Journal of Food Stability (2018) 1(1): 28-35
www.foodstability.com

Journal of Food Stability

ORIGINAL RESEARCH

Effect of Boiling on the Phenolic Content and Antioxidant Activity of Tomato (*Lycopersicon esculentum* L.) fruits

Wysenyuy Hans Berinyuy[1], Serges Cyrille Ndomou Houketchang[3], Ghislain Mbeng Nyemb[1*], Audrey Therese Nzwinda Mbite[2], Eric Serge Ngangoum[2]

[1]*School of Agriculture and Natural Resources, Catholic University Institute of Buea, P.O BOX 563, Buea, Cameroon*
[2]*School of Engineering, Catholic University Institute of Buea, P.O BOX 563, Buea, Cameroon*
[3]*Department of Biochemistry, Faculty of Science, University of Dschang, P.O BOX 67, Dschang. Cameroon*

Received: 20 November 2018 / Revised: 27 December 2018 / Accepted: 4 January 2019/ Published online: 14 January 2019

Abstract

This study was conducted in order to evaluate the effect of cooking (boiling) on the phenolic content and antioxidant activity of ripe tomato fruits. Fresh tomato fruits were divided into four groups amongst which three of them were respectively boiled at 98 °C for 10, 20 and 30 min. The last group was not processed and served as control. After processing, the fruits were dried, grounded and the natural antioxidants extracted with methanol. The dried extracts obtained were characterized by determining their total phenolic content and antioxidant activity [2,2-diphenyl-1-picrylhydrazyl radical scavenging activity (DPPH-RSA), Ferric reducing Antioxidant power (FRAP) and Metal Chelation ability (MCA)]. Results showed that the total phenolic content of fresh tomato fruits significantly increase after boiling for 10 min (11.59-18.82 mg GAE/g) and that when boiled for more than 10 min, its concentration significantly decrease (18.82-9.36 mg GAE/g). The determination of the antioxidant activity of the extracts showed that processing time significantly reduce the DPPH-RSA, the FRAP and the MCA of ripe tomato fruits. No significant difference was registered between the radical scavenging activity of fresh tomato fruits and the sample boiled for 10 min at all concentrations. However, with the other tests, the activity of the sample boiled for 10 min was significantly lower ($p<0.05$) compared to that of the fresh sample.

Practical Applications

Ripe tomato fruits should be boiled for a maximum of 10 min this in order to better preserve the natural antioxidants present, as they can significantly contribute to the reduction of the damages caused by oxidative stress in the body.

Keywords: Tomato fruits, boiling, phenolic content, antioxidant activity.

*Corresponding author:
Email address: ghislainmn@netcourrier.com (G. Mbeng Nyemb)

1. Introduction

Tomato (*Lycopersicon esculentum* L.) is a vegetable that is generally consumed fresh or after processing (Toor & Savage, 2005). It is used worldwide in the preparation of many foods in order to increase their taste, color, odor and flavor, thus making them suitable for consumption. Recently, there has been renewed attention given to the antioxidant content of tomatoes because epidemiological studies suggested that regular consumption of fruits and vegetables including tomatoes can play an important function in reducing the prevalence in cancers and cardiovascular diseases (Heber, 2000). Raw and processed tomatoes have been proven to be rich in molecules such as lycopene, polyphenols, vitamin C, E and A, that are suspected to be responsible for their antioxidant activity (Beutner *et al.*, 2001). These natural antioxidants have been demonstrated to protect the body against oxidative stress, which is one of the number one killers in the world today, since free radicals are known to be major contributors to several disorders including cancers, cardiovascular diseases, aging… (Atoui *et al.*, 2005).

