

EVALUATION OF QUALITY INDICES OF STRAWBERRY MASS

Sigita Boca, Imants Skrupskis, Evita Straumite

Latvia University of Agriculture

sigita.boca@apollo.lv

Abstract

Color, texture and aroma are the main quality attributes of food influencing consumer acceptability of food products. Color of the product is one of the factors affecting hedonic evaluation. Strawberry mass for a consumer is characteristic by its distinct red color. The stability of anthocyanins becomes most significant in the case of color quality. To investigate color quality, it is necessary to measure color, as well as pigment concentration. Fresh and thermally treated strawberry mass was analyzed. Formation and stability of anthocyanins, which is the main color formation substance of berries, are determined by different factors. Anthocyanin colors can be enhanced and stabilized by the addition of different natural or artificial acidifiers. Data of the research indicate that anthocyanin amount during storage period decreases. After 2 days storage their amount increased, but afterwards decreased, both, in fresh and thermally treated mass. The taste evaluation of strawberry mass was essentially affected by the enhancers added.

The aim of research was to analyze the quality parameter – color of strawberry mass with added acidifier which further could be used in production of different products for the needs of public catering, e.g. in production of desserts. The anthocyanin content in strawberry mass with acidifiers was determined to see the organic acid impact to color stability. Research shows, that natural enhancers – quince and sea buckthorn juices used in the research, did not substantially affect each other's pH in the product.

Key words: strawberry mass, color, enhancers, fresh, thermally treated.

Introduction

Strawberry is one of the world's largest fruit crops (Doymaz, 2008). The strawberry (*Fragaria*) is a genus of plants in the family *Rosaceae* and the fruit of these plants. There are more than 20 named species and many hybrids and cultivars. The most common strawberries grown commercially are cultivars of the Garden strawberry, *Fragaria ananassa* (Oszmianski et al., 2009). Strawberries assigned to consumption in fresh state have better taste and aroma when they are collected in consumption ripeness state (whole surface is colored uniformly). Application of suitable processing technology is necessary because of excessive production of fresh strawberries (Alvarez, 1995). In food technology strawberries have many applications. Preserved fruit occurs as frozen and dried food, which is obtained with the use of different methods: osmotic dehydration, as fruit charge in dairy industry, in fruit-vegetable industry to juice production, jams and in distilling of alcohol (El-Beltragy, 2006). Each of these methods of preserving and processing causes quality changes in comparison to raw material (Moreno, 2000).

The quality of food products, in conformity with consumers' requirements and acceptance, is determined by their sensory attributes, chemical composition, physical properties, and level of microbiological and toxicological contaminants, shelf life, packaging and labeling (Costell, 2002). Sensory evaluation concerns the interpretation of what the senses – sight, olfaction, taste, touch, audition – inform about the product (Giboreau et al., 2007). The sensory properties of food are extremely important, because these properties determine consumer acceptance. This is why sensory tests are essential in terms of quality (Kuti et al., 2004).

Color, texture and aroma are the main quality attributes of food influencing consumer acceptability of food

products. During processing these attributes may be lost or altered depending on the water content in foods. Many approaches have been taken to improve the quality of fruit products. One common approach is to apply less invasive process and the other is to use specific additives (Kopjar et al., 2008).

As color is one of the most important quality properties characterizing quality parameters of fruits and berries, in this research greater attention was paid to color stability and durability.

The color of food has always been a value of quality. Today, the attractive red color of food products, like strawberry products, is an important quality parameter influencing consumer behavior. Obtaining a strong and stable color of fruit and berry products, however, is problematic during processing and storage. The need to avoid the use of synthetic colorants and move towards the use of natural food colors has also increased research in this field during the past decades. Rein (2005) in his dissertation clarified that anthocyanins are natural pigments widely distributed in nature. They are responsible for such colors as red, purple and blue in fruits and berries, anthocyanins are mainly located in the peel. However, the stability of anthocyanins becomes most significant also in this case, as well as in the case of color quality. Anthocyanins are highly unstable and easily susceptible to degradation. As mentioned Rein (2005) in his dissertation, stability of anthocyanins is affected by pH, storage temperature, presence of enzymes, light, oxygen, structure and concentration of the anthocyanins, and the presence of other compounds such as other flavonoids, proteins, and minerals.

