The effect of grafting to the watermelon's (*Citrullus lanatus* [Thunb] Mansfeeld) nutritional values

Thesis of doctoral (Ph.D.) dissertation

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1. The antecedents of the work, objectives

The watermelon *(Citrullus lanatus [Thunb] Mansfeeld)* originates from tropical Africa and belongs to the family *Cucurbitceae (Fazeli et al. 2007).* The plant is well known worldwide as a vegetable - consumed as a fruit- can find in several countries *(Kim et al., 2014).*

As an effect of grafting the plant will be more resistant to the soil diseases and pests, besides it improves the biological metabolism, the stress tolerance, the yield quantity and quality *(Davis et al., 2008).* The rootstocks *Cucurbita maxima x Cucurbita moschata* hybrids are the ones that more influence the vigor and the yield quantity, because they have stronger growth than the rootstocks *Lagenaria.* During the observation of the qualitative parameters of the watermelon like the sugar and soluble material content, flesh firmness, color, shell thickness, it is not clear that grafting improves or not, or it has neutral effect to the quality of the crop *(Alan et al. 2017).*

The yield quality of the watermelon is effected by several aspects, but just a few of these factors were detected and measured yet. One of the most important parameter is the sugar content. Furthermore the lycopin content is a significant nutritional value *(Ryu et al., 1973).* In some cases the rootstock-scion combination increased the yield quantity but decreased the dry matter content *(Alexopoulos et al., 2007).* In contrast the other researchers have not find any difference between the grafted and non-grafted plants' dry matter content *(Colla et al., 2006).*

Based on the different scientific publications it can be stated that grafting effects the qualitative parameters of the crop positively and negatively also *(Huh et al., 2003),* therefore at the selection of the rootstock-scion combinations the compatibility, the observation of grafted plats' physiological changes, and the research of the changes in the quality of the crops are essential to the cognition of the whole process of grafting. The color and the taste of different watermelon types changes widely to the effect of the used rootstocks *(Rouphaela et al., 2010).*

Some of professionals state that human sensory organs can not repleace by measuring instruments. Despite the previous statement, it is necessary to use reliable and subjective machines, because the human sensory can be influenced, and there are materials which have health harming effects so these measures can only carried out by instruments. This study would provide useful informations for the practical life, as during the experiments I observe the nutritional values of different grafted combinations. The international literature provides contradictory informations for the effect of grafting to the nutritional values of watermelons. The grafting combinations, the environmental conditions, the nutrient filling technology all influence the nutritional values. In this study those rootstock-scion combinations will be observed, which are widely spread in the Hungarian practice, besides Hungarian growing conditions.

The objective of the presented experiment is to observe different watermelon rootstock-scion combinations' crops in three different Hungarian growing areas (Békés county, Fejér county, Jász-Nagykun-Szolnok county), with other technologies, with special emphasis on the taste and aromatic materials. The developement and evaluation of electronical tongue models topology is a kind of approaching device for the forecast of the watermelon species' taste.

2. Material and method

The experiments were set in the years 2013 and 2014. In both years the experiments were carried out in the same three places; Cece, Újkígyós and Jászszentandrás at the same growers. The used rootstocks *(FR STRONG 841)* and the measurements carried out were the same in both years, while in the second year the watermelon species have changed. As control self-rooted watermelons were examined (in 2013 a triploid watermelon *„RX 467"*, in 2014 the large *„Bonta F1"* was used). The scions were grafted to two rootstocks, one was the *„FR STRONG"* (*Lagenaria siceraria* (Mol.) Standl.), and the other was *„RS 841"* (*Cucurbita maxima Duchesne x Cucurbita moschata Duchesne*). From the different treatements 4 x 20 pieces of watermelons were planted to each growing area.

2.1. The conditions of the experiment

The experimentwas carried out in three places, during two years in 2013 and 2014 at Cece (Fejér county), Újkígyós (Békés county) and Jászszentandrás (Jász-Nagykun Szolnok county). I carried out the experiment besides different growing conditions, which were the same at the given places in the different observation years. In Cece only soil cover foil was used without irrigation. In Jászszentandrás soil cover foil was used also with drip irrigation, while in Újkígyós slipway foil wrap was applied also. The precipitation and temperature datas came from the National Meterology Service. In both years soil measurements were carried out and the applied nutrients were also registered.

2.2. The material of the experiment

The seeds of the different watermelon types and rootstocks were provided by Monsanto Hungaria Kft. In 2013 the small triploid *RX 467* watermelon was used, while in 2014 because of economical reasons we changed to the big *Bonta* watermelon type. The melons were chosen from two different group of species, because they have different characteristics, so clearer results could be given during the experiment. From the interspecific group (*Cucurbita maxima x*

Cucurbita moschata) the *RS 841* pumpkin rootstock was chosen, while from the Lagenaria group the *FR STRONG* was selected.

