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Color stability of dental temporary composite materials assessed *in vitro*

Ocena *in vitro* stabilności koloru stomatologicznych tymczasowych materiałów kompozytowych

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Abstract

Aim of the study. The purpose of this study was to evaluate color stability of temporary prosthetic materials to staining drinks, including tea, coffee and blackcurrant juice, and distilled water.

Material and methods. Color was assessed using a reflection spectrophotometer according to the CIELAB color scale, using two illuminants: D65 (daylight) and A (incandescent bulb).

Results. Luxatemp, Dentalon plus, Structur 2 SC, Prottemp II, and Zhermacryl STC exhibited poor color stability, becoming generally darker ($\Delta L < 0$) and yellower ($\Delta b^* > 0$), with Luxatemp and Dentalon plus being less prone to discoloration than the others.

Conclusions. Temporary prosthetic materials may suffer strong discoloration ($\Delta E > 6.0$) upon prolonged exposure to potentially staining beverages, and some of them even upon soaking in distilled water.

Key words: Colour stability, Dental materials, Prosthetic materials, Staining beverages; pH effect; Illuminant effect.

Streszczenie

Cel pracy. Celem tego badania była ocena stabilności koloru tymczasowych materiałów protetycznych w środowisku wody destylowanej, a także napojów o właściwościach barwiących, takich jak herbata, kawa, sok z czarnej porzeczki.

Materiał i metody. Kolor był oceniany przy użyciu spektrofotometru w oparciu o skalę CIELAB z użyciem dwóch rodzajów źródeł światła: D65 (światło dzienne) oraz A (światło sztuczne).

Wyniki. Luxatemp, Dentalon Plus, Structur 2SC, Prottemp II i Zhermacryl STC wykazały słabą trwałość koloru stając się ciemniejsze ($\Delta L < 0$) i żółtawe ($\Delta b^* > 0$), przy czym Luxatemp i Dentalon plus były mniej podatne na przebarwienia niż pozostałe materiały.

Wnioski. Tymczasowe materiały protetyczne mogą ulegać silnemu przebarwieniu ($\Delta E > 6.0$) pod wpływem długotrwałego działania potencjalnie przebarwiających płynów, a niektóre z nich nawet w kontakcie z wodą destylowaną.

Słowa kluczowe: stabilność koloru, materiały protetyczne, płyny przebarwiające; wpływ pH, wpływ oświetlenia.

Introduction

Smiling is one of the first interactions between human beings able to play a decisive role in their future relations. One of the objectives of aesthetics in dentistry is to create artificial dentition that looks as real as natural. The aesthetics of any restoration needs to consider the color, its stability and harmony with the gingivae, lips, and face of the patient. Modern dentistry needs to meet the patients' and dentists' demand not only for a healthy mouth but also for a perfect smile, with the emphasis on the perfect look. Discoloration of dental materials may be caused by intrinsic and extrinsic factors.

The intrinsic factors include chemical changes of the resin material itself. Extrinsic factors include staining by adsorption and absorption of colorants.

The objective study of color of materials used in dentistry was initiated by Yamamoto in the 1980s [1, 2]. With the growing importance of the aesthetic aspect of dentistry, international organizations dealing with colorimetry, such as CIE (Commission Internationale de l'Eclairage) in Europe and NBS (National Bureau of Standards) in the USA have introduced a number of norms, modified and unified the CIE Lab system.

In the CIE Lab system the color is described in terms of the L^* , a^* , b^* coordinates. It is assumed that a change in each of these coordinates by a unit is a threshold of color difference perception by an average, although trained, observer. According to CIE Lab the threshold value of color perception or color difference is $\Delta E = \sqrt{3} \approx 1.7$ in the space of the coordinates L^* , a^* , b^* . In recent publications the threshold of color difference perception is variously defined in the range from $\Delta E = 1$ to $\Delta E = 3.7$. Knispel and Tung have defined this threshold as $\Delta E = 1 \div 2$. Haselton has suggested that $\Delta E = 3.7$, whereas Kolbeck assumed it as $\Delta E = 1.5$ [3, 4, 5, 6]. According to some other researchers the threshold is $\Delta E = 1$. However, many authors disregard the problem of the absolute threshold of color difference perception and deal only with the maximum color difference accepted in dentistry [7, 8, 9]. Guan and Tung assume that the maximum color difference accepted in dental materials is $\Delta E = 2$, while others claim that this value is $\Delta E = 3.3$ [4, 8, 10, 11].