In order to improve and stabilize color of berries, natural berry juices were used in the research:

sea buckthorn (*Hippophae rhamnoides*) juice contains soluble sugars - glucose, fructose, vitamins (A, K, E and C, B₁, B₂), essential fatty acids Omega 3, 6, 7 and 9; fatty acids, organic acid- quinic acid, malic acids; oxalic and citric acid, tartaric acid, succinic acid, lipids, free amino acids- apartic acid, threonine; valine, methionine, leucine, lysine, tryptophan, isoleucine, phenylalanine, carbohydrates, folic acids, tocopherols and flavanoids, phenols, terpenes and tannins (Beveridge et al., 2002); Japanese quince (*Chaenomeles japonica*) juice contains soluble sugars-glucose and fructose, organic acids-malic, tartaric and citric acids, tanning agents, volatile oils, adding piquant aroma and sourish smack, essential amino acids, micro and macro elements, vitamins: C, B₁, B₂, PP, H, folacin (Hellin et al., 2003).

The aim of the research was to analyze the quality parameter – color of strawberry mass with added acidifier which further could be used in production of different products for the needs of public catering, e.g. in production of desserts. In the research, thermal treatment for strawberry mass was carried out in order to analyze further sensory properties, anthocyanin, phenol and color stability, pH and soluble matter, both, for fresh strawberry mass with enhancers and thermally treated one.

Sf – fresh strawberry mass **without enhancers**
Hf – fresh strawberry mass **with sea buckthorn juice**
Qf – fresh strawberry mass **with Japanese quince juice**
Af – fresh strawberry mass **with L (+) - Ascorbic acid, Sodium salt**
Asf – fresh strawberry mass **with Ascorbic acid**

Methods

Total phenol content was determined by the photometric method with Folin-Ciocalteu reagent and the absorbance of the blue color was measured at 760 nm. The phenolic contents of the fruits were expressed as gallic acid equivalents GAE/FW 100 g (Singleton et al., 1999).

The content of total anthocyanin (mg 100g⁻¹) was determined by the conventional method by using a spectrometer UV-1650-PC at wave length 535 nm (Moor et al., 2005).

The pH is measured using a pH meter 3510 (Jenway) according to LVS EN 1132:2001.

Color was determined during the storage in CIE L*a*b* color system using Color Tec PCM/PSM device. The measured parameters were L* for lightness, a* for redness, and b* for yellowness. Hue angle (h°) is derived from the two coordinates a* and b*. The calculations of Hue angle (h°) were made with the following equation:

$$h = \arctan (b^*/a^*) \quad (1)$$

Results were processed with Microsoft Office Excel 2007 programmer.

The hedonic evaluation and line scale methods were used based on ISO 4121:2003 “Sensory analysis –

Materials and Methods

The research was carried out at the Latvia State Institute of Fruit Growing and laboratories of the Faculty of Food Technology in Latvia University of Agriculture.

Materials

Frozen strawberries, the variety ‘Polka’, were used as a raw material for the research. The object of the research is fresh (f) and thermally treated (h) – heated at the temperature +80 °C – strawberry mass. The berry juices: sea buckthorn and Japanese quince were used as strawberry mass natural enhancers and Ascorbic acid, L (+) Ascorbic acid, Sodium salt were used as artificial enhancers. All enhancers were used with concentration of 5% of strawberry mass.

Fresh and thermally treated product (heated at the temperature + 80 °C) was analyzed. Berry mass was stored for 8 days at the temperature + 4 °C. Measurements were taken at 2 - day interval. Chemical, physical and sensory indices of the product – pH, soluble dry matter, anthocyanins, phenols and color, smell, taste, consistency intensity were determined as quality evaluation.

