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Textural properties of different melon (*Cucumis melo* L.) fruit types: Sensory and physical-chemical evaluation

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ABSTRACT

Melon fruit properties are extremely different within the species and texture is one of the quality features that most influences its acceptance. The aim of this study was the comparison of melon textural traits, evaluating the linear correlations between both perceived and instrumentally determined texture of a distinctive group of genotypes representing wide species variability. Three landrace cultivars (the Korean 'Songwhan charmi PI-161375', the Indian 'Calcuta PI-124112', and the Iraqi 'Irak C-1012') and three elite cultivars (the Spanish 'Piel de Sapo T111', the French 'Védrantais', and the American 'Dulce'), grown under the same conditions in the same place, were analyzed, together with four Spanish major commercial varieties ('Piel de Sapo', 'Amarillo', 'Galia' and 'Cantaloupe'). Measurements of pH, Soluble Solids Content (SSC), weight losses, puncture tests (6 mm and 10 mm probes), texture profile analysis (TPA), and sensory analysis were performed in 38 fruits. Results showed wide parameter range depending on each particular type of melon. Significant differences were reported for five of six sensory descriptors: hardness (1.52–4.91), initial juiciness (1.77–7.45), crunchiness (0.29–4.58), mealiness (0.41–6.37) and chewiness (2.91–5.27); and for seven of nine physical-chemical parameters: hardness (921.3–4519.0), fracturability (587.4–4280.7), cohesiveness (0.027– 0.061), adhesiveness (−15.7 to −105.0), pH (5.21–6.53), SSC (4.8–14.0) and weight losses (18.0–66.0). Puncture tests parameters were good predictors of sensory hardness, crunchiness and chewiness, while TPA gave further information about initial juiciness, fibrousness and mealiness. Discriminant analysis showed that initial juiciness and mealiness were the most discriminant variables while any instrumental parameter showed particular discriminate ability between samples. These results prove the usefulness of sensory analysis to reflect melon textural traits, when compared to single physical-chemical approach, and could be extended to the middle-late stages of variety development breeding programs.

1. Introduction

Melon (*Cucumis melo* L.) is a diploid species with extensive phenotypic and genetic variation whose fruits have been divided into several different groups according to numerous intraspecific classifications. One of these classifications defines 16 groups, five assigned to subspecies *agrestis* and eleven to subspecies *melo* (Pitrat et al., 2000; Pitrat, 2008; Burger et al., 2009). It includes *inodorus* Spanish varieties with sweet white-flesh like 'Piel de Sapo' or 'Amarillo' melons; odor and flavor intense *cantalupensis* fruits, with green to orange-salmon flesh, like 'Cantaloupe', 'Védrantais', 'Dulce' and 'Galia'; but also landraces, genetically distant from commercial melon, with exotic fruits like the Korean 'Songwhan charmi' of the *conomon* cultivar; Indian *momordica* cultivar fruits like 'Calcuta' with soft, little sweet and cream to orange flesh color; and *dudaim* cultivar fruits with smooth skin and aromatic flesh, like 'Irak'.

Melon is a commercially important horticultural crop throughout the world. Spain is the 7th largest melon producer (FAO, 2013) and the leading exporter worldwide (FAO, 2012). Melon is the 4th most consumed fruit in Spain (after orange, banana and apple) and in 2014 the consumption value was 387,914.38 kg that represented 340,499.01 € (Magrama, 2014).

Originally, the popularity of melon was due to its refreshing and tasty flesh and pleasant aroma. It was consumed mainly in the summer period as an appetizer, in cold soups or salads, and as a dessert. Increasing interest in melon consumption is associated

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with its potential human health benefits, in particular high antioxidant, and anti-inflammatory properties (Vouldoukis et al., 2004; Ismail et al., 2010), anti-diabetic benefits (Jayasooriya et al., 2000; Kenny et al., 2013), anti-ulcerogenic activity (Yesilada et al., 1999) antibacterial properties (Khan and Omoloso, 1998), and its use in folk medicine in various cultures (Subratty et al., 2005; Semiz and Sen 2007; Wu and Ng, 2008; Mahomoodally 2013).

Food quality is a multidimensional concept defined as a set of safety, nutritional and organoleptic characteristics of a product (Ismail et al., 2001). Fruit quality is a consequence of many biochemical processes that result in changes of its intrinsic properties such as color, texture, flavor and aroma, together with the exterior appearance (size, color and shape) and nutritional value. These properties exert a strong influence on producing commercially acceptable melons, and happen to be remarkably different depending on each particular melon cultivar, due to its morphological variability (Obando et al., 2008).

Texture represents one of the principal factors defining fruit quality (Bourne 2002) and in melon, as in fruits like tomato (Saladié et al., 2007), strawberry (Gunness et al., 2009), apple (Costa et al., 2011), blueberry (Giongo et al., 2013) or dates (Singh et al., 2013), textural characteristics are related to the cell walls' structure and their degradation during the ripening phase. To the consumer, there are two factors that most influence the mouth feel of a fruit or vegetable: hardness and juiciness (Toivonen and Brummell, 2008). Hardness is a decisive attribute for consumer acceptance (Hoehn et al., 2003; Harker et al., 2008), as hardness loss is perceived to be associated with quality loss. It is also a primary quality selection trait used by melon producers to enhance fruit shelf-life during transport and sale.

