CORRELATION OF ORGANOLEPTIC AND PHYSICO-CHEMICAL PROPERTIES OF WATERMELONS

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Abstract – Quality of watermelons can be assessed by a variety of physical and chemical methods, which may reflect their sensory quality. This study deals with the determination of saccharides, ascorbic acid, titratable acidity, dry matter content, refractive index and colour of the pulp of 30 watermelons purchased in stores. The results of these evaluations were correlated with the results of sensory analysis, which was evaluated by the sensory profile focussed on overall appearance, intensity of colour, juiciness, pleasantness of consistency, pleasantness of taste, overall intensity of taste, and the intensities of sweet and sour tastes. The best score from sensory analysis had samples containing about 9 g/100 g of sugar. The most statistically significant correlations were found between pleasantness of consistency and juiciness, dry matter content and refractive index, and saccharose and dry matter content. These findings could be used in practice when replacing the sensory evaluation with the physico-chemical methods, and vice versa.

Keywords: watermelon, sensory profile, sugars, colour; refractive index

1. INTRODUCTION

Watermelon (*Citrullus lanatus* var. *lanatus*) comes from Central and Southern Africa. In Central European countries (including the Czech Republic) watermelon belongs to the seasonal food consumed mainly in the summer months, from May to late September (Stone et al., 1996). Watermelon is rich in minerals and vitamins. It's a relatively low-calorie foods [1] with a significant content of folic, malic and citric acids. The most represented minerals are iron, calcium, magnesium, potassium and phosphorus. Watermelon is an important source of copper, manganese and selenium [2]. It has also an antioxidant activity because of its high content of vitamins, carotenoids and organic acids. Among the antioxidants there are vitamins A, B2 and C, as well as carotenoid lycopene. According to the results of the Central Institute for Supervising and Testing in Agriculture (CISTA) in Prague the refractive index values vary depending on the variety between 7.5 to 10.2 °Brix and vitamin C content between 36.8 to 58.1 mg/kg of the melon's pulp. Kopec [2] reports the average dry matter content 70 g/kg, sugar content 50 g/kg and the average content of vitamin C 80 mg/kg pulp.

Melons should be harvested at full maturity in order to achieve the best flavour and texture. Such ripe fruit should be firm, symmetrical, fresh, and with attractive waxy surface peel [3]. Quality of melon offered in the retail network depends largely on the identification of ripe fruit in the fields. It may also change during storage and transport. Consumer optimal quality depends on adequate carbohydrate content, aroma and texture of the pulp. Insufficiently ripe melons have less developed pulp colour, lower sugar content, a bland flavour and a firmer texture than optimally ripe melons. Taste and texture degrades dramatically in overripe melons [1]. The aim the study was to evaluate selected physical and chemical properties of watermelons from the market and compare them with their sensory properties.

2. MATERIAL AND METHODS

Thirty watermelons of oval shape, annealed hulls, red pulp and a weight range of 4 to 7.3 kg, commercially in retail chains during the summer season (from 7the of July to 7th of August) were analysed.

2.1. Sensory analysis

Two triangular slices of a thickness of 1 cm from the interior part of each melon (chilled to 5 °C) were served for sensory analysis under the conditions of the ISO 8589:2007 [4]. Sensory analysis was performed by the panel of 10 trained assessors using 100mm unstructured linear graphical oriented scale. The following descriptors were evaluated: the overall appearance (0% very bad, 100% excellent), intensity of colour (0% very light, 100% very dark), juiciness (0% very dry, 100% very juicy), pleasantness of consistency and overall pleasantness of taste (0% rejectable, 100% very pleasant), the overall intensity of taste, intensity of sweet and sour tastes (0% noticeable, 100% very strong).

2.2. Physical and chemical analyses

One quarter of the red watermelon pulp was seeded and homogenized by a hand blender for 1 minute. Each sample was analysed in triplicate.

