وزارة التعليم العالي والبحث العلمي
جامعة ميسان
كلية التربية الاساسية
Ministry of Higher Education and Scientific Research
University of Misan
College of Basic Education

Misan Journal for Academic Studies

Humanities, social and applied sciences

مجلة ميسان للدراسات الاكاديمية

العلوم الانسانية والاجتماعية والتطبيقية

ISSN (Print) 1994-697X
(Online)- 2706-722X

المجلد23 العدد 51 أيلول 2024

Sep 2024 Issue 51 Vol23

مجلة ميسان للدراسات الاكاديمية

العلوم الإنسانية والاجتماعية والتطبيقية

كلية التربية الأساسية/ جامعة ميسان/العراق

Misan Journal for Academic Studies

Humanities, social and applied sciences

College of Basic Education/University of Misan/Iraq

ISSN (Print) 1994-697X (Online) 2706-722X

المجلد (23) العدد (51) أيلول (2024)

SEP 2024 ISSUE51 VOL 23

www.misan-jas.com

journal.m.academy@uomisan.edu.iq

رقم الايداع في دار الكتب والوثائق بغداد 1326 في 2009

ISSN (Print) 1994-697X
ISSN (Online) 2706-722X

DOI:
https://doi.org/10.54633/2333-023-051-002

Investigation of piranha solution on Color Stability of heat cure acrylic

[1]Noor Azher Al-Rubaie , [2]Aseel Mohameed Al-Khafaji
[1,2] Department of Prosthodontics, College of Dentistry, University of Baghdad, / Baghdad, Iraq.
[1]noor.azhr2201@codental.uobaghdad.edu.iq
https://orcid.org/0009-0003-0278-5577
[2] aseel.khafaji@codental.uobaghdad.edu.iq

Abstract:

This study examined how piranha solution affects denture base acrylic resin color stability. Twenty acrylic resin specimens (disc shape,20 mm diameter, 2 mm thick) were made for color stability. The specimens were randomly divided into Group W (no treatment) and Group P (piranha solution treatment). Color stability is measured with Photoshop. The data was analyzed using a T-test. There was significant variance in group P values ($P \leq 0.05$). Compared to Group W, the Piranha solution treatment group (Group P) affected color value (L), hue (a), and chroma (b). This study found that the piranha solution can modify the color of heat cure acrylic surface qualities.

Keywords: Color stability. Heat cure acrylic. Piranha solution. Chroma. Sulfuric acid.

Introduction:

Acrylic resin has been effectively employed in the construction of denture bases for a considerable period (Diwan RR, et al., 2004, Yousif WA, et al., 2023, Zahraa AA, et al., 2023, Shahad LM, et al., 2024). It possesses advantageous physical, mechanical, and esthetic characteristics and may be easily manipulated with affordable equipment (Noori Z, Al-Khafaji AM, Dabaghi F, 2023). Regrettably, the material still has several drawbacks, including its tendency to change color over time and its propensity to absorb oral fluids, which is often associated with the potential for certain organisms to inhabit the surface of the denture (Diwan RR, Zarb GA, Bolender CL, 2004). Soft denture liners can be helpful for individuals who are unable to tolerate a traditional rigid denture foundation, as noted by Schmidt WF Jr et al. in 1983 and Wright PS in 1984. Soft denture liners are advised for patients to enhance the spread of force on the area where the denture is placed and to prevent the concentration of stress caused by the pressure (Qudah S, Harrison A, Huggett R, 1990). These substances have a history of over a century. They are commonly employed as padding on the indented surfaces of prosthesis in patients with damaged oral tissue, reduced jawbone, irregular bone formations, teeth grinding, dry mouth, genetic oral defects that need filling, and boosting denture retention by fitting into undercuts (Qudah S, Harrison A, Huggett R (1990, Gonzalez JB, 1977, Jagger DC, et al., 1997, Winkler S,1994).

