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ORIGINAL ARTICLE

Fruit quality evaluation of affirmed and local loquat (*Eriobotrya japonica* Lindl) cultivars using instrumental and sensory analyses

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Abstract – Introduction. Fruit quality can be evaluated by combining instrumental and sensory analyses. These methodologies have been affirmed and tested on different fruit tree species, but loquat is still little known from this point of view. **Materials and methods.** In this trial, conducted in Palermo and Catania (Sicily, Italy), both instrumental and sensory analyses were carried out on fruit of 8 loquat affirmed cultivars ('Golden Nugget', 'Peluche') and local cultivars ('Marcenò', 'Sanfilippara', 'Nespolone di Trabia', 'Virticchiara', 'Bianco Dolce' and 'BRT20') with the aim of assessing their quality traits. **Results and discussion.** The sensory results agreed quite well with the physicochemical data. Among the affirmed cultivars both 'Peluche' and 'Golden Nugget' confirmed their commercial value expressing a good overall fruit quality. On the other hand, the local Sicilian cultivars have very interesting physical, chemical and sensory profiles. **Conclusion.** The results indicated the goodness of this approach in evaluating loquat fruit quality and proved that not only the affirmed loquat cvs but also the local ones had very interesting qualitative features.

Keywords: Italy / Sicily / loquat / *Eriobotrya japonica* / fruit quality / physicochemical analysis / sensory testing

Résumé – Évaluation de la qualité des fruits de cultivars commerciaux ou traditionnels de néflier (*Eriobotrya japonica* Lindl.) par analyses instrumentales et sensorielles. Introduction. La qualité des fruits peut être évaluée en combinant les analyses instrumentales et sensorielles. Ces méthodologies ont été mises au point et testées sur différentes espèces d'arbres fruitiers, mais le néflier du Japon est encore peu connu de ce point de vue parce que l'on manque d'information sur la qualité des fruits des variétés locales traditionnelles. **Matériel et méthodes.** Dans cette étude, réalisée à Palerme et à Catane (Sicile, Italie), deux analyses instrumentales et sensorielles ont été réalisées sur les fruits de huit cultivars de néflier commerciaux ('Golden Nugget', 'Peluche') ou locaux ('Marcenò', 'Sanfilippara', 'Nespolone di Trabia', 'Virticchiara', 'Dolce Bianco' et 'BRT20') dans le but d'évaluer leurs caractéristiques de qualité. **Résultats et discussion.** Les résultats d'analyse sensorielle ont assez bien correspondu avec les données physico-chimiques. Parmi les cultivars commerciaux, 'Peluche' et 'Golden Nugget' ont tous les deux confirmé leur valeur commerciale à travers une bonne qualité globale de leurs fruits. D'autre part, les cultivars locaux siciliens ont montré des profils physiques, chimiques et sensoriels très intéressants. **Conclusion.** Les résultats indiquent la validité de cette approche dans l'évaluation de la qualité des fruits du néflier, en ayant démontré que non seulement les cultivars commerciaux mais aussi les variétés locales avaient des caractéristiques qualitatives très intéressantes.

Mots clés : Italie / Sicile / néflier du Japon / *Eriobotrya japonica* / qualité du fruit / analyse physicochimique / évaluation sensorielle

1 Introduction

Fruit quality includes the attributes that are readily perceived by the human senses and other attributes such as safety and nutrition that require sophisticated instruments to measure [1]. These characteristics include chemical constituents, mechanical properties, sensory parameters (appearance, texture, taste and aroma), nutritive values, functional properties and defects.

A quality characterization, for the market and for the consumer, implies measurable points in the commodity's development. Instrumental measurement has become one of the cornerstones of fruit quality assessment [2] and is preferred over sensory evaluation and consumer testing for many researches and commercial situations. This method provides a common language among researchers, industry and consumers because it reduces variations among individuals [3, 4]. In fact fruit

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attributes can be evaluated through a rapid and objective characterization by the instrumental measurements of weight, total soluble solids, titratable acidity, firmness and sugars [5]. On the other hand, sensory properties cannot be completely and thoroughly measured by instruments, but require the interaction between food and the individual [6, 7]. Eating quality in the broadest sense (texture, taste, odor) is one of the primary reasons consumers purchase fruit [9, 10]; the consumer is able to recognize fruit quality through a visual and sensory acknowledgment of the sensory characteristics when the fruit is eaten [11]. Sensory analysis permits the establishment of a relationship between the physical and chemical composition of the product and its sensory characteristics to quantify fruit aspects and to understand the interaction between product and consumer [8]. The discipline requires panels of human judges and the recording of the responses made by them. The panel is trained to pay attention to certain attributes and to measure their intensities [12]. This objective method does not depend on whether judges like or dislike a certain item but operates with the determining of the intensities of the sensory descriptors [13]. By applying statistical techniques to the results it is possible to make inferences and understand the product features under test [14]. These include the diversity of color, texture, odor, taste (sweet, salt, acid, and bitter) and flavor used to identify the characteristics of the fruits that could satisfy the most demanding and diverse market trends [15] and this helps to describe product characteristics through consumers' perception [16].

