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EFFECT OF GINGER AND GARLIC AS BIOPRESERVATIVES ON PROXIMATE COMPOSITION AND ANTIOXIDANT ACTIVITY OF TOMATO PASTE

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ABSTRACT

The study investigated the changes in proximate composition, lycopene and antioxidant contents of tomato paste preserved with garlic and/or ginger as biopreservatives. Fresh tomato fruits (Roma VF variety) were washed, drained, pulped, screened and concentrated by boiling. The garlic and ginger were dried in oven, milled, sieved and added to the concentrated paste at different (2 and 4%) concentrations. The samples were stored over a period of eight weeks during which the proximate composition, lycopene and total antioxidant contents were evaluated at two weeks interval. The results showed that crude protein, crude fat and ash contents of biopreserved samples containing 2% ginger increased from 2.92 to 4.47, 0.61 to 1.91 and 1.63 to 4.54%, respectively with storage time. The free radical scavenging activities increased in tomato paste samples containing blend of 2% garlic and 2% ginger (53.23 - 80.49 mg VCE/100 g) and blend of 2% garlic and 4% ginger (65.42 - 88.31 mg VCE/100 g). The combination of garlic and ginger as biopreservatives also increased the total phenolic and lycopene contents of tomato paste samples. The study showed that the use of garlic and ginger as biopreservatives either separately or in combination increased fats, lycopene and total antioxidative capacity of tomato paste with storage.

Keywords: *Biopreservatives, Garlic, Ginger, Proximate composition, Antioxidant, Lycopene, Tomato paste*

1. INTRODUCTION

Tomato is an herbaceous, usually sprawling plant in the Solanaceae on nightshade family. It is a perennial, often grown outdoor in temperate climate as an annual. Typically reaching to 1-3 m in height, it has a weak, woody stem that often vines over other plants (Oludemi, 2003). Tomato production in Nigeria is seasonal, and there is agro-ecological partition into northern and southern production zones. Over 70% of Nigerian tomato is produced under irrigation in the fadama lands of Bauchi, Sokoto, Jigawa, Kebbi, and Kano states. The Roma VF cultivar produced in the north has oval, smooth unridged fruit that is determinant in growth habit and contains total solid. Its production is between November and May and it is transported down to south from January to May. The north-south supply also involved out of season production (Alofe and Somide, 1982) and its very high perishability, account for about 36% price fluctuation in southern Nigeria towns. Tomato is also rich in the carotenoid and lycopene. Lycopene is one of the most powerful natural antioxidants (Kaur and Kapoor, 2002). In some studies lycopene, especially in cooked tomatoes, has been found to help prevent prostate cancer. Lycopene has also been shown to improve the skin's ability to protect against harmful UV rays (Redenbaugh et al., 1992). Also, tomato is a good source of fiber, which has been shown to lower high cholesterol levels, keep blood sugar levels from getting too high, and help prevent colon cancer. Tomato consumption has been associated with decreased risk of breast cancer (Zhang et al., 2009) and neck cancers (Freedman et al., 2008) and might be strongly protective against neurodegenerative diseases (Suganuma et al.., 2002; Rao and Balachanran, 2002). Tomato in the form of paste has been recommended over whole fresh tomatoes because it has been concentrated thus deliver more of their protective carotenoids (Levy et al., 1995). The susceptibility of the paste to microbial deterioration has necessitated the search for preservatives to extend its shelf life.

Many food products including tomato paste are perishable by nature and require protection from spoilage during their preparation, storage and distribution to give them desired shelf-life. For the reason that food products are now often sold in areas of the world far distant from their production sites, the need for extended safe shelf-life for these products has also expanded. The increasing demand for safe foods, with less chemical additives, has increased the interest in replacing these compounds with natural products, which do not injure the host or the environment. Natural substances such as salt, sugar, vinegar, alcohol, and essential oil are used as traditional preservatives. Natural plant extracts may provide an alternative to chemical preservatives. Over the years, much effort has been devoted to the search for new antifungal materials from natural sources for food preservation (Onyeagba et al., 2004; Boyraz and Ozcan, 2005; Haciseferogullari et al., 2005). Alliums were revered to possess anti-bacterial and anti-fungal activities and include the powerful antioxidants, sulfur and other numerous phenolic compounds, which arouse significant interests (Griffiths et al., 2002; Benkeblia, 2004; Haciseferogullari et al., 2005). Spices, herbs, essential oils and cocoa are rich in antioxidant properties in the plant itself and in vitro, but the serving size is too small to supply antioxidants via the diet. Typical spices high in antioxidants (confirmed in vitro) are clove, cinnamon, oregano, turmeric, cumin, parsley, basil, curry powder, mustard seed, ginger, pepper, chili powder, paprika, garlic, coriander, onion and cardamom (Tyler, 1994). It is however important that the use of biopreservatives such as ginger and garlic should not diminish or have adverse effects on the nutritional and organoleptic properties

