Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension
Volume 21 Number 4 (October 2022) pp. 23 - 27
ISSN 1119-7455

THE PHYTOCHEMICALS, ANTIOXIDANT ACTIVITIES AND NUTRITIVE QUALITIES OF SOME SELECTED TOMATO PASTES SOLD IN UMUAHIA METROPOLIS, ABIA STATE, NIGERIA

***[1]Ukom A.N., [1]Obikwelu C.L., [2]Okparauka I.I. and [3]Ogbu O.T.**

[1]Department of Food Science & Technology,
Michael Okpara University of Agriculture, Umudike, Nigeria
[2]Biochemistry Unit, Science Laboratory Technology,
Akanu Ibiam Federal Polytechnic, Ebonyi State, Nigeria
[3]Department of Agricultural Technology,
Enugu State Polytechnic, Iwollo, Enugu State, Nigeria

*Corresponding author's email: ukom.anthony@mouau.edu.ng

ABSTRACT

Tomato paste contains antioxidant compounds which act against free radical actions in the body and prevents oxidative damage and boost the physiological health of consumers. However, information on the phytochemicals, antioxidant activities and nutritive qualities of tomato pastes sold in Umuahia Metropolis is scarce. This work was undertaken to fill this gap on five selected commercial tomato pastes sold in Umuahia Metropolis, Abia State, Nigeria namely, Sonia (SON), Gento (GEN), Superdelicieux (SUP), Star (STA) and Clappa (CLA). The physicochemical and antioxidant activity parameters were determined by standard methods. The results showed that lycopene (4.20 mg 100g^{-1}), vitamin C (12.76 mg 100g^{-1}) and vitamin A (1.43 mg 100g^{-1}) were significantly ($p < 0.05$) higher in STA tomato paste. β-carotene (3.02 mg 100g^{-1}) and vitamin E (11.14 mg 100g^{-1}) were significantly ($p < 0.05$) higher in CLA tomato paste, while phenol was significantly ($p < 0.05$) higher in SUP tomato paste. The chemical composition revealed that total solid ranged from 28.91 (STA) to 31.67% (SON), reducing sugar ranged from 8.78 (SUP) to 16.16% (CLA), while titratable acidity ranged from 0.21 (SON) to 0.31% (GEN) and pH ranged from 4.27 (CLA) to 4.47 (STA), respectively. Minerals concentration for Ca ranged from 1.79 (CLA) to 2.86 mg 100g^{-1} (SON), Mg from 8.57 (SON) to 13.61 mg 100g^{-1} (STA), K from 7.81 (SON) to 30.44 mg 100g^{-1} (STA), Na from 12.21 (STA) to 15.59 mg 100g^{-1} (CLA) and Fe from 0.82 (STA) to 1.89 mg 100g^{-1} (SON). Stronger antioxidant activity was observed in SON paste for 1,1-diphenyl-2-picryl (DPPH) (62.07%), 2,2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) (41%) and Ferric Reducing Antioxidant Power (FRAP) (47.88%). The results revealed that concentration of nutritive quality was specific to individual tomato paste, but SON possessed stronger antioxidant activity scavenging power than other tomato pastes. From the results of physicochemical and antioxidant activity of these tomato pastes, they may be used to boost physiological performance against degenerative diseases.

Key words: Umuahia metropolis, tomato paste, physicochemical properties, antioxidant activity, health benefits

INTRODUCTION

Tomato (*Solanum lycopersicum*) is an annual vegetable commonly consumed world-wide. It was reported that over 170 million tonnes of tomato were produced in the world in the year 2014 (FAO, 2014). Among sub-Saharan African countries, Nigeria is rated as the highest producer and consumer of tomato and tomato products (Eleyowo and Amusa, 2021). Tomato is consumed in salads as paste, puree, sauce or after cooking (Ray *et al*., 2011). Due to its high perishability, much wastage is recorded in fresh tomato fruit yearly. Processing operations such as concentration and heat treatment have been applied to ensure their availability all year round. Tomato, either as fresh tomato fruits or as processed forms (such as tomato paste, tomato sauce and ketchup) possesses high nutritional values, due to its vitamins, folates, carotenoids and phenolic compounds (Khachik *et al*., 2002). Tomato contains other natural antioxidants, including ascorbic acid and phenolic compounds (phytochemicals) (Usha *et al*., 2013). Typical phytochemicals found in tomato are phytoene, phytofluene, beta-carotene, flavonoids, lycopene, quercetin, polyphenols and kaempferol.

