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The Effect of Two Natural Oils on the Surface Hardness of Heat-Cured Acrylic Denture Base Material

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Abstract

Polymethyl methacrylate (PMMA) is the most widely used denture base material in prosthodontics due to its favorable mechanical properties, esthetic appearance, and cost-effectiveness. This study aimed to evaluate the effect of three different media insulating material (distilled water) as control, linseed oil (flaxseed oil), and lemon oil Heat-polymerized acrylic resin's surface-level hardness by comparing hardness values before and after immersion .Twenty-one rectangular acrylic resin samples (65mm × 10mm × 2.5mm) were fabricated using heat-cured PMMA and divided into three groups (n=7 each): Group A (control group) immersed in distilled water, group B (linseed oil), and group C (lemon oil). Surface hardness was measured using a Shore D durometer before and after two months of immersion at 37°C in an incubator. Data were statistically analyzed using one-way ANOVA and LSD post-hoc tests ($p<0.05$). Before immersion, group C (lemon oil) exhibited the highest mean hardness (83.829), followed by Group A (82.886) and Group B (82.386), with significant differences among groups ($p=0.01$). After two months, group B (linseed oil) showed the highest mean hardness (85.314), while no significant difference was found between linseed and lemon oil groups ($p=0.236$). The control group exhibited a slight decrease in hardness, whereas both oil-treated groups showed increased hardness after immersion. Immersion in natural oils, particularly linseed and lemon oils, effectively preserved or enhanced the hardness of polymerized resin compared to distilled water. Lemon oil improved initial hardness due to its terpene and limonene content, while linseed oil maintained superior long-term hardness due to its high concentration of unsaturated fatty acids and hydrophobic nature. These findings suggest that natural oils can protect acrylic resin from water-related softening and improve its durability. Future studies are recommended to optimize oil type, concentration, and clinical application methods.

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Introduction

Acrylic resins, particularly heat-cured polymethyl methacrylate (PMMA), are widely used as denture base materials in prosthodontics due to their favorable mechanical properties, esthetic appearance, ease of processing, and cost-effectiveness [1]. Their biocompatibility and adaptability have further supported their extensive use in routine clinical practice [2].

Surface hardness is regarded as a key mechanical parameter of denture base materials, as it reflects resistance to indentation, scratching, and abrasive wear during functional loading. This property is closely associated with the durability of the prosthesis and its ability to withstand masticatory stresses [3,4]. Moreover, increased surface hardness has been linked to improved hygiene performance, since harder surfaces tend to exhibit reduced wear and lower susceptibility to plaque accumulation [4] .

Studies have shown that material modifications, incorporation of additives, and exposure

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to different environmental conditions may alter the surface hardness of acrylic resins. Factors such as polymer structure, type of reinforcement, and processing technique are considered decisive determinants of these changes [3,4]. Furthermore, recent studies have explored the potential effects of natural additives and plant-derived oils, such as flaxseed oil and lemon oil, on the surface characteristics of acrylic resin. These bioactive substances, which contain fatty acids, antioxidants, and other functional molecules, may interact with the polymer matrix and alter intermolecular bonding, affecting surface hardness, smoothness, and overall material behavior [5]. Given the functional significance of surface hardness and the wide range of clinical and environmental conditions to which denture base materials are exposed, evaluating the effects of different immersion solutions or modification techniques on heat-cured acrylic resin remains essential for understanding their influence on mechanical performance and long-term durability [1].

Material and Methods

Sample Design and Groups

Twenty-one rectangular acrylic samples (65mm × 10mm × 2.5mm) were prepared and divided into three groups:

- Group A (Control): specimens immersed in distilled water with insulating material.
- Group B (Linseed oil): specimens immersed in flaxseed oil.
- Group C (Lemon oil): specimens immersed in lemon oil.

