



*Research article*

## **Evaluation of quality attributes and consumer preference of fresh or imported mangoes in Italy**

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**Abstract:** Mango is a climacteric fruit with a very short shelf-life due to its rapid ripeness after harvest. Generally, fruit from tropical countries and directed to longer transportation (EU markets), are in general harvested firm, before complete ripening (mature-green stage). This harvest practice usefully for mango fruit storability and transportability, generally causes fruits quality and taste decrease. The present study was conducted to evaluate quality attributes and consumer preference of fresh or imported mangoes in Italy. Mango fruit imported from abroad (cv Keitt, Kent and Osteen) were collected from 2 different large-scale organized distribution markets (LD). Mango fruits (cv Keitt, Kent and Osteen) produced in Italy, were harvested from a commercial orchard (Furiano, Messina), at mature-green (GR) and mature-ripe stage (MR). Imported and local mango fruits were analyzed in terms of firmness, total soluble solids content (TSS), titratable acidity (TA) and flesh disorders. Both categories of mango fruits (imported and local) were subjected to sensory evaluation and consumer acceptability. Our results confirmed that mango ripening leads to increased expression of quality and sensory attributes, as well as, aromas, tropical flavor, and taste. Mango fruit harvested in Italy (local) showed the best quality performances in terms of weight, firmness, TSS and TA. Sensorial analysis and consumer test, confirmed this behavior, in fact, these quality attributes, were perceived by the trained panel and by the consumers, that preferred local mango fruits.

**Keywords:** *Mangifera indica*; local production; quality perception; sensory analysis; in-store consumer test

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## 1. Introduction

Mango (*Mangifera indica* L.) is one of the major fruit crop in tropical and subtropical regions. Among tropical fruits, mango production is second behind bananas (more than 113 million tons) reaching 46 million tons [1] that are mainly shipped to export markets [2].

Mango production is mostly concentrated in India, China, Thailand, Indonesia, Philippines, Pakistan and Mexico, but in the last decades its cultivation has been moving also outside the traditional geographical regions to Australia, Central and South America, South-East Asia, Hawaii, Egypt, Israel, South Africa, and Europe, especially for export [3].

The favorable climate of the Mediterranean basin areas is suitable for mango cultivation, particularly in Egypt, Israel, Spain, and in Italy, especially in Sicily [4–6].

Mango is a climacteric fruit with a relatively short shelf-life. Usually, fruit from tropical Countries and shipped to the European market are collected precociously, before complete ripening, at mature-green stage, when they are hard and green, and then are ripen progressively after harvest [5]. This practice improves storability and transportability but generally produces fruits lacking developed characteristic color, aroma and taste [5]. The most popular exported mango cultivars are *Kent*, *Tommy Atkins*, *Haden*, and *Keitt*; less known cultivars such as *Ataulfo*, *Amelie*, *Francis* and *Osteen* are now being widely accepted all over the world [1,2].

Mango fruit subjected to long transportation distances are usually harvested at the mature-green stage, firm and green but physiologically mature, whereas fruit sent to local markets or air-shipped are harvested at mature-ripe stage [7,8]. The ripening process in mature-green fruit takes within 9–14 days and includes starch to sugar conversion, decreased acidity and increased carotenoids and aroma volatiles; mature-ripe fruits shortly decline within 6 days at room temperature [9].

The largest import markets for fresh and processed tropical fruits belong to the European Union followed by the United States of America [10]; in the last decades, consumers demand for tropical fruits increased, due to several reasons such as, health consciousness, population growth of ethnic minorities in Europe and through international travel and global communication [11].

Several researches investigated the complex interactions of different factors influencing consumers choices and preferences in terms of fruits and vegetables, but only few of that were focused on tropical fruits [12], and there is a lack of data in terms of consumer and sensory analysis on fresh local production and imported mango fruits in Europe. Appearance, freshness and peel color are relevant fruit quality parameters and play a significant role in consumer mango fruit acceptability and preference [13]. Generally, during ripening, mango varieties change color from green to yellow or orange, often showing a red blush [8]. Sensory profile of mango fruits, especially color, taste, aroma and flavor, have a great impact on consumers choices [7].

Sensory experiences play a predominant role in shaping consumers satisfaction and hence acceptance of tropical fruits they are not familiar with [11]. Especially because unfamiliarity with tropical fruits and the perceived high prices are the main barriers for purchase and consumption in Europe.

The present study was conducted to evaluate quality attributes, sensory quality and consumer preference of local fresh and imported mango fruits in Italy.

## 2. Materials and methods

### 2.1. Experimental design

Mango fruit (cv *Keitt*, *Kent* and *Osteen*) produced in Italy, were harvested from a commercial orchard, located at Furiano, province of Messina (Sicily, Italy; 38 °3' N, 14 °33' E; 5 m a.s.l.). Fruit were hand-picked at mature-green (GR) and mature-ripe (MR) stage, suitable for the fresh fruit market, using skin color as maturity index [5,14,15]. Immediately after harvest weight, firmness, total soluble solids content (TSS) and titratable acidity (TA) were measured on 6 replicates of 5 fruit.

Mango fruit imported from abroad (cv *Keitt*, *Kent* and *Osteen*) were collected from 2 different large-scale organized distribution markets. On the same day, fruit with external injuries were eliminated, while the rest were presorted by cultivar, using non-destructive (color index) and destructive (firmness) criteria, into GR and MR categories to facilitate the qualitative and descriptive analysis. Imported mango fruit were analyzed in terms of weight, firmness, total soluble solids content (TSS) and titratable acidity (TA) were measured on 6 replicates of 5 fruit. 50% of GR mango fruits collected from 2 different large-scale organized markets (LD) were immediately analyzed and evaluated; 50% of GR remaining mango fruits were stored at room temperature (20 °C) for 4–8 days until they reached MR stage and then were submitted to analysis.