In recent years an instrumental-sensory binomial was developed and it was largely applied to many fruit tree species to study the relationships between sensory and physicochemical attributes of quality. In fact the recent developments in the field of sensory evaluation and instrumental analyses further implemented the interface between humans (sensory science) and machines (instrumental analyses) [4]. The use of both physicochemical and sensory analyses has been applied in apple [11, 17, 18], peach [19–21], nectarines [22], sweet cherry [23], citrus [24, 25], mango [26], kiwi [27], pomegranate [28], loquat [29] fruit production – the latter being the object of this study.

Loquat (*Eriobotrya japonica* Lindl.) is an evergreen tree originating from south-eastern China, diffused to several tropical countries [30] and, today, well adapted to subtropical and temperate climates [31–33] and, currently is cultivated extensively in the Mediterranean basin (Spain, Italy, Algeria, Turkey and Israel). Italy is the sixth producer of loquat with a cultivation area of 200 ha; 90% of the production is located in Sicily and mainly in the province of Palermo. There is a production of about 6 500 t [34], concentrated in April, May and June [35]. Affirmed cultivars were imported and diffused to Sicily from Spain, California, China while local cultivars originated from breeding programs in the 1980s and the1990s [36]. Hence, many cultivars (affirmed and local; early, intermediate and late maturation) and consequently several fruit typologies (orange or white fleshed; acid or sub-acid taste) are available for growers and consumers. In particular the local cultivars are very diffused in Italy but their marketable quality are not properly defined. *E.g.* large differences in terms of external and internal attributes can be found among orange-fleshed and white-fleshed cultivars. In effect the different types of fruit vary in properties such as size and shape, sugar content and acidity [37–39]. Even if in recent years the instrumental-sensory binomial has been applied to several loquat fruit [29] very little information is available on many genotypes particularly on local cultivars.

Table I. Origin, flesh color, maturation class and harvest date of the eight cultivars in trial. International (I); Local (L); Early maturation (EM); Intermediate maturation (IM); Late maturation (LM); Orange (O); White (W).

Cultivars	Origin	Flesh color	Maturation class	Harvest date
Golden Nugget	I	O	IM	8-May
Peluche	I	O	LM	15-May
Marcenò	L	O	IM	8-May
Sanfilippara	L	O	IM	8-May
Nespolone di Trabia	L	O	LM	15-May
Virticchiara	L	O	EM	3-May
Bianco Dolce	L	W	LM	15-May
BRT20	L	W	IM	8-May

The aim of this trial is to classify using a physicochemical and sensory analyses approach, the different kinds of fruit of affirmed and local cultivars grown in Sicily. A classification on the basis of their quality attributes grouped by homogenous characteristics could permit a better market appreciation.

2 Materials and methods

2.1 Plant materials and experimental site

The trial was conducted in a commercial field located in S. Maria di Gesù, Palermo (Sicily, Italy; 38°04′ N, 13°22′ E, 150 m a.s.l.). The examined cultivars belonged to the following varieties: 'Golden Nugget', 'Peluche' (international affirmed cvs), 'Marcenò', 'Sanfilippara', 'Nespolone di Trabia', 'Virticchiara', 'Bianco Dolce' and 'BRT20', (local cvs). 'Peluche' and 'Golden Nugget' are two yellow-orange flesh affirmed cultivars mainly diffused in Spain. 'Marcenò', 'Sanfilippara', 'Nespolone di Trabia', 'Virticchiara' are four yellow-orange flesh local cultivars originated in Sicily. 'Bianco Dolce' and 'BRT20' are defined white-fleshed cultivars characterized by a pale yellow flesh color and were obtained from breeding programs developed at Palermo University [36]. These belong to the sub-acidic category with a balanced sugar/acid ratio but very delicate for manipulation and subject to market and transport diseases.

Six uniform 13-year-old trees grafted on their own rootstock and trained to a vase shape were selected for each cultivar. The trees were spaced 5 × 5 m and submitted to the organic farming techniques. Under experimental conditions in Palermo the approximate optimal ripening dates are described in *table I*. A sample of 60 fruits per cultivar (10 fruits per tree) was made of handpicked fruits at the ripe stage suitable for the fresh fruit market using peel color as a maturity index. Thirty of these fruits were analyzed for physical and chemical properties, while the other 30 fruits were used for sensory evaluation.

Table II. List of sensory descriptors evaluated by trained panel and their definitions.

