Journal of Agricultural Sciences
Vol. 52, No 1, 2007
Pages 65-74

UDC: 663.918.5
Original scientific paper

DIETARY CHOCOLATE COLOURS DURING THEIR STORAGE UP TO 1 YEAR

Jovanka Popov Raljić[1] and Jovanka Laličić[1]

Abstract: In this work colour quality characteristics of the upper surfaces of commercial dietary chocolates of different manufacturers were investigated. Colour was determined instrumentally, using the threestimulus colorimeter "MINOLTA" Chroma meter CR 400. Results were expressed in CIE, CIELab and Hünter systems, immediately after the production (0 – 30 days and after 90, 180, 270 and 360 days of keeping in storage at the temperature of 15°C. Whitening Index (WI) was also calculated.

On the basis of the obtained results, it could be concluded that all the analysed samples of dietary chocolates had approximately the same colour characteristics qualities (lightness, nuance and colour saturation), having only negligible variations, during keeping and storage at 15°C for up to 1 year.

Key words: dietary chocolates, colour, quality, storage.

I n t r o d u c t io n

Dietary chocolates represent a special kind of the exceptionally high quality chocolates. Their raw materials could be chosen with respect of the in increasing or decreasing energetic values. During the estimation of quality of chocolates, besides determination of chemical and physical parameters, the sensory quality must be evaluated (i.e. appearance – colour, flavour, texture), immediately after the production and during their keeping and storage.

During storage, chocolate surfaces turn greyish, inducing considerable changes of colour, i.e. of lightness, nuance and saturation of colour. Turning grey of chocolate, principally, appears as the result of errors during defined phases of

[1] Jovanka Popov Raljić, PhD, Assistant Professor, Jovanka Laličić, MSc, Trainee Assistant, Faculty of Agriculture, 11081 Belgrade-Zemun, Nemanjina 6, Serbia

technological production processes, such as tempering, forming, cooling, or as the consequence of extremely long storage (Gavrilović, 2003; Hartel et all., 1999; Bricknell and Hartel, 1998; Full et all., 1996; Hachiya et all., 1989).

In the competent literature, opinions were expressed that main causes of turning chocolate grey during storage are induced indeed by temperature fluctuations and inadequate conditions of tempering, inducing migration of fats through the matrix of chocolate particles, followed by their recrystallization on the surfaces. The loss of brilliance and emersion of turning grey are the consequences of dissipation of light on the "clusters" of crystals (Briones and Aguilera, 2005; Aguilera and Mayor, 2004; Lohman and Hartel, 1994; Beckett, 2002).

Brilliance is an important quality parameter of chocolate and it is a key factor in attemperating control (Beckett, 2002). Brilliance is an optical phenomenon connected to the appearance and represents ability of the surface to reflect a direct light (ASTM, 1995).

There exists an opinion that turning grey of chocolate represents the development of a new phase in the fatty phase of the chocolate, which appears as the result of the polymorphous transformations of the fourth crystal form into the fifth, i.e. into the sixth one (Timms, 2003). Therefore, if the chocolate is kept and stored at the temperature below 15°C, it is possible to inhibit these polymorphous transformations (Kayano et all., 1999).

Changes of chocolate surface colours are mainly evaluated sensorily (using visual technique), or by colorimetric or spectrophotometric instrumental methods of measurements (Briones et all., 2005; Gonzales and Woods, 1992; Jovanović and Pajin, 2002; Radovanović and Popov-Raljić, 2000/2001).

Index of whiteness (WI) could be used as one of the parameters for defining the colour quality characteristics (whitening of chocolate surface), which is most probably the consequence of colour change induced by inadequate conditions during equalisation of chocolate temperature, after cooling phase, as well as of the inadequate keeping and storage conditions (Papadakis et all., 2000).

During this work, instrumentally were evaluated colour quality characteristics of commercial samples of dietary chocolates that were kept and stored under controlled conditions of temperature (15°C), and after 0 – 30, 90, 180 270 or 360 days.

Material and Methods

During this work, commercial dietary chocolate samples of different producers (originating from the same producing lots), purchased in one of Belgrade supermarkets, were used. Their main characteristics are summarised in Table 1.