According to some more liberal approaches to this problem, this value is $\Delta E = 3.5$ as in the work by Reich or even $\Delta E = 3.7$ as in the works by Guler and Haselton [5, 12, 13, 14]. So far, the studies of color stability of prosthetic materials have concerned several aspects. The first was to check the color agreement between the color keys used in dentistry and new dentist materials to find the best match [7, 10, 15]. Another subject of study has been to evaluate the effect of potentially discoloring diet elements (such as tea, coffee and red wine) on the color of prosthetic materials. This subject has been treated, among others, by Moon Um, Kolbeck, Villalta, Haselton, and Guler [5, 6, 9, 14, 16]. The general outcome of their works has been that the largest color difference was caused by exposure to red wine, irrespective of the type of prosthetic material studied, while coffee and tea lead to a similar and lower degree of discoloration. Moon Um, Janda, and Villalta in their study of the color difference caused by exposure to coffee, tea, and red wine have investigated the effect of distilled water [8, 9, 16]. They have proved that statistically significant changes in the color of composite and ceramic dental materials result from their hydration. The latter process has been found to produce a decrease in lightness, and an increase in yellow and in red coloring. According to the above authors, coffee and tea produce a greater discoloration effect than distilled water, with the difference between the two being statistically significant, while red wine produces a discoloration different from that caused by coffee or tea, with an increased contribution of blue and green.

Another aspect of the studies of the color stability of dental materials was the evaluation of the effect of visible and ultraviolet light on the dental

reconstruction materials. The materials were exposed to xenon and mercury lamps characterized by considerable ultraviolet emission, for the minimum time of 100 hours, because of the weakness of the effects produced. Janda studied the color of composite materials exposed to the xenon lamp radiation, while Ertan studied ceramic materials made by Empress. The authors have shown a statistically significant effect of the irradiation on the color difference of the materials studied.

In 2005, Lee for the first time evaluated and described the differences in the colors of the dental color key produced by Vita Lumin upon different illuminations: with electric bulb light (type A), daylight (type D65) and cold neon light (type F2) [17]. He proved that the variations in color parameters of the key samples strongly depend on the type of illumination.

Simple non-parametrical tests for independent and dependent samples have been the most popular statistical tools for the evaluation of results, i.e. the U-Mann-Whitney and Wilcoxon tests [6, 12, 16]. In recent works some authors used the variance analysis to detect the interactions among different factors affecting the color of the samples. Villalta, and Haselton et al. have also used the post-hoc tests, mainly the Scheffe test and the Tukey test, and the linear regression [5, 8, 14, 16, 17, 18, 19, 20].

The objective of the present study was to investigate the color stability of a series of temporary prosthetic dental materials under the influence of potentially staining drinks, and to evaluate the effect of pH on their color stability, and the effect of the illuminant on the magnitude of the color change measured.

Experimental

Materials

The study was performed on temporary prosthetic dental materials designed for short-term use in oral cavity conditions. These included: Luxatemp (DMG – Germany), chemically cured binary bis-acryl composite, for temporary crowns and bridges, color symbol A3.5; Structur 2 SC (VOCO – Germany), cold-polymerizing composite, Bis-GMA system, for temporary crowns, bridges and inlay/onlay inserts, color symbol U – universal, color symbol – A3; Protemp II (3M ESPE – Germany), ternary composite based on metacrylate esters, Bis-GMA system (glycidil methacrylate) Bisphenol-A type, color symbol A3; Zhermacryl STC (Zhermapol – Poland), cold-polymerizing polymetacrylate composite for temporary crowns and bridges and for repair of crowns and bridges faced with acryl, color M – medium, color symbol – A3; Dentalon plus (Heraeus Kulzer – Germany), cold-polymerizing polymetacrylane for temporary crowns and bridges, color M – medium, color symbol – A3.

Twelve disc-shape samples were made of each of the materials studied using a specially prepared transparent plastic mold. All the samples were produced in licensed dental laboratories strictly following the procedure and technological requirements. The diameter of the disc samples was 5 mm and they were 1.5 mm thick. The total number of samples studied was 60, 12 representing each of the materials studied.

Standardization of the samples

The surfaces of all samples were carefully polished with fine-grain sand-paper PAP 201 – 1000. In order to eliminate the non-uniform samples, each sample was examined under an optical microscope at 400x magnification prior to tests. The samples were stored at room temperature and about 75% humidity in a dark place.

