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Ozone Processing of Peach Juice: Impact on Physicochemical Parameters, Color, and Viscosity

Gabriela M. Jaramillo-Sánchez[a,b], Analia B. Garcia Loredo[c,d], Paula L. Gómez[a,d], and Stella M. Alzamora[a,d]

[a]Departamento de Industrias, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Buenos Aires, Argentina; [b]Fellowship of Consejo Nacional de Investigaciones Científicas y Técnicas de la República Argentina, Buenos Aires, Argentina; [c]Departamento de Ingeniería Química y Alimentos, Facultad de Ingeniería, Universidad Nacional de Mar del Plata, Mar del Plata, Buenos Aires, Argentina; [d]Member of Consejo Nacional de Investigaciones Científicas y Técnicas de la República Argentina, Buenos Aires, Argentina

ABSTRACT
The impact of gaseous ozone on pH, °Brix, titratable acidity, and optical and rheological properties of fresh squeezed peach juice was investigated. Peach juice was exposed to ozone (0.06–2.48 g. L^{-1}) in a bubble column at 20 ± 1 °C. Nonsignificant or slight changes in pH, °Brix, and titratable acidity were found during ozonation. Lightness (L*) slightly decreased in the first minute of O_3 exposure and then remained practically constant, while a* parameter slightly increased in all treated samples. L* and a* parameters as well as Browning Index values reflected a slight increase in browning in ozonized juices. All juices, treated and untreated, exhibited non-Newtonian flow characteristics with pseudoplastic behavior. Significant reductions in apparent viscosity and a trend toward Newtonian flow as O_3 treatment time increased were observed for ozonized juices. The Power Law model was suitable to fit rheological data.

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Ozone; Color; Peach Juice; Rheological Properties

1. Introduction

Fruit juices are recognized as a rich source of bioactive compounds including vitamins, phenolic compounds, anthocyanins, and carotenoids (Abeysinghe et al. 2007). For this reason, fruit juice consumption is considered to be one of the main strategies of a healthy lifestyle. Heat processed juices typically undergone changes in these functional compounds as well as negative modifications in color and flavor (Espachs-Barroso, Barbosa-Cánovas, and Martín-Belloso 2003; Mawele, Timothy, and Benoit 1996; Rivas et al. 2006). With increased consumer demands for nutritious, safe and chemical free high quality juices with "fresh-like" characteristics, food processors are looking for various alternative interventions to conventional thermal preservation techniques. An attractive processing option for the food industry is ozone treatment.

Ozone is an effective sanitizer with a wide antimicrobial spectrum (Graham 1997). It rapidly decomposes into oxygen leaving no toxic residues making it environmental friendly (Muthukumarappan, Halaweish, and Naidu 2000). Since the FDA's approval of ozone as a direct additive to food in 2001, ozone has been applied for processing of various fruit juices, including apple cider (Steenstrup and Floros 2004), apple juice (Choi et al. 2012; Patil et al. 2010a), orange juice (Patil et al. 2010b; Tiwari et al. 2008a), blackberry juice (Tiwari et al. 2009b), and tomato juice (Tiwari et al. 2009a).

Cullen et al. (2010) reviewed several studies on the impact of ozone on color, a key parameter in consumer acceptability of juices. Modifications in color have been observed in apple cider (Choi and Nielsen 2005; Williams, Sumner, and Golden 2005), orange juice (Tiwari et al. 2008c), blackberry juice (Tiwari et al. 2009a), and strawberry juice (Tiwari et al. 2009c). In the other hand, ozone treatment has been demonstrated to have no effect on nonenzymatic browning, cloud value, pH, °Brix, and titratable acidity of orange and tomato juice (Tiwari et al. 2008b, 2008c, 2009a) and apple cider (Choi and Nielsen 2005). Efficiency of ozone for the inactivation of microorganisms depends not only on ozone flowrate and concentration, but also on several environmental factors, such as medium pH, temperature, humidity, additives (surfactants and sugars), amount of organic matter surrounding the cells, and solids content (Choi et al. 2012; Cullen et al. 2010; Restaino et al. 1995). The effects of ozone on the physiology and quality of fruits and vegetables also vary according to chemical composition of food, ozone concentration and application time. If used in proper conditions, ozone may prevent microbial spoilage and some diseases, with a minimum amount of

CONTACT Stella M. Alzamora smalzamora@gmail.com Departamento de Industrias, Intendente Guiraldes s/n, Ciudad Universitaria, Ciudad autó noma de Buenos Aires, Argentina.

quality damage to fruit and fruit juices. These conditions must be specifically determined by trials of ozone application to all kinds of products (Karaca and Velioglu 2007). Until we know, there are no reports on ozone-induced quality changes in peach juice.