Dietary intake of tomato products containing lycopene has been shown to decrease the risk of chronic diseases like cancer (breast, colon, prostate), cardiovascular diseases and gastrointestinal disorders (Agarwal and Rao, 2000; Buculei *et al*., 2011). As much as the health benefit of tomato consumption is concerned, adulterated tomato pastes pose greater economic losses and possible

Please cite as: Ukom A.N., Obikwelu C.L., Okparauka I.I. and Ogbu O.T. (2022). The phytochemicals, antioxidant activities and nutritive qualities of some selected tomato pastes sold in Umuahia Metropolis, Abia State, Nigeria. *Agro-Science*, **21 (4),** 23-27. DOI: https://dx.doi.org/10.4314/as.v21i4.4

food toxicity have entered the Nigerian market space. William and Daniel (2015) lamented that a good number of tomato products imported into Nigeria from China and Asia were often adulterated with starch and food colour additives which could have adverse effects on consumer's health. This is compounded by poor regulatory systems and porous borders that have turn Nigeria into a dumping ground of fake and adulterated products. Several parameters have been used to monitor the quality of tomato paste, which include consistency, total solids content, titratable acidity, pH and levels of sugar (Ahmet and Vedat, 2009; Lu *et al*., 2014).

Lycopene as an antioxidant compound of tomato and tomato products has been shown to contribute to major health benefits. Other antioxidants, mainly carotenoids, phenols and flavonols in combination with lycopene contribute to maximum antioxidant benefit of tomato products. Antioxidants quench free radical actions and protect the cells from damage that is associated with cancer and heart diseases. Studies which emphasis and examine the phytochemicals and antioxidant properties of different tomato brands sold in Umuahia Metropolis are scarce. Therefore, the aim of this study was to assess the antioxidative, phytochemicals and nutritive qualities of some selected tomato paste sold in Umuahia Metropolis.

MATERIALS AND METHODS

Collection and Preparation of Samples

Five different brands of available tin tomato pastes commercially sold in Ubani Market, Umuahia Metropolis were selected in July, 2021 and given identification names as Sonia, Gento, Superdelicieux, Star and Clappa. The selected tomato brands were registered with the National Agency for Food and Drug Administration and Control (NAFDAC). The brand names, expiry dates and country of manufacture were noted (Table 1) from their label.

Preparation of Samples

Tin tomato paste brands without defect were used for assessing the physicochemical, antioxidant and nutritive qualities of tomato paste. The tomato pastes were labeled with their brand names and opened by sterilized tin cutter. The tomato paste was carefully transferred into a sterilized dry glass screw capped sample bottles prior to analysis. When not in use, the samples were kept in the refrigerator (4°C) to avoid biochemical and other possible changes.

Table 1: Information on brands, country of manufacture and expiry dates of tomato pastes evaluated

Tomato brand	Country of manufacture	Expiry date
Sonia	Nigeria	23-02-2023
Gento	China	22-10-2022
Superdelicieux	China	10-10-2022
Star	Nigeria	24-07-2022
Clappa	China	01-11-2022

Determination of Lycopene, Phenols, Carotenoid, Tocopherol, Ascorbic Acid and Vitamin A

Lycopene content was determined using the spectrophotometric method as described by Onwuka (2018). Phenol content was determined using the Folin-Ciocalteua spectrophotometric method (AOAC, 2010), while flavonoid content was determined by precipitate gravimetric method (Osuagwu and Ihenwosu, 2014). Carotenoids were determined by the spectrophotometric method of Rodriguez-Amaya and Kimura (2004). Vitamin E was determined by the method described by Achikanu *et al*. (2013), and vitamin C was determined by the method of Okwu and Josiah (2006), while vitamin A was determined by the method described by Onwuka (2018).

Determination of Chemical Properties of Tomato Paste Samples

The Colonel electrode pH meter was used (Sadler and Murply, 2010) to determine the pH content. The titratable acidity was determined using the alkaline titrimetric method (Onyeaghala *et al.,* 2016). Total solids were determined gravimetrically as the percentage weight of solids in the sample (Cavalcanti *et al*., 2008). The sugar content was determined using the method described by Ezegbe (2012).

Determination of Mineral Content of Tomato Paste Samples

The potassium and sodium contents were determined by flame photometry method as described by James (1995). Calcium and magnesium were determined by EDTA Versanate complexometric method of James (1995), while iron was determined by James (1995) method.