During the 1st month from the declared production time, i.e. in the period of 0 – 30 days, and after 90, 180, 270 and 360 days of keeping and storage at the appropriate room temperature (t = 15°C, colour was instrumentally measured by the threestimulus photoelectric colorimeter "MINOLTA" Chroma meter CR 400, with the light source D, standard viewer 65° and light beam diameter 8 mm. Colour was measured at the three predetermined places of the chocolate upper surface (n = 50).

T a b. 1. - Chocolate samples used for the experiments

Sample No.	Commercial name	Composition	Producer
1	Vollmilch, Lait entier, Full milk - Dietary milk chocolate containing fructose	Fructose, cocoa butter, whole milk powder (19%), cocoa mass, skimmed milk powder, hazelnut paste, emulsifier (lecithin), aroma, Cocoa content al least 35%	Schnee Koppe, Germany
2	Milka, Alpine milk diet, - Dietary milk chocolate containing fructose and inulin	Fructose, cocoa butter, inulin, skimmed milk powder, cocoa mass, milk fat, hazelnut paste, emulsifier (soy lecithin), aroma, table salt. Cocoa parts at least 35%, milk parts at least 14%	Kraft Foods, Austria
3	Pionir -dietary milk chocolate	Fructose, cocoa mass, whole milk powder, cocoa butter, inulin, hazelnut mass, emulsifiers (soy, lecithin, polyglycerol, polyricinoleat), vanillin aroma. Cocoa parts dry basis at least 30%, fat-free dry substance at least 10.5%	Pionir, Suborica, Serbia
4	Dorina-dietary milk chocolate without sugar	Sweetener lactilol (E966) as sugar substitute, cocoa butter, dry milk powder, whey powder, cocoa mass, sugar substitute polydextrose (E1200), hazelnuts, emulsifier lecithin (E322, sweetener aspartame (E1200) vanillin aroma. Cocoa parts at least 32%, milk fat at least 3.65%	Kraš, Croatia
5	Betis-milk chocolate without sugar and with sweetener	Cocoa butter, sweetener (E966), whole milk powder, polydextrose, skimmed milk powder, cocoa mass, emulsifier (E322), sweetener (E951), sweetener (E950), ethyl aniline, aroma. Total dry substance of cocoa parts at least 27%. Total milk dry substances at least 28%; milk fat at least 4%	Soko Štark, Belgrade, Serbia

Results were expressed in CIE system, as average values: Y = average reflectance or brilliance; λ= dominant wavelength (nm), and colour purity Č (%) (*CIE, 1986*).

In CIELab and in Hünter's Systems, results were given as average values: L*, L_{Hu} – psychometer light, a*, a_{Hu} – psychometer tone and b*, b_{Hu} – psychometer chroma (Robertson, 1977; Lukacs, 1985).

Whiteness Index (WI) was calculated according to the equation:

$$WI = 100\left[(100 - L^*)^2 + (a^*)^2 + (b^*)^2\right]^{0.5}$$

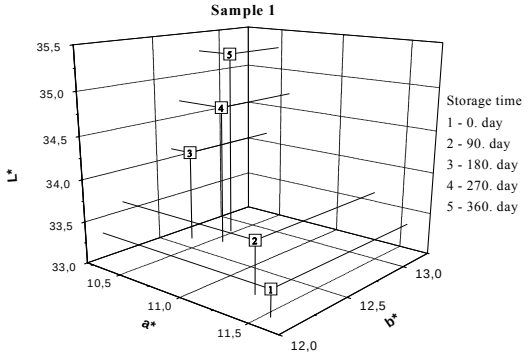
Results and Discussion

In Table 2 are shown average values of instrumental determination of colour of dietary chocolates from different manufacturers. The colour of the upper surface was measured in the period of 1 – 30 days, with respect to the declared date of production, and then after 90, 180, 270 and 360 days of keeping and storage at the temperature of 15°C. Values for psychometric light L*, tone a* and chroma b* are graphically shown (graphs 1, 2, 3, 4 and 5).