Knowledge of the rheological behavior of liquid food is essential for process design and evaluation, quality control, and consumer acceptability. The viscosity of a fruit juice is influenced by factors such as the variety or maturity of the fruit, and the treatment applied to the juice. All these factors affect the consumer acceptability of the product (Aguilo-Aguayo et al. 2009). Due to the importance of rheological properties in fruit juice processing, rheological models are constructed to represent the rheological data. The Power Law model has been used most extensively to describe the rheological behavior of most juices (Gratao, Silveira, and Telis-Romero 2007).

The objective of this work was to investigate the effect of ozone dose (0.06–2.48 g.L^{-1}) at 20 ± 1 °C on some physicochemical parameters, color, and viscosity of peach juice.

2. Materials and methods

2.1. Preparation of peach juice

Ripe peaches (*Prunus persica*, Pavía cv., 13 ± 1 °Brix, pH = 4.1 ± 0.2) were purchased in a local market and stored at 4–5 °C for 12 h. Peaches were hand peeled, cut into slices, and crushed using a domestic juice extractor (Black and Decker, JE 1500, China). Juice was then centrifuged (734 g, 10 min, 5 °C, Eppendorf, model 5804 R, Hamburg, Germany) to reduce pulp amount. Turbidity of fresh peach juice was 5000 ± 549 NTU and after centrifugation this value was reduced to 1665 ± 152 NTU (Turbidimeter LaMotte 2020we, Chestertown, Maryland, USA).

The obtained juice (12.3 ± 0.17 °Brix, pH = 4.08 ± 0.03) was immediately frozen at −79 ± 1 °C (Panasonic ultra-freezer, model MDF-U55V, Japan). Frozen juice samples were processed within 2 months of juice preparation.

2.2. Ozone treatment

The setup of the ozone processing equipment was similar to that reported by García-Loredo, Guerrero, and Alzamora (2015), Patil et al. (2010a) and Tiwari et al. (2009b). Briefly, ozone was generated using a corona discharge equipment model UTK-O-4 (UNITEK, Mar del Plata, Argentina). Pure oxygen was supplied via an oxygen cylinder (Oxigeno Central, Argentina) at 0.62 bar regulated by a control valve (model LRP-1/4–2.5, Festo, Argentina) and the flowrate was controlled at 5 L/min using a rotameter (UNITEK, Mar del Plata, Argentina). The ozone generator was connected to a bubble column (0.1 m in diameter and 0.24 m in height) with an inbuilt diffuser to sparse gaseous ozone into the juice. The electrical power supplied to the generator was set to provide an ozone concentration in the inlet gas of 18 g.m^{-3}. Ozone concentration in the gas supply was recorded using an ozone gas analyzer model UV-100 (Eco Sensors, USA). The excess of ozone was neutralized by diverting the gas stream into a glass Erlenmeyer containing 2 % (w/v) potassium iodide solution.

For treatment, 450 mL peach juice (20 ± 1 °C) was put inside the bubble column and exposed to gaseous ozone for 0.3–12 min. The applied ozone doses in the juice were calculated by multiplying the concentration of ozone in the inlet gas, the flowrate and the ozone exposure time, and dividing by the sample volume. The doses applied ranged between 0.06 and 2.48 g.L^{-1}. Juice samples not subjected to ozone treatment were designated as control group. Treated and untreated juices were de-aerated after treatment and stored at 4–5 °C in sterile bottles protected from light. Analyses were performed within 12 h of treatments.

The selection of these ozone processing conditions was supported by previous findings of García-Loredo, Guerrero, and Alzamora (2015). They demonstrated that the assayed doses resulted in lower counts of *E. coli* ATCC 11229 and *Listeria innocua* ATCC 33090 inoculated into the juice during most part of the treatment. After 12 min exposure, *E. coli* and *L. innocua* counts were reduced by approximately 4.3 and 4.9 log-cycles, respectively. Moreover, surviving microorganisms faced more difficulties to grow than in unprocessed juice.

