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Instrumental and sensory evaluation of seven apple (*Malus domestica* Borkh.) cultivars under organic cultivation in Sicily

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Abstract. In this trial we examined the quality of 7 clones belonging to more diffused apple polyclonal varietal groups, using chemical/physical and sensory analyses during two consecutive years. *Galaxy,* and their ameliorative clones *Gala Annaglò*® and *Dalitoga* (Gala clones) that ripen in summer, *Erovan* Early Red One*® and *Scarlet Spur*-Evasni*® (Red Delicious clone), *Corail Pinova* and its ameliorative clone *RoHo 3615 * Evelina*® that ripen in autumn were studied. *Gala Annaglò*® is interesting for the fruit size and peel color, *Dalitoga* for the early ripening and *Galaxy* for the crunchiness and consistency. All the Gala clones reached very high total solid soluble content confirmed by the panel judgment of the sweetness and acidity descriptors. The Red Delicious clones confirm the larger size and the high colorimetric standard of all covered red fruits; the new clone *Scarlet Spur*-Evasni*® reached an interesting fruit size and peel colour intensity and uniformity, and the best total solid soluble content to total acidity ratio confirmed by the sensory descriptors of acidity and sweetness. Moreover, it reached very high values of crunchiness, consistency and interesting values of apple flavour, honey flavour and fruit flavour. The ameliorative clone *RoHo 3615*Evelina*® was characterized by well uniform and intense coloured fruits and a more balanced total solid soluble content to total acidity ratio, and interesting values of crunchiness, consistency, apple flavour, honey flavour and fruit flavour. This study confirms the relationship between instrumental and sensory analysis.

Key words: *fruit quality, soluble solid content, titratable acidity, ground colour, panel test.*

INTRODUCTION

In Sicily apple cultivation is very ancient Nicosia (Nicosia, 1735) and it is witnessed by local genotypes selected for growing and cultivated mostly in fairly remote mountainous and hilly areas (750–850 m a.s.l.). In the last decade, a progressive renewal of these traditional orchards was based on the introduction of affirmed commercial cultivars (Lo Bianco & Farina, 2012). The choices of the apple varieties are determined by the request of a market based on quality, consistency and continuity in availability of the product. As a result, apple cultivation in Italy is oriented towards cultural standardization through 4–5 polyclonal varietal groups (Golden Delicious, Red Delicious, Fuji and Gala) characterized by specific and recognized quality characteristics (Farina & Di Marco, 2009) following European trends. These commercially affirmed cultivars, although they have reached high levels of quality, are characterized by a progressive varietal turnover with the introduction of new ameliorative clones (Sansavini et al., 2005, Kellerhals et al., 2008). In fact, over the past decade, there have been some major changes in the marketplace that are likely to have resulted in an increasing expectation of the eating quality of the apples. So even when the quality of apples remains the same, outside influences are driving up consumer expectations of apple taste (Harker et al., 2008). In particular, recent studies indicate that there is interest for both local and domestic apple production among the consumers (Denver & Jensen, 2014).

Quality of fruit is made of its external and internal factors such as size, shape, colour, taste, aroma, crunchiness and firmness (Abbott et al., 2004, Talluto et al., 2008).

Generally, researchers have tried to use measurements of flesh firmness, soluble solids content and titratable acidity to define quality (Hoehn et al., 2003).

Unfortunately, eating quality is difficult to measure objectively. Analytical measurements, soluble solids content, titratable acidity must be correlated with sensory perceptions of sweetness and sourness (Harker et al., 2002b). Flesh firmness relates to the mechanical properties (texture) of the apple flesh, mouthfeel, and juiciness and is important for consumers (Daillant-Spinnler et al., 1996) which associate them with positive characteristics such as freshness (Fillion & Kilcast, 2002). Several researchers have found a good relationship between sensory scores (obtained using a trained panel) and instrumental measurements of apple texture (Abbott et al., 1994; Karlsen et al., 1999; Harker et al., 2002a), total soluble solids content (TSSC), titratable acidity (TA) and consumer acceptability of fruit (Vangdal, 1985; Fellers, 1991; Mitchell et al., 1991). Other studies indicated that quantitative measurements of acids, TSSC and TSSC/TA ratio did not appear good predictors of taste and flavour in apples whereas TA was always amongst the best predictors of sensory attributes of acid taste, overall flavour, and apple flavour (Harker et al., 2002b).

