FRUIT PUREES

INTRODUCTION

High Pressure Processing **(HPP)** is a **non-thermal** food preservation technology that allows the control of vegetative microorganisms in food, achieving safe products with longer shelf-life while preserving nutrients and fresh taste. Industrial HPP equipment can operate at 600 MPa (87,000 psi) for several seconds to minutes at room or chilled temperature.

Fruit purees are generally processed at 500 and 600 MPa (72,500 / 87,000 psi) with a holding time between 2 and 5 min, depending on the **pH**, initial **microbial load** and **desired shelf-life** of the final product. After processing, chilled storage (< 4 ^{o}C / 39.2 ^{o}F) is required to minimize surviving microorganisms' growth and residual enzymatic activity that could lead to sensory deterioration.

Regarding physicochemical impact on food, HPP technology is milder than heat pasteurization: it does not break covalent bonds nor generates new compounds by molecule degradation, as it occurs with thermal processing traditionally applied to these products (i.e. Maillard reactions). However, HPP breaks or induces the formation of weak bonds (e.g. hydrogen bonds, hydrophobic and electrostatic interactions…) in macromolecules, such as proteins or starch (Cheftel, 1992). This allows **bacteria**, **molds**, **yeasts** and **virus** inactivation withoutmodifying nutritional and organoleptic properties of food.

The main reasons that make HPP a suitable solution for **fruit preparations** are:

- Introduction to the market of **safe products** with a **longer shelf-life** due to the inactivation of pathogens and spoilage microorganisms, as well as enzyme control
- **Fresh-like** organoleptic properties are maintained
- **Nutritional quality** is preserved

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FOOD SAFETY AND SHELF-LIFE

The **shelf-life** of **fruit purees and preparations** can be extended several times compared to that of the fresh product at the same storage temperature. HPP can also guarantee **food safety** by the inactivation of pathogens.

Shelf-life increase

The right combination of pressure and time can reduce the numbers of total aerobes, molds and yeasts to non-detectable levels (< 1.70 or < 1 log cfu/ml) **(Figure 1)**. These microorganisms are responsible of the spoilage of fresh products because they would easily grow (if present). Their HPP inactivation gives as result microbiological stable products stored under refrigeration conditions.

Food safety

Listeria monocytogenes, ***Escherichia coli*** and ***Salmonella* spp.** are the major pathogens of concern to the food industry. HPP proved to be a valid technology inactivating them in fruit and vegetable juices **(Figure 2)**.

Viruses may also be a concern in vegetables and fruit preparations, as recent outbreaks demonstrate (Maunula et al. 2009). Noroviruses are the most common cause of outbreaks and sporadic cases of gastroenteritis worldwide. However, pressures above 400 MPa/58,000 psi can inactivate them in **strawberry**, **raspberry** and **blueberry purees** (Rodríguez-Lázaro et al. 2012, Huang et al. 2016) **(Figure 3)**. An equivalent inactivation of hepatitis A virus was described in **strawberry puree** when processed at 350 MPa/50,700 psi for 5 min (Kingsley et al. 2005).

Physicochemical properties of fruit purees play a major role in the performance of HPP. Two of the most important parameters are **pH** and **water activity** (**a_w**). The synergy between low pH values and microbial inactivation by HPP is well established (Alpas et al. 2000). Regarding water activity, values above 0.96 help in the transmission of hydrostatic pressure to the food and increase the lethal effect of HPP, whereas low values may reduce the efficacy (Goh et al. 2007).

A commonly used parameter in fruit industries to measure the concentration of soluble solids is the **Brix degree** (°Brix). Water activity and °Brix are well correlated in food products,

