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Favorable Effect of Some Herbal Oils on Acrylic Resin Properties

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Abstract

Aims: To estimate the effects of plant oil (coconut oil and/or rosemary oil) in two concentrations on the hardness and roughness of cold-cured acrylic resin. **Materials and Methods**: 50 samples each measuring 30 mm in diameter and 3 mm in thickness were made from cold-cured acrylic resin. Forty samples were made with the addition of rosemary and coconut oils at concentrations of 1.5% and 2.5%, respectively, while ten samples were made without any oils (the control). Each oil concentration is represented by those ten samples. A profilometer was used to measure the surface roughness (µm) and shore D hardness for each group. One-way analysis of variance (ANOVA) and the LSD test were both used to analyze the results. A level of P≤0.05 was regarded as significant. **Results:** Adding rosemary at concentrations of 1.5% and 2.5% would increase the value of Shore D hardness, causing an enormous variance from the control ($P \leq 0.05$). However, the addition of coconut oil considerably decreased the shore D hardness in comparison to the control group. Apart from the 2.5% coconut oil, which resulted in an extremely significant rise in surface roughness from the control and other experimental groups, the results revealed no noticeable difference in surface roughness between the control group and experimental groups. **Conclusions:** The hardness of cold-cured acrylic resin was increased when adding rosemary oil in concentrations of 1.5% and 2.5%, with 1.5% rosemary achieving the best findings. However, there was no effect on surface roughness when adding rosemary and coconut oil, excluding the concentration of 2.5% coconut oil, which had an adverse impact on the surface roughness of cold-cured acrylic resin.

تأثير إيجابي لبعض الزيوت العشبية على خصائص راتنج الاكريليك

الملخص

الأهداف: تهدف هذه الدراسة لتقييم تاثير الزيوت النباتية (جوز الهند واكليل الجبل) بتركيزين (1.5% و 2,5%) على صلادة وخشونة سطح راتنج الاكريلك البارد. **المواد وطرائق العمل:** تم تحضير 50 عينة بابعاد (القطر 30مليمتر والسمك 3 مليمتر)من مادة راتنج الاكريلك البارد.تم تحصير 40 عينة مع إضافة زيت اكليل الجبل و جوز الهند بتركيزين 1.5% و 2,5% (تم تقسيمها الى 4 مجاميع لكل مجموعة 10 عينات) كما تم تحضير عشرة عينات بدون إضافة كوحدة سيطرة .خضعت جميع المجاميع الى فحص الصلادة نوع (Shore D) وأيضا فحص خشونة السطح بالمايكروميتر باستخدام جهاز (Profilometer). تم تحليل بيانات الدراسة عن طريق اختبار التباين (ANOVA) احادي الاتجاه واختبار اقل قيمة معنوية (LSD) عند قيمة الاحتمالية (P≤0.05). **النتائج:** أظهرت النتائج ان إضافة زيت اكليل الجبل بتركيزين 1.5% و 2,5% قد زاد من قيمة الصلادة لراتنج الاكريلك البارد أدى الى فرق معنوي كبير عن مجموعة السيطرة، لكن إضافة زيت جوزالهند قلل من صلادة سطح راتنج الاكريلك البارد.اضهرت النتائج ان إضافة زيت جوزالهند واكليل الجبل أدى الى اختلاف غيرملحوظ لخشونة سطح راتنج الاكريلك البارد لجميع مجاميع الدراسة ومجموعة السيطرة باستثناء تركيز 2,5% جوزالهند الذي أدى الى زيادة كبيرة لخشونة السطح. **الاستنتاجات:** صلادة راتنج الاكريلك البارد زادت بإضافة زيت اكليل الجبل بتركيزين 1.5% و 2,5% وافضل النتائج كانت لتركيز1.5% كما انه ليس هناك تاثير على خشونة السطح عند إضافة زيت جوز الهند واكليل الجبل باستثناء تركيز 2,5% جوز الهند الذي أدى الى تاثير سلبي على خشونة سطح راتنج الاكريلك البارد.