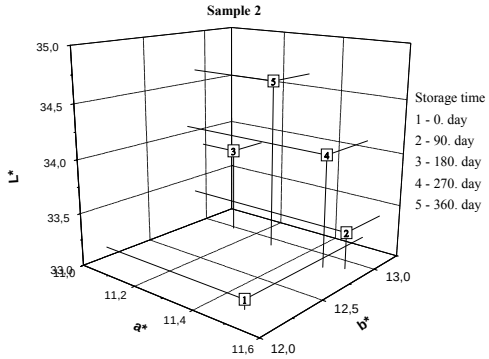
T a b. - 2. - Results of instrumental measurements of of the upper surface colour characteristics of dietary chocolate samples, during their keeping and storage up to 360 days

Sample No.	Duration of keeping and storage (days)	System of defining of colour characteristics quality								
		CIE			CIELab			Hünter		
		Y (%)	λ(nm)	Č (%)	L*	a*	b*	L_{Hu}	a_{Hu}	b_{Hu}
1	0 – 30	7.01	590	29.59	31.83	11.09	11.39	26.47	7.07	6.40
	90	7.06	590	29.59	31.95	10.96	11.23	26.58	7.68	6.34
	180	7.17	590	29.59	32.18	10.75	11.34	26.77	7.54	6.31
	270	7.27	590	29.59	32.41	10.88	11.35	26.96	7.65	6.43
	360	7.34	588	26.32	32.56	10.59	10.64	27.09	7.45	6.10
2	0 – 30	7.98	591	34.00	33.95	13.31	13.70	28.25	9.60	7.70
	90	8.51	591	34.00	35.03	12.97	13.58	29.17	9.43	7.75
	180	8.65	591	34.00	35.29	11.72	13.72	29.40	9.37	7.85
	270	8.68	588	34.74	35.36	11.54	13.88	29.47	9.32	7.93
	360	8.80	588	34.74	35.59	11.63	14.26	29.66	9.55	8.14
3	0 – 30	6.55	591	34.00	30.76	12.22	11.14	25.60	8.52	6.19
	90	6.65	590	29.59	31.00	11.96	10.95	25.79	8.35	6.12
	180	6.82	590	29.59	31.39	11.72	11.01	26.11	8.20	6.18
	270	7.00	590	29.59	31.81	11.54	11.14	26.46	8.10	6.28
	360	7.12	590	29.59	32.07	11.63	11.90	26.68	8.29	6.54
4	0 – 30	7.41	592	35.29	32.74	13.88	13.07	27.21	9.93	7.28
	90	7.50	592	35.29	32.92	14.06	13.54	27.39	10.08	7.52
	180	7.43	592	35.29	32.78	14.06	13.54	27.27	10.07	7.50
	270	7.60	591	34.00	33.14	13.67	13.02	27.57	9.81	7.30
	360	7.91	591	34.00	33.80	12.92	13.43	28.13	9.29	7.56
5	0 – 30	7.98	590	29.59	33.94	11.28	12.26	28.25	8.06	7.01
	90	8.05	590	29.59	34.09	11.13	11.88	28.38	7.96	6.84
	180	8.33	590	29.59	34.67	11.17	12.35	28.87	8.03	7.12
	270	8.42	590	29.59	34.85	11.57	12.88	29.02	8.35	7.40
	360	8.57	590	29.59	35.14	11.59	12.71	29.28	8.38	7.34

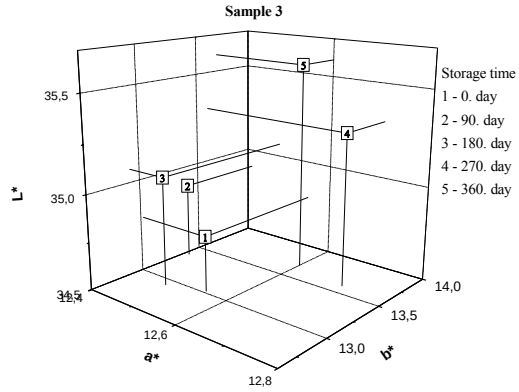
Sample 1: Vollmilch, Schnee Koppe, Germany
Sample 2: Milka, Alpine milk diet, Kraft Foods, Austria
Sample 3: Pionir, Pionir, Subotica, Serbia
Sample 4: Dorina, Kraš, Zagreb, Croatia
Sample 5: Betis, Soko Štark, Belgrade, Serbia