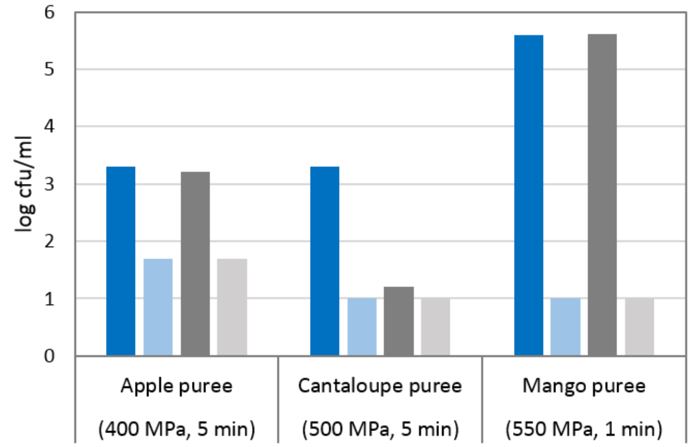

Figure 1. Total aerobic counts before (■) and after HPP (■) and molds and yeasts counts before (■) and after HPP (■) in apple (Land et al. 2010), cantaloupe (Mukhopadhyay et al. 2017) and mango puress (Guerrero-Beltrán et al. 2006)

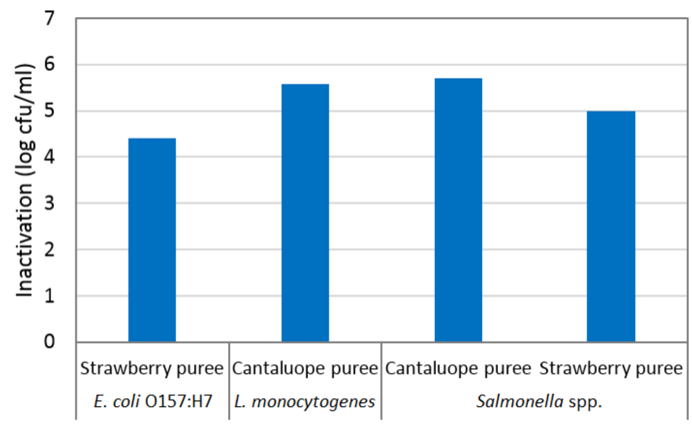

Figure 2. Inactivation of *E. coli* O157:H7, *L. monocytogenes* and *Salmonella spp.* in strawberry and cantaloupe purees (Huang et al. 2013, Mukhopadhyay et al. 2016)

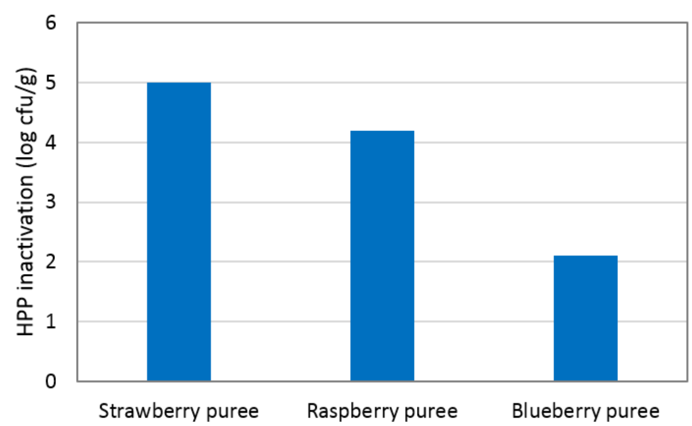

Figure 3. Norovirus inactivation after processing at 400 MPa for 2.5 min (strawberry) and 2 min (raspberry and blueberry purees) (Rodríguez-Lázaro et al. 2012, Huang et al. 2016)

meaning that high concentrations of soluble solids (i.e. high Brix degrees) will reduce water activity.

In **fruit purees**, simple sugars such as glucose, fructose or sucrose are the main soluble solids. This becomes of concern in **fruit concentrates**, where partial removal of water dramatically increases the concentration of sugars, hence rising °Brix and lowering water activity. This may reduce the performance of HPP in fruit preparations with high °Brix **(Figure 4)**

Another aspect to consider is the fact that HPP does not inactivate bacterial spores. ***Clostridium botulinum*** becomes the pertinent pathogen when the **pH** of the final product is higher than **4.6**. Refrigeration and acidification by blending the puree with **citric preparations** (e.g. orange, lemon, lime…) or adding **organic acids** (e.g. citric acid) are valid strategies to lower the pH below 4.6. In this case, *C. botulinum* spores will not grow or produce botulinum neurotoxin.

Sensorial and Nutritional Profile

Sensorial properties

HPP uses pressure instead of heat to inactivate micro-organisms and stabilize enzymes. This **prevents** the destruction of flavor and color compounds and avoids reactions that yield new molecules (i.e. Maillard reaction).

