An Evaluation of Olive Oil as a Separating Medium and Its Effect on Some Mechanical Properties of Processed Acrylic Resin Denture Base (A Comparative Study). Part Two

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ABSTRACT

Background: During acrylic resin processing, the mold must be separated from the surface of the gypsum to prevent liquid resin from penetrating into the gypsum, and water from the gypsum seeping into the acrylic resin. For many years, tin foil was the most acceptable separating medium, and because it's difficult to apply, a tin-foil substitute is used. In this study, olive oil is used as an alternative to tin foil separating medium for first time, and evaluating its effect as a separating medium on some mechanical properties such as (indentation hardness and transverse strength) of acrylic resins denture base comparing it with those processed using tin-foil and tin foil substitute such as (cold mold seal) separating medium.

Materials and Methods: One hundred Twenty four acrylic resins samples (124) were prepared falling in two main groups: (heat and cold-cured acrylic denture base resins), for each group three types of separating medium were used and five tests (10 samples) for each test were carried out, and (4) samples for the chemical composition.

Results: Tin foil is one of the most satisfactory separating media in getting the best properties when using it as a separating medium, while, a statistically no-significant difference have been noticed between olive oil and cold-mold seal samples concerning mechanical properties of tested groups. Infrared spectroscopy analysis showed that, no changes were found in the chemical composition of both heat and cold-cured acrylic resins denture base after using olive oil as a separating medium.

Conclusion:The present study concluded that olive oil may be used as a substitute for tin foil and cold – mold seal separating medium in processing both heat and cold – cure acrylic resin denture base.

Keywords: Acrylic resin separatingmedium olive oil, mechanical properties. (J Bagh Coll Dentistry 2015; 27(4):52-61).

INTRODUCTION

Separating medium is a coating applied to a surface serving to prevent a second surface from adhering to the first, or a material, usually applied on an impression to facilitate removal of the cast[(1)].If the surface of the mold is not coated with a separating material, it will be found, that a layer of gypsum impregnated with polymer remains attached to the surface of the denture and is extremely difficult to remove[(2)]. Then it is an improperly contoured, and hence it leads to produces an unaesthetic and poorly fitting denture base [(3)]. Therefore; separating medium must be applied to the surface of the mold.

Many authors consider that tin foil is the best separating medium, however it is difficult to apply, tedious, and time-consuming. As a result, the solution is sometimes referred to as a tin foil substitute have been developed[(4)].A tin foil substitute is a film forming material that is painted on the mold surface thus preventing absorption the liquid acrylic denture base resin and at the same time sealing pores of the artificial stone [(5)].

Nowadays, tin foil substitute can be used successfully if all wax residuesare carefully cleaned from the pores of the stone and the tin foil substitute is carefully applied [(3)].

A variety of materials can be used as a tin foil substitute, the most popular of separating agents are water-soluble alginates which produce a very fine film on the applied surface[(6)]. The present study is designed to evaluate olive oil as a separating medium and its effect on some mechanical properties of the processed acrylic resin denture base when compared to those processed with tin foil and alginate mold seal (cold-mold seal) separating media.

MATERIALS AND METHODS

Metal Pattern Preparation:

Two different metal patterns were constructed with two dimensions to save time and effort(figure 1).Dimensions and shape of each metal pattern were made according to the required tests.

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Figure (1): Metal Patterns. A. Indentation Hardness Test, B. Transverse Strength Test

Samples Grouping:

A total of 124 samples prepared and used during the present study. The samples were divided into (2) groups (according to the types of acrylic resin). Each group consisted of (62) samples, and these (62) samples were subdivided according to the types of separating medium used in curing process. These separating media were of (21) samples from tin foil, (20) samples from cold-mold seal, (21) samples from olive oil. And each separating medium were subdivided (according to the tests) used in the present study, (10) samples were made for each of the following tests except (4) samples for testing the chemical composition.

