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The Effect of Traditional Regional Beverages on the Color Stability of PMMA Denture Base Materials

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ABSTRACT

Aim: The color stability of PMMA-based denture base materials can be affected by personal habits, such as hygiene and beverage consumption. Color stability of denture bases is a crucial esthetic criterion for long-term success. In our study, the effect of three different local drinks consumed in the Thrace region on the color of base materials was measured.
Material and Methods: In this study, samples produced from three different PMMA-based pink acrylics (Meliodent Rapid Repair, Imicryl IQ15, Duracryl Heat Cure) with the traditional muffle method were immersed in four different solutions (Distilled water (ontrol Group), Chasteberry juice, Plum Juice, Black Mulberry Juice) (n=10) was kept for 21 days. Color measurements were made with a spectrophotometer on days 0-7 and 21, and color change values (ΔE00) were calculated. One-way ANOVA and Tukey HSD multiple comparison test were used for statistical analysis of color changes (p=0.05).
Results: The findings showed that on the seventh day, the coloration caused by plum juice in samples was significantly higher than that of distilled water (p=0.002). There was no difference in color change in other drinks, materials and times (p>0.05). It was observed that on the seventh and twenty-first days, the color change values in all beverages remained below the visual perceptible limit (ΔE00<1.72).
Conclusion: PMMA-based base materials show color change as a result of interaction with beverages, and this change varies depending on the waiting time, acrylic brand and type. As a result, color changes between base materials and beverages were not clinically significant.

Geleneksel Yöresel İçeceklerin PMMA Protez Kaidelerinin Renk Stabilitesi Üzerindeki Etkisi

Makale Bilgisi

Makale Geçmişi

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Anahtar Kelimeler:
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ÖZET

Amaç: PMMA esaslı protez kaide materyallerinin renk stabilitesi hijyen alışkanlıkları ve içecek tüketimi gibi kişisel alışkanlıklar tarafından etkilenebilir. Protez kaidelerinin renk değişiminden etkilenmemesi uzun dönem başarı için önemli bir estetik kriterdir. Çalışmamızda Trakya bölgesinde tüketilen üç farklı yöresel içeceğin kaide materyallerinin rengi üzerindeki etkisi ölçülmüştür.
Gereç ve Yöntemler: PMMA esaslı 3 farklı pembe kaide akriliğinden (Meliodent Rapid Repair, Imicryl IQ15, Duracryl Heat Cure) geleneksel mufla yöntemi ile üretilen örnekler 4 farklı solüsyonda (Distile su (Kontrol Grubu), Hayıt suyu , Erik Suyu, Karadut Suyu) (n=10) 21 gün bekletilmiştir. 0-7 ve 21. günlerde spektrofotometre ile renk ölçümü yapılmış ve renk değişim değerleri (ΔE00) hesaplanmıştır. Renk değişimlerinin istatistiksel analizleri için tek yönlü varyans analizi (one-way ANOVA) ve Tukey HSD çoklu karşılaştırma testi kullanılmıştır. (p=0,05).
Bulgular: Imicryl ile hazırlanan örnekler yedinci günde erik suyunun sebep olduğu renklenme distile suya göre anlamlı derecede yüksektir (p=0,002). Diğer içecekler, materyaller ve sürelerde renk değişimi açısından fark görülmemiştir (p>0,05). Yedinci ve yirmi birinci günlerde tüm içeceklerde renk değişimi değerlerinin gözle algılanabilecek sınırın (ΔE00<1.72) altında kaldığı görülmüştür.
Sonuç: Çalışmamızda PMMA esaslı kaide materyallerinin içeceklerle etkileşim sonucunda renk değişimi gösterdiği ve bu değişimin bekleme süresi, akrilik markası ve tipine bağlı olarak değiştiği bulunmuştur. Sonuç olarak, kaide materyalleriyle içecekler arasındaki renk değişimleri klinik olarak anlamlı değildir.