### 2.2. Quality parameters: weight, firmness, total soluble solids, titratable acidity and decay

Fruit ( $n = 30$ ) were analyzed at harvest and when were collected from the two large-scale organized distribution market. Fruit weight was determined using a digital scale. Firmness, expressed in Newton (N), was measured on opposite cheeks of each fruit with a digital penetrometer (mod. 53205, Tr Turoni, Forlì Italy) incorporating an 8 mm diameter probe, after removal of a small piece of peel. A wedge-shaped slice of flesh was taken longitudinally from each fruit and ten fruit wedges were peeled and juiced. Total soluble solids (TSS) were determined by digital refractometer (Palette PR-32, Atago Co., Ltd) and titratable acidity (TA) was measured by titration of 10 mL juice with 0.1 N NaOH to pH 8.1 (mod. S compact titrator, Crison Instruments, Barcelona, Spain) and expressed as % citric acid, which is the major acid in mango fruit [16]. Fruits were also checked for the presence of decay, whose incidence was expressed as a percentage.

### 2.3. Sensory analysis

Fruits ( $n = 5$ ) from local grower and imported from abroad were subjected to sensory evaluation at GR and MR stage.

The sensory profile was constructed by a semi-trained panel made of 10 judges that in a few preliminary meetings, by using commercial fruit, generated a list of descriptors [17]. Semi-trained panel is made up of people normally familiar with mango fruit, this kind of panel is capable of discriminating differences and communicating their reactions, though it may not have been formally trained; furthermore, a semi-trained panelist judgement will be closer to that of the average consumer [18].

Sensory analysis was focused on appearance (2 descriptors), tactile handfeel (1 descriptor), aroma (6 descriptors), flavor (6 descriptors), taste and tactile (5 descriptors) and rheological descriptors, focused on juiciness perceived in the mouth (1 descriptor) (Table 1) [5].

About 50 g sample were dispensed into a small plastic plate with a 3-digit code on the side and served to the judges [5]. The different descriptors were quantified using an eight point intensity scale where the digit 1 indicates the descriptor absence while the digit 8 the full intensity. The order of presentation was randomized between judges and water was provided for rinsing between samples [5].

#### 2.4. In-store consumer test (LOD)

An “in-store” consumer test was conducted on the two maturity stages (GR and MR) of the three mango cultivars [19,20]. Hundred and fifty ( $n = 150$ ) regular or occasional consumers were surveyed at 2 major large-scale organized distribution market in Palermo (IT). Target population was selected according to socio-demographic and psychographic marketing variables for consumer stratification (50% females, 50% males, range of age between 20 and 75) [21].

The samples (one sample from each cultivar, maturity stage and origin) were served, monadically, in plastic cups coded with 3-digit algorithms, in random order at room temperature (20 °C). Before tasting the samples, the consumers were asked about any possible allergic reactions to mango fruits. Each sample was subjected to consumer test for external appearance, firmness, taste, sweetness, exotic fruit aroma and overall acceptance; the acceptance was determined using a linear 8-point hedonic scale (1 = dislike extremely to 8 = like extremely) [22]. The order of presentation was randomized between the consumers, water was provided for rinsing between samples.

#### 2.5. Statistical analysis

Data were submitted to analysis of variance (ANOVA); means separation was performed using Tukey’s test at  $P \leq 0.05$ . The statistical analysis was carried out using Systat v.10 (Systat, USA).

**Table 1.** List of sensory descriptors [5] evaluated by semi-trained panel and their definitions, descriptors used for sensory analysis of mature-green (GR) and mature-ripe (MR) *Osteen*, *Keitt* and *Kent* local and imported (LD1 and LD2) mango (*Mangifera indica* L.) fruits.

Descriptors	Definition
<i>Appearance</i>	
Skin color	Predominant color of the main surface of the mango
Flesh color	Color of the mango flesh (from yellow to dark and intense orange)
<i>Tactile handfeel</i>	
Consistency to cut	Resistance of the fruit to the cut, evaluated manually
<i>Aroma</i>	
Sea odor	Characteristic aroma of sea perceived with the sense of smell
Peach odor	Characteristic aroma of peach perceived with the sense of smell
Exotic fruit odor	Characteristic aroma of exotic fruit perceived with the sense of smell

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Descriptors	Definition
Medicinal odor	Characteristic aroma of medicinal perceived with the sense of smell
Cheese odor	Characteristic aroma of cheese perceived with the sense of smell
Burned oil	Characteristic aroma of burned oil perceived with the sense of smell
<i>Flavor</i>	
Sea flavor	Characteristic aroma of sea perceived with the swallowing
Peach flavor	Characteristic aroma of peach perceived with the swallowing
Exotic fruit flavor	Characteristic aroma of exotic fruit perceived with the swallowing
Medicinal flavor	Characteristic aroma of medicinal perceived with the swallowing
Cheese flavor	Characteristic aroma of cheese perceived with the swallowing
Burned oil flavor	Characteristic aroma of burned oil perceived with the swallowing
<i>Taste and tactile in mouth</i>	
Acid	Basic taste on tongue stimulated by acids
Fiber in the flesh	Amount of fibers in the sample after a bite
Mealiness	Gritty, sandy texture, dry not juicy
Bitter	Taste on the tongue stimulated by bitter compounds
Sweet	Taste on the tongue stimulated by sugars and high potency sweeteners
<i>Rheological</i>	
Juiciness	The amount of juice/moisture perceived in the mouth

### 3. Results and discussion

#### 3.1. Quality parameters: weight, firmness, total soluble solids, titratable acidity and decay

Local mango fruits of each cultivar showed significantly higher weight in both maturity stage (GR and MR), most likely due to the early harvest of the imported fruits (Table 2).

In any case, firmness, TSS and TA were affected by maturity stage (GR and MR) in all mango fruits.

*Osteen*, *Keitt* and *Kent* local mango fruits showed a firmness percentage decrease of 64%, 59% and 48%, respectively, between GR and MR stage (Table 2). *Osteen*, *Keitt* and *Kent* mango imported fruits showed higher firmness percentage decrease between GR and MR than local ones, with values around 87% (Table 2).

