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APPLICATION OF HIGH PRESSURE-ASSISTED INFUSION TREATMENT TO MANGO PIECES: EFFECT ON QUALITY PROPERTIES

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Abstract

The aim of this study was to evaluate the effect of the high pressure-assisted infusion treatment on the quality properties of mango cubes. Factors studied were: sorbitol concentration (20 °Brix, 40 °Brix, 60 °Brix), calcium lactate concentration (0 %w/w, 1 %w/w, 2 % w/w) and pressure level (0.1 MPa, 300 MPa, 600 MPa). Results showed that process factors not only improved the mass transfer during the infusion process but also the solid gain was restricted by the incorporation of the calcium salt. The synergetic effect of pressure level and the addition of calcium salt preserved the mechanical properties. The tonality and chromaticity parameters of mango cubes were preserved by the antagonistic effect of the pressure level and sorbitol concentration. All microbiological counts were below the detection level. The most effective process was 600 MPa-60°Brix-2% w/w since it produced an 81.9% of inactivation of the polyphenol oxidase enzyme, which will allow preserving the final product.

Industrial relevance: The sensory and nutritional properties of fruit-based products are the main factor, determining the acceptance by consumers. During processing, these properties can be affected by different process factors, so there is a great interest in developing new processing methods that would enable the preservation of the quality properties of the fresh fruit. The present study showed that the application of the high pressure-assisted infusion process could be a promising alternative to preserve the quality of mango cubes. Therefore, based on the results, criteria for commercial production of high-quality mango cubes conserved in a sorbitol solution with adequate safety requirements could be established.

Keywords: Mango, assisted infusion, high pressure, quality properties

1. INTRODUCTION

Mango (*Mangifera indica*) is one of the most important tropical fruits in the world and the second most cultivated after banana. Mango is rich in potassium, vitamins A, B_1, B_2, and C, phenolic and β-carotenoids compounds (Masibo & Qian, 2009; Singh et al., 2013), traits that would be attractive to consumers. However, mango shelf life is short because of its high perishability, which hinders its marketability. Generally, mango is processed by thermal treatments, which often affect the quality attributes of the final product (Liu et al. 2014; Tedjo et al. 2002). Therefore, there is a demand to develop processing methods that would deliver safe products while preserving the sensorial and nutritional quality of the fresh fruit. This could enhance the demand for mango-based products.

Osmotic dehydration (OD) has been used as a pretreatment in different preservation methods to obtain partially dehydrated products. Also, it improves nutritional, sensory and functional properties of the food through impregnation of desired solutes such as minerals,

vitamins, antioxidants, and natural preservatives (Barrera et al., 2004; Rastogi et al., 2002). The disadvantage of this process applied as unique method is that it does not guarantee a safe product, due its reduced effect on inactivation of microorganisms. Therefore, another preservation method, such as high-pressure (HP) technology, is required **(Pérez-Won et al., 2016)**

HP is a processing technology in which food is packed in flexible and airtight packaging and is subjected to high pressure levels (100-900 MPa) in a uniform and a quasi-instantaneous way for a short holding time (< 10 min). HP treatments either at room or chill temperature produce the inactivation of viable microorganisms and enzymes with a minimum effect on sensory attributes and nutritional properties of products (Kaushik et al. 2014). Several authors have studied the application of HP as a pretreatment for OD since it damages the cell wall structure, making the cells more permeable. This effect increases the mass transfer rate during OD and enhances the uptake of compounds such as minerals or vitamins added to the osmotic solution (Nuñez-Mancilla et al. 2011, 2013; Pérez-Won et al. 2016; Rastogi& Niranjan, 1998; Verma et al. 2014).

However, the damage on the cell wall structure could be a disadvantage to the product texture since it induces a softening of its structure could result in an undesirable trait for the consumer. The addition of calcium salts to the osmotic solution would be an interesting alternative to preserve the texture of the fruit (Mauro et al. 2016; Norton & Sun, 2008). Calcium present in the solution interacts with the cell-matrix of the plant, forming bonds between pectin and other compounds of the cell wall, which could modify the structural response (Gras et al. 2003). From the nutritional point of view, the addition of calcium salts could in turn become an additional source of this mineral, which would help to alleviate one of the limitations of lactose-intolerant consumers.

Little information is available on the use of high pressure-assisted infusion in fruit or vegetable products. In the present work, we have studied the high pressure-assisted infusion treatment in mango cubes to obtain a safe and fortified product, conserved in a hypertonic solution of sorbitol and calcium lactate. Therefore, the aim of this work was to evaluate the effect of the process factors (sorbitol and calcium lactate concentrations and pressure level) on different quality properties (physicochemical and chromatic parameters, enzyme activity, mechanical properties, and endogenous microbiota) in mango cubes.

2. MATERIALS AND METHODS

Raw sample

Mangos (*Mangiferaindica cv Keitt*) were provided from Tropical Crops Experimental Station INTA Yuto (Jujuy, Argentina). Fruits with similar firmness were selected to complete a homogenous group and stored at 10 °C until further processing.

Sample preparation

Mangos were washed with cold water containing 100 mg/L of HClO for 2 min. After that, they were peeled and cut into cubes (15 mm x 15 mm x 15 mm) using a system of sharp stainless steel knives. Subsequently, mango cubes were dipped into an aqueous solution containing ascorbic acid (1% w/v, Biopack) and citric acid (1% w/v, Anedra) for 2 min and dried with tissue paper. Finally, the cubes were submerged in the hypertonic solution in a 1/5 (w/w) fruit/solution ratio in Cryovac BB2800 bags (Sealed Air, Buenos Aires, Argentina).

Experimental design

A completely randomized factorial design with three factors and three levels each was applied (3*3*3). The factors studied were sorbitol concentration (20 °Brix, 40 °Brix, and 60 °Brix) and calcium lactate concentration (0 %, 1 % and 2 % w/w) in the osmotic solution and pressure level (0.1 MPa, 300 MPa, and 600 MPa). Treatments were carried out in triplicate.

