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Chemical Properties and Nutritional Quality of Nigerian Grown Tomato (*Solanum lycopersicum*) Cultivars

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ABSTRACT: Tomato (*Solanum lycopersicum*)) is quantitatively consumed in Nigeria. The objective of this study was to evaluate the chemical properties and nutritional quality of Eva F1 and Roma cultivars locally grown in Nigeria. The results revealed a degree brix varying from 4.13˚ to 5.43˚ and a pH ranging from 4.28 to 4.34 corresponding to a titrable acidity of 0.88% to 1.18% citric acid equivalents. The colour measurements showed higher L* value for Roma paste (35.59) than Eva F1 paste (35.29) cultivar which indicated that Eva F1 paste is brighter than Roma paste. The moisture, ash, fat, protein, fibre and carbohydrate content ranged from 87.41% to 88.16%, 0.64% to 0.75%, 0.39% to 0.46%, 2.18% to 2.69%, 8.54% to 8.81% and 3.78% to 4.15%, respectively, for the two tomato cultivars. The results of the elemental analyses indicated that calcium, magnesium, iron and zinc concentrations were significantly higher in Roma than Eva F1 cultivar, while phosphorus was found to be significantly higher in Eva F1 cultivar. The results clearly ddemonstrated that differences between the cultivars influence the quality of tomato paste. The findings of this research will find applications in local tomato paste processing by taking advantage of unique characteristics presented by each cultivar.

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Tomato is a fruit botanically commonly grown and utilized in most parts of the world. The estimated world production of tomatoes destined for industrial processing was 39.7 million tonnes in 2022 (Dilton, 2022). China is the leading producer of tomato in the world with about 50 million tonnes followed by India with17.5 million tonnes as reported in Food and Agriculture Organisation Corporate Statistical Database (FAOSTAT, 2014). Nigeria is the largest producer of fresh tomatoes in Sub-Saharan Africa and the second largest producer of fresh tomatoes in Africa (Omosomi, 2016). However, despite Nigeria's strong position in tomato production in Africa region, the country still spends up to $500 million per year to import tomato products (especially purees, pastes and canned tomatoes) as reported by Rwomushana *et al*. (2019). This report makes the country to be positioned as one of the biggest importers of tomato paste globally. The situation is worsened by the fact that more than 45 percent of tomatoes harvested in Nigeria are wasted yearly due to poor processing technology, lack of good storage and distribution systems (Ugonna *et al*., 2015). The obvious and prevalent post harvest losses that tomato farmers accrue on a daily basis prompted new innovations targeted towards alleviating such wastage; one of this is the processing of tomatoes into tomato paste which

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has become an essential pantry staple that is reconstituted for meals in most Nigerian homes.

Tomato paste, puree or concentrate is a thick paste that is made by cooking tomatoes for several hours to reduce moisture, by straining them to remove the seeds and skin, and cooking them again to reduce to a thick rich concentrate. It is an excellent source of bioactive molecules such as lycopene, carotenoids, phenolic compounds, vitamins and other nutraceuticals (Tudor-Radu *et al*., 2016). Epidemiological studies have shown that regular consumption of tomatoes or tomato products are associated with a decreased risk of chronic diseases such as cardiovascular diseases, prostate, gastrointestinal and epithelial cell cancers (Przybylska, 2020). Most importantly, processed tomatoes do not lose their health benefits as attested by the fact that they are readily more absorbed than fresh tomatoes in human system. There are several cultivars of tomatoes grown in Nigeria. Common cultivars include "Beefsteak", "Roma", "Cherry", "Grape", "Plum", "Campari", "Patio", "Branfy wine", to name a few. Roma tomato cultivar is available in most local markets in Nigeria while Eva-F1 tomato cultivar is newly introduced by Federal University of Technology, Akure. Eva F1 was cultured to suit the Nigerian market through the collaborative efforts of the School of Agriculture and Agricultural Technology (SAAT) and the Teaching and Research Farm (TRF) of the institution. Eva F1 seedling was imported from Israel and carefully nurtured in FUTA's Green House under controlled temperature (Oluwole, 2017). The Eva F1 Tomato is a variety five times bigger in size than the commonly available one in the Nigerian market and it is capable of producing paste more than four times the latter. The tomato variety has the rare quality of imperishability over a period of two weeks from date of harvest. Roma tomato cultivar is available from April till December while Eva F1 cultivar is available from December till April.

