Document downloaded from:

http://hdl.handle.net/10251/61557

This paper must be cited as:

San José, R.; Sánchez Mata, M. C.; Cámara, M. M.; Prohens Tomás, J. (2013). Composition of eggplant cultivars of the Occidental type and implications for the improvement of nutritional and functional quality. International Journal of Food Science and Technology. 48:2490-2499.

The final publication is available at

http://dx.doi.org/10.1111/ijfs.12240

Copyright Wiley

Additional Information

**Composition of eggplant cultivars of the Occidental type and implications for the improvement of nutritional and functional quality**

Running title: **Composition of Occidental type eggplants**

Raquel San José,[1] M. Cortes Sánchez,[1] M. Montaña Cámara[1] & Jaime Prohens[2,*]

[1]Departamento de Nutrición y Bromatología II. Bromatología, Facultad de Farmacia, Universidad Complutense de Madrid, Plaza Ramón y Cajal s/n, 28040 Madrid, Spain

[2]Instituto de Conservación y Mejora de la Agrodiversidad Valenciana, Universitat Politècnica de València, Camino de Vera 14, 46022 Valencia, Spain

[*]Correspondent: Fax: +34 963879422

e-mail: jprohens@btc.upv.es

**Keywords:** Carbohydrates, organic acids, phenolics, principal components analysis, *Solanum melongena*, vitamin C

## Summary

We have investigated the diversity for composition in seven eggplant (*Solanum melongena*) cultivars of the Occidental type. The results show that, with the exception of moisture content and pH, there is a wide diversity for all the analyzed traits. Protein content was variable, but generally low. The content in available carbohydrates ranged between 2.99 and 4.19 mg/100 g, and the main soluble sugars were glucose and fructose. The fibre content was the most variable trait. In all cases the dehydroascorbic acid content was higher than the ascorbic acid content. Total phenolics content was on average 39-fold higher than vitamin C content. Multivariate analysis showed that accessions from the black and striped groups presented a similar composition profile, while the white and pickling fruits were very distinct. The pickling eggplant H11 is identified as the best source for improving the nutritional and functional properties of Occidental eggplants.

## Introduction

Eggplant (*Solanum melongena* L.) was domesticated in SouthEast Asia (Meyer *et al*., 2012). From there, the crop spread to other tropical and subtropical regions of the world, where a large number of cultivars have been developed (Daunay, 2008). Breeders and horticulturists normally distinguish among Oriental (or Asian) and Occidental (or Western) eggplants (Vilanova *et al*., 2012). Both types of eggplants are distinguished by a syndrome of morphological characteristics as well as by presenting a different genetic background (Hurtado *et al*., 2012; Vilanova *et al*., 2012). The Occidental eggplants are the most important in Europe, Africa, America and the Middle East, and breeders of

Occidental eggplant normally make use of cultivars of this type in their breeding programmes, as they represent elite materials well adapted to the cultivation conditions and demands of Western consumers.

The diversity of Occidental eggplants is large, and cultivars exist with different sizes, shapes, colours, and uses (Daunay, 2008). In this respect, the most important cultivar groups in the Western markets are the black and striped eggplants (Muñoz-Falcón *et al*., 2008, 2009). However, new cultivar types, like the white and the pickling eggplants are gaining ground (Prohens *et al*., 2009), due to the demand of diversification by consumers.

Apart from requesting new types of eggplant, many consumers are demanding vegetables with improved composition, i.e., with a higher content of nutritional and functional constituents, in particular with a higher content in antioxidants (Picha, 2006). In any case, breeding programmes must be aimed at achieving an optimal balance between pleasant taste, attractive appearance, and compounds contributing to the nutritional and functional value (Daunay, 2008). In this respect, the study of the diversity in different types of cultivars of proximate composition, carbohydrates, and antioxidants will be useful for the selection and breeding of improved Occidental eggplant cultivars.

Some studies have been aimed at assessing the diversity in some specific composition traits of eggplant, like dry matter (Raigón *et al*., 2008), protein (Raigón *et al*., 2008), ascorbic acid (Hanson *et al*., 2006; Prohens *et al*., 2007), or phenolics (Stommel & Whitaker, 2003; Hanson *et al*., 2006; Prohens *et al*., 2007; Raigón *et al*., 2008). These studies have found that the variation for dry matter content is limited in the cultivated species, while for the protein content, ascorbic acid content and, in particular, for phenolics content there is a wide range of variation among different cultivars.

Amazingly, despite the relevance of the content in carbohydrates for the taste and nutritional value of eggplant (Gajewski *et al*., 2009), as well as for new uses of eggplant like the use of eggplant flour to produce crackers with high fibre content (Perez & Germani, 2007), no recent studies have been aimed at studying its diversity. Only an old paper (Culpepper & Moon, 1933) provides some data on the diversity in total sugars, reducing sugars and sucrose, in 10 varieties, of which most of them are from the Oriental type. These authors found some variation among varieties, but no statistical treatment of the data is provided.

A lot of interest has been raised in the last years regarding the improvement of the content in antioxidants in eggplant, which stems from the fact that eggplant is one of the vegetables with higher antioxidant capacity (Cao *et al*., 1996) associated to its high content in phenolics, mostly chlorogenic acid and its isomers (Whitaker & Stommel, 2003; Hanson *et al*., 2006; Lo Scalzo *et al*., 2010; Luthria *et al*., 2012). Although raising the content in phenolics can result in the increase of the flesh browning of eggplant (Prohens *et al*., 2007; Concellón *et al*., 2012), improving the ascorbic acid (AA) content in this fruit, which prevents phenolic compounds from oxidation by polyphenol oxidase (PPO) enzyme (Macheix *et al*., 1990), might contribute to alleviate the negative effect of increasing the phenolics content on fruit flesh browning. Also, reducing the fruit pH, and therefore the polyphenol oxidase activity (Concellón *et al*., 2004), might also contribute to decreasing fruit browning; however, the variation for pH in eggplant has proved to be limited (Prohens *et al*., 2007).

To our knowledge, no studies have been devoted to the comprehensive study of diversity for composition traits that may be of relevance for the selection and breeding of cultivars of Occidental eggplants with improved composition. In this paper we study the variation of relevant composition traits of importance for the breeding of Occidental eggplants in seven eggplant cultivars of different cultivar groups (black, striped, white, and pickling). Traits studied include some proximate characters of interest for the nutritional value (proteins), taste (pH and titratable acidity), or industrial processing (moisture and pH), content in carbohydrates (total, soluble, starch, and fibre), which are important both for taste and nutritional value, and content in antioxidants, which are important for nutritional value and industrial processing (vitamin C and phenolics). The objective is to provide information for the identification of sources of variation for a breeding programme aimed at the achievement of eggplant cultivars with improved quality.

## Materials and methods

### Plant material

Seven eggplant cultivars from different origins and which presented different fruit characteristics (uses, shapes, colour, size) have been used for the present study (Table 1). Cultivars were chosen aso that they were representative of the diversity of the Occidental group of eggplants. Twenty plants of each cultivar were grown in an open-air field plot (GPS coordinates of the field plot: 39º28’55”N, 0º20’11”W) at the facilities of the Universitat Politècnica de València, Valencia (Spain) following the standard cultivation techniques for eggplant.

