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Evaluation of Qualitative Parameters and Physicochemical Properties of Local Varieties of Muskmelon (*Cucumis melo* L.) Grown in Tunisia

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ABSTRACT

The quality characteristics, carotenoids and total phenolic contents of muskmelon cultivars (*Cucumis melo* L.) were investigated. Four local muskmelons varieties ('Maazoul', 'Galaoui', 'Stambouli', and 'Fakkous') were evaluated for their agronomic characteristics, total carotenoids and total phenolic contents. Significant differences were found between muskmelon varieties in carotenoid and phenolic contents. Total carotenoid content ranged from 1.15 in 'Maazoul' to 12.82 mg kg^{-1} FW in 'Galaoui'. The highest phenolic value (474.42 mg kg^{-1} FW) was shown by 'Galaoui'. Generally, highest content of carotenoid and total phenolics were obtained for 'Galaoui' variety. In fact, total carotenoid content obtained in 'Galaoui' was more than 12-fold higher than those obtained in 'Maazoul'. This study demonstrates that carotenoid and total phenolic contents were greatly influenced by genotype emphasizing the need to evaluate the muskmelon biodiversity in order to improve its nutritional value.

Keywords: cantaloupe, carotenoids, phenolics, quality

INTRODUCTION

Cucumis melo L., commonly called as cantaloupe or muskmelon, is one of the main vegetable crops grown and consumed in Tunisia and is therefore of economic importance. Muskmelon Fruits are consumed in the summer period and are popular because the pulp of the fruit is very refreshing and sweet, with a pleasant aroma. It ranks second after watermelon (Jebari *et al*. 2004). In 2010, 9, 500 ha we dedicated to this crop and its production amounted to 96, 079 tons (FAO 2012). Muskmelon cultivars possess substantial variability in fruit quality traits, such as climacteric behavior color, texture, aroma and taste (Burger *et al*. 2002, 2006; Núñez-Palenius *et al*. 2008).

In addition to its superior consumer preference, muskmelon fruits are an extremely healthful food choice as they are rich in ascorbic acid, carotene, folic acid, and potassium as well as a number of other human health-bioactive compounds (Lester and Hodges 2008). Muskmelon fruits are also a rich source of vitamin A, C, β-carotene, carbohydrates, sugars, protein and traces of vitamin K, B1, B2, B6 and niacin. In recent years, natural compounds, particularly carotenoids and phenolics, have received a great interest because of their antioxidant activity against free radicals, suggesting protective roles in reducing risk of chronic diseases, such as cancer and cardiovascular disease (Rice-Evans *et al*. 1996; Giovanucci 1999; Agarwal and Rao 2000).

Muskmelons accumulate high amounts of β-carotene, since it represents its major mesocarp phytochemical (Hedges *et al*. 2005). USDA (2008) reported that melon is a relevant dietary source of β-carotene (20.20 mg kg^{-1} FW). The amount of carotenoid content in muskmelon is strongly influenced by varietals differences (Lester and Eishen 1995). It has been reported that orange fleshed fruit are a rich source of dietary carotenes whereas; fruits possessing a white or green mesocarp possess a comparatively lower β-carotene contents (Woblang *et al.* 2010).

Melon fruits are also a significant source of polyphenol antioxidant phytochemicals which provide health benefits, particularly to the cardiovascular system, as largely showed for other foods. These bioactive compounds (particularly the flavonoid sub-class) are known to up-regulate the formation of nitric oxide, a key chemical in promoting health of the endothelium and prevention of heart attacks (Lopez *et al.* 2007; Koleckar *et al.* 2008).

Despite their great health benefit significance, few studies reported data on carotenoids and total phenolic contents in Muskmelon varieties. In Tunisia, interest in assessing bioactive compounds with antioxidant capacity and potential health benefits is increasing (Ilahy *et al*. 2011; Tlili *et al*. 2011). Besides, the content of the different classes of antioxidants and the antioxidant activity are increasingly becoming important parameters in the qualitative evaluation of fruits (Lenucci *et al*. 2006; Ilahy *et al*. 2011; Tlili *et al*. 2011).

It is known that the amount of each antioxidant in the vegetables is strongly influenced by varietals differences and a large number of external factors such as agro-technical process, climatic conditions and ripeness during harvest and post harvest manipulation (Waterman and Mole 1994; Abushita *et al*. 2000; Dumas *et al*. 2003).