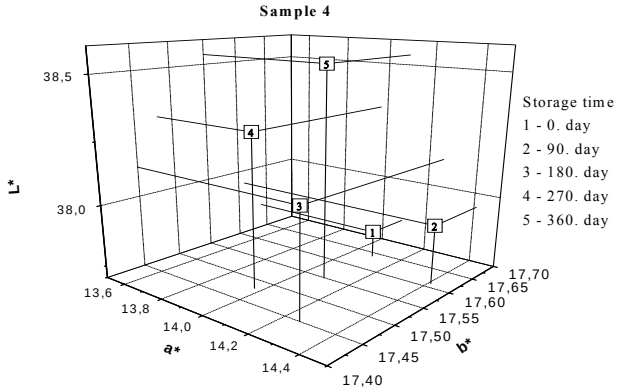
Graph. 1. - Colour quality characteristics in CIELab system on the upper surface of the dietary chocolate during up to 1 year of storage (Sample 1)



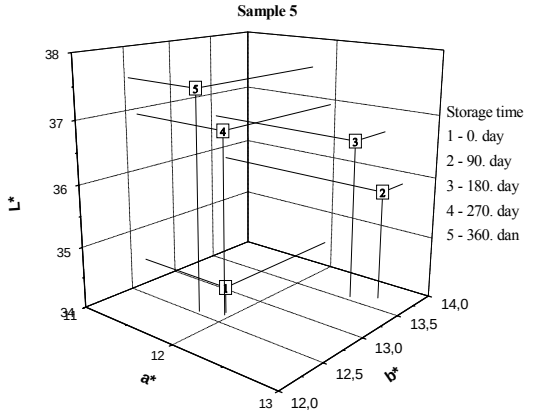
Graph. 2. - Colour quality characteristics in CIELab system on the upper surface of the dietary chocolate during up to 1 year of storage (Sample 2)



Graph. 3. - Colour quality characteristics in CIELab system, on the upper surface of the dietary chocolate during up to 1 year of storage (Sample 3)



Graph. 4. - Colour quality characteristics in CIELab system on the upper surface of the dietary chocolate during up to 1 year of storage (Sample 4)



Graph. 5. - Colour quality characteristics in CIELab system on the upper surface of the dietary chocolate during up to 1 year of storage (Sample 5)

The calculated values of Whiteness indices (WI) of all samples of dietary chocolates, during up to 360 days of keeping and storage at temperature of 15°C, are given in Table 3.

Average reflectance or brilliance of the sample 1 on the upper surface during the period of 0 – 30 days of keeping at 15°C equals Y = 7.01%. During further storage it slightly grows, so that after 360 days of storage equals Y = 7.34%. Similar feature could be also observed for psychometric light in CIELab and in Hünter's system. So, the value of L* i.e. L_{Hu} amounts to 31.83 and 26.47 respectively at the very beginning of examinations, and after 1 year they are L* =32.56, and L_{Hu} = 27.09 (Table 2; graph 1). The observed values for dominant

wavelength during the whole period of keeping and storage were approximately similar, so that values of λ = 590 nm were found for the very 1st measurement, and λ = 388 nm were observed on the 360th day of examination. According to the chromaticity diagram, both these values belong to the same region of spectrum – orange (*CIE, 1986*). During storage, values of psychometric tone (a*) and chroma (b*) decrease. Colour purities (colour saturations) were equalised and up to 270 days of storage were found to be Č = 29.59%, and after 1 year they decreased to Č= 26.32%.

T a b. 3. - Whiteness indexes (WI) of samples of dietary chocolates during keeping and storage of up to 360 days

Duration of keeping and storage (days)	Whiteness index (WI)				
	Sample No.				
	1	2	3	4	5
0 – 30	30.00	31.24	28.81	30.06	31.87
90	30.16	32.37	29.12	30.14	32.11
180	30.40	32.61	29.53	30.00	32.58
270	30.60	32.66	29.95	30.53	32.59
360	30.91	23.75	30.08	31.23	23.90

Sample 1: Vollmilch, Schnee Koppe, Germany
Sample 2: Milka, Alpine milk diet, Kraft Foods, Austria
Sample 3: Pionir, Pionir, Subotica, Serbia
Sample 4: Dorina, Kraš, Zagreb, Croatia
Sample 5: Betis, Soko Štark, Belgrade, Serbia

Based on the obtained results, dietary chocolate sample 2 was, conditionally said, the sample having the lightest colour. Namely, its brilliance was with in the interval between Y = 7.989% and Y = 8.80%, with the lightness values of L* = 33.95 to L* = 35.59 and L_{Hu} = 28.85 to L_{Hu} = 29.66, within keeping for up to 1 year. The just said was also confirmed by the calculated values for dominant wavelengths, which, according to the chromaticity diagram, belong to the yellowish – orange part of the spectrum (λ = 588 nm) (Table 2, graph 2). Psychometric tone (a*) slowly decreased during storage, but the participation of chroma (b*) had been subjected to the inconsiderable growth.