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INTRODUCTION

In light of the heat cure denture base resins outstanding characteristics, heat-cured denture base resins are commonly used as denture base material. There are a lot of advantages to using heat-cured polymethyl methacrylate (PMMA) as the basic material for dentures, including its good aesthetics, low water adsorption, and solubility, relative lack of toxicity, repairability, as well as simple processing technique [(1)]. PMMA is also being recognized for its affordability, simplicity of application and polishing, and reliance on basic processing equipment [(2)]. Another type of resin that is rarely used to make denture bases as heat-activated resins is chemically-activated or auto-polymerizing resin [(3)]. Both chemically activated resin and heat-cured acrylic resin denture base materials are approximately similar, but the only difference is the way the polymerization of the cold-cured one begins at room temperature. The composition of the monomer is varied by adding a chemical activator in the form of a tertiary amine, such as dimethyl paratoludin, to activate benzoyl peroxide and start the polymerization process [(4)]. One of the most common dental materials is cold-cured acrylic resin, which can be used for temporary crowns and bridges, repair, relining, orthodontic appliances, and maxillofacial prosthetics [(5)]. Self-cured resins reduce the duration of laboratory procedures required, but the remaining monomer raised the potential hazards of tissue reactions and lowered fracture resistance [(6)].

The increasing porosity and instability in color have been the main drawbacks of cold-cured acrylic [(7)]. The type of processing could have an effect on mechanical characteristics including hardness [(8)]. The hardness would be highly affected by the amount of residual monomer in the polymerized resin [(3)]. The hardness test is regarded as a simple and effective means of determining the mechanical features of materials based on polymers. The enhanced mechanical qualities, particularly hardness, may be applied to improve wear resistance [(9)]. Surface roughness has a direct effect on *C. albicans* adherence and biofilm formation on acrylic surfaces, probably due to PMMA larger surface areas and protected sites for colonization [(10)]. Surface roughness and *C. albicans* adherence have been directly correlated as shown in some studies. Once the surface roughness increased, both accumulation of plaque and adherence of organism enhanced [(11)].

Herbal remedies provide an effective, less-or-no-side-effect option for treating oral microbial infections. Therefore, there is an international tendency towards studying them in an attempt to find biologically safe, herbal-based medications with potent antifungal features [(12)]. Plant oils are one of these herbal medications. The impact of various oils on *C. albicans* has recently been the subject of many studies, and the findings suggest that plant oils are an appealing therapy with excellent antifungal capabilities for the treatment of denture-induced stomatitis [13]. There has been a growing interest in the usage of naturally occurring products recently. Essential oils are concentrated hydrophobic liquids derived from plants that have a variety of pharmacological actions. Several countries make use of essential oils in herbal medicine due to their antibacterial properties [14]. It has been long established to cultivate rosemary (*Rosmarinus officinalis L.*), as being regarded as a very significant medicinal and aromatic plant of the Lamiaceae family. It is thought that Ancient Egypt, Mesopotamia, China, and India have all used rosemary as a medicinal, culinary, and cosmetic ingredient [15] consequently, it is a plant that is commonly used as medicine today. Rosemary has a broad number of medicinal properties including antioxidant and antibacterial ones [16]. It has been acknowledged as a potent chemo-preventive agent [17]. Virgin coconut oil (VCO) is a chemical-free and additive-free material generated from fresh coconut or its byproducts (coconut milk and coconut milk residue) that has not been chemically treated after being extracted. It is the purest type of coconut oil, water is white in color, contains natural vitamin E, and has not been exposed to hydrolytic or atmospheric oxidation, as attested by its very low peroxide value and free fatty acid content. There are a lot of benefits related to consuming this oil such as immunity function improvement, weight control, and heart disease prevention. Having the medium chain tryglycerides (MCTs) is one of the characteristics of VCO. Lauric acid is the most essential medium-chain fatty acid detected in VCO. It accounts for 48% of VCO [18]. Coconut oil is capable of being used as a substitute plasticizer in the polymer sector. It is generally accepted that oil includes more fatty acids and may serve as a good plasticizer even in insignificant amounts [19]. Nevertheless, no studies have yet looked into how plant oils affect the physical and mechanical properties of cold-cured acrylic resin. This in vitro experiment aimed at measuring how adding rosemary and coconut oils at two concentrations affected the hardness and roughness of cold-cured acrylic resin. The null hypothesis is that the hardness and roughness of cold-cured acrylic resin will not be affected by the addition of rosemary and coconut oils.