The inadequate fitting of dentures can be attributed to differences between soft and hard tissues, which can lead to loss of bone. Additionally, the bonding among the denture base as well as the relining material is vulnerable. Microleakage can occur at the contact between the prosthetic base as well as the relining material, resulting in the detachment of the relining substance. Prosthesis liners should be acrylic dentures that are securely attached to avoid breakage and separation. This procedure may help enhance the denture's fit and reduce pressure strain when using soft liners (Abbas S, et al., 2017, Iwasaki N, et al., 2017). In order to enhance the adhesive strength between heat cure acrylic and the soft liner, the surface area of the acrylic can be enhanced employing two commonly used methods: mechanical surface roughening using sandblasting as well as air abrasion or chemical surface roughening using monomer or acid. Piranha solution, a powerful combination of sulfuric acid and hydrogen peroxide, is a commonly used acid treatment. Surface treatment techniques are used to achieve different goals, with color stability being the primary objective of dental materials. Color changes indicate getting older or damage to the materials (Dootz ER, et al., 1992, Jin C, et al., 2003, Jagger DC, et al.,1999, Makila E, et al.,1979). This device quantifies color and represents it using three coordinate values (L*, a*, b*). The Piranha solution, consisting of sulfuric acid and hydrogen peroxide, is a potent destructive and oxidizing chemical (Mohammed AA, et al., 2023, Mohammed AA, et al., 2024).

This study evaluates the heat cure acrylic with piranha solution. Null hypothesis: Piranha solution does not change the surface heat cure acrylic color. Alternative hypothesis: The piranha solution may change the color of the surface heat cure acrylic

Material and method:

Specimens' preparation:

Preparation of color stability specimens:

The disc specimen used for color change assessment has a diameter of 20 mm and a thickness of 2 mm (Abdul-Kareem S, et al., 2020, Ali AA, et al., 2023), as seen in Figure 1.

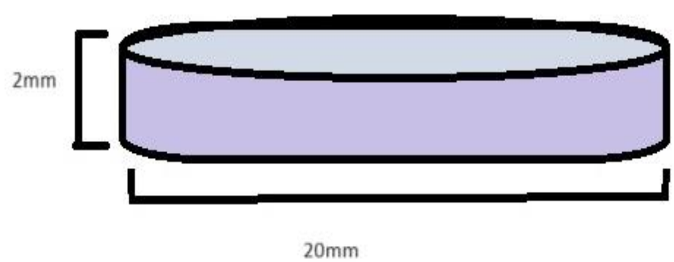

Figure 1: The form of the specimen employed to assess color stability.

The laboratory utilized a firm rubber putty (Ergamix® shore a 70, LASCOD, Italy) to facilitate the creation of the duplicates. The catalyst as well as base were combined in equal volumes, as instructed by the manufacturer, to form the silicone. Once the ingredients were combined, they were refined and transferred into a plastic container. The plastic patterns were embedded within the stone for half of the period, while the other half was left on the surface. Once the silicone had solidified, it was extracted from the packing, and any excess was trimmed using a sharp knife. The bottom portion of the flask was filled with a newly made dental stone of type IV, using a separating substance. Following that, the combination underwent vibration using a vibratory device to eliminate any trapped air. The silicone mold, containing the undamaged plastic blocks, was carefully immersed into the stone mixture. Once the stone had solidified, a material that formed a uniform barrier was applied to the whole surface, containing the plastic block, silicone, as well as stone (Figure 2).

Figure 2: A silicone mold is utilized to evaluate the color permanence of a stone after its placement.

Subsequently, the upper section of the flask was placed over the lower portion, as well as a fresh amalgamation of stones was put into it. Ultimately, the flask was tightly sealed with its lid. Once an additional stone coating was applied, the flask cracked open, and the plastic blocks were delicately extracted with a wax knife. This technique created a space or mold that could be filled with acrylic resin.

An isolating agent was applied to the top part of the stone area. The quantities of polymer monomer (PROCRYLA, PD Germany) are as follows: The liquid was quantified via a micropipette. At the same time, the powder was determined using a computerized scale with a precision of around 0.001 grams. As to the manufacturer's requirements, mixing involves using a ratio of 2.2 grams of powder for every 1 milliliter of liquid. The heat cure acrylic powder and liquid were combined in the appropriate ratio and placed in a glass container. The resultant blend was well stirred until it appeared similar to dough. After the flask became pliable, it was inserted into the presses, crushed into the stainless steel mold, and securely affixed to the lower portion. After exerting a constant force of 100 kg/cm^2 for five minutes employing the hydraulic press, the flask was removed from the media. Subsequently, a spatula was used to remove any extra material from the opening object. The flasks were tightly secured once more. Subsequently, a pressure of 100 kg/cm^2 was exerted to keep the specimen's thickness unchanged, following the instructions provided by the manufacturer (Qanber LM, Hamad TI. 2021). Afterward, clamping was carried out to aid in the curing process. Per the organization's specifications, the flask was immersed in cold water and exposed to a temperature of 100 °C for 20 minutes. Afterward, the material had the opportunity to cool on the bench until it reached the same temperature as its surroundings, which normally took between 20 and 30 minutes. Subsequently, it was subjected to a cooling process in cold water for approximately 20 minutes, by the manufacturer's instructions. Ultimately, the specimens were extracted from the stainless steel mold by disassembling the flask.

