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Lactic acid fermentation drives the optimal volatile flavor-aroma profile of pomegranate juice

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ABSTRACT

Pomegranate juice (PJ) fermented with *Lactobacillus plantarum* C2, POM1, and LP09, unstarted-PJ, and raw-PJ were characterized for the profile of the volatile components (VOC) by PT–GC–MS. Lactic acid fermentation through selected strains enhanced the flavor profile of PJ. Concentrations of desired compounds (e.g., alcohols, ketones, and terpenes) were positively affected, whereas those of non-desired aldehydes decreased. Unstarted-PJ mainly differentiated from fermented PJs for the highest levels of aldehydes and sulfur compounds, and in lesser extent of furans, whereas alcohols, ketones, and alkenes followed by terpenes and benzene derivatives mainly differentiated fermented PJs. As expected, the lowest level of VOC was found in raw-PJ. VOC profile reflected on the sensory features of fermented PJs, unstarted-PJ, and raw-PJ, which were evaluated using a consensus modified flavor profile based on 13 attributes. Fermented PJs were mainly discriminated by the higher intensity of floral, fruity and anise notes than the controls.

1. Introduction

Pomegranate (*Punica granatum* L.), a phytonutrient-rich fruit native to the Caucasian area, falls into the super-fruits category. This category has become a mainstream within the juice and functional beverages since they are an easy mechanism by which to deliver nutritional benefit (e.g., vitamins, fatty acids, and minerals) and antioxidants (e.g., phenolics) into the human diet (Gumienna et al., 2016). During the last decade, pomegranate fruit has gained worldwide interest among food scientists and functional foods industries as highlighted by the growing number of published items (up to 3800) retrieved from the main literature databases. Among processed pomegranate-based products, juices are considered those that have the highest market value (Rymon, 2011). Fruit juices are normally processed to increase their shelf-life and facilitate distribution before consumption. Pasteurization is quite efficient in preventing microbial spoilage of many types of beverages, but this is in conflict with the current interest toward the consumption of fresh-like minimal processed beverages with unchanged natural nutritional and sensory features (Mena et al., 2013). In fact, the applied heat may cause undesirable biochemical and nutritional changes (Vegara et al., 2013). Alternative mild processing methods have been explored (Guo et al., 2014). One of the most attractive biotechnological options is the lactic acid-fermented pomegranate juice (PJ) (Filannino et al., 2013). Lactic acid fermentation of vegetables and fruits, currently used as the bio-preservation method for the manufacture of finished and half-finished foods, is an important biotechnology for maintaining and/or improving safety, nutritional, sensory and shelf-life properties of

Table 1
Lists and descriptions of attributes used in the sensory descriptive analysis of pomegranate juices (Andreu-Sevilla et al., 2013; Koppel and Chambers, 2010).

Attribute	Description
Anise	Sweet, refreshing and spicy aromatics associated with anise
Astringent	The dry puckering mouthfeel associated with an alum solution
Berry	Sweet, slightly sour, and sometimes dark aromatics associated with ripe berries, such as raspberries
Fermented	Pungent, sweet, slightly sour, and sometimes yeasty/alcohol like aromatic characteristics of fermented fruits
Floral	Sweet, light, and slightly perfume impression associated with flowers
Fruity	A general term used to describe the sweet, floral, and fruity aromatics associated with a blend of fruits
Grape	The sweet, brown, fruity, and musty aromatics commonly associated with grapes
Pungent	A sharp, even irritating physically penetrating sensation in the nasal cavity
Sour	The fundamental taste factor associated with a citric acid solution
Sweet	The fundamental taste factor associated with a sucrose solution
Vinegar	Sour, astringent, and slightly pungent aromatics associated with vinegar
Wine-like	Dark-fruity alcohol-like aromatics associated with red grape wine
Molasses	The sweet, caramelized aromatic reminiscent of molasses

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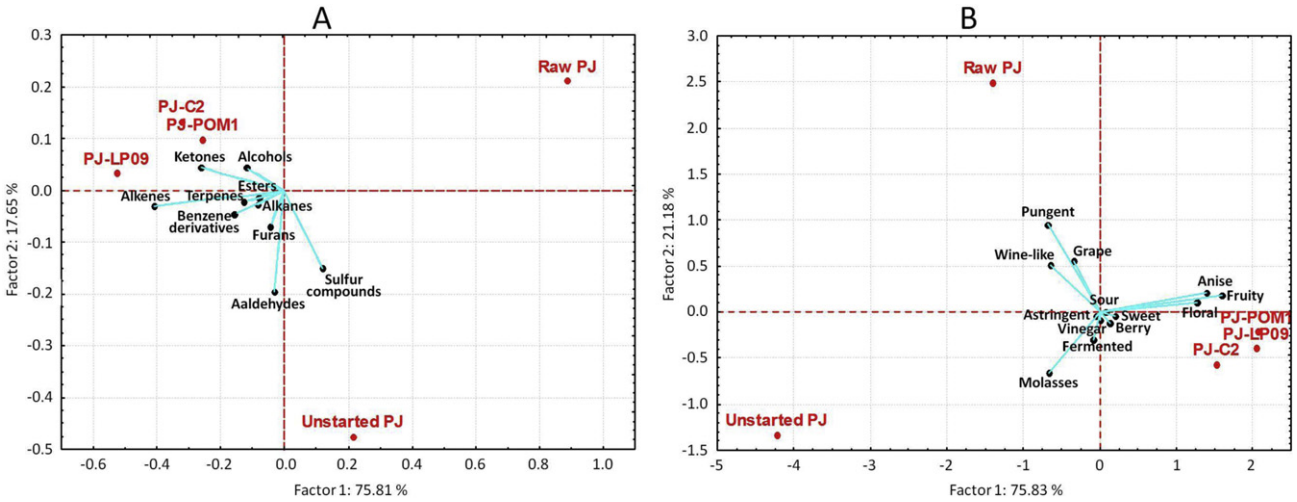