1. Ten samples for indentation hardness.
2. Ten samples for transverse strength.
3. Four samples for chemical composition

During preparation of the mold, the conventional flasking technique was followed. The lower portion of the dental flask was filled with dental type III stone (Elite model,Italy)mixed according to the manufacturer instructions (i.e./p ratio is 25ml/100g); a layer of stone mix was placed on metal block to avoid trapping of air when inserting the metal block into the stone mix after coating with separating media.

After stone was set, both the stone and metal patterns were coated with separating media. The upper half of the flask was then positioned on top of lower portion and filled with stone, with vibration to get rid of the trapped air. Stone was allowed to harden for 60 minutes before the flask was opened. The metal patterns were invested each time when the samples were to be prepared. The flask was then opened and metal patterns were removed from the mold carefully.

When using the separating medium such as tin-foil (Dentaurum, Pforzhein), it was adapted to the stone surface in each half of the flask, with fingers. While, in case of using cold-mold seal(11b,Switzerland), and oliveoil(Al-Ghassuon company Iraq), separating medium, (2cc) of olive oil was measured by using a disposable syringe and applied onto the stone surface in the flask, with a fine brush (no.0)[7].

Pink heat and cold cured acrylic resin (Triplex hot Ivoclar Vivadent, Liechtenstein) was used to fabricate the samples in the present study, following the manufacturer's instructions of powder/ liquid ratio by volume. Heat-cured acrylics were mixed (3:1), while the cold-cured acrylic was (2.5:1) by volume, and then left to reach the dough phase at room temperature (approximately 23°C). After filling the mold with the dough, the flasks were fitted and pressed together in a hydraulic bench press for (5) minutes before polymerization process.

Curing was carried out by placing the clamped flask (Hanau engineering Co.USA) in a water bath and processed by heating at 74ºC for about an hour and half. The temperature was then increased to the boiling point for 30 minutes[8], after completing the curing, the flask was allowed to cool slowly at room temperature for 30 minutes. Followed by, complete cooling of the flask with tap water for 15 minutes before deflasking. The acrylic patterns were then removed from the mold. In case of curing the cold cure acrylic resin, flasks containing the acrylic resin dough were left in a bench press curing it for 2 hours at 23ºC± 5ºC [9].

An acrylic bur was used to remove all flashes of acrylic followed by 120-grain size sand paper with continuous water-cooling (to prevent over heating) in order to get smooth surface (except the samples that are used for surface roughness test).

Polishing was accomplished using bristle brush and rag wheel with pumice(Steribimplus,Germany) using dental lathe polishing machine(Derotor,QuayleDentalQ.D,England), (low speed, 1500 rpm) till glossy surface was obtained, the final measurements of the samples were obtained using the Vernier(Rostfre;Germany).

Tests Utilized Examine Properties of the Cured Material

Infrared Spectroscopic Analysis

A- Samples Preparation:

From metal disc, (4) samples of both heat and cold-cured acrylic resin (2 for each) were prepared with dimensions of (50 ± 1mm in diameter and 0.5 ± 0.1mm thickness).

B- Test equipment and Procedure:

One type of infrared spectrophotometer were used (PYe-Unicam Sp3100).This instrument is a double beam spectrophotometer operating in the region(4000-200cm^{-1}) was found to be adequate for the observation of the structures of acrylic resins denture base[10].

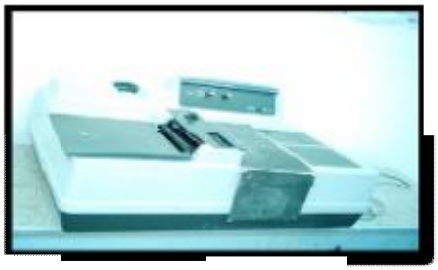


Figure (2): Infrared Spectrophotometer Device

To examine olive oil by this instrument, compressed sample of olive oil between two KBr plates (Potassium Bromide) in a disc holder to spread out as a thin film. This method was called mull technique used in the region of (4000-200cm^{-1}). The second method called thin film technique. This method used different solvents in polarity to dissolve the samples of heat and cold-cured acrylic resins denture base processed against olive oil as a separating media.