Mold Preparation

The metal flask was prepared and cleaned, then coated with a separating medium **(**Die Separator – USA, Kerr Corporation). Die stone mixture **(**Type IV Dental Stone – USA, Whip Mix Corporation) was poured into the lower half of the mold, and the resin samples were placed halfway into the mixture. After drying, the samples were coated with their respective media: and left to dry. The upper part of the mold was then placed and filled with die stone mixture, closed tightly, and left to dry completely. After removing the resin samples from the mold, the acrylic packing stage began. The mold was insulated with the respective materials (Isolant – Germany, Detax GmbH**)**. polymethyl methacrylate (PMMA) (Heat Cure Acrylic Resin **–** Germany**.**) was prepared according to the manufacturer's instructions (35 g powder and 14 mL liquid) and left for 7 minutes until reaching the dough stage. The dough was placed on the sample area and pressed firmly. The mold was placed in a water bath at 100 °C for 60 minutes for polymerization. After cooling and solidification, the samples were removed from the mold, and excess material was carefully removed using acrylic burs (Acrylic Burs – Germany, Gebr. Brasseler GmbH & Co. KG) and cylinder burs (Cylinder Burs – Switzerland, Coltène Whaledent AG)**,** followed by smoothing with sandpaper burs (Sanding Burs – Japan, Shofu Inc.) and polishing with pumice (Pumice Powder – Italy, Dorfner GmbH & Co. KG)**.**

Testing Procedure

Surface hardness was measured using a Shore D durometer before immersion. Subsequently, samples were immersed according to their group designation and stored in an incubator at 37°C for two months. After immersion, surface hardness was measured again to assess changes in surface properties.

Statistical Analysis

Data were statistically analyzed using one-way ANOVA followed by Least Significant Difference (LSD) post-hoc tests. A significance level of $p<0.05$ was considered statistically significant.

Results

Surface Hardness Test before Immersion

The descriptive statistics for surface hardness before immersion showed relatively close mean values among groups. Group C (Lemon oil) exhibited the highest mean hardness (83.829), followed by group A (Control, 82.886), and Group B (Linseed oil, 82.386) as shown in Table 1).

One-way ANOVA revealed a statistically significant difference among groups before immersion ($F=6.011$, $p=0.010$) as shown in Table 2. LSD post-hoc test showed that the difference between group A and group B was non-significant ($p=0.252$), but significant differences were found between group A and group C ($p=0.039$), and between group B and group C ($p=0.003$) (Table 3).

Surface Hardness Measurement after Immersion

After two months of immersion, mean hardness values changed significantly. Group B (Linseed oil) recorded the highest mean hardness (85.314), followed by group C (Lemon oil, 84.571), while group A (Control) showed the lowest mean hardness (82.343) (Table 4).

One-way ANOVA after immersion indicated significant differences among groups ($F=13.032$, $p=0.000$) (Table 5). LSD multiple comparisons showed group A vs group B ($p=0.000$) was significant, group A vs group C ($p=0.002$) was significant, while group B vs group C ($p=0.236$) was non-significant (Table 6).

Discussion

Polymethyl methacrylate (PMMA) continues to be widely used in denture base fabrication due to its favorable mechanical properties, ease of processing, acceptable esthetics, and relatively low cost. Nevertheless, this material remains susceptible to environmental factors such as water absorption, which may induce changes in its physical properties over time [6]. Surface hardness is a critical property for denture base materials as it directly influences resistance to wear, scratching, and overall surface degradation. Variations in hardness can occur when acrylic resin is exposed to different storage media or chemical agents over extended periods, reflecting alterations in the polymeric network [7]. In recent years, the use of natural oils in dental material research has increased due to their bioactive components, including fatty acids, phenolic compounds, and terpenes, which may interact with the resin surface or penetrate its microstructure, potentially modifying mechanical and surface properties [8,9].The present study the effect of two natural oils, lemon oil and flaxseed oil, on polymerized acrylic resin hardness used as a denture base material. Prior to immersion, minor differences in surface hardness were observed, with the lemon oil group demonstrating the highest initial hardness compared to the flaxseed oil and control groups. This effect may be attributed to the chemical composition of lemon oil, particularly its terpenes and limonene content, which can interact with the resin surface and partially fill micro-pores, enhancing surface cohesion and slightly increasing hardness [9]. After two months of immersion, significant changes in surface hardness were observed. Specimens immersed in flaxseed oil exhibited the highest mean hardness, followed by the lemon oil group, whereas the control group recorded the lowest values. The decline in the control group is likely due to water penetration acting as a plasticizer, increasing inter-chain spacing and reducing intermolecular forces, ultimately resulting in material softening [10]. Conversely, the improved or maintained hardness in the oil-treated groups may be attributed to the hydrophobic nature of these oils, which limits water diffusion into the polymer network [8]. Flaxseed oil, in particular, contains a high proportion of unsaturated fatty acids, such as linolenic acid, which may form a protective layer on the resin surface, acting as a barrier against moisture penetration. Its higher viscosity compared with lemon oil allows it to remain longer on the surface, enhancing the protective effect during extended immersion [8,11]. These findings indicate that the type of immersion medium significantly influences the hardness strength of materials, and the use of natural oils may effectively mitigate the deleterious effects of water absorption while preserving mechanical integrity. Lemon oil demonstrated a positive effect on