2.3. The method of the experiment

In both years from the different treatements 4 x 20 pieces of watermelon seedlings were plated to the growing areas. In 2013 the seedling caring and grafting was operated by a grower from Heves county. The seeding of scions was on the 2nd April, while the sowing of rootstocks happened 13 days later on the 15th April. The grafting took place on the 22nd April. The planting in Jászszentandrás was carried out on the 9th May, in Cece on the 8th May, in Újkígyós 7th May. The first harvest of the sampels in Jászszentandrás happened on the 29th June, in Cece on the 5th August, in Újkígyós on the 7th August.

In 2014 the seedling caring was carried out in Soroksár at the Corvinus University of Budapest's Vegetable growing sector. The seeds of the self-rooted seedlings and scions were sowed to propagation trays and chests of a size 60 x 40 cm, edge length 60 mm with 54 cells, on the 26th March. The seeds of the rootstocks were sowed to propagation chests on the 2nd April. Planting to the outdoor field happened on the 6th May in Jászszentandrás, on the 7th May in Cece, on the 8th May in Újkígyós. In 2014. the firs harvest of the samples was on the 21st July in Cece and Jászszentandrás while in Újkígyós it happened on the 24th July. In both years the harvested crops were stored in cool places. The processing and the first measurements were carried out on the next few days.

2.4. Measurements, observation methods

2.4.1. Preparation of the samples

For the laboratorial observations in 2013. 5-6 pieces while in 2014. 3-4 pieces of watermelon crops were harvested with the same size and developement from the different repetitions. The processing and the first measurements were carried out on the next few days. I measured the weight of the samples then I cut the melons into 4 pieces and with the help of color measuring device I measured the L*, a*, b* factors.

To carry out the sensory evaluation I chose samples from every treatements and I pay attention to the pressed homogeneous juice sample also contain watermelon from the crops that were tasted.

The pressed juice was pured to 50 ml falcon and eppendorf pipes then it was freezed. From the electronic tongue measurements the pressed liquid was filtered by paper filter and poured to the falcon pipe. At the measurements more crops were cutted (9-12 pieces from each treatements per growing areas). The extracts contain juice from the tasted fruits also.

2.4.2. Crop weight measurement

The weight of the harvested crops were measuren in 2013 and in 2014 also. The crop weight is not a nutritional factor, but it is an important property. I harvested the watermelons that were ripe enough, so I think that the measured samples represent corretly the control and grafted plants. The harvested melons from repetitions were signed with alcoholic pen (place/treatement/repetition/number), then we measured the weight by digital balance to two decimals accuracy.

2.4.3. Color measurement

Trhe color measurement by device help to simulate how the human eye see the color of an object and represent numeric datas. The reflected spectral datas are transformed so they provide reproducible color values.

2.4.4. The measurement of the refraction

In every test year the refraction of the watermelons were measured. The crops that were cut into quarters were measured at 4 parallel places from the middle of it, and 8 measures were from the edge. The refraction was measured by hand refractometer (PAL-1, ATAGO) and the result were given in Brix°. The value read from the device means the measured matter's dry matter percentage content (in this case especially sugar).

2.4.5. pH measurement

The pH value of the watermelons' flesh which were cut fresh were observed in each year. The quartes were observed with pH devices, where the measuring happened from each side of the slice. Minimum 6 measures were carried out, whish means that only 1 quarter was not measured per crop. The measure was operated with the help of digital pH device (HI 98128, pHep®, HANNA).

2.4.6. Vitamin C (ascorbic acid) measurement

From the freezed samples which were well homogenized (50 ml falcon pipe) 1-5 g was pured to a 100 ml Stift flasks, then 15 ml of extraction solution (for the making of 5% phosphoric acid and 0.01% Na-EDTA aqueous solution, 0.025 g Na-EDTA (or 0.0277 g Na-EDTA x $2H_2O$) and 14.70 ml phosphoric acid is needed)) was added. After 15 minutes of resting distilled water was added to reduce the concentration, then it was filtered. 5 ml from the filtret was filtered again through a membrain and from this a certain volume (10µm) was injected to a liquid chromatography device (*Maerae, 1988*).

2.4.7. The measurement of lycopene

The amount of lycopene was measured with spectophotometric method after hexan extraction *(Sadler et al., 1990.)* The measures happened on 502 nm. To calculate the lycopene content we used molar extinction coefficient (M cm^{-1}) *(Merck & Co, 1989).* The lycopene content was given in mg/100g fresh weight, and it was normalized in 6 Brix° dimension *(Barrett és Anthon, 2001)*.