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INTRODUCTION

In our country, especially in elderly patients with partial or complete tooth loss, removable dentures are the most commonly used form of prosthetic rehabilitation.[1] Due to its excellent physical and mechanical properties, Polymethyl methacrylate (PMMA) is the most commonly used denture base material in removable dentures. However, its disadvantages include brittleness and liquid absorption over prolonged use, which may lead to a negative impact on its mechanical properties.[2] Liquid absorption primarily arises from the polar properties of resin molecules, making PMMA denture base materials susceptible to staining through denture cleaners and exposure to liquids and food intake.[3]

Color stability is crucial for the long-term aesthetic success of dentures and is a significant factor in material selection. Non-color change of denture bases is considered crucial for success. Both dentists and patients desire dentures that maintain surface gloss and exhibit minimal staining..[3,4] Studies have shown that personal habits, such as hygiene practices and beverage consumption, can significantly affect the color stability of acrylic resin-based dental prostheses.[5] Beverages, such as black tea, coffee, cola drinks, and fruit juices, have been shown to discolor denture surfaces. These beverages may also impact the surface finish of the dentures..[6,7] Therefore, our study aimed to investigate the effect of commonly consumed fruit juice varieties in the region where our faculty is located on denture bases. This investigation was prompted by the lack of existing literature on the color effects of these local beverages on denture bases. From a clinical perspective, measuring and comparing color differences in dental materials is important for statistical significance and associating them with perceptibility and acceptability thresholds. Results obtained through visual assessments are subjective and may vary, making them less reliable. Using color measurement devices eliminates human errors and provides objective and reproducible data. These devices yield reliable and precise results.[8]

Colorimeters measure colors and express them with three coordinate values (L*, a*, b*) in the CIELAB color space. The L* coordinate represents the brightness, the a* value represents red-green chroma, and the b* value represents yellow-blue chroma. The color difference (ΔE) between two objects can be determined by comparing the respective coordinate values.[9] In our study, the current CIEDE2000 formula was used to calculate color differences (ΔE00). The CIEDE2000 formula is recommended for measuring color differences because it is more accurate than the CIELAB formula and better reflects human color perception. Additionally, the CIEDE2000 formula effectively aligns color differences with perceptibility and acceptability thresholds.[10–12]

This study aims to measure the color changes of three different PMMA-based denture base materials within three different traditional regional beverages commonly consumed in the Trakya region. Our hypothesis was that there would be no difference in color changes of base materials across different beverages.

MATERIALS AND METHODS

In this study, three different pink denture base acrylics based on PMMA were used. A summary of the materials is detailed in Table 1. A total of 120 circular samples, each 2 mm thick and 20 mm in diameter, were prepared for each denture base material, with 40 samples for each material. Sample size and measurements were based on similar studies in the literature [4,13,14] To obtain a standard surface, the samples were polished on one side for 45 seconds with a green

jumbo rubber, 15 seconds with pumice, and finished a felt and hair brush. Before color measurements, the samples were soaked in distilled water at room temperature for 48 hours.

Table 1: Materials used in the study

Name	Type of Polymerisation	Liquid/Powder Ratio (ml/g)	Polymerisation Process	Manufacturer
Meliodent Rapid Repair	Chemical Cure	0.7	2 minutes at room temperature 23 °C	Heraeus Kulzer, Hanau, Germany
Imicryl IQ15	Heat Cure	0.4	20 minutes in 100°C boiling water	Imicryl, Konya, Türkiye
Duracryl Heat Cure	Heat Cure	0.42	25 minutes in 100°C boiling water	Erk Dental, İzmir, Türkiye

A spectrophotometer (Chroma Meter CR 400, Konica Minolta, Tokyo, Japan) with the CIELAB system was used for color measurements. The device was calibrated before each measurement. Acrylic samples were measured from their centers on a grey background. Measurements were repeated three times for each sample, and the average values of L, a, and b were recorded. To evaluate color changes in different beverages, the 40 samples in each acrylic type were divided into four subgroups of 10 samples for different beverages.

The beverages used were:

1. Distilled water (Control Group)
2. Chasteberry Juice (Mindivan, Beyazlar Group, Kocaeli/Turkey)
3. Plum Juice (Ancora, Forte Gıda, Ankara/Turkey)
4. Black Mulberry Juice (Ancora, Forte Gıda, Ankara/Turkey)

Beverages were used undiluted. Samples were placed in jars containing beverages and kept at room temperature, with beverages being renewed every 48 hours. Color measurements were retaken on the seventh and twenty-first days. The samples were dried, and L, a, and b values were measured and recorded using the same method.

