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Effect of thermal and high hydrostatic pressure treatments on mango bars shelf-life under refrigeration

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ABSTRACT

Ready-to-eat mango bars, previously developed, were packaged using a heat-sealable multilayer material (PET/PE aluminium film). They were then subjected to two types of preservation treatments: thermal treatments (TT) (80 and 90 °C for 120 and 300 s) and high hydrostatic pressure (HHP) (500 MPa for 120 and 240 s), in order to compare their impact on flavour release and microbial stability of the mango bars. A similar effect of both thermal and non-thermal treatments on the referred bars characteristics was observed. As such, TT at 80 °C for 120 s was selected as ideal for bars treatment, as it is the one carried out at lower temperature and lower period of time. For bars treated with this TT, parameters such as, hardness, cohesiveness, springiness, total colour difference, browning index, sensory quality, microbial growth (aerobic colonies and yeasts and moulds) and microbiological safety (detection of Listeria monocytogenes) of the bars were monitored under refrigerated conditions (5 °C). Results indicated the TT of 80 °C, for 120 s, as the more adequate to extend the shelf-life of the mango bars. The bars presented good stability during refrigerated storage, as the monitored parameters did not change significantly. The shelf-life of the untreated mango bars was estimated to be nine days, while the thermal treatment of the bars extended their shelf-life to 18 days at 5 °C.

1. Introduction

An active promotion of fruit as a basic component of a healthy diet resulted in an increased consumer's interest for fruit products. This became an area of interest of the food industry with the development of a wide range of ready-to-eat (RTE) fresh fruit products. In fact, consumption of fruits and their products is associated with a decreased risk of degenerative diseases such as cancer and coronary heart disease, due to health promoting phytochemicals such as carotenoids, flavonoids, phenolic compounds and vitamins (Hansen et al., 2003).

From a quality point of view, it is desirable to preserve the characteristics of fruits and vegetables while being processed, namely into RTE products. The consumers consider their fresh-like appearance, taste and flavour, in addition to their convenience, the most appealing attributes for these products. Microbial spoilage, discoloration or browning, textural changes and development of off-flavour or off-odour are the major factors affecting the shelf-life of the processed fruit products (Van Boxstael et al., 2014).

Food industry needs to ensure the food products safety while maintaining their quality. The loss of compounds responsible for aroma during food processing operations is one of the major drawbacks in food industry (Daelman et al., 2013). Furthermore, the control of microbial contamination and growth in food products is essential to ensure consumers' health and well-being and to minimise loss of food through spoilage (Hussein et al., 2015; Smigic et al., 2016).

Thermal treatment (TT) is the preferred technology to inactivate microorganisms and enzymes that causes spoilage, mainly because is less expensive and more accessible than the other processing treatments. However, several studies on thermally treated fruit products such as guava puree (Yen and Lin, 1996), apples (Yamada et al., 2004), tomato and carrot purees (Patras et al., 2009), melon juice (Chen et al., 2009), fruit smoothies (Keenan et al., 2010) and tamarillo fruit (Mertz et al., 2010) reported loss of nutritional quality, in consequence, reducing the beneficial health effects.

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Nowadays, new technologies that are less disruptive to quality than traditional thermal processing are being explored such as high hydrostatic pressure (HHP). This non-thermal technique destroys the food-borne pathogens, keeping active most of the enzymes while maintaining the sensory quality of the food products (Knorr, 1993; Guo et al., 2015). HHP has been applied for many fruit and vegetable products such as strawberry puree and juice (Cao et al., 2011), pomegranate juice (Varela-Santos et al., 2012), guava puree (Yen and Lin, 1996), fruit purees (De Ancos et al., 2000) and blueberry juices (Barba et al., 2012).

In previous works, the development of a fruit bar using mango puree and gellan gum (Danalache et al., 2015a, 2015b), and the optimization of an edible coating based on gellan gum for the obtained mango bars (Danalache et al., 2016) was carried out. The next stage, which is described in this paper, was focused on evaluating the maximum storage time under refrigeration without significant microbial deterioration or loss of sensory quality of the mango bars. For this purpose, two processing methods were studied envisaging the preservation of the nutritional, sensory freshness characteristics and microbial quality of packaged mango bars.