Dry matter content was determined by drying the sample using an infrared moisture balances (Precisa HA 300). Refractive index was measured using a refractometer (PZO RR1 No. 14626, 0-35 °Brix), the Konica Minolta 600d spectrophotometer was used for colour measurements (CIE model, L* = luminance, a* = red-green axis, b* = yellow-blue axis, [5]). Titratable acidity was determined by 0.05M NaOH solution. The results were recalculated to malonic acid which is cited as the major acid in melons [6]. The content of mono- and disaccharides was determined by HPLC with refractometric detection (column Aminex HPX-87H, mobile phase 0.005M H_2SO_4). Sweetness was calculated from the content of saccharose, fructose and glucose using the coefficients according to the Canadian Sugar Institute (1 for saccharose, 1.2 for fructose and 0.65 for glucose). Ascorbic acid content was determined by the HPLC/UV (254 nm), column LiChroCart 125-4 Purospher Star RP-18e, mobile phase 5% methanol.

2.3. Statistical analysis

Statistica 12 software (StatSoft Inc.) and statistical functions of MS Excel 2007 Microsoft Corporation) were used for statistical evaluation of the results.

3. RESULTS AND DISCUSSION

The results of the sensory evaluation of watermelons are given in Table 1. Table 2 shows the results of colour measurements and Table 3 the results of chemical analyses. From the variability of results could be seen that the tested watermelons were of different maturity stage.

Table 1. Sensory analysis of watermelons.

	Maximum (%)	Minimum (%)	Mean (%)
Overall appearance	81	32	60
Intensity of colour	81	21	55
Juiciness	85	48	64
Pleasantness of consistency	82	40	61
Pleasantness of taste	80	14	55
Overall intensity of taste	70	33	55
Intensity of sweet taste	74	11	50
Intensity of sour taste	58	10	26

Table 2. Evaluation of the colour of watermelons.

	Maximum (%)	Minimum (%)	Mean (%)
L* = luminance (100 = white, 0 = black)	30.88	22.72	25.49
a* = red-green axis	17.04	4.25	11.90
b* = yellow-blue axis	9.58	2.75	6.00

Table 3. Physical and chemical analyses of watermelons.

	Maximum	Minimum	Mean
Saccharose (g/100 g)	12.13	0.01	4.63
Glucose (g/100 g)	1.26	0.43	0.92
Fructose (g/100 g)	3.36	1.54	2.57
Total mono- and disaccharides (g/100 g)	15.15	1.97	8.01
Sweetness (g/100 g)	15.45	2.13	8.21
Titratable acidity (g/100 g)	0.074	0.025	0.046
Ascorbic acid (mg/100 g)	8.22	0.03	3.17
Dry matter cont. (g/100 g)	10.24	2.71	7.58
Refractive index (°Brix)	10.50	3.00	7.82

Correlation coefficients between sensory and physico-chemical parameters are presented in Tables 4a and 4b. Statistically significant correlations at the level α = 0.05 are in bold.

Table 4a. Correlation coefficients between sensory and chemical properties.

	Saccharose	Glucose	Fructose	Sweetness	Ascorbic acid	Titratable acidity
Overall appearance	0.11	0.18	**0.36**	0.19	0.12	0.00
Intensity of colour	0.09	0.03	0.26	0.14	-0.01	-0.02
Juiciness	0.06	0.23	0.32	0.12	-0.24	**0.43**
Pleasantness of consistency	**0.44**	0.05	0.22	**0.49**	0.06	0.14
Pleasantness of taste	**0.61**	0.10	0.24	**0.68**	0.21	-0.10
Overall intensity of taste	**0.59**	-0.15	0.11	**0.62**	0.27	-0.15
Intensity of sweet taste	**0.66**	-0.07	0.12	**0.70**	0.21	-0.13
Intensity of sour taste	**-0.19**	-0.12	-0.05	-0.21	-0.07	-0.11

Statistically significant correlations (α = 0.05) are in bold.

The average content of carbohydrates in watermelons in the literature ranges from 5 g/100 g to 6.2 g/100 g pulp [2]. The average value in this study (8.2 g sugar/100 g) was slightly higher, but the obtained results varied within the wide range being generally in line with the literature data. According to Kopec [2] the average vitamin C content in watermelons is 80 mg/kg of pulp. The results given by CISTA reached lower values (36.8 to 58.1 mg/kg). The mean value of our samples was only 31.7 mg/kg, but again the results were within a wide range. The average titratable acidity reported in the literature is 0.08 g/100 g pulp [6]. Our samples had in average 0.046 g/100 g.