Fig. 1. Principal component analysis (PCA) biplot, based on volatile components concentration (Log arbitrary units of area) (A) and sensory analysis data (B) of pomegranate juice (PJ) fermented at 30 °C for 120 h by *Lactobacillus plantarum* POM1 (PJ-POM1), *L. plantarum* C2 (PJ-C2) or *L. plantarum* LP09 (PJ-LP09). PJ not added of starters and incubated at 30 °C for 120 h (unstarted-PJ), and raw PJ (raw-PJ) were used as the controls.

vegetables (Di Cagno et al., 2013). Composition and concentration of volatile flavor-aroma compounds of fruit juices have been of great interest because of their important influence on sensory properties and consumer acceptance (Beaulieu et al., 2015). Up to 75 volatiles belonging to various chemical classes have been detected in PJs (Beaulieu and Stein-Chisholm, 2016). Overall, fresh pomegranate fruit has low aromatic intensity, and the change in volatiles occurring during juice processing leads to commercial juices very far from fresh fruits, thus negatively

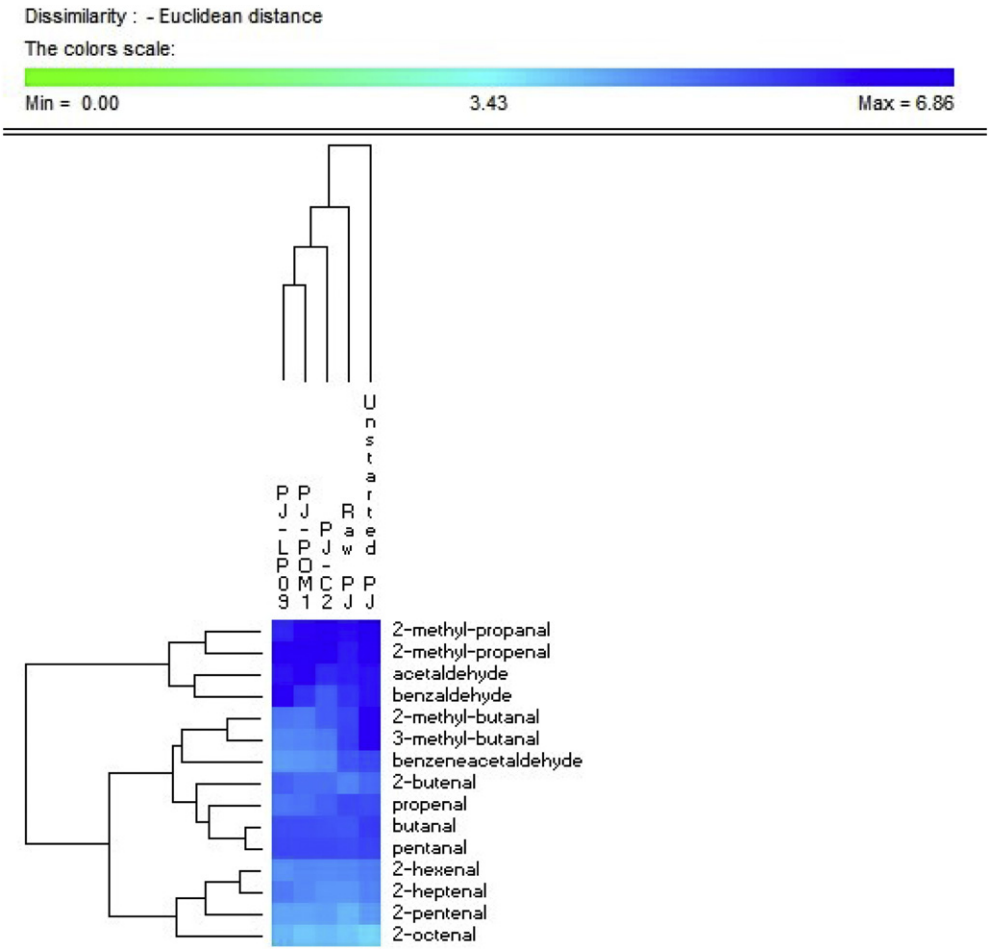

Fig. 2. Aldehydes (Log arbitrary units of area) identified in pomegranate juice (PJ) fermented at 30 °C for 120 h by *Lactobacillus plantarum* POM1 (PJ-POM1), *L. plantarum* C2 (PJ-C2) or *L. plantarum* LP09 (PJ-LP09). PJ not added of starters and incubated at 30 °C for 120 h (unstarted-PJ), and raw PJ (raw-PJ) were used as the controls.