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Original article

Chemical–physical characteristics, polyphenolic content and total antioxidant activity of three Italian-grown pomegranate cultivars

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ABSTRACT

Background: In Mediterranean countries, there is an increasing demand for pomegranate fruits due to their antioxidant properties and nutritional values. The large diffusion of new genotypes and cultivars requires the knowledge of all fruit characteristics in connection with the cultivation area, to satisfy the market demand. This study seeks to determine the fruit quality attributes and nutraceutical values of three pomegranate cultivars (Wonderful, Acco and Kamel) grown in the Mediterranean climate.
Methods: The fruits were evaluated for their main physico-chemical traits (weight, volume, height, width, thickness, total arils number, total arils weight, juiciness, fruit index, peel index and total soluble solids content/titratable acidity ratio), bioactive compounds (total phenolic content and total anthocyanin content) and antioxidant activities (radical scavenging activity and ferric reducing power).
Results: The data showed that Acco fruit is bigger, juicier and sweeter when compared with the cultivars Wonderful and Kamel. Wonderful is the smallest, least juicy and least sweet but the reddest among all the studied cultivars. Regarding the phenolic compounds and antioxidant activity (radical scavenging activity and ferric reducing power), cultivar Wonderful has the highest values and cultivar Acco contains the most anthocyanin content.
Conclusions: This study showed that pomegranate cultivars grown in the Mediterranean area exhibit an appreciable quality, but there are significant differences in quality properties of the arils and juice.

1. Introduction

The pomegranate (*Punica granatum* L.) is a tropical and subtropical evergreen shrub that belongs to the Punicaceae family. It is native to the Middle East and central Asia and has been cultivated since antiquity as a fruit crop. The fruit is spherical, with a tough calyx, and covered by a leathery pericarp derived from sepals and adhering floral tissue [1]. The rind encloses many seeds surrounded by juicy arils, which comprise the edible portion of the fruit.

Pomegranate grows well under sunlight, in dry and hot summers, and requires high summer temperatures for the fruit to ripen but, in winter, the plant thrives at minimal temperatures not lower than −12 °C [2]. During fruit development, a temperature of 38 °C and a dry climate, result in the best quality fruit. Conversely, high relative humidity and rain are detrimental to its cultivation [3]. For these reasons, regions of the Mediterranean basin, such as Egypt, Israel, Turkey, Italy, Spain, Portugal and Anatolia, have suitable climates for pomegranate cultivation [4,5] and show a remarkably high production and consumption of pomegranate fruits. However, pomegranate cultivation has also emerged in parts of Australia, Brazil, Argentina, South Africa and the USA [6,7]. Pomegranate fruit is consumed and sold as whole fresh fruit, juice, syrup, wine, teas and seed oil, among other products, and is valued worldwide for its health benefits [8].

Pomegranate fruit has a long history of use by humans as a food and medicine, demonstrating diverse bioactive properties and nutritional values [9–12,23], mostly associated with its antioxidant characteristics. The antioxidant activity of commercially available pomegranate juice is largely attributed to hydrolysable tannins (notably ellagic acid and derivatives and punicalagin isomers) derived from the rind [13], although other types of polyphenols, including anthocyanins, and ascorbic acid, either in combination or alone, also contribute to the antioxidant activity [16,17]. According to *in vitro* assays, commercial

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Table 1
Monthly mean temperature (C°) and relative humidity (%) and total rainfall (mm) during the three harvest seasons.

Parameter	2015			2016			2017		
	Aug	Sep	Oct	Aug	Sep	Oct	Aug	Sep	Oct
Mean temperature (°C)	25.9	21.6	17.9	24.4	23.1	19.3	24.9	22.8	20.1
Relative humidity (%)	26.3	36.6	43.2	44.4	39.7	48.9	39.8	41.4	45.3
Rain fall (mm)	11.0	21.0	34.0	29.6	16	36.4	12.0	40.0	39.0

pomegranate juice shows three-fold the antioxidant activity of red wine and green tea, and two- to six-fold that of other natural beverages, [14,15]. Cyanidin-3,5-*O*-diglucoside and pelargonidin-3,5-*O*-diglucoside are the most representative anthocyanins in different genotypes of pomegranate, and the predominance of anthocyanins over tannins helps to explain the high reducing activity [26–28]. Moreover, the anthocyanins impart the bright red colour of the juice [18–20], which is one of the major quality parameters appreciated by the consumer.