GR local mango fruits showed significantly higher values of TSS in each cultivar than imported ones. Indeed, *Osteen*, *Keitt* and *Kent* GR mango local fruits showed TSS values of 45%, 39% and 37% higher than imported ones, respectively. *Osteen*, *Keitt* and *Kent* MR local mango fruits showed a similar behavior with TSS values of 36%, 38% and 29% higher than imported ones (Table 2). GR and MR *Osteen*, *Keitt* and *Kent* imported mango fruit, in most cases, showed higher TA values than the local mango fruits (Table 2). Our data confirm that the early harvest of imported mango fruits improves transportability but affect negatively fruit quality parameters as firmness, TSS and TA.

MR imported mango fruit were affected by flesh disorders, particularly, 30% of MR *Keitt* imported mango fruits were affected by flesh disorders (browning), losing its marketability (data not shown). Mango imported fruit flesh disorders were probably caused by chilling injuries due to the application of temperature below 10–13 °C during long transportation and retail storage [18].

Indeed, local mango fruits were not affected by flesh disorders.

### 3.2. Sensory analysis

Panelists preferred *Osteen*, *Keitt* and *Kent* local mango fruits at both maturity stages (Figures 1–3); in particular, *Osteen* mango local fruits get the higher scores in terms of skin color, juiciness, exotic fruit flavor, exotic fruit odor and overall acceptance (Figure 1). Indeed, GR *Kent* mango imported fruits get the lowest scores in most of the descriptors, particularly in terms of overall acceptance (Figure 3A).

MR *Osteen*, *Keitt* and *Kent* local mango fruits showed higher scores in most of the descriptors, as well as, skin and flesh color, peach flavor and odor, sweetness, juiciness, exotic fruit flavor and odor etc.; and the lowest scores in terms of off-flavor and off-odor, than imported mango fruits (Figures 1B, 2B and 3B).

MR *Osteen*, *Keitt* and *Kent* mango imported fruits showed higher scores in terms of off-flavor (medicinal flavor and burned oil flavor) and off-odor (medicinal odor, burned oil odor), than local ones (Figures 1B, 2B and 3B). *Osteen*, *Keitt* and *Kent* mango imported fruits showed a noticeable increase in terms of medicinal odor, burned oil odor, medicinal flavor and burned oil flavor between GR and MR stage (Figures 1–3).

Sensory analysis was consistent with the analytical measurements, the higher TSS values of MR local mango fruits was perceived by the panelist. MR local mango fruit quality parameters measured were in line with the scores obtained in terms of overall acceptance.

### 3.3. In-store consumer test

The *in-store* consumer test population ( $n = 150$ ) consisted of 50 % female and 50% male; 68% of the consumer population was between 20 and 60 years old and 32% was between 61 and 75 years old [23].

The consumer liking of *Osteen*, *Keitt* and *Kent* local and imported mango fruits was affected by maturity stage (GR and MR) and by cultivar; in any case consumers preferred local mango fruits, result in line with sensory analysis (Figures 4–6). *Osteen* local mango fruits had the higher consumer acceptance at both maturity stage (GR and MR), with scores of 40% and 47% respectively higher than imported ones, in terms of overall acceptance (Figure 4). The overall acceptance average degree of liking for *Osteen*, *Keitt* and *Kent* local mango fruits was “moderately”, indeed, for imported mango fruits was “dislike lightly” (Figures 4–6).

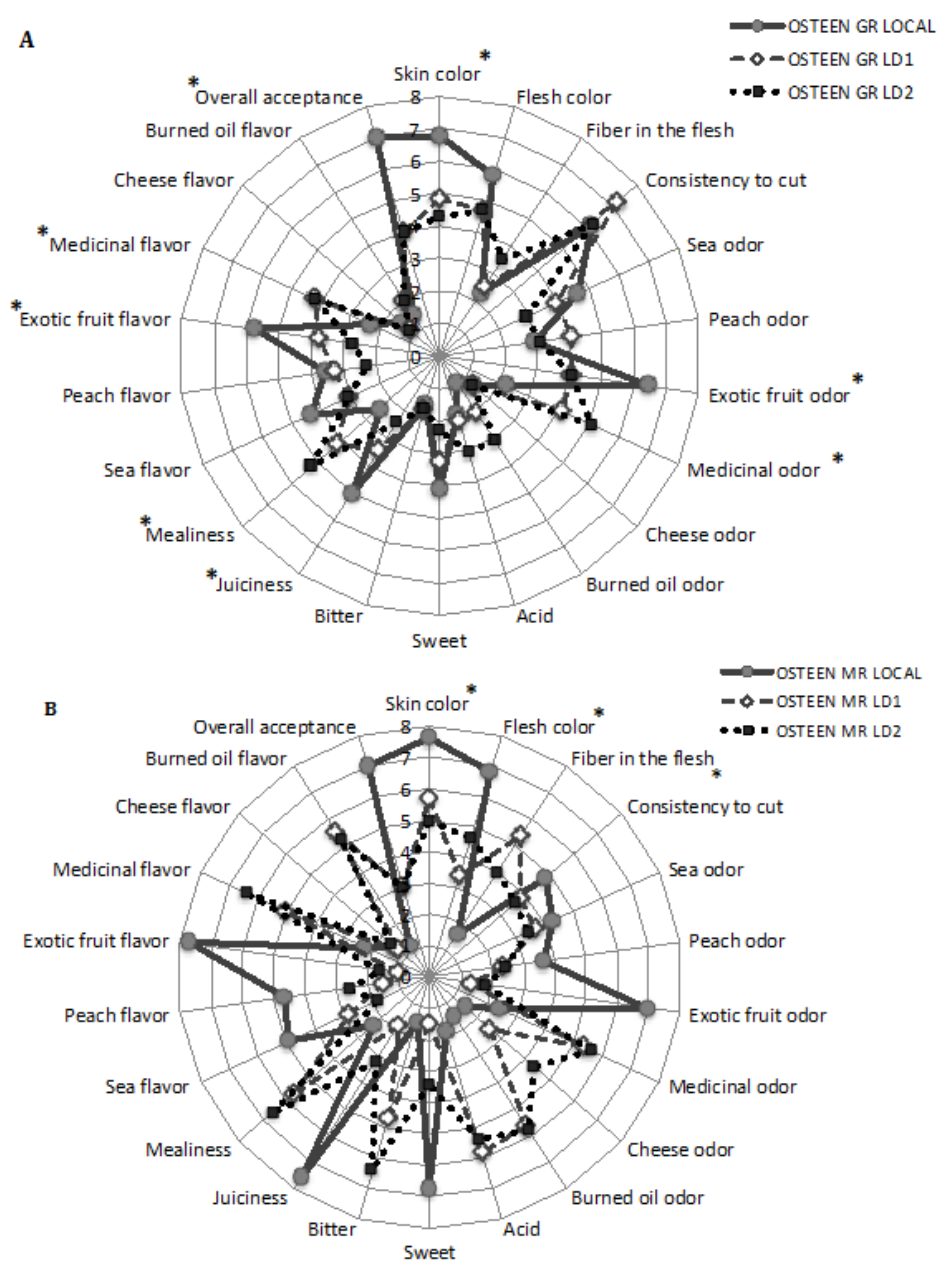
Significant differences were observed between MR *Osteen*, *Keitt* and *Kent* local and imported mango fruits in all the descriptors; in GR *Osteen* and *Keitt* ones, only the firmness score was not significantly different (Figures 4–6). A noticeable liking increase in terms of overall acceptance was observed in all the mango cultivar (local and imported) between GR and MR stage (Figures 4–6).

