic with conventionally grown fruit products for quality claims has been conducted [22]. Many of these studies conducted to compare the inherent characteristics of taste, organoleptic properties and nutritional value of fruit juices from organic and non-organic farming systems have reported no consistent differences between organic and conventional fruit products. However, majority of the well-designed studies that has found differences support the use of products from organically grown plants. Surveys conducted in relation to product quality indicate that organic plant foods are considered to be more beneficial to both health and environment, and with better organoleptic properties than their conventionally-grown counterparts [22] but sufficient scientific evidence to corroborate this claim is scarce [23]. Reports from the findings of Brandt and Molgaard., [24] have suggested that the phytochemical component of organically grown crops could be 10 - 50% more than that of conventional crops. This claim was contradicted by reviews from Bourn and Prescott., [25] who reported higher phytochemical concentrations for conventional crops as against their organic counterparts.

Therefore, in a bid to create a clear distinction between organic and conventional fruit juices, scientific studies involving an assessment of their nutritional and chemical characteristics is therefore necessary so as to provide reliable information on their quality. Also, considering the prevalence of orange and apple juices in human diet, adequate information on their chemical characteristics is deemed important. Furthermore, available literature comparing the chemical characteristics of juices obtained from apples and oranges raised under different farming systems is also scarce.

The main objective of this work therefore is to compare the quality attributes and chemical characteristics of freshly squeezed juice from orange and apple produced under different farming systems. Parameters assessed in this comparison study included total sugars (soluble solids), total ascorbic acid content, acidity, folic acid content, fructose, glucose and sucrose contents as well as some micro and macro minerals.

Materials and Methods

Chemicals, Reagents and Standards

All the chemical reagents and solvents used throughout the period of analysis were of analytical grade. D-glucose, maltose, sucrose and D-fructose, Hydrochloric acid (HCl), hydrogen nitrate (HNO_3), deacon 90 detergent, Carrez I and II solutions, standard solutions of sodium, potassium, zinc, copper, magnesium, calcium and iron were all sourced from Fisher Scientific (Leicestershire, UK). An assay kit containing sodium phosphate/citrate buffer, 3-(4,5-dimethylthiazolyl-2)-2,5-diphenyltetrazolium bromide [MTT], 5-methylphenazinium methosulphate [PMS] and ascorbate oxidase spatulas was used for the *in vitro* determination of L-ascorbic acid. For folic acid determination in vitro, an assay kit containing a microtiter plate with wells (coated with antibodies against folic acid), standard solutions of folic acid in aqueous solution, peroxidase conjugated folic acid, substrate/ chromogen solution (with added urea peroxide), stop solution of 1N sulfuric acid and sample dilution buffer (Phosphate Buffer Solution) was employed. Both kits were ordered from R-Biopharm Group (Darmstadt, Germany) stored at a temperature of between 2 and 8°C before use and were used according to the manufacturer's instructions.

Sample selection

The juice samples for this study were extracted from healthy oranges and apples produced under organic and conventional farming systems, purchased from a local supermarket in Glasgow Stores Ltd, Glasgow at different times during the 2014/2015 winter period.

The organic and non-organic oranges were of the same variety (Navel) but originated from Spain and Egypt respectively while the organic and non-organic apples were of different variety and origin [Braeburn (Germany) and Herefordshire (UK)].

Juice Extraction

Orange Juice

After peels were removed from the oranges used, the juice was extracted after cutting the fruit in quarter and subjecting these to an Andrew James power juicer (Bowburn, Co Durham, UK).

Apple Juice

Juice from apple was obtained by direct extraction after the fruits had been thoroughly washed with distilled water, using similar technique as for orange juice extraction in above.

For most of the experiment carried out, freshly extracted juice was used especially when the vitamins were determined so as to avoid alteration in the chemical composition. The juice obtained from both fruits was passed through a Whatman number 2 filter paper so as to separate the pulp and seeds that may be present in it and the volume measured using a measuring cylinder before being used for the assays.

Analytical Procedures

Determination of Total Soluble Solids

The total concentration of soluble sugars present in both organic and non-organic juices from orange and apple was measured directly in units of Brix using a Pocket Refractometer (Bellingham and Stanley Limited, North Farm Industrial Estate, Tunbridge Wells, Kent, England).

