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Colour Determination and Change of Sensory Properties of Mayonnaise with Different Contents of Oil Depending on Length of Storage

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Abstract: This paper studies the stability of three types of mayonnaise (with 75 %, 50 % and 30 % of edible refined sunflower oil and other additives) by measuring colour on photoelectric tristimulus colorimeter "MOM-colour 100", showing the results in CIE (Y(%), λ (*nm*) and Č (%)) and CIE $L^* a^* b^*$ system immediately after preparation, after 90 and 180 days of warehousing, at temperature of +5°C.

In parallel, sensory analysis was conducted by means of the analytical point system when a group of experienced tasters evaluated the appearance, colour, fragrance and taste, during the storage lasting up to 180 days.

It was established that average estimates for the appearance, colour and both, statistically do not depend significantly on the contents of mayonnaise and statistically very much depend on the time of storage. The interaction of contents of mayonnaise and time of storage statistically significantly influences the average estimate of the appearance and to all sensory properties. *Copyright © 2010 IFSA.*

Keywords: Mayonnaise, Colour measurement, Sensory evaluation

1. Introduction

Traditionally, mayonnaise is oil emulsion in water stabilized by emulgators from eggs, vinegar and spices (mustard, in particular). Produced in such a way, mayonnaise usually contains 70-80 % of fat. In spite of such a great contents of fat in comparison to water, mayonnaise is still emulsion of oil in water. Namely, oil is slowly emulgated in the prepared water phase. The result of this is the emulsion consisting of intimately joined drops of oil in the form of "foam". In contrast to this, if the phases of oil and water are mixed, the result is the emulsion of water in oil whose viscosity is similar to the viscosity of oil it was derivated from.

From the point of view of quality evaluation of mayonnaise, their microbiological safety, physical, chemical and sensory stability during storage is of greatest significance [1-8].

With respect to the commercial significance of mayonnaise, lots of authors studied the rheology of mayonnaise because of its significance in selecting recipes, conditions of conducting the process and quality control [9-17].

The appearance shown as the consistency of emulsion depends on the size of oil drops and the manner of their dispersion. The more oil in the emulsion, the more consistent the emulsion. However, quantities of oil greater than 84% cause overload to the system since drops will be thickly packed leaving a very thin layer between them. Mechanical density may easily cause coalescence of oil drops and further destruction of the emulsion [18].

It has been proved that stabile structure mayonnaise is possible to make with even 90 % of oil where the diameter of drops ranges between 2-3 μ using colloid mill. However, nowadays, when more and more attention is paid to healthy food, there appears a tendency that this product should contain as less oil as possible [19]. Also, oil is usually the most expensive component of mayonnaise, thus the producers try to reduce their participation in mayonnaise as much as possible legislation restrictions of the country in which mayonnaise is sold. Unfortunately, if the participation of oil is reduced in mayonnaise, density of oil drops will be accordingly decreased. That means that the interactions among the drops are weaker and the emulsion is less stable, and/or the appearance i.e. homogeneity is changed.

In order to achieve a stable system it is necessary that a consistent viscosity should be maintained which is achieved by good emulsifying process, greater contents of oil drops of smaller diameter and greater uniformity [20].

Mayonnaise emulsions eventually disintegrate in case of coalescence of drops, although kinetics and precise mechanisms have not fully explained. *Tung and Jones* [21] state that during storage of mayonnaise samples, distribution of size of oil drops changes resulting in the creation of fewer larger drops, which eventually leads to change of its appearance.

From a consumer's point of view, colour is defined by a tint, saturation and purity.

Colour of mayonnaise originates from egg yolk and oil and it may be adjusted by mustard or some other spices. Egg yolk is the primary source of colour of mayonnaise due to contents of adequate carotinoids [6, 7, 23]. Oil, if well-refined contributes to colour to a very low extent, except in case of using olive or saffron (safflower) oil which have a specific green tint (chlorophyll). The facts that pure fatty acids, their esters and glycerides are colourless support the above. The colour of natural lipids originates in different non-glycerid components that are extracted together with glycerides because they are soluble in them and they are more or less changed during the extraction. Natural pigments

usually include carotenoids, bilorofils or products resulting from their decomposition, phaeophytin in particular. Further, some oils contain their characteristic natural pigments: gossypol in cotton oil or sesamol in sesame oil [22].

In order to objectify the evaluation of quality of mayonnaise colour and mayonnaise-related products, instrumental methods are usually used for determining certain characteristics of colour quality. Thus, according to the statements of *Mac Dougall, 1982* [24], the colour can be defined as the combination of visually understood information contained in the light reflected or dispersed by a sample. Therefore, comparatively small changes of light may cause greater changes of colour than a long series of pigment concentration. Generally, there are several systems for colour defining, out of which the food industry usually uses the following: CIE, CIE $L^* a^* b^*$ colour system, Munsell colour system, Adams Nickerson colour system, as well as the colour on the basis of quantity and chemical condition of pigments [25-29].

Along with the appearance and colour, very important sensory properties when evaluating the stability of mayonnaise are fragrance and taste as well.

The aim of this paper was a comparative determination of colour quality parameters of three types of mayonnaise (containing 75 %, 50 % and 30 % of edible sunflower oil and other additives) at photoelectrical tristimulus colorimeter "MOM-colour 100" and sensory evaluation of the appearance, colour, fragrance and taste, as well as determination of an average sensory evaluation on the basis of weighted values for those four sensory properties during the storage up to 180 days at the temperature of +5 ºC.

2. Material and Methods

2.1. Material

Mayonnaise samples subject to study have been produced in semi-industrial conditions of the following factories of oil and vegetable fats: "Vital"-Vrbas, "Dijamant"-Zrenjanin and "Sunce"–Sombor in Serbia. Three groups of samples were produced:

Group I (samples with codes 1-5 and 7) includes delicates mayonnaise with the participation of refined sunflower oil of minimum 75 %, while the minimum participation of yolk was 6 %. Sample 6 contained 74.8 % of sunflower and 0.2 % of olive oil. Colours were added to samples 6 and 7: annatto extract E160, turmeric. The following stabilizers were used: for sample 1 - guar gum E412 and sodium alginate E401, for sample 5 – modified starch and xanthan gum E415. Sample 1 contains antioxidant askorbil palmitate E304, while EDTA E385 was added to samples 6 and 7. Also, samples 6 and 7 contain potassium sorbate E202 as a preservative. All samples were added kitchen salt, vinegar, mustard and spices.

Group II includes samples 8 and 9 belonging to the group of salad mayonnaises. The sample marked with 8 contains: 60 % of edible refined sunflower oil, yolk, mustard, vinegar, kitchen salt, sugar, acids: sorbic acid E334 and lemon acid E330; stabilizer distarch phosphate E412 and spices, while sample 9 contains: 50 % of edible refined sunflower oil, yolk, mustard, vinegar, kitchen salt, sugar, lemon acid E330, stabilizer acetylated distarch adipate E1422, caruba gum E410 and xanthan gum E415; askorbil palmitate E 304 was used as antioxidant, and potassium sorbate E202 was used as a preservative.

Group III includes samples designated with 10-12 belonging to low-energy mayonnaises according to their contents. Samples 10 and 11 contain minimum 35 % of edible refined sunflower oil, while oil

participation in sample 12 is a bit lower, being 30 %. None of samples was added yolk. However, sample 11 was added annatto extract. Samples 10 and 11 were added acids: wine, sorbic E334 and lemon E330, as well as stabilizers: acetylated distarch adipate E1422, hydroxylpropyl distarch phosphate E1442 and xanthan gum E415. Samples 11 and 12 were added preservative–potassium sorbate E202 maximum 0.1 %.

All twelve samples were packed in PET/Al/PE (polyester/aluminium/polyethylene) films for the purpose of preservation for more than 10 months [30].

2.2. Methods

Mayonnaise samples were studied immediately after being produced, after three and six months of warehousing at the temperature of +5°C.

The colour stability of samples of different types of mayonnaise was studied in the first place by instrumental defining colour quality characteristics in CIE system (glossiness or average reflectance Y(*%*), dominant wave length λ (*nm*) and purity of colour Č in *%*), while colour parameters were defined in CIE $L^* a^* b^*$ system (psychometric light L*, psychometric tone a^* and chrome b^*) by applying photoelectrical tristimulus colorimeter "MOM-colour 100". Sensory evaluation of the appearance, colour, fragrance and taste was carried out subsequently.

2.2.1. Instrumental Colour Measurements

The principle of defining a colour on "MOM-colour 100" refers to additive mixture of colour (red, green, blue). The device is set with the appropriate prescribed standard for white colour and the studied sample is placed in the appropriate space and the values x_1, x_2, y and z are read.

On the basis of read values x_1 and x_2, tristimulus value x is calculated according to formula:

$$x = x_1 + x_2, \tag{1}$$

And then trichromatic coefficients X and Y are calculated according to formula:

$$\mathrm{X} = \frac{x}{x + y + z} \tag{2}$$

$$\mathrm{Y} = \frac{y}{x + y + z} \tag{3}$$

The calculated trichromatic coefficients are used for determining a dominant wave length (λ) and colour purity (Č), on the basis of chromacy diagram (Fig. 1). The average reflectance or glossiness Y (*%*) is directly read on the device. The dominant wave length (λ) is determined as follows: point F is determined on the basis of trichromatic coefficients X and Y, then point F is connected to point C extending the straight line to the cross with spectral curve. The appropriate wave length for the relevant colour is read at the intersection point G. The colour purity (Č) represents a distance between the relevant point and "white colour". The closer the point to the source C, the lesser the purity (the purity of white point is 0 *%*) [31].

Fig. 2 shows colours encompassed by spectral curve according to CIE system.

In CIE $L^* a^* b^*$ system, colour quality characteristics are expressed on the basis of following indicators: [31-34].

$$L^* = 116 \cdot \left(\frac{Y}{Y_0}\right)^{\frac{1}{3}} - 16 \qquad L^* \text{- psychometric light} \tag{4}$$

$$a^* = 500 \cdot \left[\left(\frac{X}{X_0}\right)^{\frac{1}{3}} - \left(\frac{Y}{Y_0}\right)^{\frac{1}{3}}\right] \qquad a^* \text{- psychometric tone} \tag{5}$$

$$b^* = 200 \cdot \left[\left(\frac{Y}{Y_0}\right)^{\frac{1}{3}} - \left(\frac{Z}{Z_0}\right)^{\frac{1}{3}}\right] \qquad b^* \text{- psychometric chroma} \tag{6}$$

where X, Y, Z, refers to the official stimulant of white colour of the object.

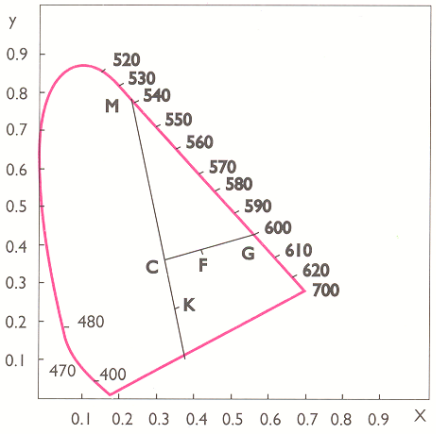
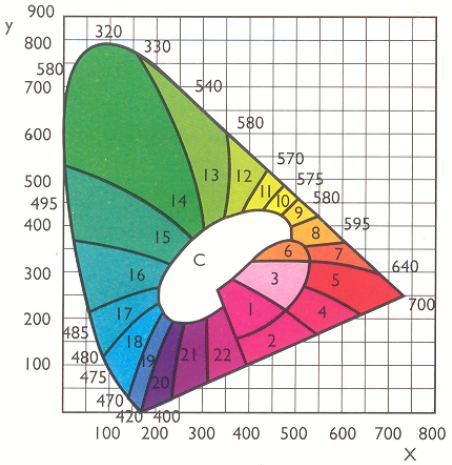


Fig. 1. Determination of dominant wavelength and purity of colour by CIE system.