Three samples of fruits, were analysed for each cultivar. each of which had a tSotal sample weight was of at least > 1 kg and includedcontained at leasta minimum of five representative fruits~~, were harvested for each variety.~~. Fruits were harvested at the end of September and beginning of October and were immediately sent -to the Universidad Complutense de Madrid, Madrid (Spain) for analysis. Fruits were kept under refrigeration for no more than 24h until analysed.

**Sample preparation and analytical methods**

~~Fruits were peeled and cut longitudinally into two portions. One of them was homogenised in a laboratory blender for the analysis of pH, titratable acidity, moisture and vitamin C content and immediately analysed. The other one was freeze-dried and stored for the analysis of proteins, soluble sugars, total available carbohydrates, fibre content, and total phenolics.~~

The following determinations were carried out on fresh homogenized samples: pH, which was measured using a Crison MicropH-2000 (Crison Instruments, Alella, Spain) pH meter (method 981.12 AOAC, 2005); titratable acidity (TA) was determined by titration with 0.1 N NaOH until pH of 8.1 was reached, and the results were expressed as meq NaOH needed to neutralize 100 g of sample (method 942.15 AOAC, 2005); moisture was evaluated by desiccation at 105 ± 2º C to constant weight (method 984.25 AOAC, 2005); vitamin C was determined by HPLC-UV after the extraction of the samples in metaphosphoric acid (Arella *et al*., 1997; Sánchez *et al*., 2000); and~~,~~ ascorbic acid (AA) was quantified before and after a reduction with L-c~~C~~ysteine in order to determine AA and total vitamin C fractions (Sánchez *et al*., 2000).

Con formato: Sangría: Primera línea: 0 cm

Freeze-dried samples were used for the following determinations: proteins were quantified as total nitrogen by Kjeldahl method, using the value of 6.25 as conversion factor of nitrogen to protein (method 920.125 AOAC, 2005); soluble sugars were identified and quantified by HPLC differential refractive index detection, after extraction in 80% methanol (Mollá *et al*., 1994); total available carbohydrates were determined by the anthrone colorimetric method, after hydrolysis with $HClO_4$ (Osborne & Voogt, 1986); starch was determined as the difference between total available carbohydrates and soluble sugars; fibre content was evaluated by enzymatic-gravimetric method (m. 985.29 andy 960.52 AOAC, 1997); and, total phenolics were determined using the Folin-Ciocalteu assay (Singleton & Rossi, 1965) using chlorogenic acid as standard. Results of the analyses of freeze-dried samples were expressed as g/100 g of fresh product.

**Analytical equipment and conditions**

A high performance liquid chromatograh (HPLC) chromatographer (Micron Analítica, Madrid, Spain) equipped with an isocratic pump (model PU-II, ( Jasco, Tokyo, Japan), an automatic injector model AS-1555 (Jasco), an Spectra Series UV100 UV-Vis detector (Thermo Separation Products, Riviera Beach, FL, USA), a R401 differential refractometer detector (Waters Associates, Milford, MA, USA), and Biocrom 2000 v. 3.0. Software (Micron Analitica, Madrid, Spain) was used. For vitamin C analysis, a Sphereclone ODS (2), 5 µm; 4.6 x 300 mm column (Phenomenex, Torrance, CA, USA) was used, working at the following conditions: water acidified to pH 2.5 with $H_2SO_4$ as mobile phase, flow-rate of 0.9 ml/min and detection at 245 nm wavelength at a retention time of 4.49 min. For soluble sugar analysis, an amino bonded column µBondapak carbohydrate, 300 x 3.9 mm (Waters), and the following analysis conditions were used: acetonitrile/water 80/20 as mobile phase, and flow-rate of 0.9 ml/min.

**Statistical analysis**

Data for each of the traits evaluated were analysed using a one-way analysis of variance (ANOVA) using a fixed-effects model for the effect of cultivarStandard errors of the mean for each variety were obtained for the composition traits analysed. A multivariate principal components analysis (PCA) was performed in order to study the relationships among composition traits as well as the composition-based relationships among the seven cultivars tested. For the PCA, a character correlation matrix was computed from standardized values and Pearson's correlation coefficient. All analyses were carried out using the STATGRAPHICS plus version 5.1. Software (Statistical Graphics Corp., Rockville, MD, USA).

## Results

**Proximate composition**

Eggplant fruits presented high values for moisture content, always above 91%. Although significant differences among cultivars exist were found (Table 2), the range of the average moisture content among the seven cultivars was of barely 2%, and the CV value was the lowest of all traits (0.8%). H11 was by far the cultivar with the lowest moisture content (91.8%), and in fact the difference between this cultivar and the cultivar ranking second in lowest moisture content (BBS118) was of 0.8%. The cultivar with the highest moisture content was Listada Clemente (93.8%).

Protein content was very variable (CV=47.2%) and ranged between 0.33 g/100 g (Dourga) and 1.13 g/100 g (H11) (Table 2), although thise latter cultivar presented much higher values than the rest of cultivars. In this respect, H11 presents a content in proteins almost twice higher than the cultivar ranking second in protein content (BBS118; 0.60 g/100 g).

The pH values show a small range of variation (CV=1.0%) and no significant differences among cultivars were detected (Table 2),. The maximum d with a difference was of only 0.15 pH units between Dourga (5.34) and H11 (5.49) (Table 2). In this case, we have five out of the seven cultivars with present similar values, ranging between 5.43 and 5.49, while the two other cultivars (Dourga and BBS118) present values much lower values (5.34 and 5.38, respectively).

The titratable acidity (TA) was more variable than the pH values (CV=14.9%), with values between 1.07 meq NaOH/100 g (CS16) to 1.65 meq NaOH/100 g (BBS118) and significant differences among cultivars (Table 2). Although the cultivar with higher TA (BBS118) also showed the lowest pH, for the rest of cultivars there was not agreement between both traits. For example, the cultivar with highest pH (H11) ranked second for high TA, and the cultivar with lowest pH (Dourga) ranked second for low TA.

**Carbohydrates**

Total available carbohydrates fraction was ranged between 2.99 g/100 g (IVIA-371) and 4.19 g/100 g (H-11) (Table 3), with highly significant differences among cultivars (Table

3). Tand the seven cultivarvarieties could be arranged in three groups depending on the total available carbohydrates: a) IVIA371 and BBS118, with values below 3.1 g/100 g; b) Dourga, LF3-24, and Listada Clemente, with values between 3.5 and 3.7 g/100 g; c) CS16 and H11, with values above 3.8 g/100 g (Table 3). Total soluble sugars ranged between 0.74 g/100 g (BBS-118), and 2.13 g/100 g (H11) (Table 3), presenting higher CV (30.3%) than total available carbohydrates (11.8%). The main soluble sugars were glucose and fructose, representing an average 47.6% and 38.6% of the total soluble sugars content, respectively (Table 3). Sucrose and maltose were also identified, although their concentrations were much lower and accounted for 7.6% and 6.9% of the total soluble sugars content, respectively (Table 3). Nonetheless, highly significant differences among cultivars were observed, (Table 3). The profile obtained using the proportion of soluble sugars in each cultivar shows that there are some differences among varietiescultivars (Figure 1). For example, BBS118 does not present quantifiable amounts of sucrose or maltose, and together with H11 is the only cultivar that presents glucose contents above 50%. Also, it is remarkable that the two black cultivarvarietiess (CS16 and LF3-24) show a similar profile of proportion of soluble sugars, and the same occurs with the two striped cultivars (IVIA371 and Listada Clemente); on the contrary, the two white cultivars (BBS118 and Dourga) present considerable differences in the profile of soluble sugars. The CV for individual soluble sugars ranged between 26.0% for fructose and 46.2% for maltose.

