

Full Length Research Paper

Changes in physicochemical properties and bioactive compounds of tomato pulp submitted to different processing techniques

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Tomato is a vegetable/fruit highly consumed all over the world. This study was to assess the effect of some postharvest processing such as thermal treatment, microwave, ultrasound and ultrasound combined with heat treatment on some physicochemical characteristics as well as nutrients content of tomato pulp during storage at room temperature. Results showed that the pulp samples submitted to ultrasonic and microwave treatments gave an increase in water content (95.65 to 96.75%) and total acidity (0.70 to 1.16% citric acid equivalent) and a decrease in pH (4.02 to 3.59) and brix degree (4.93 to 4.02% Brix) during the first 15 days of storage. Ultrasound treatment associated with heat treatment did not affect the physicochemical characteristics of tomato pulp and the β -carotene, but slightly reduced the total phenolic content during the first 15 days of storage (723.98 to 659.66 mg GAE/100 g DM). A significant increase in the total phenolic content (647.33 to 832.78 mg GAE/100 g DM) and β -carotene (10.77 to 12.90 mg GAE/100 g DM) was observed during storage of pulp samples treated with ultrasound and microwaves. This study showed that the ultrasound treatment associated with heat treatment can be recommended to processors for nutrients preservation during storage.

Key words: Tomato pulp, β -carotene, total phenolic, physicochemical characteristics, ultrasound, heat.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is a vegetable grown all over the world for its fruits, which are consumed

especially for their organoleptic and nutritional qualities. In Burkina Faso, the annual tomato production was

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estimated to 167400 tons in 2018 (DGESS/MAAH, 2020). Tomato is a climacteric fruit, known as an excellent source of bioactive molecules such as lycopene, carotenoids, phenolic compounds, vitamins and other nutraceuticals (Toor and Savage, 2005; Tudor-Radu et al., 2016). She is rich in a plethora of natural antioxidant compounds (Shatta et al., 2017). 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 (Donkor et al., 2015; Pinela et al., 2016; Przybylska, 2020). Tomatoes do not lose their health benefits as they are processed or cooked. In fact, lycopene in cooked and processed tomatoes (sauce, paste, salsa, canned tomatoes) is more easily absorbed than fresh tomatoes (Shatta et al., 2017).

Tomato after harvesting, is generally subject to culinary practices, processing and preservation. Processed tomato products included pulp, paste, powder, juice, sauce, jam, etc. During processes, several treatments such as thermal and non-thermal ones can be applied. Storage and processing may be led to changes in levels of phytochemicals, impacting the quality of the end-products (Lavelli and Giovanelli, 2003; Capanoglu et al., 2008; Chanforan, 2010). Studies on the impact of treatment methods on carotenoids, vitamins and total phenolic in processed products have shown controversial results (Abushita et al., 2000; Dewanto et al., 2002; Seybold et al., 2004; Capanoglu et al., 2008; Shatta et al., 2017). Thermal techniques are the most commonly used conventional methods for preservation. These techniques allowed the inactivation of microorganisms and enzymes in food, but have some impacts on organoleptic and nutritional qualities (Stratakos et al., 2016). Nowadays, consumers tend to require processed products that have a good taste and which maintain their nutritional qualities. Previous studies reported that combined microwave and ultrasound treatments can improve the microbiological quality of food while having a lesser impact on taste and nutritional qualities (Montemurro et al., 2014; Stratakos et al., 2016; Lagnika et al., 2017). However, the effect of the treatments on the stability of antioxidant molecules of processed tomato during storage is not well documented.

This study was to assess the effect of some of thermal and non-thermal techniques on the stability of physicochemical parameters and bioactive compounds in tomato pulp during storage at ambient temperature.

MATERIALS AND METHODS

Plant material and sample preparation

Fresh and firm tomatoes of the Mongal F1 variety were bought at a market in the city of Ouagadougou (Burkina Faso). Tomatoes were sorted, washed in water bath, disinfected for 10 min with 0.24% sodium hypochlorite and then rinsed with water. Afterwards, pulps

were separated using stainless steel pulp extractor. Obtained pulps were weighed and packaged into 72 glass jars of 300 ± 5 ml and divided into six equal parts.