Solutions preparation

Sorbitol (D-glucitol, LTSPowder 50M, Indonesia) and calcium lactate salt (ADAMA, Argentina) were used as osmotic agents. Sorbitol is considered an effective osmotic agent with high sweetening power (up to 70 % of the sweetness of sucrose) and low in calories (2.4 Kcal/g). It also has chemical, thermal, and bacteriological stability (Brochier, B., Marczak, L.; Noreña, 2014). The incorporation of calcium salts to the osmotic solution is an alternative that allows preserving the fruit texture and even, improving their nutritional value. The calcium lactate salt is as effective as its chloride form without imparting bitterness flavor associated with high concentrations (Luna-Guzmán & Barrett, 2000)

Hypertonic solutions were prepared with sorbitol in concentrations of 20 °Brix, 40 °Brix, and 60 °Brix, with or without the addition of calcium lactate (0 %, 1 % and 2 % w/w).

High-Pressure treatments

HP treatment was carried out in a Stansted Fluid Power equipment (model FPG 9400:922; Stansted Fluid Power Ltd., Stansted, United Kingdom), equipped with a 2 L capacity vessel and a maximum working pressure of 900 MPa. Samples were pressurized to different pressure levels 0.1MPa, 300 MPa and 600 MPa for 5 min. A mix of propylene glycol and distilled water (30:70 v/v) was the compression fluid at 5°C. The initial temperature of the

samples was 5 °C to ensure that the final temperature of treatments does not exceed 30 °C. The compression rate was 300 MPa.min-1. After processing, samples were chill stored (4 °C±1 °C) for 24 h (osmotic equilibrium condition). The storage time was determined by preliminary tests (data not shown).

Subsequently, mango cubes were removed from bags and were dried with tissue paper. The final weight of the samples was recorded. Each sample was divided into fractions for analysis.

Samples analysis

Except for the samples used for the analysis of mechanical properties and chromatic parameters, each fraction of mango cubes was homogenized using an electric blender (Braun MR530, Argentina) for 1 min.

Analysis of the physicochemical parameters

*Moisture content (*MC*)* was determined using an oven (Gallenkamp, UK) at 70ºC until constant weight (24h), according to Rodriguez et al.(2015). Moisture content was calculated using equation (1):

$$\mathrm{MC}\ (\%) = \frac{\mathrm{m}_w}{\mathrm{m}_t} \times 100 \qquad (1)$$

Where MC is the moisture content (% wet basis -wb-), m_w is the water mass (g), and m_t is the total mass (g).

Soluble solids (SS) content was determined with a digital refractometer (Reichert AR 200 model Hand-Held, USA) and expressed as °Brix at 20 °C.

Water activity (a_w) was determined at 25ºC using a temperature-controlled AcquaLab 4TE meter (Decagon Devices, USA) calibrated with a saturated solution of CLNa (a_w: 0.753), according to Rodriguez et al.(2015).

The pH was determined using a pHmeter (Thermo Orion, model 710A+, USA) and a combination electrode (Thermo Orion, model 8102BN, USA) and ATC probe. The instrument was calibrated with phosphate buffer at pH 4 and 7. For measurements, 10 g of samples were diluted with 100 mL of distilled water at room temperature and were manually homogenized.

All measurements were performed in duplicate.

Calculation of the Weight Reduction, Water Loss and Solids Gain

Weight reduction (WR) was calculated using equation 2:

$$WR(\%)=\frac{(m_i - m_f)}{m_i}\times 100 \qquad (2)$$

Where WR is weight reduction (%), m_i and m_f are the initial and final weight (g) of the samples.

Water loss (WL) was calculated using equation3:

$$WL\ (\%)=\left[\left(1-\frac{TS_i}{100}\right)-\left(1-\frac{TS_f}{100}\right)*\left(1-\frac{WR}{100}\right)\right]\times 100 \qquad (3)$$

Where WL is water loss (%), TS_i is initial total solids (100-MC_i, where MC_i is the initial moisture content), TS_f is final total solids (100-MC_f, where MC_f is the final moisture content) of each sample and WR is weight reduction (equation 2)

Solids gain (SG) was calculated using equation 4:

$$SG\ (\%) = \left(1 - \frac{WR}{100}\right) \times (TS_f - TS_i) \qquad (4)$$

Where SG is solids gain (%), WR is weight reduction (equation 2), TS_i is initial total solids and TS_f final total solids.

Analysis of the mechanical properties

The mechanical properties of mango cubes were determined using a Texture Analyzer (model TA-XTplus, Stable Micro Systems Ltd, Surrey, UK). The puncture test was performed at a constant speed of 1 mms^{-1} using a SMSP cylindrical puncture probe of 2 mm in diameter, at 25 °C with an established distance of up to 6 mm concerning the initial height of the cube. The mechanical properties analyzed were: Hardness (Kgf), i.e. maximum force and work of cut (Kgf*s) i.e. the area under the curve. Thirty cubes were measured for each treatment.

Analysis of the Polyphenoloxidase (PPO) activity

The extraction and test of the PPO enzyme were performed as described by Liu et al., (2014) with some modifications. Five grams of mango cubes were mixed with 20 ml of the extraction solution [0.1 M sodium phosphate buffer (pH = 6.5) and 1 % (w/v) polyvinylpolypyrrolidone (PVPP)]. The mixture was homogenized using an ultraturrax (T25 basic IKALabor technick, USA) at 4 °C for 1 min and stored at 4 °C for 1h. Subsequently, they were centrifuged (using a Sigma 3K30 Laboratory Centrifuges, Germany) at 10000 x g at 4 °C for 15 min.

For the PPO test, the reaction mixture consisted of 500 µL of enzyme extract and 2 mL of substrate solution [0.175 M catechol, (Sigma-Aldrich Corporation) in 0.1 M sodium phosphate buffer solution (pH = 6.5)]. The absorbance was measured at 420 nm, at 30 °C

for 3 min with a spectrophotometer (UV-2401 PC Shimadzu, Shimadzu Scientific Instruments, Inc., Columbia, MD, USA). The enzymatic activity was estimated from the linear portion of the absorbance vs time curve and expressed in units per g of fruit. One unit represents the amount of enzyme needed to change A420 nm at 0.01min-1 at 30 ° C. The results were expressed as a percentage of the relative enzymatic activity (AR) with respect to the fresh product.