Descriptors	Attribute definition
Appearance	
Ground color	Predominant color of the main surface of the loquat (from pale yellow to dark orange)
Flesh color	Color of the loquat flesh (from pale yellow to dark and intense orange)
Tactile handfeel	
Hardness	Amount of force required to compress gathered sample in palm
Easy peel	Resistance of the epicarp to the removal, evacuate by removing the peel with a knife
Easy stone	Resistance of the fruit to the separation, evaluated manually, separating the fruit from the stone
Aroma	
Loquat	Loquat Characteristic aroma of loquat perceived with the sense of smell
Herbaceous	Characteristic aroma of herbaceous perceived with the sense of smell
Floral flavour	Floral Characteristic aroma of floral perceived with the swallowing
Taste	
Acid	One of the four tastes caused by aqueous solutions of acid compounds perceived on the tongue
Bitterness	One of the four tastes caused by aqueous solutions of bitter compounds perceived on the tongue
Sweet	One of the four tastes caused by aqueous solutions of sweet compounds perceived on the tongue
Tactile in mouth	
Astringent	Sensory perception in the oral cavity that may include drying sensation, and roughing of the oral tissue
Rheological	
Juiciness	The amount of liquid released from the sample during first and second chew

2.2 Physicochemical analyses

Fruits were submitted to the determination of fresh weight (FW), longitudinal diameter (LD) and transversal diameter (TD), total soluble solid content (SSC), titratable acidity (TA), flesh color index (FCI) and seed weight (SW) Fruit weight was determined with a digital scale (Gibertini EU-C 2002 RS, Novate Milanese, Italy), transversal diameter with a digital caliper TR53307 (Turoni, Forlì, Italy), flesh firmness with a digital penetrometer TR5325 with a 8 mm diameter tip (Turoni, Forlì, Italy), total soluble solid content with a digital refractometer (Atago Palette PR-32, Atago Co., Ltd, Tokyo, Japan), and titratable acidity with a compact titrator (Crison Instruments, SA, Barcelona, Spain). Each fruit was photographed (first with and then without peel) with a digital camera and digital images were used to determine intensity of peel and flesh color. Specifically, we used an algorithm that converts images from RGB to CIE (Commission Internationale de l'Eclairage) L*a*b* format, extracts the fruit from the image (removing the image background), and quantifies color characteristics as the weighed distance of each pixel in the image from a reference sample (best colored area interactively chosen from a well colored fruit). The output was a peel ground color index (GCI) and a flesh color index (FCI) ranging from 0 to 1 (identical to reference sample). Moreover SSC/TA ratio and flesh/seed ratio (FL/SE) were calculated.

2.3 Sensory analyses

The sensory profile [41] was defined on a subsample of 30 fruits by a panel of 10 judges (five female and five male) that were trained to recognize the qualitative traits that would be assessed. All panelists were trained at Catania University and had a broad expertise in sensory evaluation of foods and in particular of fruits [29,42,43]. In a preliminary meeting, 16 attributes were generated (*table* II), on the basis of frequency of citation (> 60%), as listed below: two for appearance (flesh color – FC; ground color – GC), three for tactical hand feel (hardness – H; easy peel – EP; easy stone – ES), three for odor (loquat – LO; herbaceous – HO; floral – FO), three for taste (sweet – S; bitter – B; acid – A;), one for tactile in mouth (astringent – AS) one for rheological (juiciness – J), three for flavor (loquat – LF; herbaceous – LF; floral - FF). The evaluations were carried out from 10.00 to 12.00 a.m. in individual booths with controlled illumination and temperature. The study was carried out during three different sessions; samples were evaluated in triplicate. In each session, panelists tested all four cultivars under study; the sample order for each panelist was randomized and water was provided for rinsing between loquat samples. The judges evaluated the intensity of each attribute by assigning a score between 1 (absence of the sensation) and 9 (extremely intense). A computerized data collection program was used (FIZZ, Software Solutions for Sensory Analysis and Consumer Tests, Biosystèmes, Couternon, France). The characteristics of the samples from a quantitative point of view and following an order of perception were evaluated giving rise to the sensory profile [44].

2.4 Statistical analyses

The physicochemical data were tested for differences between the cultivars using the one-way analysis of variance (ANOVA; general linear model) using SYSTAT procedures. The differences between cultivars were tested with Tukey's high significance difference (HSD) test at $P \leq 0.05$ significance. Principal component analysis (PCA) was performed to investigate the relationship between physical, chemical and aromatic attributes and any possible cultivar grouping based on

Table III. Pomological traits of the 8 loquat cultivars in trial (mean ± SD, n = 30). Fruit weight (FW); Longitudinal diameter (LD); Transversal diameter (TD); Seed weight (SW); Flesh Color Index (FCI); Ground Color Index (GCI). The values marked with different letters in the same column indicate significant differences ($P \leq 0.05$).

