

Continuous and Conventional Microwave Heating Effects on the Antioxidant Capacity of Tomato Juice

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Abstract

Thermal processing extends the shelf life of fruits and vegetables by inactivating microorganisms and enzymes. The efficacy of heating depends on the properties of the food and mainly on the processing parameters. The microwave (MW) oven offers several advantages for keeping overall quality and safety of the foods products. A continuous MW oven is a new tool which can make the cooking process of plant products shorter. The present work evaluates the effect of a new industrial continuous MW oven at different heating powers (750, 900 and 1050 W) and times (from 120 to 420 s) on the antioxidant capacity of tomato juice. This treatment was compared to other tomato juice heated in a conventional MW oven (750 and 900 during 60 to 150 s). As control non heated juice was used. The results showed that the antioxidant capacity was lowered by the heating. In general, as longer the duration and higher the power applied the lower antioxidant capacity was found. However, a moderate high power dose (900 W) combined with shorter duration (120 or 150 s) kept better the antioxidant capacity than low power MW dose (750 W) combined with high treatment duration (360 or 420 s). At similar doses (time/power) the industrial MW provided a slightly lower antioxidant capacity than conventional MW. As main conclusion, when comparing the efficacy of the continuous MW oven versus the conventional one no advantage for keeping the antioxidant capacity of tomato juice was found.

Keywords: Thermal treatment; Quality; FRAP

1. Introduction

Fruits and vegetables are very good and cheap sources of natural bioactive compounds like antioxidants of interest for the human diet. These antioxidants include carotenoids, vitamins, flavonoids, other phenolic compounds, dietary glutathione, and endogenous metabolites [1,2,3]. Tomato is a very popular vegetable and has a great importance in food by their content in vitamins, lycopene, and organic acids. All tomato products (juice, ketchup, sauce, puree, paste and soup) have antioxidant characteristics determined by the presence of bioactive compounds. One of the most popular options for consuming tomatoes is tomato juice because is easy to drink, tasty, and filled with health benefits. Color and flavor are the most important quality attributes of tomato juice that influence the consumer's choice. These are usually prepared by thermal or dehydration processing and then packaged and stored. These thermal processes would certainly bring

about a number of changes in physical characteristics and chemical composition of products [3, 4, 5, 6]. Regarding food quality and safety some of these changes are undesirable and must be minimized.

The purpose of thermal processing is to extend the shelf-life of food products without compromising food quality and safety. In addition consumers demand the maximum preservation of the endogenous sensory, nutritional and health related qualities of products they eat. Short microwave (MW) treatment may be a solution to achieve this purpose. In comparison with conventional heating methods, the MW oven offers a rapid and relatively uniform heating, high energy efficiency, saving, reduced space utilization, precise process control, fast start-up, shut-down conditions and high overall quality and safety of the final product. MW thermal processing has been a major processing technology in the food industry because it gives the opportunity to have a fast thermal process,

including in a continuous mode [7]. MW has been successfully used to heat, dry, pasteurize and sterilize many food products [8, 9]. High-quality retention of product and antioxidant activity has been reported using 915 MHz MW [8]. Nowadays thermal treatment of plant derived foods by MW oven is convenient and very popular all around the world.

The objective of this study was to investigate the comparative effects on antioxidant activity of tomato juice heated by mean of a conventional discontinuous MW oven and an innovative continuous MW oven. As far as we know this kind of study is firstly reported here.

2. Materials and Methods

2.1 Plant Material

Canary tomatoes picked in the Region of Murcia were purchased from a local grocery store. Fruits free from defects and with a similar visual appearance were washed; cut into small pieces, squeezed, milled and filtered using a steel sieve.