of the final product. This work therefore aimed at assessing the influence of the use of ginger and garlic as biopreservatives at different concentrations on the proximate composition, lycopene and antioxidant contents of concentrated tomato paste stored for eight weeks.

2. MATERIALS AND METHODS

Fresh tomato fruits (Roma VF variety), garlic bulbs and ginger rhizomes were purchased from a local market in Ile – Ife, Nigeria. Fresh tomatoes were sorted for wholesomeness and intense red colour. The sorted red tomato fruits were washed and allowed to drain. The tomatoes were pulped and screened using a Langsenkamp pulping machine (Model 18 SER .L 295, U.K) according to the method reported by Oludemi (2003). The slurry was concentrated (7-12% total solids) to tomato paste by boiling in stainless steel pot smeared with palm oil so as to prevent burning (Nwanekezi and Onyeali, 2005). After concentration, the paste was divided into eight portions labelled A-G. Fresh garlic bulbs and ginger rhizomes were cleaned, peeled and 250 g each was dried in a Gallenkamp hot air oven at 65 ^{o}C for 12 h and ground with a Marlex Excella grinder (Marlex Appliances PVT., Daman). The garlic and ginger powders were then sieved through mesh size of 50 to 60 to remove the shafts and residues which were subsequently discarded (Kaewin, 2004). The garlic and ginger powder were added to the concentrated paste at different (2 and 4%) concentrations. The mixture was evenly homogenized, packaged into air tight plastic containers, stored at refrigeration temperature for further analyses.

2.1. Determination of Proximate Composition

The proximate composition of the tomato with and without powdered ginger and/or garlic at different concentrations were determined using AOAC (2000) methods.

2.2. Lycopene Determination

Tomato sample (1 g ± 0.05) was weighed into a 125 ml flask wrapped with aluminum foil to exclude light. A 50 ml mixture of n-hexane - acetone- ethanol (2:1:1; v: v: v) was added to solubilize all carotenoids (Sadler *et al*., 1990). The flask was stoppered and agitated continuously for 30 min on a magnetic stirrer plate until lycopene was completely extracted. This was confirmed in the colourless pulp fibers. Agitation was continued for another 2 min after adding 10 ml of water. The solution was then allowed to separate using separation funnel into a distinct polar (35 ml) layer and a non polar (25 ml) layer containing lycopene. The hexane solution containing lycopene was filtered through 0.22µm filter paper before measuring the absorbance using spectrophotometer at 472 nm (Sharma and LeManguer, 1996). The conversion of absorbance into lycopene concentration was based on its specific extinction coefficient ($E_{1cm}^{1\%}$) of 3450 in hexane (Sharma and LeManguer, 1996; Oludemi, 2003) using Beer Lambert equation:

$$A = ECL \quad (1)$$

$$C = \frac{A}{(EL)} \quad (2)$$

where

Absorbance (A) = the product of specific emissivity coefficient; (E), concentration of the absorbing species; (C) and path length through the sample (L)

A is the spectrophotometer readings at 472nm, ($E_{1cm}^{1\%}$) of 3450 in hexane, L is 1cm

