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TEXTURE QUALITY OF MUSKMELONS (*CUCUMIS MELO* L.) FROM DIFFERENT RETAILERS DURING STORAGE

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ABSTRACT

The subject of study was to assess and to compare the effect of storage time on flesh firmness and skin strength in muskmelons (*Cucumis melo* L.) obtained from supermarket and marketplace. Texture quality of fruit is considered to be the major determinant for customer preference that depends on harvesting maturity and proper storage conditions of fruit and its fresh-cuts. Changes in flesh firmness and skin strength were measured periodically in stored fresh-cut fruits in both groups for initial, 2nd, 5th and 6th day. Analysis of basic physical parameters revealed that muskmelons from marketplace had higher height and width perimeter and therefore also a higher weight, compared to those ones from supermarkets. Textural analysis pointed out to significant differences (p <0.05) in flesh firmness among initial day group and all tested groups from 2nd, 5th and 6th day in muskmelons from supermarket. In marketplace muskmelon group was observed significant difference (p <0.05) between samples from initial day and 5th day. Within the skin strength, there were demonstrated significant differences (p <0.05) between initial day and most of remaining storage days in both supermarket and marketplace muskmelons groups. The data for flesh firmness and skin strength were used in linear regression analysis, in order to evaluate trends during storage period. The correlation coefficients of linear model describing relationship between storage time and skin strength for the group of supermarket and marketplace muskmelons were r = -0.828 and r = -0.780, respectively, which indicated approximately equal relationship between time and skin strength in both tested groups. A strong inverse correlation (r = -0.816) between time and flesh firmness in the group of supermarket muskmelons was noticed. In the group of marketplace muskmelons, there was observed weaker inverse correlation (r = -0.441) within this relation, compared to commercial ones. The model revealed that the muskmelons from marketplace retailers tend to maintain the flesh firmness for a longer time than did commercial ones. The melon flesh quality was markedly changing during storage period and highly depends on the muskmelon origin.

Keywords: muskmelon fruit; flesh firmness; skin strength

INTRODUCTION

Melon family is an economically important crop that includes wildtypes and numerous varieties, consumed worldwide either as desert fruits, vegetable or sauce ingredients, depending on the type of fruit. Varieties vary widely in fruit size, morphology and taste, as well as vegetative traits and climatic adaptation **(Pitrat et al., 1999)**.

Muskmelon is a beautiful, juicy, tasty and delicious fruit popular for its nutritive and medicinal properties and is one of the popular products in fresh-cut fruit market. The *Cucurbitaceae* family includes squash, pumpkins, cucumbers, Muskmelons, watermelons, and gourds. *Cucumis melo* (Cantaloupe or Muskmelon) is one of the most important cultivated cucurbits, which is native to India and Africa. Muskmelon (*Cucumi smelo* L.) is characterised by number of varieties **(Maran and Priya, 2015; Aguayo et al., 2004; Maran and Priya, 2015; Pitrat et al., 2000)**.

The muskmelons are highly considered for the sweet taste of the flesh, which develop as the fruit reaches full maturity. Volatile compounds, mainly esters, increase with increasing fruit maturity, thus contributing to the desirable sweet aroma of the fruit. Moreover, fruit that remains attached to the plant accumulates sucrose, resulting in a fruit with a sweet taste **(Lignou et al., 2014)**.

Originally, the popularity of melon was due to its refreshing and tasty flesh and pleasant aroma. It was consumed mainly in the summer period as an appetizer, in cold soups or salads, and as a dessert. Increasing interest in muskmelon consumption is associated with its potential human health benefits because contain naturally occurring vitamins, minerals, and pigments, which provide antioxidant activity, anti-inflammatory properties **(Vouldoukis et al., 2004; Ismail et al., 2010)** and anti-diabetic benefits **(Kenny et al., 2013)**.

Muskmelon is an excellent source of vitamin C and a good source of vitamin A, notably through its β-carotene content. In addition, cantaloupe is a good source of potassium and vitamin B6. Cantaloupes contain carotenoids which are a group of phytochemicals that may contribute to disease prevention because of their antioxidant properties **(Solval et al., 2012)**.

Moreover, it has been reported that seeds of muskmelon boost immunity, reduce cardiovascular risks, help in normalizing blood-fat levels and contain essential nutrients for wound healing **(Yanty et al., 2008)**.