Toluene solvent, was the mostly used solvent to dissolve these samples [11].After dissolving all samples with toluene, transfer the mixture into glass petri dishes leaving the mixture of these samples for an overnight thus allowing the solvent toluene to evaporate leaving the remaining materials as a thin film (transmittance thin film), this thin film was tested in the region of (4000-200cm^{-1}).The same procedure was repeated one time for heat and cold-cured acrylic resin denture base only.

Indentation Hardness Test :

A- Samples Preparation:

From a rectangular metal pattern, 60 samples of both heat and cold-cured acrylic resins denture base (30 for each) were prepared with the dimensions of (65mmx50mmx2.5 ± 0.03mm) length, width and depth respectively[12,13].

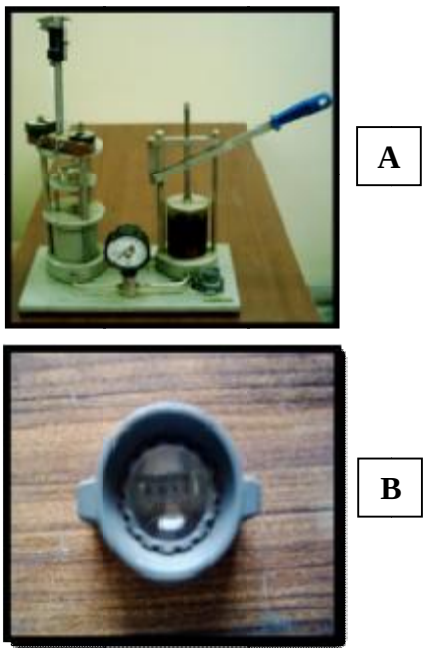
B- Test Equipment and Procedure:

Brinell hardness tester (Hydraulic press,Leybold Harris Co. British)(figure3:A) a small hardened steel or tungsten carbide ball was pressed onto the polished surface of the specimen under a known load for a definite period of time. The diameter of indentation produced was measured by means of a low-power microscope with a calibrated eye-piece. Since both the size of the ball and the load applied vary depending upon the material being tested.

In acrylic resins denture base samples, a small hardened steel or tungsten carbide ball with diameter of (5mm) was pressed into the load applied of (500N) for a time of (10 second). A microscope was used for measuring the trace formed on the sample surface after removal of applied load (figure3: B). All samples immersed in distilled water for (1) day before tested. The hardness was calculated from[4]:

$$BHN = \frac{L}{\frac{\pi D}{2}\left(D - \sqrt{D^2 - d^2}\right)}$$

Five measurements were done on different areas (the same selected area) for each sample and an average of five reading was obtained by the same examiner.



Figure(3): BrinellHardness Tester: A. Brinall Hardness Device, B. Low-Power Microscope.

Transverse Strength Test:

A- Samples Preparation:

Sixty samples of both heat and cold-cured acrylic resins denture base (30 for each) were prepared from metal pattern with dimensions of (65mmx10mmx2.5 ± 0.03mm) length, width and depth respectively[14].

B- Test equipment and Procedure:

An instron testing machine (Model 112 with digital unit & chart drive, England) was used to measure the transverse strength of samples in air by three points bending (figure4). The device was supplied with a central loading plunger and two supports with polished cylindrical surface, (3.2mm) and at least (10.5mm) long and perpendicular to the longitudinal center line.

The distance between the centers of the support was in the range of 50mm ± 0.1mm, and the loading plunger was mid-way between the

supports within 0.1mm. The tests were carried out with a constant cross head speed of (5mm/minute), and the load was measured by a compression load cell of maximum capacity of (5KN).