Extraction of Tomato Paste with Acetone

The modified method of Ukom *et al.* (2014) was used. Tomato pastes of 0.50 *g* from each sample was mixed with 5 ml of 98% acetone in a 50 ml test tubes using Ultra Turax (1KA T18 Basic Staufen, Germany) for 10 sec. and then capped and re-mixed in a Vortex mixer (Fisher Scientific, USA) for 1 min. The sample was placed on a multi-purpose rotator (Barnstead International, USA) for 30 min. at 600 rpm. The sample extract was then centrifuged at 4°C for 5 min. and at 6000 rpm (Eppendorf Centrifuge 5804R Hamburg, Germany). Sample extract (2 ml) was collected and stored in the dark at 4°C. The tomato paste extract was used for the determination of total polyphenols, flavonoids and antioxidant activity with the protocols of ABTS, DPPH, and FRAP assays.

Determination of Antioxidant Activity of the Selected Tomato Paste

The FRAP (Ferric Reducing Antioxidant Power) scavenging power of the tomato paste was determined by its ability to chelate ferrous ion (Fe^{2+}) as compared to ferrozine as the control. The method described by

Benzie and Strain (1999) was employed. The scavenging activity of DPPH (1,1-diphenyl-2-picryl) of tomato paste was determined by the method described by Manzocco *et al*. (1998). The ABTS (2,2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid) was determined according to the method of Seeram *et al*. (2006).

Statistical Analysis

Data (triplicate) was subjected to analysis of variance using the statistical package for social sciences (SPSS), version 23.0 for windows. One-way Analysis of Variance (ANOVA) was used for comparison of means. Differences between means were considered to be significant at $p < 0.05$ using Duncan's multiple range test.

RESULTS AND DISCUSSION

Phytochemical Content of Tomato Brand Paste Sold in Umuahia Metropolis

Table 2 shows the phytochemical contents of the different brands of tomato pastes. From the results, there were significant ($p < 0.05$) differences in the concentration of the phytochemical constituents in the tomato paste samples. Lycopene ranged between 2.95 and 4.20 mg $100g^{-1}$, and was highest in STA but lowest in SUD tomato paste. The β-carotene content ranged between 1.96 (GEN) and 3.02 mg $100g^{-1}$ (CLA), while vitamin C ranged between 10.50 (CLA) and 12.76 mg $100g^{-1}$ (STA). Flavonoid ranged between 0.17 (STA) and 0.25% (GEN), while phenol varied significantly ($p < 0.05$) from 2.33 (STA) to 3.28 mg $100g^{-1}$ (SUD). Vitamin A ranged from 1.23 (SON) and 1.43 IU $100g^{-1}$ (STA). Vitamin E also ranged from 9.91 (SON) and 11.14 mg $100g^{-1}$ (GEN and CLA), respectively. The lycopene, β-carotene and vitamin C contents of the tin tomato paste agree with the report of Eleyowo and Amusa (2021) on some tomato sachets sold in Lagos State, Nigeria. However, the work of Onyeaghala *et al*. (2016) on some tomato paste showed higher values than was reported in this study. These results revealed that tomato paste are rich sources of phytonutrient compounds and are important boosters of physiological health to consumers. Although some of the values are lower than the report of Onyeaghala *et al.* (2016) on phytochemicals of some tomato paste, the presence of phytochemicals like phenol, lycopene, flavonoid, carotenoid and the vitamins, A, C and E in the tomato paste are desirable as they are known to poses health benefits including antioxidant activity (Slimestad and Verheul, 2009). This suggests that consumers of these tomato pastes may be protected from oxidative damage and cell destruction. The presence of phytochemicals which have antioxidant constituent were revealed in the potential levels of antioxidant activities of DPPH, FRAP and ABTS assays. The result indicates variations in the antioxidant activities as reflected in the phytochemical constituents of the tomato pastes.