On the basis of the above observations, the aim of this study was to investigate some agronomic and physicochemical properties of some local muskmelon varieties grown in Tunisia.

MATERIALS AND METHODS

Field experiment

The experiment was carried out at the Mannouba support station latitude 36° 45′ 0″ N, longitude 10° 0′ 00″ E) located in the north of Tunis Tunisia. Four local muskmelons varieties, 'Maazooul',

Received: 18 January, 2013. Accepted: 22 February, 2013.

Original Research Paper

Table 1 Some agronomic characteristics of the different studied muskmelon varieties

Cultivars	Yield plant^{-1} (Kg)	Average fruit weight (Kg)	Fruit length (cm)	Diameter of fruit (cm)	Cavity of fruit (cm)
Maazoul	5.03 c	2.52 c	13.16 d	12.00 c	8.20 b
Galaoui	6.83 b	3.42 a	20.00 c	17.00 a	8.66 b
Stambouli	8.33 a	2.73 b	21.83 b	14.83 b	12.50 a
Fakkous	0.40 d	0.14 d	23.83 a	2.90 d	0.00
Significance	**	**	**	**	**

** Probability level of 1%; ns: not significant. Values in the same column followed by the same letters do not differ significantly (LSD test, $P<0.05$).

'Galaoui', 'Stambouli', and 'Fakous', selected by the National Agricultural Research Institute of Tunisia, were used in this experiment. Sowing was carried out on March 2nd 2011 in plug-seedling trays. Muskmelons plants were transplanted on April 12th into a sandy soil on black plastic mulch, with an in-row spacing of 100 cm and a between-row spacing of 150 cm. Four blocks were used with 10 plants per variety. After transplanting, drip irrigation was applied with 4 L h^{-1} drippers placed at 0.4 m intervals along the irrigation line. Drip irrigation ran for 1-3 h, at one to two times per week depending on the potential evapotranspiration of the research station, climate data and crop coefficient. The production methods were in accordance with the procedure utilized by the research and experimental station of Manouba, Tunis, Tunisia and recommended by the National Agricultural Research Institute of Tunisia. They included fertilization with synthetic chemical fertilizers (145 kg N ha^{-1}, 140 kg P_2O_5 ha^{-1}, 210 kg K_2O ha^{-1}) chemical fertilizer solution was added to water irrigation by pump injection twice a week. The production methods also included a hand-weeding control and plant-pathogen control with synthetic chemical pesticides. Imidacloprid (200 g L^{-1}) was used to reduce aphids, acetamipride (200 g L^{-1}) was used to reduce thrips and abamectine (18 g L^{-1}) was used to reduce mites. All these pesticides were applied once a cycle.

All varieties were simultaneously grown and subjected to identical cultural practices in order to minimize the effect of environmental condition and genotypes varieties. Fully ripe muskmelons fruits were harvested in July 2011 ('Fakous', June 2011, commercial green stage). Field ripeness was judged by tendril browning, yellowing of the ground spot and by a thumping sound with changes from a metallic ringing when immature to a soft hollow sound at maturity. All the fruit were transported to the laboratory for analysis.

Fruit tissue sampling

Fruit were cut longitudinally from stem-end to blossom end through the ground spot and tissues samples were taken from the central part of each fruit. Muskmelons flesh was cut in pieces and homogenized in a mixer. Soluble Solids Content (°Brix) and pH were determined. For further analysis, 250 g of flesh without seeds per fruit was collected, wrapped with aluminium, placed into plastic bags and kept quickly at -80°C.

Determination of agronomic characteristics

Only fully ripe muskmelons fruits were considered for analysis. Yield was expressed by fruit weight per plant (Kg). Average fruit weight (Kg), the fruit length (cm), diameter (cm) and cavity (cm) dimensions were also determined.

Determination of physicochemical properties

Soluble solids content in watermelon (°Brix) was measured by cutting a wedge of flesh from all sampling areas and squeezing the juice into a digital refractometer (Atago PR-100, NSG Precision Cells, Inc., Farmingdale, NY, USA) calibrated with a 10% sucrose solution. pH was of the juice obtained from fruit tissue was determined with an electronic pH meter (WTW, Microprocessor pH Meter, PH 539, Weilheim, Germany).