The melon fruit is perishable commodity due to high water content. Minimal processing alters the integrity of the fruit and induces surface damages increasing lightly the tissue respiration and leading biochemical deteriorations such as browning, off-flavour development and texture breakdown decreasing the fresh-cut fruit quality **(Raybaudimassilia et al., 2008)**.

Therefore, high quality of muskmelons and fresh-cuts can be maintained by using product at proper maturity, and controlling deterioration using low temperature and other tools such as modified storage and chemical treatments **(Supapvanich and Tucker, 2012; Oms-Oliu et al., 2008)**.

Fruit quality is a consequence of many biochemical processes that result in changes of its intrinsic properties such as colour, texture, flavour and aroma, together with the exterior appearance (size, colour and shape) and nutritional value. These properties exert a strong influence on producing commercially acceptable melons, and happen to be remarkably different depending on each particular melon cultivar, due to its morphological variability **(Obando et al., 2007)**.

Fruit wholesalers are there for particularly interested in the measurement of fruit texture. All these attributes are based on biochemical, physical and structural components that occur at different levels in the fruit such as turgidity and cell wall composition at cell level; number, size and morphology of cells as well as their cohesion, spatial organization and the distribution of intercellular airspaces at the tissue level. All these components evolved during fruit growth and in postharvest storage **(Harker et al., 2010)**.

Texture is one of the most important quality parameters and is partly responsible for consumer preferences of edible fruit **(Harker and Johnston, 2008)**. Textural characteristics are related to the structure of cell walls and their degradation during the ripening phase. Consumers perceive hardness and juiciness as two factors that the most influence the mouth feel of a fruit **(Toivonen and Brummell, 2008)**. The results of textural analysis can be useful for optimising the cultivation and prolonging shelf life of product during storage **(Bebejová et al., 2014)**.

The use however of grafted plants in commercial melon production is not the one anticipated. This can be attributed partly to the higher cost incurred but also to frequent problems of incompatibility involving inter-specific Cucurbita root stocks, which may eventually lead to plant decline **(Aloni et al., 2010)**.

The subject of study was to evaluate texture quality of muskmelons from different retailers in relation to storage period, and to point out to its importance in logistical chain.

MATERIAL AND METHODOLOGY

Plant material and sample preparation

Ten muskmelons (*Cucumis melo* L.) were obtained from both supermarket and marketplace retailers in June 2015. All analyses were repeated six times. The muskmelons were randomly selected on the basis of uniformity and absence of damage or blemishes and divided into two sub-groups. The first sub-group was assessed in the same day of obtaining (initial day, day 2, 5 and 6).

The fruits from second sub-group were cut into 4 pieces, seeds and placental tissue were removed, and each piece was wrapped into a stretch film and stored in refrigerator for three different time periods (2, 5 and 6 days).

After storage, the fruit were kept in the room temperature (20 °C) 30 min before analysis. It was expected that different point of sale and length of storage would make it possible to vary the textural characteristics of the investigated fruit.

Storage conditions

Cut muskmelons were stored in refrigerator (Zanussi ZRB 36104WA) at 5 ±1 °C temperature and 85 – 90% relative humidity.

Physical parameters

Fresh weight was measured using a balance (KERN PCB 3500-2) and perimeters with plastic tape measure.

Texture analysis

The flesh firmness and skin strength was performed with TA-XT Plus Texture Analyzer (Stable Micro System, Surrey, UK) and samples were examined using a Stable Micro Systems Type (version 5.0, 9.0). The measurements were made at laboratory temperature.

Flesh firmness

The test was performed on sample in cube form (10 mm ×10 mm × 10 mm). The 2 mm cylinder probe penetrated sample into 6 mm distance. The cubes were always penetrated with the original rind-side down. Pre-test speed was 1.5 $mm.s^{-1}$ and then test speed was 1.5 $mm.s^{-1}$, followed by return post-test speed of 10.0 $mm.s^{-1}$.

Skin Strength

Trigger force of 5g has been used to move 2 mm cylinder probe down onto the melon skin. Pre-test speed was 1.5

Table 1 Fresh weight, height perimeter and width diameter of commercial and market group.