Chemical Properties of Different Brands of Tomato Paste Sold in Umuahia Metropolis

Table 3 shows the quality of some selected tomato pastes. Significant variations ($p < 0.05$) existed in the chemical contents of the tomato paste. Total sugar ranged from 28.91 (STA) to 31.67% (SON), whereas the reducing sugar ranged from 8.78 (SUD) to 16.16% (CLA). The titratable acidity varied between 0.21 (SON) and 0.31% (GEN), the pH showed a range of 4.27 (CLA) to 4.47 (STA) and the total soluble solid ranged from 17.03 (GEN) to 21.63% (SUD). In all the test parameters, the variations may largely be attributed to differences in manufacturing norms, tomato varieties and environment of production. The pH range of tomato paste showed that the products were acidic. This is important in shelf stability and preservation of tomato paste to discourage the growth of spoilage bacteria. Total sugar content and total soluble solid of SUD paste were considered high possibly as a result of hydrolysable starch. The high concentration of sugar and soluble solid suggests that additives (starch) associated with sugar yield upon hydrolysis was present. Onyeaghala *et al.* (2016) reported that there was starch in tomato paste sold in western Nigeria. The high presence of sugar in this study contradicts the inscription on the tomato paste except for SON paste which clearly stated sugar addition on the tin as among the ingredients. The reducing sugar content from this study was 3-5 times higher compared to 3.26% reported by Okoye and Ekechukwu (2006) in some Nigeria fruits.

Table 2: Phytonutrient content of tomato pastes sold in Umuahia metropolis (mg $100g^{-1}$)

Tomato brands	Lycopene	β-Carotene	Vitamin C	Flavonoid (%)	Phenol	Vitamin A (IU $100g^{-1}$)	Vitamin E
SON	$4.12^{a} \pm 0.11$	$2.18^{c} \pm 0.03$	$11.88^{b} \pm 0.38$	$0.23^{a} \pm 0.01$	$2.56^{b} \pm 0.6$	$1.23^{c} \pm 3.58$	$9.91^{d} \pm 0.02$
GEN	$3.45^{c} \pm 0.04$	$1.96^{d} \pm 0.05$	$11.24^{c} \pm 0.10$	$0.25^{a} \pm 0.01$	$2.78^{b} \pm 0.09$	$1.39^{b} \pm 6.20$	$11.14^{a} \pm 0.14$
SUD	$2.95^{d} \pm 0.04$	$2.49^{b} \pm 0.46$	$12.08^{b} \pm 0.10$	$0.21^{ab} \pm 0.03$	$3.28^{a} \pm 0.19$	$1.30^{c} \pm 3.05$	$10.76^{b} \pm 0.18$
STA	$4.20^{a} \pm 0.49$	$2.17^{c} \pm 0.01$	$12.76^{a} \pm 0.16$	$0.17^{c} \pm 0.01$	$2.33^{c} \pm 0.16$	$1.43^{a} \pm 6.15$	$10.41^{c} \pm 0.04$
CLA	$3.94^{b} \pm 0.49$	$3.02^{a} \pm 0.14$	$10.50^{d} \pm 0.05$	$0.23^{a} \pm 0.01$	$2.82^{ab} \pm 0.46$	$1.28^{d} \pm 3.58$	$11.14^{a} \pm 0.25$

Values are means ± standard deviation of three replicate determinations. Different superscripts in the columns are significantly different ($p < 0.05$). SON - sonia; GEN - gento; SUD - superdelicieux; STA - star; CLA - clappa

Table 3: Chemical content of different brands of tomato pastes sold in Umuahia metropolis

Tomato brands	Total sugar (%)	Reducing sugar (%)	TTA (%)	pH	Total soluble solid (%)
SON	$31.67^{a} \pm 0.37$	$10.13^{c} \pm 0.16$	$0.21^{c} \pm 0.03$	$4.43^{a} \pm 0.12$	$18.54^{b} \pm 0.19$
GEN	$30.06^{c} \pm 0.50$	$11.23^{b} \pm 0.13$	$0.31^{a} \pm 0.02$	$4.42^{b} \pm 0.06$	$17.03^{b} \pm 0.19$
SUD	$30.72^{b} \pm 0.12$	$8.78^{d} \pm 0.13$	$0.25^{b} \pm 0.01$	$4.33^{bc} \pm 0.06$	$21.63^{ab} \pm 0.38$
STA	$28.91^{d} \pm 0.23$	$11.05^{b} \pm 0.17$	$0.23^{bc} \pm 0.01$	$4.47^{a} \pm 0.12$	$19.43^{b} \pm 0.90$
CLA	$29.83^{c} \pm 0.20$	$16.16^{a} \pm 0.31$	$0.27^{ab} \pm 0.02$	$4.27^{b} \pm 0.06$	$18.39^{b} \pm 0.66$