MATERIALS AND METHODS

Based on the type and concentration of oil used in the current study, 50 samples of cold-cured acrylic resin powder poly (methylmethacrylate) (veracril®, New Stetic S.A.,Colombia) and monomer (methylmethacrylate) (veracril®, New Stetic S.A., Colombia) were prepared and split into 5 groups classified as follows:

Group 1: (control) with 0% without any additive, group 2: samples of cold-cured acrylic resin were combined with

1.5% rosemary oil, group 3: samples of cold-cured acrylic resin were combined with 2.5% rosemary oil, group 4: cold-cured acrylic resin samples were combined with 1.5% coconut oil and group 5: samples of cold- cured acrylic resin were combined with 2.5% coconut oil by volume of oils (n=10 samples for each group).

Samples design

A plastic pattern was created to prepare molds for acrylic samples. To conduct hardness and roughness tests, a plastic pattern was created into the disk-shaped pattern as shown in Figure (1) with 30 mm in diameter and 3mm in thickness [20].

Figure (1): Plastic patterns

Mold preparation for acrylic samples

The plastic disk-shaped pattern was coated with a separating medium (Spofa Dental, Czech Republic) and set aside to dry. The type 4 dental die stone (Zhermack, Italy) was incorporated as directed by the manufacturer [21] and then placed in the bottom half of the flask as shown in Figure (2) before vibration to get rid of air bubbles. The plastic patterns were placed to nearly half of their total depth. After the bottom half was set, it was coated with a separating medium and allowed some time to dry. The upper half of the flask was to be filled with the stone, vibrated, and then covered and set aside to set [22]. After setting the stone and separating the two halves of the flask, the plastic patterns were thrown away to make room for the samples of cold-cured acrylic resin as in Figure (3).

Figure (2): Flasking of plastic patterns

Figure (3): Mold for packing procedure

Packing procedure

The cold-cured acrylic powder poly (methylmethacrylate and monomer (methylmethacrylate) for the control group were made in compliance with the instructions given by the manufacturer. The mixture was put into a separating medium-coated mold as soon as it reached the dough stage and then placed under a hydraulic press for 15 minutes [23]. After the polymerization time recommended by the manufacturer, the specimens were taken out from the molds to be checked for air bubbles, and then to exclude all the defective samples from the study

Before the specimens are ground with 320 grit size silicon carbide paper, flashes should be removed and the edges should be trimmed to have a better polished surface (3). It should be mentioned that polishing is conducted only on the side used for the microhardness (Shore D) test, whereas the other side was used for the roughness test.

Incorporation of coconut oil and rosemary oil for experimental groups

To get an exact P/L ratio, the amount of coconut oil and rosemary oil (Ridah Alwan Co., Iraq), Figure (4) in concentrations of 1.5% (0.15ml) and 2.5% (0.25ml) for each kind of oil was deducted from the total amount of the monomer (24 & 25).

Figure (4): A: Coconut oil; B: rosemary oils

The acrylic implemented in the control group was also used in the experimental group. For full homogeneity, the coconut oil or rosemary oil was incorporated with monomer for 20 seconds (26) with a probe sonication unit at 120 W and 60KHs (Soniprep 150, MSE (UK)LTD, England). Later, the powder element was added and then the mixture was mixed, packed, and processed as instructed by the manufacturer in the control group procedure (25). All of the samples were soaked in distilled water at 37°C for 2 days for conditioning before being assessed (7, 27).