This study is divided in two sections. In the first section, the effect of processing treatments (TT and HHP) on mango bars microbial stability and release of volatile flavour compounds was evaluated. In the second section, the effect of storage, during 21 days at 5 °C, on untreated and on TT mango bars properties was evaluated.

2. Materials and methods

2.1. Materials

Two types of commercial food grade gellan gum: low-acyl gellan (Kelcogel® F) and high-acyl gellan (Kelcogel® LT) were supplied by CP Kelco Corporation, Wilmington, USA.

Mature mangoes (*M. indica* L. cv. Palmer) were purchased from a local supermarket in Lisbon, Portugal and stored at 5 ± 1 °C until processing (within 24 h). Fruits were selected based on the same ripening stage (soft-ripe - best stage for consuming), uniform size and absence of any physical damage. Only one mango cultivar was selected because chemical composition may vary with the type of cultivar, and consequently, change the properties of the mango bars. Fruits with medium values for total soluble solids of 18.0 ± 0.5 ºBrix and a pH between 3.8 and 4.0 were processed.

Nerol (≥95%), decanal (≥95%), δ-3-carene (≥95%), geraniol (≥98%), ϒ-decalactone (≥99%) were provided by Sigma-Aldrich (Madrid, Spain), ϒ-octalactone (≥96%) from Acros Organics (Geel, Belgium), terpinolene (≥96%) from Fluka (Madrid, Spain) and menthone (≥96%) was purchased from Fluka Chemika (Neu-Ulm, Switzerland). Polydimethylsiloxane Solid Phase Microextraction (SPME) fibres (100 μm) were purchased from Supelco (Madrid, Spain).

2.2. Preparation of the mango bars

The fruit was manually peeled with a knife, cut into small pieces, and pureed in a food blender Vorwerk Thermomix TM-31 at 134 × g for 4 min at 22 ± 2 °C. In order to improve the gellan dispersion into the mango puree avoiding heat burn, the puree sample was transferred into a glass beaker immersed into a hot water bath. The temperature of the water bath was increased up to 90 ± 2 °C to heat the mango puree followed by the addition of gellan powder and stirring at a rotation speed of 1640 × g with a four bladed impeller for 30 s.

Samples with an overall gellan (low acyl/high acyl ratio of 25/75) concentration of 1 %wt were prepared (Danalache et al., 2015a, 2015b). The mango puree/gellan mixtures were then transferred into rectangular silicon moulds, allowed to set at room temperature (22 ± 2 °C), and stored at T = 5 °C for 30 min before the application of the coating. The pH of the mango bars was between 3.8 and 4.0. Water activity was in the range of 0.96–0.98 at 25 °C.

The short time of stirring (30 s) at T = 90 ± 2 °C was chosen in order to promote the dispersion of the gellan powder, as well as enzyme deactivation (polygalacturonase, - responsible for texture softening and polyphenol oxidase for browning), with minimal deterioration of the sensorial properties of the fruit.

The mango bars were removed from the silicone moulds. A thin wood stick was carefully introduced into the mango bars, then, the bars were dipped for 20 s into the 1 %wt/6 mM gellan gum/calcium gluconolactate solution at 88 ± 2 °C. The coated bars were left at room temperature (22 ± 2 °C) for 30 min then stored at 5 °C (Danalache et al., 2016).

2.3. Mango bars packaging

The obtained mango bars were packaged at atmospheric pressure in a multi-layered composite aluminium PET/PE film with the dimensions - 12 cm length x 8 cm width, which was heat sealed (Fig. 1). The composite films combine the advantages of various layers of materials, polyethylene terephthalate (PET) and polyethylene (PE), providing a low oxygen transmission rate and a barrier for moisture loss and light (Haji-Saeid et al., 2007).

Fig. 1. Packaged coated mango bar.