Differences among cultivars for sStarch content were highly significant, and ranged between 1.43 g/100 g (Dourga) and 2.38% g/100 g (H11), and the CV value was of 18.5%. For six out of the seven cultivars analysed (the exception was Dourga), the content in starch was higher than the content in total soluble sugars, and therefore, the ratio total/soluble sugars starch was in all cases lower than 1, with the exception of Dourga (Table 3). In this respect, the ratio total soluble sugars/starch varied between 0.32 for BBS118 and 1.50 for Dourga, which resulted in highly significant differences among cultivars and a large value for the CV (49.3%).

Fibre content ranged from 0.58 g/100 g (IVIA-371) to 2.24 g/100 g (H-11) (Table 3), with a wide variability among the eggplant cultivar~~varietie~~s analysed, which resulted in the highest *F*-ratio (226.073) and CV value for the traits analysed (55.0%) (Table 3). Two cultiva~~vari~~r~~etie~~s (H11 and BBS118) had a fibre content above 2.1 g/100 g, while three cultivar~~varietie~~s had a fibre content below 0.7 g/100 g (LF3-24, Listada Clemente, and IVIA371), i.e., at least three times lower.

Con formato: Fuente: Cursiva

**Antioxidants**

Vitamin C content ~~in eggplant varieties considered in this study~~ presented highly significant differences among eggplant cultivars considered in this study, and ranged between 2.91 mg/100 g (Dourga) and 6.54 mg/100 g (H11), with a CV value of 28.0% (Table 4). These latter cultivars also presented the highest and lowest AA contents, with values ranging between 1.02 mg/100 g (Dourga) and 2.20 mg/100 g (H11). For DHA, the lowest value was found in BBS118 (1.68 mg/100 g), and the highest again in H11 (4.34 mg/100 g), which presented a value much higher than the cultivar ranking second in DHA content (CS16; 2.87 mg/100 g) (Table 4). In all cultivars, the content of DHA was always higher than the AA content, which resulted in values for the ratio AA/DHA ranging between 0.51 (H11) and 0.90 (BBS118). However, it is remarkable that, with the exception of BBS118, the ratio AA/DHA in the rest of cultivars varied between 0.51 mg/100 g and 0.65 mg/100 g (Table 4).

Differences among cultivars for Ttotal phenolics concentration were significant and ranged between 41.0 mg/100 g (Dourga) and 81.7% mg/100 g (BBS118), with a CV value of 25.7% (Table 4). According to the values of total phenolics found, the seven cultivars could be arranged in three groups: a) Dourga and LF3-24, with values below 45.0 mg/100 g; b) CS16, IVIA371, and Listada Clemente, with values between 50.0 and 65.0 mg/100 g; and, c) H11 and BBS118, with values above 75.0 mg/100 g (Table 3).

**Multivariate analyses**

The first and second components of the PCA allows to explain theaccount for 754.7% of the total system variation (42.7% and 32.0% first and second component respectively). The first component was positively correlated with most of the traits related to the content of carbohydrates (total available carbohydrates, total soluble sugars, glucose, fructose, sucrose, maltose, and ratio total soluble sugars/starch), as well as with the vitamin C and its two forms (AA and DHA), and the pH and proteins, and it was negatively correlated with the ratio AA/DHA, starch, titratable acidity, total phenolics and moisture (Figure Table 52). The second component was positively correlated to the moisture content and to the soluble sugars sucrose, fructose, and maltose, and negatively correlated to vitamin C and its two components AA and DHA, proteins, total phenolics, fibre, titratable acidity and pH, available carbohydartes, starch, soluble sugars and ratio AA/DHA (Table 5Figure 2). The representation of the relationships among composition traits on a two-dimensional PCA biplot confirms that all traits related to carbohydrates, except starch and fibre, plot in the same area of the graph (Figure 1). The same occurs with vitamin C and its components AA and DHA.

The projection of the cultivars on a two-dimensionalthe PCA biplotgraph shows that black accessions LF3-24 and CS16 plot together and are situated close to the two striped accessions (IVIA371 and Listada Clemente), which also plot together (Figure 13). These four accessions present intermediate values for both the first and second components, although striped eggplants (IVIA371 and Listada Clemente) present slightly lower values for the first component, and slightly higher values for the second component than the black eggplants (CS16 and LF3-24) (Figure 31). The two white accessions (BBS118 and Dourga) plot in different areas of the graph, so that BBS118 presents low values of the first component and moderately low values for the second component, while Dourga presents high values for both components. The H11 cultivar plots in another part of the graph, with high values for the first component and low values for the second component (Figure 31).

## Discussion

Breeding of new eggplant cultivars with improved fruit composition relies on the availability of variation for the traits of interest. This study performed in several Occidental cultivars of eggplant with different characteristics reveals that, for most traits, there is an important diversity. S, and some materials present a favourable combination of composition traits, and therefore they could be used as sources of diversity in breeding programmes. Although our data are based on a single year, other studies indicate that the cultivar × year interaction effect for composition traits in eggplant is relatively low compared to the effect of cultivar (Hanson *et al*., 2006; Mennella *et al*., 2010; Raigón *et al*., 2010).

Con formato: Fuente: Cursiva

Con formato: Fuente: Cursiva

Con formato: Fuente: Cursiva

Con formato: Inglés (Estados Unidos)

Our study confirms that eggplant fruits present a high percentage of water, with values above 90% (Flick *et al*., 1978; Raigón *et al*., 2008),. Aalthough the coefficient of variation for this trait was the lowest of all the traits. The cultivar with less moisture content was the cultivar H11, probably associated to the type of use (pickling), which requires firmness after fermentation (Prohens *et al*., 2009). Protein content presented values similar to the ones found by Raigón *et al*. (2008), although again the H11 cultivar was, by far, the cultivar with highest content, with almost twice as high than the cultivar ranking second. pH values, which may affect the eggplant PPO activity (Todaro *et al*., 2011) did not present much variation, and showed values similar to those found by Prohens *et al*. (2007). The eggplant PPO activity in the range of pH observed does not vary much (Dogan *et al*., 2002). Therefore, breeding for reduced pH, which might decrease the eggplant PPO activity (Dogan *et al*., 2002), and therefore flesh browning in eggplant does not seem to be a realistic alternative. The variation for titratable acidity was much greater, and did not depend on pH values, which indicates that there is variation in the buffer capacity among different cultivars. Titratable acidity and pH may have an effect on eggplant flavour (Gajewski *et al*., 2009), but it remains to be investigated what is the influence exerted by them on the quality, i.e., if there is an interest in raising or decreasing the acidity.