1-violet-pink; 2-reddish pink; 3-pink; 4-violet-red; 5-red; 6-orangish red; 7-reddish orange; 8-orange; 9-yellowish orange 10-yellow; 11-greenish yellow; 12-yellow-green; 13-yellowish green; 14-green; 15-bluish green; 16-blue green; 17-greenish blue; 18-blue; 19-violet blue; 20-violet; 21-violet red; 22-reddish violet.

Fig. 2. Chromacy diagram according to CIE system with display of colours encompassed by spectral curve.

2.2.2. Sensory Analysis

The sensory evaluation of mayonnaise on the basis of analytical-descriptive point system (Table 1) was conducted by five-member committee of experienced tasters. During the sensory evaluation all

samples were appropriately designated, presented in optimal dynamics, with the application of the appropriate ISO standards [35-39].

The appearance (surface, consistency, homogeneity), colour (glossiness, i.e., brightness or colour tint, saturation and purity), as well as fragrance and taste were subject to the evaluation. A complex indicator representing the total sensory quality expressed as "% of maximum possible quality" was obtained by subtracting the sum of allocated individual grades with the total possible sum of grades and multiplying with 100.

Quality category was determined depending on the scores range; Samples which were evaluated with less than 2.5 points were considered unsatisfactory, i.e., unacceptable; grades ranging between 2.5-3.5 were characterized as good quality products, while grades between 3.5-4.5 were characterized as very good quality and grades between 4.5–5.0 were characterized as excellent products.

Table 1. Sensory evaluation of mayonnaise quality by using the scoring procedure.

Sensory properties	Description of the evaluated property	Score
Appearance	Distinctive appearance, glossy surface, consistency homogenous, smooth	5.0
	Distinctive appearance with a minor deviation	4.0
	Surface without gloss, presence of blobs or bubbles, softer or tougher consistency	3.0
	Indistinctive appearance and consistency	2.0
	Extremely indistinctive appearance and consistency	1.0
Colour	Distinctive tint, saturation and colour purity	5.0
	Minor deviation in terms of a tint, saturation and colour purity	4.0
	Moderate deviation in terms of a tint, saturation and colour purity	3.0
	Considerable deviation in terms of a tint, saturation and colour purity	2.0
	Extreme deviation in terms of a tint, saturation and colour purity	1.0
Fragrance	Pleasant fragrance, designated tones	5.0
	Minor deviation from certain fragrance tone	4.0
	Moderate deviation from a certain fragrance tone	3.0
	Considerable deviation from a certain fragrance tone	2.0
	Extremely indistinctive fragrance, atypical tone	1.0
Taste	Pleasant, distinctive taste	5.0
	Moderately pleasant, distinctive taste	4.0
	Mildly marked, non-defined taste	3.0
	Neutral taste	2.0
	Extremely indistinctive, insipid taste	1.0

2.3. Statistical Analysis

The experimental results were analyzed with the statistical package STATISTICA v. 6.

The data on the results of the evaluation of sensory properties of the studied categories of mayonnaise are presented through basic indicators of descriptive statistics and graphically through box-plots based on the arithmetic mean, standard deviation and standard error.

The statistical analysis of influence of two factors, declared contents and time of storage, to sensory properties of mayonnaise was carried out on the basis of two-factor parameter model of variance analysis. The adequacy of this model, with respect to the actual analysis was carried out on the basis of variation coefficient values and the Levene's test of homogeneity of variances. The results of the Levene's test did not show the homogeneity of variances in all situations. Transformations of data were carried out in such cases, but they did not improve the homogeneity of variances. Taking the above into account, as well as the fact that non-parameter testing has not been developed for two-factor experiment plans, and that this deficiency is attenuated with the same number of repetitions (which is the case in this study), the analysis was carried out on the basis of parameter model of variance analysis [40, 41].

In view of determining a difference between the studied types of mayonnaise individually according to the appearance and colour, as well as according to the appearance and colour taken together, the separability degree coefficients were determined [42, 43].

The equation of a straight line that approximates the movement of medium reflectance determined instrumentally has been defined by the application of the statistical software 6.1 (OriginLab. Corporation, Northampton, MA USA).

3. Results and Discussion

3.1. Instrumental Colour Measurement of Delicates, Salad and Low Energy Mayonnaise

On the basis of results obtained by instrumental colour measurement of samples of delicates mayonnaises, shown in the CIE system, immediately after preparation sample 7 possesses the highest value for the average reflectance i.e. glossiness on the surface (Y=40.53 %; S_d=0.96 and C_v=0.02), while sample 2 had the lowest value (Y=25.50 %; S_d=0.89 and C_v=0.03). Which means that sample 2 had conditionally "the darkest", and sample 1 was similar to it (Y=26.30 %; S_d=0.98 and C_v=0.04), while sample 7 was conditionally of "the lightest" colour. The same brightness, i.e., glossiness was identified in samples 6 (Y=30.22 %; S_d=0.95 and C_v=0.03) and 4 (Y=31.36 %; S_d=0.89 and C_v=0.03), then in sample 3 (Y=31.74 %; S_d=0.91 and C_v=0.03) and sample 5 (Y=32.93 %; S_d=0.32 and C_v=0.01). The change of the average reflectance Y (%) of Group I – delicates mayonnaises (samples: 1-7) was shown in Fig. 3.

The read values for a dominant wave length in the CIE system show that there are no significant differences in the colour tint among the analyzed samples. Actually, according to the values for a dominant wave length, all samples of delicate mayonnaise belong to yellow-green part of spectre, on the basis of chromatics diagram, λ=562 *nm* for sample 1; λ=564 *nm* for samples 2,4,5,6 and 7 and λ=566 *nm* for mayonnaise sample number 3. The lowest purity, i.e., colour saturation is found in the sample 1, Č=25.2 %, then in sample 3, Č=26.5 %, while the colour saturation was completely unified in all other analyzed samples of delicates mayonnaise.

The characteristics of colour quality of mayonnaise samples from Group I, immediately after production in the CIELab system are shown in Fig. 4.

The calculated values for a psychometric tone a^* are with a negative denomination, which implies the presence of a green pigment, while the values for chrome (b^*) are with a positive denomination which speaks about the presence of yellow pigment. The colour of mayonnaise may be sensory graded from light yellow to ochre yellow which depends on: egg yolk, edible vegetable oil and possible adjustments with mustard. In general, edible vegetable oil contributes very little to colour if it is well refined,

unless safflower and olive oil with distinctively green colour is applied due to presence of chlorophyll [8, 22]. Spices that are added and that have a distinctive colour must not be added in quantities that would change the colour typical of mayonnaise [44].

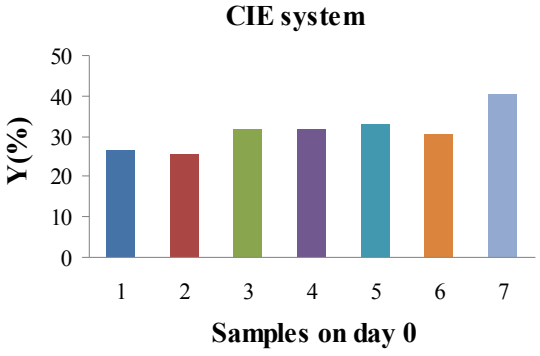


Fig. 3. Change of the average reflectance Y (%) of the first group of samples-delicates mayonnaise, immediately after production.

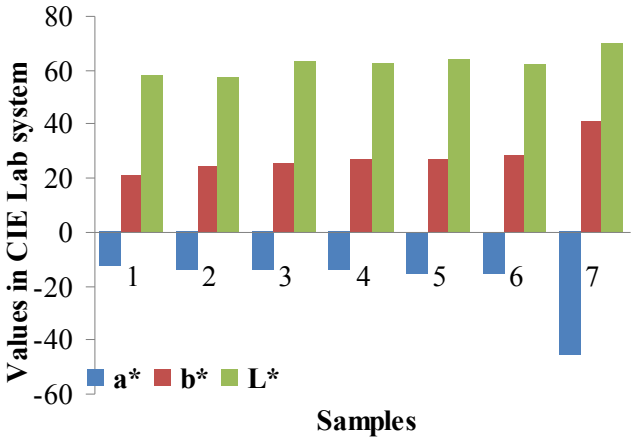


Fig. 4. Changes of psychometric light, tone and chrome in CIELab system in the first group of samples – delicates mayonnaise, immediately after production.

The analyzed sample 7 has distinctively the highest value for a psychometric tone (a^*) (participation of a green pigment) (a^*=-46.2), which apart from edible refined vegetable sunflower oil (75 %) contains added yolk, mustard, as well as permitted colours (Annatto E160 and Turmeric). Along with the tone, this sample has the highest chroma which is b^*=41.27, in the CIELab system, which is illustrated in Fig. 4.

The samples of the first group of delicates mayonnaise (1-5) which in their contents include edible refined vegetable sunflower oil min. 75 %, yolk, min. 6 % and mustard in corresponding quantity, but without added permitted colours, have approximately unified colour quality (tint, saturation and glossiness). The samples of delicates mayonnaises (6 and 7) that include the added olive oil in their contents (sample 6), as well as added colours (Annatto E160 and Turmeric) most significantly change the glossiness of surface, i.e., they become lighter, but have a greater share if green and yellow pigment in comparison to the samples of delicates mayonnaise whose contents does not include added colours. The explanation may be related to the quality of primary raw materials (edible vegetable oil, yolk, mustard), as well as technological procedure of production [7, 8, 45-47].

The results of the instrumental colour measurement for Group II of samples, salad mayonnaise, are shown in Figs. 5 and 6. Sample 8 has the following values: Y=34.42 %, S_d=0.86 and C_v=0.05, and sample 9: Y=41.98 %, S_d=0.97 and C_v=0.05. Therefore, salad mayonnaise sample 9 has the greatest value for surface glossiness, and we may conclude that it is "lighter" than sample 8 (Fig. 5). This is confirmed also by read values for a dominant wave length from chromatics diagram, based on which sample 8 belongs to yellow-green part of spectre, more precisely, it is on the very border with yellowish-green part, λ=561 *nm*, while sample 9, on the basis of calculated value, λ=555 *nm* belongs to yellowish-green part of spectre. Such results were expected since sample 8 contains 60.00 % of edible refined vegetable sunflower oil, corresponding quantity of yolk and added mustard, while salad mayonnaise sample 9 contains a lower percentage (50 %) of refined edible vegetable oil, yolk and mustard.