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initial hardness, whereas flaxseed oil showed a superior ability to maintain hardness during prolonged immersion. These outcomes suggest that the chemical composition, viscosity, and hydrophobic nature of the oils play a crucial role in modulating the surface properties of acrylic resin. Several previous investigations support these findings. Al-Rawi et al. (2010) evaluated thyme and Nigella oils and reported improved surface hardness compared with controls, suggesting that these oils reduce water sorption and enhance resistance to softening [12]. Mohammed et al. (2024) found that rosemary oil increased acrylic resin hardness, whereas coconut oil produced variable effects depending on concentration, confirming that the type of oil significantly affects hardness changes [13]. These studies are in agreement with the present results where lemon and flaxseed oils enhanced or maintained surface hardness. Conversely, some studies reported different findings. Sari et al. (2021) examined lemongrass oil nanoparticles and found no significant effect on acrylic resin hardness, although antimicrobial benefits were observed. Similarly, Hassan (2025) reported that tea tree and clove oils did not significantly enhance surface hardness, and in some concentrations slightly reduced it. These differences may be due to variations in oil composition, concentration, and method of incorporation, partially explaining the differences from the present study where lemon oil showed increased initial hardness and flaxseed oil preserved hardness over time [10]. Overall, the present study confirms that natural oils, particularly lemon and flaxseed oils, can enhance or preserve the surface hardness of acrylic resin, with effects dependent on chemical composition, viscosity, and hydrophobicity. These findings indicate a promising approach to improving the durability and longevity of acrylic-based denture materials in clinical applications.

Conclusion

Immersion in natural oils, specifically linseed and lemon oil, effectively preserved or enhanced the hardness strength of polymerized heat resin, in contrast to the control group immersed in distilled water, which exhibited a decrease in surface hardness ,and Lemon oil demonstrated a beneficial effect on the initial surface hardness, likely due to its terpene and limonene content, while linseed oil proved more effective in maintaining superior hardness over the extended two-month immersion period, which is attributed to its high concentration of unsaturated fatty acids and hydrophobic nature. Also, the type of immersion medium significantly influences the mechanical properties of acrylic denture base materials, with hydrophobic natural oils acting as a protective barrier against the plasticizing effect of water absorption, thereby contributing to the long-term durability and clinical performance of the prosthesis.

Conflicts of Interest

The authors declare no conflicts of interest.