Analysis of the chromatic parameters

The chromatic parameters of mango cubes were determined using a Minolta CR-400 colorimeter (Konica Minolta Sensing, Inc. Osaka, Japan). The instrument was calibrated with a standard white reflector plate and the system selected was CIE L* a* b*. Ten mango cubes were taken and measured on 3 sides, obtaining a total of 30 measurements for each treatment. The results were expressed as L*, h and C*. The hue angle (h) and the chroma (C*) were calculated by the software of the equipment

Microbiological analysis

Mango cubes samples were serially diluted with sterile 0.1 % (w/v) peptone solution and 1.0 mL of each dilution **was** plated into duplicate plates of appropriate agar. Plate Count Agar (PCA) (Merck, Germany) was used for counting aerobic mesophilic and psychotropic cells after incubation at 37 °C for 48 h and at 5 °C for 11 days, respectively. Yeast Extract Dextrose Chloramphenicol Agar (YEDC) (Merck, Germany) was used for counting yeast and mold cells after incubation at 30 °C for 5 days. Red Bile Dextrose Agar (VRBD) (Merck, Germany) was used for counting Enterobacter cells after incubation at 37 °C for 24 h. Results were expressed as log CFU g^{-1} (colony forming units) and the detection limit used was <1 log CFU g^{-1}.

Statistical analysis

An analysis of variance (ANOVA) was carried out using the SPSS software, version 21 (SPSS Inc., Chicago, Ill., U.S.A.). The main effect and the interaction effect of process factors were evaluated. Tukey's test was applied to compare the mean values when the ANOVA analysis showed significant differences ($p<0.05$). Mean values and standard deviations were reported. In the microbial analysis results, the statistical analysis was not performed because in all cases, the counts were under of detection limit (< 1 log CFU g^{-1}).

3. RESULTS AND DISCUSSION

Analysis of the physicochemical parameters

During infusion processing, WR is a consequence of the WL and SG. In the present work, WR was related to the behavior of the WL, since the water diffusion was higher than solids diffusion. This phenomenon is due to the selective permeability of the cell membrane that allows the diffusion of the small molecules as the water but restricts the diffusion of the big molecules as the sugar, which reduces the diffusion of the solids through of the cell tissues (Silva et al. 2014). Statistical analysis showed that the three process factors (pressure level (P), sorbitol concentration (S) and calcium lactate concentration (C)) and the PxS interaction had a significant effect ($p<0.05$) on the WR and WL. Sorbitol concentration was the most relevant factor.

Figure 1a shows the behavior of the WR and WL vs. the PxS interaction. Both WR and WL increase significantly ($p<0.05$) when sorbitol concentration increases, regardless of the pressure level employed. Pressurized samples showed higher WR and WL than non-pressurized samples ($p<0.05$). Regarding the pressure level, only samples treated at 60°Brix

showed significant differences ($p<0.05$) between levels studied. This behavior was attributed to the combination of pressures generated by the high viscosity of the solution (60°Brix at 5°C) and the pressure applied by the HP treatment. Both pressures cause damage in the cell wall, leaving cells more permeable. Thus, the mass transfer would increase between fruit and solution (Nuñez-Mancilla et al. 2011). The addition of the calcium lactate improved significantly ($p<0.05$) WR and WL, regardless of the concentrations studied ($p>0.05$) (Figure 1b). The combination of sugar and calcium salt promotes a dehydration effect, because the water activity of the solution decreases and increases the driving force (Mastrantonio et al. 2005). Similar results were found by Guiamba et al. (2016) and Tappi et al.(2017) in mango cylinders and Mauro et al.(2016) in apple.

Regarding SG, statistical analysis showed that process factors had a significant effect ($p<0.05$. Figure 2a shows the behavior of the SG vs. the sorbitol concentration. It was observed that the increase of the sorbitol concentration from 20°Brix to 40°Brix ($p<0.05$) was more relevant than when it increased from 40°Brix to 60°Brix ($p>0.05$). This behavior was attributed to the high viscosity of the solution (60°Brix at 5°C), which hinders the diffusion of solids through the tissues, forming a layer of solids on the product surface (Ferrari et al. 2010). Brochier, et al.(2014) reported the same behavior in Yacon, Abraão et al.(2013) in pumpkin and Zhao et al.(2014) in mango. Pressurized samples had a higher SG than non-pressurized samples, (Figure 2b). Similar results were reported by Dash & Balasubramaniam, (2018) and George et al.(2016) in apple slices, Nuñez-Mancilla et al.(2011) in strawberry and Rastogi & Niranjan, (1998) in potatoes. The addition of the calcium salt led to a lower SG, regardless of the concentrations (Figure 2c).

HP processing generates changes in the tissues, which enables substrates, ions, and enzymes, located in different cell compartments, to be liberated and interact with each other (Oey et al., 2008). At the same time, the pressure improves the action of pectinmethylesterase (PME), which contributes to generate the demethylation of pectin. Pectin with free carboxyl groups form crosslinked bonds with calcium, forming an "eggs-box" type structure, which provides an improvement in structural integrity and promo**tes** greater tissue firmness (Pereira et al. 2010; Tappi et al. 2017), limiting the uptake of solutes in mango cubes. Similar results were found by Tappi et al.(2017) in dehydrated apples and Silva et al.(2014) in slices of pineapples.

Analysis of the water activity (a_w) and pH

Statistical analysis showed that process factors and the PxS interaction had a significant effect ($p<0.05$) on water activity (a_w). Figure 3, shows a decrease in water activity as sorbitol concentration increases and the application of the HP processing improved this effect. Non-significant differences ($p>0.05$) between pressure levels were found. The decrease in water activity is attributed to WL and SG as a consequence of the osmotic pressure gradient between fruit and solution (Brochier, et al., 2014). This gradient is enhanced by the application of the HP processing, since it induces damages-in the tissue structure achieving a fast decrease of the aw (Rastogi & Niranjan, 1998). Similar results were found by (Nuñez-Mancilla et al., 2013). The authors reported that the application of high-pressure during osmotic dehydration significantly decreases ($p<0.05$) the aw in strawberries slices. The addition of calcium lactate the aw ($p>0.05$).

The changes in the pH of mango cubes after processing were to all practical effects, virtually negligible. The pH range of treated samples was 3.95 to 4.05.