Dalmadi et al. (2007) found that volatile profiles of **raspberry, blackcurrant and strawberry purees** were almost identical to those of the fresh purees after processing at 600 MPa/87,000 psi for 5 min. Yan et al. (2017) described that color of **tomato puree** did not change after processing at 600 MPa/87,000 psi for 5 min when compared to the unprocessed product. This can be explained because carotenoids (remained unaltered (**Figure 5**). Other authors proved that flavor components of **strawberry jam** were maintained up to 90 days under refrigeration (5 °C/ 41 °F) even when intense HPP treatments were applied (400 and 500 MPa for 30 min) (Kimura et al. 1994)

Effects on enzymatic activity

HPP may reduce enzymatic activity of certain fruit varieties. However, in some cases, HPP may induce enzyme activation and enhance the browning effect **(Figure 6)**.

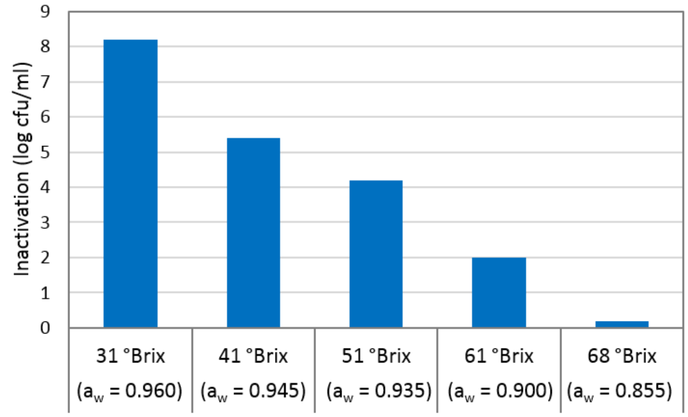

Figure 4. Inactivation of *L. monocytogenes* after HPP (600 MPa/87,000 psi, 10 min) in buffer with different concentrations of sucrose (Koseki et al. 2007)

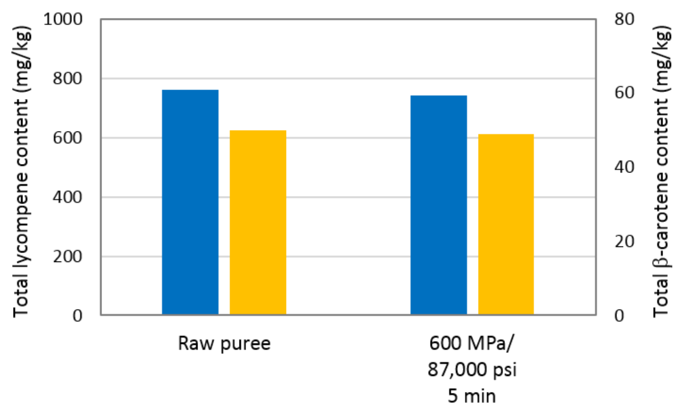

Figure 5. Concentration of total lycopene (■) and total β-carotene (■) in raw and high pressure processed tomato purees (Yan et al. 2017)

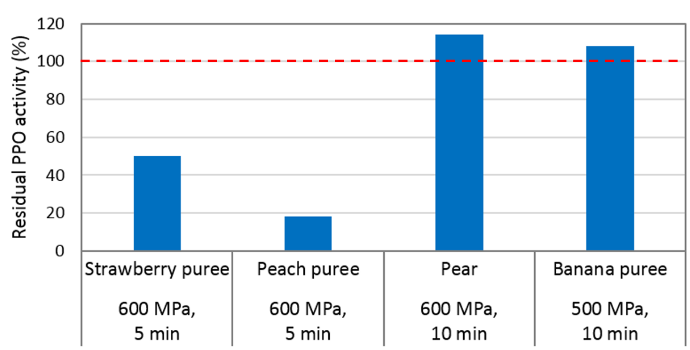

Figure 6. Residual PPO activity in strawberry, peach and banana purees and pear after HPP (---) original PPO activity) (Asaka et al. 1994, Palou et al. 1994, Guerrero-Beltrán et al. 2004, Jacobo-Velázquez et al. 2010 and Sulaiman et al. 2013)

Polyphenol oxidase (PPO) is the responsible of the browning in fruit products and purees. The way HPP affects **PPO** depends on the fruit species and variety. For instance, HPP effectively reduces the activity of **PPO** by 50% in **avocado** and **strawberry purees** after processing at 600 MPa/87,000 psi for 3 min or 5 min (Jacobo-Velázquez et al. 2010, Sulaiman et al. 2013). Inactivating or reducing the activity of **PPO** extends the shelf-life of fresh fruit products from a sensorial point of view as browning is delayed.