*Osteen*, *Keitt* and *Kent* local mango fruits were particularly preferred by consumer with high score for taste and exotic fruit aroma (Figures 4–6).

**Table 2.** Physico-chemical characteristics of mature-green (GR) and mature-ripe (MR) *Osteen, Keitt and Kent* local and imported (LD1 and LD2) mango (*Mangifera indica* L.) fruits. Data are Mean  $\pm$  SE ( $n = 30$ ).

Cultivar (Local and imported)	Weight (g)	SE	Firmness (N)	SE	TSS (Brix)	SE	TA (g L <sup>-1</sup> citric acid)	SE				
<i>Osteen</i> GR local	626	$\pm$ 7	a	28.19	$\pm$ 0.30	c	15.75	$\pm$ 0.59	a	0.58	$\pm$ 0.01	b
<i>Osteen</i> GR LD1	556	$\pm$ 5	b	83.84	$\pm$ 0.16	a	8.90	$\pm$ 0.45	b	0.85	$\pm$ 0.08	a
<i>Osteen</i> GR LD2	529	$\pm$ 4	b	74.04	$\pm$ 0.21	b	8.40	$\pm$ 0.52	b	0.79	$\pm$ 0.07	a
<i>Osteen</i> MR local	606	$\pm$ 8	a	10.04	$\pm$ 0.03	b	17.98	$\pm$ 0.42	a	0.26	$\pm$ 0.01	b
<i>Osteen</i> MR LD1	506	$\pm$ 4	b	9.80	$\pm$ 0.05	b	11.50	$\pm$ 0.42	b	0.51	$\pm$ 0.05	a
<i>Osteen</i> MR LD2	479	$\pm$ 4	c	15.20	$\pm$ 0.04	a	11.40	$\pm$ 0.39	b	0.45	$\pm$ 0.05	a
<i>Keitt</i> GR local	680	$\pm$ 5	a	33.83	$\pm$ 0.12	c	15.90	$\pm$ 0.29	a	0.54	$\pm$ 0.01	b
<i>Keitt</i> GR LD1	573	$\pm$ 5	b	61.98	$\pm$ 0.13	a	9.45	$\pm$ 0.63	b	0.83	$\pm$ 0.08	a
<i>Keitt</i> GR LD2	565	$\pm$ 6	b	56.14	$\pm$ 0.09	b	9.80	$\pm$ 0.54	b	0.86	$\pm$ 0.06	a
<i>Keitt</i> MR local	624	$\pm$ 6	a	13.72	$\pm$ 0.05	a	18.80	$\pm$ 0.26	a	0.41	$\pm$ 0.01	a
<i>Keitt</i> MR LD1	554	$\pm$ 5	b	9.90	$\pm$ 0.04	b	11.23	$\pm$ 0.32	c	0.47	$\pm$ 0.02	a
<i>Keitt</i> MR LD2	540	$\pm$ 5	b	4.12	$\pm$ 0.02	c	12.10	$\pm$ 0.44	b	0.32	$\pm$ 0.01	b
<i>Kent</i> GR local	686	$\pm$ 5	a	22.65	$\pm$ 0.08	c	14.05	$\pm$ 0.46	a	0.55	$\pm$ 0.02	b
<i>Kent</i> GR LD1	593	$\pm$ 5	b	73.94	$\pm$ 0.07	b	9.20	$\pm$ 0.65	b	0.80	$\pm$ 0.07	a
<i>Kent</i> GR LD2	614	$\pm$ 5	c	87.28	$\pm$ 0.09	a	8.50	$\pm$ 0.53	b	0.74	$\pm$ 0.08	a
<i>Kent</i> MR local	653	$\pm$ 5	a	11.77	$\pm$ 0.05	a	15.43	$\pm$ 0.41	a	0.58	$\pm$ 0.01	c
<i>Kent</i> MR LD1	502	$\pm$ 5	b	7.84	$\pm$ 0.08	c	11.32	$\pm$ 0.65	b	0.69	$\pm$ 0.06	b
<i>Kent</i> MR LD2	456	$\pm$ 5	c	9.81	$\pm$ 0.04	b	10.50	$\pm$ 0.58	c	0.85	$\pm$ 0.10	a