The test samples were held at each end of the two supports, and the loading plunger was mid-way between the supports. All samples were tested after immersed for two days in distilled water.The samples were deflected until fracture occurred. The transverse strength was calculated using the following equation[4].

$$S = \frac{3PI}{2bd^2}$$

Statistical analyses

The usual statistical methods were used in this study to analyze and assess our results, included Descriptive statistics: (Tables, Arithmetic mean, Standard deviation (S.D), Minimum, Maximum, Graphical representation by Bar-Chart) and Inferential statistics (One way analysis of variance (ANOVA), LSD (Lest Significant Difference Test).

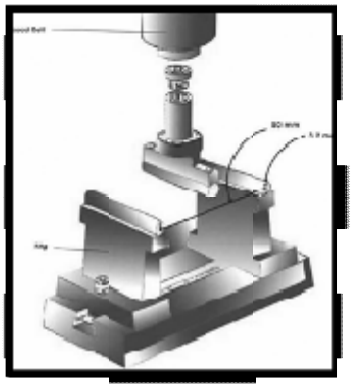


Figure (4): Instron Testing Machine

RESULTS

Descriptive and inferential statistics of some mechanical properties such as (indentation hardness and transverse strength) of heat and cold-cured acrylic resins denture base samples which are invested in stone mold as influenced by different types of separating media (tin foil, cold-mold seal, and olive oil), and a comparison between the results of them all to evaluate the olive oil as a separating medium.

Infrared spectroscopy was used to examine the chemical composition changes of heat and cold-cured acrylic resins denture base when using olive oil as a separating media.

Infrared Spectroscopy Analysis:

Table (1)shows, the spectral data of acrylic resin denture base after processed against olive oil as a separating medium, acrylic resin denture base, and olive oil. The results shows that there are some bands presented or has disappeared in spectra which can help in the identifications of three samples of (acrylic resin denture base after processed against olive oil as a separating media, acrylic resin denture base, and olive oil)as shown in figures5 and 6.

By the assignment of bands for three samples. It seems that, the same bonds in acrylic resin denture base, and olive oil structures. While there are many bonds has just appeared in spectrum of acrylic resin denture base and does not appear in spectrum of olive oil. And also there is a single mode which appear in spectrum of olive oil and cannot be seen in spectrum of acrylic resin denture base, and acrylic resin denture base processed against olive oil as a separating medium which assign to the deformation and rocking modes**,** table(1).

This evidence is to prove that olive oil is not grafted in acrylic resin denture base through the two processes heat and cold-cured acrylic resins denture base samples [10,15].

Indentation Hardness Test Result:

Mean values, standard deviation (SD) and standard error (SE) are presented in (table2) and (figure7) for indentation hardness test. The values of indentation hardness varied according to the types of separating medium that are used. The highest mean indentation hardness value was obtained in heat-cured acrylic resin denture base and tin-foil separating media (control group) (18.45980). While the lowest mean indentation hardness value was obtained in cold-cured acrylic resin denture base and olive oil separating media (15.58040).

Table (3) represents one way ANOVA by LSD multiple compression test, showed that there was a significant difference at ($P<0.05$) between different types of separating media, except for a non-significant difference at ($P>0.05$) between heat-cured acrylic resin-tin foil separating media (control group) and heat-cured acrylic-olive oil separating media, cold-cured acrylic resin- tin foil separating media.

Heat-cured acrylic resin-cold mold seal separating media and heat-cured acrylic resin-olive oil separating media, and cold-cured acrylic resin-tin foil separating media, cold-cured acrylic resin-cold mold seal separating media, cold-cured acrylic resin-olive oil separating media. Heat-cured acrylic resin-olive oil separating media and cold-cured acrylic resin –tin foil separating media, cold-cured acrylic resin-cold mold seal separating media, cold-cured acrylic resin-olive oil separating media. Cold-cured acrylic resin-tin foil separating media and cold-cured acrylic resin-cold mold seal separating media and cold-cured acrylic resin-olive oil separating media. Cold-cured acrylic resin-cold mold seal separating media and cold-cured acrylic resin-olive oil separating media.