Values are means ± standard deviation of three replicate determinations. Different superscripts in the columns are significantly different ($p < 0.05$). SON - sonia; GEN - gento; SUD - superdelicieux; STA - star; CLA - clappa. TTA - titratable acidity

Mineral Content of Different Brands of Tomato Paste Sold in Umuahia Metropolis

Table 4 shows the minerals content of tomato paste sold in Umuahia metropolis. The mineral content showed significantly ($p < 0.05$) lower concentration with Ca ranging from 1.79 (CLA) to 2.86 mg $100g^{-1}$ in SON. Magnesium ranged from 8.57 (SON) to 13.61 mg $100g^{-1}$ (STA) paste, potassium ranged from 7.81 (SON) to 30.44 mg $100g^{-1}$ (STA), whereas, sodium ranged from 12.21 (STA) to 15.59 mg $100g^{-1}$ (CLA) paste and iron ranged from 0.82 (STA) to 1.89 mg $100g^{-1}$ (SON), respectively. The minerals content revealed lower values than the report of Eleyowo and Amusa (2021), where only calcium showed similar range of values. Although these minerals were appreciably low, the tomato paste undoubtedly will supply consumers some vital dietary minerals requirement. Calcium is important for strengthening bones and teeth development as well as involved in the manufacture of red blood cells. Potassium and sodium acts as electrolytes and aid the osmoregulation of the body internal environment, while magnesium is involved in immune competence, and acts as coenzyme in physiological reactions in the body. Also, iron is involved in the manufacture of blood cells and help reduce anaemia, morbidity and mortality in children (Onyeaghala *et al*., 2016).

Antioxidant Activity of Different Brands of Tomato Paste sold in Umuahia Metropolis

Results of antioxidant activity of the tomato paste are shown in Table 5. The results show that the tomato paste demonstrated strong antioxidant activity. This suggests that tomato and tomato products are rich sources of antioxidant constituents which played out as major contributors to antioxidant activity (Slimestad and Verheul, 2009). The antioxidant activity of DPPH in the tomato paste extract ranged from 48.69 (CLA) to 62.07% (SON). Similarly, the FRAP antioxidant activity ranged from 41.39 (CLA) to 47.88% (SON). The 2,2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) antioxidant activity was between 35.28 (STA) and 41% (SON). The results showed that SON tomato paste demonstrated the highest antioxidant activity than the other tomato paste.

The antioxidant activity power of the tomato paste extracts was attributed to the presence of biological active constituents of phenols, carotenoids, lycopene, flavonoids, vitamins A, C and E which are reported to possess antioxidant properties. Tomato is reported to be the most important source of lycopene which is associated with health benefits. Tomato also contains flavonoids and phenolic acids that contribute to health benefits (Slimestad and Verheul, 2009). Tomato pastes are beneficial in protecting the body from oxidative stress, cell damage, prostate and other degenerative disorders. Rutin, the most common flavonoid in tomato, had shown correlation with antioxidant potential (Spencer *et al.,* 2005), a suggestion that flavonoid and its constituents contributed to antioxidant activity in this study. The variance in antioxidant data of tomato paste may be due to genetic, environmental and cultural/farming practices (Slimestad and Verheul, 2009).

Table 4: Minerals content of different brands of tomato pastes sold in Umuahia metropolis (mg $100g^{-1}$)

Tomato brands	Ca	Mg	K	Na	Fe
SON	$2.86^{a} \pm 0.10$	$8.57^{c} \pm 0.47$	$7.81^{d} \pm 0.27$	$12.85^{b} \pm 0.08$	$1.89^{a} \pm 0.02$
GEN	$1.91^{c} \pm 0.09$	$10.84^{b} \pm 0.17$	$9.45^{b} \pm 0.57$	$13.18^{b} \pm 0.04$	$0.97^{d} \pm 0.01$
SUD	$2.68^{b} \pm 0.05$	$9.04^{c} \pm 0.08$	$7.85^{d} \pm 0.05$	$15.37^{a} \pm 1.25$	$1.18^{c} \pm 0.09$
STA	$1.91^{c} \pm 0.04$	$13.61^{a} \pm 0.39$	$30.44^{a} \pm 0.02$	$12.21^{c} \pm 0.04$	$0.82^{e} \pm 0.05$
CLA	$1.79^{c} \pm 0.08$	$10.37^{b} \pm 0.04$	$8.69^{c} \pm 0.08$	$15.59^{a} \pm 0.21$	$1.41^{b} \pm 0.04$