References

1. Jawad, I.A.M., A.A. Qasim, and R.M. Hasan, Evaluation of surface hardness of denture base acrylic resin modified with different techniques. Al-Rafidain Dental Journal, 2023. 23(2): p. 284-297.
2. Sadek, S.A., W.M. Dehis, and H. Hassan, Different materials used as denture retainers and their colour stability. Open Access Macedonian Journal of Medical Sciences, 2018. 6(11): p. 2173.
3. Alfahdawi, I.H., Polymeric additions effect on mechanical properties of heat-polymerized denture base resin: an in vitro study. Discover Materials, 2025. 5(1): p. 97.
4. Al-Ameri, A., et al., An In-Vitro evaluation of strength, hardness, and color stability of Heat-Polymerized and 3D-Printed denture base polymers after aging. Polymers, 2025. 17(3): p. 288.
5. Khasraw, S.A. and J.F. Abdulkareem, Comparison of Flexural Strength, Hardness, and Surface Roughness of Heat-Cured and 3D-Printed Acrylic Resin Materials After Immersion in Different Disinfectants: An In Vitro Comparative Study. Oral, 2025. 5(4): p. 81.
6. Alqutaibi, A., et al., Polymeric Denture Base Materials: A Review. Polymers 2023, 15, 3258. 2023.
7. Azab, A., et al., Systematic review and meta analysis of mechanical properties of 3D printed denture bases compared to milled and conventional materials. Scientific Reports, 2025. 15(1): p. 29207.
8. Zafar, M.S., Prosthodontic applications of polymethyl methacrylate (PMMA): An update. Polymers, 2020. 12(10): p. 2299.
9. Budiarto, R., et al., Antioxidant properties of lemon essential oils: a meta-analysis of plant parts, extraction methods, dominant compounds, and antioxidant assay categories. Chemical and Biological Technologies in Agriculture, 2024. 11(1): p. 147.
10. Rafeeq, A.K., I.A. Salman, and S.W. Ibrahim, Evaluation of Hardness, Impact, and Transverse Strength Tests of Heat-Cured Acrylic Denture Base Material Following the Addition of Watercress, Tea Tree, and Clove Oils: An In Vitro Study. Dental Hypotheses, 2025. 16(1): p. 23-26.
11. Alqutaibi, A.Y., et al., Polymeric denture base materials: a review. Polymers, 2023. 15(15): p. 3258.
12. Hatim, N.A., et al., The Effect of thyme and nigella oil on some properties of acrylic resin denture base. 2010.
13. Altaie, S.F., Favorable Effect of Some Herbal Oils on Acrylic Resin Properties. Al-Rafidain Dental Journal, 2024. 24(1): p. 174-190.

Table 1. Descriptive statistics of acrylic samples before immersion.

Groups	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Group A	7	82.886	0.684	0.259	81.7	83.5
Group B	7	82.386	1.032	0.39	80.9	83.8
Group C	7	83.829	0.585	0.221	82.8	84.5
Total	21					

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Table 2. One-way ANOVA for acrylic samples before immersion.

ANOVA	Sum of Squares	df	Mean Square	F	P-value
Between Groups	7.515	2	3.758	6.011	0.01
Within Groups	11.251	18	0.625		
Total	18.767	20			

Table 3. LSD test for acrylic before immersion.

(I) Groups	(J) Groups	Mean Difference (I-J)	P-value	95% CI Lower	95% CI Upper
Group A	Group B	0.500	0.252	-0.388	1.388
Group A	Group C	-0.943	0.039	-1.831	0.000
Group B	Group C	-1.443	0.003	-2.331	0.000

Table 4. Descriptive statistics of acrylic samples after immersion.

Groups	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Group A	7	82.343	1.075	0.406	81.2	84.4
Group B	7	85.314	1.549	0.585	83.0	87.0
Group C	7	84.571	0.547	0.207	83.8	85.4
Total	21					

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Table 5. One-way ANOVA for acrylic samples after immersion.

ANOVA	Sum of Squares	df	Mean Square	F	P-value
Between Groups	33.478	2	16.739	13.032	0.000
Within Groups	23.12	18	1.284		
Total	56.598	20			

Table 6. LSD test for acrylic after immersion.

(I) Groups	(J) Groups	Mean Difference (I-J)	P-value	95% CI Lower	95% CI Upper
Group A	Group B	-2.971	0.000	-4.244	0.000
Group A	Group C	-2.229	0.002	-3.501	0.000
Group B	Group C	0.743	0.236	-0.53	2.016