Parameters	Supermarket	Marketplace
Fresh weight (g)	1378.3	1781.5
Height perimeter (cm)	48.7	50.3
Width perimeter (cm)	42.5	49.0

mm.s^{-1} and then test speed was 1.0 mm.s^{-1}, followed by return post-test speed of 10.0 mm.s^{-1}.

Statistical analysis

Linear regression analysis was used to assess evolution of flesh firmness and skin strength during storage period. Differences among groups were analysed with ANOVA. All the computational work, including the graphical presentations, was performed using XLSTAT (Addinsoft, 2014) package program.

RESULTS AND DISCUSSION

Texture represents one of the principal factors defining fruit quality and in melon, as in fruits like tomato strawberry, apple, blueberry or dates, textural characteristics are related to the cell walls' structure and their degradation during the ripening phase. To the consumer, there are two factors that most influence the mouth feel of a fruit or vegetable: hardness and juiciness **(Bianchi et al., 2016)**.

Hardness is a decisive attribute for consumer acceptance, as hardness loss is perceived to be associated with quality loss. It is also a primary quality selection trait used by melon producers to enhance fruit shelf-life during transport and sale **(Bianchi et al., 2016)**.

Texture definition is a sensory consideration, although it can be defined instrumentally. There are two ways to measure texture: sensory and instrumentally. Sensory measurement requires a previously trained panel, despite the existence of studies that employed consumer panels; instrumental measurement uses fundamental, empirical or imitative methods. Fundamental tests, like ultimate strength, Poisson's ratio or Young's modulus, measure viscosity and elasticity; empirical tests, like puncture, shear, and extrusion, measure parameters found to be correlated with sensory texture. Imitative tests are those that imitate with instruments the way food products are subjected in the mouth **(Bianchi et al., 2016)**.

The weight and perimeter parameters of melons from supermarket and group of melons from market place are presented in Table 1. Muskmelons from marketplace have higher height and width perimeter and therefore also a higher weight.

The flesh firmness of melons from supermarket and group of melons from market place are presented in Table 2. There were significant differences in flesh firmness between initial day group and all tested groups from 2nd, 5th and 6th day in melons from supermarket. In marketplace group of melons was observed significant difference between samples from initial day and 5th day. Decreasing of melon firmness or tend to be softened of their flesh was a common pattern for several fruit and it

Table 2 Mean, standard deviation and coefficient of variation of flesh firmness.

	Flesh firmness							
	Supermarket				Marketplace			
	Initial day	2 day	5 day	6 day	Initial day	2 day	5 day	6 day
***M* (g)**	816.06^{A,B,C}	525.56^{A,D,E}	339.30^{B,D}	387.07^{C,E}	284.47^{A}	277.61	245.52^{A}	248.03
***SD* (g)**	87.94	60.79	59.36	69.63	29.72	49.09	28.69	48.46
***CV* (%)**	10.78	11.57	17.50	17.99	10.45	17.68	11.69	19.54

Note: Results are shown as mean. Means in same row for group with same letter are significantly different (p <0.05).

Table 3 Mean, standard deviation and coefficient of variation of skin strength.

	Skin strength							
	Supermarket				Marketplace			
	Initial day	2 day	5 day	6 day	Initial day	2 day	5 day	6 day
***M* (g)**	6376.87^{A,B,C}	5659.87^{A,D,E}	4143.89^{B,D}	4351.35^{C,E}	3889.74^{A,B,C}	2561.73^{A,D,E}	1919.45^{B,D}	1909.23^{C,E}
***SD* (g)**	542.21	324.54	517.84	467.81	311.88	474.78	476.99	465.62
***CV* (%)**	8.50	5.73	12.50	10.75	8.02	18.53	24.85	24.39

Note: Results are shown as mean. Means in same row for group with same letter are significantly different (p <0.05).

Table 4 Fresh weight, height perimeter and width diameter of supermarket and market place group.