The recent developments in the field of sensory evaluation and instrumental analysis further accentuate the interface between humans (sensory science) and machines (instrumental analysis) (Ross, 2009). More recently, several studies have focused on the quality of many fruits using instrumental and sensory analyses (Allegra et al., 2015; Montevecchi et al., 2013; Sortino et al., 2015; Gentile et al., 2016), and specifically on apples (Karlsen et al., 1999; Donati et al., 2006; Skendrović Babojelić et al., 2007). Taste panel data have been used to assess preferences among standard and newer apple cultivars (Stebbins et al., 1992; Røen et al., 1996) and as a selection tool in apple breeding (Hampson et al., 2000). Other studies have used sensory analysis to evaluate differences and preferences among clones of Gala, Red Delicious and Jonagold (Kappel et al., 1992; Greene & Autio, 1993). Several researches have demonstrated a relationship between the sensory perceptions of apple texture (firmness, crispness, crunchiness) and instrumentally measured parameters in order to predict fruit quality (Abbott et al., 1994; Mehinagic et al., 2004).

However, the relationship between instrumental data and consumer acceptability is cultivar specific, and there is insufficient information to make recommendations.

The aim of this work was to define the quality characteristics of seven apple cultivars and their ameliorative clones under organic cultivation in mountainous areas of Sicily investigating the relationship between instrumental (firmness, soluble solids content and titratable acidity) and sensory (taste, odour and flavour) measurements.

MATERIALS AND METHODS

The trial was conducted in an experimental orchard in Caltavuturo (Palermo, 37° 49' N and 850 m a.s.l.) in central Sicily, Italy. Seven apple varieties were considered in this work: *Galaxy, Gala Annaglò®* and *Dalitoga* (Gala clones) that ripen in summer, *Erovan* Early Red One®*, *Scarlet Spur*-Evasni®* (Red Delicious clone), *Corail Pinova* and its clone *RoHo 3615 * Evelina®* that ripen in autumn.

Three 10-year-old trees per each cultivar were selected. Trees were grafted on M9 rootstock, trained to a central leader and planted in North-South direction with an inter-trees spacing of 1.5 m and 5 m between rows.

The soil was classified as sandy clay loam with pH 7.3 and 1.8% active carbonates. The irrigation system was drip irrigation and trees were submitted to organic farming cultural care (Reg. 834/2007 ex-EEC EEC 2092/91 no).

Fruits were collected at commercial ripening stage (Table 1) using starch pattern index (rated between 1 = no staining and 5 = complete staining) as the maturity index (Peirs et al., 2002).

Table 1. Harvest dates and starch indexes (1–5 scale) of the 7 apple cultivars in the trial

Cultivar	Harvest date		S. Index	
	1st year	2nd year	1st year	2nd year
Galaxy	18-Aug	14-Aug	2.80	3.05
Gala Annaglò®	23-Aug	18-Aug	2.78	2.93
Dalitoga	16-Aug	12-Aug	2.45	2.71
Erovan Early Red One®*	07-Sep	01-Sep	2.10	2.20
Scarlet Spur-Evasni®*	11-Sep	03-Sep	1.95	2.11
Corail Pinova	06-Sep	01-Sep	3.62	3.51
*RoHo 3615*Evelina®*	06-Sep	02-Sep	3.47	3.71

At commercial ripening a sample of 30 fruits x tree x cultivar were collected and submitted to analytical and sensory evaluations. Biometrical and physical-chemical characteristics were also observed: flesh firmness (FF) expressed in kg cm^{-2}, total soluble solid content (TSSC) expressed in % (Brix°), titratable acidity (TA) expressed in g L^{-1} of malic acid and TSSC/ TA ratio. Fruit weight (FW) was determined by digital scale, longitudinal diameter (LD) and transversal diameter (TD) by digital caliper TR53307 (Turoni, Forlì. Italy), FF by digital penetrometer TR5325 (Turoni, Forlì. Italy), TSSC by digital refractometer Atago Palette PR-32 (Atago Co., Ltd. Tokyo. Japan), TA and pH using a CrisonS compact titrator (Crison Instruments. SA. Barcelona. Spain).