Notations used in the research:

Sh – heated strawberry mass **without enhancers**
Hh – heated strawberry mass **with sea buckthorn juice**
Qh – heated strawberry mass **with enhancers Japanese quince juice**
Ah – heated strawberry mass **with L (+) - Ascorbic acid, Sodium salt**
Ash – heated strawberry mass **with Ascorbic acid**

Guidelines for the use of quantitative response scales”. A 9-point hedonic scale (9 – extremely like, 5 – neither like nor dislike, and 1 – extremely dislike) was used to determine the degree of acceptance of the products. Panellists evaluated intensity of sensory properties (aroma, colour, taste, consistence and after taste), the line scale (ISO 4121:2003) was used. A panel of 28 panellists, consisting of 21 females and 7 males at age from 24 to 68, took part in this study.

The results were processed by mathematical and statistical methods. Data were subjected to one way analysis of variance (ANOVA) and Two-Way analysis of variance (ANOVA), by Microsoft Office Excel 2007, significance was defined at p<0.05.

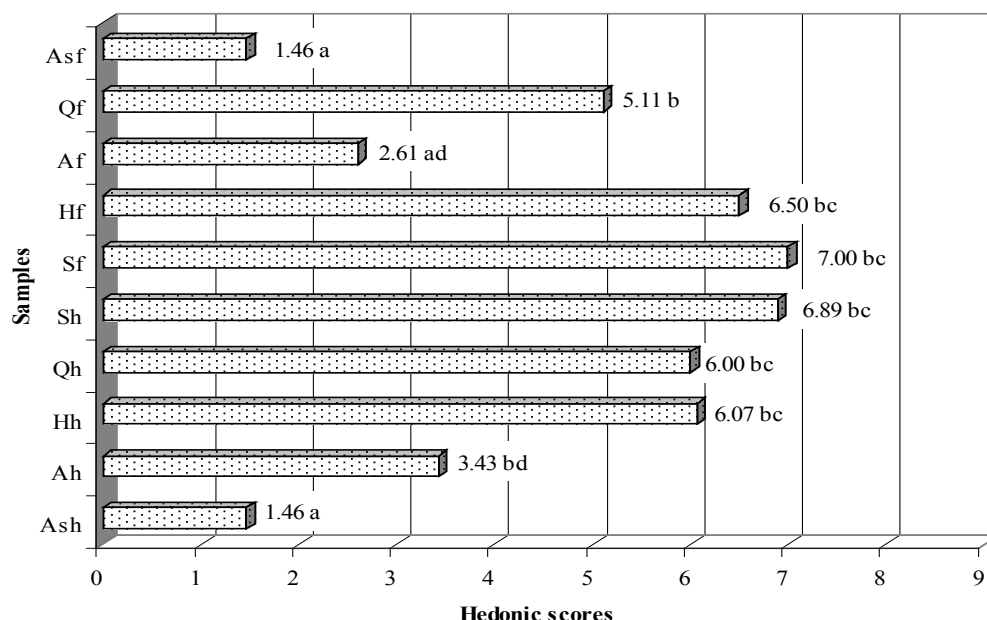
Results and Discussion

Formation and stability of anthocyanins is determined by different factors. Formation of anthocyanins is enhanced by the presence of monosaccharides and disaccharides. It is established that varieties of darker red color have higher antioxidative activity than the lighter ones (Courtney and Rui, 2002). Anthocyanin colors can be enhanced and stabilized by the addition of different natural or artificial

acidifiers. Natural berry juice and artificial acidifier - L (+) - Ascorbic acid, Sodium salt impact to color stability of strawberry mass was analyzed and compared in the research.