Clinical studies have revealed that the intake of polyphenols in pomegranate juice improves biochemical parameters, including biomarkers of oxidative stress, protecting against the onset of age-related and degenerative diseases [21,22], as well as chronic diseases related to over-production of free radicals [24,25]. All pomegranate polyphenols (for example, phenolic acids, punicalagins, gallic acid, catechin, chlorogenic acid, caffeic acid, epicatechin, ferulic acid, ellagic acid and kaempferol) show antioxidant activity associated with the indirect inhibition of inflammatory markers, such as tumour necrosis factor-alpha (TNF-alpha) [9]. In this context, pomegranates could be considered as a potential natural drug [9].

$>$ 500 different cultivars of pomegranate have been identified [12]. It is crucial to acknowledge all fruit characteristics to select the best cultivars to meet the market demand for quality fruits, consumer preferences, and locality, such as the upper infra-Mediterranean lower sub-humid bioclimatic belt.

Mediterranean pomegranates are based on local cultivars, and their composition can differ from those of Oriental varieties, displaying a large variety of chemical–physical traits and distinct flavour profiles. Meanwhile, modern cultivation is based on cultivars developed by breeding programs for satisfying new markets and consumer needs. The Wonderful cultivar is the most widely planted commercial pomegranate cultivar in Mediterranean countries and is the industry standard variety [29]. This cultivar was imported from the USA about 100 years ago. Its large-sized sweet-and-sour fruit contain red arils and ripen at the beginning of October. The Mediterranean basin recently introduced two additional cultivars: Kamel and Acco. Acco pomegranate is growing in importance, due to its early availability (it can be eaten from the end of summer when the Wonderful is not available), sweet flavour and deep red fruit and skin. Kamel fruit has a dark red skin that appears very early in fruit development, red arils, a sweet-sour flavour and good juice production [12].

Thus, this research reports and compares three years of data concerning the physico-chemical characteristics, antioxidant activity and the major bioactive compound content present in the cultivars Wonderful, Acco and Kamel.

2. Materials and methods

2.1. Vegetal material

One hundred and fifty fresh pomegranate fruits of Wonderful, Acco and Kamel cultivars (10 fruits × 5 plants × cultivar), were harvested in the years 2015, 2016 and 2017, from a commercial orchard located in Partinico (Palermo, Sicily, Italy). The plants in the research area were spaced 4.0 × 2.5 m, grown from cutting and trained to a vase shape. All fruits were hand-picked at commercial ripening, using skin colour as the maturity index. As mentioned above, Wonderful originated from Florida > 100 years ago, while Acco and Kamel are two new varieties derived from Israel and only recently introduced into the Mediterranean countries. The three studied varieties mature in succession, constituting a continuous offer for the market (Table 1).

According to the estimations provided by the weather station located closest to the research area (189 m above sea level), the average temperatures in this region hover around 18.9 °C, and the average rainfalls are close to 647 mm, with 78 rainy days [30,31]. Under the bioclimatic aspect, the station is referred to as the upper infra-Mediterranean lower sub-humid bioclimatic belt [32]. The monthly mean temperature (C°), relative humidity (%) and total rainfall (mm) during the three harvest seasons (Table 1) provide conditions highly amenable to pomegranate cultivation.

2.2. Physico-chemical analyses

To evaluate the pomological and physical–chemical traits of pomegranate fruits, 10 fruit × five plants × cultivar were hand-picked after 15 weeks from flower set (15th October) and analysed for fresh weight (FW), size (SZ), volume (VL), skin colour (SC), juiciness (JUI), juice colour (JC), aril size (AS), aril weight (AW), total soluble solids content (TSSC) and titratable acidity (TA). FW and AW (g) were determined using a digital scale (Gibertini EU–C 2002 RS, Novate Milanese, Italy). Fruit length, width and peel thickness (mm) were measured on the polar axis of the fruit, between the apex and stem, and perpendicular to the polar axis direction, respectively, using a TR53307 digital calliper (Turoni, Forlì, Italy). Fruit volume (cm^3) was calculated by a liquid displacement method. SC, JC and aril colour were recorded in the CIELab system, using a Minolta CR-400 colorimeter (Konica Minolta Sensing, Inc., Japan). In the CIELab colour space, L^* indicates the brightness, a^* ranges from green ($-a^*$) to red ($+a^*$), and b^* varies from blue ($-b^*$) to yellow ($+b^*$). The colour characteristics of pomegranate cultivars are potential indicators of the maturity index of the fruit, for controlling the harvest and defining the commercial categories of the produce [33,34]. TSSC (°Brix) was measured using an Atago Palette PR–32 digital refractometer (Atago Co., Ltd., Tokyo, Japan). TA was determined by titrating 10 mL of juice with NaOH (0.1 N) to pH 8.1, and the results were expressed as a percentage of citric acid (in grams per litre).