Ground colour and cover colour as well as starch index were determined via digital image analysis of each fruit by Fruit Analysis System (F.A.S.) (Francaviglia et al., 2013). Digital images were used to determine percentage and intensity of peel red color. In particular, we used an algorithm that converts images from RGB (additive color model in which red, green and blue light are added together in various ways to reproduce a broad array of colors) to CIE L*a*b* (mathematic description of all perceivable colors in the three dimensions ***L*** for lightness and ***a*** and ***b*** for the color opponents green–red and blue–yellow) format. It extracts the fruit from the image (removing the image background), separates the total fruit area into two sub-regions: cover colour (closer to red) and ground colour (closer to green) according to an adjustable green–red threshold, and quantizes colour characteristics of each region as the weighed distance of each pixel in the image from pure green (ground colour) or pure red (cover colour). The output is an index (CI) for the cover colour ranging from 0 (no red) to 1 (red). Percentage of cover colour was calculated dividing the number of pixels of the red region by the number of pixels of the entire fruit area. Cover colour fruit area was expressed as a percent of total surface (CP).

The sensory profile (UNI 10957, 2013) was defined on a subsample of 10 fruits per tree per cultivar by a panel of 10 judges (five female and five male) who evaluated the intensity of each attribute by assigning a score between 1 (absence of the sensation) and 9 (extremely intense). All panelists were trained at Catania University and have a wide expertise in sensory evaluation of foods and in particular in fruits (Farina et al., 2010; Mazzaglia et al., 2010; Farina et al., 2011; Liguori et al., 2014; Farina et al., 2016). In a preliminary meeting, 19 attributes were generated, on the basis of frequency of citation (> 60%), as listed below: six for odour (Apple – AO; Vegetal – VO; Honey – HO; Fruit – FO; Almond – ALO; Off – OFO) three for tastes (Acid – A; Sweet – S; Bitter – B), four for rheological (Juiciness – J; Consistency – C; Crunchiness – CR; Sponginess – SP), six for flavour (Apple – AF; Vegetal – VF; Honey – HF; Fruit – FRF; Almond – ALF; Offtaste – OFF). 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. In each session, the panelists tested all cultivars under study; the sample order for each panelist was randomized and water was provided for rinsing between apple 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. Biosystemes. Couternon. France).

Data analysis was carried out using the program SYSTAT v.11 (SYSTAT Software Inc.). Statistical significance was defined at $P < 0.05$. Differences between apple samples according to physicochemical characteristics were investigated with a one-way ANOVA using cultivars as main factors. The sensory data for each attribute were submitted to analysis of variance (one-way ANOVA), with samples as effects. The significance of these effects was assessed by F-tests.

RESULTS AND DISCUSSIONS

Gala fruits were ready to be harvested in the second half of August, in particular, *Dalitoga* had the earliest maturation followed by *Galaxy* and *Gala Annaglò*®; Red Delicious clones and Pinova clones reached commercial harvest during the first half of September (Table 1). Although the three Gala clones ripen in the summer, earlier than the other, Red Delicious and Pinova clones were harvested in early autumn, so the ripening times were quite similar for all clones. Dalitoga was harvested before Galaxy enlarging the harvest window. Starch index indicated that all fruits had reached their commercial ripening (Angelini et al., 2008).

The analysis of pomological traits showed wide variability among the different clones. The analysis of variance of the internal (Table 2) and external (Table 3) quality parameters highlights significant differences between different polyclonal groups and between clones. All examined clones reached the legal standards for the edible quality of apples that have been in place in many apple-growing regions of the world (Harker et al., 2008) through a numerical lower limit for commercial size, diameter or fruit weight (Reg. CE n.85/2004). In particular, fresh weight ranging from 162.12 g of *Dalitoga* and 235.69 g of *Scarlet Spur*-Evasni*®. Among Gala clones, *Gala Annaglò*® have the best fresh weight. Red Delicious clones produce the biggest fruits, in particular *Scarlet Spur*-Evasni,* with a very interesting size. The two Pinova clones had the same fresh weight. An elevated commercial size is more appreciated by the consumer and it sprouts prices that are more profitable for the producers. In this case, all the fruit were classified in the 'extra' size.