	Flesh Firmness		Skin Strength	
	Supermarket	Marketplace	Supermarket	Marketplace
Model	Y = 783.36 + -92.6472 X	Y = 293.63 + -10.3399 X	Y = 6535.43 + -487.803 X	Y = 3750.69 + -410.6611 X
Linear Correlation (*r*)	-0.816	-0.441	-0.828	-0.790
Coefficient of Determination (R^2)	0.666	0.194	0.686	0.623
***p*-value**	1.17992 x 10^{-6}	0.03	5.74905 x 10^{-7}	4.5 x 10^{-6}
Intercept	783.357	293.634	6535.426	3750.688
Slope	-92.647	-10.340	-487.803	-410.661

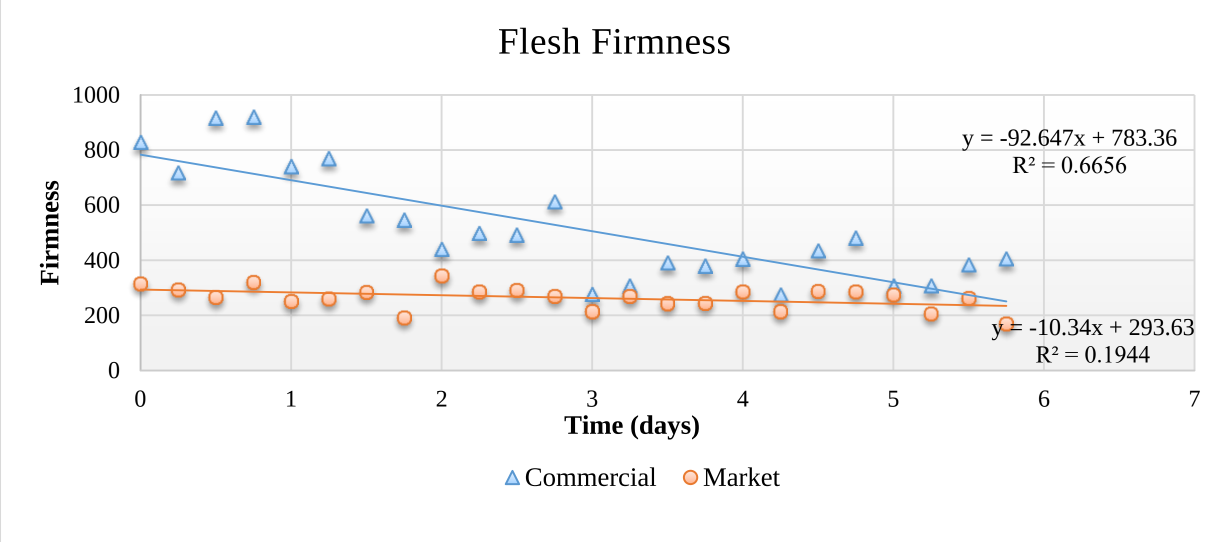

Figure 1 The relationship between time and skin Strength in the group of melons from supermarket and group of melons from marketplace.