This instrument contained a rugged exterior of metal and plastic which serves to protect the optical lenses, prisms and mirrors inside. At one end of the optical refractometer is a viewing hole which was used for viewing the results while the other opposite end contained a slide with a lid where about 30 µL of each sample was placed during the course of determination and viewed through the viewing hole.

The sugar level was determined by noting the point on the scale where the two colors of blue and white intersect on the index. Readings given on the index by the instrument were dependent on the amount of sugar present in the sample. Evaluation of the percent total sugar concentration of clear filtrate of juice samples was carried out at a temperature of 20°C.

Determination of Acidity

A Seven Easy pH meter (Mettle Toledo Group, Schwerzenbach, Switzerland) was used in the determination of the concentration of hydrogen ions [H^+] in all analyzed juice samples and this was used as an index for reporting the acidity of samples.

The electrode of the pH meter was dipped into all samples analyzed after the instrument was standardized with appropriate standards with known pH of 4, 7 and 10. However, the electrode was rinsed with distilled water before proceeding from one sample to the other. Readings on the display unit of the meter were allowed to be stable before being recorded so as to ensure accuracy.

Determination of Glucose, Sucrose, Maltose and Fructose Sugars

The experiment was conducted with the aid of the High Performance Liquid Chromatography (HPLC) purchased from Conex chromatography system Ltd (Burnside Farm, Sommers Lane, Blaidrummond, UK).

The HPLC instrument used was equipped with a refractive index detector (waters 2410) with a 515 isocratic pump while the separation was achieved through a column containing 80% acetonitrile and 20% water and thermostated at 30°C.

Before the analysis was conducted, the HPLC instrument used was standardized by injecting 20 µL of standard solution prepared by weighing 1g each of glucose, sucrose, maltose and fructose into a beaker and stirred properly using magnetic stirrer (Scientific and Educational Aids Ltd., Windsor, Berks) so as to allow for complete dissolution of the component standard sugars in distilled water. This solution was then further reconstituted with distilled water (1 in 100) in a volumetric flask and 2 mL was thereafter transferred to sterile bottles until ready for injection.

Clear filtrates (1 mL each) of both the organic and non-organic juice samples that have been screened through a Whitman number 2 filter paper were pipetted into a 100 mL volumetric flasks. In order to improve clarity of juices and eliminate turbidity, Carrez solutions I and II were added to each volumetric flask at the rate of 2 mL each of Carrez solution and reconstituted to the mark with distilled water, followed by mixing by repeated inversions after stopper must have been replaced. These were stored in sterile bottles until analysis was conducted.

All samples were allowed to pass through an HPLC filter before injection with a syringe. The standard sugar solution was injected three times and their chromatograms displaying both retention times and peak areas were recorded. However, juice sample were injected twice.

Chromatographic peaks for the respective sugars were identified and their retention times were used to generate their peak areas from the results obtained from the complete injection of both standard sugar solutions and each juice sample. The retention times of the different sugar components in the chromatograms of juice samples were compared against those obtained from the injection of known standards.

Calculation of concentration (expressed in g/100 mL) of glucose, sucrose, maltose and fructose sugars in both organic and non-organic orange and apple juices was carried out by matching the peak area of each standard sugar with that for the corresponding sugar in each of the juice samples. This value was approximated to the original sample dilution factor of 100.

Determination of Vitamin C (L-Ascorbic Acid)

L-ascorbic acid content of juice samples from organic and non-organic oranges and apples was determined using the colorimetric method.

The principle employed in the conduct of this experiment is based on the fact that L-ascorbic acid and some more reducing substances are capable of reducing the tetrazolium salt (MTT) in the presence of the electron carrier (PMS) at a pH of 3.5 to a formazan.

For the specific determination of L-ascorbic acid, in a blank assay only the L-ascorbic acid fraction as part of all reducing substances present in the sample is believed to be oxidatively removed by ascorbic oxidase in the presence of oxygen from the air. The dehydroascorbate formed does not react with MTT/PMS.

The absorbance difference between each sample and that of the corresponding blank is assumed to be equivalent to the quantity of L-ascorbic acid in the sample. The MTT-formazan is the measuring parameter and is determined by means of its light absorbance in the visible range at 578 nm.