2.4.8. The measurement of the sum antioxidant and polifenol

For the measurement the freezed and pressed liquid was used stored in the 1 ml eppendorf pipes. After melting the samples were centrifuged on 20°C, with 1500 turn/minute during 12 minutes to separate the parts with different density. The determination of the summarized antioxidant capacity of the plants was carried out with the modified method of Benzie and Strain (1966) which was used first for the determination of the summarized capacity of plazma (FRAP). The summarized fenol capacity related to gallic acid which is closely related to antioxidant capacity was measured with Folin-Ciocalteu reagent on λ = 760 nm (*Singleton és Rossi, 1965*) spectophotometry.

2.4.9. The statistics of the observed parameters

The refraction, acid content, all antioxidant, polifenol, lycopene, ascorbic acid, color and the weight of the crops statistical evaluation was carried out with the help of IBM SPSS Statistic 23 program. The normality of residuums were proved with Kolgomorov-Smirnov test in both years, and the homogenity of scatter was also proved with Levene's test. For the analysis of the datas, correlation and two-factor blocks ANOVA model were applied. From the mean comparative tests the Tukey post hoc analysis and if it was necessary, the Games - Howell trial was used.

2.4.10. Electronic tongue measurements

Alpha Astree II electronic tongue was applied to measure the juice of watermelons *(Alpha M.O.S., 2003)*. The calibration was performed with homogenized non-grafted watermelon's juice. At the same time 14 glasses could be places into the storage of the device. Between each measurements the sensors were cleaned with destillized waterto reach a stable potential. The watermelon juice samples were stored in freezer, which were melted just before the tests. The watermelon samples were not diluted, and the measurement were carried out at five times. The observations were carried out at room temperature between the following conditions: 100 ml sample volume, 120 s analysis time, 10 s cleaning time.

The analysis of the electronical tongue measurements results were carried out with principal component and discriminant analysis. The principal component analysis or PCA is not

a supervised method for the data's qualitative analysis (*Richards et al., 2002*). Furthermore I used LIDA, which is a supervised method in the interest of the analysis of the actual system's differentiation, with the maximalization of the distance between each groups by the conversion of the variables *(Berrueta et al., 2007).* Calculations and chemometrical analysis were carried out with R-studio 3.0.

2.4.11. Sensory evaluation

In both years the sensory evaluation took place at the Laboratory of the Szent István University, which is suitable for the ISO 8589:2007 standard's requirements. The testers in both years (12 person in 2013 and 10 person in 2014) are the qualified workers of the laboratory. These tasters have participated on a training where the ISO 8586:2012 was the standard at their selection. The reliability of the result was provided with thye repetition of the tests. The samples were rated on a scale from 0 to 100 in all the 17 sensory characters cases (*ISO 11035:1994*). The preparation of watermelon slices happened besides the same standardized parameters in each year (*ISO 6658:2005*).

To monitor the performance of testers the PanelCheck software was used, with one or two way statistical methods: to show the non-significant effect of products (2-factorial ANOVA), the examination of the agreement of tasters (Tucker-1 plot, Manhattan plot), the differentiation ability of testers *(Losó, 2011;)*.

3. Results

3.1. The weight of observed crops

In the year 2013 the weight of the crops were between 3-5 kg according to the species. The average weight of crops from Cece was nearly the same, but in Jászszentandrás and Újkígyós crops from the interspecific rootstock were heavier 0.9 and 0.5 kg on average than the samples of *Lagenaria* or the self-rooted rootstocks. The weigh of the watermelon was determined by the gowing area and the treatement significantly, but the two factors together have not influenced it.

In 2014 the results of the samples from Cece were inadequat to the expectations, especially in the case of *Lagenaria* treatement, where the 4.4 kg average weigth is the half of what is in the description of the species. I see the reason for this in the technology, because in Jászszentandrás and Újkígyós the watermelon sizes were adequate. The value of crop sizes in 2014 was determined mostly by the growing area and the interaction (place*treatement), while the type of treatement had not caused any effect.