Analysis of the mechanical properties

Statistical analysis determined that all process factors had a significant effect ($p<0.05$) on the hardness, whereas sorbitol concentration (S) and calcium lactate concentration (C) affected the work of cut. Non-significant effects of the interactions were found. Samples pressurized had higher hardness than non-pressurized ones, regardless of the pressure level ($p>0.05$) (Figure 4a). This behavior was to the incorporation of the calcium salt due to a higher mass transfer between the fruit and the solution. Also, as we mentioned before, the HP process increases the PME activity, which induced the demethylation of the pectin. Both, the incorporation of the calcium salt and the increase of the PME activity, contribute to the formation of a gel network structure capable of retaining water and increasing the rigidity of the middle lamella and the cell wall of the samples, which improves the structural integrity and promotes a higher firmness in the processed fruit and vegetables (Ferrari et al. 2010; Pereira et al. 2010; Tappi et al. 2017). Several authors reported similar results. Fraeye et al., (2010) concluded that HP processing of strawberries infused with PME and calcium favored the demethylation of pectin. This effect was reflected in a firm texture and microstructural preservation. Ferrari et al.(2010) studied the effect of the OD in melon cubes treated with sucrose and calcium lactate and reported that the addition of the calcium salt preserved the structure of the tissues of melon cubes. Torres et al., (2006) reported that mango cylinders treated with sucrose solution and calcium salt improved the firmness of the samples. Pereira et al., (2010) reported that guavas slices treated with calcium lactate in a sucrose and maltose solution (60°Brix) resulted in more resistant and harder samples compared with the control ones (without calcium).

Figure 4c shows that as sorbitol concentration increases, hardness and work of cut decreased. This effect was more relevant when sorbitol concentration increased from 20 °Brix to 40 °Brix ($p<0.05$). Castelló et al.(2009) reported a decrease in the firmness and work of cut and a higher deformation when osmotic solution concentration increased from 20 to 30° Brix in apple slices. Torres et al. (2006) treated mango slices in sucrose solution (40 and 60 °Brix) and found that samples treated with the solution more concentrated induced a softening on them. In our work, the application of the HP processing with the uptake of the calcium salt counteracted the softening generated by the contact with the osmotic solution (Figure 4b). During osmotic dehydration, the water loss causes cellular collapse, generating cell deformation and shrinkage (Junqueira et al., 2017).This effect leads to a reduction of the turgor pressure and plasmolysis, causing the softening of the tissue and reducing the firmness (Castelló et al. 2009; de Oliveira et al. 2016).

Analysis of the polyphenoloxidase activity (PPO)

Statistical analysis showed that all process factors double interactions and the triple interaction had a significant effect ($p<0.05$) on the PPO activity. Figure 5, shows that, as the concentrations of sorbitol and calcium lactate increase, PPO activity decreased in non-pressurized samples. During the infusion process, the uptake of solids and water loss changes the environmental conditions (temperature, pH, solvent composition, pressure) where the structure of the enzyme is found stable. These changes can disturb this balance leading to changes in the structural conformation or changes at or near the active site, resulting in loss of enzyme activity (Lopes, et al., 2010)

On the other hand, the application of HP processing favored the PPO activity inhibition as the pressure level increased. Similar results were reported by Guerrero-Beltrán

et al. (2004; 2006) both in peach and mango purees and García-Parra, González-Cebrino, Delgado, Cava, (2016) in pumpkin puree. Authors found that an increase in the pressure level significantly decreased the PPO activity, and they attributed it to changes in the protein structure induced by the HP process. Regarding the effect of the concentrations of sorbitol and calcium lactate it did not show a clear trend in the pressurized samples, so we considered that the application of high-pressure had a larger effect than the others process factors.

Statistical analysis indicated that the most effective treatment in PPO inactivation was 600MPa-60°Brix-2%Ca, achieving inhibition of 81.9% of the PPO activity. This process will allow the preservation of the quality of the final product for a longer time.

Analysis of the chromatic parameters

The chromatic parameters analyzed are shown in Figure 6. Statistical analysis showed that only pressure level affected the luminosity (L*), regardless of the level applied ($p>0.05$). The L* values of the pressurized samples were lower than non-pressurized ones, indicating that samples treated with HP had a darker appearance compared to the non-pressurized samples (Figure 6a). Similar results were reported by Nuñez-Mancilla et al., (2013) in strawberry. This effect could be attributed to the fact that the use of high-pressure induced water loss, so it generated a concentration effect of the pigments in the fruit tissue. At the same time, the processing temperature (5°C) used in this work made a more viscous sugar solution, which hindered a possible pigment loss (Pereira et al., 2006)

Regarding the tonality (h) and saturation (C*), statistical analysis showed that pressure level (P) and sorbitol concentration (S) had a significant effect on these parameters. HP processing significantly increased ($p <0.05$) h values, whereas the C*

values decreased (Figure 6b), regardless of the level applied ($p>0.05$). On the other hand, as sorbitol concentrations increased, the h values decreased, whereas the C* values increased (Figure 6c). Although pressurized and non-pressurized samples showed significant differences in h values, they were in the range of 88° - 92°. These values correspond to the yellow color of the fresh mango pulp. Therefore, this result would indicate that the HP assisted-infusion process does not generate changes in the pigments of the processed samples (Oey et al. 2008; Terefe et al. 2009). As for color saturation (C*), the application of HP treatment induced a loss of it in mango cubes. The effect on C* was like of L*, so the decrease in the color saturation could also be attributed to the concentration of pigments.

Regarding the effect of the concentration of sorbitol on the C* and h, the increase of the solution concentration involves a higher dehydration. This leads to a concentration of pigments in the vegetable tissues, improving the chromaticity of samples (Silva et al. 2014). As for h values, the lowering of this parameter indicated that samples exhibited a more orange color (<h). Similar results were found by Mastrantonio et al. (2005) in guavas and (Silva et al. 2014) in pineapple. Results showed an antagonistic effect of the pressure level and sorbitol concentration on the h and C* parameters. Therefore, we considered that the high pressure-assisted infusion process enables the preservation of the appearance of mango cubes.

Microbiological analysis

Fresh and processed samples had negative counts in the microbiological analysis. These results indicated that the HClO bath before processing was effective to decrease the natural microbiota. Also, good hygienic practices during processing and low pH of the fruit (<4.2) inhibited microbial growth and development in mango cubes (Liu et al. 2014; Pereira et al.

2010; Torres et al. 2008). Based on these results, we suggest assessing the true effectiveness of the HP process conducting a shelf life assay.