2.3. Total soluble solids, titratable acidity, and pH

Soluble solids were measured using a digital refractometer model PR-1 (Atago, Tokyo, Japan). Refractive index was recorded and converted to °Brix. For measurement of titratable acidity (TA), 10 mL of samples were titrated against standardized 0.1N NaOH (Merck, Germany) to the phenolphthalein end point (pH = 8.2 ± 0.1). The volume of NaOH required was converted to grams of citric acid per 100 mL of juice (Equation [1]). The pH of peach juice samples was measured using a digital pHmeter (model 310, Orion, TX, USA) calibrated with commercial buffer solutions(Sigma-Aldrich, Dublin, Ireland) at pH 7.0 and 4.0. All measurements were performed in triplicate at 20 ± 1 °C.

$$\% \, Acidity = \frac{V_{NaOH}.N_{NaOH}.0.067.100}{V_{sample}} \tag{1}$$

Where V_{NaOH} corresponds to the mL of NaOH used for titration, 0.1 is the normality value for NaOH solution, 0.067 is conversion factor for malic acid, and V_{sample} is the sample volume.

2.4. *Color measurement*

Color of untreated and treated juice was measured with a handheld tristimulus reflectance spectrocolorimeter (Minolta Co., Model CM-508-d, Japan) using a 1.1-cm measuring aperture. Values were obtained for D65 illuminant and 2° observer. Before the test, the instrument was calibrated with a standard white provided by the manufacturer. To prevent light scattering from sides, measurements were carried out within a cylindrical recipient (diameter 2.5 cm and height 1.0 cm) featuring a transparent bottom and opaque walls. Determinations were carried out contrasting with a white background, using 4 mL of juice. Color measurements were performed fivefold.

The CIE color coordinates (X,Y,Z) and the L*,a*, b* components of CIELAB space were recorded, where L* indicates lightness or luminance, a* indicates chromaticity on green (–) to red (+) axis, and b* chromaticity on blue (–) to yellow (+) axis. These numerical values were converted into color functions: "chroma" (C_{ab}*), "hue" (h_{ab}*), and "browning index" (BI), using the following equations:

$$C^*_{ab} = \left(a^{*2} + b^{*2}\right)^{\frac{1}{2}} \tag{2}$$

$$h^*_{ab} = arctg\left(\frac{b^*}{a^*}\right) \tag{3}$$

$$BI = \frac{[100\ (x - 0.31)]}{0.172} \tag{4}$$

where:

$$x = \frac{X}{X + Y + Z} \tag{5}$$

2.5. *Rheological analysis*

Viscosity measurements were carried out using a Paar Physica rheometer (model MCR 300; Anton PaarGmBH, Graz Austria). The experiments were carried out in the controlled stress mode. A cone/plate sensor system (CP 25–2) with a gap width of 5.10^{-5} m and 3.5 mL of juice was used to measure the viscosity of the peach juice after exposing to ozone. The rheometer was equipped with a Peltier plate for accurate control of the temperature within the gap (20 ± 0.1 °C). Flow curves and the apparent viscosity were registered using a shear rate ($\dot{\gamma}$) in the range of 0–100 s^{-1}. Five replications were measured for each sample. Samples were maintained at rest for 20 min in the sensor unit before measurements in order to ensure uniform temperature and reduce immediate effects due to sample manipulation. Shear stress (τ) *vs.* shear rate ($\dot{\gamma}$) curves were fitted with the Power Law or Ostwald-de Waele equation:

$$\tau = k\dot{\gamma}^n \tag{6}$$

where τ is the shear stress, γ is the shear rate, k is the consistency index, and n is the flow behavior index. For a Newtonian behavior, $n = 1$ and for a pseudoplastic one, $n < 1$. Smaller is the value of n, more shear-thinning is the juice.

2.6. *Statistical analysis*

All the results were expressed as mean ± standard deviation of the mean (mean ± SD). Analysis of variance was done to establish the presence or absence of significant differences among the samples in soluble solids, titratable acidity, and pH. Significance level was set at $\alpha < 0.05$. When significant differences were found, the Tukey test was performed. Multivariate analysis of variance was used to detect differences among the samples in color parameters and viscosity. Significance level was set at $\alpha < 0.05$. Hotelling corrected for Bonferroni test was performed in case of finding significant differences. These statistical analyses were carried out using Infostat v2009 software (Córdoba, Argentina).