In conducting the *in vitro* assay, the bottle with the solution containing MTT and sodium phosphate/citrate buffer at an approximate pH of 3.5 was warmed up to 37°C in a Size 2 Gallenkamp Economy incubator (Fisons Plc Scientific Equipment Division, Leicestershire, UK) and 1 mL was pipetted into each cuvette. Contents of each cuvette were then diluted by adding 1 mL of distilled water into each of them. Freshly extracted clear solutions of all juice samples were measured at the rate of 1 mL each into all cuvettes. Ascorbic acid oxidase spatulas were then placed on the cuvettes containing the sample blank. Contents of each cuvette were therefore allowed to mix by stirring with a plastic spatula followed by incubation at 37°C for 6 min in an incubator. During this period of incubation, the contents of the sample blank assay were sufficiently stirred to allow for air mixing every 2 min for 5 sec using the ascorbic acid spatulas. Thereafter, the absorbance (A_1) of the sample blanks as well as corresponding samples were read using a Jenway 6305 spectrophotometer (Bibby Scientific Ltd, Dunnow, Essex, UK) set at a wavelength of 578 nm.

After taking the absorbance readings, the reaction was started by the addition of 0.1 mL of PMS solution which was carefully weighed out using a micro pipette into all cuvettes and the contents were mixed and allowed to stand for exactly 15 min in an incubator operated at a temperature of 37°C. The cuvette holder was covered with an aluminum foil at this stage because the reaction is sensitive to light after the PMS must have been added.

The absorbance (A_2) of all sample blanks and respective samples were immediately read one after the other and values were recorded. The absorbance differences (A_2-A_1) for both sample blank and sample of all juices analysed was calculated and the difference between calculated values for each sample and the corresponding blank noted.

The concentration of L-ascorbic acid in the sample was calculated based on the extinction coefficient of MTT-formazan using the formula:

$$c = \frac{V \times MV}{\varepsilon \times d \times v} \Delta A [mg / l]$$

where V = Final volume [mL]

v = Sample volume [mL]

MW = Molecular weight of sample [mg/mol]

D = light path [cm] and

έ = extinction coefficient for MTT-formazan at 578 nm = 16.9 [$1 \times mmol^{-1} \times cm^{-1}$]

Therefore, to obtain values for the concentration (c) of L-ascorbic acid in the samples analyzed

$$c = \frac{2700 \times 0.17613}{16.9 \times 1.00 \times 0.10} \times \Delta A = 281.4 \times \Delta A [mg\ L - ascorbic\ acid\ \ per\ sample\ solution]$$

$$\Delta A = [A_2 - A_1] sample - [A_2 - A_1] sample\ blank$$

Determination of Folic Acid

The quantitative analysis of folic acid content of the fruit juice samples was conducted using the enzyme immunoassay method.

Samples for this assay were prepared by diluting clear juice filtrate (that have been screened through Whattman number 2 filter paper) in 100 mL volumetric flasks and then reconstituting with distilled water. Samples were used immediately after preparation without storage.

The experiment commenced with the insertion of a sufficient number of wells into the microwell holder for all standards and samples analysed. All wells were well labeled and then 50 µL of each standard solution (in the folic acid kit) and reconstituted juice samples was added to separate wells, using a new pipette tip for each standard or sample.

To each well, 50 µL of enzyme conjugate solution was also added and contents were mixed gently by shaking the plates manually. The plates were then incubated for 15 min at room temperature. The liquid was poured out of the wells and the microwell holder was tapped upside down vigorously (three times in a row) against an absorbent paper so as to ensure complete removal of liquid from the wells.

With the aid of a multi-channel pipette, the wells were filled with 250 µL of deionized water. The wells were emptied again and all remaining liquid evacuated. The washing step was repeated three more times so as to allow for proper washing.

After the washing step, 100 µL of stop solution was then added to each well, mixed gently by manual shaking of plates and was incubated for 10 min at room temperature in the dark. The plates were mixed manually and gently by shaking after 100 µL of the stop solution have been added to each well.

The absorbance was measured using an Epoch microplate spectrophotometer (Bio Teck Instruments Inc., Highland Park, Winooski, Vermont, USA) set at a wavelength of 450 nm.

In calculating for the folic acid concentration in the sample,

$$\frac{absorbance\ standard\ (or\ sample)}{absorbance\ zero\ standard} \times 100 = \%\ absorban$$

The zero standards were thus made equal to 100% and the absorbance values expressed in percentages of the zero standard. The values calculated for the standards were then entered in a system of coordinates on semi logarithmic graph paper against the folic acid concentration [μL^{-1}].