The sample 3 is relatively "the darkest one" according to the colour nuance. Starting from the 0th, and up till the 360th day, values of the average reflectance seem to be the lowest if compared with all other samples of the dietary chocolates analysed, and having values from Y = 6.55% to Y = 7.12% i.e. L* = 30,76 to L* = 32.07 and L_{Hu} = 25.60 to L_{Hu} = 26.68. Psychometric tone (a*) during storage decreases, chroma (b*) slowly grows and colour saturation (λ = 590 ÷ 591 nm) remains approximately the same and belongs to the orange part of the spectrum (Table 2, graph 3).

The analysed samples of dietary chocolates (sample 4) are with respect to the qualities of colour characteristics most similar to sample 1, but samples of "Dorina" chocolate, Kraš, Croatia are a little bit lighter than samples 1. Therefore, it had values of Y = 7.41% in the period from 0th to 30th day, and Y =7.91% after 360 days of storage. Psychometric tone (a*) during keeping and storage decreases from a* =13.88 to a* = 12.92 in the CIELab system, but the values of b* grow (from b* = 13.07 to b* = 13.43). The dominant wavelength is with in the interval λ = 591 - 592 nm, and, based on the chromaticity diagram, it belongs to the orange part of the spectrum (Table 2, graph 4).

The sample 5, dietary chocolate "Betis", Soko Štark, Belgrade, Serbia, is characterised by uniform, i.e. the same values for dominant wavelengths (colour nuance) and purity (colour saturation) during the whole period of keeping and storage at 15°C and up to one year of storage (λ = 590 nm – orange part of the spectrum, Č = 29.59%). Very small variations could be also observed for the calculated values of psychometric tone (a*) and chroma (b*) (Table 2, graph 5). Values for colour lightness amount from L* = 33.94 during the 1st month to L* = 35.14 on the 360th day of storage.

Whiteness index (WI) of different commercial dietary chocolate samples during their keeping and storage and especially after 1 year, grows stightly, which is in agreement with the literature data reported by Bricknell and Hartel, (1988), as well as by Papadakis et all., (2000), and which indicates to the appearance of the greyish- whitish (turned grey) chocolate. However, as the turning grey depends of the microstructure of chocolate formed during the production process and further on, during storage, colour changes, inter alias, are specific for each kind of chocolate (Aguilera et Mayor, 2004).

During keeping and storage of samples of dietary chocolates of different producers at 15°C and up to 1 year, it is possible to confirm claims of particular authors who say that the characteristics of colour quality are primarily influenced by composition, particular phases of technological process of production as well as inappropriate and/or too long storage (Gavrilović, 2003; Hartel et all., 1999; Bricknell and Hartel, 1998; Full et all., 1996; Hachiya et all., 1989). In addition, it could be only supposed that during storage the polymorphous transformations were prevented (Koyano et all., 1990).

Conclusion

For the confectionery industry, turning greyish represents the greatest problem with respect of defining the chocolate quality, after the product leaves factory, and especially if it is kept and stored under the inappropriate conditions. In the present work it was found out that colour changes (lightness, nuance, colour saturation) of the surface of dietary chocolates (estimated instrumentally – CIE, CIELab and Hünter) are insignificant up to 270 days, only if the chocolates (finished products) are kept and stored at the temperature of 15°C.