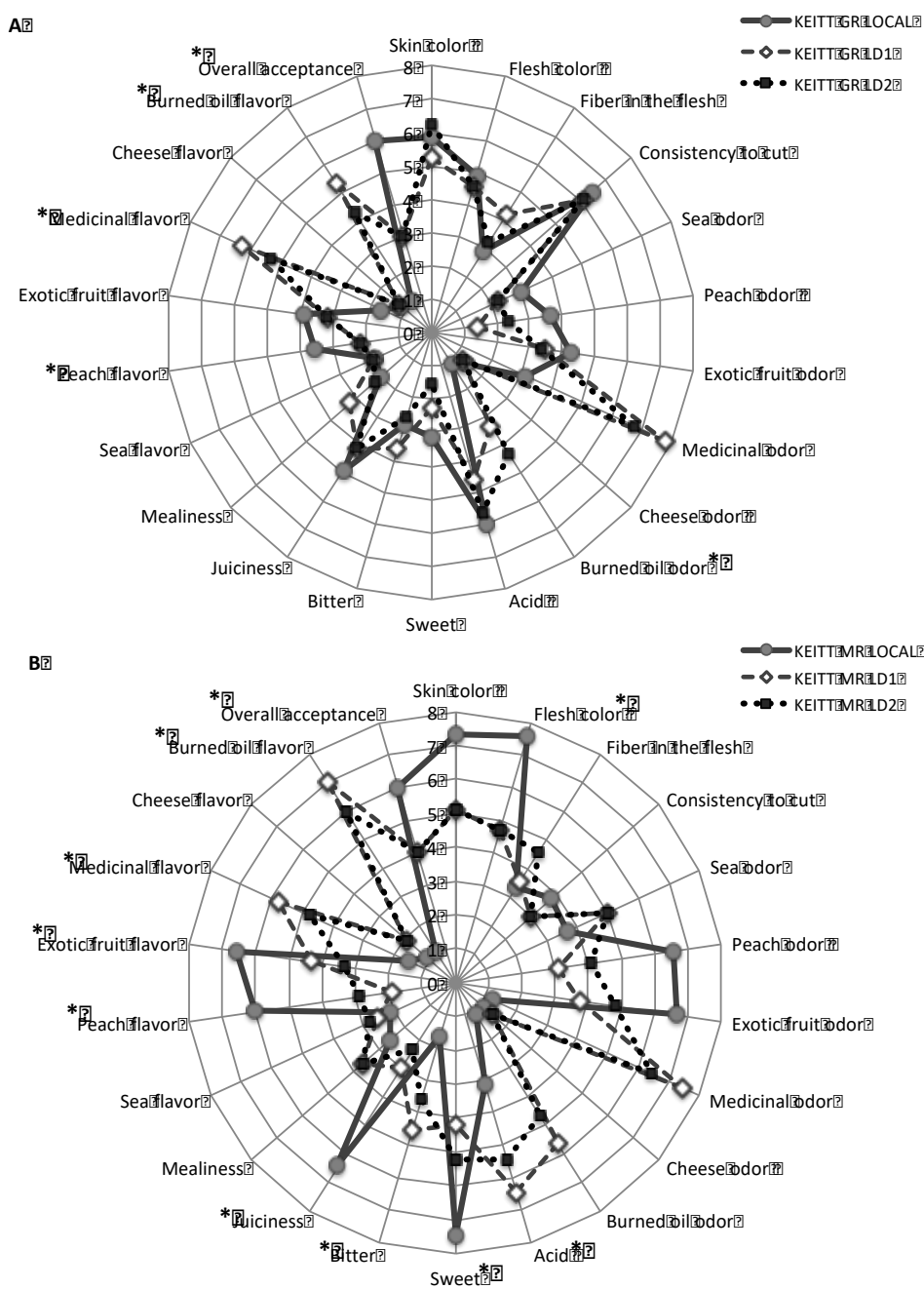
\* Values labelled with a different letter in the same column are significantly different for each ripening stage (Tukey's test at  $P \leq 0.05$ ).



**Figure 1.** Sensory analysis of mature-green (GR) (A) and mature-ripe (MR) (B) *Osteen* local and imported (LD1 and LD2) mango (*Mangifera indica* L.) fruits. Data are Mean of 5 fruit for each ripening stage.