According to the sensory analysis results the best watermelons were those with sucrose content of about 9 g/100 g pulp. Liu et al. [7] stated that sucrose content is a good indicator of ripeness of watermelons, because sucrose is created by enzymatic activity of sucrose synthase and sucrose phosphate synthase during the melons' maturation. On the other hand, the content of other sugars remains constant.

Table 4b. Correlation coefficients between sensory and physico-chemical properties.

	Dry matter content	Refractive index	L*	a*	b*
Overall appearance	**0.45**	**0.43**	0.26	**0.53**	**0.59**
Intensity of colour	0.33	0.28	**0.54**	**0.66**	**0.83**
Juiciness	0.28	0.32	0.00	0.28	0.22
Pleasantness of consistency	**0.66**	**0.68**	-0.03	0.35	0.23
Pleasantness of taste	**0.81**	**0.82**	-0.09	**0.44**	0.21
Overall intensity of taste	**0.63**	**0.68**	0.01	0.30	0.13
Intensity of sweet taste	**0.84**	**0.82**	0.01	**0.48**	0.32
Intensity of sour taste	-0.19	-0.17	0.26	-0.16	-0.07

Statistically significant correlations (α = 0.05) are in bold.

Some nice statistically significant correlations between sensory and physico-chemical parameters were found. The intensity of colour was correlated with parameters L*, a* and b*. Titratable acidity affected the juiciness; the pleasantness of consistency was dependent on the dry matter content and refractive index. The pleasantness of taste correlated with the sucrose content, dry matter content and refractive index. There was also the relationship with the colour parameter a*. The overall intensity of taste related to the sucrose content, vitamin C and acidity. The intensity of sweet taste was in correlation with the content of sucrose, total solids and the colour parameter a*. On the contrary, the intensity of sour taste was not statistically dependent on titratable acidity and vitamin C. The sucrose content correlated with glucose, vitamin C, dry matter content, refractive index and titratable acidity. The total sweetness significantly correlated with the total solids and a refractive index, as well as with the content of vitamin C and titratable acidity.

Regression equations and the coefficients of determination were calculated among the selected sensory, physical and chemical parameters of

watermelons. It was found that 70 % of the pleasantness of taste is determined by the dry matter content, saccharose content and the value of the parameter a*. A multiple regression equation for the influence of these three factors on the pleasantness of taste (y_1) was:

$y_1 = -13.07 - 0.66x_1 + 7.76x_2 + 1.06x_3$

x_1 – saccharose content,
x_2 – dry matter content,
x_3 – parameter a*,
regression coefficient R=0.8361.

Fifty-one percent of the pleasantness of consistency was determined by the dry matter content, refractive index and sucrose content. A multiple regression equation for the influence of these three factors on the pleasantness of consistency (y_2) was:

$y_2 = 23.60 + 4.38x_4 - 1.06x_5 + 1.04x_6$

x_4 – refractive index,
x_5 – saccharose content,
x_6 – dry matter content,
regression coefficient R=0.71293.

Both regression coefficients were quite high and indicated strong significant correlation. Another, but not so strong correlation (regression coefficient R=0.4341, coefficient of determination R^2=0.1885) was calculated between juiciness (y_3) and titratable acidity (x_7). The equation was: $y_3 = 51.79 + 263.86x_7$.

4. CONCLUSIONS

The sensory quality of the tested watermelons samples correlated with their physical and chemical properties. The content of sucrose was the important criterion of their ripeness, as it increases during maturation. Samples containing about 9 g/100 g of sugar were evaluated as the best in sensory analysis. Many statistically significant relationships between selected parameters of watermelons was calculated. Correlation between the pleasantness of taste or the intensity of sweet taste and the dry matter content, refractive index, saccharose content and sweetness were the strongest. The findings of this study could be used in practice when replacing the sensory evaluation with the physico-chemical methods, and vice versa.

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