Determination of carotenoids content

Total carotenoid content was extracted with hexane/ethanol/acetone (2:1:1, v/v/v) containing butylated hydroxytoluene (BHT) and analyzed using a spectrophotometer (Cecil BioQuest CE 2501, Cecil Instruments, Ltd., Cambridge, UK) at 450 nm, as described by Fish *et al*. (2002). Total carotenoids were expressed as mg of β-carotene equivalents Kg^{-1} fresh weight (FW) (mg β-carotene eq Kg^{-1} FW).

Total phenolic determination

Total phenols were extracted as described by Martinez-Valverde *et al*. (2002) on triplicate aliquots of homogenate juice (0.3 g). Briefly, 5 mL of 80% aqueous methanol and 50 µL of 37% HCl were added to each sample. The extraction was performed at 4°C, for 2 h, under constant shaking (300 rpm). Samples were centrifuged at 10000 × *g* for 15 min. The total phenols assay was performed by using the Folin-Ciocalteu reagent as described by Spanos and Wrolstad (1990) on triplicate 50 µL aliquots of the supernatant. The absorbance was read at 750 nm using a spectrophotometer (Beckman DU 650, Beckman Coulter, Inc., CA, USA). Results were expressed in mg gallic acid equivalent (GAE) kg^{-1} FW.

Statistical analysis

Effects of variety on the nutritional properties of cultivars were assessed by analysis of variance (ANOVA). When a significant difference was detected, means were compared using the least significant difference (LSD) test ($P < 0.05$). All statistical comparisons were performed using SAS Version 6.1 software (SAS Institute, Cary, NC, USA).

RESULTS AND DISCUSSION

Agronomic characteristics

The most important agronomic characteristics of the different studied muskmelon varieties are presented in **Table 1**.

The yield of marketable fruit of the studied muskmelon varieties was significantly different between cultivars ($P < 0.01$). The results varied from 0.40 to 8.33 Kg plant^{-1} in 'Fakous' and 'Stambouli' cultivars, respectively.

In regards to average fruit weight, the results showed that it was significantly different between cultivars ($P < 0.01$). The varieties produced fruit with average weight ranging between 0.144 and 3.5 Kg. *C. melo* var. *flexuosus* ('Fakous') produced small sized fruit.

For length of fruit differences were significant between studied watermelon varieties ($P < 0.01$). It varied from 13 to 25 cm for 'Maazoul' and 'Fakous' varieties, respectively. Similarly, differences in cavity of fruit were significant between studied muskmelon varieties ($P < 0.01$), varying from 0 to 12.5 cm for 'Fakous' and 'Galaoui' varieties, respectively.

Physicochemical properties

The soluble solids content, pH, carotenoid and total phenolic contents values were significantly different between studied muskmelon varieties ($P < 0.01$).

The soluble solids content of the muskmelon varieties are presented in **Fig. 1**. The results showed that values varied from 3.1 to 9 in 'Fakous' and 'Maazoul' cultivars, respectively. The pH of the muskmelon varieties are presen-

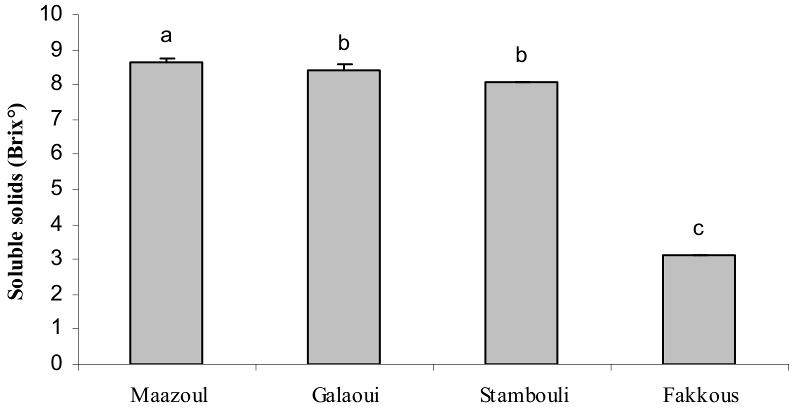

Fig. 1 Soluble solids content of the four muskmelon varieties. Values for each variety with the same letters are not significantly different (LSD test, $P<0.05$).

