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Impact of cooking on apricot texture as a function of cultivar and maturity

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ABSTRACT

The rapid loss of fruit firmness is a qualitative decisive factor for characterizing apricot (*Prunus armeniaca* L.) use (fresh or processed) and commercialization pathways (short or storage). To better understand the texture variability in apricot, we studied the impact of a heat treatment as a function of fruit harvest stage on a large range of cultivars. Eighteen apricot cultivars were characterized at two maturity stages before and after cooking (85 °C in light syrup). A compression test allowed sorting the fruits to obtain homogeneous batches. Kramer shear tests provided global firmness of cooked fruits and puncture tests were performed on the median equatorial area of apricot flesh for fresh and cooked fruits. Among the registered variables, the apricot texture expressed by the "Work to limit" integrates the global evolution and allows a good discrimination of the ripening effect. The texture data was used to classify the varieties according to their firmness and suitability for industrial processing. Thus Vertige, Candide and Gaterie, followed by Orangered and Bergarouge, have been found as the most suitable cultivars for industrial processes.

1. Introduction

Apricot (*Prunus armeniaca* L.) is a fleshy fruit of economic and nutritional interest. With a world production of 4.04 million tons in 2012 (FAOSTAT, 2013), it is the third most widely grown stone fruit, after peach and plum. The fruit is consumed fresh or processed in dried, canned apricot, jam, marmalade, pulp, juice, etc. However, the commercialization and the marketing of apricots are difficult because of their rapid softening and the associated susceptibility to physical damage and disease (DeMartino, Massantini, Botondi, & Mencarelli, 2002; Kovacs, Meresz, Kristof, & Németh-Szerdahel, 2008; Ella Missang, Maingonnat, Renard, & Audergon, 2011).

Firmness and texture are important quality attributes for apricot fruit; they influence consumer acceptability, postharvest manipulation, storage shelf-life, microbial susceptibility and suitability for processing into different products. Commonly, apricot fruits are harvested firm (thus early) to limit damage during handling and shipping. However at this stage, the other quality attributes such as appearance, taste, aroma and nutritional value are not sufficiently developed (Botondi, Crisà, Massantini, & Mencarelli, 2000; Bruhn et al., 1991). In addition, apricots appear to be particularly sensitive to softening during cooking which is a limiting factor in processing technology, marketing and use of apricots and their products. During preparation of halved apricots, safety requires that the fruit reach at least 85 °C at heart. Only little information is available on texture of canned apricot fruit (Chitarra, Labavitch, & Kader, 1989; Ella Missang et al., 2011; Mallidis & Katsaboxakis, 2002). Some varieties have poor resistance to heat, which causes disintegration of the fruit (Ella Missang et al., 2011). Apricot is also characterized by high heterogeneity in its tissue structure, with five layers: an epidermis, a hypodermal layer, a middle layer of thin walled parenchyma cells, a layer of radially elongated cells and a layer of small cells adjacent to the pit (Archibald & Melton, 1987). These five layers have different responses during thermal treatment (Ella Missang et al., 2011) with the median equatorial area

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appearing the most representative for texture characterization in the fruit.

Our aim was to identify apricot cultivars suitable for processing to canned halves, by characterizing texture alteration after processing. The impact of the harvest stage and the effect of heat treatment (85 °C) have been characterized on the median equatorial area of the fruits of 18 representative apricot cultivars.

2. Materials and methods

2.1. Plant materials

Apricot fruits were harvested in 2015 in INRA orchards at Amarine (Gard, France) and Gotheron (Drôme, France). The 18 apricot cultivars selected were: A4034, A5350, Bergarouge® Avirine, Bergeron, Candide, Congat, Elgat, Frisson, Gaterie, Goldrich, Helena du Roussillon® Aviera, Hargrand, Moniqui, Orangered® Bhart, Polonais, Ravilong (A3759), Tardif de Bordaneil and Vertige. About 160 fruits from each cultivar were harvested slightly after the conventional date and brought to the laboratory within 2–3 h for sorting in maturity classes by compression (§ 2.3.1). Maturity stages were defined as: M1 = 130 kPa ± 5 kPa (commercial) and M2 = 100 kPa ± 5 kPa (half-ripe). One batch of 32 fruits for each stage was sorted for each cultivar, each batch being subdivided into 12 fruits for test on fresh fruits and 20 fruits for test after cooking.

2.2. Preparation of cooked apricots

The heat treatment was performed in light syrup, based on sucrose commercial sugar cane syrup diluted to 16 °B. Fruit halves (one half per fruit) were dropped into the syrup at 70 °C and cooked until 85 °C at heart (the temperature were controlled using a thermocouple and the time needed was about 20 min). After cooking, fruits were cooled to room temperature on iced water.