Pectin methylesterase (PME) is another enzyme commonly found in fruits and vegetables. Activation of this enzyme may occur during HPP, which causes gelation (Bodelón et al. 2013). Selection of varieties with **low PME activity** or **blanching** are valid alternatives to overcome gel formation.

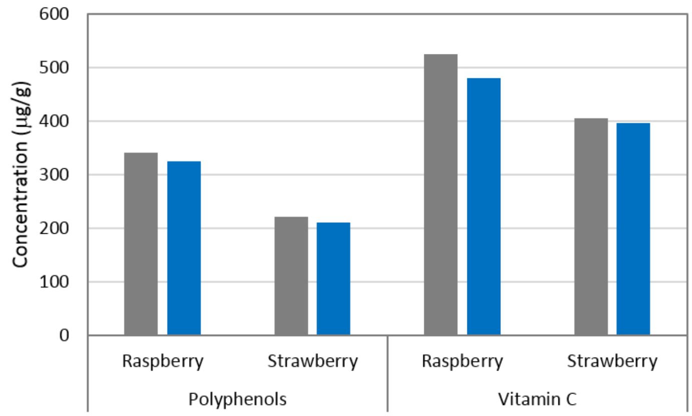

Figure 7. Polyphenols and vitamin C concentration in strawberry and raspberry purees before (■) and after HPP (■) (600 MPa/87000 psi for 20 min) (Verbeyst et al. 2012)

Nutritional properties

Consumption of fruits and vegetables has been reported to **lower the risk** of chronic diseases. **Antioxidant compounds** are responsible for these desired effects, being vitamin C and polyphenols the most important in berry fruits. Verbeyst et al. (2012) proved that concentration of these components in **strawberry** and **raspberry purees** were maintained after an intense treatment of 600 MPa/87000 psi during 20 min (**Figure 7**).

In some cases, HPP promotes the extraction and bioavailability of bioactive compounds. De Ancos et al. (2000) found that vitamin A concentration increased up to a 27% in **persimmon puree** after processing at 400 MPa for 15 min. As a consequence of this, in-vitro antioxidant capacity of the puree increased a 24% when compared to the fresh product.

HEAT PASTEURIZED vs HPP FRUIT PREPARATIONS

Traditional heat pasteurization induces **chemical degradation** of micronutrients and biomolecules (Vikram et al. 2005) and may trigger chemical reactions (such as the Maillard reaction) generating **new chemical compounds**.

According to Sulaiman et al. (2017) a heat pasteurization process of 65 °C/150 °F for 15 min caused a greater loss of antioxidant activity than an intense HPP treatment (600 MPa/87,000 psi for 15 min) in a **strawberry puree**. Additionally, the HPP puree was more stable during cold storage than its pasteurized homologue **(Figure 8)**.

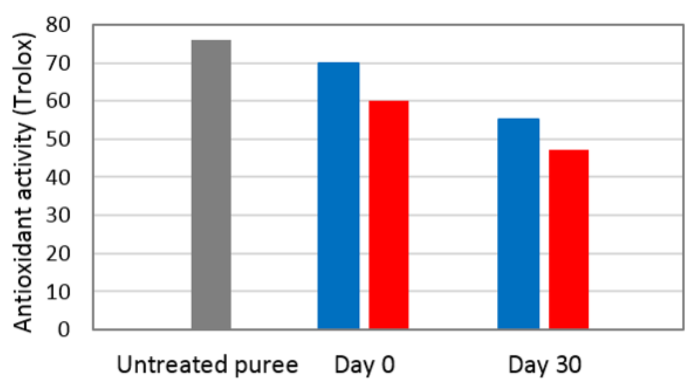

Figure 8. Antioxidant activity of untreated (■), heat pasteurized (■) (65 °C/150 °F, 15 min) and high pressure processed (■)(600 MPa/87,000 psi for 15 min) strawberry puree during 30 days of storage at 3 °C/37 °F (Sulaiman et al. 2017)