The concentration read from the standard curve on the graph was then multiplied by the dilution factor of 100 in order to derive the actual folic acid concentration contained in the sample.

Mineral Analysis

Five grams of each freshly extracted juice from both organic and non-organic orange and apple was weighed into separate crucibles and labeled correctly.

Crucibles were then placed in an oven (Scientific Laboratory Supplies, UK) maintained at 105°C for 2 h before being transferred to a Gallenkamp muffle furnace (Tactical 308) maintained at 550°C for 3 h for ashing.

After this period, the crucibles were allowed to cool for 15 min in a desiccator and then weighed. Ash from each sample was thereafter left to dissolve in dilute solutions of nitric acid before being used for the assay.

Determination of Sodium and Potassium Concentrations

The method adopted involved the dilution of the fruit juice samples with water and acid, followed by filtration and finally aspiration directly into the instrument.

A Jenway Flame Photometer (Bibby Scientific and Educational Aids (ABR) Ltd. Windsor, Berks) was used in determining the concentrations of both sodium and potassium in the orange and apple juices obtained from conventional and organic farming systems.

All glass wares used for the mineral analysis were immersed into a 5% Decon 90 solution for 24 h, rinsed thoroughly with distilled water and then left to dry at a temperature of about 35°C before usage.

In this analysis, 2, 4, 6, 8 and 10 ppm each of sodium and potassium standard solutions containing nitric acid were prepared by dilution with appropriate quantities of distilled water. Distilled water served as the blank solution for control.

To 10 mL of the already prepared samples, 50 mL of deionized water was added and the resulting solution was filtered through a Whattman Number 2 filter paper into a 1-Litre capacity volumetric flask and diluted to the mark with deionized water. The stopper was replaced and the sample solution was mixed cautiously by inversion of the flask up to three times. Samples were kept refrigerated in sterile bottles until when utilized for the analysis.

The flame photometer was set up for the determination of sodium firstly as was outlined in the instruction manual. The instrument was set to zero with the blank solution. Prepared standard solutions of sodium were then aspirated and their stable readings were recorded.

A graph of the reading against standard concentration was plotted. Solutions of all juice samples were aspirated and readings recorded. From the graph plotted earlier, the concentration of sodium in each sample was read off and recorded.

In order to proceed in the analysis for potassium concentrations in the fruit juices, the filter position was adjusted in order to select the potassium filter and the same steps were applied as for sodium determination. Potassium concentrations were observed to be outside the range of standards for all samples analysed and samples were further diluted to 1:10 for assay in the flame photometer.

The concentration of sodium and potassium obtained from the graphs were multiplied by dilution factors of 100 and 1000 respectively and the results were expressed in ppm or mg/L of these mineral elements in the original fruit juices.

Determination of Calcium, Iron, Copper and Zinc Concentrations

The AAnalyst200 Atomic Absorption Spectrophotometer (Perkin Elmer Ltd., Beaconfield, Bucks, UK) was used in the determination of these minerals. This instrument has an in-built touch screen and burner system and constitutes a double beam atomic absorption spectrometer for flame analysis. It is capable of performing single element determination in an automated capacity.

The method involved hydrolyzing the juice samples with a strong acid (HNO_3 or HCl) depending on the acid content of the standard used and reconstituting with water. In the case of calcium determination, 0.5% lanthanum chloride solution was added.

For the preparation of standard solutions, 1, 2, 3, 4 and 5 ppm of calcium standards were prepared. Standards for copper determination were prepared in a similar way as calcium, except that lanthanum chloride was not used. For zinc, 0.2, 0.4, 0.6, 0.8 and 1.0 ppm of standard solution were used while for iron, this was 1, 2, 3, 4, 5 and 6 ppm.

In preparing the samples for assay, 10 mL of HNO_3 was added to 20 mL of each juice sample in a 100 mL volumetric flask and the volume was made up to mark with deionized water.

The stopper was then replaced and contents of the flask were mixed by inversion and shaking slowly and cautiously before it was screened through a Whattman number 2 filter paper to allow for the removal of any solid particle that may be present in preparation for analysis. Samples were transferred to sterile bottles and refrigerated at 3°C until use.

