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Impact of canning and storage on apricot carotenoids and polyphenols

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ABSTRACT

Apricot polyphenols and carotenoids were monitored after industrial and domestic cooking, and after 2 months of storage for industrial processing.

The main apricot polyphenols were flavan-3-ols, flavan-3-ol monomers and oligomers, with an average degree of polymerization between 4.7 and 10.7 and caffeoylquinic acids. Flavonols and anthocyanins were minor phenolic compounds. Upon processing procyanidins were retained in apricot tissue. Hydroxycinnamic acids, flavan-3-ol monomers, flavonols and anthocyanins leached in the syrup. Flavonol concentrations on per-can basis were significantly increased after processing. Industrial processing effects were higher than domestic cooking probably due to higher temperature and longer duration. After 2 months of storage, among polyphenols only hydroxycinnamic acids, flavan-3-ol monomers and anthocyanins were reduced.

Whichever the processing method, no significant reductions of total carotenoids were observed after processing. The *cis*-β-carotene isomer was significantly increased after processing but with a lower extent in domestic cooking. Significant decreased in total carotenoid compounds occurred during storage.

1. Introduction

Apricot (*Prunus armeniaca* L.) is a fruit of high economic and nutritional relevance. Apricots are a rich source of phenolics and carotenoids that may contribute to reduced risks of several degenerative diseases, such as cancer, cardiovascular diseases, caused by oxidative stress (Terry et al., 2001).

Because of its climacteric characteristic, apricots present a challenge in postharvest storage as they have a very short storage life due to high respiration rate and rapid ripening process linked to ethylene behavior after picking (Gouble et al., 2006). In order to extend their consumption and because of their short seasonal availability, apricots are commonly preserved and consumed after thermal processing methods including canning (halves in syrup for example) and pureeing.

Heat treatments are known to induce significant changes in chemical composition of foods, affecting the bioaccessibility and contents of compounds such as vitamins, carotenoids and polyphenols. Thermal processing of peaches results in a loss of 21% of total procyanidins (Hong, Barrett, & Mitchell, 2004) and some of these losses could be attributed to a leaching into the syrup of the low molecular-weight procyanidins. Cooking of pears results also in a preferential retention of the larger procyanidins in the pear sections whereas procyanidins of low degree of polymerisation and caffeoylquinic acid leach into the cooking water (Renard, 2005). The same mechanism has been observed in apple puree (Le Bourvellec et al., 2011). For cherry products, there is little loss of total phenolics with canning, but approximatively 50% of total phenolics are redistributed to the syrup (Chaovanalikit & Wrolstrad, 2004a). These results contrast with those of Brownmiller, Howard, and Prior (2009) who report that after canning berries 65% of the total procyanidins are retained. The thermal degradative processes depend also on phytomicronutrient structures. Hydroxycinnamic acids and (−)-epicatechin are more labile than flavonol glycosides during processing of cherry (Chaovanalikit & Wrolstrad, 2004b). Pasteurization of peach significantly reduces the carotenoid concentrations. Concentration of zeaxanthin and β-cryptoxanthin are reduced whereas levels of lutein and β-carotene are unaffected by the heat treatment (Oliveira, Pintado, & Almeida, 2012). Furthermore, thermal processing also induces a change in isomeric composition of canned tomato, due to the trans to cis isomerization (Lessin, Catigani, & Schwartz, 1997). Lessin et al. (1997) also found an increase in total β-carotene, α-carotene and β-cryptoxanthin following canning of carrots, collard greens, spinach and sweet potatoes, but losses in peaches and tomatoes. Overall, the discrepancy observed between the different food matrices might be attributable to the great variability of the shape of the food matrices (Bureau et al., 2015). Canning may improve extractability of carotenoids from cellular matrix, therefore resulting in higher levels in thermally processed products. However, excess

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heat may also lead to degradation.

Storage may also affect retention of phytomicronutrients. Oliveira et al. (2012) report a reduction of total phenolic in canned peach during the initial 18 days of storage, followed by a plateau. However, the authors did not assay the syrup in this study. Decreases of procyanidin concentration has been reported during storage of canned peaches, however theses losses are due to the migration from fruit matrix to syrup (Hong et al., 2004). Anthocyanin degradation occurs in canned cherries and their syrup stored for 5 months at room temperature (Chaovanalikit & Wrolstrad, 2004a, 2004b), and cyanidin-3-O-rutinoside and pelargonidin-3-O-rutinoside undergo partial hydrolysis during storage (Chaovanalikit & Wrolstrad, 2004b). Oliveira et al. (2012) show that changes in carotenoids occur during storage of peach with increased levels of zeaxanthin and reduction, by decreasing order, of β-cryptoxanthin > β-carotene > lutein. Campbell and Padilla-Zakour (2013) also reported that β-cryptoxanthin and β-carotene decrease over the storage period (in canned apricots and peaches) while lutein (in peaches) and zeaxanthin (in both fruits) are lost. Based on HPLC data apricot phenolic and carotenoid compounds are more stable under storage than those of peaches (Campbell & Padilla-Zakour, 2013). However, tomato paste β-carotene and lycopene remained constant through 12 months of storage (Koh, Charoenprasert, & Mitchell, 2011). The contents of carotenoid and phenolic compounds during food processing depend on the chemical structure of the phytomicronutrients, on the fruit matrix, on the intensity of the heat treatment and also on storage.