We used fine-grit polish (stone burs) and 600-grit sandpaper to remove any additional superfluous material. The procedure was executed using a consistent water supply to avert the excessive heating of the specimens. Polishing specimens was accomplished using a lathe machine with a cotton brush and pumice. A digital Vernier caliper calibrated every specimen, ensuring accurate measurements. The specimens were subjected to an ultrasonic cleaning method utilizing distilled water cleansers for about 20 minutes (Cavalcant YW, et al., 2014). The acrylic resin specimens were placed in a chamber containing clean water and subjected to a temperature of 37 °C for 48 hours. This process was carried out to remove any residual monomer in the specimens (Yasser AD, et al., 2017, Cavalcant YW, et al., 2014).

Groups of specimens:

A total of twenty specimens were fabricated using acrylic resin. The arrangement appeared in the following manner:

1. Group W: Acrylic resin specimens were untreated with piranha solution (Control group).
2. Group P: Acrylic resin specimens were treated with piranha solution.

Preparation of the piranha solution:

The Piranha solution was formulated by carefully blending sulfuric acid and hydrogen peroxide to obtain the appropriate ratio. The activity was placed in a meticulously constructed structure to ensure safety (Dos Santos FSF et al., 2021). Furthermore, the production of brown-soluble washing products has the additional benefit of reducing carbon emissions (Chalmpes N et al., 2022). Combining the ingredients in glass jars and spinning them was important to get an even texture. Sulfuric acid (98%; PanRwac AppliChem, Spain) was introduced into the glass container, followed by hydrogen peroxide (35%; THOMAS baker, India). The solution provided by Piranha exhibits many ratios (1:3, 1:5, 1:7, and 1:9), each of which offers certain advantages that may be utilized as required. For this investigation, a volume ratio of 1:7 was employed. Furthermore, the reverse procedure prevents any potential explosion resulting from the incorrect sequencing, as the ratios involved are precisely fifty percent by volume (Atalay S, et al., 2021). Following the addition of hydrogen peroxide, it is necessary to allow the piranha solution to stabilize for roughly two minutes before introducing the specimens. Acrylic resin specimens from group P were immersed in a glass jar containing a piranha solution consisting of hydrogen peroxide and sulfuric acid in a volume ratio of 1:7. Acrylic resin specimens from group P were submerged in the solution for 40 seconds, as shown in Figure 3.

Figure 3: Fabrication of piranha solution

After allowing every specimen to air dry for two minutes, it was immersed in the piranha solution. Following the treatment, the specimens undergo ultrasonic washing in distilled water as well as ethyl alcohol for roughly 10 minutes. Subsequently, they were left to undergo natural ventilation at the surrounding temperatures for around fifteen minutes (Chalmpes N et al., 2022).

Testing technique:

After being stored in a 37°C incubator for 24 hours, the specimens were washed with distilled water and left to dry in the air. This process was previously described by Ali AA et al. in 2023 and Abdul-Kareem S et al. in 2020. The control specimens and all specimen study groups were photographed using a digital imaging approach. An SLR camera that included a 105 mm macro lens was used, and the photographs were captured on a black background to enhance the sharpness of the clear heat cure acrylic specimens. The camera was positioned perpendicular to the specimens at a height of 10 cm. It had been set to the manual setting, enabling complete control over camera settings, such as a shutter speed of 1/60 and ISO of 3200, with a f-stop of 5.6. The dimensions stayed constant while capturing the images. The study employed computational modeling to extract the Red, Green, and Blue (RGB) values from Adobe Photoshop's pre-existing functions. Subsequently, the results were transformed into (L-a-b) or (v-h-c) values. Each specimen's color characteristics (L, a, and b) were evaluated in three distinct groups.