Tomatoes are generally cooked by boiling in water or microwaving, frying, before consumption. These cooking processes will bring a number of changes in the physicochemical characteristics of the vegetable (Rehman *et al.*, 2004). During processing, the total phenolic content, the lycopene and vitamins of the tomatoes can significantly be reduce as well as their antioxidant activity. Heat can lead to the volatilization of some of the phenolic antioxidants and decomposition of lycopene, vitamin C and A, thus reducing the protective effect of those molecules involved in the prevention of degenerative diseases in humans. People generally cook tomatoes for long because they want to reduce their acidity to an acceptable level, but at the same time they lost some important molecules.

In several studies, the effect of heat and cooking time on the phenolic content and antioxidant activity of vegetables among which tomatoes have been demonstrated. Mayeaux *et al.* (2006) showed that the lycopene concentration significantly reduce with the increase in temperature and heating time. Sahlin *et al.* (2004) demonstrated that boiling and baking of tomatoes has little effect on their ascorbic acid, total phenolic content, lycopene contents and antioxidant activity, while frying significantly reduce these molecules. In the same line, Zhang & Hamauzu (2004) also showed that cooking affect the antioxidant component and activity of Broccoli. Ismail *et al*. (2004) also showed that thermal treatments reduce the total phenolic content in all vegetables. Though considerable attention had been given to the study of the effect of cooking on the phenolic content and antioxidant activity of tomatoes, very few reports are available on tomato fruits produced and consumed in Cameroon. We can hypothesize that boiling time affects the phenolic content and antioxidant activity of tomato fruits produced in Cameroon, thus reducing their protective effect against diseases related to oxidative stress.

The objective of this study is therefore to evaluate the effect of boiling on the phenolic content and antioxidant activity of ripe tomato fruits.

2. Materials and methods

2.1. Material

Fresh tomatoes (*Solanum lycopersicum)* were purchased from Muea local market, Buea, South-West Region, Cameroon in December 2017. All chemicals and reagents used were of analytical reagent grade.

2.2. Methods

2.2.1. Sample preparation and processing

Fresh and ripe tomato fruits were divided into four different groups (T1, T2, and T3 and TC respectively with each group weighing 400 g). Each of the groups weighed 400 g each; T1, T2 and T3 were each boiled at 98 °C for 10, 20, and 30 min respectively and were given the codes BT 10 min, BT 20 min and BT 30 min respectively.

The last group (TC) remained unprocessed and served as control. It was given the code Control. After this, all the above mentioned samples were dried to constant weight in an electric oven for 48 h at 50 °C for further analysis.

2.2.2. Sample preparation and processing

Dried tomato samples were blended using a grinding machine (Moulinex). 50 g of each sample powder *(Control, BT 10 min, BT 20 min and BT 30 min)* was extracted with 400 mL of methanol for 48 h at room temperature. The mixture was regularly subjected to shaking during the extraction. The extract was filtered with a Whatman No. 1 filter paper, and residues were again extracted with 200 mL of methanol to ensure maximum extraction of phenolic compounds. The combined filtrates were subjected to rotary evaporation at 40 °C under reduced pressure for the removal of the solvent. The dried extract was used for the determination of the total phenolic content and antioxidant activities.

2.2.3. Total phenolic content

The effect of processing on the total phenolic content of tomato was determined using the Folin-Ciocalteu colorimetric method, as described by Gao *et al.* (2000). In a test tube of 5 mL volume, 20 µl of a 2 mg/mL extract solution was added, followed by the Folin-Ciocalteu reagent (0.2 mL) and distilled water (2 mL). After 3 min incubation of the solution mixture at room temperature, 1 mL of 20% sodium carbonate solution was added and the mixture reincubated for 20 min under the same conditions. The absorbance of the resulting blue coloured solution was measured at 765 nm using a spectrophotometer. The total phenolic content of the extract was calculated from the gallic acid standard curve, and expressed as milligrams equivalents gallic acid per gram of extract.