2.2 Microwave Treatment

Tomato juice (200 mL) were filled into a beaker glass and covered with plastic storage bag. After that beakers were placed in a conventional discontinuous commercial MW oven (SANYO Electric Industrial Co., LTD., UK., 2450 MHz) or in an innovative continuous industrial MW oven (SAIREM IBERICA S.L., SI-MAQ0101, Barcelona, Spain). Conventional MW ovens have a power rating from 600 to 900 W, while continuous MW ovens can be up to 15 KW. In addition this last MW oven includes a computer interface and a fiber optic slip ring for online temperature measurement. Subsequently the samples were treated with different powers and times combinations as reported in Table 1. These combinations were selected after some preliminary experiments.

Once heating all samples were frozen at -80°C until further analysis.

2.3 Determination of Total Antioxidant Capacity

The Total Antioxidant Capacity (TAC) was determined by using the ferric reducing ability of plasma (FRAP) method [10]. This assay depends upon the reduction at low pH of ferric tripyridyltriazine complex to the ferrous tripyridyltriazine by a reductant (antioxidant). The reagents used for the FRAP assay were: a)

Acetate buffer 300 mM pH 3.6: Weigh 3.1g sodium acetate trihydrate and add 16 ml of glacial acetic acid and make the volume to 1000 mL with MilliQ water. b) 2, 4, 6-tripyridyl-triazine: 0.1562 g in 0.166mL HCl. c) FeCl₃. 6 H₂O: 0.5404 g in 100mL MilliQ water. The working FRAP reagent was prepared by mixing a, b and c in the ratio of 10:1:1 just before testing.

Preparation of samples: 2.5 mL MeOH was added to 0.5mL (500 µL) tomato juice (the glasses were covered by foil). The extraction was carried out in an orbital shaker for 1 hour at 200×g in darkness inside a polystyrene box with an ice bed. The samples were filled out in two eppendorf (by a Pasteur pipette) which were placed in a centrifuge for 10 min at 4 °C and 15×rpm.

Determination of TAC: On a cuvette were added 6µL of sample or standard solution and 198 µL of reagent (with at least 3 cells for blank (6µL MeOH and 198 µL of reagent)). This cuvette was kept for 30-40 min at room temperature in the dark to react. After that the absorbance was read in a spectrophotometer (Tecan Infinite M200, Männedorf, Switzerland) at 593 nm. All of these stages were carried out in the ice and dark.

The analysis were carried out before (control) and after each MW treatment. All analyses were made by triplicate and results were expressed as mg ascorbic acid equivalent (AAE) 100 mL⁻¹ of tomato juice.

2.4 Statistical Analysis

Mean values (n = 3) were subjected to ANOVA and least significant difference test (LSD) at p < 0.05.

3. Results and Discussion

3.1 Antioxidant Capacity

As expected, the TAC of the tomato juice was influenced by the time and power parameters in both MW ovens. According to results displayed in Table 1, in general, the TAC significantly decreased by increasing the power and time of thermal treatment in both MW ovens. In the conventional MW oven the initial TAC in control samples was 56.11 mg AAE 100 mL⁻¹. The maximum decrease (until 78.56 %) was found in the highest power and time (900 W and 150 s) treatment. On the other hand, in the continuous industrial MW oven the control samples of tomato juice were found to have a

TAC of 53.18 mg AAE 100 mL⁻¹. This initial TAC level reached the highest decrease (until 56.71 %) under the 1050 W and 150 s treatment (Table 1). The current results agree with those of Barrett et al. [11] who reported that antioxidant components like AA reduced in microwaved tomato juice. Also Zhang and Hamazu [4] and Martínez-Hernández et al. [3] reported that antioxidant activity in broccoli were heavily lost during a conventional MW cooking process.

A long duration of treatment at low power reduced the TAC as a short duration treatment using high power. However, a moderate high power dose (900 W) combined with shorter duration (120 or 150 s) kept better the antioxidant capacity than low power MW dose (750 W) combined with high treatment duration (360 or 420 s). At similar doses (750 W during 120 s or 900 W during 120 and 150 s) the industrial MW provided a slightly lower antioxidant capacity than conventional MW (Table 1).

Table 1. Effect of different microwave treatments on the total antioxidant capacity (mg AAE 100 mL⁻¹) and of tomato juice.