- Lightness, sometimes called value, is measured on a scale ranging from 0 (representing black) to 100 (representing white).
- The hue is a component that consists of shades of green and red.
- The blue-yellow component of color is referred to as chroma.

The mean value was calculated by measuring every specimen's L, a, and b values on each occasion. Afterward, the color changes (ΔL, Δa, and Δb) were calculated. The equation used to compute the total color change (ΔE) was employed:

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$$

Analytical statistics:

The color stability was calculated and summarized for each individual. The statistical program GraphPad Prism 9.5.0.730 (x64) was employed to compute each group's mean and standard deviation. The Tukey HSD and one-sided ANOVA statistical tests were used to compare the results collected from each group. A statistical significance criterion was established with a threshold of $P < 0.05$.

Results:

Color stability, value (L):

Figure 4 displays the descriptive statistical examination value (L) of color stability test data across all groups. Group P (L1) had the highest mean value, 86±1.633. In contrast, Group W (L0) had the lowest mean value (77.2±0.918).

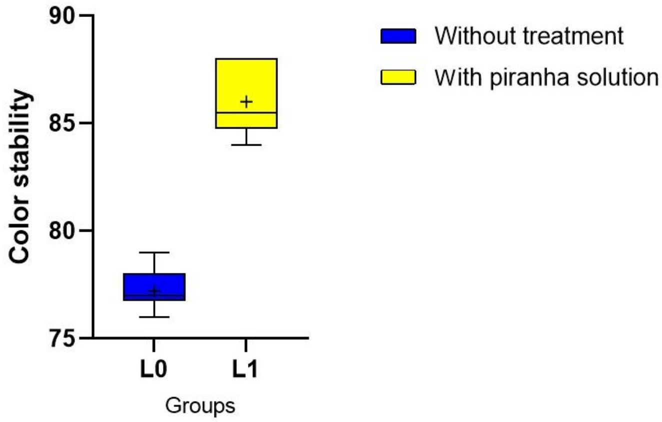

Figure 4: A boxplot chart compares the color stability test values (L) between the treatment and without-treatment groups.

The T-test demonstrated a statistically significant difference between the two groups, as seen in Table 1.

Table 1: T-test value (L) of color stability test.

Groups	T-test	Df	M.D	P value	Confidence interval 95%
Between Groups	14.85	18	8.8	<0.0001*	-7.555 to 10.04

Color stability, Hue (a):

Figure 5 displays the descriptive statistical analysis of the hue (a) values in all groups for the color stability test. Group W (a0) had the highest average value of 22.5±1.434. Conversely, Group P (a1) had the lowest mean value (1.4±1.506).

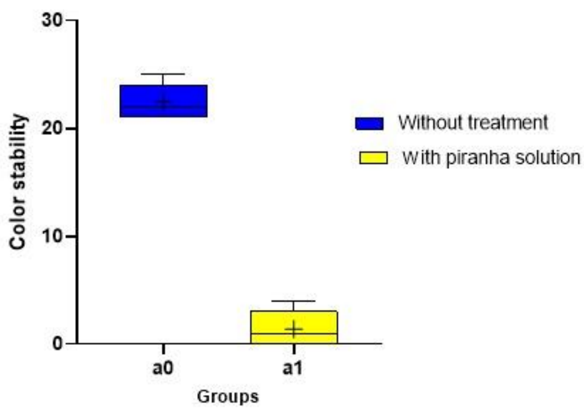

Figure 5: Boxplot diagram comparing the hue (a) values of the treatment group with those without treatment in the color stability test.

The T-test demonstrated a statistically significant distinction comparing the two groups, as seen in Table 2.

Table 2: T-test for the hue (a) of color stability test.

Groups	T-test	Df	M.D	P value	Confidence interval 95%
Between Groups	32.09	18	-21.1	<0.0001*	٢٢-.48 to -19.72

Color stability, chroma (b):

Figure 6 displays the statistical description of chroma (b) for the color stability test across all groups. Group W (b0) exhibited the highest average score of 2.3±1.059. Conversely, Group P (b1) exhibited the lowest mean value (1±1.054).