To determine the differences in color measurements on acrylic denture base materials on the 0th, 7th, and 21st days, ΔE00 values were calculated using the CIEDE2000 formula provided below.

$$\Delta E_{00}^{*} = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T \frac{\Delta C'}{k_C S_C} \frac{\Delta H'}{k_H S_H}}$$

Statistical Analysis: Data analysis was conducted using statistical software (SPSS 26.0 for Windows; IBM Corp, SPSS Inc, Chicago, IL, USA). Color differences were evaluated using one-way ANOVA and Kruskal-Wallis tests, while differences between beverages were analyzed with multiple pairwise comparison tests, applying Bonferroni correction. The statistical significance level was set at p=0.05.

RESULTS

Table 2 presents the group means and standard deviations of color change values exhibited by different materials in various beverages after a specific duration. A significant difference in color changes was found for samples prepared with Imicryl on the seventh day. The color change in samples soaked in plum juice was significantly higher than those soaked in distilled water (p=0.002). However, no significant difference was observed among other beverages. There was no significant difference between beverages in terms of color changes observed on the twenty-first day.

For samples prepared with Meliodent and Duracryl, no significant differences were observed among beverages in terms of color changes measured on both the seventh and twenty-first days. Table 3 presents the test

results and significance values of base resins with time and beverage variables.

Table 2: Color change and standard deviation values

Material	Beverage (Group)	Day 7 ΔE_{00} (SD)	Day 21 ΔE_{00} (SD)
Imicryl	Distilled water (A)	0.27 (0.31)	0.98 (0.47)
	Black Mulberry juice (B)	0.35 (0.16)	0.69 (0.27)
	Plum juice (C)	0.91 (0.63)	1.13 (0.74)
	Chasteberry juice (D)	0.34 (0.26)	0.51 (0.18)
Meliodent	Distilled water (E)	0.59 (0.55)	0.79 (0.62)
	Black Mulberry juice (F)	0.59 (0.66)	0.59 (0.69)
	Plum juice (G)	0.81 (0.59)	0.94 (0.83)
	Chasteberry juice (H)	0.80 (0.64)	0.90 (0.73)
Duracryl	Distilled water (K)	0.52 (0.44)	0.73 (0.49)
	Black Mulberry juice (L)	0.73 (0.46)	0.87 (0.43)
	Plum juice (M)	0.56 (0.40)	0.69 (0.43)
	Chasteberry juice (N)	0.36 (0.36)	0.54 (0.31)

Table 3: Statistical analysis results of color change of denture base materials

Independent-samples Kruskal-Wallis Test		**Meliodent**		**Duracryl**		**Imicryl**	
		Day 7	Day 21	Day 7	Day 21	Day 7	Day 21
	Sig	0.354	0.470	0.140	0.272	0.003	0.045
Pairwise Comparisons	A-B	-	-	-	-	0.836	1.000
	A-C	-	-	-	-	0.002*	1.000
	A-D	-	-	-	-	1.000	0.082

In comparison among materials, no significant differences were found in color changes among the three acrylics and all beverages on the seventh and twenty-first days. The ΔE00 color change values for all beverages on the seventh and twenty-first days were measured below the threshold perceptibility of 1.72.[15]

DISCUSSION

This study evaluated the color changes of various denture base materials due to exposure to local beverages. Significant discoloration was observed due to plum juice in samples prepared with Imicryl IQ15 denture base material on the seventh day. No significant differences were observed among other denture materials, beverages, or time intervals. Therefore, the null hypothesis was partially accepted.