In addition, the maturity index (TSSC/TA), fruit index (longitudinal diameter/transversal diameter × 100) and peel index (peel thickness/fruit weight) were calculated [35]. The peel index is a parameter applicable to sizing the fruit and indicates the typology of usable packaging. Arils from the other fruit tissues were separated, and their juice extracted using a hand-operated citrus squeezer.

Table 2
Pomological characteristics of the three pomegranate cultivars Acco, Kamel and Wonderful.

Cultivar	Weight (g)	Fruit width (mm)	Fruit height (mm)	Volume (cm^3)	Peel thickness (mm)	Peel index	Fruit index	Maturity index
Acco	368.3 ± 36.7 a	92.2 ± 4.3 ns	82.3 ± 3.8 a	394.0 ± 53.8 a	3.38 ± 2.1 b	0.01 ± 0.001 a	89.4 ± 5.4 a	0.82 ± 0.02a
Kamel	348.3 ± 54.6 ab	91.0 ± 4.9 ns	76.0 ± 4.6 ab	380.8 ± 57.1 a	7.93 ± 2.2 a	0.02 ± 0.001 ab	83.5 ± 3.3 ab	0.25 ± 0.08 b
Wonderful	289.5 ± 74.0 b	89.9 ± 6.9 ns	69.2 ± 7.4 b	210.8 ± 73.6 b	9.98 ± 1.6 a	0.04 ± 0.01 b	76.9 ± 5.4 b	0.29 ± 0.07 b

Values marked with different letters in the same column indicate significant differences ($p < .05$).

Table 3
Arils and juice characteristics of the three pomegranate cultivars Acco, Kamel and Wonderful.

Cultivar	Arils (number)	Arils total weight (g)	Total juice (mL)	Total soluble solid content (°Brix)	Titratable acidity (%)	Ascorbic acid (mg/100 mL)
Acco	573.3 ± 90.4 ns	184.7 ± 41.6 a	67.3 ± 15.8 a	14.9 ± 3.5 ab	18.1 ± 4.0 c	12.4 ± 2.9 c
Kamel	619.4 ± 108.3 ns	122.9 ± 25.1 b	52.5 ± 14.2 b	12.9 ± 2.7 b	39.2 ± 2.6 b	10.5 ± 1.5 b
Wonderful	552.2 ± 197.2 ns	93.4 ± 20.9 c	38.4 ± 11.1 c	15.0 ± 2.7 a	52.7 ± 9.3 a	12.7 ± 2.3 a

Values marked with different letters in the same column indicate significant differences ($p < .05$); ns = not significant.

Table 4
CIELab colour values of skin, juice and arils of Acco, Kamel and Wonderful fruit.

Cultivar	Skin colour		
	L^*	a^*	b^*
Acco	41.4 ± 13.1 a	40.9 ± 22.1 a	23.0 ± 13.2 a
Kamel	40.0 ± 18.4 a	43.0 ± 10.2 b	11.6 ± 6.3 b
Wonderful	39.1 ± 14.6 a	46.2 ± 12.3 a	20.9 ± 8.6 ab
Cultivar	Arils colour		
	L^*	a^*	b^*
Acco	23.0 ± 13.5 a	15.6 ± 8.9 ab	10.1 ± 3.8 a
Kamel	39.5 ± 14.0 a	36.5 ± 8.7 b	9.03 ± 7.3 a
Wonderful	29.6 ± 9.9 a	24.1 ± 7.4 a	13.7 ± 2.2 a
Cultivar	Juice colour		
	L^*	a^*	b^*
Acco	25.8 ± 10.5 b	60.6 ± 5.04 ab	4.7 ± 5.3 ab
Kamel	40.8 ± 15.2 a	28.8 ± 12.4 ab	12.8 ± 5.8 a
Wonderful	22.5 ± 6.4 b	10.7 ± 6.4 a	2.5 ± 2.3 b

Values marked with different letters in the same column indicate significant differences ($p < .05$).