Surface hardness test

A digital Shore D microhardness tester durometer (Shore D, HT-6510A, BYQTER, China, DIN53505, ISO/R868, ASTM D2240, JIS R7215), Figure (5) has been used to determine the hardness of the polished surface. Typically, the indenter was quickly and firmly compressed with the applied load equal to 50 N and a depressing time of measuring equal to 10 seconds whereas the highest reading was being recorded. For each sample, the average of three measurements that were collected at different sites was recorded (24).

Figure (5): Sample under the test of Shore D hardness.

Surface roughness test

A digital roughness tester (TR220 Portable Roughness Tester, TIME Group Inc.

Beijing TIME High Technology Ltd.) has been used during the surface roughness test. There is a sharp, sensitive, and diamond-made needle (stylus) in this device, which serves as a surface analyzer to record the reading of surface roughness and the profile of surface defects Figure (6). The test was performed according to the profilometer instructions [22]. Each sample was subjected to three measurements and the average value was calculated.

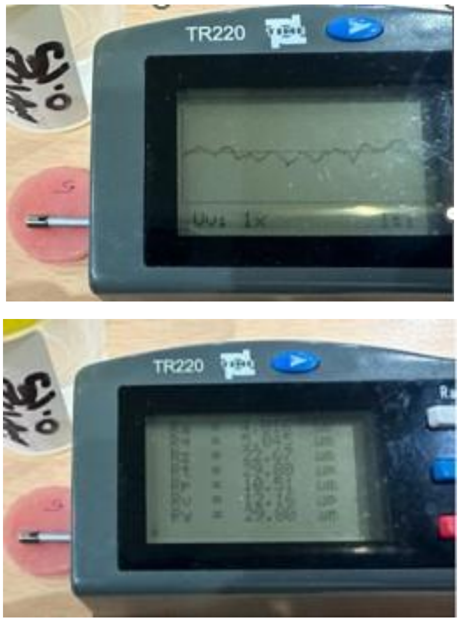

Figure (6): Sample with surface roughness tester

Statistical method

The Statistical Package for Social Science (SPSS) version 20 has been used as computer software for analyzing the findings of the research. Descriptive statistics consists of mean, standard deviation, minimum, and maximum and graphical presentation via bar chart., Shapiro-Wilk test was used to determine the normality distribution for Shore D hardness and surface roughness (µm) for all the groups. Inferential statistics, on the other hand including One-way analysis of variance (ANOVA) was used to compare means among all groups whereas Less Significant Difference (LSD) was used for multiple comparisons for both hardness and roughness (µm) tests. Statistically $P \leq 0.05$ was deemed as significant. However, a highly significant P-value was recorded for ≤ 0.01.

RESULTS

Hardness test

The shore D hardness test results demonstrated that the rosemary oil groups had a higher mean value in shore D hardness than the control group at two different oil concentrations (1.5% and 2.5%). As seen in Tables (1 & 2) and Figure (7), the 2.5% coconut oil group, however, had a lower mean value in comparison to the control group.

Table (1): Mean values of microhardness (Shore D) for all tested groups

	N	Mean	Std. Deviation	Minimum	Maximum
Control group	10	78.925	3.161	74.666	84.500
Rosemary oil 0.15	10	83.925	1.808	81.333	86.166
Rosemary oil 0.25	10	81.240	3.930	74.833	85.000
Coconut oil 0.15	10	77.203	3.892	68.333	81.833
Coconut oil 0.25	10	66.388	9.770	55.000	86.666
Total	50	77.536	7.894	55.000	86.666

Table (2): Normality test for microhardness (Shore D) using Shapiro-Wilk test.