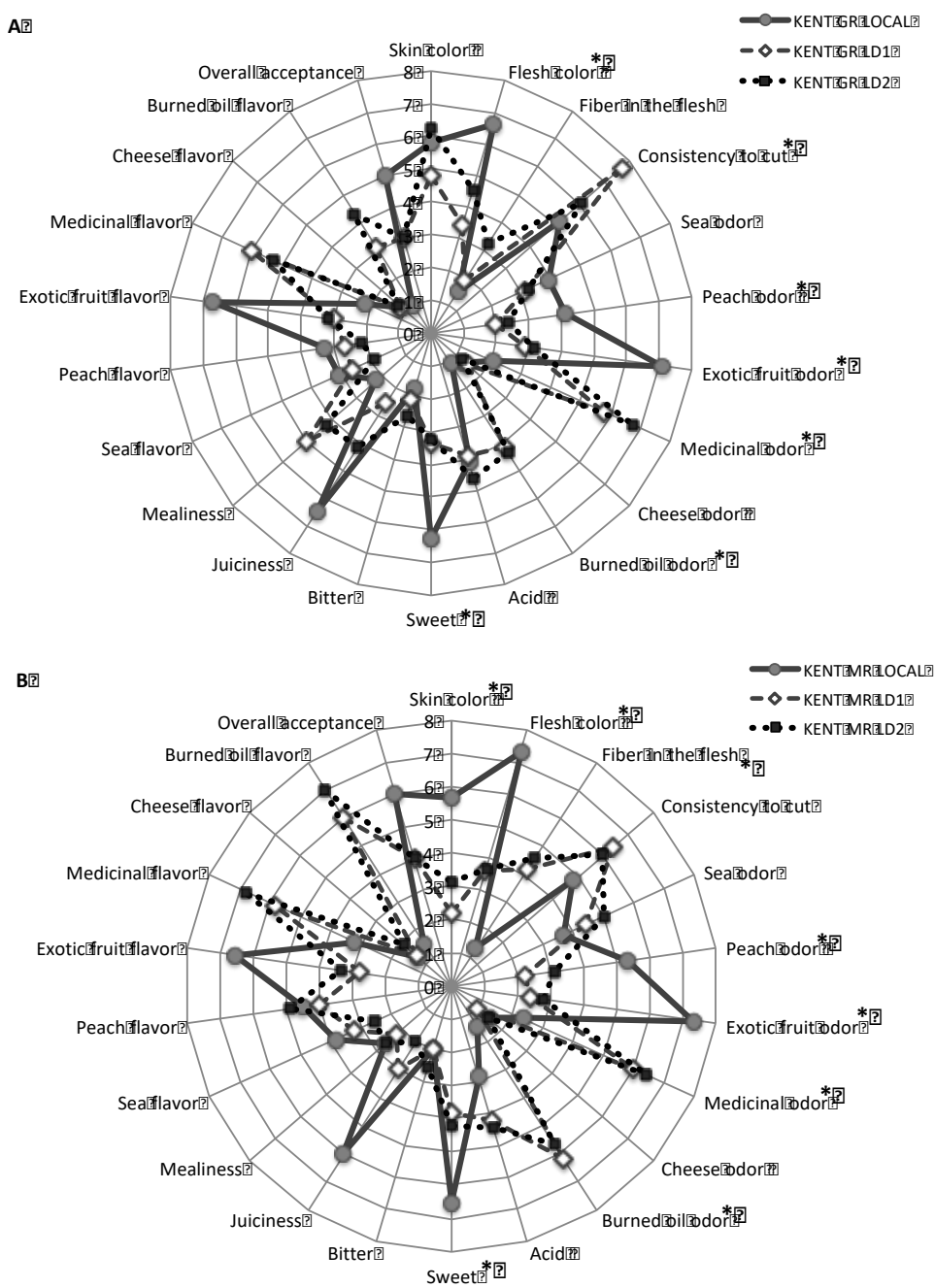
\* Indicate significant differences for values (Tukey's test at  $P \leq 0.05$ ).





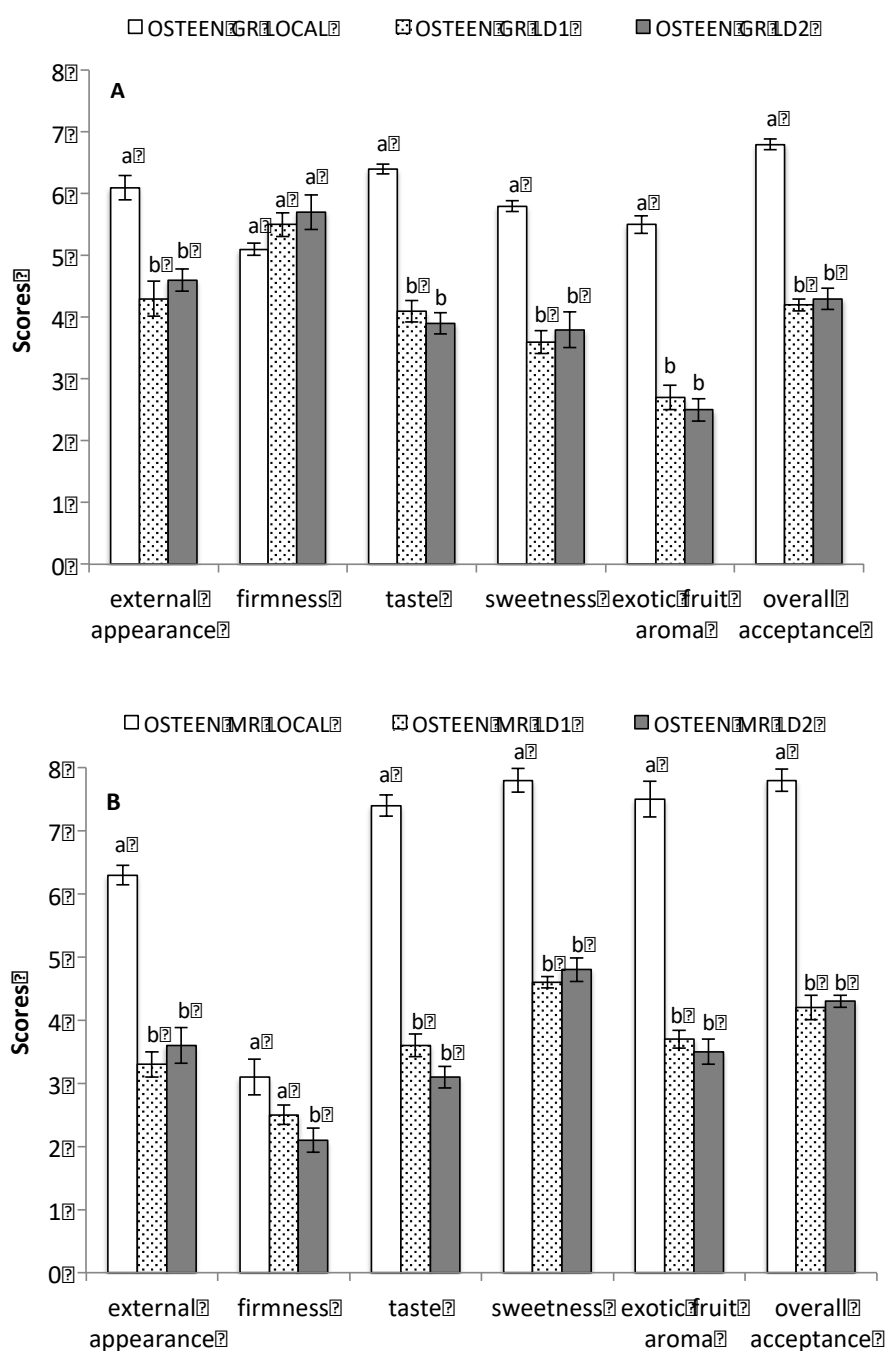
**Figure 2.** Sensory analysis of mature-green (GR) (A) and mature-ripe (MR) (B) *Keitt* local and imported (LD1 and LD2) mango (*Mangifera indica* L.) fruits. Data are Mean of 5 fruit for each ripening stage.