The content in total available carbohydrates is similar to that found in former studies (Culpepper & Moon, 1933; Esteban *et al*., 1989; Hernández-Hernández *et al*., 2011). The comparatively reduced levels of available carbohydrates in eggplant contribute to a low content in calories in this fruit. Variation for available carbohydrates is moderate and again cultivar H11 is the one presenting highest levels. The soluble sugars, which are responsible for a sweet taste in eggplant (Gajewski *et al*., 2009; Nookaraju *et al*., 2010), present a wide variation among the materials studied, which suggests that selection for a higher content may result in fruits with a better taste. The most common sugars are fructose and glucose, while sucrose content is low, suggesting that there is a considerable invertase activity in the eggplant fruit (Boo *et al*., 2010). There are also differences in the sugars profile among the different cultivars, and given that different sugars have different sweetening capacity (Nookaraju *et al*., 2010), increasing the content of fructose over other soluble sugars could be of interest to develop cultivars with improved overall sweetness, as has been done in other crops, like tomato or pepper (Levin *et al*., 2000; Eggink *et al*., 2012). The content in starch of eggplant is, in general, higher than the total soluble sugars, which is probably caused by the fact that the fruit of eggplant is harvested when physiologically immature, and therefore that the hydrolysis of starch has not been completed (Singh *et al*., 2000). However, one of the cultivars (Dourga), which presents the highest content in total soluble sugars and the lowest content in starch, presents a total soluble sugars/starch ratio much higher than the other cultivars, and above 1, which may be an indication that starch hydrolysis is more active in this cultivar (Luengwilai *et al*., 2010).

Differences among cultivar~~varietie~~s in the fibre content have also been important, which is a relevant fact for improving fruit quality, as eggplant is considered a~~s a~~ good source of fibre for reducing cholesterol (Jenkins *et al*., 2003). Also, dehydrated eggplant has been shown to be of interest for producing crackers with high fibre content (Perez &

Germani, 2007). In this respect, H11 and BBS118 accessions have shown the highest fibre content and could represent a good source of variation for this trait.

Our results show that eggplant presents a relatively low content in vitamin C when compared with other vegetables (Lee & Kader, 2000), and similar to the values obtained in other studies (Hanson *et al*., 2006; Prohens *et al*., 2007; Raigón *et al*., 2010). However, the variation among the different cultivars found is important, being H11 the cultivar with the greatest concentration. The oxidized form of vitamin C (dehydroascorbic acid; DHA) prevails over the reduced form (ascorbic acid; AA), although in cultivar BBS118 the concentrations of both forms are similar. In some vegetables, AA values are higher than those of DHA, which increases during postharvest (Wills *et al*., 1984), while in others the DHA form is usually ~~is~~ the predominant one (Sánchez-Mata *et al*., 2012). In our case, the fact that DHA concentrations are higher than those of AA may suggest that in eggplant fruit AA plays a significant role in neutralizing reactive oxygen species, and therefore may have a significant antioxidant activity (Atkinson *et al*., 2005) Although AA is present in eggplant in low concentration (Lee & Kader, 2000), and a part of it may be lost in cooking processes (Rawson *et al*., 2011), AA can be transformed into DHA, which also has vitamin C activity (Tsujimura *et al*., 2008). In this respect, cooked eggplant has been reported to los~~s~~e 1/3 of the vitamin C content after grilling (Das *et al*., 2011). Also, it is remarkable that AA prevents flesh browning after cutting the fruit flesh by protecting phenolic compounds from oxidation by PPO enzyme (Nicolas *et al*., 1994), so the increase of AA amount in eggplant fruits may contribute to reduce eggplant flesh browning, which is nowadays one of the main goals of eggplant breeding programs. In this respect for both AA and DHA, cultivar H11 has presented the highest levels.

Eggplant has a high antioxidant capacity (Cao *et al*., 1996), which is of great interest for improving the marketing of this crop (Picha, 1996; Sun-Waterhouse, 2011). The main phenolics in the eggplant flesh are chlorogenic acid and its conjugates, which normally account for up to 95% of the total phenolics in the fruit flesh (Whitaker & Stommel, 2003). Chlorogenic acid and AA have similar antioxidant activities (Kim *et al*., 2002; Triantis *et al*., 2005), and the chlorogenic acid values are much higher (on average 39 times higher), which confirms that phenolic acids account for most of the antioxidant activity of eggplant (Akanitapichat *et al*., 2010; Luthria, 2012). Here, the values we have obtained are similar to those found in other studies (Prohens *et al*., 2007; Raigón *et al*., 2008, 2010; Concellón et al., 2012). Cultivars BBS118 and H11 had the highest content in phenolics, with values ~~of almost~~ tw~~ice~~o fold ~~as~~ higher ~~as~~ than those found in the accessions with lowest concentration (Dourga and LF3-24), and indicate that they could represent sources of variation of interest for breeding modern cultivars with high phenolics concentration (Prohens *et al*., 2007). The high content in phenolics of eggplant together with the low content in soluble carbohydrates could contribute to the antidiabetic effect of eggplant (Kwon *et al*., 2008; Coman *et al*., 2012)

The multivariate PCA analysis of composition traits revealed as a useful tool to discriminate between organically and conventionally produced eggplants (Raigón *et al*., 2010). Here, we have found that the PCA analysis is useful to establish relationships between composition traits and cultivars in eggplants. ~~In this respect, t~~The cultivar~~varietie~~s corresponding to the most important cultivar groups of Occidental eggplants (black and striped) plot together, showing that they present a similar combination of composition traits and a limited variation. In this respect, the study of genetic diversity using molecular markers of black and striped eggplants has shown that they present a reduced genetic diversity (Muñoz-Falcón *et al*., 2008, 2009). On the other hand, the two white eggplants and the pickling eggplant H11 plot in different parts of the PCA graph, showing that they present a different composition profile and could, not only be useful for the diversification of eggplant, but also as sources of variation for breeding programmes for improving the composition of the main black and striped cultivar types.

Overall, the results indicate that the pickling eggplant H11 could be a source of variation of great interest for the improvement of eggplant cultivars for the fresh market. This cultivar~~variety~~, which belongs to the *Almagro*-type (Prohens *et al*., 2009), and shows the highest contents of proteins, total available carbohydrates, soluble sugars, fibre, vitamin C, AA and DHA~~AA~~, as well as high levels of total phenolics.

In conclusion, our study shows that Occidental cultivars of eggplant present an important diversity for most of the traits studied. This~~, which~~ is a prerequisite for an efficient selection and for the development of successful breeding programmes. ~~It also allowed the identification of a source of variation that may be of interest for breeding programmes aimed at improving the nutritional quality of Occidental eggplants.~~

## Acknowledgements

This work was partially financed by the Ministerio de Ciencia y Tecnología (AGL2009-07257 and AGL2012-34213).

## References

Akanitapichat, P., Phraibung, K., Nuchklang, K. & Prompitakkul, S. (2010). Antioxidant and hepatoprotective activities of five eggplant varieties. *Food and Chemical Toxicology*, **48**, 3017-3021.

AOAC (1995) AOAC Official Methods of Analysis. Supplement March 1996. Arlington, VA, USA: Association of Official Agricultural Chemists.

Arella, F., Deborde, J.L., Bourguignon, J.B & Hasselmann, C. (1997). Application de la chromatographie en phase liquide haute performance à la détermination de l´acide L-ascorbique et de la vitamine C totale dans les aliments. Ètude interlaboratoire. *Annales del Falsifications, de l'Expertise Chimique et Toxicologique*, **90**, 217-233.