Table 2. Pomological traits of 7 apple cultivars in the trial. Mean of two years ±SD ($n = 90$)

Varietal group	Cultivar	FW (g)	LD (mm)	TD (mm)	LD/ TD	FF (kg cm^{-2})	GCI	CP (%)
	Galaxy	158.00 ± 4.21d	63.22 ± 2.21 d	60.02 ± 2.25 b	1.05 ± 0.04 c	6.90 ± 0.89 ns	0.876 ± 0.004 b	92.4 ± 2.15 b
	Gala Annaglò®	168.48 ± 4.21 c	67.36 ± 3.25 c	63.32 ± 2.42 b	1.06 ± 0.05 c	6.78 ± 0.75 ns	0.901 ± 0.005 ab	97.3 ± 2.12 a
	Dalitoga	162.12 ± 5.42 cd	58.40 ± 2.68 d	73.88 ± 2.65 a	0.79 ± 0.04 d	6.81 ± 0.70 ns	0.871 ± 0.004 b	90.1 ± 2.05 b
	Erovan Early Red One®*	187.56 ± 6.25 b	77.47 ± 3.24 ab	63.56 ± 2.67 b	1.21 ± 0.03 a	6.44 ± 0.58 ns	0.902 ± 0.005 ab	92.5 ± 2.65 b
	Scarlet Spur -Evasni*®	235.29 ± 8.22 a	82.94 ± 2.41 a	72.39 ± 2.89 a	1.14 ± 0.06 ab	6.24 ± 0.98 ns	0.931 ± 0.004 a	98.2 ± 2.03 a
	Corail Pinova	165.00 ± 5.21 c	70.22 ± 2.65 b	63.58 ± 2.68 b	1.10 ± 0.05 b	6.20 ± 0.87 ns	0.872 ± 0.005 b	92.3 ± 2.23 b
	RoHo 3615 Evelina*®	166.25 ± 5.68 c	71.59 ± 3.21 b	64.12 ± 2.41 b	1.11 ± 0.04 b	6.51 ± 0.78 ns	0.903 ± 0.004 ab	97.1 ± 2.41 a

Fruit Weight – FW; Longitudinal Diameter – LD; Transversal Diameter – TD; LD/TD Ratio; Flesh Firmness – FF; Colour Index – CI; Percentage of cover colour – CP. The values marked with different letters in the same column indicate significative significant differences ($P \leq 0.05$).

Table 3. Physicochemical parameters of 7 apple cultivars in the trial. Mean of two years ±SD (= 90)

Varietal group	Cultivar	TSSC (°brix)	AT (g L^{-1})	TSSC/AT	PH
	Galaxy	16.50 ± 0.42 a	4.10 ± 0.20 d	4.02 ± 0.09 a	3.05 ± 0.05 ns
	Gala Annaglò®	15.50 ± 0.45 b	4.83 ± 0.18 b	2.29 ± 0.07 c	3.04 ± 0.04 ns
	Dalitoga	16.80 ± 0.65 a	4.23 ± 0.21 c	3.97 ± 0.08 a	2.95 ± 0.05 ns
	Erovan Early Red One®*	16.15 ± 0.51 a	7.31 ± 0.19 a	2.51 ± 0.09 c	2.93 ± 0.04 ns
	Scarlet Spur-Evasni*®	13.80 ± 0.42 c	4.46 ± 0.17 c	3.09 ± 0.07 b	3.02 ± 0.04 ns
	Corail Pinova	16.50 ± 0.39 a	6.80 ± 0.23 a	2.43 ± 0.08 c	3.02 ± 0.05 ns
	*RoHo 3615*Evelina*®	14.05 ± 0.38 c	7.02 ± 0.20 a	2.00 ± 0.08 d	3.05 ± 0.06 ns

Total soluble solids content – TSSC; Titratable Acidity – TA; TSSC/TA ratio and pH. The values marked with different letters in the same column indicate significantly differences ($P \leq 0.05$).