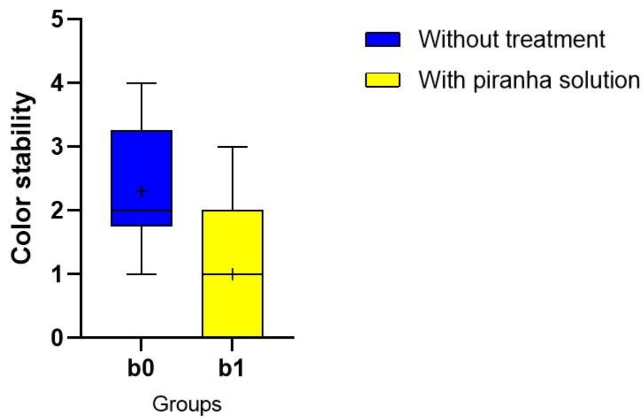

Figure 6: Boxplot graphic comparing the chroma (b) values of the treatment and control groups in the color stability test.

The T-test demonstrated a difference in statistical significance between the two groups, as seen in Table 3.

Table 3: T-test for chroma (b) of color stability test.

Groups	T-test	Df	M.D	P value	Confidence interval 95%
Between Groups	2	18	-1.3	<0.0001*	-2.293 to -0.307

Discussion:

Color is the perceptual quality resulting from the interaction between the light spectrum and the photoreceptor cells within the eyes. Objects or substances are categorized and characterized based on physical attributes, including their ability to absorb, reflect, or emit light. Establishing a color distance makes it possible to assign numerical values to colors based on their coordinates. Color recognition can be accomplished by giving numerical coordinates to colors using a color space specification (Fars J, et al., 2012). Color determination is often achieved by visual examination by quantifying the hue, saturation, as well as brightness of the reflected light. The base material of dentures is transparent to create a pleasing appearance and is colored in a way that seamlessly matches the color of real teeth and gums.

Furthermore, they must possess exceptional color durability in the ever-changing conditions of the mouth. Color alteration is a necessary consequence of replacement, typically caused by age-related changes, the application of disinfectants, or the inclusion of additives (Bisha AK, 2019).

One alternative method for quantifying color without direct physical contact involves digital cameras. Photographs are captured by digital cameras using a photosensitive material to record the scene. This technique generates pictures depicted by red, green, and blue (RGB) values assigned to each pixel. The researchers utilized this approach in the investigation because of its many advantages (Joiner A, Luo W, 2017).

The ΔL* value of color (lightness) showed a substantial decrease in translucency and an increase in lightness in group P compared to group W, as shown in Table 1. These compounds are important because they result from the oxidation of carbon-carbon double bonds, which leads to the development of colored peroxide compounds and the ongoing production of colorful degradation products. Research has demonstrated that the degradation of the surface of denture base resins leads to an increase in lightness and a decrease in chroma. The alteration in optical characteristics leads to the modification of the color of acrylic resin (Moon A, Powers JM, Kiat-Amnuay S, 2012).

Arguments for this may be found in a study undertaken by Polyzois et al. (Polyzois G, et al., 2012), which discovered a notable change in the color of the denture base when it was soaked in the denture cleaner chlorhexidine gluconate and sodium hypochlorite. The browning of the denture base may be attributed to the potent oxidizing capabilities of this solution, which leads to oxidation as a consequence of the escape of oxygen. Ahmed A and Aseel MA, in their study conducted in 2023, argue that no statistically significant distinction was seen between polyamide specimens submerged in electrolyzed water at concentrations of 100 ppm and 200 ppm and in distilled water.

There was a substantial drop in hue for group P compared to the control group W, indicating a color shift in Δa*. The reference is to Table 2. The size of micro pitting and deviations within the heat cure acrylic polymer may result in a noticeable reduction in color hue. These irregularities, caused by the piranha solution, can selectively scatter or absorb certain wavelengths of light, resulting in color changes. The uniformity and dimension of the micro pits are important factors, as prolonged treatment may result in dissimilar coloration and impact the overall color hue of the material.

Following treatment with the piranha solution, there was a notable reduction in color chroma compared to the control group, as seen in Table 3, for the Δb* (chroma) color change. Group P saw a substantial reduction in color saturation (chroma), potentially due to the rough surface's ability to absorb and disperse light, resulting in less vibrant colors.