Cultivars	FW (g)	LD (mm)	TD (mm)	SW (g)	FCI	GCI
Golden Nugget	53.81 ± 3.75 b	46.33 ± 1.33 c	44.68 ± 1.28 b	9.15 ± 0.89 a	0.965 ± 0.05 a	0.966 ± 0.03 a
Peluche	86.27 ± 5.46 a	75.42 ± 2.60 a	60.22 ± 1.53 a	10.16 ± 0.74 a	0.961 ± 0.04 a	0.961 ± 0.01 b
Marcenò	48.46 ± 4.32 c	45.88 ± 1.11 c	41.47 ± 1.49 b	6.05 ± 0.93 bc	0.942 ± 0.09 b	0.962 ± 0.01 b
Sanfilippara	54.49 ± 5.74 b	51.49 ± 1.87 b	43.36 ± 1.90 b	5.12 ± 0.88 c	0.963 ± 0.02 a	0.964 ± 0.02 ab
Nespolone di Trabia	50.48 ± 3.79 b	47.10 ± 1.42 c	44.28 ± 1.41 b	5.50 ± 0.56 c	0.954 ± 0.06 ab	0.951 ± 0.01 c
Virticchiara	42.46 ± 2.15 d	43.16 ± 0.89 d	41.86 ± 0.84 b	9.47 ± 0.79 a	0.939 ± 0.09 b	0.956 ± 0.03 c
Bianco Dolce	47.13 ± 1.72 c	48.04 ± 0.81 c	40.15 ± 0.79 c	5.70 ± 0.44 a	0.923 ± 0.03 c	0.925 ± 0.02 d
BRT20	45.30 ± 2.82 c	43.76 ± 1.00 d	42.18 ± 1.15 b	9.82 ± 0.49 bc	0.920 ± 0.04 c	0.920 ± 0.01 d

Table IV. Chemical-physical parameters of the 8 loquat cultivars in trial (mean ± SD, n = 30). Total soluble solid content (SSC); Titratable Acidity (TA); SSC/TA ratio and flesh seed (FL/SE) ratio. The values marked with different letters in the same column indicate significantly differences ($P \leq 0.05$).

Cultivars	SSC (°Brix)	TA (g L^{-1} malic acid)	SSC/TA	FL/ SE
Golden Nugget	15.85 ± 0.77 b	18.24 ± 3.19 ab	0.90 ± 0.19 bc	6.28 ± 2.22 c
Peluche	11.60 ± 0.59 d	11.10 ± 0.62 cd	1.04 ± 0.03 b	6.96 ± 0.92 c
Marcenò	13.42 ± 0.63 cd	17.90 ± 2.82 ab	0.76 ± 0.09 c	10.53 ± 1.52 b
Sanfilippara	13.83 ± 1.07 c	20.72 ± 2.02 a	0.69 ± 0.09 c	14.48 ± 2.04 a
Nespolone di Trabia	12.57 ± 0.43 cd	18.14 ± 1.63 ab	0.67 ± 0.07 c	9.60 ± 2.15 b
Virticchiara	18.00 ± 0.82 a	10.37 ± 1.37 cd	1.76 ± 0.23 a	6.72 ± 1.19 c
Bianco Dolce	13.00 ± 0.57 cd	11.52 ± 2.72 cd	1.12 ± 0.13 b	8.57 ± 1.43 b
BRT20	14.60 ± 0.99 b	8.37 ± 0.93 d	1.74 ± 0.28 a	6.74 ± 1.32 c

similar properties. Cluster analysis by the k-means technique was performed on the principal components (PCs) to single out cultivar grouping. The biplot technique was used to display the relative positioning of quality attributes and cultivars according to the first two PCs.

3 Results and discussion

3.1 Physicochemical characteristics

The examined loquat cultivars showed a great variation in external (*table* III) and internal (*table* IV) quality characteristics. The international cvs Peluche showed the best FW, TD and LD followed by the local cvs Sanfilippara and Nespolone di Trabia whereas the smallest fruits were with cv. Virticchiara. Weight and diameter define fruit size and are important economic and marketing characteristics, since consumers accept to pay more for the biggest fruit [45, 46]. The organic cultivation technique could have influenced the fruit weight in all cultivars that showed smaller size in respect to the fruit produced with conventional cultural cares [35].

Skin color is the first characteristic of quality perceived by the consumers who generally prefer a well and intense colored fruit, even during fruit eating. In this case, Golden Nugget and Peluche, exhibited the highest values of FCI, followed by Sanfilippara and Nespolone di Trabia, and of GCI values, whereas, as expected, the white-fleshed local cvs Bianco Dolce and BRT20 showed the lowest values. Probably this fact could affect consumer choice and was a reason of the limited market success of the white cultivars.