Many different types of sensory methods have been proposed and used to evaluate and control the sensory

quality of foods. The results of the analysis of variance show that $F_{cal} = 51.15 > F_{crit} = 1.92$; it means that there are significant differences in the degree of liking among the strawberry mass. The degree of liking of strawberry mass, evaluated by hedonic scores is presented in Figure 1.



Values, marked with the same letters, are not significantly different ($p > 0.05$)

Figure1. Evaluation results of strawberry mass using 9-point hedonic scale.

According to the hedonic scale panellists evaluated strawberry mass with enhancers in the range from 1 (dislike extremely) to 7 (like moderately). Results of the hedonic scores showed that the panellists liked ($p > 0.05$) samples Sf (fresh strawberry mass without enhancers) and Sh (heated strawberry mass without enhancers) the most because they had pleasant, slightly sour taste with the most distinct strawberry taste. Analysis shows that there is no significant difference in hedonic scores among the samples Hh, Hf, Qh, Qf, Sh and Sf ($p > 0.05$), which is strawberry mass with natural enhancers and strawberry mass without enhancers. The panellists liked the least Ash (heated strawberry mass with Ascorbic acid) and Asf (fresh strawberry mass with Ascorbic acid) ($p > 0.05$), because they were too sour and

the taste (aftertaste) of citric acid was felt. The sample Sf (fresh strawberry mass without enhancers) did not differ in degree of liking from the samples Sh (heated strawberry mass without enhancers) and Hh, Hf, Qh, Qf (fresh and heated strawberry mass with natural enhancers), but significant difference exists between samples Ash, Asf, Af and Ah (fresh and heated strawberry mass with artificial enhancers) in the degree of liking. The panelists evaluated degree of liking separately for every characteristic feature.

Strawberry mass for a consumer is characteristic by its distinct red color and strawberry taste. The assessment results of the intensity of sensory properties – aroma, colour, taste, consistency and aftertaste of strawberry mass are presented in Figure 2.

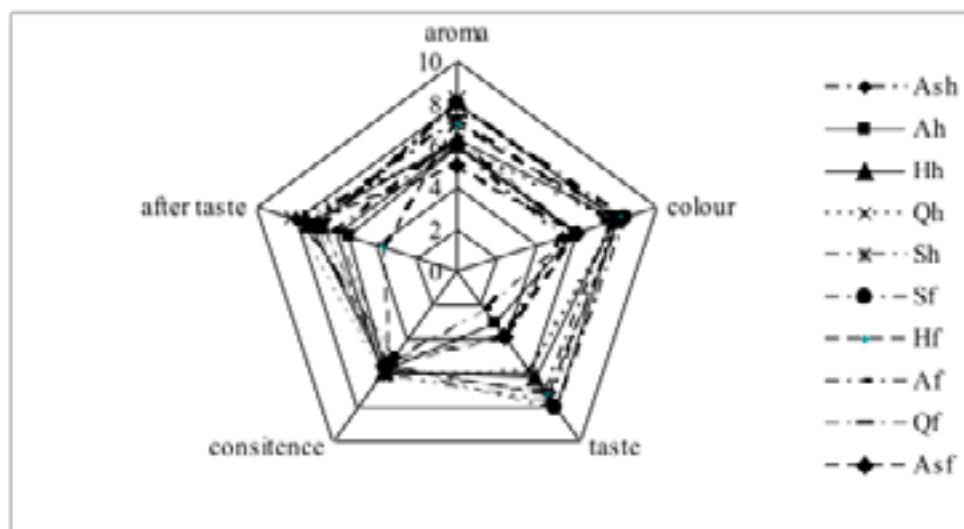


Figure 2. Intensity of sensory properties of strawberry mass.