LD/TD ratio indicated uniform oval rounded shape for *Galaxy* and *Gala Annaglo®* and oblong shape for Pinova clones and Red Delicious clones*:* Gala clones had the typical rounded shape whereas Red Delicious the typical heart-shaped fruit. Firmness and SSC can explain an important portion of consumer preferences for apples (Harker et al., 2008). FF values were no less than 6.00 kg cm^{-2} and were similar for all the observed cultivars ranging from 6.20 of *Corail Pinova* to 6.90 of *Galaxy.* In every case, FF is compatible with the commercial standard and favourable to postharvest operations and storage. Moreover, our data are similar to the research of Harker et al. (2008) that showed a substantial increase in consumer acceptance as firmness increased from 3.7 to 6.3 kg cm^{-2}.

As expected, Red Delicious clones presented the highest CI value whereas CP was different inside of each clonal group (Table 2). Considering Gala clones, *Gala Annaglo®, Galaxy, Dalitoga* were characterized by the typical red coloration over the entire surface with often indistinct red over-striping. Moreover, the ameliorative clone *Gala Annaglo®* presented the highest CI and CP in respect to the other two clones. These results are in accordance with those previously reported by Iglesias et al. for Galaxy (2008). Moreover, the intensity of red colouration was strongly related to the total surface area covered as reported by White & Johnstone (1991).

Among Red Delicious clones*, Scarlet Spur*-Evasni* showed the appearance with the highest CI and CP values. *RoHo 3615*Evelina®* fruit was characterized by very attractive uniform intense red coloured peel. This last was selected as an ameliorative clone of Pinova and confirms this aim with higher values of colour index and cover colour percentage in respect to *Corail Pinova*. The ameliorative clones of each polyclonal group that present more intense fruit coloration and uniformity could have a higher economical value. In fact, today retail groups (GD) and supermarket chains (DO) tend to show some preference for more uniform and more intense coloured fruits. Colour must be considered as a primary trait to select for, since consumers are strongly attracted to well coloured fruits, especially for Gala clones (Iglesias et al., 2008).

TSSC values were, for all cultivars, compatible with commercial standards of fresh fruit, but the highest contents were recorded in *Galaxy*, *Erovan* Early Red One®* and *Corail Pinova*, the oldest clones of each group. In every case, all observed clones reached very high values ranging from 13.80 to 16.50 in respect to the standard varietal values (Angelini et al., 2008). Fruit acceptability was positively affected by high TSSC (Harker et al., 2008) The lowest TA content was observed in Gala clones followed by Red Delicious, whereas Pinova clones, as expected, showed the highest values.

In our experiment, TSSC/TA ranging from 2.00 in *RoHo 3615*Evelina®* to 4.02 in *Galaxy*. As expected the Gala clones produced the sweetest fruit and Pinova the more acidic fruit. pH does not differ significantly between the varieties.

By the results of the sensory attributes (Table 4) the observed cultivars differed significantly for the descriptors VO, FO, A, S, B, C, CR, SP, J, AF, VF, HF, FRF, and OFF. Sensory profiles are described in Fig. 1.

Table 4. Sensory profiles of the 7 observed apple cultivars as evaluated by a trained panel. Mean of two years ±SD (n = 90)