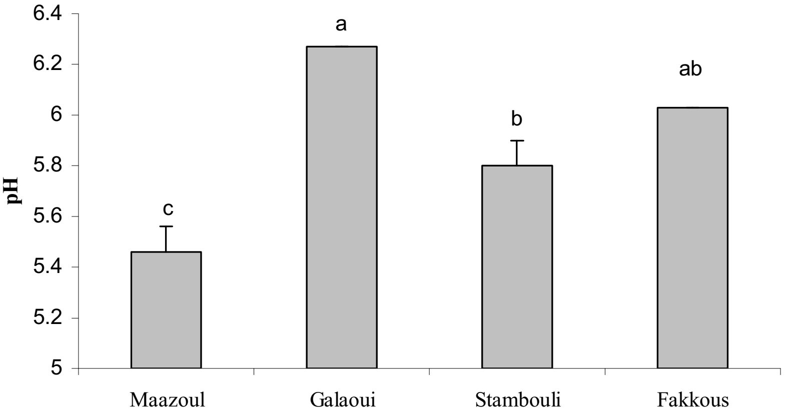

Fig. 2 pH of the four muskmelon varieties. Values for each variety with the same letters are not significantly different (LSD test, $P<0.05$).

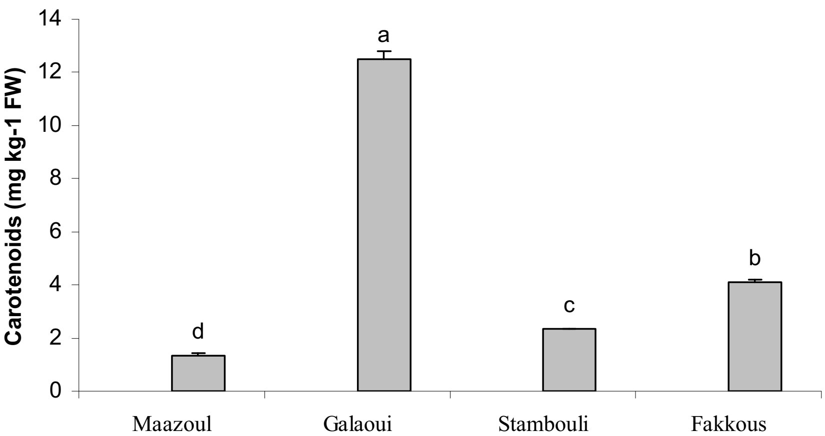

Fig. 3 Carotenoid content of the four muskmelon varieties. Values for each variety with the same letters are not significantly different (LSD test, $P<0.05$).

ted in **Fig. 2**. The pH values varied from 5.46 to 6.27 in 'Galaoui' and 'Maazoul' cultivars, respectively.

The carotenoid content of the studied muskmelon varieties was shown in **Fig. 3**. The results showed that values ranged from 1.15 mg kg^{-1} FW in 'Maazoul' (green flesh), to 12.82 mg kg^{-1} FW in 'Galaoui' (orange flesh). The carotenoid content obtained in "Galaoui' was more than 12-fold higher than those obtained in 'Maazoul'. Generally, highest values for carotenoids were obtained for orange pulp varieties. Our results are close to the range reported by Menon and Ramana Rao (2012) who focused on the nutritional quality of muskmelon cv 'Barvani' fruit as revealed by its biochemical properties during different rates of ripening. At the ripe stage, the authors found that total phenols content was 1.5 mg catechin equivalent mg^{-1} FW, total polyphenol attained more than 2 mg gallic acid equivalent mg^{-1} FW and carotenoid content attained 0.011 mg g^{-1} FW. Woblang *et al.* (2010) studied the influence of pre- and post-harvest factors on β-carotene content, its *in vitro* bio-accessibility and antioxidant capacity in melons. The authors reported significant cultivar effects on β-carotene content ranging from 1 to 23 mg Kg^{-1} FW. Much higher values attaining 31 mg g^{-1} FW were obtained in orange pulp muskmelon cultivars by Navazio (1994). These divergent results were probably due to variety or environmental differences.