3. Results and discussion

3.1. *Physicochemical parameters*

Mean values for soluble solids, pH, and titratable acidity of control and treated peach juices samples are listed in Table 1. In general, ozonized peach juice did not present

Table 1. Soluble solids (°Brix), pH, and titratable acidity (mean values and standard deviation) of fresh and ozonized peach juice.

Treatment (min)	Ozone dose ($g.L^{-1}$)	° Brix	pH	Titratable acidity (% malic acid)
0	0.00	$12.30 \pm 0.17^{a,b}$	4.1 ± 0.1^{a}	0.43 ± 0.01^{a}
0.3	0.06	$12.13 \pm 0.15^{a,b,c}$	4.1 ± 0.1^{a}	0.42 ± 0.01^{a}
0.6	0.12	$11.97 \pm 0.12^{b,c}$	4.1 ± 0.1^{a}	$0.44 \pm 0.01^{a,b}$
1	0.21	$12.27 \pm 0.12^{a,b}$	4.0 ± 0.1^{a}	$0.45 \pm 0.01^{a,b}$
2	0.41	12.37 ± 0.21^{a}	4.0 ± 0.1^{a}	0.43 ± 0.01^{a}
3	0.62	$12.10 \pm 0.10^{a,b,c}$	4.0 ± 0.1^{a}	$0.44 \pm 0.01^{a,b}$
5	1.03	11.87 ± 0.06^{c}	4.0 ± 0.1^{a}	$0.450 \pm 0.001^{b,c}$
7	1.45	$11.77 \pm 0.15^{c,d}$	4.0 ± 0.1^{a}	$0.44 \pm 0.01^{a,b}$
10	2.07	$11.47 \pm 0.12^{d,e}$	4.0 ± 0.1^{a}	$0.44 \pm 0.01^{a,b}$
12	2.48	11.23 ± 0.06^{e}	$4.0 \pm 0.1\ ^{a}$	0.48 ± 0.01^{c}

Different letters in each column indicate significant differences between times at a confidence level of 95%.

Table 2. Mean values and standard deviations in color parameters and functions for fresh and ozonized peach juice.

Treatment (min)	Ozone dose (g.L^{-1})	L*	a*	b*	C*	h*
0	0	29.83 ± 0.24	8.89 ± 0.28	35.11 ± 0.87	36.21 ± 0.90	75.79 ± 0.26^{a}
0.3	0.06	27.42 ± 0.22	10.53 ± 0.32	34.84 ± 0.43	36.39 ± 0.49	73.18 ± 0.34^{b,c}
0.6	0.12	27.11 ± 0.36	10.79 ± 0.20	35.38 ± 0.23	36.99 ± 0.20	73.04 ± 0.35^{c,d}
1	0.21	26.69 ± 0.46	10.70 ± 0.39	34.11 ± 0.57	35.75 ± 0.63	72.60 ± 0.45^{c,d}
2	0.41	25.70 ± 0.44	11.39 ± 0.27	34.10 ± 0.92	35.95 ± 0.92	71.52 ± 0.48^{e}
3	0.62	25.57 ± 0.36	11.38 ± 0.33	33.97 ± 0.26	35.83 ± 0.31	71.48 ± 0.46^{e}
5	1.03	26.26 ± 0.21	10.45 ± 0.65	34.31 ± 0.26	35.87 ± 0.20	73.06 ± 1.08^{d}
7	1.45	26.55 ± 0.55	10.46 ± 0.55	34.24 ± 0.36	35.80 ± 0.23	73.01 ± 0.99^{c,d}
10	2.07	26.48 ± 0.46	10.73 ± 0.57	34.69 ± 0.61	36.31 ± 0.74	72.82 ± 0.62^{c,d}
12	2.48	27.63 ± 0.25	9.54 ± 0.32	34.64 ± 0.59	35.93 ± 0.59	74.60 ± 0.49 ^{b}

Treatments labeled with the same letter show no significant differences at a confidence level of 95%.

significant differences in soluble solids content as compared to fresh juice for processing times ranging from 1 to 5 min, but a slight significant decrease was achieved for greater ozone doses. Changes observed in pH values between control and treated juices were negligible or undetectable. Similarly, overall no significant changes in titratable acidity values of ozonized samples with respect to control were detected (average 6.60 ± 0.25 mL 0.1 N NaOH volume consumed by treated and untreated samples). Similar results were reported for ozone processing of orange juice (Tiwari et al. 2008b), tomato juice (Tiwari et al. 2009a), grape juice (Tiwari et al. 2009d), and apple cider (Choi and Nielsen 2005).