SSC is responsible for fruit taste, affecting fruit sweetness and consequently consumer appreciation. SSC was greater in 'Virticchiara' followed by 'Golden Nugget' and 'BRT20' whereas the other varieties reached similar values. As for TA, the local ecotypes 'Marcenò', 'Sanfilippara', 'Nespolone di Trabia' and, among the international varieties, 'Golden Nugget' had higher values. Conversely, 'Peluche', 'Virticchiara' and, as expected, the whitefleshed Bianco and BRT 20 had the lowest values. These last two, in fact, are grouped as subacid genotypes. All the values were similar to the SSC observed by Xu *et al.* [47], Pio *et al.* [48] and higher in agreement with Hasegawa [7].

Consequently, the higher values of SSC/TA ratio were observed in 'Virticchiara' and 'BRT20' followed by 'Bianco Dolce', 'Peluche' and 'Golden Nugget'. 'Marcenò', 'Sanfilippara' and 'Nespolone di Trabia', although they had an adequate SSC, on the other hand, they had the highest TA.

At last, FL/SE expressed the edible part of the fruit and it was an important characteristic for market needs. All fruits were in commercial ranges and 'Sanfilippara' reached the most interesting value.

3.2 Sensory quality traits

Sensory results from the trained panel (*figure* 1) proved that both affirmed and local loquat cultivars had good

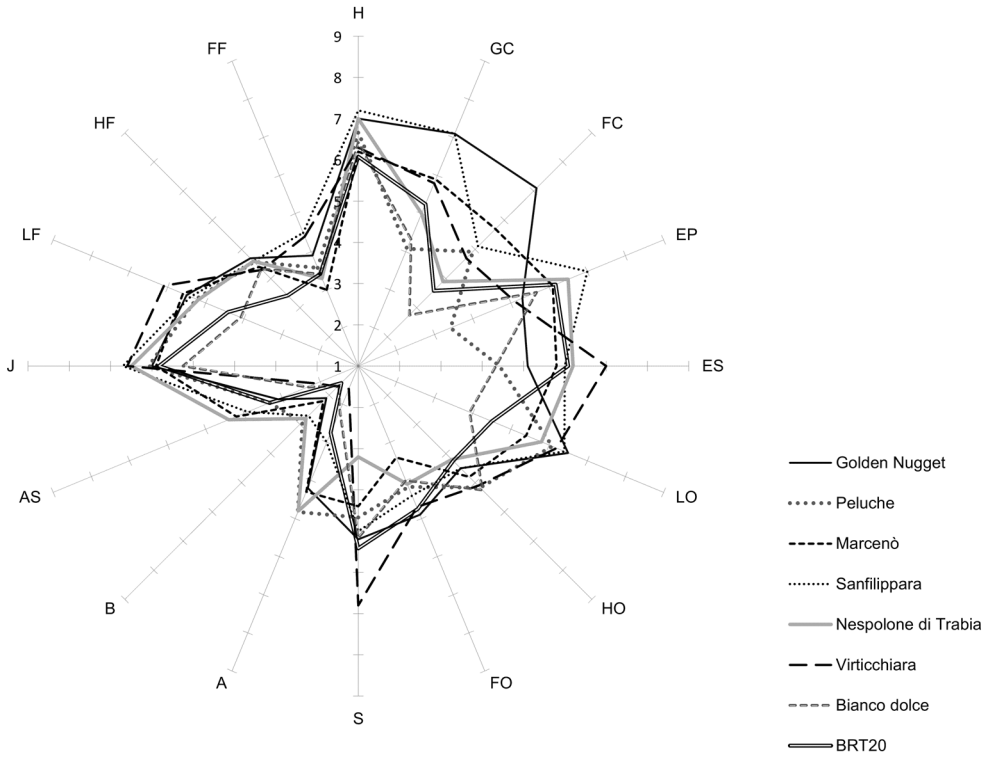

Figure 1. Sensory profiles of the 8 observed loquat cultivars as evaluated by a trained panel. Hardness (H); Ground color (GC); Flesh color (FC); Easy peel (EP); Easy stone (ES); Loquat odor (LO); Herbaceous odor (HO); Floral odor (FO); Sweet (S); Acid (A); Bitter (B); Astringent (AS); Juiciness (J); Loquat flavor (LF); Herbaceous flavor (HF); Floral flavor (FF).

characteristics for fresh consumption because of the high intensities of several key attributes.

As for appearance characteristics, GC ranged from 4.08 for 'Peluche' to 7.10 for 'Golden Nugget' and 'Sanfilippara', whereas for FCI the judges expressed a low result for the white ecotypes 'Bianco Dolce' and 'BRT20' as expected.