4. CONCLUSION

Result showed that the high pressure assisted-infusion treatment could be an interesting alternative to preserve the fresh-like quality of mango. Both the application of high-pressures and the use of hypertonic solutions did not only improve the mass transfer during the infusion process but also the incorporation of the calcium salt prevented an excessive solids gain, which would avoid an undesirable flavor in the mango cubes. The synergistic effect of the pressure level and calcium salt allowed to counteract the softening effect, which may arise by the application of the hypertonic solution. The activity of the polyphenoloxidase enzyme decreased as the pressure level and the concentrations of sorbitol and calcium lactate increase, achieving an inactivation of 81.9 % with the treatment at 600MPa-60°Brix-2%w/w. The tonality and saturation of color were preserved by the antagonistic effect of the pressure level and sorbitol concentration, although pressurized samples were darker than non-pressurized samples. Regarding the microbiological quality, all counts analyzed were below the detection level after 24 hs of refrigerated storage. Based on the results described above, we considered that the best combination of the process factors was 600MPa-60°Brix-2% w / w since was achieved a higher inactivation percentage of enzyme inactivation, which allows the preservation of the final product quality.

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FIGURE CAPTIONS

Figure 1- Effect of high pressure-assisted infusion on weight reduction (WR %) and water loss (WL %): a) Effect of the interaction of the pressure level-sorbitol concentration and b) Effect of the calcium concentration. Different letters mean significant differences according to Tukey´s test ($p<0.05$). Lowercase letters indicate significant differences in weight reduction and uppercase letters indicate significant differences in water loss.

Figure 2- Effect of the high pressure-assisted infusion on solids gain (SG %) a) Effect of the pressure level, b) Effect of the sorbitol concentration and c) Effect of the calcium concentration. Different letters mean significant differences according to Tukey´s test ($p<0.05$).

Figure 3- Effect of the interaction of the pressure level-sorbitol concentration on activity water (aw). Different letters mean significant difference according to Tukey´s test ($p<0.05$)

Figure 4- Effect of high pressure-assisted infusion on mechanical properties **a) Effect of the pressure level** b) Effect of the calcium concentration and c) Effect of the sorbitol concentration. Different letters mean significant differences according to Tukey´s test ($p<0.05$). Lowercase letters indicate significant differences in Hardness and uppercase letters indicate significant differences in work of cut.

Figure 5- Effect of high pressure-assisted infusion on residual activity of the polyphenoloxidase enzyme

Figure 6- Effect of high pressure-assisted infusion on chromatic parameters of mango cubes: "a)" and "b)" Effect of the pressure level on L*, C* and h and **c)** Effect of the sorbitol concentration on C* and h. Different letters mean significant differences ($p<0.05$).

Figures “b)” and “c)”: Lowercase letters indicate significant differences in C* and uppercase letters indicate significant differences in h.

AUTHOR STATEMENT

Perdomo Carolina: methodology, Investigation. **Vaudagna Sergio**: Validation, Funding acquisition, Project administration, Writing - Review & Editing, Funding acquisition **Cap Mariana:** Methodology, Writing - Review & Editing **Rodriguez Anabel:** Investigation, Resources, Visualization, Validation, Project administration, Writing - Original Draft

HIGHLIGHTS

- Process factors improved the water loss and weight reduction and decrease of the aw
- The incorporation of the calcium salt hindered the solids gain
- The mechanical properties, chromaticity, and tonality were conserved after processing
- Microbiological counts were below the detection level
- Treatment at 600MPa-60°Brix-2% w/w allow achieved an 81.9% of inactivation Polyphenoloxidase enzyme

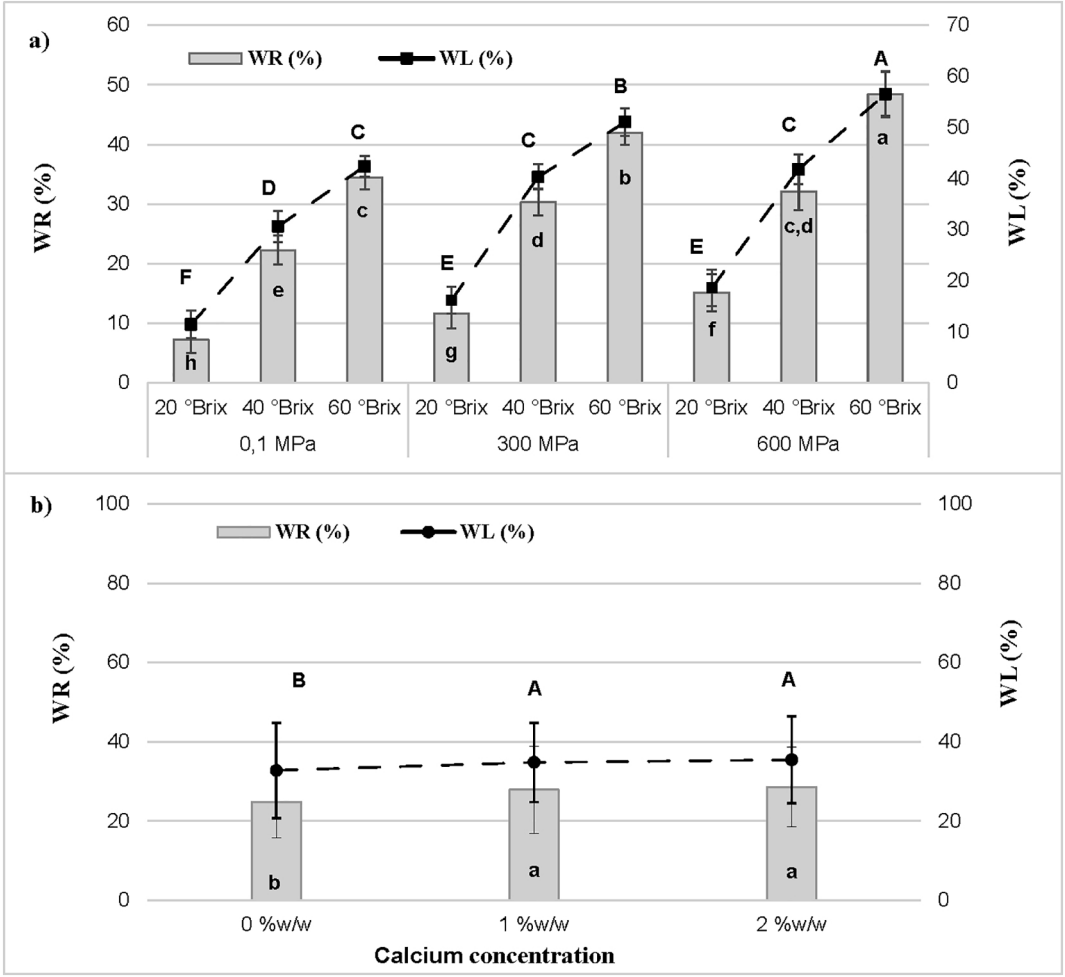
a)
WR (%)
WL (%)
20 °Brix
40 °Brix
60 °Brix
0,1 MPa
300 MPa
600 MPa
b)
0 %w/w
1 %w/w
2 %w/w
Calcium concentration