Groups for Hardness test (shore D)	Shapiro-Wilk		
	Statistic	df	P value
Control group	.938	9	0.560
Rosemary oil 0.15	.907	9	0.294
Rosemary oil 0.25	.865	9	0.109
Coconut oil 0.15	.871	9	0.125
Coconut oil 0.25	.922	9	0.412

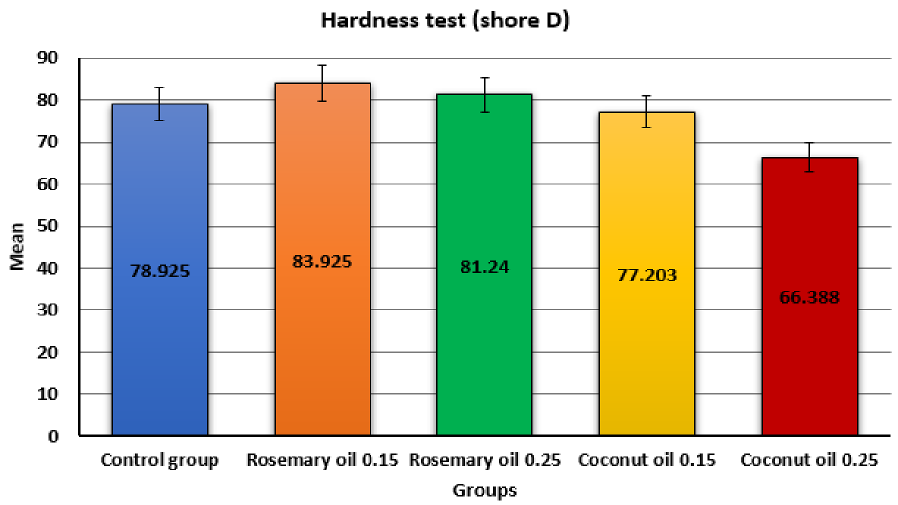

Figure (7): Bar chart showing the mean value of microhardness (Shore D) for all tested groups.

The analysis of variance (ANOVA) test Table (3) showed a highly significant difference between the experimental and control groups at P≤ 0.001. As a consequence, the LSD test of multiple comparisons was conducted among all the groups analyzed as showed in Table (4). There was no significant difference between the mean values of both groups, except with the 2.5% coconut oil group, which revealed a highly significant difference P≤ 0.001.

Table (3): The analysis of variance (ANOVA) test for the microhardness test (shore D).

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1627.665	4	406.916	14.602	< 0.001
Within Groups	1114.708	40	27.868		
Total	2742.373	44			

Table (4): Post Hoc Test (LSD) for microhardness (Shore D) among tested groups.

	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.
LSD	**Control group**	Rosemary oil 0.15	-5.000*	2.489	0.050
		Rosemary oil 0.25	-2.315	2.489	0.358
		Coconut oil 0.15	1.722	2.489	0.493
		Coconut oil 0.25	12.536**	2.489	<0.001
	Rosemary oil 0.15	Rosemary oil 0.25	2.685	2.489	0.287
		Coconut oil 0.15	6.722**	2.489	0.010
		Coconut oil 0.25	17.536**	2.489	<0.001
	Rosemary oil 0.25	Coconut oil 0.15	4.037	2.489	0.113
		Coconut oil 0.25	14.851**	2.489	<0.001
	Coconut oil 0.15	Coconut oil 0.25	10.814**	2.489	<0.001

* The mean difference is significant (P value ≤ 0.05), ** The mean difference is highly significant (P value ≤ 0.01)

Surface roughness test

The results of the surface roughness test, as seen in Table (5) and Figure (8) were found to have similar mean values for each, whereas the 2.5% of coconut oil revealed the highest average value in surface roughness. Regarding the analysis of variance (ANOVA) test, Tables (6 & 7) showed a highly significant difference between the experimental and control groups at P≤ 0.001. Table (8) provided the results of an LSD test which revealed a highly significant difference of P≤ 0.001 when compared coconut oil 2.5 to the other groups.

Table (5): Mean values of surface roughness(µm) for all tested groups.

