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Conditions for producing long shelf life fruit salads processed using mild pasteurization

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ABSTRACT

The development of a fruit salad using mild processing conditions is demand to fulfill consumers' requirements for convenience, long-lasting and healthy foods ensuring safety but preserving the properties of a fresh product. This work intended to investigate the effect of mild-pasteurization and storage temperature on two distinct fruit salads, with different pH (Orange-based fruit salad pH 4.2 and Pear-based fruit salad pH 3.9), to identify the conditions favorable to develop a long shelf life fruit salad. The fruit salads were pasteurized at mild-temperature (70 or 80 °C) and stored at 4 or 25 °C over a period of 98 days. These pasteurization treatments ensured enzymatic inactivation and food safety. However, fruit combination influences fruit salads stability during storage, being colour the most affected parameter due to non-enzymatic browning reactions. Acidity of the fruit salad is important to inhibit oxidation reactions and extend shelf life, as well as the total soluble solids that seem to diminish oxidation process and loss of ascorbic acid. Thus, using mild-pasteurization it is possible to develop fruit salads with shelf life up 2 months stored at room temperature, reducing costs, by simply controlling fruit combination (*i.e.* type of fruits, acidity and sugar content).

1. Introduction

The fruit market has an increasing need for innovation and adaptation to nowadays consumers demand for convenience, long-lasting and healthy foods (Benlloch-Tinoco, Igual, Salvador, Rodrigo, & Martínez-Navarrete, 2014). Moreover, consumers require minimally processed food to ensure safety preserving the properties of a fresh product. The manufacturing of single-dose fruit salads with long shelf life brings advantages to the food industry, while prolonging the time of a food product at the market, increasing its odds of being sold avoiding its waste disposal after expiration date. The waste is an actual concern since about 40–50% of annual food waste arises from fruit and vegetables sector (FAO, 2014).

Thermal processing has been used as a strategy to extend shelf life of fruit products. Pasteurization is the most conventional thermal process used to guarantee food safety and quality by enzyme oxidative inactivation (*e.g.* polyphenol oxidase and peroxidase) and microbial inhibition (Vegara, Martí, Mena, Saura, & Valero, 2013; Vervoort et al., 2011). Fruit juices are pasteurized at temperatures ranging 72 to 110 °C for 15 s to 2 min (Chaikham, Apichartsrangkoon, & Seesuriyachan, 2014; Elez-Martinez, Soliva-Fortuny, and Martin-Belloso, 2006; Esteve, Frígola, Rodrigo, & Rodrigo, 2005). Canned fruits are normally pasteurized at higher temperatures (93–115 °C) for a long period of time (17–20 min) (Campbell & Padilla-Zakour, 2013; Jiménez, Martínez-Tomé, Egea, Romojaro, & Murcia, 2008). These severe conditions, comparing with fruit juices, ensure that all solids parts of fruit pieces reach the temperature needed to guaranty food safety. However, higher time/temperature pasteurization results in breakdown of the cell structure affecting the texture of fruits (Dobiáš, Voldřich, & Čurda, 2006). Pasteurization also contributes to loss of bioactive compounds (*e.g.* phenolics and vitamins) (Popescu & Iordan, 2012), as well as fruit browning due to the Maillard reaction (Echavarría, Pagán, & Ibarz, 2014). Colour is one of the most important properties in food and beverages since it is the first characteristic evaluated by the consumers (Vegara et al., 2013). Along storage

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several deterioration reactions happen contributing to the loss of quality namely Maillard reaction and Strecker degradation (Esteve & Frígola, 2007) resulting in development of off-flavour and change of sensorial properties (colour and texture). The presence of furfural and 5-hydroxymethylfurfural (HMF) in stored fruit products is an indicator of their quality loss. Depending on fruit product processing, storage temperatures are variable, for example, minimally processed fresh-cut fruits (Lemamy, Lebrun, Omouessi, Ndeboko, & Mouecoucou, 2014) and smoothies (Andrés, Villanueva, & Tenorio, 2016) are normally stored at 4 °C, while canned peaches and apricot can be stored at room temperature (20 °C) (Jiménez et al., 2008).

To the best of our knowledge, literature only reports studies on minimally processed fresh-cut fruits with short shelf life (≤6 days) regarding their biochemical and physicochemical properties (Lemamy et al., 2014; Martins, Ramos, Martins, Oliveira, & Stringheta, 2015), as well as studies on fruit salads acceptability by consumers (Cardoso, Pinheiro, Perez, Patelli, & Faria, 2010; Manzocco, Rumignani, & Lagazio, 2013). This work intends to propose the pasteurization of fruit salads at a temperature relatively lower than the typically used for pasteurization of juices and canned fruits, but applied for a longer period of time than usually used. The objective is the extension of the shelf life comparing to minimally processed fruits (6 days), while avoiding colour and texture changes resulting from high pasteurization temperatures. Moreover, this work evaluates the effect of the storage temperature on the shelf life of the fruit salads treated under the proposed pasteurization conditions. The stability of the fruit salads with distinct fruit combinations, pasteurized at 70 or 80 °C was studied over 98 days. Titratable acidity, pH and total soluble solid, as well as ascorbic acid, total phenolic content and antioxidant capacity were evaluated. The sensorial properties (colour, taste, texture and aroma) and food safety (aerobic microorganism and yeast and moulds) of the salads were also evaluated. This study will allow proposing strategies to extend the shelf life of pasteurized fruit salads maintaining their freshness characteristics.