Figure 1

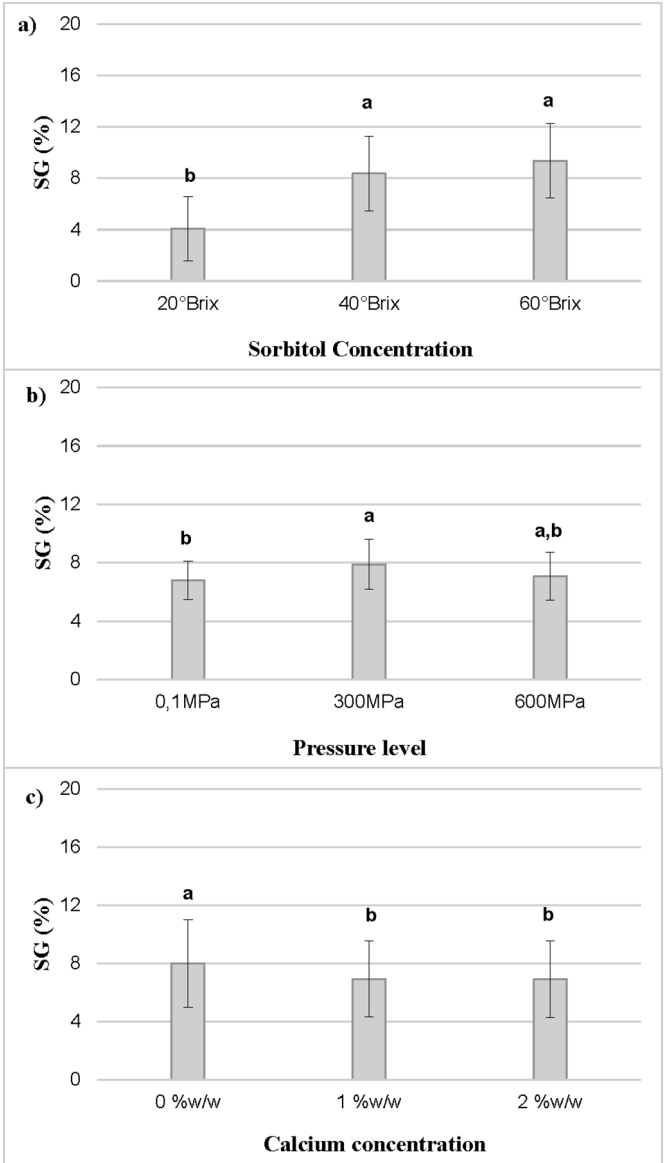
a)
SG (%)
20
16
12
8
4
0
b
a
a
20°Brix
40°Brix
60°Brix
Sorbitol Concentration
b)
SG (%)
b
a
a,b
0,1MPa
300MPa
600MPa
Pressure level
c)
SG (%)
a
b
b
0 %w/w
1 %w/w
2 %w/w
Calcium concentration

Figure 2

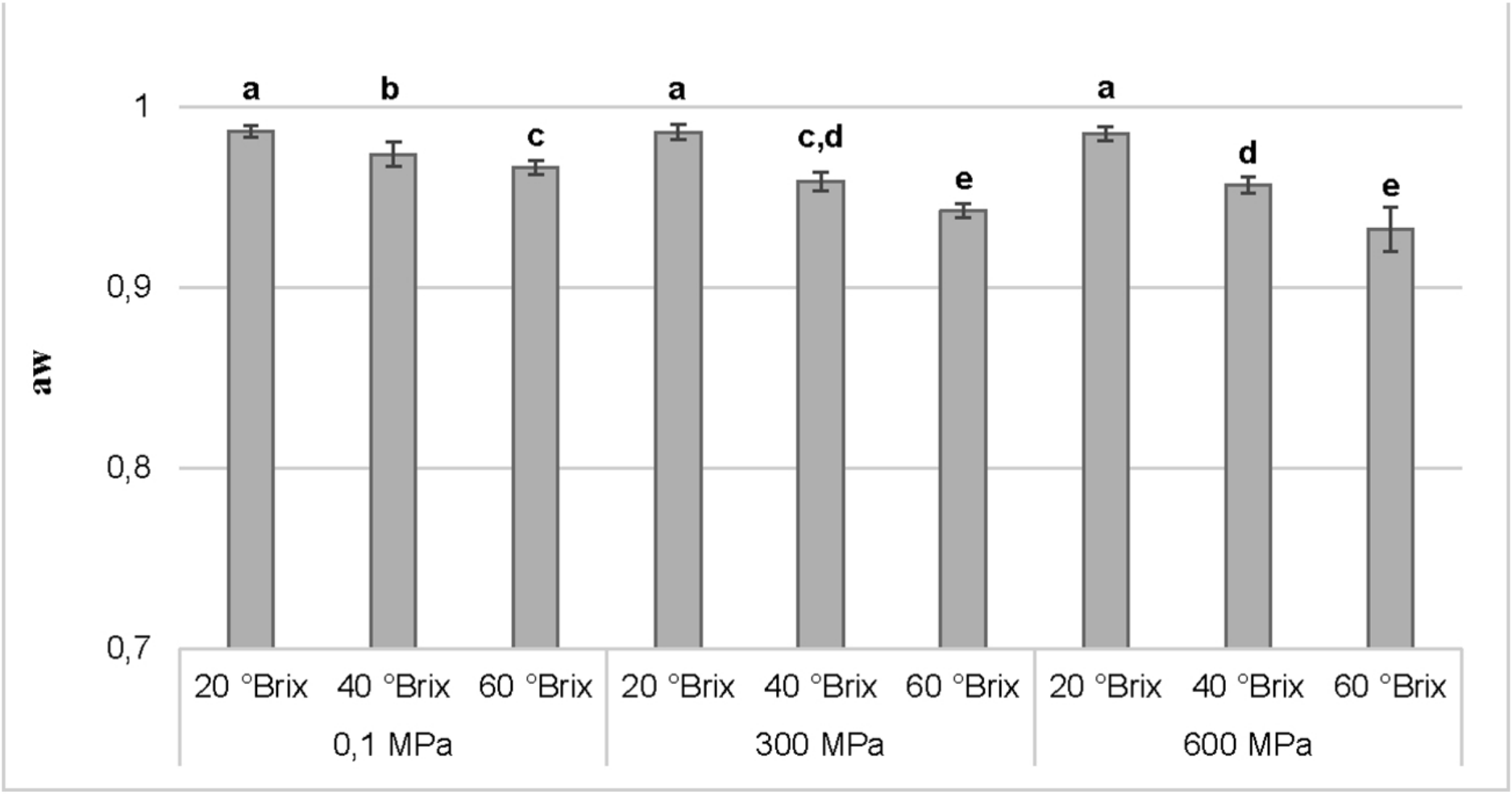
aw
1
0,9
0,8
0,7
a
b
c
a
c,d
e
a
d
e
20 °Brix
40 °Brix
60 °Brix
20 °Brix
40 °Brix
60 °Brix
20 °Brix
40 °Brix
60 °Brix
0,1 MPa
300 MPa
600 MPa