2.3. Determination of Total Antioxidant of Tomato Paste Blends

Extraction of antioxidant was carried out on the paste using Yurttas *et al.* (2000) and Diana *et al.* (2007) methods with minor modifications. Each sample (10 g) was mixed with 100% methanol in conical flasks. Extraction was executed using magnetic stirrer for 30 min at room temperature. After 30 min, the extract was filtered through Whatman No. 1 filter paper. The crude extracts were stored in refrigerator until required for further analysis. Total phenolic content was determined using modified procedure of Saleem *et al.* (2001). Each extract (0.1 g/ ml in water) was mixed with 5.9 ml distilled water, and 1.0 ml of the diluted extract was mixed with 1.0 ml Follin Ciocateau reagent. The mixture was allowed to stand for 2-5 min, and 2 ml of 20% (w/v) Na_2CO_3 was added. After 30 min of rigorous mixing with a vortex mixer, reading was taken at 725 nm using a spectrophotometer. The result was expressed as Gallic acid equivalent (GAE) using a calibration curve with Gallic acid as standard (100 mg/ l).

2.4. 1, 1-diphenyl-2-picrylhyrazyl (DPPH) radical scavenging activity of tomato paste extract

DPPH radical scavenging activity of the samples of tomato product was measured using the procedure of Cakir *et al*. (2003). A 1 ml solution of DPPH radical solution in methanol was prepared and 1 ml of solution was mixed with 3 ml of the sample solutions in ethanol. Finally, after 30 min, absorbance was measured at 517 nm against methanol as blank. Decreasing of DPPH solution absorbance indicates an increase of the DPPH radical scavenging activity that was calculated in the equation:

$$\%\text{DPPH free radical scavenging} = \frac{control\ absorbance - sample\ absorbance}{control\ absorbance} \times 100 \quad (3)$$

The DPPH solution without sample solution was used as control.

2.5. Statistical Analysis

All experiments were conducted in triplicate. Data reported are averages of three determinations. Analysis of variance (ANOVA) was performed and differences in mean values were evaluated using Tukey`s test at $p < 0.05$.

3. RESULTS AND DISCUSSION

3.1. Proximate Composition

Addition of ginger, garlic, or ginger-garlic blends reduced the crude protein content in the biopreserved tomato paste compared to the control sample as shown in Table 1 to 4 respectively. However, the crude protein content of all tomato paste samples significantly ($p < 0.05$) increased with increasing storage time. In the sample without any of the biopreservatives, the initial protein content of 4.41% increased to 5.18% an increase of 17.46% within the period of storage while in samples with 2% ginger and 4% ginger, percentage increment of 53.31 and 44.35% were observed over the initial protein content. Higher increases in crude protein contents were recorded for samples preserved with ginger powder. Application of ginger-garlic combination did not produce similarly high increases in protein content of preserved tomato paste although a range of 11.24 – 40.11% increase in protein content was observed.

The crude fat contents of all the samples increased throughout the period of storage and the increases were significantly higher than those of the control sample. The crude fat contents of samples with 2% garlic and 2% ginger, 2% garlic and 4% ginger and 2% ginger and 4% garlic were in the range 0.5-1.36%, 0.77-1.46% and 0.78-1.42%, respectively while that of control sample varied from 0.37-0.74%. Increases in fat content could be explained in terms of increase in the number of microbes with storage. It has been established that microbes when present in high number can add to the protein and fat content of foods in which they thrive. Presence of ginger, garlic or a combination of both suppressed the number of microbes and by extension the quantity of protein and fat they added to the tomato paste. The presence of essential and fatty oils in garlic and ginger (Peter and Kandiannan, 1999) may have also contributed to the

Table 1: Proximate Composition of Tomato Paste and Ginger at different Concentration (dry weight basis)