3.2. Result of color measurements

In the observation year 2013 significant differences were find in case of the following factors: by location the lightness factor (L*) and the blue-yellow (b*), by treatements the green-red (a*) and blue-yellow (b*). In Cece and Jászszentandrás the a^* and b^* factors showed separation by the interspecific treatement. Crops from Újkígyós, any of the three factors did not formed a separate group. According to correlation test the factors a^*, b^*, L^* are linked to each other. Based on the CIELab system between the treatements the color differences were noticeable and visible

Test that were carried out in 2014 based on the statistical evaluatins by location only factor b* showed important differences. The rootstock RS 84's crops were darker and more colorful both for the red and yellow colors. In Jászszentandrás according to the average datas the self-rooted and interspecific plants crops had the most lighter flesh color, while the most darker were in case of *Lagenaria.* Factors a* and b* were darker only in case of RS 841. Overall there was no significat difference between the control and the treated crops. Samples from Újkígyós formed homogenous groups in all three cases (factors). The CEILab system proved that in Cece and Újkígyós the control and the treatements were differenciated easily. In Jászszentandrás from the harvested crops the treatements could be differenciated visibly from each other, while the self-rooted was hardly separated from the grafted ones.

3.3. Results of refraction tests

In Cece in 2013 in extensive conditions crops from the plants grafted to interspecific *RS 841* rootstock had the highest average dry matter content, it exceeded by 0,2 Brix° the values of the self-rooted ones. Watermelons which were cultivated on the rootstock *FR STRONG* from *Lagenaria* had an average 9,7 Brix° result, while crops of the rootstock *RS 841* with 0,6 Brix° and the self-rooted crops with 0,4 Brix° were behind it. According to the datas from Jászszentandrás and Újkígyós there was any difference between the treatements. In 2014 with the statistical evaluation of the analysis no significant difference was detected at the case of any growing areas.

3.4. pH values of crop flesh

pH results from 2013 showed significant differences based on statistical analysis by treatements. In Cece (Self-rooted - *Lagenaria*, Self-rooted – Interspecific) and Jászszentandrás (Self-rooted, *Lagenaria* – Interspecific) treatements could be divided to two homogenous groups. At the third experimental venue treatements form one homogenous group. In 2014 the differences were still not significant. Treatements were compared by growing areas. In Cece and

Jászszentandrás there is hardly any difference between the results, which is proved by the homogeneity test also. In contrast in Újkígyós treatements could be divided into two homonegos groups by the results (Self-rooted, Intespecific – *Lagenaria*). In both years the measured crops' pH was sightly acidic independently from the species and venues.

3.5. Ascorbic acid results

Ascorbic acid measurements were only carried out in 2014. Samples from all three growing areas showed big differences. In Cece I measured the highest 3.26 mg/100g vitamin C content in the case of plants grafted to *Lagenaria* rootstock, while the control and interspecific rootstocks with 1.66mg/100g and 1.64mg/100g provided exactly the same results.

Samples of Jászszentandrás had almost duplicated vitamin C content than samples from Cece. In this place the rootstock *Lagenaria* produced the best results. The control plant had second place, the interspecific one had the third. The control and grafted watermelons separated from each other but there was no significant difference (Tukey HSD: $p < 0,750$).

In Újkígyós the interspecific treatement's crops had the highest ascorbic acid concentration: 4.46 mg/100g, which is classified to a separate group statistically also.

3.6. Results of lycopene measurement

In 2013 statistically detectable differences could be measured. In Cece the interspecific rootstock performed the best results, better than the control and *Lagenaria*. Statistically two different group can be form according tot he Tukey HSD post hoc test (Self-rooted - Lagenaria, self-rooted - interspecific). The two grafted watermelon differed significantly. The homogenity tests have not showed difference between the treatements in Jászszentandrás and Újkígyós. The amount of lycopene was measured in 2014 also, according to statistics there is no important difference between the treatements. Based on the Tukey HSD post hoc test in Cece, Jászszentandrás and Újkígyós homogenous groups were formed from the values.

3.7. Results of the overall antioxidant content

In 2013 the three growing areas' results observing by treatements, there was no significant difference. The analysis took a difference in Újkígyós between the two grafted plants' results. In 2014 the statistical calculations showed that between the treatements there is no significant difference. The scatter was high which explains the homogenous groups.

3.8. Results of polifenol measurements

If we summarize the three places results, we gain significant differences between the treatements. In Újkígyós the polifenol concentration was the highest and most balanced, while in Jászszentandrás and Cece differences were detected. Values of the crops from Cece presented that the self-rooted treatement differs from the *Lagenaria* and the interspecific ones. In Jászszentandrás result could be classified to two homogenous groups. To the first group the *Lagenaria* and the self-rooted plants belong, to the second group the two grafted treatement's plants' belong. The results from Újkígyós not differ from each other. In 2014 in Cece, in Jászszentandrás and Újkígyós the polifenol concentration was high. According to statistics treatements in Jászszentandrás had significant effect. The two grafted watermelons' polifenol results differed from each other clearly only at this location.