It is imperative to note that the nutritional composition of tomato may vary depending on several factors such as variety, cultivation techniques, the locality and the sampling period as reported by Hernandez Suarez *et al*. (2008). Different cultivars may present variability of the physical and chemical properties of tomato paste thereby impacting the quality of the end-products. Hence, the objective of this paper is to evaluate the chemical properties and nutritional quality of Eva F1 and Roma cultivars of locally grown tomato purchased from from Ikorodu market, Lagos State, Nigeria.

MATERIALS AND METHODS

Raw materials: Eva-F1 and Roma tomato cultivars were purchased from Ikorodu market, Lagos State, Nigeria. Figure 1 shows Eva F1 tomato cultivar and Roma tomato cultivar, respectively.

Preparation of tomato paste: About 1.5 kg of each tomato cultivar were sorted and washed to remove dirt and impurities on the surface. The tomatoes were then placed in metal sieve over boiling water at 96.5^{o}C and steam blanched for 5 min to reduce the water content and to decrease microbial load. The tomatoes were then blended until smooth and the puree is poured into muslin cloth to drain excess water out for 7 h. The paste was filled into previously sterilized jars and sealed. The tomato paste jars are then pasteurized by placing in pressure pot containing boiling water for 10 min. The jars were then left to cool and stored in the refrigerator maintained at 4°C prior to analyses. Figure 2 shows Eva F1 tomato paste and Roma tomato paste in jar, respectively.

Fig. 1: (a) Eva F1 tomato cultivar (b) Roma tomato cultivar

Fig. 2: (a) Eva F1 tomato paste (b) Roma tomato paste

Evaluation of physicochemical properties: The physicochemical properties of the tomato paste were carried out in the Chemical Laboratory of the Bowen University. For the determination of the pH, the tomato paste (10 g) was mixed with 100 mL of water to get a 10% solution. The pH meter (model 3305 Jenway Ltd, UK) was calibrated by immersing in a buffer solution. The electrode was then immersed in the homogenous solution to obtain the pH value. The total titratable acidity (%, as citric acid) of the tomato pastes were determined by titration with 0.1N NaOH using phenolphthalein as indicator according to Esra *et al*. (2021).The samples are mixed thoroughly to obtain a uniform mixture for the determination of the soluble solids (brix). The sample is then applied on the refractometer. The reading displayed on the refractometer is the brix.Total sugar in the samples was carried out according to the reported method of Lane and Eynon (2005).The lycopene content of the tomato paste was determined by extracting the lycopene and measuring its absorbance (max) at 503 nm spectrophotometrically according to Strivasta and Kumar (2004).

Measurement of colour attributes: The colour of different samples of tomato paste was measured at room temperature using the Konica Minolta Spectrophotometer (CR- 410, Japan). The sample (30 g) was placed in the sample holder and the surface colour was measured at three different positions. The colour readings were displayed as $L^*a^*b^*$ values where L* (100 = white; 0 = black) is an indication of lightness; *a** measures chromaticity, with positive values indicating redness and negative values indicating greenness; while *b** also measures chromaticity, with positive values indicating yellowness and negative values indicating blueness. The red yellow ratio (Y_R), hue angle (h_{ab}) and color intensity [according to Park *et al*. (2002)] were calculated using equations 1, 2 and 3, respectively.

$$Y_R = \frac{a^*}{b^*} \quad (1)$$

$$h_{ab} = \tan^{-1}(b*/a*) \quad (2)$$

$$C^* = \sqrt{a^{*2} + b^{*2}} \quad (3)$$

ΔE_{ab} is the difference between two colours designated as two points in the Lab colour space. With values assigned to each of the L, a, and b attributes of two colours, simple geometry can be used to calculate the distance between their two placements in the Lab colour space. ΔE_{ab} is calculated using equation 4.

$$\Delta E_{ab} = \sqrt{(L_1-L_2)^2 + (a_1-a_2)^2 + (b_1-b_2)^2} \quad (4)$$

Proximate composition: Moisture, crude protein, crude lipid, crude fiber, and ash were determined according to AOAC (2002). Quantification of carbohydrates (CHO) occurred by difference, following the schematic equation 5.

$$CHO = [100 - (LC + CP + AS + MC + CF)] \quad (5)$$

Where LC = lipid content; CP = crude protein; AC = ash content; MC = moisture content; CF = crude fibre content

Conversion values were used to determine the calorific value: 4 Kcal/g for carbohydrates, 4 Kcal/g for proteins, and 9 Kcal/g for lipids.