Table (1): Infrared Assignment of Acrylic Resin Denture Base When Processed againstOlive Oil as a Separating Medium, Acrylic Resin Denture Base, and Olive Oil

Assignment	Olive oil wave no.cm^{-1}	Acrylic resin wave no. cm^{-1}	Acrylic processed against olive oil wave no.cm^{-1}
-OH(stretching)	-	3480(m.)	3440(m)
-CH_2(stretching)	3080(m.)	3040(v.s.)	3040(v.s.)
-CH(stretching)	-	3000(v.s.)	3000(v.s.)
-CH_2(stretching) (CH_3 stretch olive oil)	2980(v.s.)	2980(v.s.)	2980(v.s.)
-CH_2(stretching)	2880(s.)	2880(s.)	2885(v.s.sh.)
C=O(stretching)	1750(s.)	1750(v.s.)	1750(v.s.)
C=C(stretching)	-	1650(m.)	1680(s.sh.)
=CH_2(deformation)	-	1500-1440(v.s.)	1500-1480(v.s.)
-CH_3(deformation)	1470(m.)	-	-
-CH_3(deformation)	1460(w.sh.)	-	-
-OH(deformation)	-	1400(s.)	1420(v.s.)
-OH(deformation)	-	1300(v.s.)	1300(v.s.)
C-O(deformation)	1210(m.sh.)	1220(v.s.)	1200(v.s.)
-CH_3(deformation)	1180	-	-
-CH_2(deformation)	1120	-	-
=CH_2 (rocking)	-	1080(s.)	1060(s.)
-CH (wagging)	-	1000(w.sh.)	1000(m.sh.)
=CH_2 (wagging)	-	940(w.)	950(m.)
-CH_3 (rocking)	900(w.)	-	-
=CH_2 (rocking)	-	850(w.)	850(m.)
C=O(deformation)	750(w.)	760(m.)	740(m.)