Values are means ± standard deviation of three replicate determinations. Different superscripts in the columns are significantly different ($p < 0.05$). SON - sonia; GEN - gento; SUD - superdelicieux; STA - star; CLA – clappa; Ca - calcium; Mg - magnesium; K - potassium; Na - sodium; Fe - iron

Table 5: Antioxidant activity of different brands of tomato pastes sold in Umuahia metropolis

Tomato brands	DPPH (%)	FRAP (%)	ABTS (%)
SON	$62.07^{a} \pm 0.28$	$47.88^{a} \pm 1.51$	$41.00^{a} \pm 1.28$
GEN	$57.77^{b} \pm 0.84$	$45.46^{b} \pm 0.64$	$40.71^{a} \pm 0.63$
SUD	$55.53^{c} \pm 1.02$	$44.06^{c} \pm 0.07$	$38.55^{b} \pm 0.51$
STA	$57.59^{b} \pm 1.06$	$43.70^{c} \pm 0.07$	$35.28^{c} \pm 0.14$
CLA	$48.69^{d} \pm 0.03$	$41.39^{d} \pm 0.06$	$38.74^{b} \pm 0.32$

Values are means ± standard deviation of three replicate determinations. Different superscripts in the columns are significantly different ($p < 0.05$). DPPH - 1,1-diphenyl-2-picryl; FRAP - ferric reducing antioxidant power; ABTS - 2,2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid. SON - sonia; GEN - gento; SUD - superdelicieux; STA - star; CLA - clappa

CONCLUSION

This work evaluated the phytochemicals, antioxidant activity and nutritive quality of some selected tomato paste sold in Umuahia metropolis, Abia State, Nigeria. It was found that the tomato paste contains diverse health promoting phytonutrient constituents: phenolic, flavonoids, vitamins A, B, C and E, carotenoids, lycopene and some essential minerals like iron and potassium. These constituents are important anti-oxidants that fight against oxidative damage and provide immune function in cellular tissues. The high antioxidant activity by ABTS, FRAP and DPPH assays especially in SON tomato paste authenticate this claim. However, the high sugar contents of the tomato paste question adulteration or intended addition of sugar containing substances particularly starch from the paste imported from Asia and China. It is recommended that NAFDAC should monitor tomato pastes sold in Nigeria to ensure they meet the standard to safeguard the health of Nigerians and prevent shortchanging of tomato consumers.

REFERENCES

Achikanu C.E., Eze-Steven P.E., Ude C.M. and Ugwuokolie O.C. (2013). Determination of the vitamin and mineral composition of common leafy vegetables in south eastern Nigeria. *Int. J. Curr. Microbiol. Appl. Sci.,* **2 (11),** 347-353

Agarwal S. and Rao A.V. (2000). Tomato lycopene and its role in human health and chronic diseases. *Canad. Med. Assoc. J.,* **163 (6),** 739-744

Ahmet T. and Vedat E. (2009). Estimation of certain chemical constituents of fruits selected tomato genotypes grown in Turkey. *Afr. J. Agric. Res.,* **4 (10),** 1086-1092

AOAC (2010). *Official Methods of Analysis*, 18th edition. Association of Official Analytical Chemist, Washington DC, USA

Benzie I.F.F. and Strain J.J. (1999). Ferric reducing/ antioxidant power assay: Direct measure of biological fluids and modified version for simultaneous measurement of total antioxidant power and ascorbic acid concentration. In: L. Packer (ed.), *Methods Enzymology* (pp. 15-27). Academic Press, Orlando FL

Buculei A., Poroch-Seritan M., Psibilschi A-M. and Rebenciuc I. (2011). Research concerning the evolution of heavy metals content in the fresh and metal-can of preserved vegetables (tomatoes). In: Katalinic B. (ed.), Ann. DAAAM 2011 & Proc. 22nd Int. DAAAM Symp, Vienna, Austria

Cavalcanti A.L., Fernandes L.V., Barbosa A.S. and Vieira F.F. (2008). pH, titratable acidity and total soluble solid content of pediatric anti tussive medicine, *Acta Stomatol. Cecr.,* **42,** 164-170

Eleyowo O.O. and Amusa O.D. (2021). Antioxidants, microbial load and heavy metal contents of some sachet tomato paste obtained in Lagos State, Nigeria. *J. Appl. Sci. Environ. Manage.,* **25 (4),** 631-636