Both diluted samples of hydrolyzed standards and juices were aspirated into the atomic absorption spectrophotometer and the values were recorded. The concentrations of calcium, iron, zinc and copper present in each of the juice sample detected by the instrument were then adjusted to the dilution factor of 2. The results were expressed in ppm.

Statistical Analysis

All experiment was conducted in triplicates except indicated otherwise. Data obtained from this study were analysed using the IBM SPSS Statistics version 21.0 (released in 2012 in Armonk, New York) and comparison between and among means was done using the Student's t-test and means were declared statistically different at a confidence level of 95%.

Results and Discussion

Some Physico-chemical characteristics of juices from organic and conventionally grown orange and apple are presented in (Table 1).

Characteristics	Orange		Apple	
	Organic	Conventional	Organic	Conventional
Weight (g)/fruit	184.75 ± 7.35	209.92 ± 5.24	133.06 ± 3.71	118.02 ± 2.93
Volume of juice/fruit (mL)	79.12 ± 2.14	82.51 ± 4.36	88.10 ± 1.22	86.85 ± 1.41
% juice/fruit	42.84 ± 1.43	39.35 ± 1.52	62.71 ± 0.16	67.38 ± 0.15
pH of juice	4.03 ± 0.02	3.96 ± 0.03	3.34 ± 0.01	3.69 ± 0.02
Total sugars (%Brix)	10.78 ± 1.28	11.61 ± 1.09	12.8 ± 1.12	13.56 ± 1.07

Table 1: *Some Physico-chemical characteristics (mean ±standard deviation) of freshly extracted juices of organic versus conventionally grown orange and apple fruits.*

On the basis of mean weight per fruit from which juice samples were extracted, oranges grown conventionally were observed to be heaviest (209.92g) while conventional apples were lightest (118.02g). Both the organic and non-organic fruits of either apple or orange were not significantly different in terms of weight. However, there was a significant difference between the mean weights of orange and apple fruits from either organic or non-organic sources.

The results also showed that the total soluble solids contained in the samples analysed was greater for juice extracted from conventionally grown sources (between 11.6 and 13.56°Brix) than their organic counterparts, which was between the range of 10.78 and 12.8°Brix, although this was not significantly different. However, apple juices revealed more percent soluble solids (between 12.8 and 13.56°Brix) than juices obtained from orange (10.78 – 11.6°Brix) and this was also not significant different at $p < 0.05$. Juice obtained from conventional apples was observed to contain highest amounts of total soluble solids (13.56°Brix) among all the juice samples analysed while the least concentrations were detected in organic orange juice (10.78°Brix). There was generally no significant difference between the total soluble solid concentrations of conventional versus organic juice of the same fruit. Also, in comparing the organic and non-organic juice of apple fruits against their orange counterparts, there was no significant difference.

Apple fruits were found to contain more juice volume per fruit and percentage juice per fruit than orange juices and this was observed to be higher (88.10 mL) in those obtained from organic sources. There was however no significant difference in the volume of juice produced between the organic and non-organic counterpart of the same fruit species. A significant difference was noticed between the percent juice obtained per organic or conventional fruit species and their counterparts. The lowest juice per fruit was obtained from conventional oranges. In terms of pH, apple juices were observed to be more acidic (3.34 – 3.69) than juices from orange (3.96 – 4.03) and acidity was found to be higher in those from organic sources for orange and conventional sources for apples. Orange and apple fruit juices are generally acidic in nature and the values of pH for all samples were not significantly different.

The % Brix concentrations obtained from this experiment using a hand held optical refractometer for both organic and non-organic juices from orange and apples are in agreement with those detected by Serpen., *et al.* [3] in which he observed that the total sugar concentration of juice from orange and apple fruits are usually in the range of 8 – 13 % and 11 – 16 % respectively. Results obtained for total sugars in both organic and non-organic orange juice also agrees with the findings of Kelebek and Selli [20] in which he concluded that the total sugar concentration of Dortoyl yeril orange (*Citrus sinensis L. Osbeck*) juice is between 9.51 and 12.58%.

The detected pH values (between 3.96 and 4.03) of juice from orange species analysed were observed to be slightly higher than that reported by Kelebek and Selli [20]. Both results obtained for pH and °Brix in organic and non-organic juices from apple species were lower than that reported by Lee., *et al*. (2013) for custard apple which had average pH and total soluble solid values of 5.77 and 23°Brix respectively.