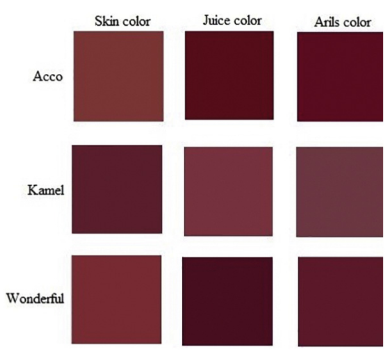

Fig. 1. Colour of skin, juice and arils in Acco, Kamel and Wonderful cultivars recorded in the CIELab colour space and converted to the red–blue–green scale. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

2.3. Standards and chemicals

ABTS [2,2′-azinobis(3-ethylbenzothiazoline-6-sulphonic acid)] diammonium salt, Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid), gallic acid (GA), potassium persulphate, 2,4,6-tripyridyl-S-triazine (TPTZ), iron (III) chloride hexahydrate ($FeCl_3.6H_2O$) and Folin–Ciocalteu's phenol reagent were purchased from Sigma Sigma-Aldrich, St. Louis, http://www.sigmaaldrich.com). All other materials and solvents were of analytical grade unless indicated otherwise.

2.4. Nutraceutical analysis

The vitamin C content in the ethanol extracts was measured by enzyme colorimetric assay, with a maximum absorbance at 570 nm. The vitamin C concentrations were calculated with reference to a calibration curve constructed using ascorbic acid of increasing concentrations, and expressed as milligrams of ascorbic acid in 100 g of FW.

The total phenolic content (TPC) was determined by the reduction of phosphotungstic-phosphomolybdic acid (Folin–Ciocalteu's reagent) to a blue pigment in alkaline solution, according to Folin and Denis [36]. Accordingly, 10 µl of the diluted sample was mixed with 4 mL of Folin–Ciocalteu reagent (previously diluted eight-fold), and the mixture was allowed to stand at room temperature for 5 min. Next, 2 mL of 10% (*w/v*) Na_2CO_3 solution was added, and the volume made to 10 mL with water. After incubation at room temperature in the dark for 90 min, the absorbance was read at 740 nm, using a spectrophotometer (Beckman Coulter DU-800, Fullerton, CA). GA was used to construct the calibration curve, and the results were expressed as milligrams of gallic acid equivalents (GAE) per 100 g FW. All measurements were done in triplicate.

Total anthocyanin content (TAC) of samples was determined using the pH differential method with some modifications [37]. A 20-µl aliquot of each pomegranate juice sample was added separately to 980 µl of KCl buffer (pH 1.0) and NaOAc buffer (pH 4.5). The absorbance was measured at 535 and 700 nm for both sets of pH 1.0 and 4.5 solutions, using 50% ethanol as a blank. The TAC was calculated using Eq. (1), and the results were expressed as milligrams of cyanidin-3-glucoside equivalents in 100 g of FW.

$$\text{Total monomeric anthocyanin} = (A \times \text{MW} \times \text{DF} \times 1000)/\varepsilon \times \quad (1)$$

where A (absorbance) = $(A_{515\text{nm}} - A_{700\text{nm}})$pH 1.00 – $(A_{515\text{ nm}} - A_{700\text{ nm}})$ pH 4.5; MW (molecular weight) = 449.2; ε (the molar absorptivity of cyanidin-3-glucoside) = 26,900, which was used as the standard; DF is the dilution factor; and l is the path length.

The total antioxidant activity (TAA) of each cultivar were analysed using the ABTS radical scavenging capacity assay [38] and ferric reducing antioxidant potential (FRAP) assay [39]. These methods are distinguished by their mechanism of action and complement the analysis of the antioxidant potential of the fruits. The ABTS method is based on colorimetric monitoring of the decay of the $ABTS^{\bullet+}$ radical cation, caused by the oxidation of $ABTS^{\bullet+}$ radicals when contacting an antioxidant. $ABTS^{\bullet+}$ was prepared by reacting ABTS with potassium persulphate [40]. The mixture was incubated in the dark at room temperature for at least 16 h and was then diluted with ethanol to an absorbance of 0.70 ± 0.05 at 734 nm. Once prepared, the $ABTS^{\bullet+}$ solution (990 ml) was mixed with the aqueous sample (10 µl, diluted 10–40 times), and the absorbance was recorded at 0.0 and 2.5 min. Samples were analysed in triplicate within the linearity range of the assay, as previously described [41].