Processing treatment

The treatment techniques were previously described by Lagnika et al. (2017) with a slight modification as follows. The six groups have been submitted to the following treatments: a first group not having undergone any treatment, it was used as a control (C); a second group was subjected to a heat treatment at 65°C for 15 min in a water bath (WB65); a third group was subjected to a heat treatment at 85°C for 15 min in a water bath (WB85); a fourth group was sonicated (Bioblock Scientific, Vibra-Cell 88169, Germany) at a power of 286-312 W and a frequency of 35 kHz; a fifth group was subjected both to heat treatment and sonication (USWB). The temperature was kept below 65°C using an ice-bath around the reactor. The temperature of the juice was monitored using a thermometer so that the temperature remained below 65°C; the last group of pulp was treated in microwave with a power of 630 W for 1 min at a temperature of 72°C (MW). Each treatment was done in triplicate.

The different tomato pulp samples were stored at room temperature ($29 \pm 02^\circ\text{C}$) and analyzed over time at 15 days intervals for 45 days ($t_0=0$, $t_1=15$, $t_2=30$, $t_3=45$ days).

Analytical methods

Determination of water content, pH, acidity and brix degree

The water content was determined by drying in an oven at 105°C overnight (NF-V03-707, 2000). Acidity and pH were determined according to standardized method (AFNOR, 1986). Briefly, sample (5 g) is mixed with in 25 ml of distilled water, with magnetic stirrer, the pH was measured.

For the acidity, the solution is centrifuged at 5000 g for 5 min; the collected supernatant was then titrated with 0.1 M NaOH in the presence of a few drops of phenolphthalein and the acidity was calculated as citric acid equivalent. Brix degree was measured directly with refractometer (B+S RFM712, United Kingdom) (Norme Francaise-VO5-109, 1970).

Determination of β -carotene

The β -carotene content was quantitated by High Performance Liquid Chromatography (HPLC, AGILENT 1100, Germany). Analyses were carried out under yellow light and the sample containers were protected from light using aluminium foil. For the preparation of standard curve, 0.15 mg of β -carotene (standard, Sigma BCCV2933) was dissolved in 3 ml of hexane. Dilutions 1/10, 1/100, 1/1000 of this solution were made. The optical densities (OD) were read at 450 nm. The sample solutions with OD between 0.1 and 0.9 were chosen. Their concentration was then calculated according to the formula: $C = (OD / \epsilon_\lambda) \times 10^{-3}$ ($\mu\text{g ml}^{-1}$). Where "OD" is the optical density and ϵ_λ is the molar extinction coefficient at 450 nm.

For the extraction, a sample (1 g) of paste was put in a tube. The β -carotene was extracted by vortexing with 2×2 ml of hexane in the presence of echinenone (internal standard) at a concentration of $0.6 \text{ pmol } \mu\text{l}^{-1}$. After vigorous stirring, the mixture was centrifuged at 3000 rpm, for 5 min at -5°C . The supernatants were combined and evaporated under a stream of nitrogen. The resulting residue was combined with 800 μl of acetonitrile containing 15 pmol/20 μl of the internal standard. After filtration, the sample was injected in the HPLC column (Kinetex Phénomenex) using a loop of 20 μl . After

injection of the calibration mixture, of defined concentration, and including the internal standard, for each peak, a relative calibration factor was calculated according to Somé et al. (2004).