Evaluation of intensity of sensory properties of strawberry mass shows that there is no significant difference ($F_{\text{cal}} = 1.34 < F_{\text{crit}} = 1.92$) in consistency, but there is significant difference in intensity of aroma, colour, taste and aftertaste. The main differences among the samples for colour, aroma, taste and aftertaste intensity were expressed to the strawberry mass with natural enhancers (Hh, Hf, Qh, Qf), but the lowest intensity of sensory properties were expressed to the strawberry mass with artificial enhancers (Ash, Asf, Af, Ah). The least distinct aftertaste was identified to the sample Hf (fresh strawberry mass with sea buckthorn), but by adding Ascorbic acid (As) and L (+) – Ascorbic acid Sodium salt (A) to the strawberry mass, aftertaste became more intense. It was likely caused by characteristic properties of artificial enhancers added.

As panellists considered fresh and heated strawberry mass with Ascorbic acid (Ash and Asf) being too acid and unsuitable for nutrition, then for further research only fresh and heated strawberry mass with L (+) – Ascorbic acid Sodium salt (Af and Ah) was used as artificial enhancers for the strawberry mass. Therefore, color durability and stability in the strawberry mass depending on the added acidifier will be analyzed further in the research.

Attractive color is one of the most important sensory characteristics of fruit and berry products. The color of red berry products is unstable and susceptible to degradation. The main color formation substances of berries are anthocyanins of phenol group, which are the red color formers (Ancos et al., 2000). Polyphenols and anthocyanins present in different berries work as collectors of peroxide radicals. Anthocyanins are a group of many diverse chemical compounds with variable properties, therefore not only the general content is significant, but also their composition. More valuable is delphinidin as it

is more stable in processing. Strawberries improve blood composition and help the body to release from residues of chemical substances and their compounds. Strawberries contain a substance with anti-cancer activity, which can protect cells from the influence of synthetic and natural cancerogenic substances (Melo et al., 2000).

Rein (2005) in the dissertation wrote that fortification of fruit and berry juices with ascorbic acid is a common method to protect against oxidation and to increase the nutritional value of a food product. The ascorbic acid is thought to have several different roles in anthocyanin color stability. Ascorbic acid enhances polymer pigment formation and bleaches anthocyanin pigments. Also the formation of hydrogen peroxide from ascorbic acid oxidation can influence anthocyanin stability (Talcott et al., 2003). Anthocyanins are also considered to be protected by ascorbic acid against enzymatic degradation. Fruit treatment by organic acid reduces oxidative changes of the color. Whereas ascorbic acid may have a protective effect with regard to anthocyanins because it reduces the o-quinones formed before their polymerization. However, ascorbic acid as well as products of its degradation increases the anthocyanin degradation rate where the fortification with ascorbic acid accelerated anthocyanin degradation in strawberry mass (Wilska-Jeszka, 2007).

The anthocyanin content in strawberry mass with acidifiers was determined to see the organic acid impact to color stability. In literature strawberries (*Fragaria ananassa*), having quite a light red hue, contain anthocyanins between 10-80 mg 100 g⁻¹ wrote Cordenunsi et al., 2003, but in this research the anthocyanin content is 20.2 mg 100 g⁻¹. In our research, the anthocyanin amount in strawberry mass with added acidifiers is indicated in Figure 3.