Similarly, Patras et al. (2009) described that the same HPP treatment retained a higher concentration of total phenols and ascorbic acid (vitamin C) in **strawberry** and **blackberry purees** when compared to the same heat pasteurized products (70 °C/158 °F for 2 min) **(Figure 9)**.

When it comes to taste and flavor, HPP can **extend the shelf-life** of fresh products while maintaining their **organoleptic properties**. According to Marszalek et al. (2015) expert panelists did not find differences in terms of color, taste, aroma, consistency and overall quality in a **strawberry puree** before and after processing at 500 MPa/72,500 psi for 5 min **(Figure 10)**. When compared to thermal pasteurization, HPP also gives as a result high-quality purees, as described by Keenan et al. (2011). HPP **apple puree** (500 MPa/72,500 psi for 1.5 min) scored higher in terms of sensory acceptability than thermal pasteurized puree (90 °C/195 °F for 10 min) during 30 days of storage at 4 °C/39 °F **(Figure 11)**.

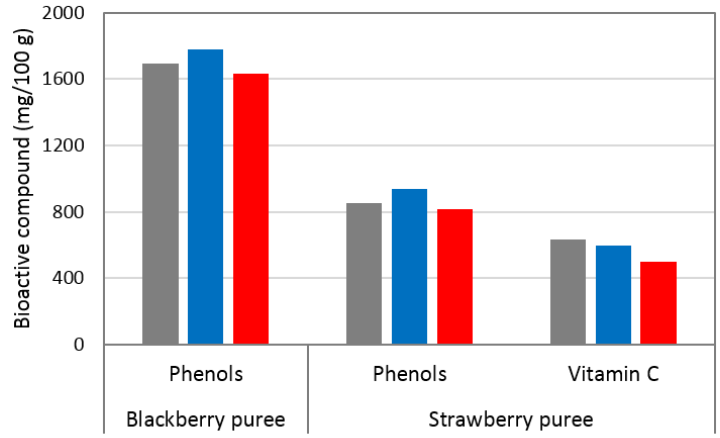

Figure 9. Total phenols and vitamin C concentration in untreated (■), HPP (600 MPa/87,000 psi for 15 min) (■) and heat pasteurized (70 °C/158 °F for 2 min) (■) strawberry and blackberry purees (Patras et al. 2009)

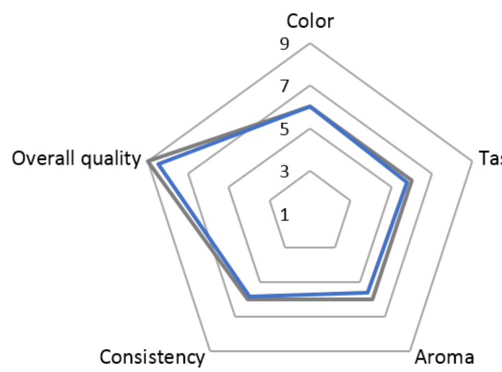

Figure 10. Sensorial profiles of untreated (■) and HPP processed (500 MPa/72,500 psi for 5 min) (■) strawberry puree (Marszalek et al. (2015)

Conclusions

Fruit jams and **marmalades** were one of the first high-pressure processed products introduced in the market in the early 90's. Since then, the number of **fruit purees** and preparations has steadily increased.

When physicochemical parameters are the appropriate, **HPP** is an effective technology in extending the shelf life of fresh fruit purees while nutritional and organoleptic quality are maintained. This is possible thanks to the inactivation of pathogens and spoilage bacteria. The use of **cold pressure** prevents the destruction of bioactive compounds and the formation of non-desirable substances with a negative impact in the quality of fruit-based products.