The color stability test results indicate that the acrylic resin experiences color instability, regardless of whether it is colored or not, as demonstrated by the results ($\Delta E > 1.5$). It is important to recognize that both inherent and extrinsic causes can cause changes in color intensity and chromatic variations (Ali AA, et al., 2023, Abdul-Kareem S, et al., 2020). Adding intrinsic or external colors to acrylic can resolve this issue.

Conclusions:

Based on the parameters of this research, it can be assumed that the impact of the piranha solution on the color stability of the heat cure acrylic denture foundation was noticeable to the naked eye after being immersed for 40 seconds. However, it was observed that the hue and chroma of this material significantly decreased. There has been a substantial increase in value.

Reference:

Abbas S, Mahmood WS. (2023). Effect of montmorillonite incorporation on shear bond strength and surface hardness of acrylic base soft lining material (In vitro study), CDJ. https://doi.org/10.7126/cumudj.1250433

Abd Alrazaq YW, Khalaf BS. (2013). Bond strength of 3d printed acrylic resin with silicone soft liner after ethyl acetate surface treatment (A Review of Literature). 22(48) . https://orcid.org/0000-0003-2288-4241

Abdul-Kareem S, Al-Maroof AG, Fadhil NH. (2020). Color stability of different aesthetic resin composite materials: a digital image analysis. Indian Journal of Forensic Medicine & Toxicology. 16;14(1):1210-5. https://doi.org/10.37506/ijfmt.v14i1.239

Abdulrazzaq ZA, Khalaf BS. (2023). Natural Fibers Reinforcement of Denture base materials: Natural Wool Reinforcement (A Review of Literature). 22(47). https://orcid.org/0009-0003-8677-1534

Abed AA, Al-Khafaji AM. (2023). Examining how PMMA and polyamide denture base materials' physical characteristics are affected by electrolyzed water used as a denture cleaner. Bionatura. 8. 1-8. 10.21931/RB/CSS/2023.08.03.99.

Ali AA, Safi IN. (2023). Impact of nano-cellulose fiber addition on physico-mechanical properties of room temperature vulcanized maxillofacial silicone material. J Taibah Univ Med Sci.16;18(6):1616-1626. https://doi.org/10.1016/j.jtumed.2023.07.002

Alsmael MA, Al-Khafaji AM. (2023). Improving surface properties of PEEK for dental applications by using piranha solution, International Journal of Dentistry. https://doi.org/10.1155/2023/7840601

Atalay S, Çakmak G, Fonseca M, Schimmel M, Yilmaz B. (2-21). Effect of thermocycling on the surface properties of CAD-CAM denture base materials after different surface treatments. J. Mech. Behav. Biomed. Mater. https://doi.org/10.1016/j.jmbbm.2021.104646

Bishal AK, Wee AG, Barão VA, Yuan JC, Landers R, Sukotjo C, Takoudis CG. (2019). Color stability of maxillofacial prosthetic silicone functionalized with oxide nanocoating. J The Journal of Prosthetic Dentistry.121(3), 538-543. https://doi.org/10.1016/j.prosdent.2018.06.007

Cavalcant YW, Bertolini MM, Del Bel Cury AAA, da Silva WJ. (2014). The effect of poly (methyl methacrylate) surface treatments on the adhesion of silicone-based resilient denture liners, J. Prosthet. Dent. https://doi.org/10.1016/j.prosdent.2013.07.031

Chalmpes N, Baikousi M, Giousis T, Rudolf P, Salmas CE, Moschovas D, et al. (2022). Biomass waste carbonization in piranha solution: A route to hypergolic carbons, MDPI Journal. *2*(1), 137 153; https://doi.org/10.3390/micro2010009

Diwan RR, Zarb GA, Bolender CL. (2004). Prosthodontic Treatment for Edentulous Patients, 12th edition. Mosby, St. Louis, pp 190–193.