Atkinson, C.J., Netsby, R., Ford, Y.Y. & Dodds, P.A.A. (2005). Enhancing beneficial antioxidants in fruits: a plant physiological perspective. *BioFactors*, **23**, 229-234.

Boo, H., Kim, H. & Lee, H. (2010). Changes in sugar content and sucrose synthase enzymes during fruit growth in eggplant (*Solanum melongena* L.) grown on different polyethylene mulches. *HortScience*, **45**, 775-777.

Cao, G., E. Sofic & Prior R.L. (1996). Antioxidant capacity of tea and common vegetables. *Journal of Agricultural and Food Chemistry*, **44**, 3426-3431.

Coman, C., Rugină, O.D. & Socaciu, C. (2012). Plants and natural compounds with antidiabetic action. *Notulae Botanicae Agrobotanici Cluj-Napoca*, **40 (1)**, 314-325.

Concellón, A., M.C. Añón & A.R. Chaves. (2004). Characterization and changes in polyphenol oxidase from eggplant fruit (*Solanum melongena* L.) during storage at low temperature. *Food Chemistry*, **88**, 17-24.

Concellón, A., Zaro, M.J., Chaves, A.R., & Vicente, A.R. (2012). Changes in quality and phenolic antioxidants in dark purple American (*Solanum melongena* L. cv. Lucia) as affected by storage at 0 degrees C and 10 degrees C. *Postharvest Biology and Technology*, **66**, 35-41.

Culpepper, C.W. & Moon, H.H. (1933). Composition of eggplant fruit at different stages of maturity in relation to its preparation and use as food. *Journal of Agricultural Research*, **47**, 705-717.

Das, S., Raychaudhuri, U., Falchi, M., Bertelli, A., Braga, P.C. & Das, D.K. (2011). Cardioprotective properties of raw and cooked eggplant (*Solanum melongena* L). *Food & Function*, **2**, 395-399.

Dogan, M., O. Arslan, & S. Dogan. 2002. Substrate specificity, heat inactivation and inhibition of polyphenol oxidase from different aubergine cultivars. *International Journal of Food Science and Technology*, **37**, 415-423.

Daunay, M.C. 2008. Eggplant. In: *Handbook of Plant Breeding: Vegetables II* (edited by J. Prohens & F. Nuez). Pp. 163-220. New York, NY, USA: Springer.

Eggink, P.M., Maliepaard, C., Tikunov, Y., Haanstra, J.P.W., Bovy, A.G. & Visser, R.G.F. (2012). A taste of sweet pepper: volatile and non-volatile chemical composition of fresh sweet pepper (*Capsicum annuum*) in relation to sensory evaluation of taste. *Food Chemistry*, **132**, 301-310.

Esteban, R.M., Molla, E., Villarroya, M.B. & López-Andreu, F.J. (1989). Changes in the chemical composition of eggplant fruits during storage. *Scientia Horticulturae*, **41**, 19-25.

Flick, G.J., Burnette, F.S., Aung, L.H., Ory, R.L. & St. Angelo, A.J. (1978). Chemical composition and biochemical properties of mirlitons (*Sechium edule*) and purple, green, and white eggplants (*Solanum melongena*). *Journal of Agricultural and Food Chemistry*, **26**, 1000-1005.

Gajewski, M., Katarzyna, K. & Bajer, M. (2009). The influence of postharvest storage on quality characteristics of fruit of eggplant cultivars. *Notulae Botanicae Agrobotanici Cluj-Napoca*, **37 (1)**, 200-205.

Hanson, P.M., Yang, R, Tsou, S.C.S., Ledesma, D, Engle, L & Lee, T. (2006). Diversity in eggplant (*Solanum melongena)* for superoxide scavenging activity, total phenolics and ascorbic acids. *Journal of Food Composition and Analysis*, **19**, 594-600.

Hernández-Hernández, O., Ruiz-Aceituno, L., Sanz, M.L. & Martínez-Castro, I. (2011). Determination of free inositols and other low molecular weight carbohydrates in vegetables. *Journal of Agricultural and Food Chemistry*, **59**, 2451-2455.

Hurtado, M., Vilanova, S., Plazas, M., Gramazio, P., Fonseka, H.H. & Fonseka, R. (2012). Diversity and relationships of eggplants from three geographically distant secondary centers of diversity. *PLoS ONE*, **7**, e41748.

Jenkins, D.J.A., Kendall, C.W.C., Marchie, A., Faulkner, D.A., Wong, J.M.W., de Souza, R., Emam, A., Parker, T.L., Vidgen, E., Lapsley, K.G., Trautwein, E.A., Josse, R.G., Leiter, L.A. & Connelly, P.W. (2012). Effects of a dietary portfolio of cholesterol-lowering foods vs lovastatin on serum lipids and C-reactive protein. *Journal of the American Medical Association*, **290**, 502-510.

Kim, D.O., Lee, K.W., Lee, H.J. & Lee, C.Y. (2002). Vitamin C equivalent capacity (VCEAC) of phenolic phytochemicals. *Journal of Agricultural and Food Chemistry*, **50**, 3713-3717.

Kwon, Y.I., Apostolidis, E. & Shetty, K. (2008). *In vitro* studies of eggplant (*Solanum melongena*) phenolics as inhibitors of key enzymes relevant for type 2 diabetes and hypertension. *Bioresource Technology*, **99**, 2981-2988.

Lee, S.K. & Kader, A.A. (2000). Preharvest and postharvest factors influencing vitamin C content of horticultural crops. *Postharvest Biology and Technology*, **20**, 207-220.

Levin, I., Gilboa, N., Yeselson, E., Shen, S. & Schaffer, A.A. (2000). *Fgr*, a major locus that modulates the fructose to glucose ratio in mature tomato fruits. *Theoretical and Applied Genetics*, **100**, 256-262.

Lo Scalzo, R., Fibiani, M., Mennella, G., Rotino, G.L., dal Sasso, M., Culici, M., Spallino, A. & Braga, P.C. (2010). Thermal treatment of eggplant (*Solanum melongena* L.) increases the antioxidant content and inhibitory effect on human neutrophil burst. *Journal of Agricultural and Food Chemistry*, **58**, 3371-3379.

Luengwilai, K., Tananuwong, K., Shoemaker, C.F. & Beckles, D.M. (2010). Starch molecular structure shows little association with fruit physiology and starch metabolism in tomato. *Journal of Agricultural and Food Chemistry*, **58**, 1275-1282.

Luthria, D.L. (2012). A simplified UV spectral scan method for the estimation of phenolic acids and antioxidant capacity in eggplant pulp extracts. *Journal of Functional Foods*, **4**, 238-242.

Macheix, J.J., Fleuriet, A. & Billot, J. (1990). Fruit phenolics. Boca Raton, FL, USA: CRC Press.

Mennella, G., Rotino, G.L., Fibiani, M., D'Alessandro, A., Francese, G., Toppino, L., Cavallanti, F., Acciarri, N. & Lo Scalzo, R. 2010. Characterization of health-related compounds in eggplant (*Solanum melongena* L.) lines derived from

Con formato: Español (alfab. internacional)

Con formato: Español (alfab. internacional)

Con formato: Español (alfab. internacional)

Con formato: Español (alfab. internacional)

Con formato: Español (alfab. internacional)

Con formato: Español (alfab. internacional)

Con formato: Inglés (Estados Unidos)

Con formato: Fuente: Cursiva, Inglés (Estados Unidos)

Con formato: Inglés (Estados Unidos)

introgression of allied species. *Journal of Agricultural and Food Chemistry*, **58**, 7597-7603.