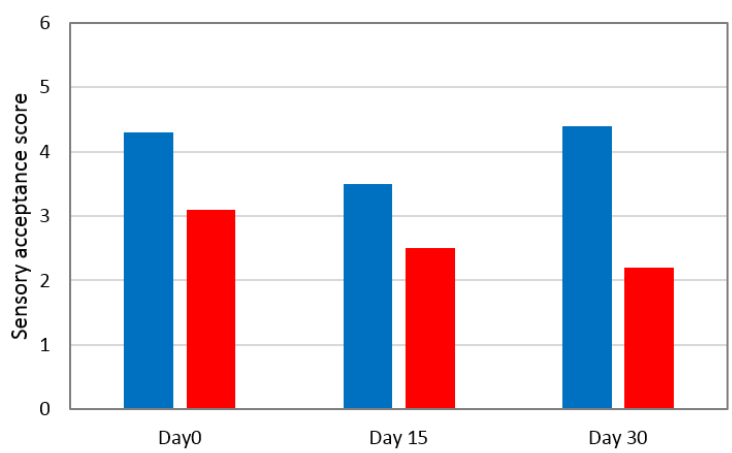

Figure 10. Sensory acceptance of HPP (500 MPa/72,500 psi for 1.5 min) (■) and thermal pasteurized (90 °C/195 °F for 10 min) apple puree (■) (Keenan et al. 2015)

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REFERENCES

Alpas, H., Kalchayanand, N., Bozoglu, F., & Ray, B. (2000). Interactions of high hydrostatic pressure, pressurization temperature and pH on death and injury of pressure-resistant and pressure-sensitive strains of foodborne pathogens. *International journal of food microbiology*, *60*(1), 33-42.

Bodelón, O. G., Avizcuri, J. M., Fernández-Zurbano, P., Dizy, M., & Préstamo, G. (2013). Pressurization and cold storage of strawberry purée: colour, anthocyanins, ascorbic acid and pectin methylesterase. LWT-Food Science and Technology, 52(2), 123-130.

Cheftel, J. C. (1992). Effects of high hydrostatic pressure on food constituents: An overview. In C. Balny, R. Hayashi, KK. Heremans & P. Masson (Eds), High Pressure and Biotecnology, Colloque INSERM (Vol. 224) 195-209

Dalmadi, I., Polyak-Feher, K., & Farkas, J. (2007). Effects of pressure-and thermal-pasteurization on volatiles of some berry fruits. *High Pressure Research*, *27*(1), 169-171.

de Ancos, B., Gonzalez, E., & Cano, M. P. (2000). Effect of high-pressure treatment on the carotenoid composition and the radical scavenging activity of persimmon fruit purees. *Journal of Agricultural and Food Chemistry*, *48*(8), 3542-3548.

Goh, E. L., Hocking, A. D., Stewart, C. M., Buckle, K. A., & Fleet, G. H. (2007). Baroprotective effect of increased solute concentrations on yeast and moulds during high pressure processing. *Innovative food science & emerging technologies*, *8*(4), 535-542.

Guerrero-Beltrán, J. A., Barbosa-Cánovas, G. V., & Swanson, B. G. (2004). High hydrostatic pressure processing of peach puree with and without antibrowning agents. *Journal of food processing and preservation*, *28* (1), 69-85.

Guerrero-Beltrán, J. A., Barbosa-Cánovas, G. V., Moraga-Ballesteros, & Swanson, B. G. (2006). Effect of pH and ascorbic acid on high hydrostatic pressure-processed mango puree. *Journal of Food Processing and Preservation*, *30*(5), 582-596.

Huang, R., Ye, M., Li, X., Ji, L., Karwe, M., & Chen, H. (2016). Evaluation of high hydrostatic pressure inactivation of human norovirus on strawberries, blueberries, raspberries and in their purees. International journal of food microbiology, 223, 17-24.

Jacobo-Velázquez, D. A., & Hernández-Brenes, C. (2010). Biochemical changes during the storage of high hydrostatic pressure processed avocado paste. *Journal of food science*, *75*(6).

Keenan, D. F., Brunton, N., Butler, F., Wouters, R., & Gormley, R. (2011). Evaluation of thermal and high hydrostatic pressure processed apple purees enriched with prebiotic inclusions. Innovative Food Science & Emerging Technologies, 12(3), 261-268.