Standardization of the experimental fluids

To study the discoloration, the solutions of coffee, tea and blackcurrant juice were used. Doubly distilled water was used to prepare the solutions and for comparison. Liquid I was a solution of coffee made of a classical Jacobs Monarch brand in a pressure espresso, the dosage was 60 g of coffee per 1 liter of staining solution. Liquid II was a solution of black English Tetley tea in leaf; the dosage was 10g per 1 liter of water. The tea was brewed at about 95°C for 5 minutes, and then the cooled solution was filtered through a tissue. Liquid III was a popular and commonly available blackcurrant juice made by Hortex, Poland.

The pH of the solutions was measured and controlled by a microcomputer pH-meter CP551 (Elmetron), with a measuring electrode and a thermometer; pH adjustments were made by adding citric acid or sodium hydroxide, as required. The instrument was calibrated using standard buffer solutions prior to each series of measurements.

Measurements

Color and spectral reflectance at the baseline and after staining were measured according to the CIE-LAB color scale relative to the standard illuminant D65 (daylight) and A (electric bulb light) on a reflection spectrophotometer. The first measurements were made 72h after the sample preparation and before staining. Three samples of each material were placed in each experimental solution (coffee, tea, blackcurrant juice) and in doubly distilled water. Subsequent color measurements were made after the exposition times of: 0.5h, 2h, 5h, 15h, 30h, and 60h. After each period of exposition, the samples were rinsed three times with doubly distilled water and left to dry for 1.5h at room temperature. Dried samples were subjected to spectrophotometric measurements. After the measurements the samples were immersed in the experimental solutions for the following period of exposure. The

samples were brushed with a Brown, Professional care 7500 Centre OC 17545X electric toothbrush after 60h of immersion in the staining solutions. Each surface of each sample was brushed with doubly distilled water for 10s using the force of 0.5N directed normally to the sample surface and the color of the samples was examined once again after the brushing.

Results

The changes in the color parameters ΔL^* , Δa^* , Δb^* and the color difference ΔE determined for the samples studied are presented in the subsequent tables. The colors (shades) of the table cells correspond to the degree of color change under the influence of a given liquid at a certain pH and for 60 hours of the exposure time.

The following criteria of the color difference perception were assumed: the imperceptible difference was that below 1.7 units in the L^* , a^* , b^* space of CIE, the slightly perceptible difference was that between 1.7 and 3.0 units, the clearly perceptible difference was between 3.0 and 6.0 units, and the pronounced difference was that exceeding 6.0 units.

The color differences determined for the materials studied are collected in the Tables given below. The following changes were measured: changes in lightness, ΔL^* , evaluated in the light of illuminant A and in the light of illuminant D65 – the data presented in table 1. The changes in the color parameters Δa^* and Δb^* in the light of illuminant A are presented in table 2, while the same in the light of illuminant D65 are presented in table 3. Finally, the changes in the total color ΔE in the light of illuminant A and illuminant D65 are presented in table 4.

Discussion

Protemp

Pronounced changes in the lightness, $\Delta L^* > 6.0$, were observed for the samples immersed in juice and tea at pH 4 and 6, respectively. Clearly perceptible changes were noted for the samples immersed in coffee at pH 4 and juice at pH 8. This material seems to be the most resistant to coffee. The changes were imperceptible for the samples immersed in distilled water, $\Delta L^* < 1.7$. An increase in the red component was pronounced for the samples immersed in blackcurrant juice at pH 4, $\Delta a^* > 3.0$, while in the other samples this increase did not exceed $\Delta a^* = 3$. A pronounced increase in the yellow component Δb^* was noted for the samples immersed in coffee and tea at pH = 4, clearly perceptible changes $3 < \Delta b^* < 6$ were found in the samples immersed in coffee and tea at pH 6 and 8, respectively, being imperceptible for the samples soaked in distilled water. For the samples immersed in blackcurrant juice for 60h the increase

in the yellow component was below the level still acceptable in dentistry, $\Delta b^* < 3$. Change in the total color was the greatest ($\Delta E > 6$) for the samples immersed in juice at pH 4 and 6, tea at pH 4, 6, and 8, and coffee at pH = 4. For the other samples the changes were clearly perceptible ($3 < \Delta E < 6$), being imperceptible for those subject to distilled water, $\Delta E < 1.7$.