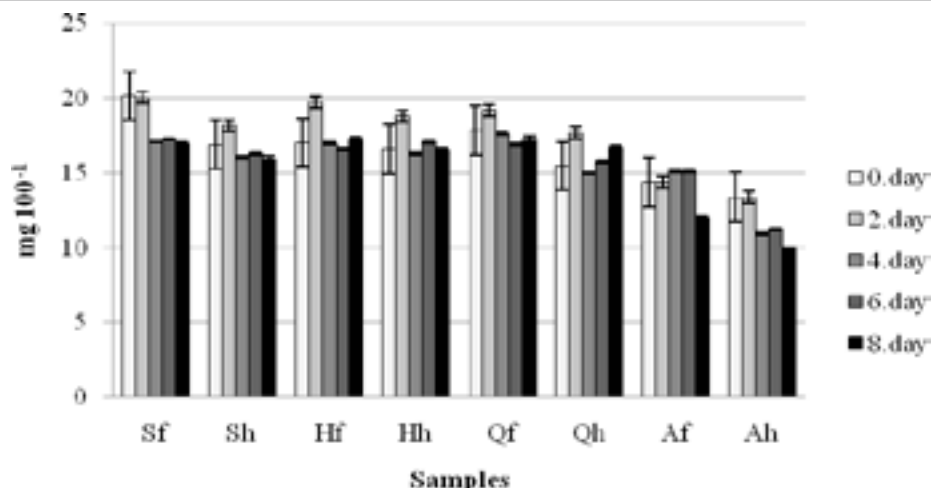


Figure 3. Anthocyanins in strawberry mass with enhancers.

Data of the Figure indicate that anthocyanin amount during storage decreases. After 2-day- storage their amount increases, but afterwards decreases, both, in fresh and thermally treated mass. Anthocyanin amount in fresh strawberry mass is larger than in a thermally treated mass. It might prove that during thermal treatment with the increase of temperature anthocyanin amount decreases. Anthocyanin stability is affected by temperature. Cavalcanti et al., 2010 wrote that degradation rate of anthocyanins increases during processing and storage as the temperature rises. Decomposition of anthocyanins depends also on the temperature and heating duration (Melo et al., 2000).

The stability of anthocyanins is affected by many factors – pH, storage temperature, presence of enzymes, light, oxygen, structure and concentration of the anthocyanins, and the presence of other compounds such as other

flavonoids, proteins, and minerals.

Anthocyanins show great susceptibility toward pH being more stable in acidic media at low pH values than in alkaline solutions with high pH values. The taste evaluation of strawberry mass was essentially affected by the enhancer added. As the Fig. 2 shows the control samples Sf and Sh (7.1 – 7.2) and Hf- fresh strawberry mass with sea buckthorn juice (7.3) had the highest degree of liking. As the next best degree of liking by pannelists was Qf – fresh strawberry mass with Japanese quince juice (6.5). Natural enhancers – quince and sea buckthorn juices used in the research, did not substantially affect each other's pH in the product. The initial higher pH value of the control samples (Sf and Sh) can be explained by the fact that there is no enhancer added. Fig. 4 shows pH value analyzed in the research.

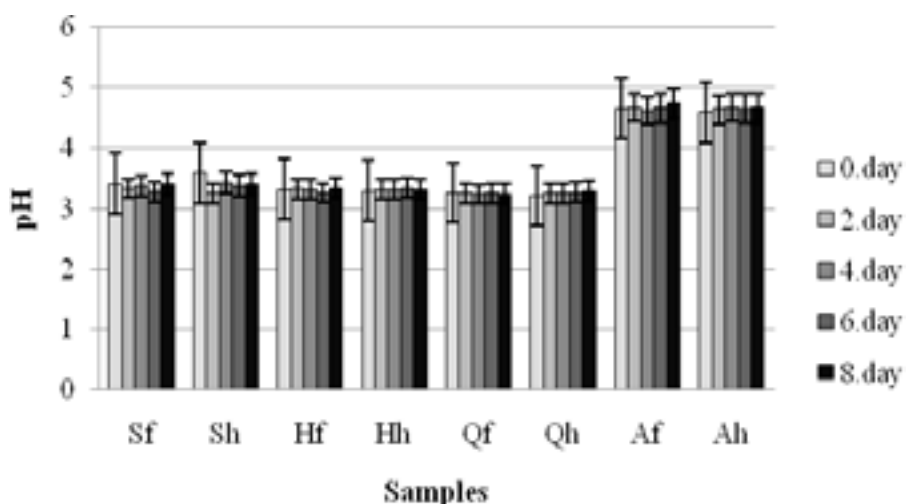


Figure 4. pH value of strawberry mass with enhancers.