2.2.4. Antioxidant activity

2.2.4.1. Radical scavenging activity

The ability of each extract to scavenge the 2,2-diphenyl-1-picryl hydrazyl (DPPH) radical was determined according to the method of Braca *et al.* (2002). 4.5 mL of 0.002% alcoholic solution of DPPH was added to 0.5 mL of different concentrations (125, 250, 500, 1000 and 2000 µg/mL) of samples and standard solutions separately, in order to have final concentrations of products of 25-200 µg/mL. The samples were kept at room temperature in the dark and after 30 min, the absorbance of the resulting solution was measured at 517 nm. The absorbance of the samples, control and blank were measured in comparison with methanol. Synthetic antioxidant, butylated hydroxyl toluene (BHT), which is a recognized

powerful radical scavenger, was used as positive control. The following formula was used for the calculation of the radical scavenging activity:

$$AA\% = [(Abs_{control} - Abs_{sample}) \times 100/Abs_{control}]$$

2.2.4.2. Ferric reducing antioxidant power

The antioxidant potential of tomato extract was also evaluated for their ability to reduce iron (III) to iron (II) following the method of Oyaizu (1986). An aliquot of 0.5 mL plant extract (250, 500, 1000, and 2000 µg/ mL) was mixed with 1 mL phosphate buffer (0.2 M, pH 6.6) and 1 mL of 1% aqueous $K_3Fe(CN)_6$ solution, well shaken and incubated at 50°C for 30 min. After incubation, 1 mL of 10% TCA solution was added to stop the reaction and the mixture was centrifuged at 1008 g for 10 min. 1.5 mL of supernatant, 1.5 mL of distilled water and 0.1 mL of 0.1% $FeCl_3$ solution were mixed and incubated for 10 min and absorbance read at 700 nm on spectrophotometer. The final concentration of the extract solutions were of 12.5-200 µg/mL. A blank sample, containing all the reagents but no extract was prepared in the same conditions. Catechin, a powerful ferric reducer, was used as positive control to compare the reducing power of the extracts. A higher absorbance indicates a higher reducing power.

2.2.4.3. Metal chelation activity

The antioxidant activity of the different extracts was also evaluated for its ferrous ion chelating activity (Benzie & Szeto, 1999). In test tubes containing 160 µl of sample solution (1000 µg/mL), 160 µl of aqueous solution of 1, 10-phenanthroline (0.25 %) and 400 µl of methanolic $FeCl_2$ (0.1 %) were added. After 10 min incubation at room temperature, 880 µl of distilled water was added and the absorbance was measured at 510 nm. The metal chelating efficiency of the oil was compared to that of Catechin (positive control). The inhibition percentage (IP) of the formation of the complex Fe^{2+}-phenanthroline was calculated using the following formula:

$$IP\% = Abs_{sample} \times 100/Abs_{control}$$

2.2.5. Statistical analysis

Results (Mean ±Standard deviation) obtained in the present study were subjected to one-way analysis of variance (ANOVA) with Student-Newman- Keuls test using Graphpad-InStat version 3.05, to evaluate the statistical significance of the data. A probability value at $p < 0.05$ was considered statistically significant.

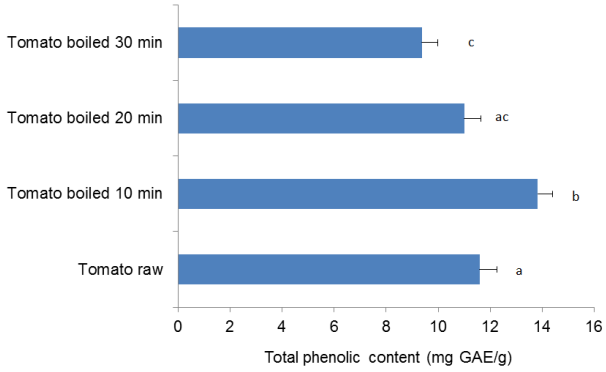
3. Results

3.1 Total Phenolic content

The changes in total phenolic content of tomato fruits during cooking by boiling is presented in Figure 1. A significant increase ($p<0.05$) in phenolic content of tomato was observed after 10 minutes boiling. From the 20th to the 30th minute, a significant decrease ($p<0.05$) in this parameter was registered. The highest decrease ($p<0.05$) was registered after boiling the fruits for 30 minutes. No significant difference ($p>0.05$) was observed between the total phenolic content of raw and boiled tomatoes (20 min).