Descriptors	*Galaxy*	*Gala Annaglò®*	*Dalitoga*	*Erovan* Early Red One®*	*Scarlet Spur* - Evasni®*	*Corail Pinova*	*RoHo 3615* Evelina®*
Apple odour	$6.6^{n.s.}$	6.0	6.5	5.8	7.0	5.6	6.0
Vegetal odour	5.5^{a}	4.5^{b}	5.5^{a}	5.1^{ab}	4.3^{b}	5.1^{ab}	5.5^{a}
Honey odour	$4.3^{n.s.}$	4.1	4.1	4.0	3.6	3.8	4.5
Fruit odour	4.8^{ab}	3.5^{c}	4.4^{ab}	5.1^{a}	4.5^{b}	5.0^{a}	4.7^{ab}
Almond odour	$3.1^{n.s.}$	3.3	3.0	3.3	3.0	3.6	3.5
Off odour	$2.5^{n.s.}$	2.4	2.0	2.3	2.1	1.8	2.1
Acid	3.4^{b}	3.3^{b}	6.1^{a}	5.8^{a}	3.3^{b}	5.1^{a}	5.8^{a}
Sweet	7.3^{a}	5.8^{ab}	5.2^{bc}	5.5^{b}	6.3^{a}	4.6^{c}	5.2^{bc}
Bitter	2.2^{b}	2.4^{b}	3.0^{ab}	2.7^{b}	2.4^{b}	3.3^{a}	2.8^{ab}
Consistency	5.4^{b}	4.6^{c}	5.2^{b}	4.3^{c}	7.0^{a}	5.1^{bc}	6.4^{ab}
Crunchiness	6.1^{ab}	4.3^{c}	5.5^{bc}	4.7^{bc}	6.3^{ab}	5.4^{bc}	7.5^{a}
Sponginess	5.4^{b}	7.1^{a}	5.8^{ab}	6.4^{a}	5.0^{b}	6.6^{a}	5.5^{b}
Juiciness	6.2^{b}	4.7^{c}	5.2^{bc}	6.8^{ab}	7.1^{a}	6.2^{b}	7.4^{a}
Apple flavour	6.2^{ab}	5.4^{b}	5.3^{b}	5.4^{b}	7.2^{a}	6.0^{ab}	6.3^{ab}
Vegetal flavour	5.1^{a}	4.0^{b}	4.5^{ab}	4.4^{ab}	4.5^{ab}	4.6^{ab}	4.2^{b}
Honey flavour	3.3^{b}	4.5^{a}	3.2^{b}	3.6^{b}	3.8^{ab}	3.6^{b}	4.7^{a}
Fruit flavour	6.1^{a}	3.6^{c}	4.3^{bc}	4.3^{bc}	4.5^{bc}	5.7^{ab}	5.0^{b}
Almond flavour	$2.8^{n.s.}$	2.8	2.6	2.3	2.6	3.6	3.7
Off flavour	2.8^{ab}	3.2^{a}	2.1^{b}	3.5^{a}	2.2^{b}	1.7^{c}	1.7^{c}

The values marked with different letters in the same column indicate significant differences ($P \leq 0.05$).

In particular, for odour descriptors, vegetal odour ranged from 4.3 for *Scarlet Spur* -Evasni®* to 5.5 of *Galaxy, Dalitoga,* and *RoHo 3615* Evelina®*. The greatest intensity of fruit odour was observed in *Erovan* Early Red One®* (5.1) and *Corail Pinova* (5.0) whereas *Gala Annaglò®* (3.5) showed lower intensity. As expected, *RoHo 3615* Evelina®* (5.8) and *Corail Pinova* (5.1) had the highest intensity of acid descriptor: this fact confirms the high value of TA and the low TSSC/TA ratio. These fruit was perceived as less sweet due to the fact that this apple is the ones that presents higher acidity. On the contrary, *Dalitoga* (6.1) showed a high value of acid descriptor whereas chemical-physical data indicated not acid fruit. In this study, °Brix/titratable acidity ratio was the best predictor of consumer response. The sweetest fruits were *Galaxy* (7.3), *Gala Annaglò®* (5.8) and *Scarlet Spur* -Evasni®* (6.3), and this confirmed the TSSC/AT ratio. As observed by Harker et al. (2002) there is a good relationships between °Brix/titratable acidity ratio and consumer acceptability of fruit.

Bitterness ranged from 3.3 for *Corail Pinova* to 2.2 for *Galaxy*. The judges expressed a low appreciation in regard to consistency for *Gala Annaglò®* (4.6) and *Erovan* Early Red One®* (4.3) fruits; on the contrary the highest values were observed in *Scarlet Spur* -Evasni®* (7.0) and *RoHo 3615* Evelina®* (6.4). The sensory evaluation of fruit consistency was not directly correlated with because analytical evaluation did not consider many parameters such as texture as observed by Harker (2002a). Similar behaviour was observed for crunchiness: *RoHo 3615* Evelina®* (7.5) and *Scarlet Spur* -Evasni®* (6.3) showed the highest values with the exception of Galaxy (6.1) while *Gala Annaglò®* reached the lowest intensity. For the sponginess, *Gala Annaglò®*, *Corail*