The differences observed in the total soluble solid content between apple and orange fruits as well as between fruit of the same species under the same or different farming system could be attributed to variation in degree of maturity influenced by flowering rate and time. However, all pH values were within the range reported for tropical fruit species (3.2 to 6.0) by Lee., *et al*. [8]. Organic acid concentrations are known to affect pH values of fruits and concentrations decrease during maturation phase of crops due to respiration [8]. Abnormal values for acidity have been identified to affect the activities of the digestive system [4].

(Table 2) shows the individual and total sugar concentration obtained using HPLC in freshly extracted orange and apple juices obtained from organic versus conventional sources. From the results so obtained, sucrose content was consistently higher in all analysed samples, followed by the concentration of fructose and then glucose. Maltose sugar was not detected in any of analysed samples. Juice extracted from conventionally grown apples was observed to contain highest in terms of sucrose concentration (5.66 g/100 mL) while the lowest concentration of 4.21 g/100 mL detected was in juice obtained from non-organic oranges. Glucose concentration was higher in juice obtained from conventionally grown fruits as compared to their organically raised counterparts. Concentration of glucose in all juices analysed was highest (3.11 g/100 mL) in oranges grown conventionally and the least was observed in organic apple juice (2.59 g/100 mL). The highest concentration of fructose sugar (4.81 g/100 mL) was detected in juices extracted from non-organic apples. Both organic and non-organic orange juices were observed to contain lower amounts of fructose concentrations (3.12 – 3.39 g/100 mL) than their apple juice counterparts (4.3 – 4.81 g/100 mL). Again, conventional apple juice was highest in total sugar concentration and lowest amounts detected in juice extracted from organic orange.

Sugar (g/100mL)	Orange		Apple	
	Organic	Conventional	Organic	Conventional
Sucrose	4.47 ± 0.33	4.21 ± 0.12	5.53 ± 0.06	5.66 ± 0.13
Glucose	2.79 ± 0.16	3.11 ± 0.04	2.59 ± 0.15	2.83 ± 0.07
Fructose	3.12 ± 0.11	3.39 ± 0.08	4.30 ± 0.07	4.81 ± 0.03
Maltose	N. D	N. D	N. D	N. D
Total	10.38 ± 0.20	10.72 ± 0.06	12.42 ± 0.09	13.30 ± 0.23

Table 2: *Concentrations of glucose, fructose, maltose and sucrose (mean ±standard deviation) in freshly extracted orange and apple juices obtained from organic and non-organic sources.*

N.D – Not detected.

From the results obtained and analysed statistically, it can be concluded that a significant difference exists in the fructose concentration of juices extracted from orange versus apple fruits raised under the same or different farming system. The glucose concentration of organic orange juice was significantly different from that of organic apple juice. For sucrose, differences were not significant in all analysed samples.

The total sugar contents of all juice samples obtained using the HPLC instrument were however slightly lower than those obtained while using the Bellingham and Stanley hand-held optical refractometer. This may be due to the highly selective and sensitive nature of the HPLC in the analysis of food components, thereby producing more accurate results [26].

The sugar content of fruits determines its degree of sweetness which ultimately contributes largely to the overall nutritional quality of fruit juices. The significant differences observed between the sugar content of fruits of the same or different species and produced under the same or different farming systems could be largely attributed to the variation in the enzymatic activities of fruits which has been known to affect sweetness [8] as well as the differences in the cultivar, degree of maturity, storage time and conditions, environmental, soil and climatic conditions of fruits utilized in conducting the experiment [27].

Also, it has been reported that fruits having a high exposure to sunlight tend to contain more total sugars than those located in the shaded region of fruit trees [9]. Maltose was not detected in all juices and this is because it is a disaccharide sugar formed from the hydrolysis of starch by the enzyme, amylase. Fruit juices are low or devoid of starch and the enzyme amylase. The starch content of fruit juices decreases with ripening as the concentrations of reducing and non-reducing sugars increases during this phase. Report from this study on the individual composition of fruits comprising of the three sugars, sucrose, glucose and fructose corroborates the findings of Kelebek and Selli [20].

Results showing the ascorbic acid as well as folic acid concentrations of orange and apple juices obtained from organic versus conventional sources are presented in (Table 3).