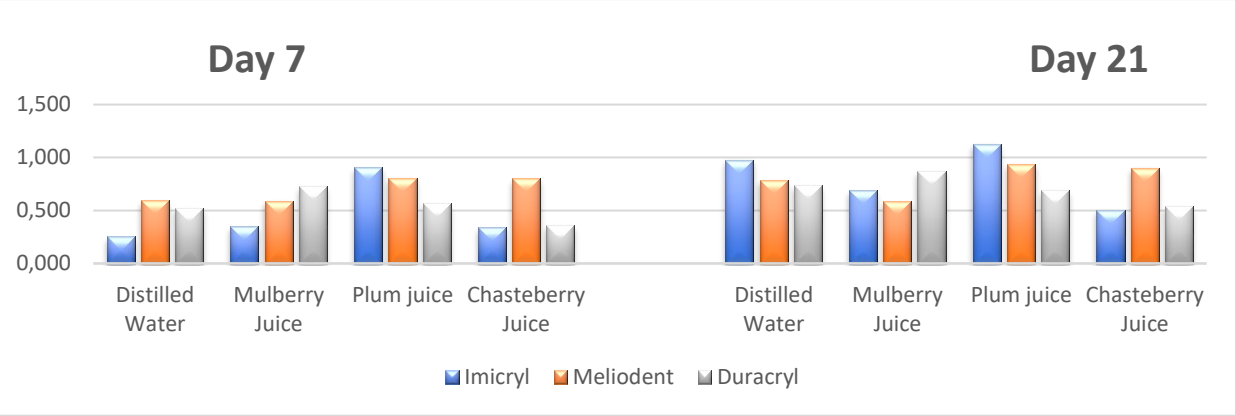
External staining on restoration surfaces is influenced by physical and chemical forces like van der Waals forces, chemical bonds, and hydrophobic interactions facilitating the adhesion of color pigment particles.[16], Liquid absorption in PMMA materials is associated with the polar properties of molecules.[3,17] Additionally, the size of molecules exposed to acrylic resins plays a significant role in color change, primarily due to pigment absorption.[18] The addition of nanoparticles to the denture base has been shown to act as an inorganic filler, reducing porosity and thus resulting in less staining.[19]

The measurement and comparison of color and color changes yield subjective and complex results due to various factors like light conditions, material optical properties, and human perception. To minimize potential errors, color measurement devices like spectrophotometers have been developed and used in various studies as they are highly regarded for detecting color and color differences.

In our study, distilled water, used as the control group, also caused discoloration in acrylic resins. Although this change was not statistically significant and remained below the perception threshold, it was comparable to changes observed in other beverages (Graph 1). Similar results were found by Aysan et al. when examining color changes in different beverages for denture base materials. Potential reasons for color change in distilled water include water

absorption by the polymer structure, the effect of the soaking environment, and the discoloration properties of distilled water.[4] While several studies have noted color changes in PMMA base materials due to distilled water, the exact reason remains open for further investigation.[8,20–23]

Graph 1: Graph of color change values for three materials and four beverages



Ren et al. evaluated perceptibility and acceptability threshold values for color changes in denture acrylics. According to the CIEDE2000 formula, the perceptibility threshold for ΔE00 at a 50:50 confidence interval was 1.72, while the acceptability threshold was 4.08.[15] In our study, all color change values measured in PMMA base materials remained below the perceptibility threshold. This suggests that these beverages will not cause a noticeable color change in the base materials. Additionally, color changes in pink acrylic resins are reported to be less perceptible compared to tooth-colored restorative materials.[15]

A limitation of our study is that the acrylics used are conventional, although some might been chemically or heat-cured. Today, additive and subtractive manufacturing techniques for denture materials are also used. Gruber et al. reported significantly higher color changes for 3D-printed denture base materials than conventional and subtractively manufactured ones.[23] Further studies may include these new production techniques for examination.

CONCLUSION

1. PMMA denture base materials exhibited some color change due to interaction with beverages.
2. The extent of this change increased with prolonged exposure and varied according to the acrylic brand and type used.
3. Overall, the color changes observed between denture base materials and beverages were not clinically significant.

Ethical Approval

Since sources obtained from humans or animals were not used in this study, ethics committee approval was not obtained.

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: HMA, ÖHÇ, İE, GU, Data collection and processing: ÖHÇ, İE, GU, Analysis and interpretation: HMA, Literature review: ÖHÇ, İE, GU, Writing: HMA.

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