As a representative example, the respective variations of lightness and color parameters for Protemp are presented in Figure 1 and 2, shown

respectively for the illuminants A and D65. The Figures clearly indicate the effect of the immersion time and pH on all of the parameters evaluated, along with the effect of the illuminant.

Zhermacryl

Pronounced changes in lightness, $\Delta L > 6.0$, were observed for the samples immersed in juice at pH 4 and 6. The changes were clearly perceptible in the other samples except in those exposed to coffee at pH 6 and 8, where the changes were imper-

Table 1. Changes in the lightness L^* of materials studied after 60 h of immersion in a given liquid in the light of illuminant A and illuminant D65

Tabela 1. Zmiany w jasności L^* badanych materiałów po 60 godz. zanurzenia w danym płynie, w świetle iluminantów D65 i A

		illuminant A					illuminant D65						
		Protemp	Zhermacryl	Dentalon	Luxatemp	Structur			Protemp	Zhermacryl	Dentalon	Luxatemp	Structur
		ΔL^*	ΔL^*	ΔL^*	ΔL^*	ΔL^*			ΔL^*	ΔL^*	ΔL^*	ΔL^*	ΔL^*
Juice	H ₂ O	-0.45	-3.59	-0.41	-2.83	-2.52	Juice	H ₂ O	-0.57	-3.73	-0.53	-2.94	-2.36
	pH4	-6.76	-9.86	-8.19	-5.74	-10.23		pH4	-7.24	-10.22	-8.37	-5.96	-10.71
	pH6	-5.97	-6.09	-7.73	-7.14	-9.62		pH6	-6.14	-6.21	-7.84	-7.39	-9.86
	pH8	-3.55	-5.04	-5.26	-4.67	-5.06		pH8	-3.62	-5.17	-5.30	-4.87	-5.32
Coffee	H ₂ O	-0.44	-3.69	-0.47	-2.65	-2.49	Coffee	H ₂ O	-0.55	-3.72	-0.61	-2.78	-2.63
	pH4	-3.25	-3.49	-2.09	-6.35	-14.52		pH4	-3.69	-3.85	-2.34	-6.72	-15.19
	pH6	-1.22	-1.41	-5.21	-4.53	-10.94		pH6	-1.51	-1.72	-5.43	-4.76	-11.54
	pH8	-1.03	-1.54	-2.79	-6.65	-9.80		pH8	-1.38	-1.69	-2.91	-6.97	-10.36
Tea	H ₂ O	-0.58	-3.79	-0.43	-2.75	-2.40	Tea	H ₂ O	-0.59	-3.90	-0.57	-2.85	-2.56
	pH4	-8.82	-4.49	-6.32	-3.54	-5.40		pH4	-9.46	-5.11	-6.61	-3.92	-6.09
	pH6	-7.16	-5.96	-4.76	-5.10	-1.96		pH6	-7.58	-6.51	-4.99	-5.61	-2.40
	pH8	-5.74	-5.75	-4.89	-4.28	-4.64		pH8	-6.02	-6.11	-5.06	-4.59	-5.02

- Pronounced difference, $|\Delta L| > 6.0$
- Clearly perceptible difference, $3 < |\Delta L| < 6.0$
- Slightly perceptible difference, $1.7 < |\Delta L| < 3.0$
- Imperceptible difference, $|\Delta L| < 1.7$

Table 2. Changes in the color parameters a^* and b^* of materials studied after 60 h of immersion in a liquid in the light of illuminant A and illuminant D65

Tabela 2. Zmiany parametrów koloru a^* i b^* ocenianych materiałów po 60 godz. zanurzenia w płynach, w świetle iluminantów D65 i A