3.2. Color

Table 2 shows color parameters (L*, a*, b*) and functions (C*, h*) for fresh juice and for juices treated with ozone at different times. Fresh peach juice was represented by L*,a*, and b* values of 29.8 ± 0.2, 8.9 ± 0.3, and 35.1 ± 0.9, respectively. Although L*, a*, b*, C*, and h* values did not show large variations, multivariate statistical analysis indicated significant differences ($F_{9,40} = 69.31$; $p < 0.0001$) between treated and control juices. The lightness of peach juice slightly diminished in the first minute of treatment and did not present larger variations for higher treatment times. a* parameter slightly increased in all ozonized samples while b* parameter was not greatly affected by ozone exposure. In accordance with the pattern observed for a* and b* parameters, h* values of ozonized juices exhibited a mild decrease indicating that juice color became more orange. Chroma values remained without greater variation along ozone processing.

Changes observed in L* and a* parameters reflected a slight increase in browning in ozonized juices. This effect was also evidenced in BI values of ozonized samples (Figure 1). Treated samples showed significant differences ($F_{9,40} = 17.84$; $p < 0.0001$) with respect to control. But, in general, there were not significant differences in ozonized juices regardless of treatment time. BI values slightly increased during the first minutes of ozone exposure (until 2 min) and remained rather constant for higher processing times.

Several authors have reported changes in color due to ozone application. Tiwari et al. (2008c), (2009a), 2009b) observed a slight clearance, i.e., an increase L* values and a decrease in a* and b* values when ozone concentrations (0–7.8% w/w) and exposure time (0–10 min) were increased in orange, strawberry, and tomato juice. Similarly, Patil et al. (2010a) and Torres et al. (2011) found an increase in L* and b* values and a decrease in a* values in apple juice when ozone exposure time increased. Ozone has a high oxidation potential (2.07 V) resulting in the degradation of most organic compounds It has been reported that ozonation of organic dyes results in loss of color due to the oxidative cleavage of chromophores (Nebel 1975) by an attack on conjugated double bonds. The chromophore of conjugated double bonds of carotenoids is responsible for peach juice color (Melendez-Martinez, Vicario, and Heredia 2007). Carotenoid pigments which contribute to yellow, orange, or red color in peach juice contain one or more aromatic rings. The ozone and hydroxyl radicals (OH^-) generated in the aqueous solution may open these aromatic rings and lead to partial oxidation of products such as organic acids, aldehydes, and ketones (Patil and Bourke 2012). However, the clearing of peach juice due to carotenoids degradation was not evidenced in the conditions of ozonation evaluated in this work. Browning development in ozonized peach juice could be associated not to only to enzymatic action but to a nonenzymatic phenomenon, which could be induced by the oxidation of phenolic compounds by ozone (Cullen et al. 2010; McEvily, Iyengar, and Otwell 1992). Regarding enzymatic browning, hyper reactivity of ozone may contribute to the inhibition of several enzymes. Jaramillo-Sánchez et al. (2017) analyzed the effectiveness of

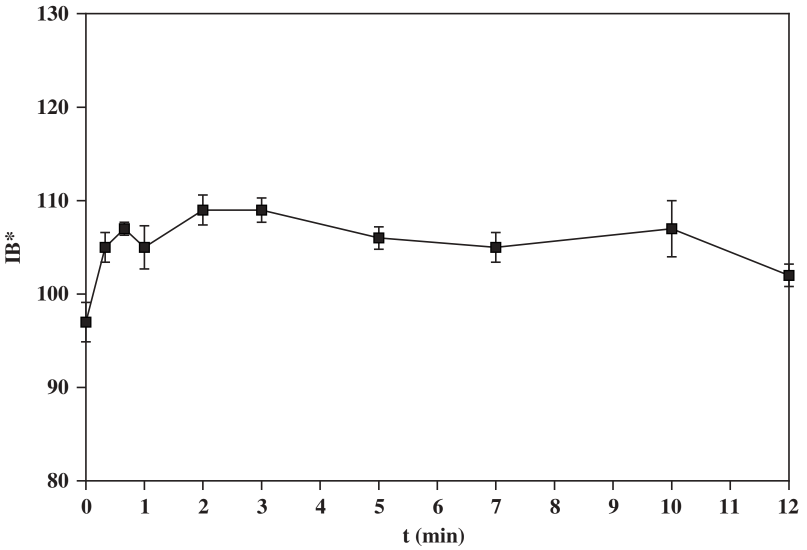

Figure 1. Browning index (BI) mean values of fresh and ozonized peach juice error bars represent the standard deviation.