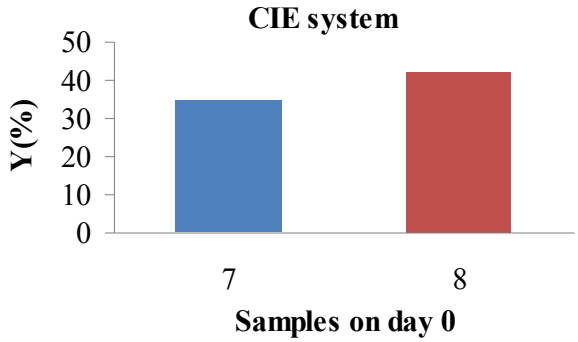


Fig. 5. Change of the average reflectance Y (%) other group of samples–salad mayonnaise, immediately after production.

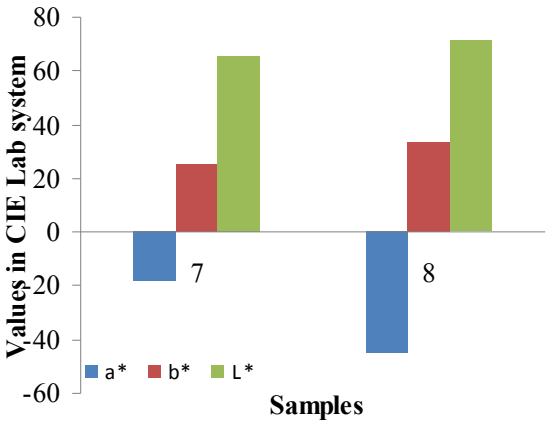


Fig. 6. Changes to psychometric light, tone and chroma of the second group of samples–salad mayonnaise – in the CIELab system, immediately after production.

It may be recognized that sample 9 has a significantly higher participation of a green pigment in comparison to sample 8. The calculated values for the psychometric tone for the sample 8 are: a^*=-18.52; S_d=0.93 and C_v=0.06, and for sample 9: a^*=-45.14; S_d=0.92 and C_v=0.04. The participation of yellow pigment is also less for sample 8 (b^*=25.34), in comparison to the analyzed sample 9 (b^*=33.64). The values for psychometric light are in correlation with the values for the average reflectance i.e. glossiness, while the sample 8 is a bit darker (L^*=65.29) than the sample 9 (L^*=70.85) (Fig. 6).

Samples 10 and 12 from Group III – low energy mayonnaise have approximately the same values for the average reflectance (Fig. 7): Y=33.79 %, S_d=0.89 and C_v=0.03 and Y=34.20 %, S_d=0.97 and C_v=0.06. The obtained values point to the fact that the above samples of low energy mayonnaise are of unified colour quality in terms of glossiness of surface, while the sample 11 is a bit "darker" (Y=26.38 %; S_d=0.97 and C_v=0.04), in comparison to the previous two studied samples. The changes to the average reflectance i.e. glossiness of surface of the analyzed low energy mayonnaises are shown in Fig. 7.

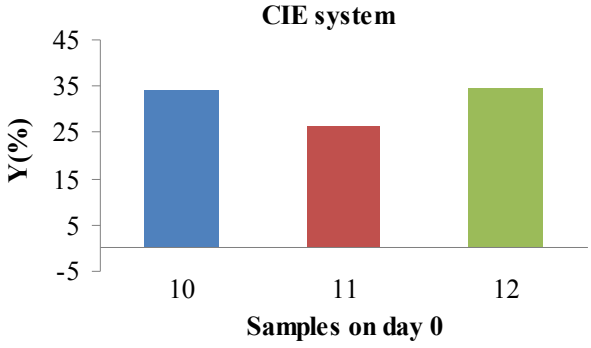


Fig.7. Change of the average reflectance Y (%) of the third group of samples–low energy mayonnaise, immediately after production.

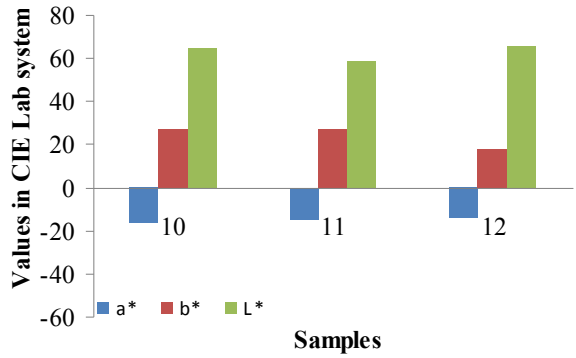


Fig. 8. Changes of psychometric light, tone and chroma in the third group of samples–low energy mayonnaise – in the CIELab system, immediately after production.

The average of low energy mayonnaise 11, has a bit lower value for brightness (L^*=58.39; S_d=0.93 and C_v=0.05), but it is the only sample in the analyzed group which include the added colour in its contents, Annatto extract E160. The participation of the green pigment is the highest in the analyzed sample of low energy mayonnaise of a producer 10 (a^*=–16.44). The similar participation of psychometric tone is found in the samples 11 and 12, a^*=–14.94 and a^*=–14.03. The participation of the yellow pigment (psychometric chroma) was similar in the samples 10 (b^*=26.64) and 11 (b^*=27.05). Low energy mayonnaise produced by producer 12 has a considerably lower participation of yellow pigment (b^*=17.47). The analyzed sample 12, in comparison to previous two samples (10 and 11) includes in its contents at least 30 % of oil, mustard, kitchen salt, sugar, lemon acid E330, no added colours, but includes the added stabilizers: acetylated distarch adipate E1422, hydroxylpropyl distarch phosphate E1442 and xantan gum E1415, as well as added preservative, potassium sorbate E202, influencing the colour change. The obtained data for the average reflectance, psychometric light, tone and chroma may be precious from the point of view of sustainability of mayonnaise [7, 46-50].

The average reflectance of colour, after 90 days of storage of the first group of mayonnaises–delicates mayonnaises (samples 1 to 7), second group of samples–salad mayonnaises (samples 8 and 9) and the samples of low energy mayonnaises (10-12) are shown in Figs. 9 to 14.

If the results obtained in colour measurement after 90 days of storage (Fig. 9-14), for all three types of samples are compared with the colour results for the same samples after their production (Fig. 3-8), it may be clearly identified that there are no significant differences, i.e., that the colour with respect to glossiness, tint and saturation is rather stable and of corresponding quality.

Figs. 15-20 show the changes of the average reflectance, psychometric light, tone and chroma of delicates, salad and low energy mayonnaise after 180 days of storage at the temperature of +5 ºC.

During the period from the 90th and 180th day of storage, there has been the increase of value of the average reflectance for I group of samples. However, irrespective of the change of glossiness, i.e. brightness of colour of delicates mayonnaises during warehousing, it must be pointed out that the samples have the same colour tint on the basis of chromatic diagram (λ=561 to 562 *nm*).

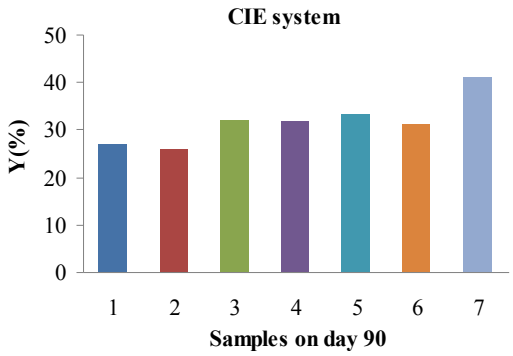


Fig. 9. Change of the average reflectance Y (%) of the first group of samples-delicates mayonnaise, after 90 days of storage.

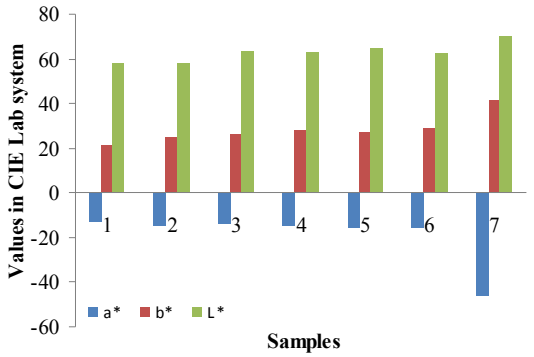


Fig. 10. Change of psychometric light, tone and chroma in the first group of samples–delicates mayonnaise – in the CIE Lab system, after 90 days of storage.

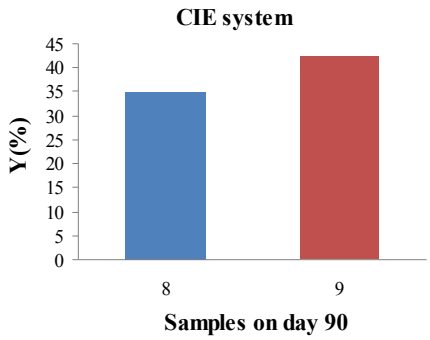


Fig. 11. Change of the average reflectance Y (%) of the second group of samples–salad mayonnaise, after 90 days of storage.

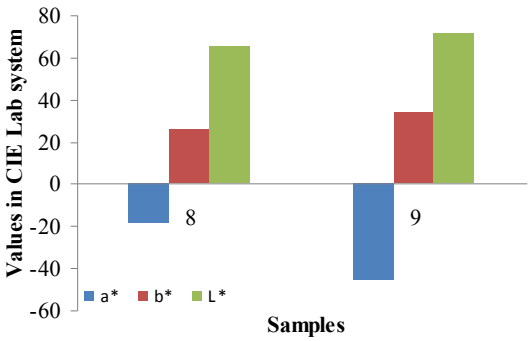


Fig. 12. Change of psychometric light, tone and chroma in the second group of samples–salad mayonnaise - in the CIE Lab system, after 90 days of storage.

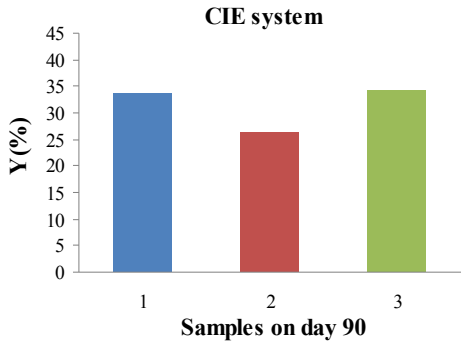


Fig. 13. Change of the average reflectance Y (%) of the third group of samples–low energy mayonnaise, after 90 days of storage.

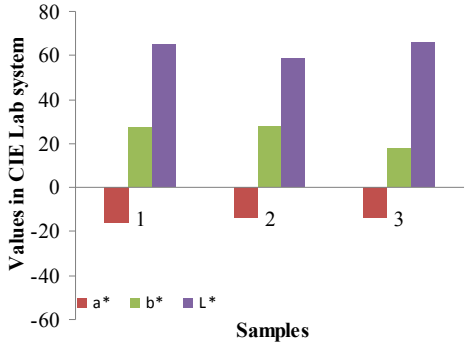


Fig. 14. Change of psychometric light, tone and chroma in the third group of samples–low energy mayonnaise – in the CIE Lab system after 90 days of storage.

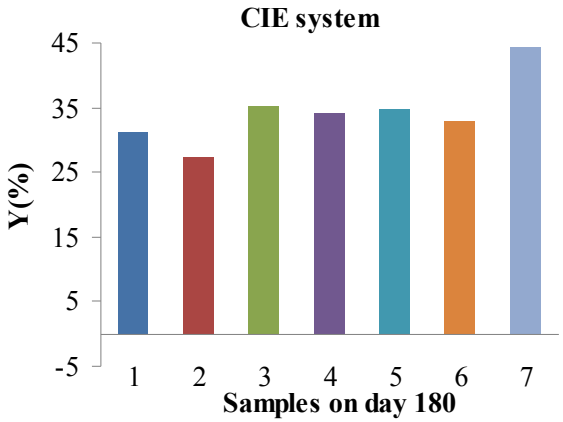


Fig. 15. Change of the average reflectance Y (%) of the first group of samples- delicates mayonnaise, after 180 days of storage.