Mineral composition: The ash residue was digested using 5 cm^3 of concentrated nitric acid and then filtered using a filter paper into 100 cm^3 volumetric flask and was diluted to the mark with distilled water. It was then transferred into sampling bottle for subsequent analyses. The filtrate was used in the determination of calcium, magnesium, iron and zinc respectively using Atomic Absorption Spectrophotometer (AAS, Hitachi Z6100, Tokyo, Japan). Phosphorus content was determined by Phosphomolybdate method (AOAC, 2005). All analyses were performed in three repetitions.

Statistical Analysis: Statistical analyses were conducted using Statistical Package for the Social Sciences version 17.0 software (SPSS Inc., Chicago, IL, USA). The results obtained from the present study are represented as the mean values of three individual replicates ± the standard deviation. Significant differences between the mean values were determined using Duncan's multiple range tests at a significance level of $p \leq 0.05$.

RESULTS AND DISCUSSION

Physicochemical properties of Roma and Eva-F1 tomato paste: The physicochemical characteristics of tomato paste from the two cultivars are presented in Table 1. The pH ranged between 4.28 and 4.34 corresponding to a total acidity of 1.18% and 0.88%, respectively. The reported pH values in this study were higher than those obtained by Fagbohoun and Kiki (1999) and Dossou *et al*. (2007) who reported values from 3.70 to 4.10 and 4.01 to 4.17, respectively. However, it is imperative to note that pH values lower than 4.5 during tomato processing inhibit the growth of bacteria from the genera *Clostridium* and *Bacillus*, which can cause deleterious changes in the product. The titratable acidity of the Roma cultivar (0.88%) was significantly lower than the value reported in the Eva-F1 cultivar (1.18%). However, these values were higher than the range of 0.52 to 0.63% reported by Gadzhieva *et al*. (2018) though the values fall within the range of 0.24–4.32% reported by previous researchers (Adebooye *et al*., 2006; Olaniyi *et al*., 2010; Gharezi *et al*., 2012). The present work found a higher acidity in the paste made from Eva F1 tomato compared with that of Roma tomato. The acidity of tomato is an indicator of fruit maturity. Asides, it is essential in the development of flavor of tomato products as reported by Esra *et al*. (2021). It is however imperative to note that low acids and the resultant high pH in certain variety of tomatoes are considered a weak point for processing. This is pertinent because thick-walled, firm fruited lines had been used in breeding for such varieties for mechanical harvest. The average acidity of processing tomatoes is about 0.35% as citric acid, hence, both Roma and Eva F1 tomato varieties are ideal for processing into paste. The total soluble solids reported as degree brix ranged from 4.13 to 5.43 with a significant difference among the two cultivars. The degree brix values obtained for the Roma and Eva-F1 tomato cultivars are comparable with the values ranging from 2.02 to 4.57 for sixteen indigenous tomatoes varieties from Tunisia as reported by Aoun *et al*. (2013). Generally, the flavor of tomato paste is closely associated with the soluble solids content and titratable acidity. Average total sugar content of Eva-F1 and Roma tomato paste cultivars were reported to be 0.48 and 0.83%, respectively. Tomato contains majorly glucose and fructose with miniscule quantity of sucrose. In essence, the sugar content of tomato determines the sweetness and flavor. The value reported in the Roma tomato paste will render the cultivar sweeter and acceptable compared to Eva-F1 cultivar**.** The lycopene content recorded for the Roma tomato paste cultivar was 96.46% which is higher than the 94.33% recorded for the Eva-F1 tomato paste cultivar. Lycopene is the main carotenoid found in tomatoes and it comprises approximately 83% of the total pigment and gives the characteristic red color (Gould, 1983). Lycopene from tomato paste is 2.5 times readily bioavailable in humans than lycopene from fresh tomatoes especially when boiled with oil, a common processing option in tropical African regions as reported by Ahmed and Vedat (2009). Most importantly, it has been reported that lycopene consumption decreased the presentation of prostate cancer and cholesterol level in low density lipoprotein (Djuric and Powell, 2001). It could be concluded from the Table 1 that there exists variation in the physical properties of paste prepared from Roma and Eva F1 tomato cultivars.