Pinova and *Erovan* Early Red One*® followed by the other three cultivars. On the other hand, *Scarlet Spur* -Evasni*® (7.1) and *RoHo 3615* Evelina*® (7.4) has the greater intensity of juiciness, whereas *Gala Annaglò*® has the lesser intensity. For flavour descriptors, apple flavour was greater in *Scarlet Spur* -Evasni*® (7.2) followed by *RoHo 3615* Evelina*® (6.3)*,* *Galaxy* (6.2) and *Corail Pinova* (6.0); *Galaxy* (5.1) had the highest value while *Gala Annaglò*® (4.0) and *RoHo 3615* Evelina*® reached the lowest values (4.2); Honey flavour ranged from 4.7 of *RoHo 3615* Evelina*® and 3.2 of *Dalitoga*; *Galaxy* (6.1) and *Corail Pinova* (5.7) showed the highest fruity flavour values; on the contrary, *Gala Annaglò*® reached the lowest value (3.6). Finally, relating to the off flavour, all the values were very low ranging from 3.2 to 1.7.

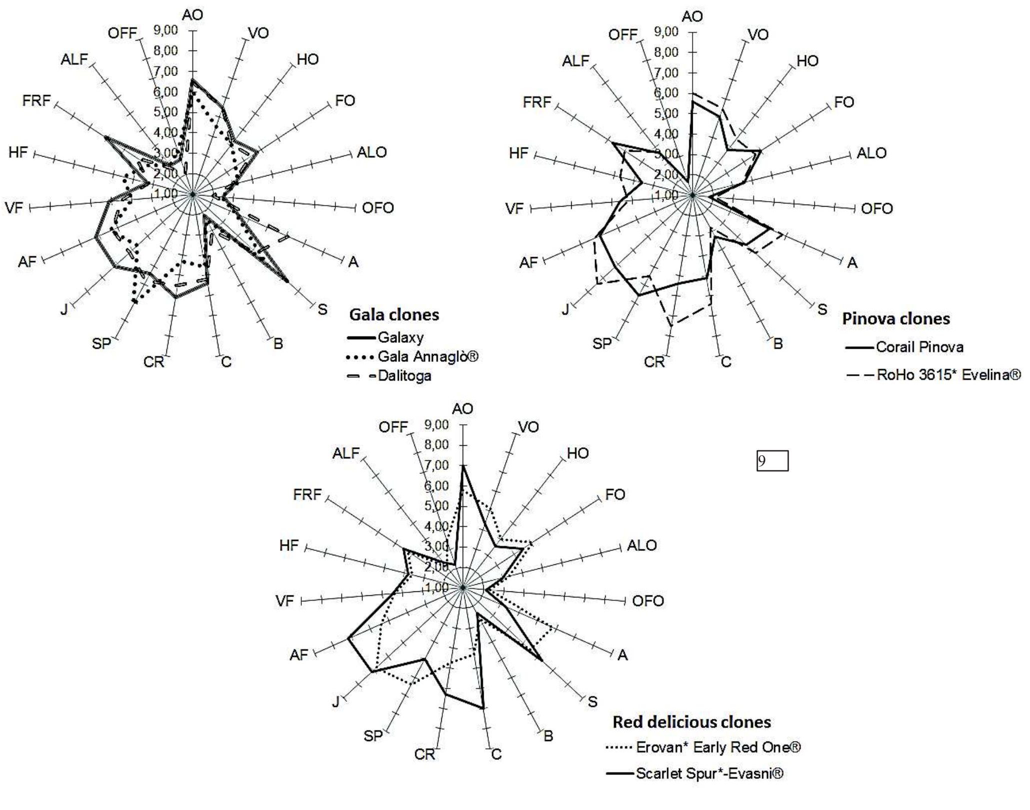

Figure 1. Spider plot of the observed apple fruits. AO – Apple odour; VO – Vegetal odour; HO – Honey odour; FO – Fruit odour; ALO – Almond odour; OFO – Off odour; A – Acid; S – Sweet; B – Bitter; C – Consistency; CR – Crunchiness; SP – Sponginess; J – Juiciness; AF – Apple flavour; VF – Vegetal flavour; HF – Honey flavour; FRF –Fruity flavour; ALF – Almond flavour; OFF – Off flavour.