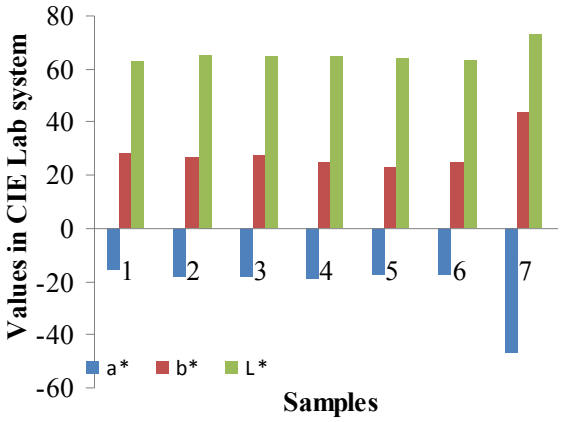


Fig. 16. Change of psychometric light, tone and chroma in the first group of samples–delicates mayonnaise – in the CIE Lab system, after 180 days of storage.

During the storage up to 180 days, there have been insignificant changes in the values of the average reflectance i.e. glossiness in the analyzed samples of salad mayonnaise in comparison to the same samples immediately after production and after 90 days of storage. Thus the average reflectance for sample 8 is Y=36.74 %; S_d=0.70 and C_v=0.02) in the CIE system, while the values of psychometric light are: L^*=65.30; S_d=0.70; C_v=0.01 in the CIE Lab system. Salad mayonnaise designated with 9 has the calculated value for the average reflectance Y=43.70%; S_d=0.40 and C_v=0.01, and for psychometric light L^*=67.20; S_d=0.60; C_v=0.01. Thus, according to the obtained values for brightness, sample 9 is a bit lighter i.e. "brighter" than the sample 8 (Fig. 17 and 18).

The participation of psychometric tone is significantly lower in the sample 8 (a^*=–13.30), in comparison to sample 9 (a^*=–44.57) and points to a different presence of a green pigment (Fig. 18). Psychometric chroma i.e. the participation of a yellow pigment in the sample 8 is b^*=21.53, while in sample 9 it is b^*=26.93. The obtained results irrespective of the previous statement that the "tint" of the samples is *the same* during the whole storage period, point out that after 180 days of storage there have been insignificant changes that may not be explained, most probably, in comparison to the angle of colours (a^*/b^*) [32].

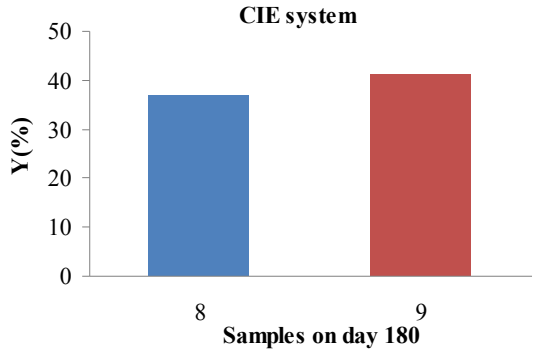


Fig. 17. Change of the average reflectance Y (%) of the second group of samples-salad mayonnaise, after 180 days of storage.

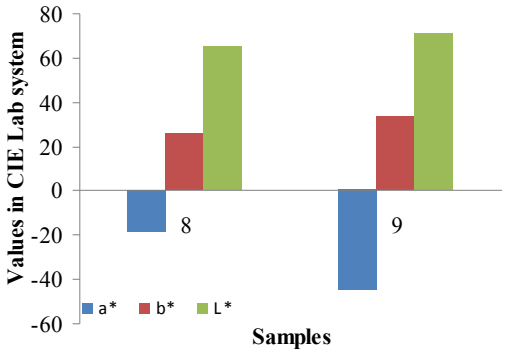


Fig. 18. Change of psychometric light, tone and chroma in the second group of samples–salad mayonnaise - in the CIE Lab system, after 180 days of storage.

With respect to colour tint, all the samples of low energy mayonnaise remained unchanged even after 180 days of storage and they belong to yellow-green part of spectre (λ=561 *nm*). Psychometric light is the greatest in the sample 10 and it amounts (L^*=62.62), its value is a bit lower in the sample 12 (L^*=61.48), and significantly lower in the sample 11 (L^*=41.90) (Fig. 19 and 20).

The results of ten-times repeated instrumental determination of colour of delicates, salad and low energy mayonnaise have been statistically processed, and along with the arithmetic mean, $\bar{X}$, standard deviation, S_d, and variation coefficient, C_v, the variance analysis was performed as well. The significance of differences among average reflectance, Y(%) has also been determined, depending on the contents oil (75 %; 50 %; 30 %) in samples (Table 2) and the time of storage (0, 90 and 180 days) of samples (Table 3).

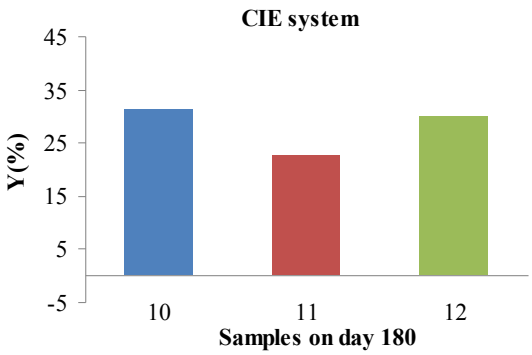


Fig. 19. Change of the average reflectance Y (%) of the third group of samples–low energy mayonnaise, after 180 days of storage.

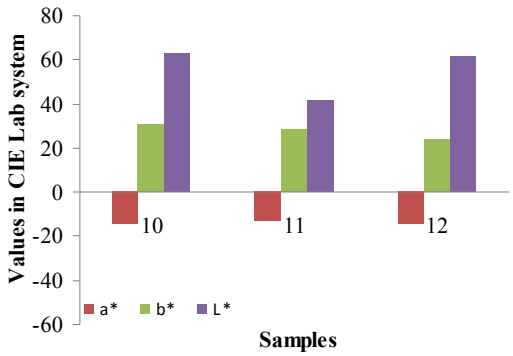


Fig. 20. Change of psychometric light, tone and chroma in the third group of samples–low energy mayonnaise – in the CIE Lab system after 180 days of storage.

The average reflectance in salad mayonnaise is statistically significantly different than the value of the average reflectance of delicates mayonnaise, as well as than the value of the average reflectance of low energy mayonnaise (Table 2).

Table 2. Influence of declared contents on the values of the average reflectance of samples.

Declared contents	Average reflectance Y (%)
Delicates mayonnaise	30.32
Salad mayonnaise	38.52
Low energy mayonnaise	32.34

Table 3. Influence of time of storage on the values of the average reflectance of samples.

Time of storage (days)	Average reflectance (%)
0	33.63
90	33.89
180	33.66

On the basis of results of instrumental measuring, the linear model of changes of the average reflectance Y (%) has been determined for each studied example of delicates, salad and low energy mayonnaises depending on the length of storage. The degree of dependence of the average reflectance on the length of storage has been qualified through Pearson's coefficient of correlation. The correlation coefficients range between 0.90 and 0.98 pointing to statistically very strong relation ($p<0.01$) between the average reflectance and the time of mayonnaise storage, as well as that the determined linear functions excellently describe the change of glossiness of surface of mayonnaise in the function of storage time. (Table 4).

Table 4. Linear models of the average reflectance (y) of studied samples depending on the time of storage (x) up to 180 days.

Model: $\hat{y}_i = a + bx_i$			
Sample No.	**Parameters**		**Correlation coefficient (r)**
	a	**b**	
1	25.69	0.03	0.92
2	25.33	0.01	0.95
3	31.23	0.02	0.90
4	30.95	0.02	0.90
5	32.65	0.01	0.90
6	30.03	0.01	0.97
7	40.05	0.02	0.91
8	34.12	0.01	0.91
9	41.73	0.01	0.90
10	33.77	0.01	0.98
11	26.01	0.02	0.92
12	33.83	0.01	0.90

3.2. Sensory Evaluation of Quality of Group I Samples–delicates Mayonnaise

Delicate mayonnaise samples have been evaluated immediately after production with a very high average grade for the appearance ($\overline{x}$=4.75; S_d=0.33 and C_v=6.95) and colour ($\overline{x}$=4.73, S_d=0.37 and C_v=7.82), while they have been evaluated with the highest grade fir fragrance and taste by the members of the evaluation committee ($\overline{x}$=5.00; S_d=0.00 and C_v=0.00), thus the value of the weighted average grade is 4.87 or 97.42 % of maximum possible quality. After the evaluation made on the 90th day, the grades have been insignificantly changed (p=0.239 and p=0.406): for the appearance ($\overline{x}$=4.66; S_d=0.37 and C_v=7.94) and colour ($\overline{x}$=4.79, S_d=0.32 and C_v=6.68), thus the average grade is $\overline{x}$=4.86 or 97.12 % of the maximum possible quality. After 180 days, the appearance and colour of delicate mayonnaise have been evaluated statistically by considerably (p<0.01) lower average grades ($\overline{x}$=3.66 and; $\overline{x}$=3.96), and the individual grades were more heterogeneous (C_v=16.12 and C_v=8.84). The value of the weighted average grade on the 180th day is 4.39 or 87.8042 % of the maximum possible quality.

It is interesting to point out that the grades for sensory properties fragrance and taste have not changed during the whole period of studying and they amounted 5.00. However, the average grades for sensory properties of the appearance and colour have influenced by their changes the decreasing tendency of the average weighted evaluation of delicates mayonnaise with the increased storage time, as well as the increase of non-uniformity of grades (Fig. 21). The average weighted value of sensory quality of the 180th day is statistically considerably different (p<0.01) than the weighted average grades on the 0th and the 90th day. The difference of the weighted average grades of the 0th and the 90th day is not statistically significant (p=0.587).

On the basis of the analysis of sensory properties variance: appearance, colour and weighted average value (Table 5) of delicate mayonnaise, it may be concluded that the samples of different producers (declared contents) have been given the appearance average grades that are statistically considerably different (p<0.01) Also, the time of storage caused statistically significant differences in average grades (p<0.01). The interaction of factors – declared contents and time of storage considerably statistically influenced the average grades for the appearance (p<0.01), and considerably on the average grades for colour (p=0.049) and the weighted average grade (p=0.025).