The FRAP assay is based on the reduction of the Fe^{3+}–TPTZ complex to the ferrous form at low pH in the presence of antioxidant compounds [39]. Briefly, 160 µl of FRAP reagent, prepared daily, was mixed with 30 µl of water and 10 µl of the sample (diluted 25–100 times) or standard. After incubation at 37 °C for 30 min, the absorbance at 595 nm was measured. All measurements were repeated three times, in both tests. The TAA evaluated by the ABTS or FRAP protocol was expressed as mmol Trolox equivalents (TE)/100 g FW.

2.5. Statistical analysis

Data were presented as mean ± standard deviation, and analysed using one-way analysis of variance and Tukey's *post hoc* test at $p < .05$. All statistical analyses were conducted using XLSTAT software version 9.0 (Addinsoft, Paris, France). Nutraceuticals data were analysed using

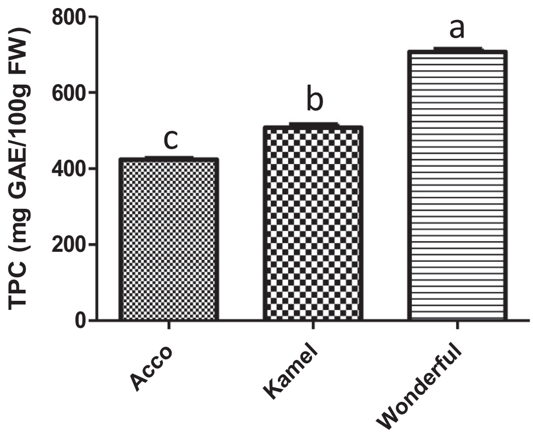

Fig. 2. Total polyphenolic content (TPC, expressed as gallic acid equivalents [GAE, mg] per 100 g fresh weight [FW]) of three different pomegranate cultivars, determined by the Folin–Ciocalteau method. Each value represents the mean ± SD ($n = 3$). For each bar, different letters indicate significant differences ($p < .0001$) by Tukey's multiple range test. Letter "a" indicates the highest value.

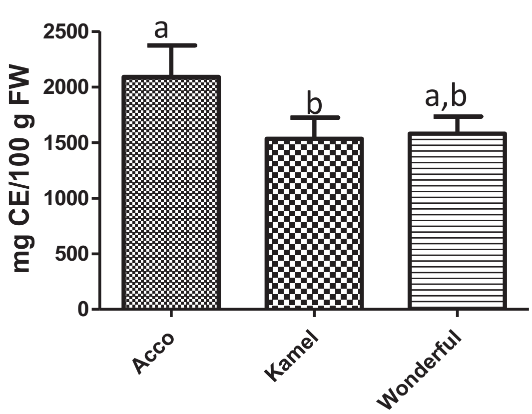

Fig. 3. Total anthocyanin content (expressed as catechin equivalents [CE, mg] per 100 g fresh weight [FW]) of three different pomegranate cultivars, determined by the pH differential method. Each value represents the mean ± SD ($n = 3$). For each bar, different letters indicate significant differences ($p = .0356$) by Tukey's multiple range test. Letter "a" indicates the highest value.

GraphPad Prism v5 software (GraphPad Software Inc., La Jolla, USA).

3. Results and discussion

3.1. Pomological characteristics of fruits

The FW varied among the genotypes, decreasing from Acco to Kamel and, finally, Wonderful, which had the lowest FW (Table 2). FW, VL and JC are important marketing attributes because of their influence on consumer preference [19]. Moreover, there is an excellent market for large fruit [12]. There were noticeable differences in the shape of the cultivars; Acco fruit had a spherical form, whereas, both Kamel and Wonderful were obloid. The shape traits showed statistical differences in height but not width.

Pomegranate fruits may be marketed in cardboard boxes and polyurethane trays, based on their size, which is defined by commercial trading practices as count, diameter or weight [43]. In such instances, the package must be labelled accordingly. By weight, the fruit of Wonderful belongs to Class D, whereas, Acco and Kamel are Class C fruit. Considering fruit diameter (width), all the fruits could be commercialised in Class A.