3.2. Radical Scavenging Activity

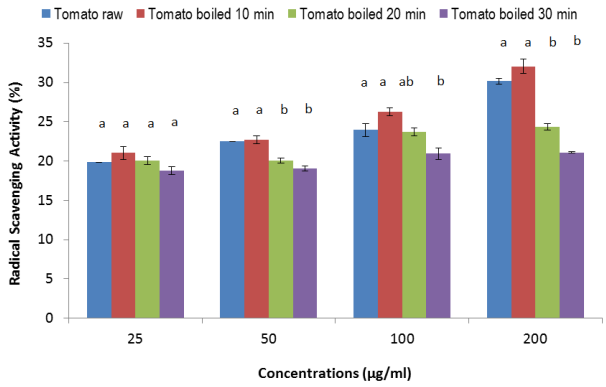
The Radical Scavenging Activity of processed and unprocessed tomato samples is presented in Figure 2. Apart from the extract obtained from the tomato boiled for 30 min which presented similar activity at all concentrations,



Data are presented as mean (±SD) (n=3) (a-c). Value with different superscripts are significantly different (p<0.05)

Figure 1: Changes in total phenolic content of tomato during processing

the activity of all the other extracts was increased with their concentrations. No significant difference (p>0.05) was registered between the Radical Scavenging Activity (RSA) of raw and boiled (10 min) tomato. However, the best activity was recorded with tomatoes boiled for 10 min. As previously observed with total phenolic content, the Radical Scavenging Activity of tomato decreased with boiling time and was significantly lower after boiling for 20 and 30 minutes respectively.

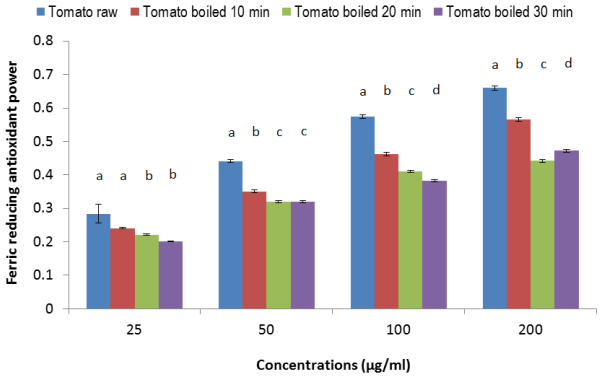


Data are presented as mean (±SD) (n=3) (a-b). Value of the same concentrations with different superscripts are significantly different (p<0.05)

Figure 2: Evolution of the radical scavenging activity of tomato during processing

3.3. Ferric Reducing Antioxidant Power

Figure 3 illustrates the changes in Ferric Reducing Antioxidant Power of processed and unprocessed tomato samples. Generally, the Antioxidant Power was increased with the concentration of extracts. The Antioxidant activity significantly decreased (p<0.05) with boiling time.



Data are presented as mean (±SD) (n=3) (a-b). Value of the same concentrations with different superscripts are significantly different (p<0.05)

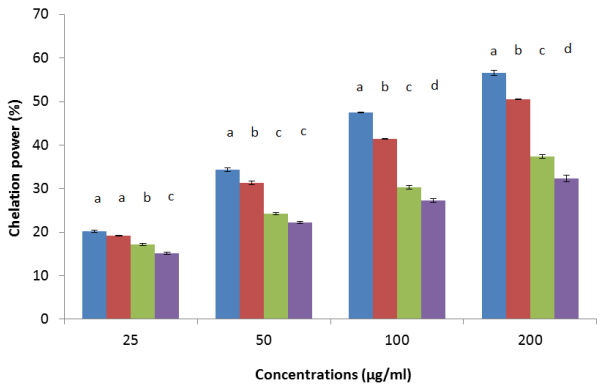
Figure 3: Changes in ferric reducing antioxidant power of tomato during processing

3.4 Metal Chelation Ability

The changes in metal chelation ability of treated and untreated tomato samples are presented in Figure 4. The Metal Chelation Ability of all the extracts was increased with their concentrations. A significant decrease (p<0.05) in this parameter was observed in all the processed samples compared to the control (raw tomato). The lowest activity was obtained after boiling for 30 minutes.