		Protemp	Zhermacryl	Dentalon	Luxatemp	Structur	Protemp	Zhermacryl	Dentalon	Luxatemp	Structur
		Δa^*	Δa^*	Δa^*	Δa^*	Δa^*	Δb^*	Δb^*	Δb^*	Δb^*	Δb^*
Juice	H ₂ O	0.66	0.85	1.07	1.17	0.81	1.32	1.72	1.37	3.29	2.45
	pH4	4.91	2.93	1.75	1.73	3.81	3.33	3.32	1.25	2.38	4.98
	pH6	1.25	0.87	1.47	1.61	2.29	2.10	1.48	0.39	3.74	3.37
	pH8	0.60	0.80	0.21	0.97	1.55	0.72	1.73	0.95	3.31	3.75
Coffee	H ₂ O	0.69	0.94	0.08	1.13	0.73	1.41	1.62	1.43	3.40	2.15
	pH4	2.43	2.12	1.39	1.87	3.27	6.50	5.00	3.79	6.00	11.49
	pH6	1.57	1.60	1.05	1.20	2.95	4.31	3.63	4.01	3.81	10.07
	pH8	2.53	0.87	0.61	1.52	3.10	4.37	2.22	2.06	5.39	8.48
Tea	H ₂ O	0.64	0.58	1.01	1.10	0.83	1.25	1.58	1.40	3.33	2.23
	pH4	3.93	3.91	1.95	2.02	3.97	8.48	8.16	3.80	5.81	10.45
	pH6	2.64	3.67	1.76	2.83	2.66	5.86	6.94	2.40	7.88	6.20
	pH8	1.78	3.89	1.19	1.68	2.05	3.71	0.73	2.24	5.11	5.85

- Pronounced difference, $(|\Delta a^*| \text{ or } |\Delta b^*|) > 6.0$
- Clearly perceptible difference, $3.0 < (|\Delta a^*| \text{ or } |\Delta b^*|) < 6.0$
- Slightly perceptible difference, $1.7 < (|\Delta a^*| \text{ or } |\Delta b^*|) < 3.0$
- Imperceptible difference, $(|\Delta a^*| \text{ or } |\Delta b^*|) < 1.7$

Table 3. Changes in the color parameters a^* and b^* of materials studied after 60 h of immersion in a given liquid in the light of illuminant A and illuminant D65**Tabela 3.** Zmiany parametrów koloru a^* i b^* ocenianych materiałów po 60 godz. zanurzenia w płynach, w świetle iluminantu D65

		Protemp	Zhermacryl	Dentalon	Luxatemp	Structur	Protemp	Zhermacryl	Dentalon	Luxatemp	Structur
		Δa^*	Δa^*	Δa^*	Δa^*	Δa^*	Δb^*	Δb^*	Δb^*	Δb^*	Δb^*
Juice	H ₂ O	0.15	0.15	0.55	0.06	0.15	1.26	1.60	1.15	3.20	2.39
	pH4	3.34	1.89	1.27	0.79	1.97	2.66	2.84	1.00	2.19	4.46
	pH6	0.43	0.34	0.95	0.31	0.39	2.01	1.41	0.27	3.60	3.31
	pH8	0.26	0.28	-0.10	-0.04	0.32	0.69	1.65	1.00	3.22	3.57
Coffee	H ₂ O	0.19	0.16	0.64	0.05	0.05	1.29	1.58	1.27	3.16	2.08
	pH4	0.62	0.86	0.46	0.10	0.13	6.18	4.68	3.63	5.84	11.18
	pH6	0.33	0.98	0.08	0.03	0.07	4.11	3.28	3.91	3.73	9.82
	pH8	1.01	0.27	0.08	-0.09	0.70	4.08	2.08	2.01	5.27	8.07
Tea	H ₂ O	0.14	0.14	0.46	0.04	0.16	1.22	1.54	1.25	3.19	2.12
	pH4	1.64	1.88	0.87	0.24	0.84	7.91	7.54	3.61	5.63	10.07
	pH6	0.76	1.88	1.02	0.44	0.81	5.57	6.37	2.19	7.61	5.93
	pH8	0.61	3.45	0.48	0.01	0.31	3.53	0.25	2.16	5.03	5.68

Pronounced difference, $(|\Delta a^*| \text{ or } |\Delta b^*|) > 6.0$

Clearly perceptible difference, $3.0 < (|\Delta a^*| \text{ or } |\Delta b^*|) < 6.0$

Slightly perceptible difference, $1.7 < (|\Delta a^*| \text{ or } |\Delta b^*|) < 3.0$