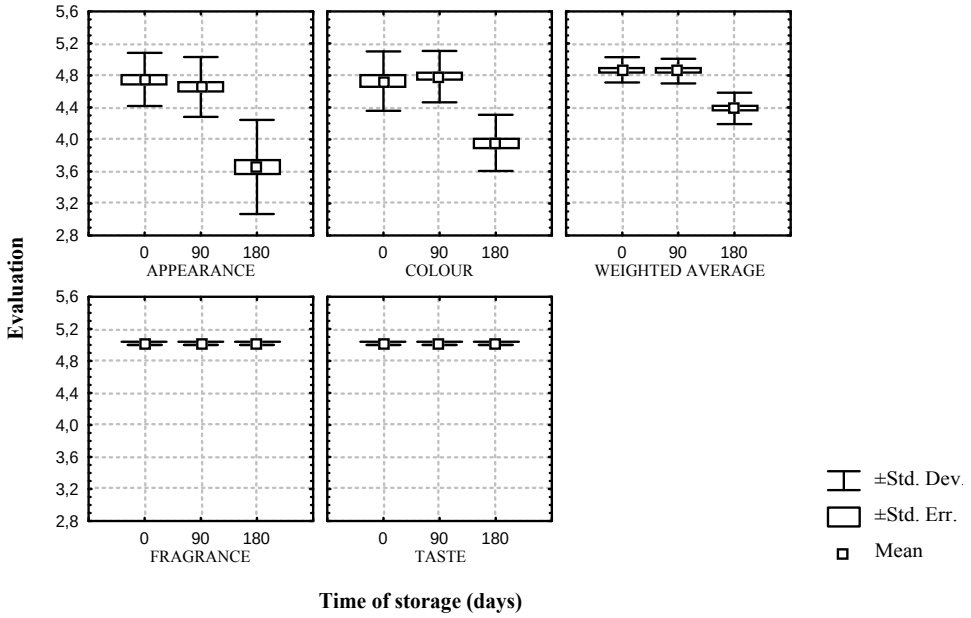


Fig. 21. Box-plots for sensory properties of delicates mayonnaise.

Table 5. The results of the analysis of the variance of sensory properties of the first group of samples – delicates mayonnaise.

Sensory property of quality	Declared contents		Time of storage		Interaction	
	F	p	F	P	F	p
Appearance	10.273	0.000	119.607	0.000	3.586	0.000
Colour	7.447	0.000	91.578	0.000	1.876	0.049
Weighted average value	12.690	0.000	165.061	0.000	2.108	0.025

The similar tendency is found in the grades for delicates mayonnaise of the studied seven producers, i.e. for samples 1-7 (Figs. 22, 23 and 24).

According to the appearance, during all three periods taken together, the best rated sample was sample 5 with the average grade 4.73, while sample 3 was the worst rated with the average grade 4.08. The samples of delicates mayonnaises, under the codes 1, 6 and 7 were given the same average grade for the appearance (4.17). On the basis of results of LSD- test, the appearance of delicates mayonnaises of producers 2, 4 and 5 statistically has no differences, and it is considerably better in comparison to the appearance of other samples (Fig. 22).

The changes of sensory property appearance for all samples of delicates mayonnaises, during the first 90 days are not significant ($p=0.239$), and during further storage up to 180 days there appear significant changes in the appearance of mayonnaise ($p<0.01$) in all samples other than in sample 5 ($p=0.06$).

The same grade, 4.67, as the best average grade for colour was given to samples 2, 4 and 5. The colour of sample 6 was given a lower grade in comparison to their colour, but that difference is not statistically significant ($p=0.341$). It has been established that samples 1 and 7 are not statistically considerably different in colour ($p>0.05$), but are considerably different in this sensory property than other samples ($p<0.01$).

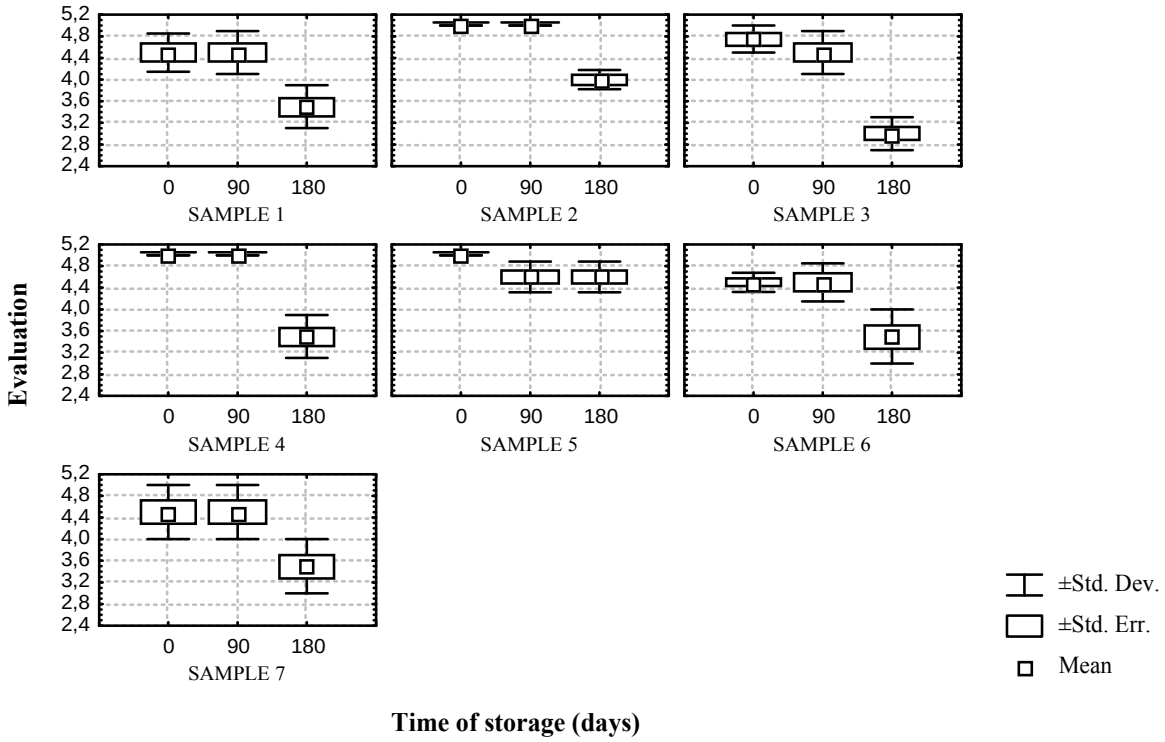


Fig. 22. Box-plots for sensory property appearance for the first group of samples delicates mayonnaise.

The result of LSD–test points out that the colour of delicates mayonnaise has been evaluated as stable up to 90th day ($p=0.41$), and then it deteriorates significantly in terms of statistics ($p<0.01$). The average grade for colour has been considerably reduced in all samples of delicates mayonnaise in comparison to their average grades immediately after the production, as well after 90 days of storage, other than in case of sample 6. The average grade for colour after 90 days for sample 6 of delicates mayonnaise statistically considerably differs ($p<0.01$) than the average grade immediately after production and after 180 days.

After approximately 90 days, sample 6 considerably differs in the average grade for sensory property colour - ($p<0.01$) in comparison to the samples 1, 3 and 7, and after 180 days in comparison to sample 1. The average grade for colour of sample 7 immediately after production statistically considerably deviates from the grades given to the samples of delicates mayonnaise 2, 4 and 5. After 90 days, the stated differences are even greater, i.e. very significant. On the 180th day the average grade for colour of sample 7, statistically considerably differs than the average grade for colour of samples 1-5 (Fig. 23).

These results are in compliance with the results of instrumental determination of characteristics of colour quality that show that there has been a deterioration of colour purity i.e. saturation after 180 days.

At the same time, sample 5 was evaluated as the top quality delicates mayonnaise on the basis of all sensory properties, and sample 1 conditionally as “the lowest quality” but still having an excellent quality. From the statistics point of view, samples 2 and 4 do not differ from sample 5 ($p>0.05$). Samples 3, 6 and 7 are similar in sensory characteristics to sample 1 ($p>0.05$).

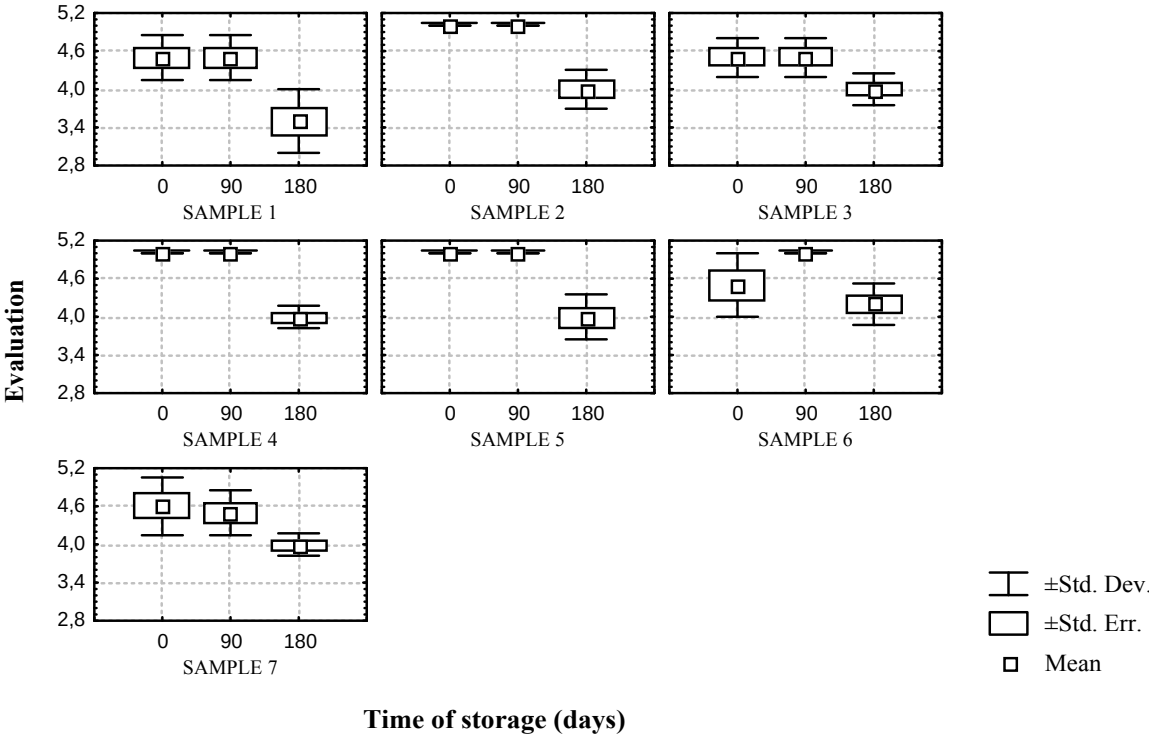


Fig. 23. Box-plots for sensor property colour for the first group of samples–delicates mayonnaise.