Determination of total phenolic

The total phenolic content of pulp tomato was determined by spectrophotometry according to Singleton et al. (1999) with slight modifications. For extraction, 1% methanol-HCl solvent was used for extraction. Tomato pulp (5 g) was mixed with 100 ml of the solvent and ground for 10 min in a homogenizer and then transferred to conical flask. The ground samples were extracted using the maceration technique by soaking the samples in the solvents for 24 h, 4°C; followed by filtration using Whatman No. 1. The filtered extract was used to determine the total phenolic content. For the assay, 0.250 ml of each sample was introduced into test tubes and mixed with 1.25 ml of a 2 N Folin-Ciocalteu reagent. After 5 min of incubation, 1 ml of 7.5% sodium carbonate was added to generate the phenolate ions. The tubes were covered with aluminium foil and placed in a water bath at 65°C for 20 min before the absorbance was read at 760 nm using spectrophotometer (JENWAY, Bibby Scientific Ltd., United Kingdom). The samples were prepared in triplicate for each analysis and the mean value of absorbance was obtained. The results were expressed in mg of gallic acid equivalent (GAE) per 100 g of dry matter.

Statistical analysis

All experiments were performed in triplicate. The data were submitted for analysis of variance (ANOVA) using the XLSTAT software (Ver.2014.5.03, Addinsoft). The differences between the means were evaluated by the Duncan test. Significance was defined at $P < 0.05$.

RESULTS AND DISCUSSION

There was significant difference in water content, total acidity, brix degree and pH of the tomato pulp subjected to different processing treatments during 45 days of storage (Table 1).

The water content of the control, US and MW samples increased (95.64 ± 0.024 to $96.84 \pm 0.25\%$) during the first 15 days (t_0 to t_1) of storage with a significant difference ($p < 0.05$). On the other hand, for the WB65, WB85 and USBW samples, the water content remained stable (95.60 ± 0.063 to $95.75 \pm 0.02\%$) during storage.

The pH values changed from 3.46 ± 0.01 to 4.02 ± 0.03 in the control sample (C). In the other samples, a decrease, stability or increase was observed (Table 1).

The total acidity changed inversely compared to pH during the first 15 days of storage. The total acidity of the control, US and MW samples increased significantly ($p < 0.05$) from 0.67 ± 0.03 to $1.19 \pm 0.14\%$ during the first 15 days. However, the total acidity remained stable for the BW65, BW85 and USBW samples during storage.

The Brix degree also changed according to treatments (Table 1). It can be particularly noticed that the Brix degree of control, US, and MW samples significantly decreased during the first 15 days of storage. For the

BW65, BW85 and USBW samples, it remained stable (4.91 ± 0.00 to 4.80 ± 0.05) during storage.

In general, the treatment at the water-bath (65 and 85°C) and the ultrasonic treatment combined with a heat treatment have maintained stable the water content, pH, total acidity and brix degree of the tomato pulp samples during storage. In contrast, ultrasonic and microwave treatments varied the water content, pH, total acidity and brix degree from t_0 to t_1 before stabilizing from t_1 to t_3 . A study by Lagnika et al. (2017) on pineapple juice treated with ultrasound, water bath and ultrasound combined with mild heat pasteurization had found similar results on the evolution of pH, total acidity and degree of brix during storage. The change in physicochemical parameters of treated tomato pulp samples may depend on treatment time and the used method. The variation of total acidity, pH and brix degree during the first 15 days of storage (t_0 to t_1) of the US and MW tomato pulp samples could be due to chemical reactions such as hydrolysis, oxidation, fermentation and the decomposition (Lagnika et al., 2017). The decrease in pH may be due to the production of organic acid (citric acid) and the hydrolysis of endogenous polysaccharides during storage (Bhardwaj and Pandey, 2011).

The total phenolic contents of the US and MW samples increased from 647.33 to 832.78 mg GAE/100 g DM during the first 15 days (t_0 to t_1) of storage (Figure 1) with a significant difference ($p < 0.05$).

The total phenolic content of BW65, BW85 and USBW samples decreased from 492.10 to 514.68 mg GAE/100 g DW during the first 15 days (t_0 to t_1) with a significant difference ($p < 0, 05$) and then stabilized (t_1 to t_3). The decrease in phenolic compounds was small for samples treated with ultrasound combined with heat treatment. This is in line with the findings of Lavelli and Giovanelli (2003) and Garcia-Alonso et al. (2009) that showed that when preserving tomatoes, the content of phenolic compounds can remain stable or increase.