	N	Mean	Std. Deviation	Minimum	Maximum
Control group	10	2.047	0.147	1.908	2.376
Rosemary oil 0.15	10	2.494	0.185	2.245	2.758
Rosemary oil 0.25	10	2.443	0.213	2.184	2.845
Coconut oil 0.15	10	2.652	0.590	1.507	3.430
Coconut oil 0.25	10	5.135	1.291	2.928	6.682
Total	50	2.954	1.281	1.507	6.682

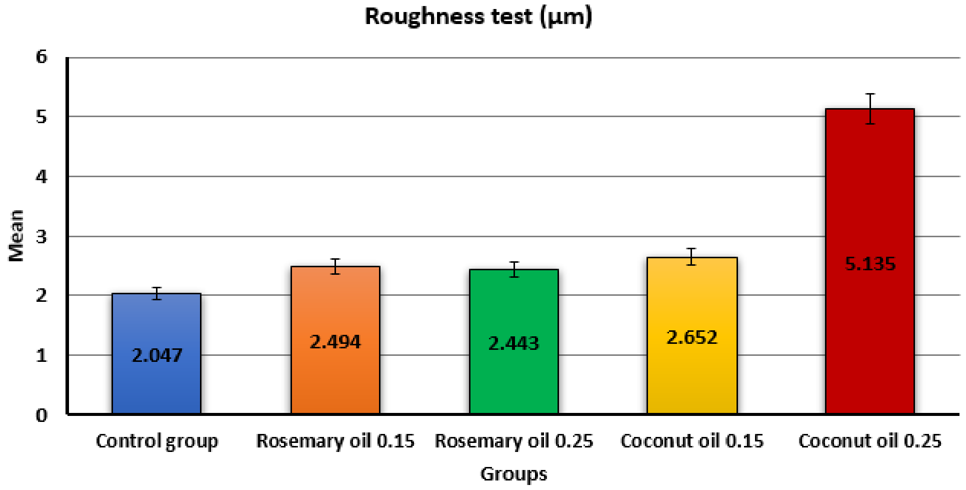

Figure (8): Bar chart showing the mean value of surface roughness (µm) for all tested groups.

Table (6): Normality test for Surface roughness (µm) using the Shapiro-Wilk test.

Groups for Roughness test (µm)	Shapiro-Wilk		
	Statistic	df	P value
Control group	.965	9	0.080
Rosemary oil 0.15	.908	9	0.303
Rosemary oil 0.25	.930	9	0.480
Coconut oil 0.15	.952	9	0.708
Coconut oil 0.25	.943	9	0.611

The data for all the groups in both microhardness (Shore D) and surface roughness are normality distributed since P value is greater than 0.05.

(7): The analysis of variance (ANOVA) test for surface roughness test (µm).

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	55.274	4	13.818	32.652	<0.001
Within Groups	16.928	40	.423		
Total	72.202	44			

Table (8): Post Hoc Test (LSD) for surface roughness(µm) among tested groups.

	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.
LSD	Control group	Rosemary oil 0.15	-0.447	0.307	0.153
		Rosemary oil 0.25	-0.396	0.307	0.204
		Coconut oil 0.15	-0.605*	0.307	0.055
		Coconut oil 0.25	-3.087**	0.307	<0.001
	Rosemary oil 0.15	Rosemary oil 0.25	0.051	0.307	0.868
		Coconut oil 0.15	-0.158	0.307	0.609
		Coconut oil 0.25	-2.640**	0.307	<0.001
	Rosemary oil 0.25	Coconut oil 0.15	-0.209	0.307	0.499
		Coconut oil 0.25	-2.691**	0.307	<0.001
	Coconut oil 0.15	Coconut oil 0.25	-2.482**	0.307	<0.001

* The mean difference is significant (P value ≤ 0.05).
** The mean difference is highly significant (P value ≤ 0.01).

DISCUSSION

Based on the outcomes of this in vitro study, the null hypothesis was rejected. The outcomes of this investigation revealed an increase in hardness value when applying rosemary oil concentrations of 1.5% and 2.5%, with a higher hardness value reported for the 1.5% concentration. Yet, there is no significant statistical difference between them. The optimum saturation of the matrix formation between PMMA and oil occurred at concentrations of 1.5% and 2.5%, which might account for such an effect. This can be attributed to the water sorption of meth methacrylate denture base material. It seems also probable that this is due to unreacted monomer with oil-coated polymer (27). There is a link between residual monomer and water sorption in such a way that less monomer conversion occurs if residual monomer is present, which could end up resulting in increased sorption since hardness increases as long as water sorption increases. Thus, both of those characteristics are related to surface properties (28 & 29).