3.9. Results of electronic tongue measurement

In 2013 the at the case of the measurements with electronic tongue, with the evaluation of PCA analysis the groups of samples could be separated according to the origin of samples **(Figure 1)**. Signs of the samples from Jászszentandrás and Újkígyós region were easily differenciated. Values from the growing areas Cece and Újkígyós overlapped at the sample „us1". The LDA analysis proved the results of PCA, that the growing areas can be differenciated.

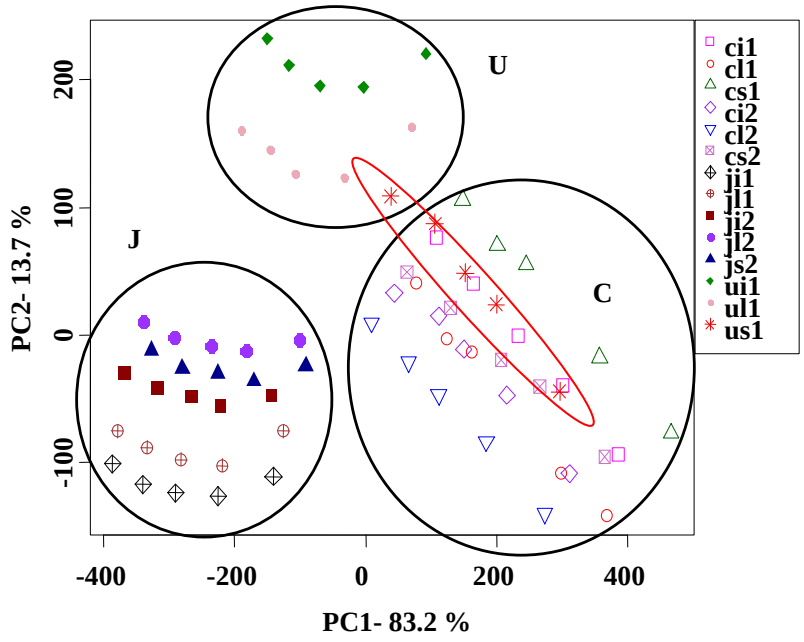


Figure 1: Analysis of watermelon samples from each growing areas with PCA (PC1-PC2) (Samples in the black ellips means growing area, red ellips shows sample from Újkígyós that overlaps the samples from Cece) -

The selection PCA analysis of the electronic tongue observation in the case of the samples from 2014 show good separation based on their origin and treatement **(Figure 2).** The first two main component explains 97% the variance of datas. The results showes that the observed watermelon species' groups differed according to the region (harvest area) based on the first main component (PC1). The gained results of linear discriminance analysis are similar to the PCA analysis results', where each groups were separated based on the growing area.

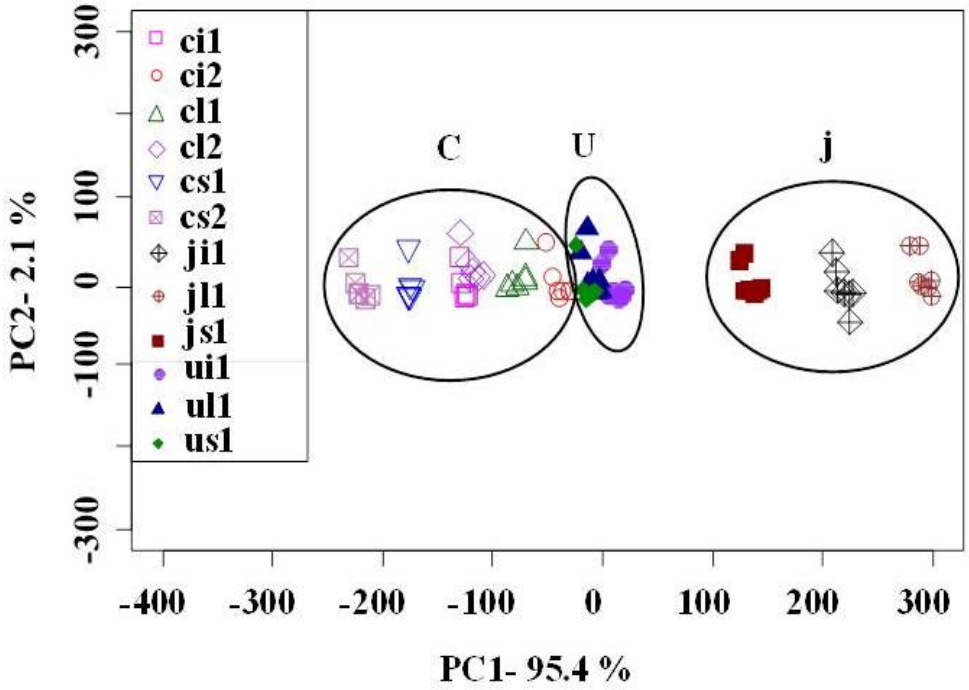


Figure 2: Analysis of watermelon samples from each growing areas with PCA (PC1-PC2), (Samples in the black ellips means growing area) – 2014

As a consequence it can be established that the usage of electronic tongue is possible to detect the origin of watermelons. The results showed that the differences between the grafted and non-grafted watermelons are smaller, than the technological and environmental influence. The analysis can be used in case of monitoring the effect of different treatement methods on watermelons.