\* Indicate significant differences for values (Tukey's test at  $P \leq 0.05$ ).



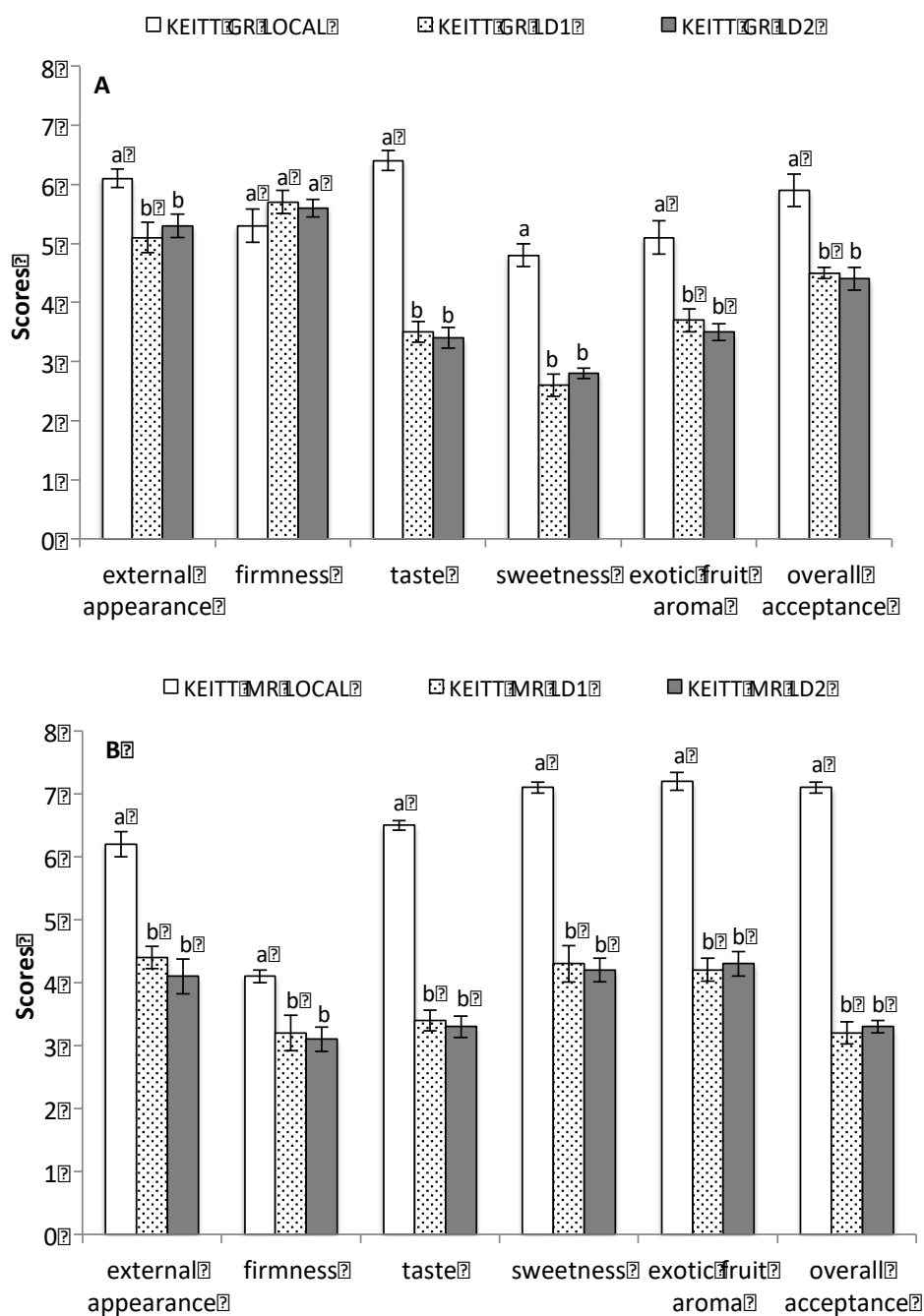
**Figure 3.** Sensory analysis of mature-green (GR) (A) and mature-ripe (MR) (B) *Kent* local and imported (LD1 and LD2) mango (*Mangifera indica* L.) fruits. Data are Mean of 5 fruit for each ripening stage.

\* Indicate significant differences for values (Tukey's test at  $P \leq 0.05$ ).