Table 1: Physicochemical properties of Roma and Eva-F1 tomato paste

Parameter	**Roma tomato paste**	**Eva-F1 tomato paste**
Total Soluble solids, °Brix	$4.13^a \pm 0.06$	$5.43^b \pm 0.12$
pH	$4.28^a \pm 0.02$	$4.34^b \pm 0.01$
Titratable acidity as citric acid,%	$0.88^a \pm 0.01$	$1.18^b \pm 0.01$
Total sugars as invert,%	$0.83^b \pm 0.01$	$0.48^a \pm 0.02$
Lycopene content ,%	$96.46^b \pm 0.01$	$94.33^a \pm 0.03$

All values are means of three determinations ± standard deviation. Means followed by the same letter are not significantly different from each other

Colour attributes of Roma and Eva-F1 tomato paste: Results in Table 2 indicate the existence of significant differences between the colour values of Roma and Eva F1 tomato pastes. The measurements with the Chroma Meter system (CIELab) showed higher L* value (brightness) for Roma cultivar (35.59) than Eva

F1 cultivar (35.29). These values are comparable with the range of values 32–35 reported by Ordóñez-Santos *et al*. (2009). The b* value of the paste made with Roma and Eva-F1 tomato cultivar was 14.80 and 14.68, respectively. However, the values were significantly lower than a range from 29 to 41 reported by Ordóñez-Santos *et al*. (2009). The redness (a*) values of the Roma and Eva-F1 cultivar was 21.51 and 21.77, respectively. Thus, a slightly better red colour was observed in paste from Eva FI compared with Roma cultivar. The a^* / b^* ratio ranged from 1.45 to 1.48 in the tomato pastes. According to Turkish Food Codex, color value for tomato paste should be minimum 1.80 based on a*/b* ratio (Anon, 2014). A ratio greater than 1.90 indicates that the tomato paste can be accepted as of first quality in terms of colour while a ratio of less than 1.80 gives poor quality tomato paste as reported by Akillioglu *et al.* (2015). The color intensity (C*) value and red hue angle (h_{ab}) ranged from 26.11 to 26.26 and 33.98 to 34.53, respectively. The ΔE_{ab} value of 0.42 (less than 1) between the Roma tomato paste and Eva-F1 tomato paste showed that the difference between the pastes was not perceptible by the human eye. Colour of tomato paste is important regarding its application in food system as pigmentation found in such ingredient will be noticeable in finished products which in turn affect the consumer acceptability. Moreso, tomato paste is used for color and taste of some food preparations. However, it is imperative to note that maintaining the natural color in processed and stored foods has been a major challenge in food processing. In the case of tomato products (i.e. paste), an important reaction is the degradation of the red pigment lycopene, originally in the trans form, that isomerizes to the cis structure during heating, resulting in changes of color (Rodrigoh *et al*., 2007). Hence, the colour presented by each tomato cultivar may be a criterion for their use in food preparations by the consumers.

Table 2: Colour attributes of Roma and Eva-F1 tomato paste

Colour parameters	Roma tomato paste	Eva-F1 tomato paste
L^*	$35.59^b \pm 0.18$	$35.29^a \pm 0.37$
a^*	$21.51^a \pm 0.26$	$21.77^b \pm 0.05$
b^*	$14.80^b \pm 0.11$	$14.68^a \pm 0.13$
a*/b*	1.45	1.48
C*	26.11	26.26
h_{ab}	34.53	33.98
ΔE_{ab}	Control	0.42

All values are means of three determinations ± standard deviation. Means followed by the same letter are not significantly different from each other (p≥0.05)

Proximate composition of Roma and Eva-F1 tomato paste: Table 3 shows the proximate composition of the Roma and Eva-F1 tomato paste. The moisture content of the Roma cultivar was 88.97% which is slightly higher than that of the Eva-F1 cultivar (87.41%). The reported moisture values reported in this study were in agreement with the values reported by Mohammed *et al.* (2017) and Adubofuor *et al.* *(*2010) who have reported the moisture content of some tomato in the range of 84.15-90.75%, but higher than those of Adebooye *et al*. (2006) who reported 78.56%. The crude fat in the tomato paste is 0.39% and 0.46% for the Roma and nEva-F1 cultivar, respectively and these values is closely related to the value of 0.62% rreported for fresh tomato paste by Abdullahi *et al.* (2016). The lesser fat content of the tomato pastes reported in this study may be as a result of the steam blanching of the tomato prior to production of the paste. Moist heat treatment decreased the fat content possibly as a result of diffusion into the processing water. Also, agronomical activities during production of tomato may also account for dissimilarity.