Meyer, R.S., Karol, K.G., Little, D.P., Nee, M.H. & Litt, A. 2012. Phylogeographic relationships among Asian eggplants and new perspectives on eggplant domestication. *Molecular Phylogenetics and Evolution*, **63**, 685-701.

Mollá, E, Cámara, M.M., Díez, C. & Torija, M.E. (1994). Estudio de la determinación de azúcares en frutas y derivados. *Alimentaria*, **254**, 87-93.

Muñoz-Falcón, J.E., Prohens, J., Vilanova, S. & Nuez, F. (2008). Characterization, diversity, and relationships of the Spanish striped (*Listada*) eggplants: a model for the enhancement and protection of local heirlooms. *Euphytica*, **164**, 405-419.

Muñoz-Falcón, J.E., Prohens, J., Vilanova, S. & Nuez, F., (2009). Diversity in commercial varieties of black eggplants and implications for broadening the breeders' gene pool. *Annals of Applied Biology*, **154**, 453-465.

Nicolas, J.J., Richard-Forget, F.C., Goupy, P.M., Amiot, M.J. & Aubert, S.Y. (1994). Enzymatic browning reactions in apple and apple products. *Critical Reviews in Food Science and Nutrition*, **34**, 109-157.

Nookaraju, A., Upadhyaya, C.P., Pandey, S.K., Young, K.E., Hong, S.J., Park, S.K. & Park, S.W. (2010). Molecular approaches for enhancing sweetness in fruits and vegetables. *Scientia Horticulturae*, **127**, 1-15.

Perez, P.M.P. & Germani, R. (2007). Elaboração de biscoitos tipo salgado, com alto teor de fibra alimentar, utilizando farinha de berinjela (*Solanum melongena* L.). *Ciência e Tecnologia de Alimentos*, **27**, 186-192.

Con formato: Inglés (Estados Unidos)
Con formato: Inglés (Estados Unidos)
Con formato: Inglés (Estados Unidos)
Con formato: Inglés (Estados Unidos)
Con formato: Inglés (Estados Unidos)

Picha, D. (2006). Horticultural crop quality characteristics important in international trade. *Acta Horticulturae*, **712**, 423-426.

Prohens, J, Rodríguez- Burruezo, A, Raigón, M.D. & Nuez, F. (2007). Total phenolic concentration and browning susceptibility in a collection of different varietal types and hybrids of eggplant: implications for breeding for higher nutritional quality and reduced browning. *Journal of the American Society for Horticultural Science*, **132**, 638-646.

Prohens, J., Muñoz-Falcón, J.E., Rodríguez-Burruezo, A., Ribas, F., Castro, A. & Nuez, F. (2009). ‘H15’, an *Almagro*-type pickling eggplant with hogh yield and reduced prickliness. *HortScience*, **44**, 2017-2019.

Osborne, D.R. & Voogt, P. (1986). Análisis de los nutrientes de los alimentos. Zaragoza, Spain: Acribia.

Raigón, M.D., Prohens, J., Muñoz-Falcón, J. & Nuez, F. (2008). Comparison of eggplant landraces and commercial varieties for fruit content of phenolics, minerals, dry matter and protein. *Journal of Food Composition and Analysis*, **21**, 370-376.

Raigón, M.D., Rodríguez-Burruezo, A. & Prohens, J. (2010). Effects of organic and conventional cultivation methods on composition of eggplant fruits. *Journal of Agricultural and Food Chemistry*, **58**, 6833-6840.

Rawson, A., Patras, A., Tiwari, B.K., Noci, F., Koutchma, T. & Brunton, N. (2011). Effect of thermal and non thermal processing technologies on the bioactive content of exotic fruits and their products: review of recent advances. *Food Research International*, **44**, 1875-1887.

Sánchez, M.C., Cámara, M., Díez, C. & Torija, M.E. (2000). Comparison of high-performance liquid chromatography and spectrofluorimetry for vitamin C analysis of green beans (*Phaseolus vulgaris* L.). *European Food Research and Technology*, **210**, 220-225.

Sánchez-Mata, M.C., Cabrera Loera, R.D., Morales, P., Fernández-Ruiz, V., Cámara, M., Díez Marqués, C., Pardo-de-Santayana, M. & Tardío, J. (2012). Wild vegetables of the Mediterranean area as valuable sources of bioactive compounds. *Genetic Resources and Crop Evolution*, **59**, 431-443.

Singh, M., Dhawan, K. & Malholtra, S.P. (2000). Carbohydrate metabolism in tomato (*Lycopersicon esculentum* L. Mill) fruits during ripening. *Journal of Food Science and Technology*, **37**, 222-226.

Singleton, V.L. & Rossi, J.A. (1965). Colorimetry of total phenolics with phosphomolybdic phosphotungstic acid reagents. *American Journal of Enology and Viticulture*, **16**, 144-158.

Stommel, J.R. & Whitaker, B.D. (2003). Phenolic acid composition of eggplant fruit in a germplasm core subset. *Journal of the American Society for Horticultural Science*, **128**, 704-710.

Sun-Waterhouse, D. (2011). The development of fruit-based functional foods targeting the health and well ness market: a review. *International Journal of Food Science & Technology*, **46**, 899-920.

Todaro, A., Cavallaro, R., Argento, S., Branca, F. & Spagna, G. (2011). Study and characterization of polyphenol oxidase from eggplant (*Solanum melongena* L.). *Journal of Agricultural and Food Chemistry*, **59**, 11244-11248.

Triantis, T., Stelakis, A., Dimotikali, D. & Papadopoulos, K. (2005). Investigations on the antioxidant activity of fruit and vegetable aqueous extracts on superoxide radical anion using chemiluminiscence techniques. *Analytica Chimica Acta*, **536**, 101-105.

Tsujimura, M., Higasa, S., Nakayama, K., Yanagisawa, Y., Iwamoto, S. & Kagawa, Y. (2008). Vitamin C activity of dehydroascorbic acid in humans –association between changes in the blood vitamin C concentration of urinary excretion after oral loading–. *Journal of Nutritional Science and Vitaminology*, **54**, 315-320.

Vilanova, S., Manzur, J.P. & Prohens, J. (2012) Development and characterization of genomic simple sequence repeat markers in eggplant and their application to the study of diversity and relationships in a collection of different cultivar types and origins. *Molecular Breeding*, **30**, 647-660.

Whitaker, B.D. & Stommel, J.R. 2003. Distribution of hydroxycinnamic acid conjugates in fruit of commercial eggplant (*Solanum melongena* L.) cultivars. *Journal of Agricultural and Food Chemistry*, **51**, 3448-3454.

Wills, R.B.H., Wimalasiri, P. & Greenfield, H. (1984). Dehydroascorbic acid levels in fresh fruit and vegetables in relation to total vitamin C activity. *Journal of Agricultural and Food Chemistry*, **32**, 836-838.