The increase in the total polyphenol content of the ultrasonic and microwave samples during storage could be justified by an improvement in the extraction of these compounds in the tomato pulp initiated during the treatments. The increase can be explained by diffusion, during cooking, of the phenolic compounds previously linked to the cellular constituents (Kebe, 2014). This evolution may be related to the stimulation of the activity of the enzymes involved in the biosynthesis of polyphenols during storage.

The β -carotene increased significantly ($p < 0.05$) as those of total phenolic in tomato pulp samples treated with ultrasound and microwaves during storage (Figure 2).

For BW65, BW85 and USBW samples, the level remained stable. Lavelli and Giovanelli (2003) working on tomato products (pulp, puree, paste) stored at 40°C for three months also observed a decrease in β -carotene content. However, Ordóñez-Santos et al. (2009) have

Table 1. Changes of the moisture content, pH, total acidity and brix degree of the tomato pulp subjected to different processing treatment during 45 days of storage.

Parameter	Treatments	Time of storage (days)			
		t ₀ (0)	t ₁ (15)	t ₂ (30)	t ₃ (45)
Water content (%)	C	95.53 ± 0.02 ^c	97.07±0.45 ^{ab}	96.94±0.13 ^{ab}	97.39±0.65 ^a
	WB65	95.60 ± 0.13 ^c	95.73±0.03 ^c	95.66±0.04 ^c	95.90±0.0 ^c
	WB85	95.66 ± 0.06 ^c	95.63±0.03 ^c	95.51±0.14 ^c	95.63±0.19 ^c
	US	95.65 ± 0.04 ^c	96.75±0.18 ^b	96.80±0.03 ^b	96.78±0.01 ^b
	USWB	95.55 ± 0.00 ^c	95.67±0.03 ^c	95.59±0.14 ^c	95.71±0.05 ^c
	MW	95.74±0.08 ^c	96.71±0.12 ^b	96.74±0.07 ^b	96.91±0.65 ^{ab}
pH	C	4.02±0.01 ^{ab}	3.56±0.10 ^{cd}	3.46±0.1 ^c	3.54±0.03 ^{cd}
	WB65	4.01±0.00 ^b	4.05±0.01 ^{ab}	4.08±0.02 ^{ab}	4.14±0.02 ^a
	WB85	4.02±0.00 ^{ab}	4.06±0.01 ^{ab}	4.09±0.00 ^{ab}	4.12±0.00 ^{ab}
	US	4.03±0.00 ^{ab}	3.59±0.00 ^c	3.59±0.07 ^{cc}	3.58±0.03 ^c
	USWB	4.02±0.00 ^{ab}	4.05±0.01 ^{ab}	4.09±0.00 ^{ab}	4.13±0.02 ^a
	MW	4.02±0.01 ^{ab}	3.57±0.09 ^{cd}	3.53±0.12 ^{cd}	3.54±0.14 ^{cd}
total acidity (% citric acid equivalent)	C	0.60±0.05 ^b	1.19±0.01 ^a	1.25±0.00 ^a	1.24±0.10 ^a
	WB65	0.63±0.09 ^b	0.63±0.00 ^b	0.64±0.04 ^b	0.60±0.02 ^b
	WB85	0.69±0.01 ^b	0.70±0.12 ^b	0.68±0.10 ^b	0.70±0.10 ^b
	US	0.71±0.01 ^b	1.16±0.20 ^a	1.19±0.09 ^a	1.23±0.12 ^a
	USWB	0.73±0.06 ^b	0.69±0.14 ^b	0.75±0.16 ^b	0.75±0.00 ^b
	MW	0.70±0.03 ^b	1.14±0.28 ^a	1.13±0.27 ^a	1.25±0.018 ^a
brix degree (% Brix)	C	4.90±0.00 ^a	3.82±0.07 ^{cd}	3.85±0.07 ^{cd}	3.60±0.00 ^{de}
	WB65	4.90±0.00 ^a	4.90±0.00 ^a	4.95±0.07 ^a	4.60±0.00 ^b
	WB85	4.95±0.07 ^a	4.95±0.07 ^a	4.90±0.00 ^a	4.85±0.07 ^{ab}
	US	4.93±0.05 ^a	4.02±0.12 ^c	4.00±0.00 ^c	3.75±0.07 ^{cd}
	USWB	4.93±0.00 ^a	4.97±0.05 ^a	5.05±0.07 ^a	4.95±0.07 ^a
	MW	4.95±0.00 ^a	3.88±0.05 ^{cd}	3.95±0.07 ^c	3.40±0.07 ^e