Time in weeks	Sample code	% Crude Protein	% Crude Fat	% Crude Fibre	% Crude Ash	% CHO
0	B	3.32±0.02^{e}	0.58±0.01^{d}	1.12±0.01^{a}	1.49±0.01^{d}	93.49±0.01^{a}
	C	3.45±0.02^{d}	0.64±0.01^{d}	1.32±0.01^{a}	1.59±0.01^{d}	93.00±0.01^{a}
2	B	4.14±0.01^{d}	0.81±0.01^{c}	0.88±0.01^{bc}	2.44±0.02^{c}	91.73±0.15^{b}
	C	4.17±0.01^{c}	0.88±0.01^{c}	1.05±0.01^{b}	2.98±0.02^{c}	90.92±0.15^{b}
4	B	4.47±0.01^{c}	0.94±0.02^{b}	0.91±0.01^{b}	4.17±0.01^{b}	89.51±0.01^{c}
	C	4.64±0.01^{b}	0.95±0.02^{b}	0.92±0.01^{c}	4.24±0.01^{b}	89.25±0.01^{c}
6	B	4.68±0.01^{b}	1.08±0.01^{a}	0.84±0.01^{c}	4.27±0.01^{a}	89.13±0.02^{c}
	C	4.81±0.01^{b}	1.12±0.01^{a}	0.91±0.01^{c}	4.34±0.01^{ab}	88.82±0.02^{c}
8	B	5.09±0.03^{a}	1.08±0.01^{a}	0.85±0.01^{c}	4.27±0.01^{a}	88.71±0.01^{d}
	C	4.98±0.03^{a}	1.19±0.01^{a}	0.92±0.01^{c}	4.34±0.01^{a}	88.57±0.01^{c}

**Values with different superscript on the same column are significant at $p < 0.05$. Samples codes: B: Tomato Paste + 2% Ginger, C: Tomato Paste + 4% Ginger.*

Table 2: Proximate Composition of Tomato Paste and Garlic at different concentration (dry weight basis)

Time in weeks	Sample code	% Crude Protein	% Crude Fat	% Crude Fibre	% Crude Ash	% CHO
0	D	2.92±0.02^{e}	0.61±0.01^{c}	1.19±0.01^{a}	1.63±0.01^{e}	93.65±0.01^{e}
	E	2.68±0.02^{e}	0.88±0.01^{c}	0.98±0.01^{a}	1.15±0.01^{c}	94.31±0.01^{c}
2	D	3.46±0.01^{d}	0.98±0.01^{b}	0.85±0.01^{b}	2.91±0.02^{d}	91.80±0.15^{d}
	E	3.32±0.01^{d}	0.94±0.01^{c}	0.88±0.01^{b}	3.97±0.02^{b}	90.89±0.15^{b}
4	D	4.17±0.01^{c}	1.12±0.02^{a}	0.68±0.01^{c}	3.70±0.01^{c}	90.33±0.01^{c}
	E	4.24±0.01^{c}	1.02±0.02^{b}	0.88±0.01^{b}	4.47±0.01^{a}	89.39±0.01^{a}
6	D	4.37±0.01^{a}	1.19±0.01^{a}	0.68±0.01^{c}	4.23±0.01^{b}	89.53±0.02^{a}
	E	4.64±0.01^{a}	1.06±0.01^{b}	0.81±0.01^{c}	4.47±0.01^{a}	89.02±0.02^{a}
8	D	4.47±0.03^{a}	1.19±0.01^{a}	0.71±0.01^{c}	4.54±0.01^{a}	89.09±0.01^{b}
	E	4.48±0.03^{a}	1.21±0.01^{a}	0.85±0.01^{c}	5.07±0.01^{a}	88.39±0.01^{a}

Values with different superscript on the same column are significant at $p < 0.05$ D: Tomato Paste + 2% Garlic, E: Tomato Paste + 4% Garlic

Table 3: Proximate Composition of Tomato Paste with Garlic and Ginger as Biopreservatives (dry weight basis)