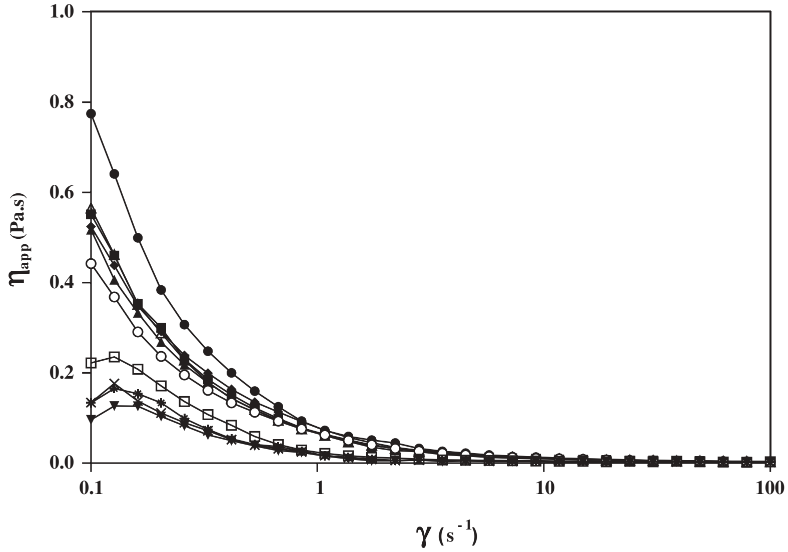

Figure 2. Apparent viscosity (ηapp) mean values vs. shear rate of fresh and ozonized peach juice. Control(●), 2 s (■), 4 s (▲), 1 min (♦), 2 min (Δ), 3 min (○), 5 min (□), 7 min (*), 10 min (▼), and 12 min (×) O_3 exposure time.

ozone for inactivating polyphenoloxidase (PPO) and peroxidase (POD) enzymes in peach juice using a bubble column in similar experimental condition (doses applied: 0.06–2.48 $g.L^{-1}$) as in this work. The PPO and POD activities declined with increasing treatment time in a nonlinear tendency. For instance, peach juice ozonized during 1 min showed a significant decrease in the residual activity of PPO and POD: 50.0 %and 20.4% of the initial value, respectively, while at 12 min treatment, these values reduced to 97.3% and 99.8%. Thus, enzymatic activity could contribute to peach juice browning, mainly at the beginning of the process.

3.3. *Rheological properties*

Viscosity vs. shear rate curves for ozonized peach juices as affected by ozone processing time are shown in Figure 2. All juices exhibited shear thinning behavior. For low viscosity peach juices, flow data showed some scatter at shear rates below 0.15 s^{-1} and reading were considered as artifacts. Apparent viscosity for ozonized juices decreased as ozone exposure time increased. Rheological behavior of peach juices followed the Power Law. Adjusted coefficient of determination (R^2_{adj}) values varied from 0.92 to 0.99, indicating that the fitting of the model to the measured data was very

Table 3. Mean values and standard deviations of consistency (*k*) and flow index (*n*) in fresh and ozonized peach juice.

Treatment (min)	Ozone dose (g.L^{-1})	*k* (Pa.s^n)	*n*
0	0.00	0.058 ± 0.011	0.371 ± 0.048^a
0.3	0.06	0.053 ± 0.009	0.374 ± 0.044^a
0.6	0.12	0.055 ± 0.016	0.358 ± 0.054^a
1	0.21	0.067 ± 0.006	0.322 ± 0.017^a
2	0.41	0.052 ± 0.006	0.381 ± 0.028^a
3	0.62	0.057 ± 0.012	0.347 ± 0.032^a
5	1.03	0.012 ± 0.005	0.659 ± 0.051^b
7	1.45	0.010 ± 0.001	0.682 ± 0.047^b
10	2.07	0.006 ± 0.001	0.743 ± 0.071^b
12	2.48	0.007 ± 0.002	0.730 ± 0.049^b

Treatments labeled with the same letter show no significant differences at a confidence level of 95%.