Ezegbe C.C. (2012). Nutritional *Quality and Physico-chemical Properties of Oil and Seed of Chinese Fan Palm*. MSc Thesis, Dept. Food Science & Technology, Federal University of Technology, Owerri, Nigeria

FAO (2014). Food and agriculture organization statistical database. Food and Agriculture Organization of the United Nations, Rome. Retrieved 02/06/2018 from http://www.fao.org/publications/

James S.C. (1995). *Analytical Chemistry of Food.* Chapman and Hill Printers, London

Khachik F., Carvalho L. and Berristein P.S. (2002). Chemistry, distribution and metabolism of tomato carotenoids and their impact on human health. *Exp. Biol. Med.,* **227 (10),** 845-851

Lu Z., Michelle A.S., Rick C., Diane M.B. and Michael J.M. (2014). Determination of quality parameters of tomato paste using guided microwave spectroscopy. *Food Control,* **40,** 214-223

Manzocco L., Anese M. and Nicoli M.C. (1998). Antioxidant properties of tea extracts as affected by processing. *Lebens-mittel-Wissenscheftund-Technol.,* **31 (7-8),** 694-698

Okoye C.O.B. and Ekechukwu C.D. (2006). Determination of sugar content in some Nigerian fruits. *Bio-Res.,* **4 (2),** 121-122

Okwu D.E. and Josiah C. (2006). Evaluation of chemical composition of two Nigerian medicinal plants. *Afr. J. Biotechnol.,* **5 (4),** 357-361

Onwuka G.I. (2018). Food *Analysis and Instrumentation, Theory and Practices*. Naphthalin Prints, Lagos, Nigeria

Onyeaghala A.A., Ijagbone I.F. and Kalu O.C. (2016). Comparative and quality analysis of different tomato brands sold in major markets in Ibadan, Nigeria. *Afr. J. Food Sci.,* **10 (10),** 213-226

Osuagwu G.G.E. and Ihenwosu A.O. (2014). Phytochemical composition and antimicrobial activity of the leaves of *Alchora cordifolia, Sanvier aliberica and Ilvaria chamae* (P. Beauv). *Am. J. Phytomed. Clin. Therap.,* **2 (1),** 001-012

Ray R.C., El-Sheikha A.F., Panda S.H. and Montet D. (2011). Antioxidant properties and other functional attributes of tomato – an overview. *Int. J. Food Ferment. Technol.,* **1 (2),** 139-148

Rodriguez-Amaya D.B. and Kimura M. (2004). *Handbook for Carotenoids Analysis*. Harvest Plus, Washington DC and Cali Columbia

Sadler G.D. and Murphy P.A. (2010). pH and titratable acidity: In: *Food Analysis*. https://doi.org/10.1007/978-1-4419-1478-1_13

Seeram N.L., Adams Y., Zhang R., Lee D., Sand H., Scheuller D. and Heber D. (2006). Blackberry, black raspberry, blueberry, cranberry, red raspberry and strawberry extract inhibit growth and stimulate apoptosis of human cancel cell in vitro. *J. Agric. Food Chem.,* **54,** 9329-9339

Slimestad R. and Verheul M. (2009). Review on flavonoids and other phenolics from fruits of different tomato (*Lycopersicon esculentum* Mill.) cultivar. *J. Sci. Food Agric.,* **89,** 1255-1270

Spencer J.P.E., Kuhnle G.G.C., Hajirezaei M., Mock H-P., Sonnewald U. and Rice-Evans C. (2005). The pheno-typic variation of the antioxidant potential of different tomato varieties. *Free Rad. Res.,* **39**, 1005-1016

Ukom A.N., Ojimelukwe P.C., Ezeama C.F., Ortiz D.O. and Aragon I.J. (2014). Phenolic content and antioxidant activity of some under-utilized Nigerian yam (*Dioscorea spp*) and cocoyam (*Xanthosoma maffa* scoth) tubers. *J. Environ. Sci. Toxicol. Food Technol.,* **8 (7),** 104-111

Usha H.R., Neena J., Suvarna V.C., Surendra H.S. and Nagaraju N. (2013). Evaluation of storage stability leaf curl resistant cultivars for producing dehydrated tomato. *Disc. J. Agric. Food Sci.,* **1,** 1-7

William H. and Daniel N. (2015). Tomato scare – raises eyebrows over sugar, starch in puree. *J. Food Sci.,* **17 (4),** 24-32