Time in weeks	Sample code	% Crude Protein	% Crude Fat	% Crude Fibre	% Crude Ash	% CHO
0	F	4.10±0.03^{c}	0.50±0.01^{d}	1.05±0.01^{a}	1.39±0.01^{a}	92.96±0.01^{c}
	G	3.39±0.03^{d}	0.77±0.01^{d}	0.94±0.01^{a}	1.29±0.01^{c}	93.61±0.01^{c}
	H	4.27±0.02^{a}	0.78±0.01^{a}	1.25±0.01^{a}	1.46±0.01^{b}	92.24±0.01^{b}
2	F	4.14±0.01^{c}	1.19±0.01^{c}	0.98±0.01^{b}	2.85±0.02^{c}	90.84±0.15^{b}
	G	4.27±0.01^{c}	1.20±0.01^{c}	0.81±0.01^{a}	3.22±0.02^{b}	90.50±0.15^{b}
	H	4.27±0.01^{a}	1.25±0.01^{a}	0.91±0.01^{a}	3.36±0.02^{c}	90.21±0.15^{ab}
4	F	4.20±0.01^{c}	1.29±0.02^{b}	0.85±0.01^{c}	4.00±0.01^{b}	89.66±0.01^{c}
	G	4.44±0.01^{b}	1.39±0.02^{b}	0.88±0.01^{a}	4.27±0.01^{a}	89.02±0.01^{a}
	H	4.34±0.01^{a}	1.05±0.02^{b}	0.85±0.01^{a}	4.20±0.01^{b}	89.56±0.01^{a}
6	F	4.33±0.01^{b}	1.36±0.01^{a}	0.68±0.01^{c}	4.10±0.01^{a}	89.53±0.01^{b}
	G	4.58±0.01^{b}	1.39±0.01^{ab}	0.78±0.01^{a}	4.27±0.01^{a}	88.98±0.01^{a}
	H	4.64±0.01^{a}	1.22±0.01^{a}	0.84±0.01^{a}	4.26±0.01^{a}	89.04±0.02^{a}
8	F	4.64±0.03^{a}	1.36±0.01^{a}	0.77±0.01^{d}	4.10±0.01^{a}	89.13±0.01^{b}
	G	4.75±0.03^{a}	1.46±0.01^{a}	0.68±0.01^{a}	4.31±0.01^{a}	88.80±0.01^{a}
	H	4.75±0.03^{a}	1.42±0.01^{a}	0.81±0.01^{a}	4.31±0.01^{a}	89.71±0.01^{a}

**Values with different superscript on the same column are significant at $p < 0.05$ F: Tomato Paste + 2% Garlic +2% Ginger, G; Tomato Paste + 2% Garlic +4% Ginger, H: Tomato Paste + 2% Ginger + 4% Garlic*

Table 4: Proximate Composition of Tomato Paste (dry weight basis)

Time in Weeks	% Crude protein	% Crude fat	% Crude fibre	% Ash	% CHO
0	4.41±0.03^{c}	0.37±0.01^{b}	1.38±0.01^{c}	1.56±0.01^{a}	92.28±0.01^{a}
2	4.58±0.01^{c}	0.81±0.01^{a}	1.49±0.01^{b}	1.66±0.02^{d}	91.46±0.15^{b}
4	4.84±0.01^{b}	0.78±0.02^{a}	1.59±0.01^{b}	3.39±0.01^{c}	89.40±0.01^{c}
6	5.19±0.01^{a}	0.75±0.01^{a}	1.80±0.01^{a}	4.03±0.01^{b}	88.23±0.01^{d}
8	5.18±0.03^{a}	0.74±0.01^{a}	1.96±0.01^{a}	4.14±0.01^{a}	87.98±0.01^{e}

Values with different superscript on the same column are significant at $p < 0.05$

observed increase in fat contents of biopreserved tomato paste samples.

The crude fibre content of all the samples decreased throughout the period of storage time. The crude fibre content of tomato paste was significantly ($p < 0.05$) higher than those of other biopreserved samples. Ash content of the samples increased with storage time. The increases noticed in samples containing ginger, garlic or a combination of ginger-garlic were in the range of 172 -234.1% while an increase of 165% was found for control sample.

The carbohydrate content of tomato paste, tomato paste and 2% ginger and tomato paste and 4% ginger were significantly ($p < 0.05$) lower than other samples during storage. The reduction in level of carbohydrate and fibre could be considered to have been utilized by microbes that increased with storage time. Carbohydrates especially in form of reducing sugars are easily metabolized by microorganisms (Molin, 2007).