Dootz ER, Koran A, Craig R (1992) Comparision of the physical properties of 11 soft denture liners. J Prosthet Dent 67:707–712. https://doi.org/10.1016/0022-3913(93)90250-R

Dos Santos FSF, da Silva MVHN, Tomás H, Fook MVL. (2021). Surface bioactivation of polyether ether ketone (PEEK) by sulfuric acid and piranha solution: Influence of the modification route in capacity for inducing cell growth. *Biomolecules*, *11*(9), 1260. https://doi.org/10.3390/biom11091260

Fars J, Fernandes TP, Huchzermeyer C, Huchzermeyer C, Kremers J, Param GV,et al. Chromatic discrimination measures in mature observers depend on the response window. Scientific Reports. 2022 May 31;12(1):9072. https://doi.org/10.1038/s41598-022-13129-w

https://doi.org/10.1111/jerd.12109

Iwasaki N, Yamaki C, Takahashi H, Oki M, Suzuki T. (2017). Effect of long-time immersion of soft denture liners in water on viscoelastic properties, Dent. Mater. J. https://doi.org/10.4012/dmj.2016-320

Jagger DC, Harrison A, Jandt KD. (1999). The reinforcement of dentures. J Oral Rehabil 26:185–194. https://doi.org/10.1046/j.1365-2842.1999.00375.x

Jagger DC., Harrison A. (1997). Complete dentures the soft option. An update for general dental practice. *Br Dent J* 182, 313–317. https://doi.org/10.1038/sj.bdj.4809374

Jin C, Nikawa H, Makihira S, Hamada T, Furukawa M, Murata H. (2003). Changes in surface roughness and colour stability of soft denture lining materials caused by denture cleansers. J Oral Rehabil 30:125–130. https://doi.org/10.1046/j.1365-2842.2003.01014.x

Joiner A, Luo W. (2017). Tooth colour and whiteness: A review, Journal of Dentistry. 67. S3-S10. 0300-5712.https://doi.org/10.1016/j.jdent.2017.09.006.

Juan B. (1977). Gonzalez, Use of Tissue Conditioners and Resilient Liners, Dental Clinics of North America. 21, 2, 249-259, 0011-8532. https://doi.org/10.1016/S0011-8532(22)03207-4.

M. Alsmael. A. Al-Khafaji. (٢٠٢٤). Evaluation of High-Performance Polyether Ether Ketone Polymer Treated with Piranha Solution and Epigallocatechin-٣-Gallate Coating, International Journal of Dentistry. https://doi.org/١٠,١١٥٥/٢٠٢٤/١٧٤١٥٣٩

Makila E, Honka O. (1979). Clinical study of a heat-cured silicone soft lining material. J Oral Rehabil 6:199–204. https://doi.org/10.1111/j.1365-2842.1979.tb01281.x

Mohammed SL. Farhan FA. (2024). Effect of addition zirconia/chitosan filler on mechanical properties of heat cure polymethyl methacrylate resin. Vol 23 No 50 (2024): june. https://orcid.org/0009-0000-6921-2261

Moon A, Powers JM, Kiat-Amnuay S. (2014). Color stability of denture teeth and acrylic base resin subjected daily to various consumer cleansers. J Esthet Restor Dent. 26:247–55.

Noori Z, Al-Khafaji AM, Dabaghi F. (2023). Effect of tea tree oil on candida adherence and surface roughness of heat cure acrylic resin. JBCD. https://doi.org/10.26477/jbcd.v35i4.3513

Polyzois G, Niarchou A, Ntala P, Pantopoulos A, Frangou M. (2012). The effect of immersion cleanserson gloss, colour and sorption of acetal denture base material. Gerodontology. 30(2): 150-156. https://doi.org/10.1111/j.1741-2358.2012.00657.x

Qanber LM, Hamad TI. (2021). Effect of plasma treatment on the bond of soft denture liner to conventional and high impact acrylic denture materials, JBCD. https://doi.org/10.26477/jbcd.v33i3.2948

Qudah S, Harrison A, Huggett R. (1990). Soft lining materials in prosthetic dentistry: a review. Int J Prosthodont 3:477–483

Schmidt WF Jr, Smith DE. (1983). A six-year retrospective study of Molloplast-B-lined dentures. Part II: Liner serviceability. J Prosthet Dent 50:459–465. https://doi.org/10.1016/0022-3913(83)90563-2

Winkler S. (1994). Essentials of complete denture prosthodontics, 2nd ed. Ishiyaku Euro America, St. Louis, pp 427–432.

Wright PS. (1984). The success and failure of denture soft-lining materials in clinical use. J Dent 12:319–327

Yasser AD, Fatah NA. (2017). The effect of addition of zirconium nanoparticles on antifungal activity and some properties of soft denture lining material, JBCD, 2017. https://doi.org/10.12816/0042988