**Table 1** Cultivars used for the present study and their origin, use, and main fruit characteristics

| Cultivar | Origin | Cultivar group | Use | Fruit shape | Fruit colour | Fruit weight (g)[‡a] |
|---|---|---|---|---|---|---|
| BBS118 | Ivory Coast | White | Cooking, frying | Oval | White | 143.5±11.3 |
| CS16 | Barcelona, Spain | Black | Cooking, frying | Long | Dark purple | 197.8±28.1 |
| Dourga | Commercial variety, France | White | Cooking, frying | Semi-long | White | 220.3±8.7 |
| H11 | Almagro, Spain | Pickling | Pickles | Oval | Purple (sun exposed parts) in a green background | 226.5±31.8 |
| IVIA371 | Valencia, Spain | Striped | Cooking, frying | Semi-long | Purple stripes in a white background | 331.1±24.3 |
| LF3-24 | Breeding line INRA, France | Black | Cooking, frying | Long | Dark purple | 208.2±27.3 |
| Listada Clemente | Commercial variety, Spain | Striped | Cooking, frying | Semi-long | Purple stripes in a white background | 256.0±30.4 |

[‡a] Average±SE of three samples, each of which had a total sample weight of >1 kg and contained at least five representative fruits.

**Table 2** Proximate composition traits (mean±SE; n=3), and and coefficient of variation (CV), *F*-ratio obtained from the ANOVAs, and least significant difference (LSD; P=0.05) in the seven eggplant cultivars analyzedanalysed

| Cultivar | Moisture (g/100g) | Proteins (g/100g) | pH | Titratable acidity (meq NaOH /100g) |
|---|---|---|---|---|
| BBS118 | 92.6±0.2 | 0.60±0.03 | 5.38±0.03 | 1.65±0.13 |
| CS16 | 92.9±0.2 | 0.47±0.02 | 5.43±0.04 | 1.07±0.04 |
| Dourga | 93.1±0.2 | 0.33±0.02 | 5.34±0.04 | 1.12±0.09 |
| H11 | 91.8±0.1 | 1.13±0.02 | 5.49±0.03 | 1.44±0.12 |
| IVIA 371 | 93.7±0.5 | 0.59±0.07 | 5.48±0.02 | 1.29±0.07 |
| LF3-24 | 93.5±0.1 | 0.43±0.04 | 5.45±0.04 | 1.31±0.09 |
| Listada Clemente | 93.8±0.1 | 0.41±0.02 | 5.47±0.15 | 1.35±0.06 |
| Average | 93.0 | 0.57 | 5.44 | 1.32 |
| CV (%) | 0.8 | 47.2 | 1.0 | 14.9 |
| *F*-ratio† | 4.375* | 72.145*** | 1.238ns | 5.165* |
| LSD (P=0.05) | 0.6 | 0.09 | 0.15 | 0.26 |

†

ns, *, **, *** indicate non-significant, or significant at P<0.05, 0.01, and 0.001, respectively.

Con formato: Fuente: Cursiva
Con formato: Fuente: Sin Negrita
Tabla con formato
Con formato: Fuente: Cursiva
Con formato: Superíndice
Con formato: Superíndice
Con formato: Superíndice
Con formato: Superíndice
Con formato: Superíndice
Con formato: Superíndice

**Table 3** Carbohydrates content (mean±SE; n=3~~)~~), and coefficient of variation (CV), *F*-ratio obtained from the ANOVAs, and least significant difference (LSD; P=0.05) in the seven eggplant cultivars analysed ~~and coefficient of variation (CV) in the seven eggplant cultivars analysed~~

| Cultivar | Total available carbohydrates (g/100g) | Soluble sugars (g/100 g) | | | | | Starch (g/100g)[‡a] | Ratio total soluble sugars/starch | Fibre (g/100g) |
|---|---|---|---|---|---|---|---|---|---|
| | | Total soluble sugars (g/100g) | Glucose (g/100 g) | Fructose (g/100 g) | Sucrose (g/100 g) | Maltose (g/100 g) | | | |
| BBS118 | 3.05±0.02 | 0.74±0.12 | 0.39±0.07 | 0.35±0.04 | 0.00±0.00~~tr.~~ | 0.00±0.00~~tr.~~ | 2.31±0.04 | 0.32±0.07 | 2.15±0.06 |
| CS16 | 3.82±0.20 | 1.48±0.18 | 0.68±0.08 | 0.56±0.06 | 0.13±0.02 | 0.11±0.02 | 2.34±0.06 | 0.63±0.14 | 1.82±0.04 |
| Dourga | 3.55±0.09 | 2.13±0.09 | 1.04±0.05 | 0.83±0.04 | 0.13±0.01 | 0.14±0.00 | 1.43±0.02 | 1.50±0.07 | 1.17±0.03 |
| H11 | 4.19±0.16 | 1.81±0.13 | 0.95±0.19 | 0.63±0.13 | 0.10±0.03 | 0.13±0.04 | 2.38±0.06 | 0.76±0.26 | 2.24±0.10 |
| IVIA371 | 2.99±0.25 | 1.30±0.12 | 0.53±0.06 | 0.51±0.04 | 0.14±0.01 | 0.11±0.01 | 1.69±0.07 | 0.77±0.08 | 0.58±0.03 |
| LF3-24 | 3.55±0.07 | 1.49±0.12 | 0.71±0.05 | 0.55±0.08 | 0.12±0.01 | 0.11±0.02 | 2.06±0.03 | 0.72±0.08 | 0.68±0.02 |
| Listada Clemente | 3.62±0.13 | 1.24±0.15 | 0.51±0.07 | 0.50±0.06 | 0.13±0.01 | 0.10±0.01 | 2.38±0.04 | 0.52±0.04 | 0.66±0.06 |
| Average | 3.53 | 1.45 | 0.69 | 0.56 | 0.11 | 0.10 | 2.08 | 0.75 | 1.33 |
| CV (%) | 11.8 | 30.3 | 34.6 | 26.0 | 45.6 | 46.2 | 18.5 | 49.3 | 55.0 |
| *F*-ratio[†] | 10.132[***] | 11.489[***] | 8.510[**] | 5.166[**] | 14.461[***] | 10.453[***] | 69.813[***] | 12.169[***] | 226.073[***] |
| LSD (P=0.05) | 0.40 | 0.40 | 0.25 | 0.20 | 0.04 | 0.04 | 0.14 | 0.32 | 0.15 |

[† ns, *, **, ***] indicate non-significant, or significant at P<0.05, 0.01, and 0.001, respectively.

Con formato: Fuente: Cursiva
Con formato: Interlineado: Múltiple 1,3 lín.
Con formato: Interlineado: Múltiple 1,3 lín.
Con formato: Interlineado: Múltiple 1,3 lín.
Con formato: Interlineado: Múltiple 1,3 lín.
Con formato: Interlineado: Múltiple 1,3 lín.
Con formato: Interlineado: Múltiple 1,3 lín.
Con formato: Interlineado: Múltiple 1,3 lín.
Con formato ...
Con formato: Fuente: Sin Negrita
Con formato ...
Con formato ...
Tabla con formato
Con formato ...
Con formato: Superíndice
Con formato: Superíndice
Con formato: Superíndice
Con formato: Superíndice
Con formato: Superíndice
Con formato: Superíndice
Con formato: Superíndice
Con formato: Superíndice
Con formato: Superíndice
Con formato ...