Imperceptible difference, $(|\Delta a^*| \text{ or } |\Delta b^*|) < 1.7$

Table 4. Color difference E of materials studied after 60 h of immersion in a given liquid in the light of illuminant A and illuminant D65**Tabela 4.** Różnice kolorów badanych materiałów po 60 godz. umieszczenia w płynach, w świetle iluminantu A i D65

		illuminant A					illuminant D65						
		Protemp	Zhermacryl	Dentalon	Luxatemp	Structur			Protemp	Zhermacryl	Dentalon	Luxatemp	Structur
		ΔE	ΔE	ΔE	ΔE	ΔE			ΔE	ΔE	ΔE	ΔE	ΔE
Juice	H ₂ O	1.54	4.07	1.79	4.49	3.60	Juice	H ₂ O	1.49	4.08	1.65	5.89	3.75
	pH4	8.99	10.81	8.46	6.45	11.99		pH4	8.41	10.78	8.53	6.40	11.77
	pH6	6.45	6.33	7.87	8.22	10.44		pH6	6.47	6.37	7.90	8.23	10.41
	pH8	3.68	5.39	5.35	5.81	6.48		pH8	3.70	5.43	5.40	5.83	6.41
Coffee	H ₂ O	1.63	4.14	1.85	4.46	3.37	Coffee	H ₂ O	1.44	4.15	1.55	4.89	3.35
	pH4	7.66	6.45	4.55	8.93	18.80		pH4	7.22	6.12	4.34	8.90	18.86
	pH6	4.75	4.21	6.66	6.04	15.16		pH6	4.39	3.83	6.69	6.04	15.15
	pH8	5.16	2.84	3.52	8.70	13.32		pH8	4.42	2.70	3.54	8.74	13.15
Tea	H ₂ O	1.52	4.15	1.78	4.46	3.38	Tea	H ₂ O	1.37	4.20	1.45	4.28	3.32
	pH4	12.85	10.10	7.63	7.10	12.42		pH4	12.44	9.30	7.58	6.87	11.80
	pH6	9.62	9.85	5.61	9.80	7.03		pH6	9.44	9.31	5.54	9.48	6.45
	pH8	7.06	6.98	5.61	6.88	7.74		pH8	7.00	7.02	5.53	6.81	7.59

Pronounced difference, $|\Delta E| > 6.0$

Clearly perceptible difference, $3.0 < |\Delta E| < 6.0$

Slightly perceptible difference, $1.7 < |\Delta E| < 3.0$

Imperceptible difference, $|\Delta E| < 1.7$

ceptible, $\Delta L < 1.7$. The increase in the red component was above the level acceptable in dentistry, $\Delta a^* > 3$, for the samples exposed to tea at pH 4, 6, and 8, being imperceptible for those exposed to distilled water. A pronounced increase in the yellow component was observed for the samples exposed to tea at pH 4 and 6, $\Delta b^* > 6$, clearly perceptible changes appeared for the samples immersed in coffee at pH 4 and 6, being imperceptible in distilled water, $\Delta b^* < 1.7$. The changes in ΔE were pronounced ($\Delta E > 6$) for the samples exposed to juice at pH 4 and 6, tea at pH 4, 6, and 8, and coffee at pH = 4, being slightly per-

ceptible in samples exposed to coffee at pH = 8. The changes were clearly perceptible in the other samples ($3 < \Delta E < 6$).

Dentalon

The changes in lightness were pronounced, $\Delta L^* > 6$, in the samples exposed to juice at pH 4 and 6, and tea at pH 4, slightly perceptible ($\Delta L < 3$) in those exposed to coffee at pH 4 and 8. The changes were clearly perceptible ($3 < \Delta L^* < 6$) in the other samples, being imperceptible in those immersed in distilled water ($\Delta L^* < 1.7$). The increase in the red component was imperceptible for the majority