Values are mean ± standard deviation of triplicates. Data in same column with different letters are significantly different ($p < 0.05$). C: Control: tomato pulp without any treatment; WB65: tomato pulp subjected to a heat treatment at 65°C for 15 min in a water bath; WB85: tomato pulp subjected to a heat treatment at 85°C for 15 min in a water bath; US: tomato pulp sonicated; USWB: ultrasound combined with mild heat pasteurization; MW: tomato pulp treated in microwaves bath.

observed a significant increase of β -carotene content in pulp stored for 6 months at 20°C. The increase of β -carotene content of tomato pulp from the US and MW samples during storage could be due to their better extractability. The increase could also be linked to an improvement in the availability of β -carotene by softening or breaking of cell walls (Asami et al., 2003; Bernhardt and Schlich, 2006).

The ultrasound treatment, microwave and ultrasound combined with heat treatment have been retained polyphenols and β -carotene during storage compared to water bath. The decrease of β -carotene during storage can be related by an isomerization initiated during heat treatment. In fact, while Marx et al. (2003) showed that moderate heat treatment had a low rate on the trans-cis isomerization of β -carotene, Mordi (1992) has shown that

β -carotene could be degraded by transient isomerization followed by the formation of a singlet diradical.

Conclusion

This study showed that ultrasound treatment combined with heat treatment slightly affected the levels of total phenolic content but maintained stable the β -carotene and the physicochemical characteristics of tomato pulp during storage. Compared to the other treatments, ultrasound treatment associated with a thermal treatment is the best processing method for tomato pulp treatment regarding to its bioactive compounds preservation during storage. This processing may be applied along with the respect good manufacturer practices of the products