Vitamin	Orange		Apple	
	Organic	Conventional	Organic	Conventional
Ascorbic acid (mgL^{-1})	480 ± 0.33	390 ± 0.28	220 ± 0.16	190 ± 0.19
Folic acid (μgL^{-1})	72.52 ± 0.08	84.23 ± 0.04	61.29 ± 0.05	76.14 ± 0.01

Table 3: *The ascorbic and folic acid contents (mean ± standard deviation) of freshly extracted juices of organic versus conventionally grown orange and apple fruits.*

From this analysis, mean ascorbic acid concentration was observed to be higher (between 390 and 480 mg/L) in juices extracted from orange than those obtained from apple fruits (between 190 and 220 mg/L). The lowest amount of ascorbic acid was detected in conventionally grown apple juice (190 mg/L) while juice from organic orange was highest (480 mg/L) in terms of ascorbic acid concentration. Juices obtained from organic apple versus organic orange fruits differ in their ascorbic acid composition and this was observed to be significant at $p < 0.05$. Similarly, there was a significant difference in ascorbic acid concentration between juices from non-organic apple fruits and their counterparts from orange. Variations in vitamin C contents between juice obtained from both the organic and non-organic fruits of the same species (orange or apple) were also observed to be significant.

Generally, juices extracted from fruits grown conventionally were observed to contain higher concentrations of folic acid than those from organic sources and differences were significant at $p < 0.05$. The highest folic acid concentration was detected in conventional orange juice (84.23 μg/L) while lowest amounts were observed in juice extracted from organically grown apples (61.29 μg/L). The folic acid concentrations of the juices analysed were observed to follow the same trend as that for ascorbic acid with significant differences existing between the organic and conventional samples of both fruit species. However, it can be concluded from this analysis that the ascorbic acid concentration of juice is usually greater than the folic acid concentration.

The variations observed in the ascorbic acid and folic acid concentrations of juices extracted from the same or different fruit species produced under the same or different farming system could largely be due to the storage conditions of the fruits, variety, ripening conditions, storage time, season of harvesting, environmental factors, mode of transportation from farm to shop which may lead to degradation of the vitamin composition depending on the associated temperature. Fruits exposed to high temperatures usually reduce in terms of their vitamin quality and composition (Santini., *et al.*2014). Tree positioning may also have exerted effect on the variation of vitamins as some of these vitamins are readily oxidized in certain conditions (for example, exposure to high sunlight). The application of herbicides, pesticides and fertilizers under the conventional system may also account for the lower values detected in juices of orange and apple fruits for folic acid and ascorbic acid concentrations as against their organic juices. These chemicals may affect vitamin concentrations in fruits and juices.

Orange juices are naturally higher in terms of ascorbic acid and folic acid concentrations than their apple counterparts, although the reason for this is not well known. Orange juices provide a major source of vitamin C in the diet of humans since this vitamin cannot be produced nor stored in adequate amounts needed by the body.

The impact of farming systems on the concentrations of some macro- as well as micro-minerals in both freshly extracted orange and apple juices as determined from this assay is as presented in (Table 4).

The results showed that the micro- and macro-mineral compositions of orange juices are higher than that of apple juice. Highest amounts of sodium, potassium, calcium and copper were detected in juices extracted from organically grown oranges as against other samples tested. Among the minerals tested, the highest mineral element detected in all juice samples was potassium while the lowest observed was copper. Mean potassium concentrations were within the range of 1490.58 and 1716.35 ppm, with the lowest concentration detected in juices extracted from organically grown apples. Mean sodium concentrations were observed be within 176.63 and 436.52 ppm in all juices, with the lowest value obtained for organic apple juice. However, conventional orange juice was observed to contain the highest mean concentration (1.38 ppm) of zinc while iron concentration was highest (1.68 ppm) in juice obtained from conventionally grown apples. Lowest mean amounts of copper (0.26 ppm) and calcium (1.76 ppm) were detected in juice from conventional apples while highest concentrations of copper and calcium were both observed in organically grown oranges. Generally, concentrations of iron, copper and calcium were observed to be low in all analysed juice samples. In comparing the micro- and macro- mineral content of samples, it can be concluded that a significant difference exists between organic and non-organic juices of the same or different fruit species for potassium, sodium, calcium, iron and copper. However, juices from orange and apple produced organically were observed to have no significant difference in their concentrations of zinc. The reverse was true for juices extracted from conventionally grown fruits.