3.2. Lycopene concentration of tomato paste with Garlic and/or Ginger

Addition of ginger, garlic, ginger-garlic blends reduced the lycopene concentration of tomato paste as shown in Table 5. However, increases from 5.87 to 9.02 mg/100 g for tomato paste containing 2% garlic and 2% ginger, 5.25 to 8.62 mg/100 g for tomato paste samples containing 2% garlic and 4% ginger, and 7.60 to 9.08 mg/100 g for tomato paste samples containing 2% ginger and 4% garlic were observed during storage. For tomato paste samples containing only 2% garlic and 4% garlic the lycopene concentration showed similar trends from 6.97 to 8.89 mg/100 g and 7.14 to 9.06 mg/100 g respectively. Sample without preservatives and samples containing only ginger at 2 and 4 % exhibited decreases in lycopene content. The greatest reduction (35.06%) in lycopene content was recorded for sample without preservative. The study has shown that garlic and ginger had a synergistic effect on lycopene content of bio-preserved tomato paste. Application of the two on tomato paste is advantageous as it increases the much desired lycopene. Use of thermal treatment has been shown to be responsible for lycopene isomerization and degradation during thermal processing and dehydration processing although exposure to light is also a problem (Lu *et al.*, 1996). Changes in lycopene content in tomato paste during storage have also been reported (Anguelova and Warthesen 2000; Takeoka *et al.*, 2001; Dewanto *et al.*, 2002; Hackett *et al.*, 2004; Seybold *et al.*, 2004; Goula *et al.*, 2006; Toor and Savage, 2006).

3.3. Total antioxidant content of tomato paste with garlic and/or Ginger

The free radical scavenging activity as presented in Table 6 increased in tomato paste containing 2% garlic and 2% ginger (53.23 - 80.49 mg VCE/100 g), 2% garlic and 4% ginger (65.42 - 88.31 mg VCE/100 g), and 2% ginger and 4% garlic (67.76 - 78.24 mg VCE/100g). For tomato paste samples containing only 2% garlic and 4% garlic the radical scavenging activity followed a similar trend increasing from 42.92 to 65.64 and 60.35 to 81.22 mg VCE/100 g, respectively. However, gradual decrease was observed in samples containing only 2% ginger and 4% ginger from 79.87 - 60.83 and 96.62 - 87.64 mg VCE/100g, respectively. The free radical scavenging activity of control sample (tomato paste without preservatives) exhibited gradual decrease (74.93-42.16 mg VCE/100g) with storage time. The addition of ginger at 4% has very high initial free radical scavenging activity (96.62 mg VCE/100g) when compared with the initial value of 74.93 VCE/100g shown by the control sample.

The total phenolic content (TPC) of the samples containing garlic and ginger as presented in Table 7 increased throughout the period of storage from 350.0 to 680.0 mg Gallic acid equivalent (GAE)/100 g for tomato paste samples containing 2% garlic and 2% ginger, 383.5 - 714.0 mg GAE/100 g for tomato paste samples containing 2% garlic and 4% ginger, and 384.0 - 726.5 mg GAE/100 g for tomato paste samples containing 2% ginger and 4% garlic. For tomato paste samples containing only 2% garlic and 4% garlic the radical scavenging activity followed similar trend in the range 164.5 - 337.5 and 193.0 - 340.5 mg GAE/100 g respectively. The addition of biopreservatives to tomato paste increased the phenolic content of the samples particularly in samples containing only 2% garlic, 4% garlic as well as in blends of 2% garlic and 4% ginger.

The increase in total phenol content during storage may be due to the reaction of polymeric phenols with the water moiety to form monomers. Total phenol content increase was reported in instant tomato pickle mix (blending optimized levels of tomato powder and other spice ingredients) during storage period (Narsing Rao *et al.*, 2011). Velioglu *et al.* (1998) and Holasova *et al.* (2002) reported that high total phenol content increases the antioxidant activity and there is a linear correlation between phenolic content and antioxidant activity (Gheldof and Engeseth, 2002). Similar changes in polyphenol content in tomato were also observed by Cieslik *et al.* (2006) and Davoodi *et al.* (2007). For tomato paste samples containing only 2% ginger and 4% ginger, the TPC decreased throughout the period of storage from 159.5 to 97.5 and 163.5 to 102.5 mg GAE/100 g respectively. The total phenolic content of tomato samples followed similar trend decreasing from 95-66.5 mg GAE/100 g. Khatun *et al.* (2006) found a negative change in the total phenolic content of nutmeg, ginger and fenugreek during cooking. The total antioxidant capacity ranged from 79.49 to 29.35 mg VCE/100 g extract has been reported for unheated spice and 101.91 – 20.30 mg VCE/100 g for the heated spices extract.