Dose	Conventional MW	Continuous MW
0 (control)	56.11 ± 0.42 a (100%)	53.18 ± 0.12 a (100%)
750 w - 60 s	54.51 ± 0.56 a (97.15%)	-
750 w - 120 s	52.24 ± 0.41 b (93.10%)	-
750 w - 210 s	50.45 ± 1.06 bc (89.91%)	46.09 ± 0.18 b (86.67%)
750 w - 300 s	-	41.02 ± 0.31 d (77.13%)
750 w - 360 s	-	38.03 ± 0.09 g (71.51%)
750 w - 420 s	-	35.06 ± 0.19 h (65.93%)
900 w - 60 s	49.50 ± 1.09 c (88.22%)	-
900 w - 120 s	45.48 ± 0.75 d (81.06%)	41.90 ± 0.32 c (78.79%)
900 w - 150 s	44.08 ± 0.25 d (78.56%)	40.13 ± 0.15 e (75.46%)
900 w - 180 s	-	38.97 ± 0.08 f (73.28%)
1050 w - 120 s	-	32.11 ± 0.19 i (60.38%)
1050 w - 150 s	-	30.16 ± 0.25 j (56.71%)

* Data are averages of three replicates ± SE. Values in brackets are the retention percentage of TAC respect to the control. Different letters

in the same column indicate significant differences among mean values ($p < 0.05$).

4. Conclusion

MW heating technology reduced the initial TAC in tomato juice. However, its application in a continuous way with the equipment used in the current work was not efficacy enough when compared to the conventional discontinuous system.

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6. References

- [1] Tapiero H., Townsend D.M., Tew K.D. 2004. The role of carotenoids in the prevention of human pathologies. *Biomedicine Pharmacotherapy* 58: 100-110.
- [2] Young A.J., Lowe G.M. 2001. Antioxidant and prooxidant properties of carotenoids. *Archives of Biochemistry and Biophysics* 385 (1): 20 – 27.
- [3] Martínez-Hernández G.B., Artés-Hernández F., Gómez P., Artés F. 2013. Induced changes in bioactive compounds of kailan-hybrid broccoli after innovative processing and storage. *J. Funct. Foods*. 5: 133–143.
- [4] Zhang D., Hamazu Y. 2004. Phenolics, ascorbic acid, carotenoids and antioxidant activity of broccoli and their changes during conventional and microwave cooking. *Food Chem.* 88: 503-509.
- [5] Zhang M., Tang J., Mujumdar, A.S., Wang, S. 2006. Trends in microwave-related drying of fruits and vegetables. *Trends Food Sci. Technol.* 17: 524-534.
- [6] Sukhwant M. K., Harvinder K., Tejinder G. 1992. Effect of cooking on fibre content of vegetables. *J. Food Sci. Technol.* 29: 185–186.
- [7] Coronel P., Truong V.D., Simunovic J., Sandeep K.P., Cartwright G.D. 2005. Aseptic processing of sweet potato purees using a continuous flow microwave system. *J. Food Sci.* 70 (9): 531–53.

[8] Decareau R.V. 1992. History of the microwave oven. In: Microwave foods: new product development. Trumbull: Food Nutrition Press Inc. 1-46.

[9] Picouet P.A., Landl A., Abadias M., Castellari M., Viñas I. 2009. Minimal processing of a Granny Smith apple purée by microwave heating. *Innov. Food Sci. Emerging Technol.* 10: 545-550.

[10] Benzi I.F.F., Strain J.J. 1966. The ferric reducing ability of plasma (FRAP) as a measure of 'antioxidant power': The FRAP assay. *Analytical Biochemistry* 239: 70-76.

[11] Barrett D.M., Weakley C., Diaz J.V., Watnik M. 2007. Qualitative and Nutritional Differences in Processing Tomatoes Grown under Commercial Organic and Conventional Production Systems. *J. Food Sci.* 72 (9): 441-51.