This result is in agreement with Hatim *et al.*, (27) in addition to Al-Nema *et al.*, (28) who proved that the hardness would increase when adding Ginger, Marmia, and Eucalyptus to heat-cured acrylic resin. However, these findings are in contrast to those of Shukur (21), who used tea tree oil to heat-cure acrylic resin and observed that the hardness decreased as long as the concentration of tea tree oil increased. This difference may be attributed to the type of essential oil used in the study or the different oil concentrations applied. It should be mentioned that the effect of rosemary oil on the mechanical properties of PMMA, whether from heat-cured or cold-cured acrylic resin has not yet been discussed in other studies associated with the same field. Furthermore, the mechanism of rosemary oil has not been fully investigated because of the existence of various groups of chemicals. The mean value of micro-hardness is highly significantly reduced by P≤0.001 when virgin coconut oil in varied quantities is added to cold-cured acrylic resin at two different oil concentrations: 1.5% and 2.5%. This could be attributed to the prospective use of coconut oil as a substitute plasticizer in the polymer sector. Oil can work as a good plasticizer even in tiny quantities, as it includes more fatty acids than any other materials. (30) Plasticizers are commonly used as typical additives in addition to their capability of reducing the viscosity of the materials and, at the same time, enhancing chain mobility, workability, low-temperature resistance, and weathering resistance (31), being unattached to the resin permanently, plasticizers leach away and cause considerable changes to the mechanical properties of the material (32). Due to its tendency to act as a transition phase between polymer chains, coconut oil decreases polymer-polymer interactions, and, consequently, reduces thermal stability (33).

In addition, it was found that the addition of coconut oil to a polylactic acid matrix causes the load at the break to decrease. This may be explained by a decrease in the intermolecular forces between polymer chains (19).

According to Alemen *et al.*, (34), there was no evidence of a chemical reaction between virgin coconut oil and lining materials. This indicates that the link between lining material and virgin coconut oil tends to be physical rather than chemical (34). Once an organic oily additive is added to the polymer lattice, the physical configuration of the lattice changes from an irregular pattern to another one that is more regular and straighter, causing the polymer chains to slide over one another and produce a more flexible material (7). Lee *et al.*, demonstrated that the remaining monomer molecules act as plasticizers and, as a result, affect the resilience of polymerized resin (35).

The findings of the present research are in agreement with those of Rahi and Mahmood, who proved that the hardness of acrylic resin is indirectly proportional to radish oil concentration in a way that the former decreased as long as the latter rose. This decrease may be a result of oil-coating polymer particles, which prevent monomers from being converted into polymers and leave a large number of monomers. The latter has an adverse impact on the mechanical features through a plasticizing effect (24). It is, thus, concluded that the matrix of virgin coconut oil-cold-cured acrylic resin demonstrates a decrease in hardness. Furthermore, there are no comparable studies in this domain to figure out the findings of this research. The hardness of 1.5% concentration of coconut oil is higher than that of 2.5% concentration, which may be the result of an unreacted monomer with an oil-coated polymer and is in agreement with Al-Nema's *et al.*, findings (28). While opposing Alamen *et al.*, (34) who discovered a highly noticeable drop in the hardness values for 1.5% virgin coconut oil in comparison to that of 2.5%. This might be explained by the fact that the study done by Alamen *et al*., who used soft liner material, was different from the material used in our study.

According to a study by Bhasney *et al.*, coconut oil would enter or diffuse within polylactic acid chains at lower concentrations, strengthening interfacial adhesion, which can be described as network formation. Nevertheless, the molecules of the coconut cling together as the concentration of coconut oil rises, resulting in empty void pockets along with the absence of any network. The enhancement of flexibility was, therefore, accomplished [(19)]. The research revealed that rosemary oil has higher hardness than coconut oil, which may be associated with the chemical composition of the main unsaturated fatty acids, which were linoleic acid, oleic acid, and lignoceric acid [(36)].