4. CONCLUSIONS

The results obtained in this study showed that tomato paste could be preserved with either ginger, garlic or ginger-garlic blends at 2 or 4 % w/w which showed that the crude protein, fat, and ash content increased with storage. Lycopene and total antioxidant contents of tomato paste preserved with 2 and 4% garlic or ginger-garlic blends also improved considerably during storage.

Table 5: Lycopene Concentration of Tomato Paste during Storage (mg/100g sample)

	Weeks				
	0	2	4	6	8
A	9.07±0.06^{a}	8.92±0.03^{a}	8.47±0.08^{b}	7.88±0.04^{c}	5.89±0.16^{d}
B	9.14±0.04^{a}	9.07±0.06^{a}	8.80±0.14^{b}	8.67±0.03^{bc}	8.55±0.07^{b}
C	8.96±0.03^{b}	8.89±0.04^{b}	8.52±0.06^{b}	8.44±0.04^{b}	8.43±0.10^{c}
D	6.98±0.07^{d}	7.68±0.28^{c}	8.39±0.08^{b}	8.52±0.04^{b}	8.89±0.71^{a}
E	7.14±0.06^{c}	7.87±0.04^{c}	8.57±0.04^{ab}	8.81±0.01^{ab}	9.06±0.01^{a}
F	5.87±0.09^{e}	6.22±0.03^{d}	7.24± 0.06^{c}	7.71± 0.01^{b}	9.02± 0.14^{a}
G	5.25±0.07^{f}	5.45±0.03^{e}	6.64±0.05^{d}	7.74±0.04^{c}	8.62±0.11^{a}
H	7.60±0.04^{c}	7.77±0.07^{c}	8.54±0.18^{b}	8.55±0.08^{b}	9.08±0.07^{a}

**Values with different superscript on the same column are significant at $p < 0.05$. Sample codes: A: Tomato Paste, B: Tomato Paste + 2% Ginger, C: Tomato Paste + 4% Ginger, D: Tomato Paste + 2% Garlic, E: Tomato Paste + 4% Garlic, F: Tomato Paste + 2% Garlic +2% Ginger, G; Tomato Paste + 2% Garlic +4% Ginger, H: Tomato Paste + 2% Ginger + 4% Garlic.*

Table 6: DPPH Radical Scavenging Activity of Tomato Paste (mg VCE/100 g)

	Weeks				
	0	2	4	6	8
A	74.93	56.64	54.64	46.34	42.16
B	79.87	75.38	71.75	70.46	60.83
C	96.62	88.40	88.34	87.76	87.64
D	42.92	49.87	58.96	63.43	65.64
E	60.35	72.23	74.41	76.24	81.22
F	53.24	59.13	73.64	73.69	80.49
G	65.41	76.40	85.05	86.58	88.31
H	67.76	70.26	70.85	77.76	78.24

**Samples codes: A: Tomato Paste, B: Tomato Paste + 2% Ginger, C: Tomato Paste + 4% Ginger, D: Tomato Paste + 2% Garlic, E: Tomato Paste + 4% Garlic, F: Tomato Paste + 2% Garlic +2% Ginger, G; Tomato Paste + 2% Garlic +4% Ginger, H: Tomato Paste + 2% Ginger + 4% Garlic.*

Table 7: Total Phenolic Content of Tomato Paste (mg GAE/100 g)

	Weeks				
	0	2	4	6	8
A	95.00	83.50	81.00	78.50	66.50
B	159.50	157.00	116.00	114.50	97.50
C	163.50	152.40	150.00	138.00	102.50
D	164.50	207.00	240.50	307.00	337.50
E	193.00	238.00	283.50	333.50	340.50
F	350.00	428.50	469.00	524.50	681.00
G	383.50	452.50	476.00	612.00	714.00
H	384.00	464.50	480.00	647.50	726.50

Samples codes: A: Tomato Paste, B: Tomato Paste + 2% Ginger, C: Tomato Paste + 4% Ginger, D: Tomato Paste + 2% Garlic, E: Tomato Paste + 4% Garlic, F: Tomato Paste + 2% Garlic +2% Ginger, G; Tomato Paste + 2% Garlic +4% Ginger, H: Tomato Paste + 2% Ginger + 4% Garlic.

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