3.10. Results of sensory evaluation

3.10.1. Results of sensory analysis from 2013

Figure 3 shows the sensory evaluation of crops from Cece. During statistical analysis I found significant differences between the treatements in case of the red color intensity of the flesh, where crop from rootstock *RS 841* had the best results. Further important differences were between the treatements in case of rind thickness, fibrosity, juiciness, venousness, global scent

intensity, sweetness, taste durability and taint. The other tested features did not show big differences with 5% first-gen fault. The fibrosity gained the highest point in case of crops from *RS 841*. Scores closer as possible to the control means the preservation of the quality, so in this case the *Lagenaria's* grafted crops had better results. The juiciness, global scent intensity, sweetness and taste durability was more intensive at the self-rooted crops. The lagenaria had the second place, while the interspecific was the next in the rank of popularity in case of the mentioned features. Venousness appeared more intensively in both cases (rootstock type).

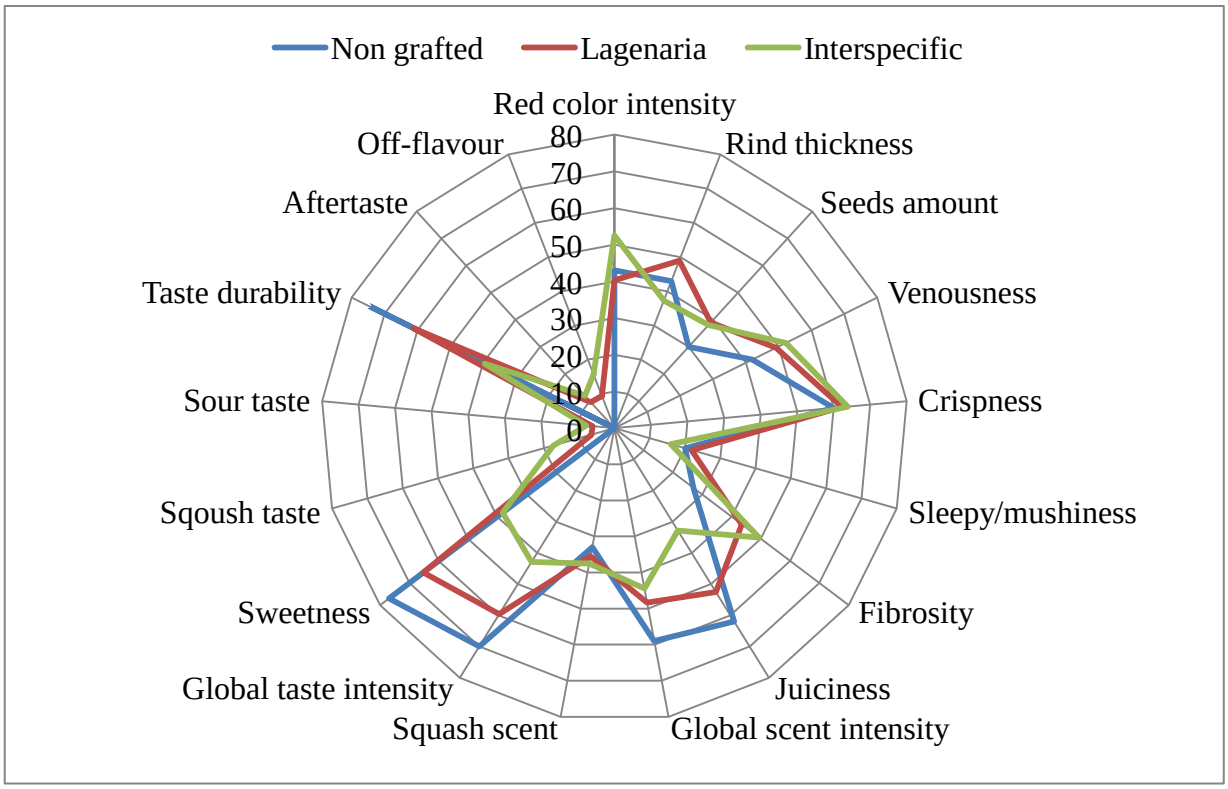
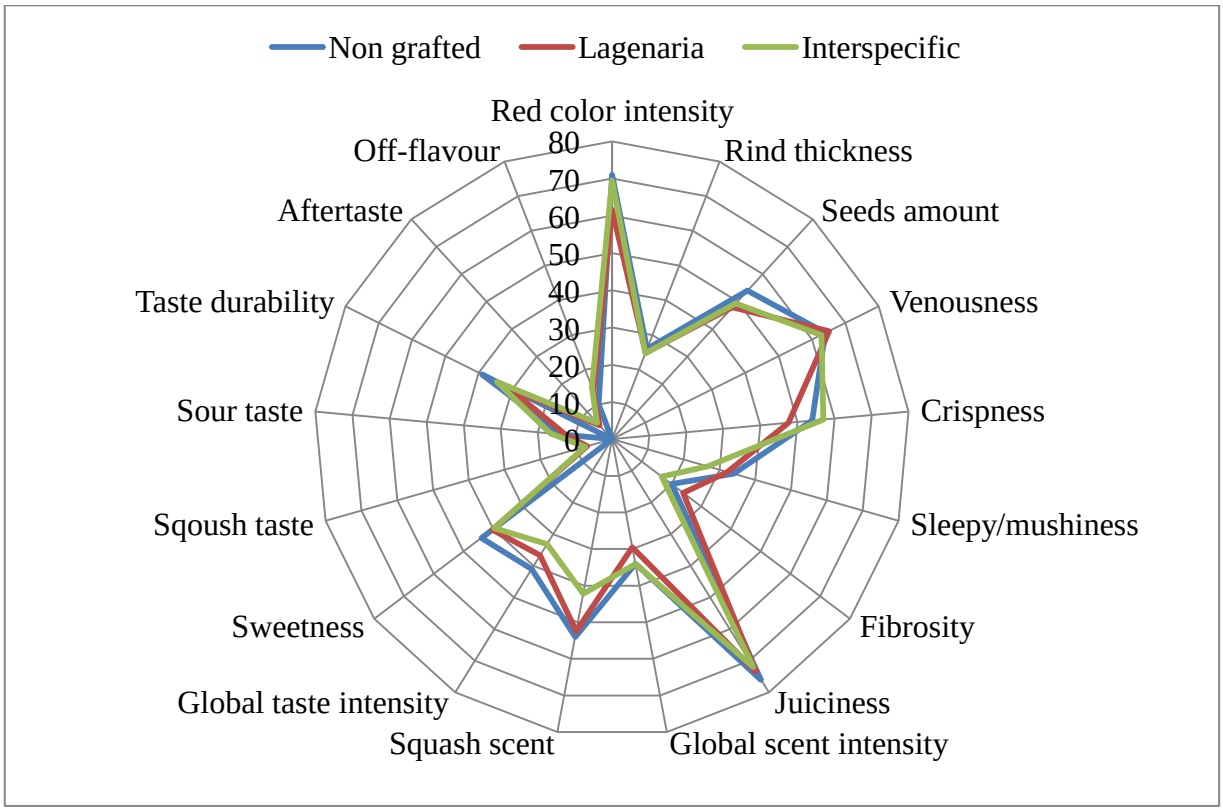


Figure 3: Cece – results of sensory evaluation ($p < 0,05$) – 2013

In 2013 during statistical analysis I found significant differences between the treatements in case of the red color intensity, where the self-rooted plants had worse points than the interspecific treatements. There was significant difference in case of rind thickness, venousness, seeds amount, mushiness, fibrosity, global tate intensity, sweetness and taste durability. The RS 841 produced the worst result at the rind thickness, seeds amount and venousness. The other features have not showed significant differences. Crops from Újkígyós showed big differences in case of seven characteristics. The juiciness, global taste intensity, sweetness and taste durability differed from each other mostly. In case of these features the tasters liked the self-rooted fruits better.