The pH data found out in the research indicate that pH in strawberry mass with natural enhancers ranges from pH 3 till 3.6, but in strawberry mass with added Ascorbic acid, Sodium salt pH is 4.6 – 4.7. It means that by using natural enhancers anthocyanins are more stable and color is more intense, but by using artificial enhancer the medium

becomes more alkaline at the presence of soda and salt.

To investigate color quality it is necessary to measure color, as well as pigment concentration. The CIEL a*b* system is very effective for measuring color differences and tracking color changes during processing and storage. Color is three dimensional, where L*= lightness with

100= absolute white and 0=absolute black. Hue angle (h°) is derived from the two coordinates a^* and b^* and

determined as $\arctan b^*/a^*$ (formula 1). The values of Hue angle is shown in Table 1.

Table 1

Color stability determination with Hue angle

Day	Samples							
	Sf	Sh	Hf	Hh	Qf	Qh	Af	Ah
0	41.4	40.9	41.0	40.0	44.3	46.0	31.7	48.9
2	46.4	44.2	45.0	44.9	42.5	43.2	37.0	61.5
4	38.9	41.3	42.7	40.9	43.2	39.2	31.1	60.4
6	46.2	43.5	43.8	42.9	42.2	43.3	36.2	61.9
8	43.5	43.0	42.2	36.5	33.3	40.8	38.8	64.1

Changes of the h° angle in Table 1. indicate that strawberry mass with added sea buckthorn juice (Hf and Hh) initially gives a positive result for anthocyanin stability, although after 8 - day storage the color of heat treated mass changes for 10% ($h^\circ=36.5$), but that of fresh mass – only for 2% ($h^\circ=42.2$). Fresh strawberry mass with added quince juice (Qf and Qh) during the first 6 days change color the least and is the most stabile. Whereas H angle for the strawberry mass with added artificial enhancer accelerates quickly – heat treated mass for 27% and fresh one for 22% that indicates essential change in color stability.

When comparing s taste and nutritional value among the juices used in the research, it has to be pointed out that sea buckthorn juice is one of the most valuable, rich in vitamins and other biologically active substances. Quince juice and sea buckthorn juice contain a little bit higher soluble dry matter content as the control samples, which affect taste properties of the product and liking rate. In general, it can be concluded that researched natural juices (sea buckthorn and quince) are recommended for usage in public catering as healthy acidifiers, color and taste enhancers in making desserts from different berries.

Conclusions

1. The main differences among the samples for color, aroma, taste and consistency intensity were expressed to the strawberry mass with natural enhancers (Hh, Hf, Qh, Qf), but the lowest intensity of sensory properties was expressed to the strawberry mass with artificial enhancers (Ash, Asf, Af, Ah).
2. Analysis shows that there is no significant difference in hedonic scores among the samples Hh, Qh, Sh, Sf, Hf and Qf ($p>0.05$), which are samples with natural enhancers and strawberry mass without enhancers.
3. Anthocyanin amount in fresh strawberry mass is larger than in a thermally treated mass. Color is stable in acid medium, what is provided by natural juices. It indicates that strawberry mass with added sea buckthorn and Japanese quince juice initially gives a positive result for anthocyanin stability during storage.
4. For production of desserts thermal treatment was used causing color changes. For public catering it is recommended to use strawberry mass with natural enhancers.