Figure 3

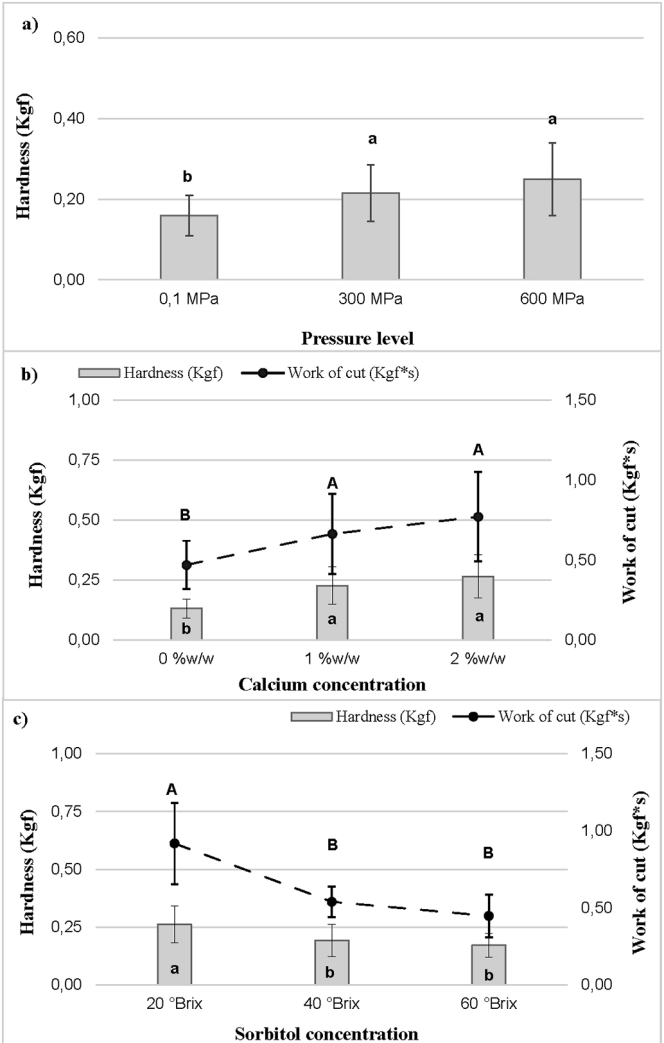
a)
Hardness (Kgf)
0,60
0,40
0,20
0,00
b
a
a
0,1 MPa
300 MPa
600 MPa
Pressure level
b)
Hardness (Kgf)
Work of cut (Kgf*s)
1,00
0,75
0,50
0,25
0,00
1,50
1,00
0,50
0,00
B
A
A
b
a
a
0 %w/w
1 %w/w
2 %w/w
Calcium concentration
c)
Hardness (Kgf)
Work of cut (Kgf*s)
1,00
0,75
0,50
0,25
0,00
1,50
1,00
0,50
0,00
A
B
B
a
b
b
20 °Brix
40 °Brix
60 °Brix
Sorbitol concentration