The same behavior was observed for odor and flavor descriptors. In particular FO ranged from 4.00 for 'Bianco Dolce' to 4.90 for 'Golden Nugget' and LF ranged from 4.08 for 'Bianco Dolce' to 5.50 for 'Golden Nugget'. Similar appreciation was expressed by the judges for the appearance and flavor descriptors of 'Golden Nugget' in Spain [48].

Among taste parameters, for S, except 'Nespolone di Trabia' (3.20), all the observed genotypes showed values ranging from 4.41 for 'Marcenò' to 6.80 for 'Virticchiara'. Acid ranged from 1.60 for 'Virticchiara' followed, as expected by 'Bianco Dolce' and 'BRT20', to 4.83 for 'Peluche'. All genotypes exhibited very low values for B ranging from 1.58 for 'BRT20' to 2.92 for 'Peluche' and AS that ranged from 2.10 for 'Virticchiara' to 4.41 for 'Nespolone di Trabia'.

Even if J value ranged from 5.25 for 'Bianco Dolce' to 6.70 for 'Sanfilippara' fruits maintained very high H values that ranging from 6.08 for 'BRT20' to 7.20 for 'Sanfilippara'.

3.3 Relationships between sensory and chemical attributes

The sensory results agreed quite well with the physicochemical data. 'Bianco Dolce', 'BRT20' and 'Golden Nugget' reached the highest scores for S and at the same time presented the highest SSC. Moreover these genotypes scored the lowest values for A and the lowest values of TA. In opposition, 'Marcenò' and 'Nespolone di Trabia' scored the highest values of A and B and reached the highest values of TA. SSC/TA values confirm this relationship between instrumental and sensory analysis. A similar correlation was evidenced between the highest FCI and GCI values in association with FC and GC scores for the genotypes 'Golden Nugget' and 'Sanfilippara'. The same behavior was observed for the same qualitative parameters in the whitefleshed cvs Bianco Dolce and BRT20.

3.4 Multivariate analysis

When the 24 fruit quality attributes were considered together, PCA showed that nearly 98% of the variability observed was explained by the first six components (*table* V). PC1, PC2 and PC3 accounted for 38.9, 245 and 141 respectively of the total variability. Table V shows the correlation between the original variables and the first three PCs: PC1 represents mainly H, FCI, LO, A, B, AS, HF FW, LD, TA, SSC/TA and FL/SE; PC2 explains GCI, ES, HO, S, J, LF FF, SW and SSC; PC3 represents EP and FO Although the number of principle components considered does not allow an easy interpretation of associations (*table* VI), further analyses with perceptual mapping procedures (biplot) and clustering produced some interesting results. In particular, the analysis revealed some expected associations such as the one between SSC, SSC/TA and