REFERENCES

1. Gavrilović, M. (2000): Tehnologija konditorskih proizvoda, Faculty of Technology, Novi Sad, Serbia.
2. Hartel, W. R., Bricknell, J., Tietz, R. (1979): Chocolate: Fat Bloom During Storage – the Influence of Structural Elements 53rd PMCA Production Conference, 80 – 90.
3. Bricknell, J., Hartel, W.R. (1998): Relation of Fat Bloom in Chocolate to Polymorphic Transition of Cocoa Butter, JAOCS 11, 1609 – 1615.
4. Full, A. N., Reddy, Y.S., Dimick, S.P., Ziegler, R. G. (1996): Physical and Sensory Properties of Milk Chocolate Formulated with Anhydrous Milk Fat Fractions, Journal of Food Science, 5, 1068 – 1084.
5. Hachiya, J., Koyano, T., Sato, K. (1989): Observation of Seeding Effects on Fat Bloom of Dark Chocolate, Food Microstructure, 8, 257 – 261.
6. Briones, V., Aguilera, J. M. (2005): Image Analysis of Changes in Surface Colour of Chocolate, *Food Research International*, 38, 1, 87 – 94.
7. Aguilera, M., Mayor, G. (2004): Fat Migration in Chocolate: Diffusion or Capillary Flow in a Particulate Solid – A Hypothesis Paper, *Journal of Food Science,* 69, 7, 167 – 174.
8. Lohman, M., Hartel, R. W. (1994): Effect of Milk Fat Fractions on Fat in Dark Chocolate, Journal American Oil Chemistry Society, 71, 3, 267 – 275.
9. Beckett, S. T. (2002): The Science of Chocolate (1st ed.), Cambridge, Royal Society of Chemistry.
10. ASTM, Standard Test Method for Specular Gloss. Designation D 523. In: 1995 Annual Book of ASTM Standards, Volume 6.01: Paint – test for Chemical, Physical and Optical Properties: Appearance, Durability of Non-metallic Materials. Philadelphia: American Society for Testing and Materials (1995).
11. Timms, R. E. (2003): Confectionery Fats Handbook, Properties, Production and Application, The Oil Press, Bridgewater, England.
12. Koyano, T., Hachia, I., Sato, K. (1990): Fat Polymorphism and Crystal Seeding Effect on Fat Bloom Stability of Dark Chocolate, *Food Structure*, 9, 231 – 240.
13. Briones, V., Aguilera, J.M., Brown C. (2006): Effect of surface topography on color and gloss of chocolate samples, Journal of Food Engineering, 77, 776 – 783.
14. Gonzales, R. C., Woods, R. E. (1992): Digital Image Processing (pp. 282 – 325) (2nd ed.), Boston, MA: Addison – Wesley Longman Publishing Co. Inc.
15. Jovanović, O., Pajin, B. (2002): Sensory and Instrumental Evaluation of Physical Characteristics, APTEFF, 33, 1 – 174, 19 – 25.
16. Radovanović, R., Popov-Raljić J. (2000): Senzorna analiza prehrambenih proizvoda, Belgrade.
17. Papadakis, S., Abdul-Malek, R. E., Kamden, K., Yam, L. (2000): Versatile and Inexpensive Technique for Measuring Colour of Foods, *Food Technology*, 54, 12, 48 – 51.
18. CIE, Colorimetry (2nd ed.). Publication CIE No. 15.2, Vienna: Central Bureau of the Commission Internationale de L'Ectarge. (1986).
19. Robertson, A. R. (1977): The CIE 1976 Colour Difference Formulae, *Colour Research Applied*, 2, 7 – 11.
20. Lukács, Gy. (1985): Hungarian Scientific Instruments (1).

Received May 24, 2007
Accepted July 16, 2007

BOJA DIJETETSKIH ČOKOLADA TOKOM SKLADŠTENJA DO GODINU DANA

Jovanka Popov Raljić[1] I Jovanka Laličić[1]

R e z i m e

U ovom radu su ispitane karakteristike kvaliteta boje gornje površine komercijalnih dijetetskih čokolada, različitih proizvođača. Boja je određena instrumentalno, na fotoelektričnom tristimulusnom kolorimetru "MINOLTA", Chroma meter, CR 400. Rezultati su izraženi u CIE, CIE Lab i Hünter-ovom sistemu i to odmah nakon proizvodnje (0-30 dana), posle 90, 180, 270 i 360 dana čuvanja i skladištenja, pri temperaturi do 15°C. Izračunata je vrednost indeksa beline (WI).

Na osnovu dobijenih rezultata možemo zakjlučiti da su svi analizirani uzorci dijetetskih čokolada približno istih karakteristika kvaliteta boje (svetloća, nijansa, zasićenost), uz blaga, neznatna odstupanja, a tokom čuvanja i skladištenja na temperaturi do 15°C do godinu dana.

Primljeno 24. maja 2007.
Odobreno16. jula 2007.

[1] Dr Jovanka Popov Raljić, vanredni profesor, mr Jovanka Laličić, asistent, Poljoprivredni fakultet, 11081 Beograd-Zemun, Nemanjina 6, Srbija