Texture definition is a sensory consideration (ISO 5492 1992), although it can be defined instrumentally. There are two ways to measure texture: sensory and instrumentally. Sensory measurement requires a previously trained panel, despite the existence of studies that employed consumer panels (Szczesniak et al., 1975); instrumental measurement uses fundamental, empirical or imitative methods. Fundamental tests, like ultimate strength, Poisson's ratio or Young's modulus, measure viscosity and elasticity; empirical tests, like puncture, shear, and extrusion, measure parameters found to be correlated with sensory texture; while imitative tests are those that imitate with instruments the way food products are subjected in the mouth, i.e., as TPA does (Szczesniak 1963).

With regard to melon fruit texture, little attention has been given to the complementary approach of sensory evaluation of melons and their physical characteristics. 'Songwhan charmi PI 161375', known for its resistance to 'Cucumber mosaic virus (CMV)', has been used in crosses with the Spanish Piel de Sapo T111 to study genetic control of quality traits, ripening behavior or postharvest disorders (Eduardo et al., 2005; Fernández-Trujillo et al., 2008; Obando et al., 2008; Obando-Ulloa et al., 2008; Dos-Santos et al., 2013; Saladié et al., 2015). In these studies however, textural behavior beyond flesh firmness or juiciness was not evaluated. 'Calcuta PI 142112' melon, reported to have resistance to diseases like downy and powdery mildew, was previously used in crosses with Védrantais (Perchepied et al., 2005), a susceptible cultivar, while 'Irak C-1012' was used to study gene content variations of melon wide phenotypic diversity (González et al., 2013). These landraces were also never evaluated from both a sensory and instrumental textural perspective. Dulce and Védrantais are two genotypes representative of climacteric type that have been used to study melon ripening behavior. To our knowledge and with exception for flesh firmness (Saladié et al., 2015), no information on their sensory and physical texture characteristics have been published.

The combination of sensory and physical-chemical methodologies allows a closer understanding of melon fruit texture. The aim of this work was to compare melon fruit variability within a specific group of genotypes, evaluating its quality parameters with emphasis on textural properties. Fruits were chosen concerning wide species variability: three landrace cultivars (the Korean 'Songwhan charmi PI-161375', the Indian 'Calcuta PI-124112', and the Iraqi 'Irak C-1012') and three elite cultivars (the Spanish 'Piel de Sapo T111', the French 'Védrantais', and the American 'Dulce'), while four Spanish major commercial varieties were used as reference ('Piel de Sapo', 'Amarillo', 'Galia' and 'Cantaloupe'). Sensory analysis, Texture Profile Analysis (TPA), puncture tests with two probe sizes, pH, soluble solids content (SSC) and weight losses were measured in the fruits and the extent of linear correlation between them determined.

2. Materials and methods

2.1. Plant material

Ten different melon (*C. melo* L.) types, six melon cultivars and four commercial varieties, were sensory and physical-chemical analyzed (Table 1). Plants were grown during the summer of 2012 in a greenhouse in 'Torre Marimon' (Barcelona) in peat bags under 16 light hours minimum, constant temperature (20 °C) and drip irrigation. The lines were arranged in a completely randomized design. Flowers were hand pollinated and each plant was allowed to set a single fruit.

Maturity was defined by change in color and abscission of the fruits: 40–45 days after pollination (DAP) for Calcuta and Irak, 45 DAP for Védrantais and 50 DAP for Dulce, while for Piel de Sapo T111 and Songwhan charmi maturity was considered to be the point at which fruits had high sucrose content, and thus optimal fruit quality. This was at, 55 and 50 DAP for Piel de Sapo T111 and Songwhan charmi, respectively, as determined in a previous study (Saladié et al., 2015). Commercial varieties were retrieved from a local market.

2.2. Melon samples

Fruits were transversally hand cut with a sharp knife into 2 cm slices, from which the stem and the blossom-ends were discarded. Central slice was used for physical-chemical determinations whereas contiguous ones were used for sensory evaluation. The slices to be used in sensory evaluation were wrapped in cling film and stored at 4 °C until the moment of the tasting. From the slices to be used for physical-chemical determinations, six cylindrical pieces of 2 × 1.5 cm were made by pressing a fruit corer of 1.5 cm diameter against the flesh. The cylinders were carefully placed into a tray that once wrapped in cling film was also stored at 4 °C for a maximum of two hours. All the analysis were performed at harvest.

2.3. Physical-Chemical Evaluation

The pH was determined in triplicate through the central slice flesh using a 5053-T puncture electrode pH-meter (Crison Instruments S.A., Barcelona, Spain) equipped with temperature probe.

Instrumental texture profile analysis (TPA) test described by Bourne (1978) and puncture tests (Bourne, 1979) with 6 and 10 mm diameter probes were performed in a Texture Analyzer TA-HD Plus (Aname, Spain) equipped with a 50 kg load-cell. Parameters achieved with both methods are listed and described in Table 2. TPA measurements were made in six cylindrical pieces of 2 × 1.5 cm per fruit, previously obtained with a corer. Samples were compressed twice to 75% of their original height at a crosshead speed of 1 mm/s. Three puncture measurements were done directly in the central section of the slices, between the core/seed cavity and the rind areas, at 1 mm/s speed with a 0.5 cm penetration of the probes.