References

1. Alvarez C.A. (1995) Air dehydration of strawberries: Effects of blanching and osmotic pretreatments on the kinetics of moisture transport. *Journal of Food Engineering*, 25, pp. 167-178.
2. Ancos B., Ibanez E., Reglero G., Cano M.P. (2000) Frozen storage effects on anthocyanins and volatile compounds of raspberry fruit. *Journal of Agricultural and Food Chemistry*, 48, pp. 873-879.
3. Beveridge T., Harrison J.E., Drover J. (2002) Processing Effects on the Composition of Sea Buckthorn Juice from *Hippophae rhamnoides* L. Cv. Indian Summer *Journal of Agricultural and Food Chemistry*, 50, pp. 113-116.
4. Cavalcanti R.N., Santos D.T., Meireles M.A.A. (2010) Non-thermal stabilization mechanisms of anthocyanins in model and food systems. An overview. *Food Research International*, doi: 10.1016/j.foodres. Elsevier Ltd., 11 p.
5. Cordenunsi B.R., Nascimento J.R.O., Lajolo F.M. (2003) Physico-chemical changes related to quality of five strawberry fruit cultivars during cool-storage. *Food Chemistry*, 83, pp. 167-173.
6. Costell E. (2002) A comparison of sensory methods in quality control. *Food Quality and Preference*, Volume 13, Issue 6, pp. 341-353
7. Courtney W. and Rui H.L. (2002) Antioxidant Capacity and anticancer properties of red raspberries. *Acta Horticulture*, 585, ISHS, pp. 451-457.
8. Doymaz İ. (2008) Convective Drying Kinetics of S trawberry. *Chemical Engineering and Processing, Process Intensification*, Volume 47, Issue 5, pp. 914-919.
9. El-Beltragy A. (2006) Solar drying characteristics of strawberry. *Journal of Food Engineering*, 78, pp. 456-464.
10. Giboreau A., Dacremont C., Egoroff C., Guerrand S., Urdapilleta I., Candel D. and Dubois D. (2007) *Food Quality and Preference*, Volume 18, Issue 2, pp. 265-274.
11. Hellin P., Vila R., Jordan M.J., Laencina J., Rumpunen K., Ros J.M. (2003) Characteristics and composition of chaenomeles fruit juice. I/In: *Japanese quince*

- *Potential fruit crop for Northern Europe. Sid.*, pp. 127-139.
12. Kopjar M., Piližota V., Hribar J., Simčič M., Zlatič E. and Nedić Tiban N. (2008) Influence of trehalose addition and storage conditions on the quality of strawberry cream filling, *Journal of Food Engineering*, Volume 87, Issue 3, pp. 341-350.
 13. Kuti T., Hegyi A. and Kemény S. (2004) Analysis of sensory data of different food products by ANOVA. *Chemometrics and Intelligent Laboratory Systems*, Volume 72, Issue 2, pp. 253-257.
 14. Melo M.J., Moncada M.C., Pina F. (2000) On the red colour of raspberry (*Rubus idneus*). *Tetrahedron Letters*, 41, Issue 12, pp. 1987-1991.
 15. Moor U., Karp K., Pöldma P. and Pae A. (2005) Cultural Systems Affect Content of Anthocyanins and Vitamin C in Strawberry Fruits. *European Journal of Horticultural Science*, 70 (4). S., ISSN 1611-4426, pp. 195-201.
 16. Moreno J. (2000) Effect of blanching/osmotic dehydration combined methods on quality and stability of minimally processed strawberries. *Food Research International*, 33, pp. 609-616.
 17. Oszmianański J., Wojdyła A., Kolniak J. (2009) Effect of l-ascorbic acid, sugar, pectin and freeze-thaw treatment on polyphenol content of frozen strawberries. *Food Science and Technology*. Volume 42, Issue 2, pp. 581-586.
 18. Rein M. (2005) Copigmentation reactions and color stability of berry anthocyanins. *Dissertation*. University of Helsinki, Department of Applied Chemistry and Microbiology, Food Chemistry Division, 87 p.
 19. Singleton V.L., Orthofer R., Lamuela-Raventos R.M. (1999) Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. *Methods in Enzymology*, 299, pp. 152-178.
 20. Talcott S.T., Brenes C.H., Pires D.M., Del Pozo-Insfran D. (2003) Phytochemical stability and color retention of copigmented and processed muscadine grape juice. *Journal of Agricultural and Food Chemistry*, 51, pp. 957-963.
 21. Wilska-Jeszka J. (2007) Food colorants. In Z.E. Sikorski (ed.), *Chemical and functional properties of food components*, Boca Raton: CRC Press, pp. 245-274.