4. Discussion

Phenolic compounds are amongst the main secondary metabolites detected in plants. They are generally used by these organisms to protect themselves against external aggressors. They are known and significantly exploited for



Data are presented as mean (±SD) (n=3) (a-b). Value of the same concentrations with different superscripts are significantly different (p<0.05)

Figure 4: Changes in metal chelation activity of tomato during processing

their powerful antioxidant activity (Bouba *et al.*, 2010). The changes in total phenolic content of tomato fruits showed that their concentration increased after boiling for 10 min before starting to decrease after 20 to 30 min boiling. This can be explained by the fact that after 10 minutes the phenolic content of different cells was released due to their lysis. The significant decrease in this parameter from the 20th to the 30th min can be attributed to the decomposition of phenolic antioxidant and vitamins (Vitamin C and β-carotene) as these compounds have a limited thermal stability in certain conditions. These results are in accordance with those reported by Dewanto *et al.* (2002) and Mayeaux *et al.* (2006) who respectively showed that the amount of Vitamin C and lycopene significantly decreased with processing time at high temperature (88-150 ^{o}C). Similar observations were made by Agamy (2016) who demonstrated that microwave cooking significantly reduces the phenolic, Vitamin C and β-carotene content of tomato. However, Dewanto *et al.* (2002) showed that there was no significant change in the total phenolic composition of raw and processed tomato (at 88 ^{o}C for 2, 15 and 30 min respectively).

The result of the antioxidant activity of tomato samples after processing showed that their activity significantly reduced with boiling time. This result is in line with the variations observed in the total phenolic content as it has been demonstrated that the antioxidant activity of plant extracts is strongly related to their phenolic content (Bouba *et al.*, 2010; Womeni *et al.*, 2013). The destruction of these phenolic antioxidants by heat consequently leads to the reduction of the antioxidant activity. These results are not in agreement with those reported by Agamy (2016) and Dewanto *et al.* (2002) which showed that the antioxidant activity of tomato fruits increased with processing temperature and time. These differences can be attributed to the extraction conditions and the nature of the extraction solvent as these authors used acetone and acetyl-acetate. These solvents have the property to extract antioxidants like lycopene which have good antioxidant activity. Boiling tomato for 10 min is suitable for the preservation of its natural antioxidants as well as its activity against free radicals and reactive oxygen species. This can be a nutritional way to prevent damages related to oxidative stress in the body.

5. Conclusion

The objective of this study was to evaluate the effect of processing time on the phenolic content and antioxidant activity of tomato fruits. The results of these investigations showed that the phenolic content and Radical Scavenging Activity of tomato increased after 10 min boiling. However, these parameters together with the Ferric Reducing Antioxidant

Power and Metal Chelation Activity significantly decrease after 20 and 30 min of boiling respectively. Tomato fruits should be boiled for a maximum of 10 min this in order to make available its natural antioxidant for the well-being of consumers as they can help to fight against the damages caused by oxidative stress.

Conflict of interest

The authors declare that they do not have any conflict of interest.

Ethics

This Study does not involve Human or Animal Testing

References

Atoui, A. K., Mansouri, A., & Boskou, G. (2005). Panagiotis Kefalas,Tea and herbal infusions: Their antioxidant activity and phenolic profile. *Food Chemistry*, 89, 27-36.

Benzie, I. F. F., & Szeto, Y. T. (1999). Total Antioxidant Capacity of Teas by the Ferric Reducing/ Antioxidant Power Assay. *Journal of Agricultural and Food Chemistry,* 47, 633-636.