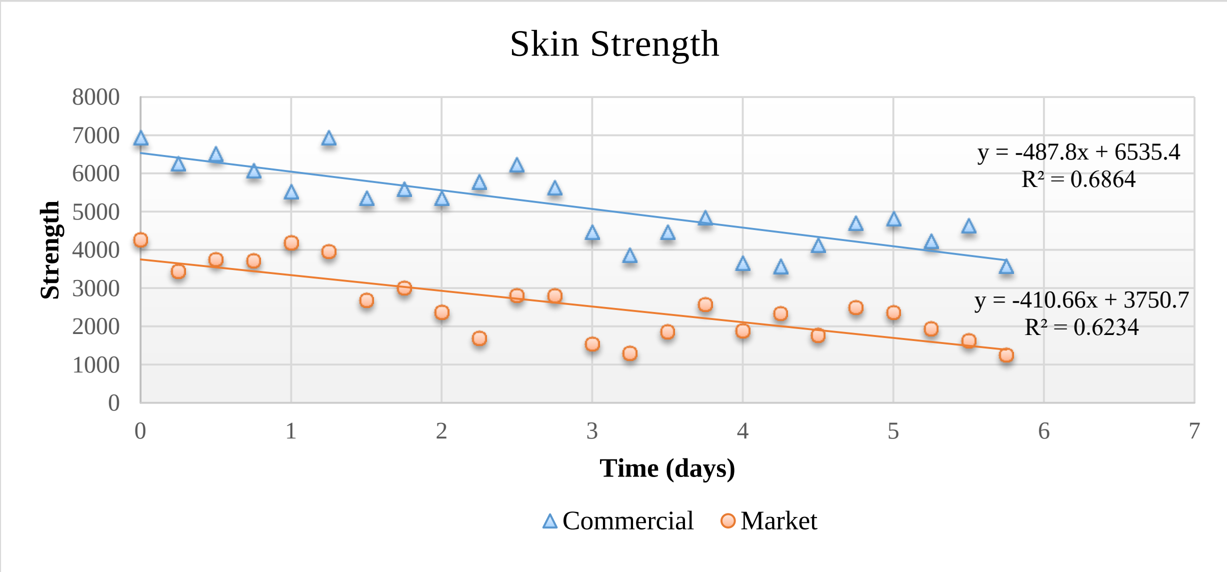

Figure 2 The relationship betweentime and skin Strength in the group of melons from supermarket and group of melons from marketplace.

can be associated with the decline in cell wall strength, cell wall adhesion and turgor changes **(Toivonen and Brummel, 2008)**.

During fruit ripening, there is a decline in turgor which contributes to textural changes **(Shackel et al., 1991; Harker and Sutherland, 1993)**, probably due partly to an accumulation of osmotic solutes in the cell wall space **(Almeida and Huber, 1999)**, and partly to postharvest water loss from the ripening fruit **(Saladie et al., 2007)**.

Degradation of pectine during storage may occur. **Van Buggenhout et al., (2009)** describe that in process-induced textural changes play a role enzymatic and chemical pectin changes: a) enzymatic degradation by the successive demethoxylation and depolymerisation by pectin methylesterase (PME) and polygalacturonase (PG), respectively; b) chemical degradation via a ß-elimination reaction or acid hydrolysis.

The skin strength of melons from supermarket and group of melons from market place are presented in Table 3. Similar trend as flesh firmness in commercial melons was observed for skin strength in both groups. Fresh-cut products are highly susceptible to weight and water loss because of internal tissues are exposed and lack skin or cuticle **(Watada and Qi, 1999)**, and wrapped the fresh-cut products using a plastics film protected skin of fresh-cut pieces and effect of external environment can be reduced.

Ripening can be rapidly initiated by wounding in pre-climacteric fruit **(Starrett and Laties, 1993)**. The rate of softening of fresh-cut fruit pieces is often markedly more rapid than in intact whole fruit **(O'Connor-Shaw et al., 1994)**. Tissue softening is frequently the major problem limiting the shelf-life of fresh-cut products **(Agar et al., 1999)**, which even when refrigerated can become unacceptable in as little as 2 days for tropical fruit such as papaya **(O'Connor-Shaw et al., 1994)**. During ripening naturally increases activity which leads to the degradation of cellulose and hemicellulose in fruit skin a subsequently softening of tissue **(El-Zoghbi, 1994)**.

Figure 3 *Cucumic melo* L. (WORLD CAPITAL, 2016).

The linear regression analysis revealed strong inverse correlation (r = -0.816) between time and flesh firmness in the group of supermarket muskmelons.

In the group of marketplace muskmelons, there was observed weaker inverse correlation (r = -0.441) within this relation, compared to commercial ones (Figure 1, Table 4).

In the group of supermarket muskmelons coefficient of determination (R^2 = 0.666) indicated average strength of relationship between time and flesh firmness, whereas in the group of marketplace muskmelons the model explained a less total variability, as coefficient of determination indicated weak relationship (R^2 = 0.194).

In both tested groups were evidences of correlation with statistical significance. Therefore, the relationship between time and flesh firmness is stronger in the group of muskmelons from supermarket (p <0.01), compared to group of marketplace muskmelons (p <0.05).

In both supermarket and marketplace groups of muskmelons, there was observed strong inverse correlation between time and skin strength, which had value of r = -0.828 and -0.790, respectively. In both groups, the models explained most of the total variability within endogenous variables and relationship above (R^2 = 0.686 and R^2 = 0.623, respectively). In both tested groups were evidences of correlation with statistical significance (p <0.01). The relationship between time and skin strength was approximately equal in both tested groups (Figure 2, Table 4).

CONCLUSION

The flesh firmness and skin strength followed a decreasing linear trend that was storage time dependent. From these results it was possible to understand that at the marketability limit, loss of flesh firmness was more critical in the supermarket group than in market place group. This information should be used to optimise the logistical chain with the aim of increasing the quality of fresh muskmelons on the market while also reducing the related costs.

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