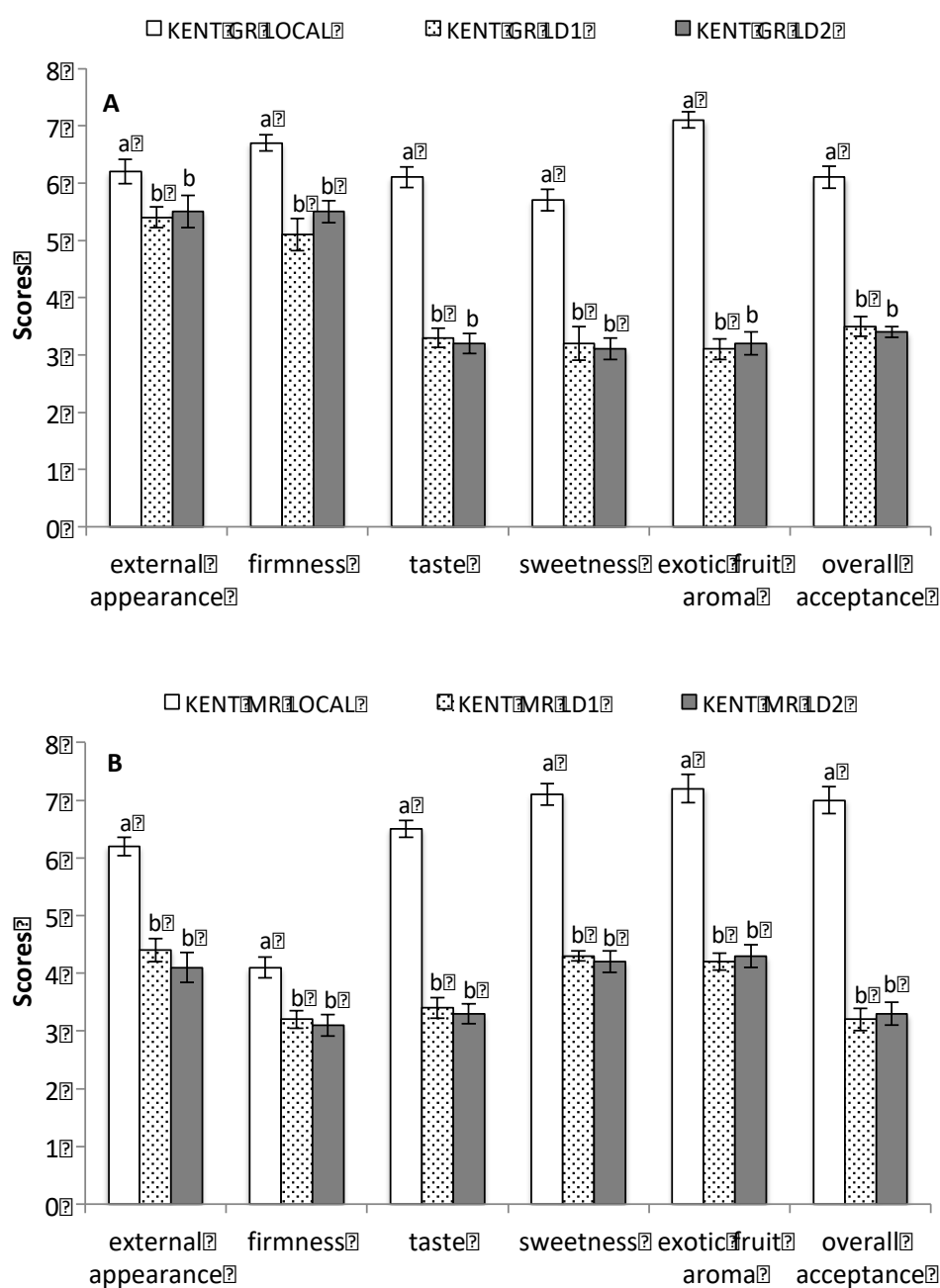
**Figure 4.** Consumer acceptance of mature-green (GR) (A) and mature-ripe (MR) (B) *Osteen* local and imported (LD1 and LD2) mango (*Mangifera indica* L.) fruits.

\* Degree of liking: 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike lightly, 5 = neither like or dislike, 6 = like slightly, 7 = like moderately, 8 = like very much. Data are Means  $\pm$  SE ( $n = 150$ ). Values labelled with different letters, in each consumer descriptor (external appearance, firmness, taste, sweetness, exotic fruit aroma and overall acceptance) are significantly different (Tukey's test at  $P \leq 0.05$ ).



**Figure 5.** Consumer acceptance of mature-green (GR) (A) and mature-ripe (MR) (B) *Keitt* local and imported (LD1 and LD2) mango (*Mangifera indica* L.) fruits.

\* Degree of liking: 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike lightly, 5 = neither like or dislike, 6 = like slightly, 7 = like moderately, 8 = like very much. Data are Means  $\pm$  SE ( $n = 150$ ). Values labelled with different letters, in each consumer descriptor (external appearance, firmness, taste, sweetness, exotic fruit aroma and overall acceptance) are significantly different (Tukey's test at  $P \leq 0.05$ ).



**Figure 6.** Consumer acceptance of mature-green (GR) (A) and mature-ripe (MR) (B) *Kent* local and imported (LD1 and LD2) mango (*Mangifera indica* L.) fruits.

\* Degree of liking: 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike lightly, 5 = neither like or dislike, 6 = like slightly, 7 = like moderately, 8 = like very much. Data are Means  $\pm$  SE ( $n = 150$ ). Values labelled with different letters, in each consumer descriptor (external appearance, firmness, taste, sweetness, exotic fruit aroma and overall acceptance) are significantly different (Tukey's test at  $P \leq 0.05$ ).

#### 4. Conclusions

Our study showed that local fresh mango fruits were preferred by the panelist and the consumers, despite the fruits did not come from their origin tropical countries; probably due to the precociously harvest of imported mango fruits. Furthermore, our data confirm the high potential of Southern Italy for mango fruit production.

Local mango fruits showed higher size; higher level of TSS and the best scores in terms of taste in both maturity stages (GR and MR), in particular the data obtained on MR local mango fruits showed that ripening is strictly correlated to sensory perception of consumers/panelist and influenced consumer preferences and potentially choices.

Sensory experiences play a predominant role in consumers' satisfaction and hence the acceptance of tropical fruit in EU markets. Our study brings out some important factors dealing with the relationship between taste and product acceptance; mango consumer taste scores acceptance resulted strictly connected.

Until now, a large number of consumers are still unfamiliar with fresh local mango fruits and for that reason, producers and retailers should promote educational initiative to inform people about tropical local production and to improve the large potential for the fresh mango market in Italy.

#### Conflict of interest

All authors declare no conflicts of interest in this paper.

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