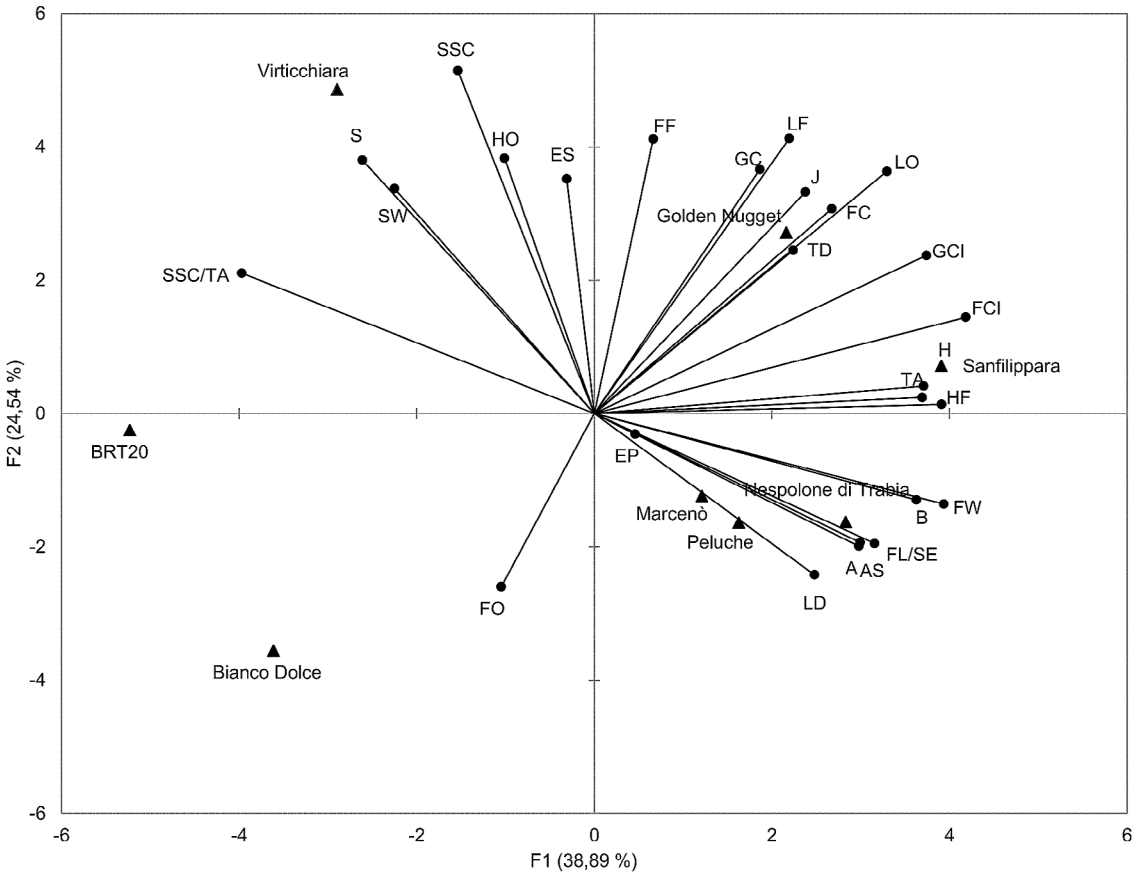

Figure 2. Two-dimensional positioning of cultivars and physical, chemical and sensory attributes determined by Biplot technique (PCA). Open and closed symbols indicate the two groups obtained by k-means clustering of object and vector coordinates. Hardness (H); Ground color (GC); Flesh color (FC); Easy peel (EP); Easy stone (ES); Loquat odor (LO); Herbaceous odor (HO); Floral odor (FO); Sweet (S); Acid (A); Bitter (B); Astringent (AS); Juiciness (J); Loquat flavor (LF); Herbaceous flavor (HF); Floral flavor (FF); Fruit weight (FW); Longitudinal diameter (LD); Trasversal diameter (TD); Seed weight (SW); Flesh Color Index (FCI); Ground Color Index (GCI); Total soluble solids (SSC); Titratable acidity (TA).

S or A, AS and B or LO and LF; some other interesting relationships were observed between instrumental and sensory attributes such as the association between GC and FC with GCI and FCI or TA and HF (*figure* 2). Based on this positioning on the biplot, some expected relationships are shown by PCA, such as an opposite relationship between SSC/TA and TA, between SSC/TA and B, between A and S, between AS and S (*figure* 2). PCA also revealed some direct relationships between SSC and S, between SSC/TA and S, between FO and LO, between J and LO, between J and LF, between HF and H; in addition, some other interesting relationships have been revealed, such as a direct relationship between GCI and FCI, between GCI and LO. Specifically, cluster analyses in this case indicated that 'Golden Nugget' and 'Sanfilippara' form one group and are positioned in the top right quadrant along with FF, GC, LF, J, FC, LO, GCI, FCI, H and TA; 'Marcenò', 'Peluche' and 'Nespolone di Trabia' form a second group and are spread in the bottom right quadrant with FW, FL/SE, AS, A, LD and EP; 'Bianco Dolce' and 'BRT20' form a third group and are positioned in the bottom left quadrant with FO (*figure* 2); 'Virticchiara' was located alone in the top right left quadrant with ES, HO, SSC, S, SW, SSC/TA. Cultivar grouping did not indicate any separation related to origin or ripening season but white flesh cultivars were separated from the rest.

Table V. Eigenvalues and proportion of total variability among loquat cultivars as explained by seven principal components (PC).

PC	Eigenvalue	Variance (%)	Cumulative variance (%)
1	10.11	38.90	38.89
2	6.38	24.54	63.44
3	3.66	14.111	77.55
4	2.22	8.57	86.12
5	1.61	6.22	92.33
6	1.37	5.30	97.63
7	0.61	2.37	100.00

4 Conclusion

Sensory results validate the analytical data indicating the virtue of this approach in evaluating loquat fruit quality. On

Table VI. Component loadings for quality attributes and component scores for cultivars from PCA. Hardness (H); Ground color (GC); Flesh color (FC); Easy peel (EP); Easy stone (ES); Loquat odor (LO); Herbaceous odor (HO); Floral odor (FO); Sweet (S); Acid (A); Bitter (B); Astringent (AS); Juiciness (J); Loquat flavor (LF); herbaceous flavor (HF); Floral flavor (FF); Fruit weight (FW); Longitudinal diameter (LD); Transversal diameter (TD); Seed weight (SW); Flesh Color Index (FCI); Ground Color Index (GCI); Total soluble solids (SSC); Titratable acidity (TA).