The object's interaction with its environment is significantly influenced by the material's surface roughness as being regarded as a vital property [(37)]. One of the key objectives of resin restoration is to establish a highly smooth surface free of small scratches, if any, so that the accumulation of microorganisms on the exterior surface can be lessened, as possible, on the final restoration. [(38)] The value of roughness in other studies varies due to changes in the method applied, including experimental procedures and surface roughness measuring processes. This is attributed to the fact that the roughness of a material is mostly determined by its inherent features, operator skills, and polishing technique [(39)].

According to the findings of the current research, incorporating 1.5% coconut oil and rosemary oil and 2.5% rosemary oil into the cold-cured acrylic resin would produce the same mean value of the surface roughness. Statistically, there was a highly significant difference between the control group and 2.5% coconut oil, whereas the difference between the control group and 1.5% coconut oil was significant. This can be recognized by studying the polylactic acid-coconut oil surface, which exhibits abnormalities and coarse fractures, according to studies by Bhasney *et al*., Yet, adding smaller concentrations of coconut oil, like 1wt%, resulted in a smooth surface with network-like growth and no aggregates, providing a proof of the plasticizer's strong compatibility with the polylactic acid matrix. It is important to note that coconut oil has a low melting point of 24 °C and that cold-cured acrylic resin can be polymerized at room temperature. Despite this, the polymerization process generates heat that could help coconut oil to vaporize and become trapped inside the cold-cured acrylic resin, which upon cooling creates voids. With the support of shear force during processing and diffusion of polymer chains through the coconut oil droplets, the coconut oil droplets were partially intercalated or exfoliated.

However, some agglomerates of unexfoliated coconut oil droplets were still present. Using coconut oil as a plasticizer through polylactic acid makes it much easier to diffuse, which could contribute to the exfoliation of coconut oil droplets [19].

It should be mentioned that there are not enough studies in this domain to compare the findings of the current research with those of other studies. When Naser and Abdul-Ameer [22] mixed lemongrass essential oil with heat-curing soft lining material, they concluded that surface roughness had decreased more in the experimental groups than in the control group. This discrepancy with the findings of the present research may be attributed to the different types of materials used because they used soft liner and seed oil in their study. It also contradicts both of Muttagi and Subramanga [26].

On the contrary, Godil [40] applied osmium sanctum oil to soft denture lining and discovered that the roughness of the surface was unaffected, which may support this finding. Namala and Hegde [41] used heat cure specimens soaked in a thyme essential oil solution, and they observed that there was just a slight rise in surface roughness. This may be because of the difference in procedure represented by the samples being immersed in the oil solution rather than having the oil incorporated into the acrylic resin material.

Based on a different study, the reason why the control group was higher than the experimental groups in surface roughness was likely due to the acceleration of polymerization, promoting further arrangement and addition of polymer chains, creating a fine, smooth surface [39].

As a result of the chemistry between the molecules of oil and the particles of resin, a decrease in surface roughness may be caused by an increase in the polymer chains bonds which, in turn, leads to fewer particles chipping apart from the surface during de-flasking and grinding [26] Since this might not have occurred in this study, the result of surface roughness was not lower than that of the control group.

It is of great importance to consider the changes in experimental procedures, as well as the type of acrylic resin, surface hardness, and roughness measuring protocols used. It seems difficult to compare hardness and roughness values from different investigations. Further research is highly required to assess the roughness, hardness, as well as other physical and mechanical qualities after adding oils since the specimens used in this in vitro study failed to accurately represent the size or anatomy of the acrylic resin denture base for complete dentures or the oral environment found in the oral cavity.

CONCLUSION

Considering the limitations of the present investigation, rosemary oil could increase hardness at concentrations of 1.5% and 2.5%, achieving the best results with the 1.5% concentration. Except for coconut oil at a concentration of 2.5% which appeared to have the highest roughness rating of all groups, there was no effect of adding rosemary oil or coconut oil on the surface roughness.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this manuscript.

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