The comparison between sensory and chemical attributes showed some interesting relations (Table 5). The instrumental quality measurements for apple cultivars were well correlated with the several sensory attributes. Flesh firmness was positive correlated with off odour (0.6638) and negative correlated with honey odour (-0.6458). Total solid soluble content was positive correlated with sweet (0.8973), apple flavour (0.6637) whereas negative correlated with consistency (-0.8092*) and honey flavour (-0.6349).

TSSC/TA was inverse correlated with vegetal flavour (**-0.7643)**. Inverse correlations were determined between tritatable acidity and apple odour (**0.6502)**, and positive correlation between tritatable acidity and almond odour (**0.7697)**.

Table 5. Coefficients of correlation between flesh firmness (FF), total soluble solids (TSSC), titratable acidity (TA) and sensory attributes in apple fruits

Sensory attributes	FF	TSCC	TA	TSSC/TA
Apple odour	-0.3943	-0.2556	-0.6502*	0.4826
Vegetal odour	0.4049	0.4203	0.1829	0.2833
Honey odour	-0.6458*	0.0535	0.1116	-0.0413
Fruit odour	-0.4456	0.2281	0.5210	0.0873
Almond odour	-0.4833	0.1717	0.7697	-0.7105
Off odour	0.6638*	-0.0589	-0.3723	0.2481
Acid	-0.1291	0.1623	0.5910	-0.2000
Sweet	0.4654	0.8973*	-0.6371	0.5902
Bitter	-0.4410	0.2460	0.5331	-0.2988
Consistency	-0.3372	-0.8092*	-0.2105	0.0637
Crunchiness	-0.1533	-0.5891	0.0595	0.0289
Sponginess	0.0536	0.5014	0.3325	-0.4859
Juiciness	-0.5989	-0.5163	0.4984	-0.2430
Apple flavour	-0.4940	0.6637	-0.1468	0.0463
Vegetal flavour	0.1439	0.4553	-0.3380	-0.7643
Honey flavour	-0.1177	-0.6349*	0.3499	-0.8025
Fruit flavour	-0.0852	0.3014	0.0670	0.3111
Almond flavour	-0.2840	-0.1715	0.4237	-0.4795
Off flavour	0.3778	0.3229	-0.0815	0.0568

The values marked with * indicate significant differences ($P \leq 0.05$).

CONCLUSIONS

The ameliorative clone *Gala Annaglò*® is interesting for the fruit size and peel color, *Dalitoga* for the early ripening and *Galaxy* for the crunchiness and consistency. All the Gala clones reached very high total solid soluble content confirmed by the panel judgment of the sweetness and acidity descriptors. Referring to the odour and flavour *Galaxy* clone produced a more aromatic fruit with the highest values of fruit odour, apple flavour and fruit flavour. The Red Delicious clone confirmed the larger size and the high colorimetric standard of all red covered fruits; the new clone *Scarlet Spur**-Evasni*® reached an interesting fruit size and peel colour intensity and uniformity, and the best total solid soluble content to total acidity ratio confirmed by the sensory descriptors of acidity and sweetness. Moreover, it reached very high values of crunchiness, consistency and interesting values of apple flavour, honey flavour and fruit flavour. The ameliorative clone *RoHo 3615**Evelina*® was characterized by uniform and intense coloured fruit and a more balanced total solid soluble content to total acidity ratio and good values of crunchiness, consistency, apple flavour, honey flavour and fruit flavour. The combined approach for perceptible quality profiling of apples based on sensory and instrumental techniques permitted to study a correlation between sensory and instrumental data.

Finally, although, all the varieties were cultivated in organic farming, they had reached required commercial parameters. The higher colour index, found in ameliorative clones, may result in a much greater acceptance of the fruits from the consumer generally attracted by more intense shades of red. Sensory results obtained by new clones did not exhibit any losses in the characteristics of the affirmed variety. This presents a possibility to the Sicilian apples, in particular in the organic industry, as these represent quality fruits obtained with sustainable methods.

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