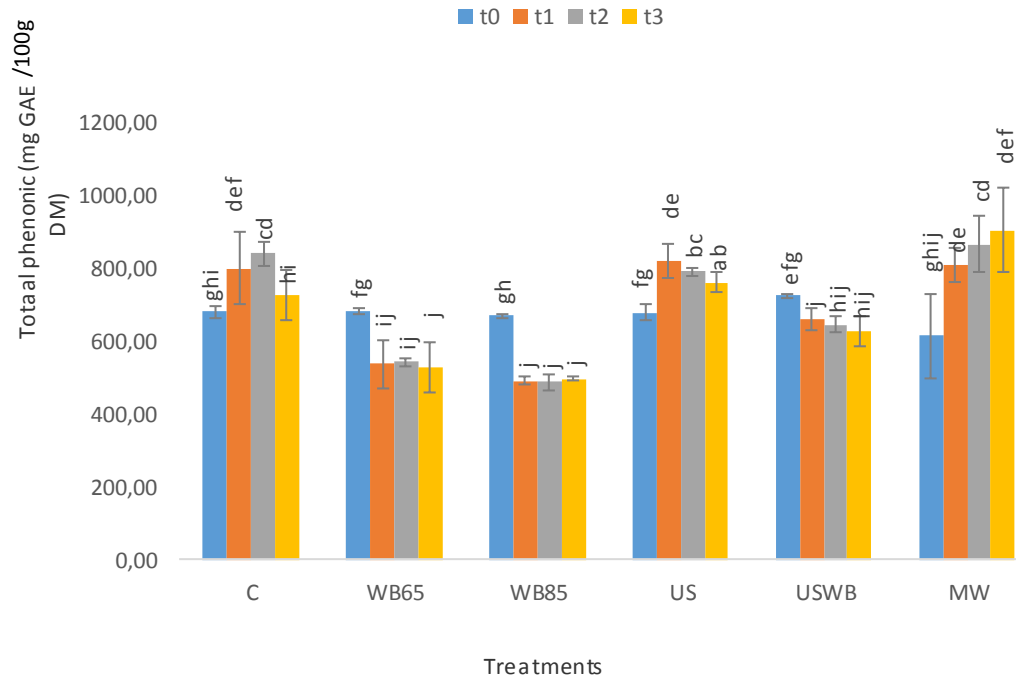


Figure 1. Variation of the total phenolic content of the tomato pulp of different treatments stoked for 45 days and a half at room temperature. Error bars indicated one standard deviation. Data points marked with the same letter are not significantly different ($p < 0.05$). t0: 0, t1: 15 days, t2: 30 days, t3: 45 days of storage. C: Control: tomato pulp without any treatment; WB65: tomato pulp subjected to a heat treatment at 65°C for 15 min in a water bath; WB85: tomato pulp subjected to a heat treatment at 85°C for 15 min in a water bath; US: tomato pulp sonicated; USWB: ultrasound combined with mild heat pasteurization; MW: tomato pulp treated in microwaves bath.

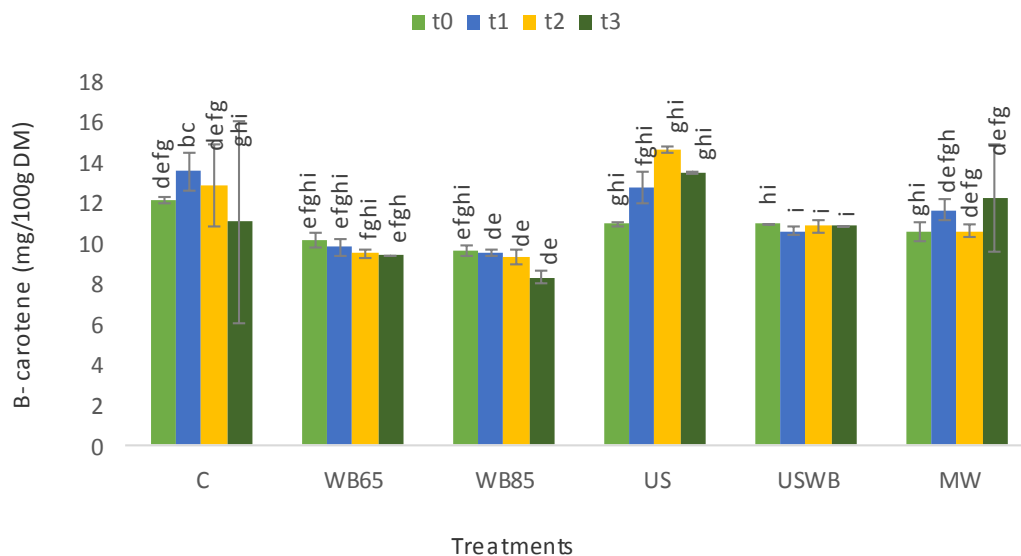


Figure 2. Variation of the β -carotene content of the tomato pulp of different treatments stoked for 45 days and a half at room temperature. Error bars indicated one standard deviation. Error bars indicate one standard deviation. Data points marked with the same letter are not significantly different ($p < 0.05$). t0: 0, t1: 15 days, t2: 30 days, t3: 45 days of storage. C: Control: tomato pulp without any treatment; WB65: tomato pulp subjected to a heat treatment at 65°C for 15 min in a water bath; WB85: tomato pulp subjected to a heat treatment at 85°C for 15 min in a water bath; US: tomato pulp sonicated; USWB: ultrasound combined with mild heat pasteurization; MW: tomato pulp treated in microwaves bath.

during storage.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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