Kimura, K., Ida, M., Yosida, Y., Ohki, K., Fukumoto, T., & Sakui, N. (1994). Comparison of keeping quality between pressure-processed jam and heat-processed jam: changes in flavor components, hue, and nutrients during storage. *Bioscience, biotechnology, and biochemistry*, *58*(8), 1386-1391.

Kingsley, D. H., Guan, D., & Hoover, D. G. (2005). Pressure inactivation of hepatitis A virus in strawberry puree and sliced green onions. Journal of food protection, 68(8), 1748-1751.

Koseki, S., & Yamamoto, K. (2007). Water activity of bacterial suspension media unable to account for the baroprotective effect of solute concentration on the inactivation of Listeria monocytogenes by high hydrostatic pressure. *International journal of food microbiology*, *115*(1), 43-47.

Kovač, K., Diez-Valcarce, M., Raspor, P., Hernández, M., & Rodríguez-Lázaro, D. (2012). Effect of high hydrostatic pressure processing on norovirus infectivity and genome stability in strawberry puree and mineral water. International journal of food microbiology, 152(1-2), 35-39.

Landl, A., Abadias, M., Sárraga, C., Viñas, I., & Picouet, P. A. (2010). Effect of high pressure processing on the quality of acidified Granny Smith apple purée product. Innovative Food Science & Emerging Technologies, 11(4), 557-564.

Maunula L, Roivainen M, Keränen M, Mäkelä S, Söderberg K, Summa M, von Bonsdorff C H, Lappalainen M, Korhonen T, Kuusi M, Niskanen T. (2009) Detection of human norovirus from frozen raspberries in a cluster of gastroenteritis outbreaks. *Euro Surveillance* 14(49)

REFERENCES

Marszałek, K., Mitek, M., & Skąpska, S. (2015). The effect of thermal pasteurization and high pressure processing at cold and mild temperatures on the chemical composition, microbial and enzyme activity in strawberry purée. Innovative Food Science & Emerging Technologies, 27, 48-56.

Mukhopadhyay, S., Sokorai, K., Ukuku, D., Fan, X., & Juneja, V. (2017). Effect of high hydrostatic pressure processing on the background microbial loads and quality of cantaloupe puree. *Food Research International*, *91*, 55-62.

Palou, E., López-Malo, A., Barbosa-Cánovas, G. V., Welti-Chanes, J., & Swanson, B. G. (1999). Polyphenoloxidase activity and color of blanched and high hydrostatic pressure treated banana puree. *Journal of Food Science*, *64*(1), 42-45.

Patras, A., Brunton, N. P., Da Pieve, S., & Butler, F. (2009). Impact of high pressure processing on total antioxidant activity, phenolic, ascorbic acid, anthocyanin content and colour of strawberry and blackberry purées. *Innovative Food Science & Emerging Technologies*, *10*(3), 308-313.

Sulaiman, A., & Silva, F. V. (2013). High pressure processing, thermal processing and freezing of 'Camarosa' strawberry for the inactivation of polyphenoloxidase and control of browning. *Food Control*, *33*(2), 424-428.Attributes in Tomato Juice. *Food and Bioprocess Technology*, *10*(5), 808-818.

Sulaiman, A., Farid, M., & Silva, F. V. (2017). Strawberry puree processed by thermal, high pressure, or power ultrasound: Process energy requirements and quality modeling during storage. *Food Science and Technology International*, 1082013216685485.

Verbeyst, L., Hendrickx, M., & Van Loey, A. (2012). Characterisation and screening of the process stability of bioactive compounds in red fruit paste and red fruit juice. *European Food Research and Technology*, *234* (4), 593-605.

Vikram, V. B., Ramesh, M. N., & Prapulla, S. G. (2005). Thermal degradation kinetics of nutrients in orange juice heated by electromagnetic and conventional methods. *Journal of Food Engineering*, *69*(1), 31-40.

Yan, B., Martínez-Monteagudo, S. I., Cooperstone, J. L., Riedl, K. M., Schwartz, S. J., & Balasubramaniam, V. M. (2017). Impact of Thermal and Pressure-Based Technologies on Carotenoid Retention and Quality Attributes in Tomato Juice. *Food and Bioprocess Technology*, *10*(5), 808-818.