good. Table 3 lists the Power Law parameters for the juices with different ozonation times. Significant differences ($F_{9.30} = 32.86$; $p < 0.0001$) in consistency (*k*) and flow behavior (*n*) indices were observed between control and ozonized samples after 5 min and longer exposure times (Table 3). The consistency index decreased as a function of ozone exposure time from 0.058 (untreated juice) to 0.007Pa.s^n (processing time: 12 min), while the flow behavior index increased from 0.37 for control to 0.73 for the juice ozonized during 12 min. The change in *n* parameter indicated that rheological pattern of peach juice, pseudoplastic in nature, evolved toward a Newtonian behavior as ozone processing time increased. At a shear rate of 0.1 s^{-1}, the reduction in peach juice viscosity by 12 min ozone treatment regarding the untreated juice was 82% while at a shear rate of 10 s^{-1} the apparent viscosity of ozonized juice was 68% lower than the untreated juice. Taking into account that oral perception occurs over a range of shear rates between 10 s^{-1} and 100 s^{-1}, depending on the flow behavior of the particular food (Shama, Parkinson, and Sherman 1973), the modification of juice viscosity induced by ozonation would not have an important impact on the perceived viscosity. Moreover, it is well known that, when comparing instrumental and sensory measures of viscosity, humans perceive smaller differences in fluids viscosity than those recorded by a viscometer (Christensen 1973).

Present results are in agreement with the findings of Torres et al. (2011) who reported a decrease in apparent viscosity and *k* values and an increase in *n* values in ozonized apple juice (1–4.8% w/w ozone) during 12 min. A similar behavior was found after ozone application (7.8% w/w, 10 min) to guar, CMC and pectins dispersions: apparent viscosity was reduced in 95.5%, 81.6%, and 31.7%, respectively (Tiwari et al. 2008a).

Fruit juices are composed of an insoluble phase (the pulp) dispersed in a viscous solution (the serum). The dispersed phase or pulp is formed of fruit tissue cells and their fragments, cell walls and insoluble polymer clusters and chains. The serum is an aqueous solution of soluble polysaccharides, sugars, salts, and acids. The fruit juice rheological properties are thus defined by the interactions inside each phase and between them (Augusto, Ibarz, and Cristianini 2012). Because of its strong oxidizing activity, ozone exposure has been reported to decrease molecular weight of food polymers as pectins, resulting in a decrease in viscosity (Muthukumarappan et al. 2016). Degradation of polymers could be due to either direct reaction with ozone or indirect reaction with secondary highly reactive species, such as •OH, $HO^{2\bullet}$, •O_2, and •O_3. For instance, three different mechanisms were proposed for the degradation of the carbohydrates (cellobiose, lactose, and dextran) in aqueous solution: ozonolytic degradation of β-D-glucosidic linkages, oxidative degradation by hydroxyl radicals formed from water, and acid hydrolysis (Wang, Hollingsworth, and Kasper 1999). Direct O_3 reaction selectively depolymerizes polysaccharides while radical and hydrolytic reactions degrade carbohydrates nonselectively. Other study showed that chitosan oxidative depolymerization by ozone significantly reduces apparent viscosity in treated solutions with respect to control solution (Seo, King, and Prinyawiwatkul 2007). Depolymerization of macromolecules would be mainly attributed to selective degradation of ß-D glucoside bonds between units by electrophilic attack on the C(1)–H bond by ozone molecules. Ibarz, Garvín, and Costa (1996) observed a nonNewtonian behavior in juices containing pectin and pulp, while depectinized and clarified juices exhibited a Newtonian behavior. Thus, the depolymerization of pectins and other macromolecules induced by ozone could explain the tendency toward a Newtonian behavior observed in peach juice exposed to higher ozone doses.

4. Conclusions

Nonsignificant or slight changes in pH, °Brix, and titratable acidity were found during ozonation. Slight but significant variations in color parameters and functions in juices exposed to ozone doses between 0.06 and 2.48 g. L^{-1} were found. L* parameter decreased (≈12%) and a* parameter and BI function increased (≈ 20% and 10%, respectively) during the first minutes of ozone treatment and remained rather constant for higher treatment times. All juices exhibited shear thinning behavior, but significant reductions in apparent viscosity were observed for ozonized juices after 5–12 min of treatment.

It can be concluded that ozonation represents a rapid and efficient technology for peach juice preservation producing minor changes on some quality parameters (color, rheological properties).

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