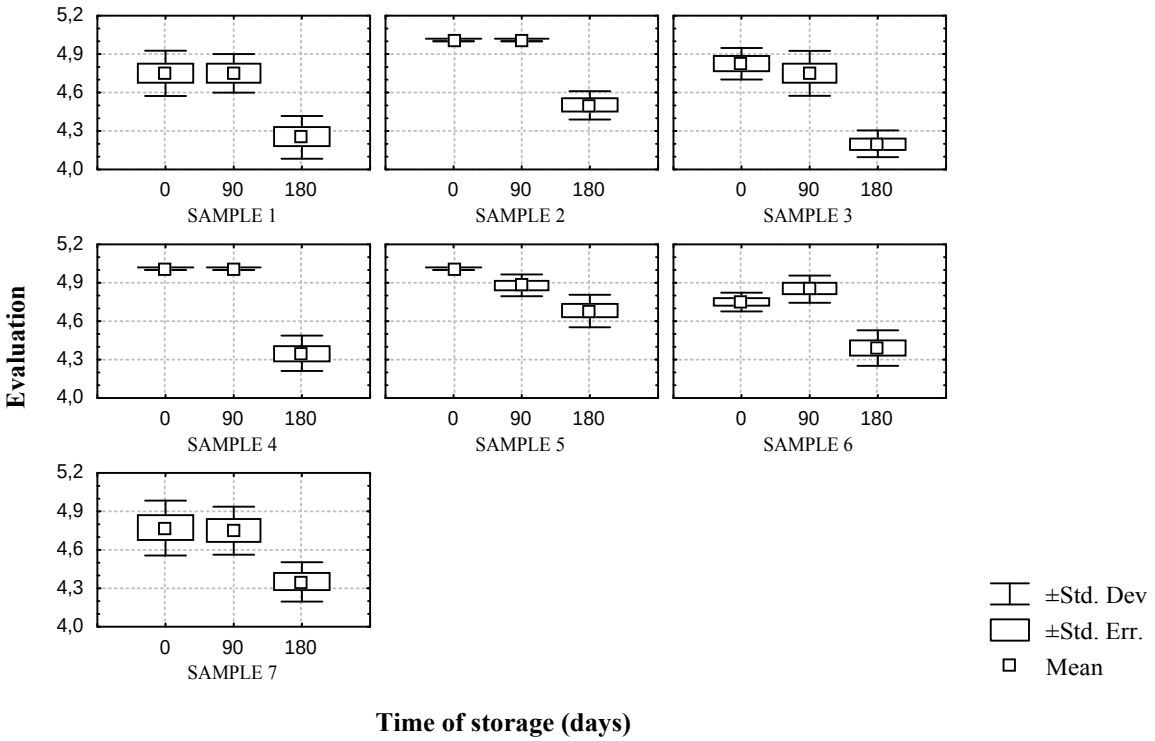


Fig. 24. Box-plots for the average weighted grade for the studied sensory properties for the first group of samples–delicates mayonnaise.

The change of the average weighted grade by the 90th day was not statistically significant ($p>0.05$), however with the extension of storage time of analyzed samples, the sensory properties statistically considerably changed to a great extent ($p<0.01$).

Delicates mayonnaise of the producer under number 5 after 180 days of storage, sample 6 immediately after production and sample 7 immediately after production and on the 90th day had considerably ($p<0.01$) better sensory characteristics than the products in samples designated with 2 and 4. The difference in sensory properties of delicates mayonnaise samples designated with 3 and 6 is significant at the end of period of 180 days. Sample 4 is evaluated at first as considerably better than the sample 3, and considerably better than sample 1, and considerably better than samples 1 and 3 after 90 days of storage of products (Fig. 24).

3.3. Sensory Evaluation of Quality of Samples of Group II–salad Mayonnaise

Immediately after production and after 90 days of storage, the appearance and colour of salad mayonnaise samples (8 and 9) have been evaluated with the average grade of 4.75 with the variation coefficients of 6.95 % and 6.11 % on the 0th day and 7.37 % on the 90th day. These properties have been evaluated with the same average grade, 4.25 and 180 days, while the individual grades for colour were non-unified more often (C_v=9.88 %), compared to the appearance (9.65 %). All tasters evaluated fragrance and taste with a maximum grade in each tasting session. In accordance with that, the weighted average grade of 4.88 i.e. 97.50% of maximum possible quality until the 90th day, and in the end of the studied period it was reduced to 4.62, and/or 92.50 % of the possible maximum.

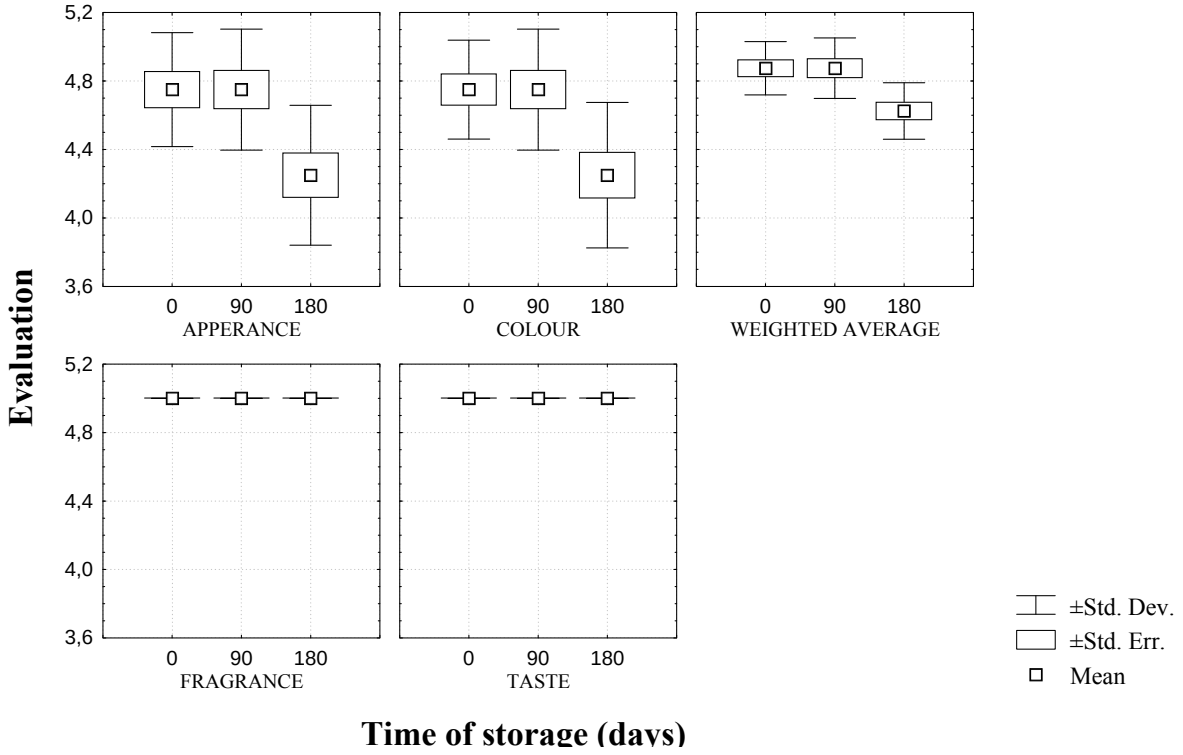


Fig. 25. Box-plots for sensory properties of salad mayonnaise.

The results of the variance analysis of sensory properties of the second group of samples–salad mayonnaise show that the factors declared contents and time of storage had a significant influence on the average grades for the appearance, colour and average weighted price ($p<0.01$). These factors had an independent influence (Table 6).

Table 6. The results of the analysis of the variance of sensory properties of the second group of samples–salad mayonnaise.

Sensory property of quality	Declared contents		Time of storage		Interaction	
	F	p	F	P	F	p
Appearance	25.714	0.000	11.429	0.000	0.000	1.000
Colour	27.692	0.000	12.308	0.000	0.000	1.000
Weighted average grade	40.909	0.000	18.182	0.000	0.000	1.000

Samples 8 and 9 are statistically considerably different ($p<0.01$) according to the studied sensory properties (Table 6).

According to the allocated grades, sample 8 and sample 9 kept the unchanged appearance and colour until the 90th day ($p=1.00$), and thus the weighted price, while at each tasting session, products 8 were evaluated significantly ($p<0.01$) by higher average grade (Figs. 26, 27 and 28).

All tasters evaluated sample 8 with the grade 5.00 until the 90th day, thus the value of the weighted average grade amounted $\bar{x}=5.00$ or 100 % of the maximum possible quality. After 180 days of warehousing, there have been some changes in colour and the appearance, thus the value of the average weighted grade was $\bar{x}=4.75$ or 95.00 % of maximum possible quality. In comparison to sample 8, sample 9 was evaluated by statistically considerably lower grades for sensory properties of colour and the appearance, up to 90 days by 4.50, and in the end of evaluation by 4.00. The weighted average grade for sample 9 for the first 90 days was $\bar{x}=4.75$ or 95.00 % of maximum possible quality, and after 180 days statistically considerably lower ($p<0.01$ in Tab. 6) $\bar{x}=4.50$ i.e. 90.00 % of maximum possible quality.

The results of LSD-test show that the change of the appearance of salad mayonnaise, and sample 8 and sample 9, after the 90th day is statistically significant ($p<0.01$). The decrease of the average grade is accompanied by the increase of variability.

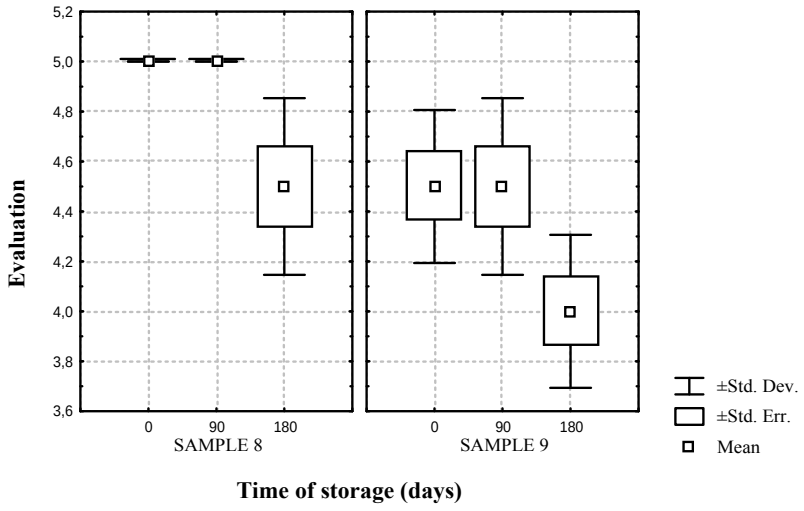


Fig. 26. Box-plots for sensory property appearance of the second group of samples–salad mayonnaise.

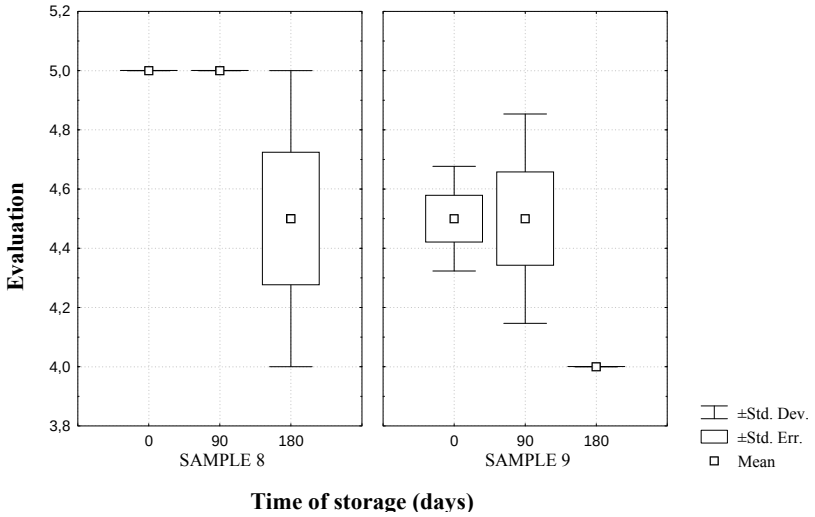


Fig. 27. Box-plots for the sensory property colour of the second group of samples–salad mayonnaise.