Beutner, S., Bloedorn, B., Frixel, S., Blanco, I. H., Hoffmann, T., Martin, H., Maeyer, B., Noack, P., Ruck, C., Schmidt, M., Schulte, I., Sell, S., Ernst, H., Haremza, S., Seybold, G., Sies, H., Stahl, W. & Walsh, R. (2001). Quantitative assessment of antioxidant activities of properties of natural colorants and phytochemicals; carotenoids, flavonoids, phenols and indigoids. The role of β-carotene in antioxidant functions. *Journal of the Science of Food and Agriculture*, 81, 559-568.

Bouba, A, A., Njintang, Y. N., Scher, J., & Mbofung, C. M. F. (2010). Phenolic compounds and radical scavenging potential of twenty Cameroonian spices. *Agriculture and Biology Journal of North America*, 1, 213-224.

Braca, A., Sortino, C., Politi, M., Morelli, I. & Mendez, J. (2002). Antioxidant activity of flavonoids from Licania licaniaeflora. *Journal of ethnopharmacology*, 79, 379-381.

Dewanto, V., Wu, X., Kafui, K. A., & Liu, R. H. (2002). Thermal Processing Enhances the Nutritional Value of Tomatoes by Increasing Total Antioxidant Activity. *Journal of Agricultural and Food Chemistry*, 50, 3010-3014

Gao, X., Ohlander, M., Jeppsson, N., Björk, L. & Trajkovski, V. (2000). Changes in antioxidant effects and their relationship to phytonutrients in fruits of sea buckthorn (*Hippophae rhamnoides* L) during maturation. Journal of Agricultural and Food Chemistry, 48, 1485-1490

Heber, D. (2000). Colorful cancer prevention: α-carotene, lycopene, and lung cancer. *The American Journal of Clinical Nutrition*, 72, 901-902.

Ismail, A., Marjan, Z. M. & Foong, C.W. (2004). Total antioxidant activity and phenolic content in selected vegetables. *Food Chemistry*, 87, 581-586

Mayeaux, M., Xu, Z., King, J. M., & Prinyawiwatkul, W. (2006). Effects of cooking conditions on the lycopene content in tomatoes. *Journal of Food Sciences*, 71, 461-464

Agamy, N. F. (2016). Effect of boiling and microwave cooking on some antioxidant compounds in highly consumed vegetables in Egypt. *Central European Researchers Journal*, 2, 76-84.

Oyaizu, M. (1986) Studies on Products of Browning Reactions: Antioxidative Activities of Product of Browning Reaction Prepared from Glucosamine. Japan Journal of Nutrition, 44, 307-315. peroxidation. *Methods Enzymol*, 186, 421-431

Rehman, J., Traktuev, D., Li, J., Merfeld-Clauss, S., Temm-Grove, C. J., Bovenkerk, J. E., Pell, C. L., Johnstone, B. H., Considine, R. V., & Keith, L. (2004). Secretion of Angiogenic and Antiapoptotic Factors by Human Adipose Stromal Cells. *Circulation Research*, 109, 1292-1298.

Sahlin, E., Savage, G. P. & Lister, C.E. (2004). Investigation of the antioxidant properties of tomatoes after processing. *Journal of Food composition and Analysis*, 17, 635-647.

Toor, R. K. & *Savage*, G. P. (2005). Antioxidant Activity in Different Fractions of Tomatoes. *Food Research International*, 38, 487-494

Womeni, H. M., Tonfack, D. F., Tiencheu, B., & Linder, M. (2013). Antioxidant potential of methanolic extracts and powders of some Cameroonian spices during accelerated storage of soybean oil. *Advances in biological chemistry*, 3, 304-313.

Zhang, D. & Hamauzu, Y. (2004). Phenolics, ascorbic acid, carotenoids and antioxidant activity of broccoli and their changes during conventional and microwave cooking. *Food Chemistry*, 88, 503-509.