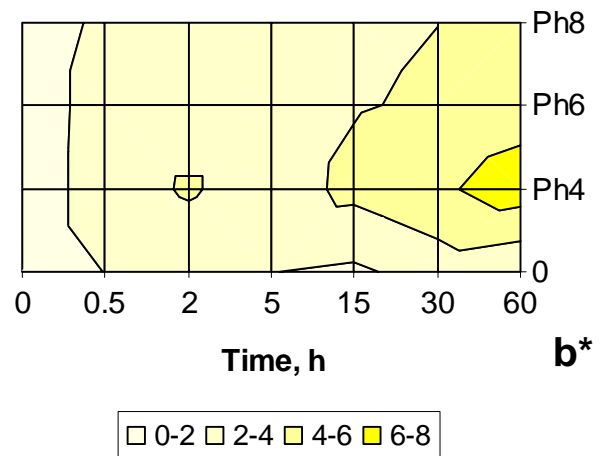
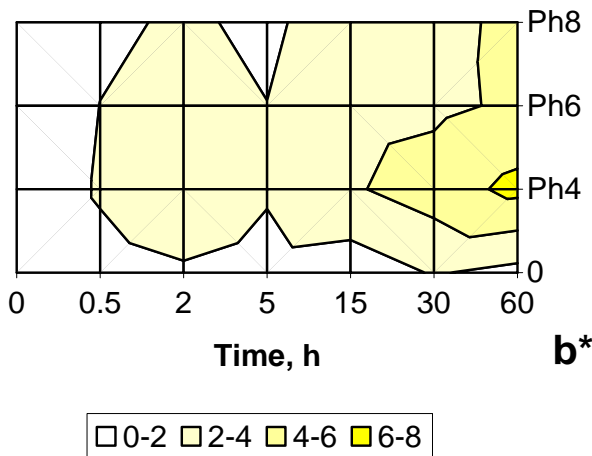
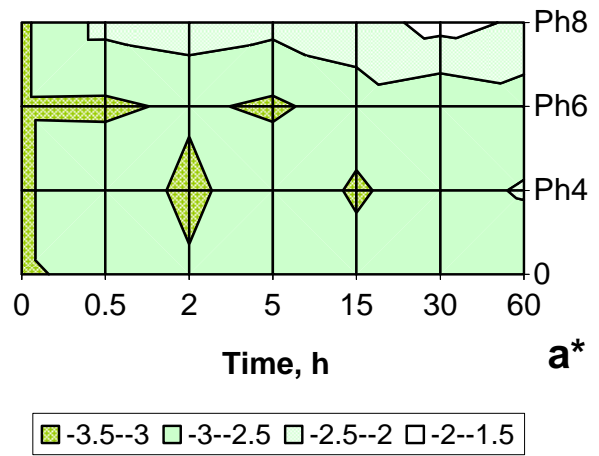
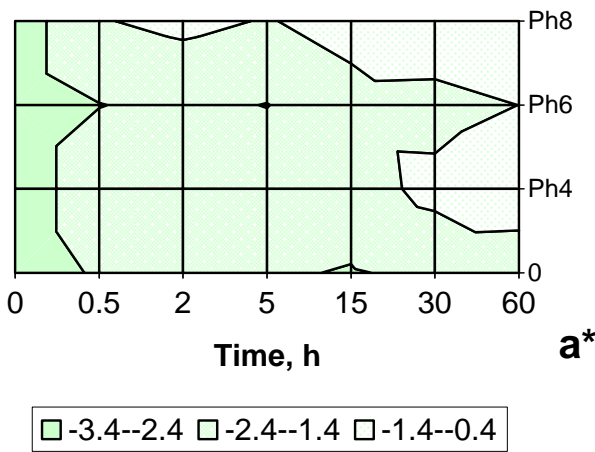
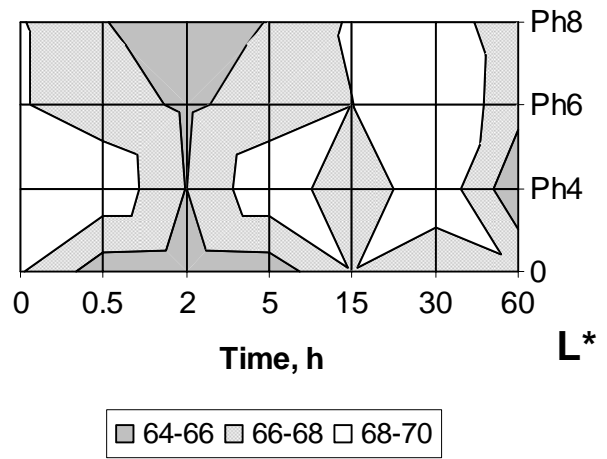
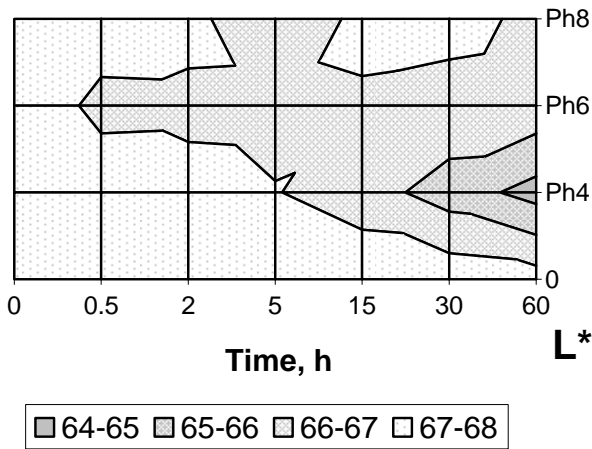