2. Material and methods

2.1. Fruit salads preparation

The fruit salad samples were prepared and thermally treated at Nutrigreen, S.A, in Portugal. Two fruit salads were prepared, Pear-based Fruit Salad (PbFS) and Orange-based Fruit Salad (ObFS). The PbFS salad had the following constitution: apple, melon, mango, and grape slices (15 g fresh weight of each fruit) and ready-made (not filtered) pear juice (40 g). The ObFS salad was compose by pieces of kiwi, orange, pineapple, and mango (15 g fresh weight of each fruit) and ready-made (not filtered) orange juice (40 g). The utensils used to cut the fruits were disinfected with sodium hypochlorite (NaClO) (0.05 g/L) and the fruits were also submitted to a sodium hypochlorite (0.05 g/L) bath before peeling. After disinfection, the utensils and fruits were submitted to a water bath (periodically changed) to remove sodium hypochlorite. The fruits were peeled and cut in cubes manually with approximately 0.5 cm of edge length. The pieces of fruits were dipped into a 50 g/L calcium ascorbate solution over 2 min to avoid oxidation and consequent browning during fruit salads preparation. The fruit salads with a total weight of 100 g (60 g of fruit pieces - 15 g of each fruit - and 40 g of fruit juice) were packed in a container (EnvaHot61, EDV packaging) (Barcelona, Spain), previously disinfected with ethanol 700 mL/L. For containers, it was used ethanol instead of sodium hypochlorite for disinfection purposes due to their faster evaporation before filling the containers with fruit salads. The container was sealed with a film composed by a combination of biaxially oriented polyester with a coextruded barrier film of polyamide/EVOH/polypropylene (ILPRA Foodpack Speedy 2006) (Vegevano, Italy). After packaging, the fruit salads were pasteurized at 70 or 80 °C during 15 min using a pasteurizer (ILPRA thermosaldatrici, model AU650/1800) (Vegevano, Italy) and then stored over 98 days at 4 or 25 °C. All fruit salads (*ca.* 205 samples for each fruit salad (NFS or TFS)) were prepared at the same day. For each fruit salad, five fruit salads were not pasteurized, 100 samples were pasteurized at 70 °C and 100 samples were pasteurized at 80 °C. Then, 50 samples from each pasteurization temperature were stored at 4 °C and the other 50 samples were stored at 25 °C. For each analysis time, five fruit salads were used: two for microbial assessment, pH, acidity, and total soluble solids; one for sensorial analysis; and one for colour measurement, antioxidant capacity, ascorbic acid, and total phenolics content.

2.2. Microbiological assessments

The microbiological analyses were performed in the fruits processing company (Nutrigreen S.A.) as described by Abadias, Usall, Anguera, Solsona, and Viñas (2008) with some modifications. The assessments of aerobic microorganisms and yeasts and moulds in the processed fruit salads samples were carried out using plate count agar (PCA) and yeast extract dextrose chloramphenicol agar (YGC), respectively. The microbial assessments were made just after the thermal treatment at 70 or 80 °C and each 14 days, using two distinct fruit salads, each one assessed in duplicate, over the 98 days of storage at both storage temperatures (4 and 25 °C). The total content (100 g) of fruit salad was transferred to an aseptic bag and the pieces of fruits were smashed to obtain a homogenous mixture. Then, the mixture (1 mL) was spread on a petri plate with the appropriate medium. Appropriate dilutions with peptone water were performed when microbial counts exceeded the possible visual counts in Petri dish. All this process was carried out under a laminar flow chamber. The microbial counts were made after the incubation time of 72 h at 25 °C.

2.3. Peroxidase activity

Peroxidase was extracted following the procedures described by Chaikham et al. (2014). Thus, 20 mL of fruit salad was used to extract the enzyme with a mixture of sodium hydrogen phosphate buffer (50 mL, 0.05 mol/L, pH 6.2) and 0.1 mol/L sodium chloride. All solutions were stirred for 30 min and then centrifuged (Sigma, 3k30 model) (Shrewsbury, United Kingdom) at 2200*g* and 4 °C for 30 min.

Peroxidase (POD, EC 1.11.1.7) activity was measured spectrophotometrically as described by Cardoso, Mafra, Reis, Nunes, Saraiva, & Coimbra (2010). An aliquot (100 μL) of enzymatic extract properly diluted was added to 1.45 mL of substrate solution (0.1 mol/L sodium phosphate buffer, pH 6.5, containing 0.083 mol/L of phenol, 1.15 mmol/L of 4-aminoantipyrine and 0.95 mmol/L of H_2O_2), previously equilibrated at 25 °C. The increase in optical density at 510 nm was recorded every 5 min, during 30 min, and after 24 h using the following equation:

$$\%\ inativation = \frac{\Delta AbsNP - \Delta AbsT0}{\Delta AbsNP} \times 100$$

where AbsNP and AbsT0 are the absorbance differences observed at 24 h for the fresh fruit salad (NP) and the pasteurized fruit salad (T0), respectively. The results were expressed in absorbance *per* hour.