We observed a greater peel thickness in Wonderful and Kamel fruits than Acco fruit, as confirmed by the peel index (Table 2). For produce of equivalent weights, the market preference is for fruits with a higher proportion of edible content [42]. Acco also presented a higher maturity index (TSSC/TA) when compared with Kamel and Wonderful cultivars (Table 2). This parameter is important because it is responsible for the taste and flavour of the pomegranate.

3.2. Arils and juice characteristics

Pomegranate fruits possess seeds and juice-containing arils (Table 3). Minimally processed pomegranates (ready-to-eat arils) are attracting increasing international demand, due to their desirable characteristics, healthiness, high economic importance and the changing food consumption patterns. Internal parameters measured on pomegranate fruit arils determine the economic value of this fruit and are important factors for growers, market and industry [44]. According to the observed data, the highest number of arils was observed in Kamel (Table 3). The highest AW was observed in Acco, followed by Kamel and, lastly, Wonderful, which displayed both the lowest AW and JC (Table 3). Hence, Acco arils were juicier than those of Kamel and Wonderful. For the TSSC, Wonderful and Acco were similar to each other. Instead, Kamel fruits have a low TSSC, while the percentage of organic acids (TA) is lowest in Acco and highest in Wonderful (Table 3).

As indicated by the colour data (Table 4 and Fig. 1), Wonderful is characterised by intense red peel, juice and arils. Kamel presented a vivid red peel, and bright red juice and arils. Acco showed a dark red peel, with vivid light red arils and juice.

3.3. Bioactive compounds

Acco and Wonderful contained more vitamin C relative to Kamel (Table 3). High TPC values were obtained and simultaneously comparable with other literature data [45,46]. The highest TPC belonged to Wonderful, which was significantly higher in comparison to Kamel and Acco. Moreover, the TPC of Kamel was significantly different from that of Acco (Fig. 2).

The TAC in pomegranate juices of the three varieties analysed was determined using the pH differential method with some modifications [37]. Acco exhibited the highest TAC. However, the only statistically significant difference was observed between Acco and Kamel, as reported in Fig. 3.

Concerning antioxidant activity ($ABTS^{\bullet+}$ radical scavenging activity and FRAP) of pomegranate, our results showed significant variability in the nutraceutical potential of the studied cultivars. The mean $ABTS^{\bullet+}$ value was 2551 TE/100 g FW. The highest $ABTS^{\bullet+}$ scavenging activity was displayed by cultivar Wonderful. The $ABTS^{\bullet+}$ activity displayed by cultivar Acco was significantly different from those of Kamel and Wonderful, and cultivar Kamel had a significantly greater $ABTS^{\bullet+}$ radical scavenging activity than cultivar Acco (Fig. 4).

Regarding the ability of pomegranate juice to reduce Fe^{3+} to Fe^{2+}, the highest value was registered in cultivar Wonderful. The mean value was 14,303 μmol TE/100 g FW. Wonderful showed a 1.875- and 1.56-fold higher mean FRAP value than those of Acco and Kamel, respectively, and cultivar Kamel registered a significantly higher FRAP value relative to Acco (Fig. 5).

Importantly, our results have shown highly significant correlations between the TAA and FRAP results, TAA and TPC, and, also, between the FRAP and TPC, although the study was conducted only on three cultivars (Table 5). The TAC and TPC were not correlated, and no correlation was observed between the $ABTS^{\bullet+}$ radical scavenging activity and FRAP values. According to literature data, a good amount of vitamin C is contained in pomegranates [47], but in our study, the vitamin C content was not correlated with any of the other parameters studied, and polyphenols are fully responsible for the antioxidant

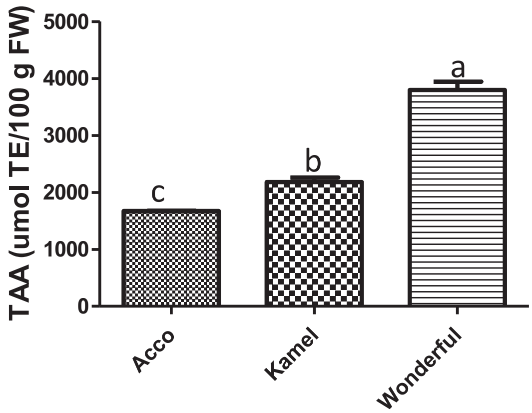

Fig. 4. Total antioxidant activity (TAA, expressed as Trolox equivalents [TE, μmol] per 100 g fresh weight [FW]) of juices of three different pomegranate cultivars, determined by the ABTS assay. Each value represents the mean ± SD ($n = 3$). For each bar, different letters indicate significant differences ($p < .0001$) by Tukey's multiple range test). The letter "a" indicates the highest value.