Figure 4

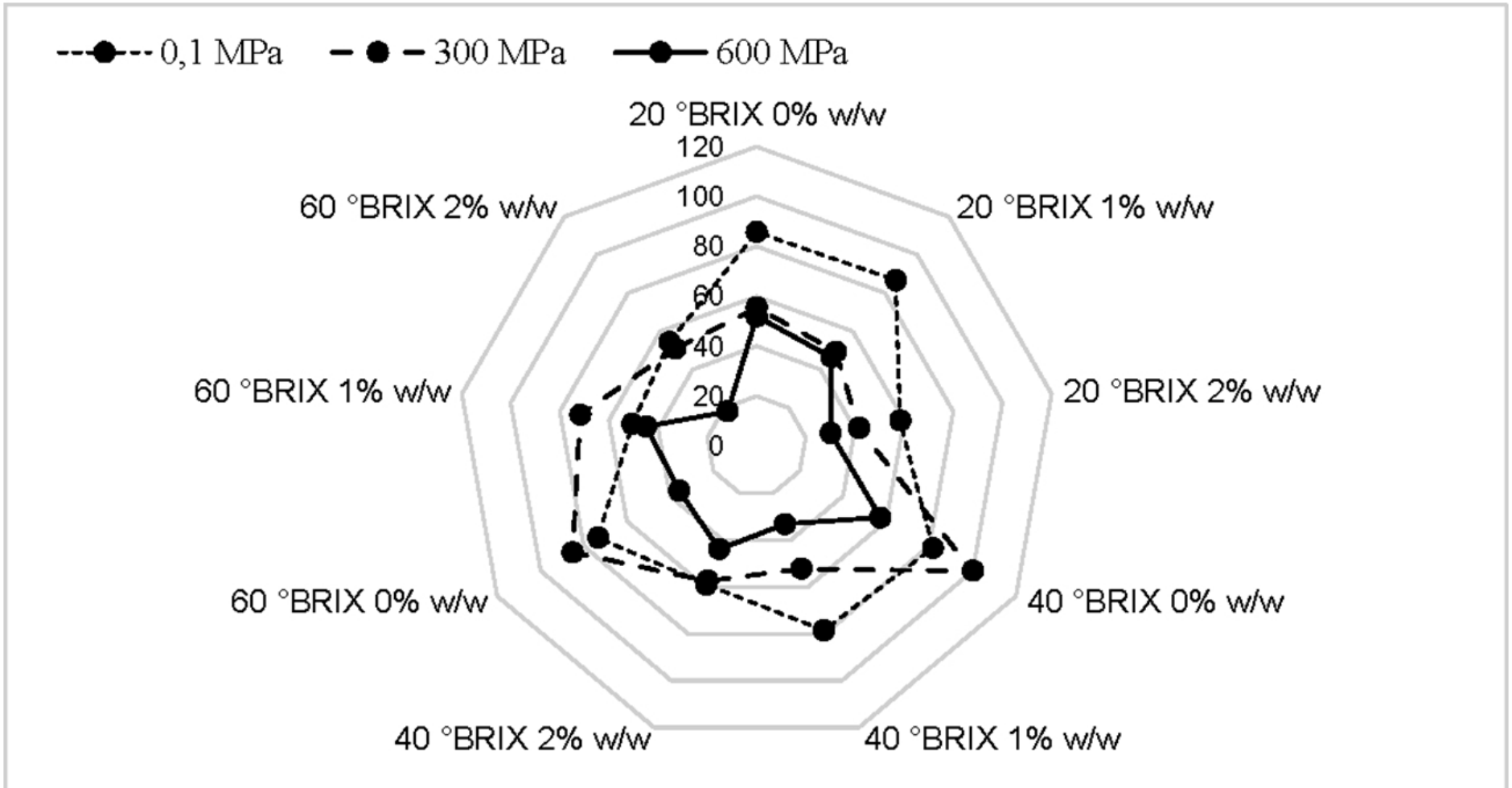
0,1 MPa
300 MPa
600 MPa
20 °BRIX 0% w/w
120
100
80
60
40
20
0
20 °BRIX 1% w/w
20 °BRIX 2% w/w
40 °BRIX 0% w/w
40 °BRIX 1% w/w
40 °BRIX 2% w/w
60 °BRIX 0% w/w
60 °BRIX 1% w/w
60 °BRIX 2% w/w

Figure 5

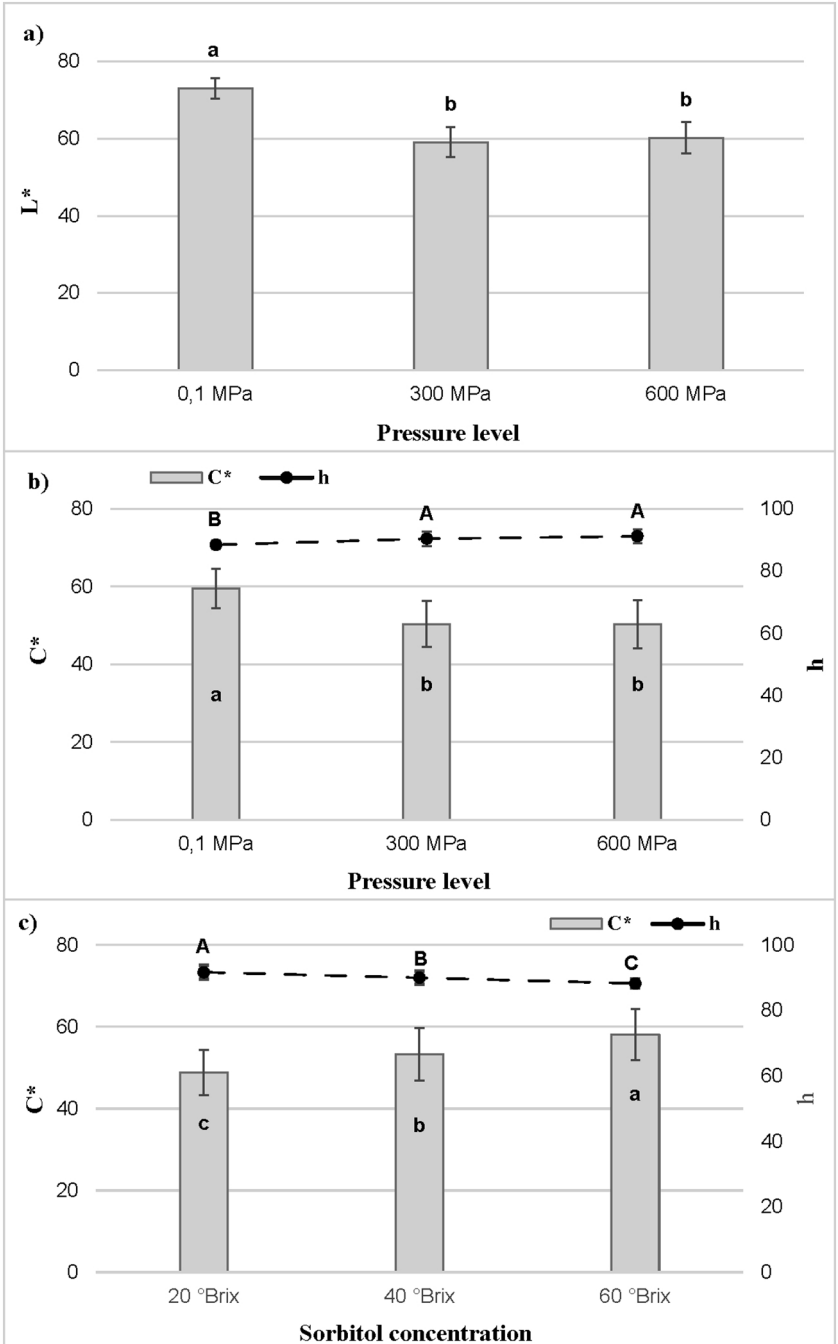
a)
L*
a
b
b
0,1 MPa
300 MPa
600 MPa
Pressure level
b)
C*
h
B
A
A
a
b
b
0,1 MPa
300 MPa
600 MPa
Pressure level
c)
C*
h
A
B
C
c
b
a
20 °Brix
40 °Brix
60 °Brix
Sorbitol concentration

Figure 6