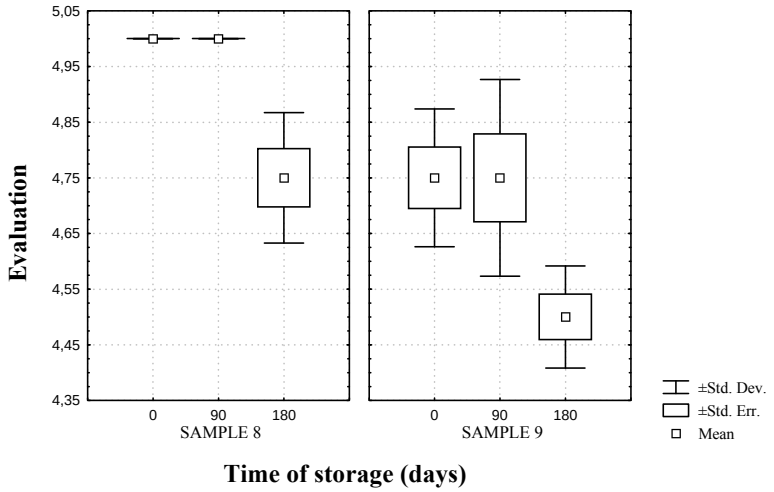


Fig. 28. Box-plots for the average weighted grade for the studied sensory property of the second group of samples–salad mayonnaise.

3.4. Sensory Evaluation of Quality of III Group Samples–low Energy Mayonnaise

All tasters evaluated the taste and fragrance of low energy mayonnaise with the maximum grade (5.00) at each tasting session, as was the case with delicates and salad mayonnaise samples. The average sensory grade for the appearance decreased from 4.83 to 4.50 for the first 90 days of storage, while it was 3.83 on the 180th day of storage. According to the results of LSD-test, the appearance of low energy mayonnaise has considerably changed by the 90th day of storage ($p=0.044$), and then the change was even more distinctive ($p<0.01$). Also, individual grades were not uniform (C_v: 7.02 %; 10.67 % and 18.02 %). On the production day, low energy mayonnaise was evaluated with the average grade for colour 4.70 (C_v=7.02 %), with 4.67 after 90 days (C_v=6.85 %) and with 4.17 (C_v=8.39 %) after 180 days of storage, thus the results of the statistical measurements show that the colour was evaluated with statistically considerably lower grade on the 180 day in comparison to its colour on the 0th and 90th day of storage.

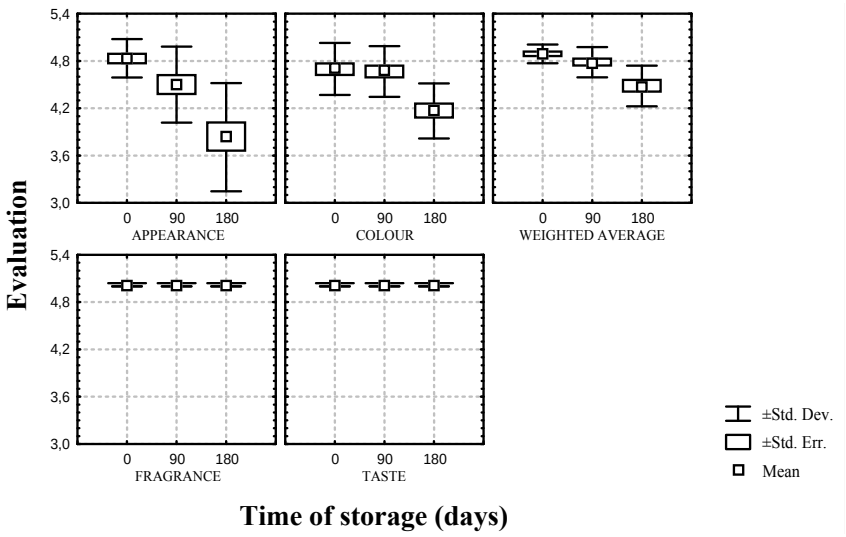


Fig. 29. Box-plots for sensory properties of low energy mayonnaise.

The weighted average grade for the studied sensory properties (appearance, colour, fragrance and taste) of low energy mayonnaises (samples 10, 11 and 12), was the highest on the 0th day, $\bar{X}$=4.89 or 97.78 % of maximum possible quality, while after storage up to 90 days it was insignificantly reduced (p=0.722) and on the 90th day amounted $\bar{X}$=4.78, while on the 180th day it amounted $\bar{X}$=4.48 or 89.66 % of maximum possible quality. That value was statistically significantly much less (p<0.01) in comparison to both previous average weighted grades.

The results of the method of variance analysis (Table 7) show that the appearance, colour and the weighted average grade of low energy mayonnaise depend significantly on the composition of mayonnaise and time of its storage. Interactive impact of these two types of factors is not statistically significant for colour (0.986), it is very significant for the appearance (p<0.01) and significant for the weighted average grade.

Table 7. The results of the analysis of the variance of sensory properties of the third group of samples–low energy mayonnaise.

Sensory property of quality	Declared contents		Time of storage		Interaction	
	F	p	F	P	F	p
Appearance	93.333	0.000	93.333	0.000	8.333	0.000
Colour	18.151	0.000	20.731	0.000	0.086	0.986
Weighted average grade	67.950	0.000	75.497	0.000	3.657	0.013

Each sample of low energy mayonnaise was significantly very different in the average appearance than other samples (Fig. 30 and the levels of significance of LSD-test: p<0.01), while samples 10 and 12 do not differ in the average grade for colour (p=0.722).

Low energy mayonnaise of producer 11 did not change its appearance until the 90th day and at the beginning it was evaluated with the same grade as the product 10. The appearance of products 10 and 12 significantly changed between sensory analyses, and during each analysis the appearance significantly depended on the composition (for LSD-test p<0.01).

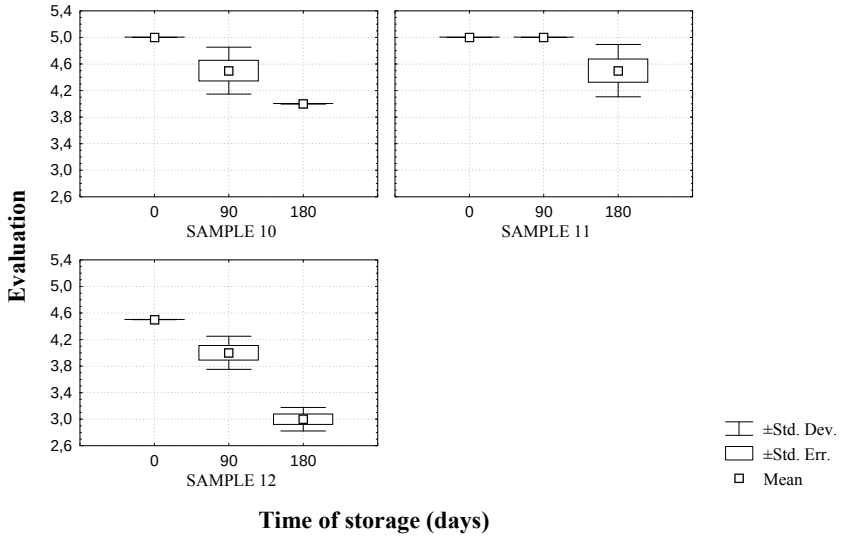


Fig. 30. Box-plots for sensory property appearance for the third group of samples–low energy mayonnaise.

The sample designated with 11 differed significantly in colour in terms of statistics than the samples designated with 10 and 12 ($p<0.01$), while the colour for samples 10 and 12 was evaluated with the approximately same grade ($p=0.722$).

Please note that the changes of colour in each analyzed sample of low energy mayonnaise 10–12 were very significant after 180 days ($p<0.01$) both in comparison to colour immediately after production and the colour evaluated after 90 days (Fig. 31).

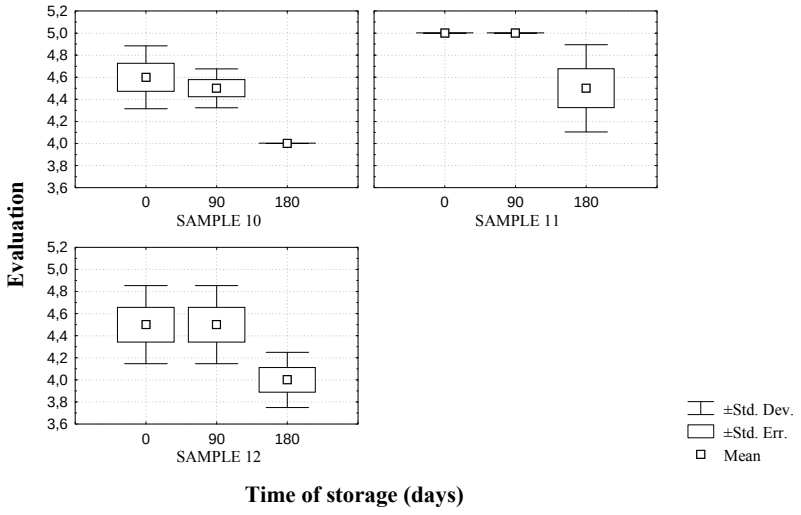


Fig. 31. Box-plots for sensory property colour for the third group of samples-low energy mayonnaise.

On the basis of weighted average grades, the samples of low energy mayonnaise of different producers were statistically considerably different ($p<0.01$)

During each analysis (0, 90 and 180 days), the weighted average price for samples 10 and 12 may be considered equal according to the results of statistical testing ($p=0.538$, $p=1.000$ and $p=1.000$). Sample 11 was evaluated as considerably better on the 0^{th} and much considerably better on the 90^{th} and

180th day in comparison to sample 10. The averaged grades for samples 11 and 12 at each evaluation were statistically considerably different ($p<0.01$).

3.5. Sensory Evaluation of Quality of Delicates, Salad and Low-energy Mayonnaise

Sensory properties of quality fragrance and taste, for all analyzed groups (delicates, salad and low energy mayonnaise) of mayonnaise samples during the whole period of analysis were evaluated with the maximum number of points (5.00) and they did not change during the storage up to 180 days.

The results of variance analysis for variable sensory properties appearance and colour (Table 8) show that three studied types of mayonnaise do not differ, but that the period of storage significantly influences these sensory properties. The interaction of factors of groups and storage time is significant for the appearance and as a result for the average sensory quality.

Table 8. Results of variance analysis of variable sensory properties of groups of samples.

Sensory property of quality	Group		Time of storage		Interaction	
	F	p	F	P	F	p
Appearance	3.039	0.0505	48.988	0.000	2.509	0.044
Colour	0.836	0.435	46.855	0.000	1.799	0.131
Weighted average grade	2.852	0.061	64.092	0.000	2.789	0.028

The appearance and colour, as well as the average sensory quality of all three groups of mayonnaise taken together (Fig. 32-34) was evaluated as statistically considerably changed on the 180th day in comparison to the 0th and 90th day, although the change of the appearance with the salad mayonnaise were evaluated as rather weak, i.e. statistically significant ($p=0.014$).