The crude protein in the tomato pastes were 2.18% and 2.69% for the Roma cultivar and Eva-F1 cultivar, respectively. These values were comparable to a range of 2.23-2.60% reported by Mohammed *et al.* (2017). The high water content of Roma tomato paste might result in low level of protein compared to that of Eva-F1 tomato paste. The differences may also be as a result of varietal influence, environmental conditions and other agronomical practices during production (Agbemafle *et al.,* 2015). The ash content of the Roma tomato paste was 0.75% which was significantly higher than 0.64% reported for the Eva-F1 cultivar. The higher ash content in Roma cultivar may be as a result of the ability of plant bearing this tomato fruit to absorb minerals from the soil compared to the Eva FI cultivar (Agbemafle *et al.,* 2015). The two cultivars of tomato used contained varying amount of crude fibre with the Eva-F1 tomato paste having higher content of 5.02% compared with Roma tomato paste containing crude fibre of 4.37%. These values were within the range of 3.2% - 7.2% as reported by Sanusi *et al.* (2020). The principal components of dietary fibers are lignin, cellulose, hemicelluloses, pectins, resistant starch and non-digestible oligosaccharides. The quantity of cellulose fluctuates during fruit ripening as indicated by Brummell (2006). The carbohydrate content of the Roma tomato paste (4.15%) was significantly higher than the value reported in Eva-F1 cultivar (3.78%). These values are within the range (3.65-7.23%) reported by Garuba *et al*. (2018). The energy values of the samples ranged from 28.83 to 30.02 Kcal/100g. Previous study reported energy value of 34.67 kcal/100g in tomato paste (Abdullahi *et al.*, 2016). The lower energy value noted with Roma tomato paste could be explained by the lower content in lipid compared to the content in carbohydrate and protein.

Table 3: Proximate composition of Roma and Eva-F1 tomato paste

Parameters	Roma tomato paste	Eva-F1 tomato paste
Moisture	88.16^{b} ±0.02	87.41^{a} ± 0.02
Fat (%)	0.39^{a} ± 0.01	0.46^{b} ± 0.01
Protein (%)	2.18^{a} ± 0.01	2.69^{b} ± 0.01
Ash (%)	0.75^{b} ± 0.04	0.64^{a} ± 0.01
Fibre (%)	4.37^{a} ± 0.33	5.02^{b} ± 0.04
Carbohydrate (%)	4.15^{b} ± 0.05	3.78^{a} ± 0.01
Energy (Kcal/100g)	28.83^{a}	30.02^{b}

All values are means of three determinations ± standard deviation. Means followed by the same letter are not significantly different from each other

Mineral composition of Roma and Eva-F1 tomato paste: The mineral composition of the tomato pastes is presented in Table 4. The calcium content in the Roma cultivar (93.27 mg/100 g) was significantly higher than the value reported in the Eva-F1 cultivar (91.35 mg/100 g). The magnesium concentration in the Roma tomato paste cultivar was 18.83 mg/100 g while the Eva-F1 tomato paste cultivar had a value of 18.51 mg/100 g. However, the phosphorus in the Roma cultivar (10.07 mg/100 g) is lower than that of the Eva-F1 cultivar (10.59 mg/100 g). The iron content of the Roma and Eva-F1 tomato paste cultivar were 0.66 mg/100 g and 0.59 mg/100 g, respectively. The zinc content in the Roma cultivar and Eva-F1 cultivar varied significantly with value of 6.41 mg/100 g and 0.81mg/100 g, respectively. Cultivation conditions have significant effect on the uptake of elements, but there is no overall trend; each element is affected according to its own specific properties (Gundersen *et al*. 2001). Magnesium, phosphorus and calcium are essential macro-elements and on average an adult requires more than 100 mg/day, while iron and zinc are the second essential trace element with adults requiring less than 100 mg/day (Sarpras *et al*., 2019).

Table 4: Mineral composition of Roma and Eva-F1 tomato paste

Mineral	Roma tomato paste	Eva-F1 tomato paste
Calcium	93.27^{b} ± 0.12	91.35^{a} ± 0.01
Magnesium	18.83^{b} ± 0.06	18.51^{a} ± 0.08
Phosphorus	10.07^{a} ± 0.02	10.59^{b} ± 0.02
Iron	0.66^{b} ± 0.01	0.59^{a} ± 0.01
Zinc	6.41^{b} ± 0.01	0.81^{a} ± 0.01

All values are means of three determinations ± standard deviation. Means followed by the same letter are not significantly different from each other

Conclusion: Tomato fruit cultivars (Roma and Eva F1) were found to contain plethora of nutrients. This study showed that varietal difference affected physicochemical characteristics of tomato paste. The colour presented by each tomato cultivar may be interesting for the consumers in their applications as food ingredient. There also exist variations in the nutritional quality of tomato paste made from both varieties. The findings of this research will find applications in local tomato paste processing by taking advantage of unique characteristics of each cultivar.

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