With the increased recognition of the role of plant-based phenolics and carotenoids in human health and nutrition, it is increasingly important to understand how various processing conditions and storage impact these phytomicronutrients. Nevertheless, information is lacking on how different thermal processing methods and storage of processed products influence the apricot qualities. This study evaluated changes in sugar, acid, polyphenol and carotenoid compositions and contents in response to thermal processing (industrial processing and domestic cooking, halves in syrup) and storage of canned apricots.

2. Material and methods

2.1. Chemical

Acetonitrile of HPLC grade and acetic acid were from Fischer Scientific (Pittsburgh, PA, USA). *Tert*-Butyl methyl ether (MTBE) of HPLC grade was from Merck (Darmstadt, Germany). Methanol of HPLC grade was from VWR international (Fontenay-sous-bois, France). 5-O-caffeoylquinic acid, (+)-catechin, (−)-epicatechin, sucrose, glucose, fructose, citric acid, β-carotene, β-apo8′-carotenal, and toluene-α-thiol were from Sigma Aldrich (Darmstadt, Germany). Quercetin, cyanidin-3-O-galactoside, and 3-O-caffeoylquinic acid were obtained from Extrasynthèse (Lyon, France). Malic acid was obtained from R-Biopharm AG (Darmstadt, Germany). Phytoene was obtained from CaroteNature (Lupsingen, Switzerland).

2.2. Plant material and sample preparation

Four apricot cultivars were collected in June 2015 in INRA experimental orchards, Gotheron at St Marcel-les-Valence (Drôme, France) and Amarine at Bellegarde (Gard, France) and in SERFEL (Station d'Expérimentation Régionale pour les Fruits et Légumes) orchard at Saint Gilles (Gard, France): 'Orangered® Bhart', 'Iranien', 'Goldrich' and 'Hargrand'. These various orchards, located in different regions, allowed to have all 4 cultivars at the same two dates (23 and 25/06), imposed by canning schedule. These cultivars presented different colors: 'Orangered® Bhart', a dark orange apricot with red blush, 'Iranien' a green-white cultivar with a little red blush on sunny fruits, 'Goldrich' a dark orange one without blush and 'Hargrand' a pale orange apricot without blush. They were chosen according to their texture evolutions after processing (Ribas-Agusti et al., 2017). For each cultivar, about 250 fruits were harvested at a commercial maturity stage. Firmness of entire fruits was assessed by compression test (see section physical characterization) in order to obtain samples of homogeneous representative texture hence maturity level for each cultivar and between cultivars. So, for each cultivar, 86 fruits were sorted and divided in three batches: the first batch of 24 fruits was used for analysis of fresh apricots, the second batch of 20 fruits was used for domestic cooking, and the third batch of 42 fruits was used for canning. For each process, part of the fruits was for biochemical analysis and the other part for texture analysis.

2.3. Fresh fruit

For biochemical analysis, three replicates of four fruits each were constituted randomly. In each replicate, fruits were cut into small pieces and immediately frozen using liquid nitrogen. Apricots were then divided in two bags, A and B. Bags A were freeze-dried, stored at −20 °C, and used for phenolic characterization. Bags B were stored at −80 °C and used for infrared, total soluble solids (TSS), titratable acidity (TA), carotenoids, sugars and organic acids.

2.4. Canning treatment

Canning was carried out by the Centre Technique de la Conservation des Produits Agricoles (CTCPA, Avignon, France). The fruits were cleaned, manually cut through the middle and pitted. Six apricot halves were put into each can (425 mL), to which hot syrup (70 °C) was added (16° Brix, sucrose). The fruit proportion in the final product varied from 42% ('Iranien') to 67% ('Hargrand'). Cans were sealed and then heated at 95 °C. The temperature of the syrup in the can was monitored by placing thermocouples into two cans, it reached 95 °C after 14 min. and remained at this temperature for 2 min thereafter. Finally cans were sprayed with cold water to reach 30 °C.

For each cultivar, 14 cans of 6 halves each were obtained and distributed as follows:

- 3 cans for biochemical analysis one day after canning;
- 4 cans for texture analysis one day after canning;
- 3 cans for biochemical analysis after 60 days storage at room temperature (22 °C);
- 4 cans for texture analysis after 60 days storage at room temperature (22 °C).

For biochemical analysis, syrup and fruits, of each can, were separated and weighted. Fruits were analyzed as described for fresh ones. Syrup was homogenized and 50 mL were frozen and stored at −20 °C until freeze-drying and polyphenol analysis.

2.5. Domestic cooking

The 20 fruits were cut through the middle and pitted. Apricot halves (40) were plunged in cane sugar syrup (16° Brix, 900 mL) at 70 °C and cooked for about 20 min, until a final temperature of 85 °C was reached inside the apricot halves as monitored with a Fluke 51 K/J thermometer (John Fluke, Everett, Washington, USA). Then apricot halves were immediately drained and cooled on ice bed. The fruit proportion in the containers varied from 22% ('Iranien') to 29% ('Hargrand').

After cooking, syrup and fruits were separated, 18 halves, distributed in three samples of six halves, were used for biochemical characterization. Syrup and fruits were weighted. Syrup was homogenized and 50 mL were frozen and stored at −20 °C until freeze-drying and polyphenol analysis.