3.10.2. Results of sensory analysis from 2014

According to statistical analysis differences could be show only in case of fibrosity. The other features gained differenc at the chosen 5% first-gen fault. In case of fibrosity the Lagenaria treatement's evaluation is other than the self-rooted's **(Figure 4.).**



1. ábra: Cece – results of sensory evaluation ($p < .0,05$) – 2014

In the second growing area (Jászszentandrás) I found significal difference between the treatement in case of rind thickness, seeds amount, venousness, mushiness, fibrosity, sweetness, taste durability and aftertaste. The scent and taste intensity, sweetness and taste durability was the strongest at *FR STRONG*. The sqoush scent, sour taste, taint was felt at self-rooted and grafted plants's crops, but sqoush taste and aftertaste only in the grafted ones. The seeds amount and mushiness in the interspecific, while venousness in the case of *Lagenaria* rootstock was better. There was no significal difference at the third region's srops (Újkígyós) in case of the following features: crispness, fibrosity, global scent intensity, sqoush scent, global taste intensity, sweetness, sqoush taste, taste durability, sour taste, aftertaste and taint, but the other ones produced differences. In case of red color, juiciness, global taste intensity the FR STRONG rootstock, while the global scent intensity, taste durability the self-rooted watermelons were

better. Seetness got 44 and 43 points from tasters at the control and grafted plants. Results of sensory evaluation of 2014 from Újkígyós were balanced.

3.11. New scientific results

I give the following scientific results according to the evaluation of the experiment done with grafted watermelons (*Citrullus lanatus* [Thumb] Mansfeeld) in the years 2013 and 2014:

1. The experiment have proved that the growing area and the applied technology influence the quality of crops, better than the grafting combination.
2. According to the measurements done, I have proved that there are certain qualitative parameters that influences the rootstock.
3. Measurement methods applied in the experiment provided exact informations, which are those features that change during the rootstock-scion relationship (weight, color, pH, lycopene, polifenol). I have got information from the degree of these changes also.
4. Results of sensory evaluation have showed that squosh taste is presented in the crops of grafted plants, but it's degree is not significant.
5. The experiment have proved that crops can distinguish based on their growing areas.

4. Conclusions and proposals

The analysed results are summarized in the **Table 1**. Based on the evaluation of all the measured parameters the interspecific treatements proved to be better, then the self-rooted or *Lagenaria* treatement's plants. The comperison of the sensory evaluations red color intensity, the color measurement a * and lycopene results I came to the conclusion that there is a correlation between them.

Table 1: The summarized table of measured parameters (self-rooted: S; *Lagenaria*: L; interspecific: I; the big letters signe the best treatements by the results with the different parameters and summarized proposal by location)

Measurements		2013			2014		
		Cece	**Jászszentandrás**	**Újkígyós**	**Cece**	**Jászszentandrás**	**Újkígyós**
Weight		SLI	I	I	I	SLI	SLI
Color	**L***	SLI	I	SLI	SLI	SLI	SLI
	a*	I	I	SLI	SLI	SLI	SLI
	b*	I	SLI	SLI	I	SLI	SLI
Refraction		I	SLI	SLI	SLI	SLI	SLI
pH		L	I	SLI	SLI	SLI	SLI
Ascorbic acid					SLI	SLI	I
Lycopene		I	I	SLI	SLI	SLI	SLI
Antioxidant		SLI	SLI	L	SLI	SLI	SLI
Polifenol		L	I	SLI	SLI	I	SLI
Sensory evaluation		SL	SL	SL	SI	L	L
Summarized		**I**	**I**	**L**	**SI**	**L**	**L**

The experiment strengthened that in case of watermelon the grafting influence the crops, therefore I find it important to carry out an experiment based on the nutrients where the effects of different nutrition supplies could be observed in case of grafted plants's crops. For this other research my results could be good basis, because according to my results specified qualities can be emphasized.

According to the evaluation of the experiment on grafted watermelons (*Citrullus lanatus* [Thumb] Mansfeeld) in 2013 and 2014 I make the following proposals for cultivation:

1. Based on the results, the application of grafted plants is recommended in case of extensive cultivation without irrigation.
2. In extensive circumstances in case of sandy soil the RS 841 rootstock isrecommended from interspecific group instead of FR STRONG from *Lagenaria*.
3. In my opinion the electronic tongue can be used for the detection of crops by their growing area, thus providing traceability.
4. From the observed rootstocks the *RS 841* can be offered to those farmers who cultivate between controversial circumstances.

5. Based on my results I came to the conclusion that the watermelon species RX 467's crops growed on the interspecific rootstock (*RS 841*), contain lycopene in higher concentration than the ones growed on self-rooted or FR STRONG rootstocks.

6. The experiment pointed that the connection of sensory evaluation and color measurement or sensory evaluation and electronic tongue measurement combinations provide more exact results.

5. Publications from the subject of the dissertation

Journal articles with impact factor:

D. Fekete, G. Balazs, V. Bőhm, E. Várvölgyi, N. Kappel (2019): Sensory evaluation and electronic tongue for sensing grafted and non-grafted watermelon taste attributes. Acta Alimentaria. in press IF: 0,357.

In reviewed article:

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