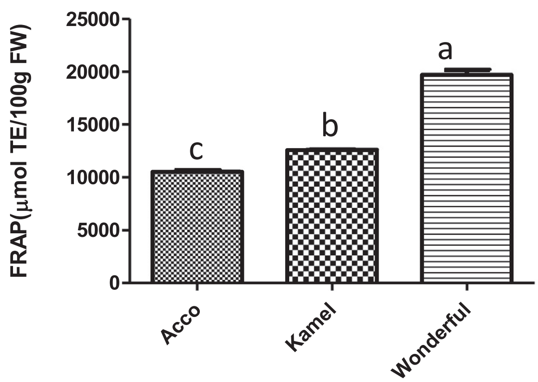

Fig. 5. Ferric reducing antioxidant power (FRAP, expressed as Trolox equivalents [TE, μmol] per 100 g fresh weight [FW]) of juices of three different pomegranate cultivars. Each value represents the mean ± SD ($n = 3$). For each bar, different letters indicate significant differences ($p < .0001$) by Tukey's multiple range test. The letter "a" indicates the highest value.

Table 5
Correlation coefficients of the most important characteristics observed in the three studied pomegranate cultivars.

Parameter	VITC	TPC	TAC	TAA	FRAP
VITC	–	−0.159	−0.134	−0.125	0.221
TPC	−0.159	–	−0.675	0.998*	0.997*
TAC	−0.134	−0.6755	–	−0.6278	−0.6162
TAA	−0.125	0.998*	−0.628	–	0.999*
FRAP	0.221	0.997*	−0.616	0.999*	–

VITC (vitamin C), TP (total polyphenolic content), TAC (total anthocyanin content), TAA (total antioxidant activity), FRAP (ferric reducing antioxidant power). Values marked with different letters in the same column indicate significant differences $p < .0001$ (*).

activity. To prove this hypothesis, separation and characterisation of the polyphenolic compounds in pomegranate extract by high-performance liquid chromatography–mass spectrometry, with concurrent determination of the vitamin C content are required.

4. Conclusions

This study showed that pomegranate cultivars grown in the Mediterranean area exhibit an appreciable quality, but there are significant differences in the morphology, as well as the physico-chemical properties of the arils and juice. Thus, great variability exists among these cultivars, according to marketable traits, such as SZ, peel index, JUI, acidity, TSSC, bioactive compounds and *in vitro* antioxidant activity. In particular, our results reveal that Acco produced the biggest and the juiciest fruits, characterised by dark red skin, brilliant arils and light red juice, with the best TSSC/AT ratio and TAC, but the lowest FRAP and TAA. Conversely, Wonderful fruit is smaller in size but has intense red peel, arils and juice, with a low number of arils, which are also less juicy and more acidic than those in cultivar Acco, but the fruit is also characterised by elevated TPC, TAA and FRAP activity. It is well known that the consumer is attracted to the intense colour of fruits. In this context, Wonderful fruit stands out for its intense red peel and juice. Moreover, this cultivar had the highest nutraceutical value. Regarding fruit taste only, Acco could be preferred for its sweet juice. Kamel showed intermediate characteristics between the other two cultivars and the fruit had a brilliant red peel and bright red arils and juice.

Finally, these pomegranate cultivars are selected not just for fresh consumption, but also for the food and health industries, considering the high amount of total polyphenolics, antioxidant potential ($ABTS^{\bullet+}$ radical scavenging activity and FRAP activity) and TAA. In this context, Wonderful can be emphasised over the cultivars Acco and Kamel. The physico-chemical properties found in this study may be useful in selecting pomegranate genotypes for cultivation, marketability and fruit processing in countries with a Mediterranean climate.

Declaration of Competing Interest

The authors declare no conflict of interest.

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