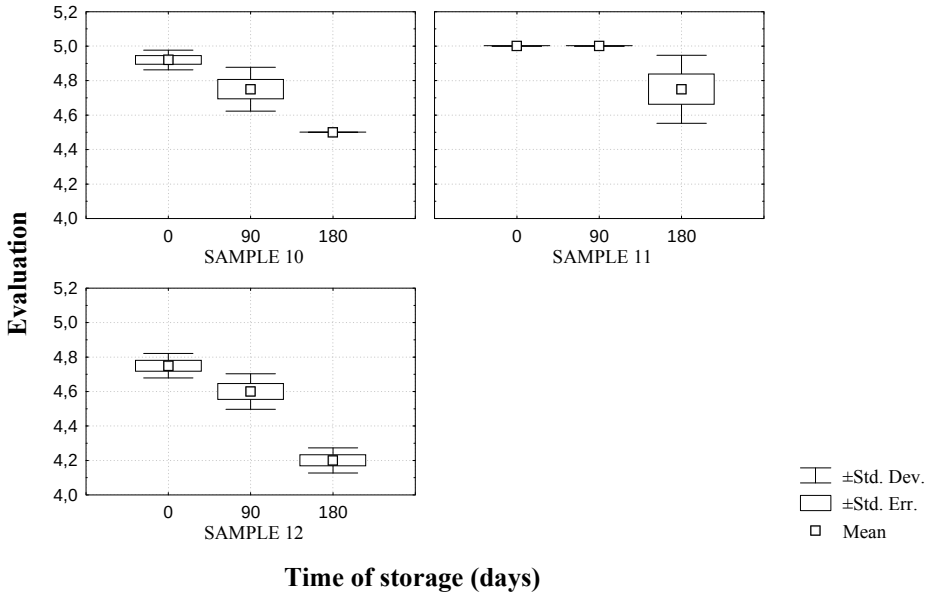


Fig. 32. Box-plots for the average grade of studied sensory properties for the third group of samples-low energy mayonnaise

In case the influence of storage time is not taken into account, all three groups of samples taken together do not differ in analyzed sensory properties. However, as Fig. 32 shows, and the results of tests of the lowest significant difference show that as well, salad mayonnaise is evaluated with statistically better average grade for the appearance and total sensory quality in comparison to delicates mayonnaise ($p=0.015$ and $p=0.018$) due to a far better grade on the 180th day ($p<0.01$). The appearance of salad mayonnaise on the 180th day was evaluated as the better than the appearance of low energy mayonnaise ($p=0.024$), but this had no significant effect to the collective grade. The proportion of grades for colour was almost the same on the 180th day between the samples of salad and delicates mayonnaise ($p=0.020$).

The difference in the evaluated sensory properties appearance and colour of mayonnaise of the studied three groups of mayonnaise was quantified also through the separability coefficient, statistical indicator of separation of groups according to one or more criteria together (Table 9).

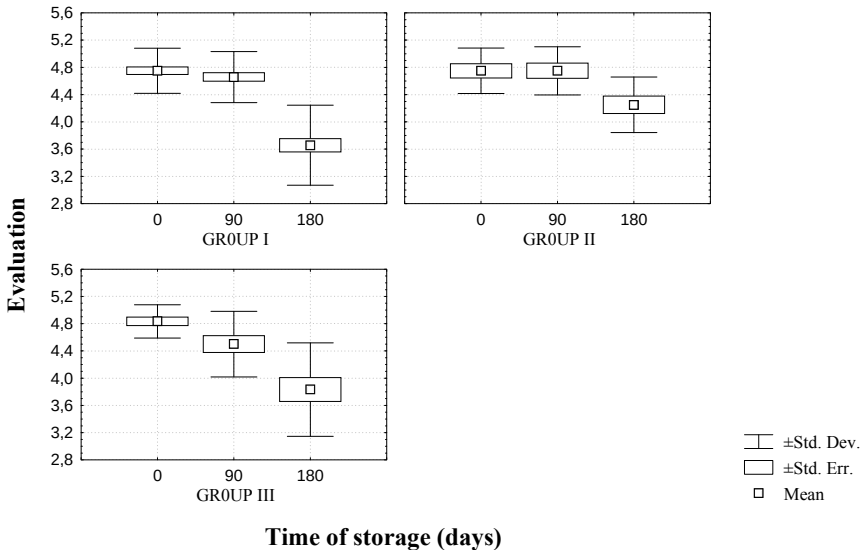


Fig. 33. Box-plots for sensory property of appearance for groups of samples.

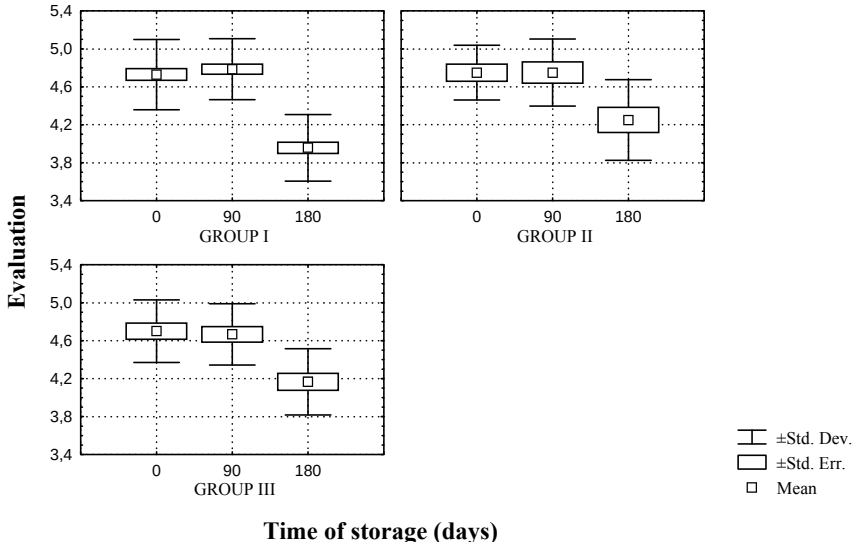


Fig. 34. Box-plots for sensory property colous for groups of samples.

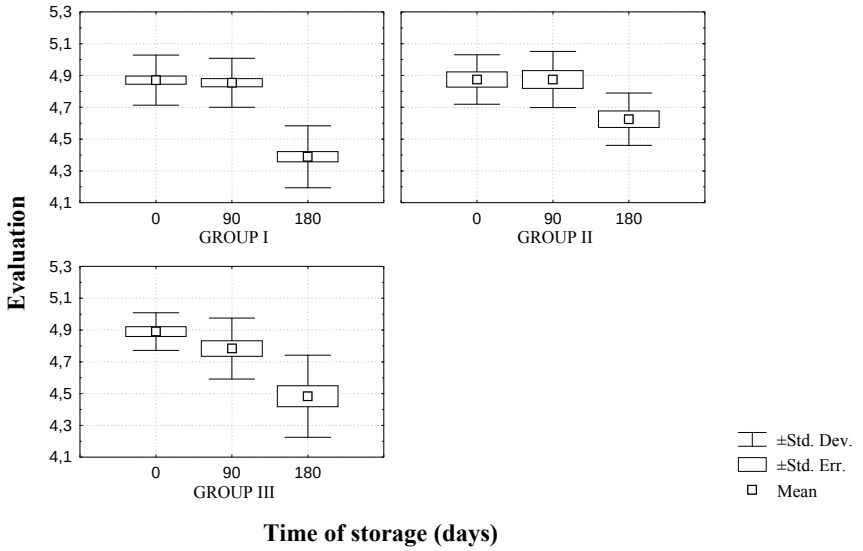


Fig. 35. Box-plots for the weighted grades for groups of samples.

Table 9. Separability coefficients.

Groups of mayonnaise	Sensory property							
	Appearance				Colour			
	Time of storage (days)							
	0	**90**	**180**	**0-180**	**0**	**90**	**180**	**0-180**
Delikates-salad	0.000	0.371	0.902	0.578*	0.086	0.143	0.911	0.224
Delikates-low energy	0.333	0.407	0.268	0.331	0.245	0.455	0.846	0.455
Salad-low energy	0.333	0.600	0.714	0.523	0.333	0.333	0.333	0.333
Delikates-salad-low energy	**0.211**	**0.433**	**0.547**	**0.368**	**0.247**	**0.333**	**0.804**	**0.404**

*Since the products of delicates and salad mayonnaise producers were evaluated as same products at first evaluation, only on the 0th day. This separability coefficient refers to the period of 90 and 180 days

During the sensory evaluation immediately after the production, the appearance and colour of delicates and salad mayonnaise were evaluated as approximately the same. The greatest difference was established after 180 days, for colour (0.911) and for the appearance (0.902), between the samples of delicates and salad mayonnaise. Also, the colour of delicates mayonnaise was evaluated as different in comparison to the colour of low energy mayonnaise (0.846) after 180 days.

During storage, salad mayonnaise differed in the appearance than delicates (0.578) and low energy (0.523) and less in colour (0.224 and 0.333). The groups of samples of delicates and low energy mayonnaise differed more in colour (0.455) than in the appearance (0.331).

The samples of mayonnaise of all three groups of mayonnaise achieved the most uniform appearance and colour immediately after production (0 days), and then the differences increased, and the appearance of mayonnaise differed more after 90 days (0.433) than the colour (0.333), then the differences became more distinctive after 180 days (0.804 versus 0.547).

The separability degree in colour and appearance at the same time for all three categories of mayonnaise was 0.228 on the 0th day, 0.380 on the 90th day and 0.663 on the 180th day, and the average for all three evaluations was 0.386.

4. Conclusions

By instrumental measuring of three groups of delicates, salad and low energy mayonnaise it may be established that the differences in values of the average reflectance Y(%) ("brightness" i.e. "glossiness") during storage up to 180 days were irrelevant and statistically not significant ($p>0.05$).

The contents of edible refined sunflower oil of min. 75 % (delicates mayonnaise) and 30 % (low energy) does not significantly influence the change of the average reflectance – glossiness or brightness of colour – differences are statistically irrelevant ($p>0.05$).

The contents of oil of 50 or 60 % (salad mayonnaise) influences the change of average reflectance Y(%) and the differences are statistically very significant ($p<0.01$).

By applying two-factor variance analysis it has been established that the average grades of sensory properties (appearance and colour), as well as weighted average grade are not statistically different among all three studied types of mayonnaise ($p>0.05$).

If the storage time is extended to 180 days, the average grade for the sensory property appearance becomes significantly reduced, as well as the colour and the average weighted quality of mayonnaise irrespective of type.

The studied properties and their average value have not statistically changed to a great extent from the 0^{th} to the 90^{th} day ($p>0.05$).

Sensory properties, fragrance and taste of all evaluated samples during the whole evaluation period remained unchanged, i.e. evaluated with the maximum grade ($\overline{X}=5.00$).

The grade for the sensory property of appearance and weighted average grade of quality statistically depended on the simultaneous influence of declared contents and the influence of storage up to 180 days ($p<0.01$).

In all evaluated groups of samples, colour remained unchanged during the first 90 days, and with the extension of storage time up to 180 days, the grades were statistically considerably lower which was in correlation with the results of the instrumental determination of characteristics of colour quality.

Interactive influence of two factors: declared contents and time of storage to sensory property colour, was not statistically significant ($p>0.05$).

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Guide for Contributors

Aims and Scope

Sensors & Transducers Journal (ISSN 1726-5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because it is an open access, peer review international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per annual by International Frequency Association (IFSA). In additional, some special sponsored and conference issues published annually. *Sensors & Transducers Journal* is indexed and abstracted very quickly by Chemical Abstracts, IndexCopernicus Journals Master List, Open J-Gate, Google Scholar, etc.

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Contributions are invited on all aspects of research, development and application of the science and technology of sensors, transducers and sensor instrumentations. Topics include, but are not restricted to:

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- Theory, principles, effects, design, standardization and modeling;
- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
- Sensors interfaces, buses and networks;
- Signal processing;
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- Nanosensors;
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