Tlili *et al.* (2011) investigated the changes in major antioxidant compounds and antioxidants activities of five watermelon (*Citrullus lanatus* (Thunb.) Mansfeld) cultivars grown simultaneously in open-field of the south of Italy and harvested at four different stages of ripening. At the red-ripe

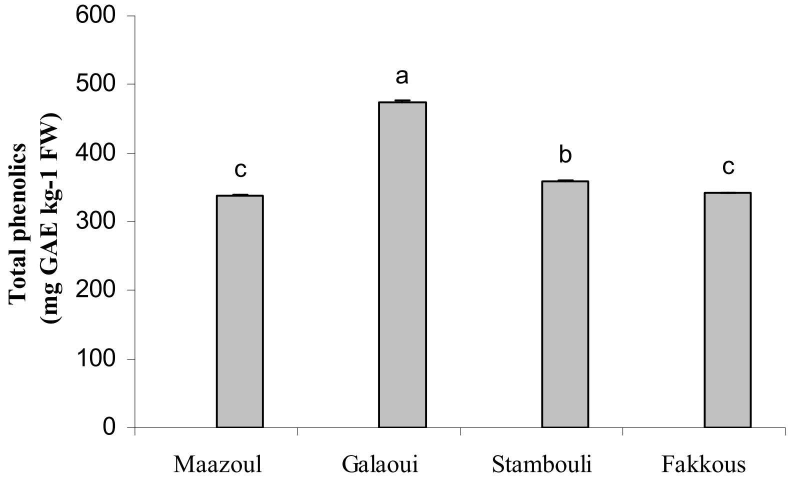

Fig. 4 Phenolic content of the four muskmelon varieties. Values for each variety with the same letters are not significantly different (LSD test, *P*<0.05).

stage, the authors found variation in total carotenoids from 86.7 mg kg^{-1} FW in 'Aramis' to 180.1 mg kg^{-1} FW in 'Giza'. In another study, Tlili *et al*. (2010) studied the phytochemical composition and antioxidant activity of selected watermelon varieties grown in Tunisia and found that lycopene content reached very high levels (>90 mg kg^{-1} FW) and varied from 47.40 mg kg^{-1} FW in 'Dumara' to 112.00 mg kg^{-1} FW in 'P503'. They reported also that 'Giza' had a similar lycopene level to 'P503'. The lycopene contents in both 'P503' and 'Giza' were more than 2-fold higher than those of 'Dumara' and 'P403'.

The total phenolics of the muskmelon varieties are presented in **Fig. 4**. The results showed total phenolics varied from 338.06 to 477.14 mg GAE kg^{-1} FW. The highest level was obtained in "Galaoui' and the lowest was obtained in 'Maazoul'. Generally, highest values for total phenolics were obtained for orange pulp varieties. Our results confirm those of Teow *et al*. (2007) and Wu *et al*. (2004) who reported that orange flesh of muskmelon had shown high antioxidant activities and also contained substantial amount of phenolic compound. Furthermore, our results were close to the range reported by Miguel (2008) and Teow *et al*. (2007) ranging from 360 mg GAE kg^{-1} FW to 510 mg GAE kg^{-1} FW. The obtained values were considerably higher compared to those reported by Moreira (2009) reached 160 mg GAE kg^{-1} FW. Higher values ranging between 920 mg GAE kg^{-1} FW to 1150 mg GAE kg^{-1} FW were obtained muskmelon in by Kolayli *et al*. (2010). Therefore, the results confirmed that genotype significantly affects total phenol content in muskmelon, as reported by many authors (Teow *et al*. 2007; Miguel 2008; Moreira 2009; Kolayli *et al*. 2010). While genetic control is the primary factor in determining phenols in fruits and vegetables, their level may be affected by environmental conditions, such as light and temperature (Macheix *et al*. 1990; Chittara 2005) and analytical methodology. The data also proved that muskmelon can constitute a good source of phenolics in Tunisian diet because of its availability and high consumption as was reported for American diet. In fact, Vinson *et al*. (2001) reported that muskmelon is the third among eight fruits that provide 80% of the daily phenols in the American diet.

CONCLUSIONS

This study has confirmed the important role played by genetic in determining antioxidant components of muskmelon. Therefore, our results provided evidence that orange fleshed muskmelon contained the highest value for carotenoid and phenolic contents. In fact, the variability detected among the four local muskmelon varieties emphasized an existing unexploited variability in muskmelon germplasm and stresses the need to evaluate more muskmelon genotypes and to support conventional breeding programs to improve muskmelon nutritional value.

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