Factors	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Quality attributes			*Component loadings*				
H	0.8206	0.0725	0.1407	0.4655	0.2079	0.0404	0.2001
GC	0.4123	0.6433	0.4381	0.0273	0.1249	–0.3743	–0.2605
FC	0.5920	0.5402	–0.2493	–0.2360	0.1891	–0.4002	–0.2097
EP	0.1020	–0.0545	0.9868	–0.0590	0.0204	–0.0623	–0.0716
ES	–0.0685	0.6184	0.5373	–0.3464	–0.1795	0.4148	0.0050
LO	0.7290	0.6383	–0.1938	0.0163	–0.0054	0.1516	–0.0155
HO	–0.2236	0.6734	–0.0070	0.4387	0.5338	0.1365	0.0211
FO	–0.2315	–0.4566	0.6365	0.5460	0.1414	0.1182	0.0245
S	–0.5775	0.6683	–0.1516	0.2854	–0.2385	–0.1685	–0.1736
A	0.6983	–0.3427	–0.3062	–0.3947	0.3681	0.0988	0.0101
B	0.8705	–0.2385	–0.1831	0.0525	–0.0241	0.3841	–0.0293
AS	0.6590	–0.3498	0.3285	–0.4305	0.1863	0.2418	–0.2388
J	0.5261	0.5843	0.2108	0.0196	–0.1755	0.5534	–0.0065
LF	0.4860	0.7254	–0.1549	–0.3189	–0.3248	0.0768	0.0231
HF	0.8171	0.0425	–0.2248	0.1620	–0.2354	–0.2372	0.3770
FF	0.1470	0.7239	0.0857	0.6255	–0.1981	0.0949	–0.0871
FW	0.8025	–0.2277	–0.3153	0.3006	0.2685	–0.0357	–0.2024
LD	0.5484	–0.4253	–0.4618	0.4616	–0.1098	0.1689	–0.2267
TD	0.4954	0.4304	0.4900	–0.0658	0.5308	0.0124	0.2073
SW	–0.4978	0.5931	–0.4372	–0.1080	0.4165	0.0920	–0.1251
FCI	0.9257	0.2541	–0.2452	0.1152	0.0166	0.0043	0.0703
SSC	0.8273	0.4169	–0.2392	–0.1616	–0.2375	–0.0343	0.0304
TA	–0.3400	0.9044	0.1517	–0.0277	–0.0397	–0.1753	0.1019
SSC/TA	0.8651	0.0241	0.4108	–0.0624	–0.0061	–0.2791	0.0221
FL/SE	–0.8782	0.3702	–0.1466	0.0247	0.0219	0.2536	–0.0694
Cultivars			*Component scores*				
Golden Nugget	2.1625	2.7172	–0.8684	0.2045	2.0604	–1.7967	0.3379
Peluche	1.6282	–1.6333	–4.3203	0.5468	–0.0840	1.0733	–0.3978
Marcenò	1.2118	–1.2349	0.2890	–3.0126	–1.2162	–1.1536	–0.6274
Sanfilippara	3.9077	0.7184	2.3690	2.1228	–0.7598	0.2196	–0.9505
Nespolone di Trabia	2.8310	–1.6239	1.6445	–0.9487	0.6360	1.5041	1.3047
Virticchiara	–2.8960	4.8598	–0.4668	–0.1295	–1.6243	0.6012	0.5598
Bianco Dolce	–3.6136	–3.5559	0.2321	1.6678	–0.7493	–1.3489	0.7004
BRT20	–5.2316	–0.2474	1.1210	–0.4511	1.7372	0.9010	–0.9271

the other hand, this study proved that fruits of local Sicilian cultivars ('Sanfilippara', 'Nespolone di Trabia', 'Virticchiara', 'BRT20' and 'Bianco Dolce') have very interesting physical, chemical and sensory profiles, leading to reasonably good overall fruit quality. In fact, among the affirmed cultivars widely used for loquat cultivation, both 'Peluche' and 'Golden Nugget' confirmed in this study their commercial value expressing very interesting physicochemical and sensory characteristics and a good overall fruit quality. 'Peluche' fruit size was smaller in respect to other studies but this result was due to the organic farming technique of cultivation and it was defective only in ground color. Similar interesting features were observed in the local cvs Sanfilippara and Nespolone di Trabia in terms of fruit size, fruit color, and several sensory descriptors except, in this last ecotype, for sweet and astringent. In other local cultivars such as 'Virticchiara' the good physicochemical properties and the excellent taste characteristics were accompanied by a limited fruit size and a less than optimal flesh/seed ratio. The white flesh cultivars, even if characterized by a pale peel and flesh color revealed good chemical and taste properties. Finally, the main conclusion is that this physicochemical and sensory study proved that the local cultivars show interesting results and a wide range of interesting marketable characteristics in comparison with the affirmed

varieties. However, further research is needed on these cultivars in terms of nutraceutical and aromatic characteristics.

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