2.3. Texture analysis

2.3.1. Sorting of whole fruit in firmness classes

Whole fruit firmness was measured with a compression test that gives a combination of skin resistance and flesh firmness (Grotte, Duprat, Loonis, & Pietri, 2001). The measurement consists in determining the pressure (Pa) required to compress whole apricots by 3% of their equatorial height with a texturometer (Penelaup, Serisud, Nimes, France) equipped with flat disc (5 cm diameter) (probe speed = 100 mm/min).

2.3.2. Puncture tests

Puncture tests were realized on 12 fresh and 10 cooked halves. For each, a tissue slice of about 1.5 cm thick was cut longitudinally. The median equatorial area (Fig. S1) was retained according to Ella Missang et al. (2011) and Ella Missang, Maingonnat, Renard, and Audergon (2012).

The puncture was made using a multi-purpose texturometer (Tplus, Ametek, Lloyd, Fareham, UK) equipped with a 50 N load cell (flat cylindrical probe, 2 mm diameter, 100 mm/min penetration rate, 9 mm depth). Different parameters were registered from the force/displacement curves: Maximum Load (F_{max}, N), Deflection at Maximum Load ($DefF_{max}$, mm), Work to Maximum Load (W_{max}, J), Load at Limit (F_{lim}, N), Work to Limit (W_{lim}, J) and Load average for the plateau (F_p, N); this last variable was calculated only for fresh fruit (Fig. S2a).

2.3.3. Kramer shear test

Kramer shear test was performed using the same multi-purpose texturometer but equipped with a 1000 N load cell. Ten cooked apricots halves were cut longitudinally and divided into three batches corresponding to three replicates. About 120–130 g of cooked fruit slices was placed perpendicular in the Kramer (K) cell and sheared at 20 cm/min speed. Registered parameters (Fig. S2b) expressed for 100 g of cooked fruit are: Maximum Load ($F_{max}rK$, N), Work to Maximum Load ($WF_{max}rK$, J) and Work to Limit ($WF_{lim}rK$, J).

2.4. Statistical analysis

Standard deviations of the means were calculated for each series of duplicates using the sum of individual variances pondered by the individual degrees of freedom (Box, Hunter, & Hunter, 1978). Statistical analysis was performed using IBM SPSS Statistics 19 software. ANOVA and cluster analysis were carried out for the 18 apricot cultivars on all measured parameters. For each variety and maturity stage, data set corresponds to replications on 12 fresh fruits, 10 cooked fruits and 3 fruit batches.

3. Results and discussion

3.1. Impact of processing on texture profile

The puncture test allowed acquiring two types of profiles (Fig. 1), one for fresh fruits and the other for cooked fruits. These typical force/displacement profiles are frequently found in other fruit and vegetables such as apple (Costa, 2016), carrot and jicama (Nguyen et al., 2010).

Fresh fruit firmness is characterized in a first stage by a slope related to the elasticity of apricot flesh, needing a higher force for initial penetration. After cooking, the same pattern is observed with a lower slope value and a larger displacement. At the end of that phase the maximum load is registered for both fresh and cooked tissues, for most of the cultivars. In fresh apricots, F_{max} values range between 1 N and 4.5 N after 1.5 mm–2 mm of penetration. In cooked fruits, F_{max} values are lower and range between 0.2 and 0.8 N after 4–5 mm of penetration (Fig. 1).

After F_{max}, the second part of the curve is characterized by a periodic pattern, which could be linked to the presence of conductive vessels in the flesh. For cooked apricots, the shape of the curve seemed close to that of the fresh fruits but more attenuated.

The correlation analysis (Table 1) between registered parameters on all fresh cultivars at M1 stage highlights the relationships

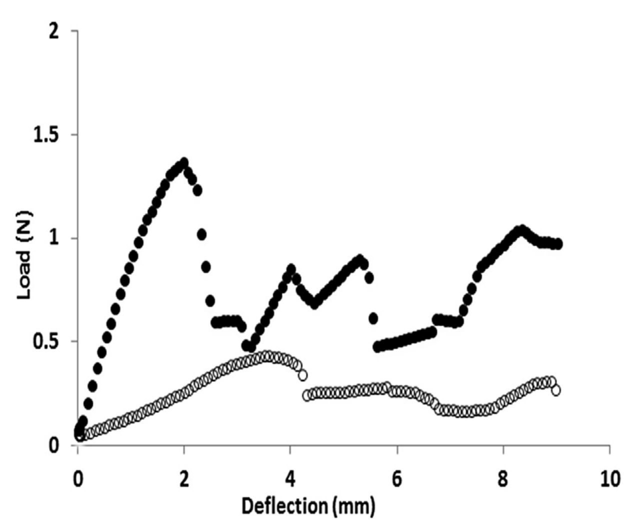

Fig. 1. Typical puncture curves on the median equatorial area for fresh (●) and cooked (○) apricot: example of Orangered® Barth (cov) at half ripe maturity (M2).