Figure 1. Changes in the lightness L^* and in the color parameters a^* and b^* of Proteмп studied before and after immersion in coffee, as a function of time and pH – illuminant A

Rycina 1. Zmiany w jasności L^* i parametrach koloru a^* oraz b^* materiału Proteмп przed i po zanurzeniu w kawie, w funkcji czasu i pH – iluminant A

Figure 2. Changes in the lightness L^* and in the color parameters a^* and b^* of Proteмп studied before and after immersion in coffee, as a function of time and pH – illuminant D65

Rycina 2. Zmiany w jasności L^* i parametrach koloru a^* oraz b^* materiału Proteмп przed i po zanurzeniu w kawie, w funkcji czasu i pH – iluminant D65

of samples ($\Delta a^* < 1.7$). The increase in the yellow component was clearly perceptible ($\Delta b^* > 3$) in the samples immersed in coffee at pH 4 and 6, and in tea at pH = 4. The changes were slightly perceptible, at most, in the other samples. Pronounced total color change ($\Delta E > 6$) was noted for the samples exposed to juice at pH 4 and 6, coffee at pH 6, and tea at pH = 4. The changes in samples immersed into distilled water were imperceptible under illuminant D65 and slightly perceptible under illuminant A.

Luxatemp

Pronounced changes ($\Delta L > 6$) were observed in the samples exposed to juice at pH 6, and coffee at pH 4 and 8, with the changes being slightly perceptible ($1.7 < \Delta L < 3$) in distilled water, and clearly perceptible in other conditions ($3 < \Delta L < 6$). The increase in the red component a^* was imperceptible under illuminant D65 and slightly perceptible under illuminant A in the samples subject to tea at pH 4 and 6. The increase in the yellow component b^* was pronounced in the sample exposed to tea at pH 6, and clearly perceptible in all of the other samples ($\Delta b^* > 3$). The total color changes were pronounced in almost all of the samples ($\Delta E > 6$), being clearly perceptible even in distilled water ($3 < \Delta E < 6$).

Structur

Pronounced changes in the lightness $\Delta L^* > 6$ were observed in the samples exposed to coffee at all pH considered, to juice at pH 4 and 6, and to tea at pH 4. The changes were slightly perceptible ($1.7 < \Delta L^* < 3$) in distilled water. The increase in the red component was significantly greater under illuminant A as compared to illuminant D65, $\Delta a^* > 3$ for the samples exposed to all liquids at pH 4 in illuminant A. Here the increase in the yellow component was the strongest of all the materials studied. Pronounced changes ($\Delta b^* > 6$) were noted for the samples exposed to coffee at pH 4, 6 and 8, and tea at pH 4 and 6. The changes were slightly perceptible, $1.7 < \Delta b^* < 3$, only in samples immersed into distilled water. Pronounced total color changes ($\Delta E > 6$) were noted in all samples except of those immersed into distilled water, being clearly perceptible even in distilled water, with $\Delta E > 3$.

Conclusions

Colorimetric measurements were made on five temporary materials, Luxatemp, Structur 2 SC, Prottemp II, Zhermacryl STC, and Dentalon plus, before and after controlled immersion treatments in solutions of coffee, tea and blackcurrant juice, and into distilled water for comparison. The color analysis of the examined samples of temporary materials after sixty hours of soaking in staining solutions proved that Dentalon and Luxatemp

were the materials less prone to discoloration. Moreover, it was shown that the change of total color of the temporary materials involved significant changes in lightness ΔL^* , with the samples becoming darker, and yellowness Δb^* , with the samples becoming yellower. Discoloration caused by coffee, tea and blackcurrant juice was generally stronger in acidic solutions (pH = 4), except from that of Luxatemp, which discolored stronger at pH = 6 in tea and blackcurrant juice. The acidity effect is probably caused by the reduced stability of the studied materials in acidic solutions, resulting in accelerated penetration of the dyes into the bulk of the material. The effect of the illuminant on the measured total color changes was quite moderate, although sometimes the change of the illuminant caused the sample to move from one of the 4 categories used to classify the changes to another, neighboring category. The effect of the illuminant on the color coordinates was the strongest for Δa^* , as this color coordinate depends on the relative contribution of the red light, which is strongly reduced in the D65 illuminant as compared to the A illuminant.

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