[‡a] Determined as the difference between total available carbohydrates (measured by colorimetry) and total soluble sugars (measured by HPLC).

**Table 4** Antioxidants content~~s~~ (mean±SE; n=3) ~~and coefficient of variation (CV) in the seven eggplant cultivars analysed~~, and coefficient of variation (CV), *F*-ratio obtained from the ANOVAs, and least significant difference (LSD; P=0.05) in the seven eggplant cultivars analysed

| Cultivar | Vitamin C (mg/100g) | AA[‡] (mg/100g) | DHA[‡] (mg/100g) | Ratio AA/DHA[‡] | Total phenolics (mg/100g) |
|---|---|---|---|---|---|
| BBS 118 | 3.19±0.48 | 1.51±0.17 | 1.68±0.35 | 0.90±0.05 | 81.7±15.0 |
| CS16 | 4.73±0.17 | 1.86±0.08 | 2.87±0.16 | 0.65±0.08 | 53.0±3.1 |
| Dourga | 2.91±0.23 | 1.02±0.04 | 1.89±0.25 | 0.54±0.04 | 41.0±0.8 |
| H11 | 6.54±0.77 | 2.20±0.11 | 4.34±0.70 | 0.51±0.08 | 76.1±7.4 |
| IVIA371 | 3.68±0.17 | 1.41±0.04 | 2.27±0.22 | 0.62±0.06 | 61.4±5.7 |
| LF3-24 | 3.90±0.22 | 1.39±0.14 | 2.51±0.26 | 0.55±0.06 | 43.6±2.3 |
| Listada Clemente | 3.68±0.40 | 1.36±0.05 | 2.32±0.47 | 0.59±0.03 | 62.5±11.2 |
| Average | 4.09 | 1.54 | 2.55 | 0.62 | 59.9 |
| CV (%) | 28.0 | 25.0 | 31.5 | 20.0 | 25.7 |
| *F*-ratio[†] | 12.327*** | 18.127*** | 6.513** | 5.285** | 5.590** |
| LSD (P=0.05) | 1.06 | 0.27 | 1.05 | 0.17 | 19.9 |

[†] ns, *, **, *** indicate non-significant, or significant at P<0.05, 0.01, and 0.001, respectively.

[‡] AA=ascorbic acid; DHA=dehydroascorbic acid.

**Con formato:** Fuente: Cursiva

**Con formato:** Superíndice

**Con formato:** Fuente: Sin Negrita

**Tabla con formato**

**Con formato:** Superíndice

**Con formato:** Superíndice

**Con formato:** Superíndice

**Con formato:** Superíndice

**Con formato:** Superíndice

**Con formato:** Inglés (Estados Unidos)

**Con formato:** Título 1, Justificado, Interlineado: Doble, Punto de tabulación: No en 5,82 cm

**Table 5** Correlation coefficients for each composition trait for the first and second principal components, eigenvalue, and relative and cumulative proportion of the total variance explained by these components, in a set of seven eggplant accessions.

| | Common principal component coefficients | |
|---|---|---|
| Traits | Component 1 | Component 2 |
| Moisture | -0.124 | 0.307 |
| Proteins | 0.112 | -0.366 |
| pH | 0.066 | -0.174 |
| Titratable acidity | -0.201 | -0.251 |
| Total available carbohydrates | 0.269 | -0.170 |
| Total soluble sugars | 0.345 | -0.054 |
| Glucose | 0.331 | 0.031 |
| Fructose | 0.304 | 0.168 |
| Sucrose | 0.232 | 0.217 |
| Maltose | 0.330 | 0.129 |
| Starch | -0.222 | -0.108 |
| Ratio total soluble sugars/starch | 0.314 | 0.019 |
| Fibre | 0.004 | -0.319 |
| Vitamin C | 0.197 | -0.321 |
| Ascorbic acid (AA) | 0.092 | -0.374 |
| Dehydroascorbic acid (DHA) | 0.237 | -0.278 |
| Ratio AA/DHA | -0.308 | -0.108 |
| Total phenolics | -0.157 | -0.329 |
| | | |
| Eigenvalue | 7.690 | 5.757 |
| Variance explained (%) | 42.7 | 32.0 |
| Cumulative variance explained (%) | 42.7 | 74.7 |

Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...
Con formato ...

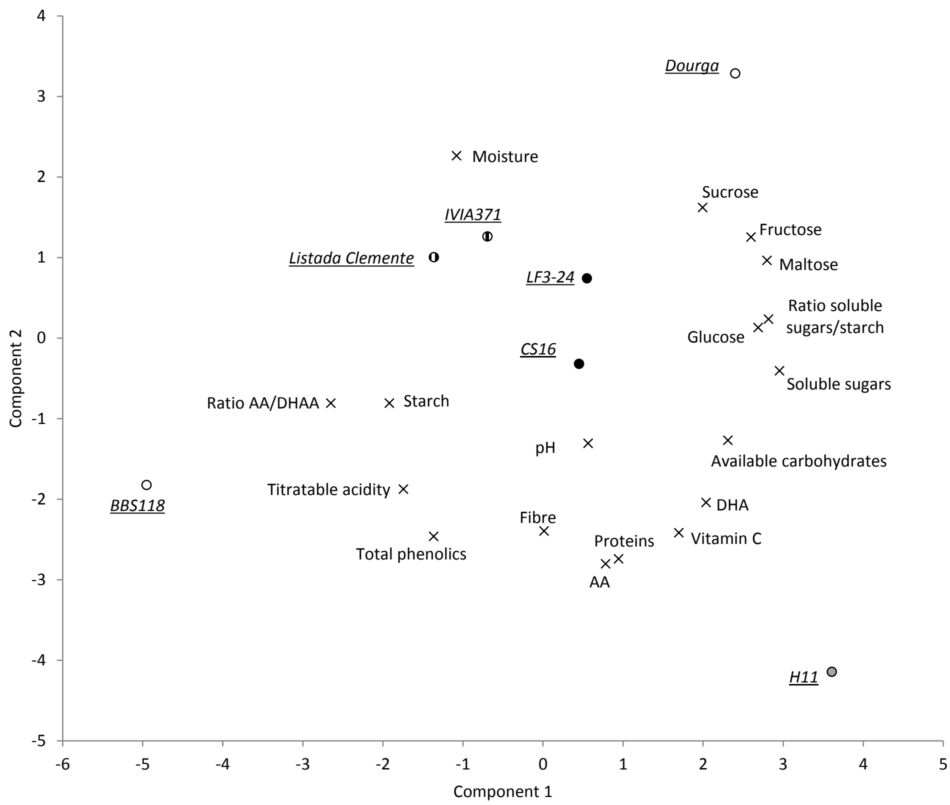


**Figure** 1~~2~~ Biplot representation of the r~~R~~elationships among the 18 composition traits studied ~~(above)~~ and among the seven eggplant cultivars characterized according to the two first principal components of PCA (42.7% and 32.0% of the total variation, respectively). Traits are indicated by crosses and normal font, and cultivars by circles and underlined italics font. The fruit type is indicated by the filling of the circles: black for the dark purple cultivars, striped for the striped cultivars, white for the white cultivars, and grey for the pickling cultivar.

**Con formato:** Fuente: Sin Negrita