Mineral element (ppm or mg/L)	Orange		Apple	
	Organic	Conventional	Organic	Conventional
Sodium	436.52 ± 0.02	209.84 ± 0.01	176.63 ± 0.03	239.20 ± 0.02
Potassium	1716.35 + 0.03	1668.27 ± 0.05	1490.38 ± 0.03	1586.54 ± 0.01
Calcium	6.33 ± 0.12	5.71 ± 0.16	2.47 ± 0.23	1.76 ± 0.15
Iron	1.52 ± 0.08	1.23 ± 0.11	0.97 ± 0.13	1.68 ± 0.35
Copper	0.84 ± 0.01	0.63 ± 0.04	0.53 ± 0.01	0.26 ± 0.02
Zinc	1.33 ± 0.10	1.38 ± 0.22	1.06 ± 0.05	1.08 ± 0.03

Table 4: *Concentrations of some macro- and micro- minerals (mean ±standard deviation) in freshly extracted juices of organic versus conventionally grown orange and apple fruits.*

Minerals are essential in meeting the essential nutritional needs of humans. They regulate water retention and maintenance for the activation of various metabolic processes within the body [4]. Sodium and potassium (main macro-minerals present in fruit juices) act as electrolytes, assisting in regulating the composition of body fluids and cells while phosphorus and calcium (also macro-minerals) perform chief structural roles in the body and are all needed in large quantities. Calcium, phosphorus and magnesium are chief constituents of bones and teeth. Trace minerals function to enhance various enzymatic reactions in the body often by acting as catalysts. They are therefore needed in smaller quantities. The mineral composition reported in this study for sodium and potassium are higher than those reported in canned, sachet and packaged juices which were within the range of 185.7 and 335.0 ppm for sodium and 54.5 and 412.0 ppm for potassium. This is an indication that freshly extracted juices are more in terms of mineral composition. The processing and packaging of these juice samples may have affected their mineral concentrations. Heat treatment may be responsible for the loss of mineral nutrients recorded.

Variation in the composition of some micro- and macro- minerals detected in this study between juices extracted from the same or different fruit species under conventional or organic farming systems may be due to differences in cultivar, production system used, maturity state at harvest, soil and climatic conditions [28].

Conclusion

Considering the frequent consumption of products produced from juice extracted from orange and apple fruits grown either in organic or non-organic farming systems on a global basis and its positive impact on humans and the economy, there is need to constantly monitor the quality of freshly extracted juice before it is processed further into these standard products for the market.

This is equally important as the final product quality of commercial fruit juices from both organic and non-organic sources depends largely on the quality of the original freshly squeezed juice with which they are produced.

Also, food products processed from organic sources have received good patronage from consumers as compared to their organic counterparts without them having adequate knowledge of their nutritional characteristics and compositions. Proper understanding of the chemical characteristics and nutritional composition of both organic and conventional fruit juices would enhance their processing attributes into various food products.

From the results obtained from this study, it can be concluded that although there is slight variation in terms of some Physico-chemical characteristics as well as the nutritional quality between orange and apple fruit juices obtained from either organic or conventional farming systems, using such indices as total soluble solids, individual sugar concentrations, ascorbic and folic acid concentrations, some macro- as well as micro- mineral compositions, acidity, and % juice per fruit, these variations are mostly significant when comparing juices from different fruit species. Some of these differences are in favour of juices from organic fruits while others favor conventional juices. In some cases, as was observed in terms of zinc concentrations, no significant difference was detected between the organic juices of the same fruit.

Generally, the variations in the nutritional quality and chemical characteristics of freshly squeezed juices could be attributed to several factors including species, variety, farming system adopted, environmental, soil and climatic conditions, time of harvesting, length of storage, extraction technique, storage conditions, incidence of diseases and pests as well as origin of fruits.

Consumers who have keen interest in choosing between fruit products obtained from plants grown under different farming systems are particularly favored in these findings as this information will enable them make informed decisions and assist in the formulation of dietary guidelines.

However, we wish to recommend that further research on the amino acid profile, antioxidant activity, organic acids and phenolic acids of organic and conventional juices from orange and apple is necessary for more effective comparison between and among them.

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