m = medium, s = strong, w = weak, v = very shoulder

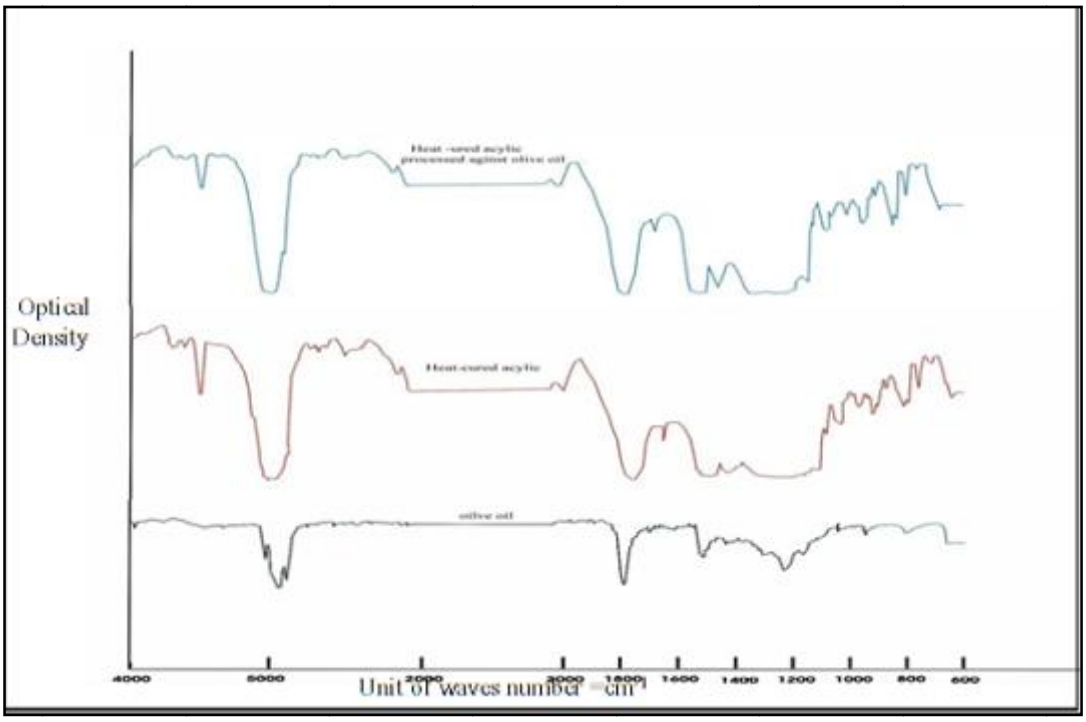


Figure (5): Infrared Spectra of Olive Oil, Heat-Cured Acrylic Resin, and Heat-Cured Acrylic Resin Processed against Olive Oil as a Separating Media

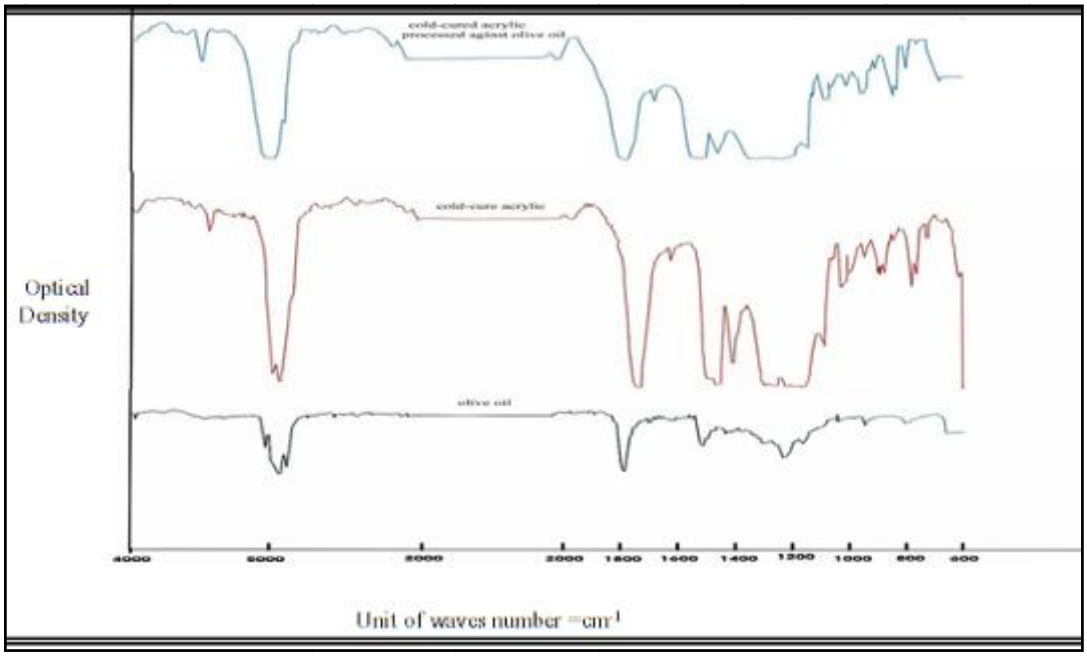


Figure (6): Infrared Spectra of Olive Oil, Cold-Cured Acrylic Resin, and Cold-Cured Acrylic Resin Processed against Olive Oil as a Separating Media

Table (2): Mean and Standard Deviation, Standard Errors for Indentation Hardness of Heat and Cold-Cured Acrylic Resins Denture Base as Influenced by Different Types of Separating Media.

Statistics	Heat-cured acrylic			Cold-cured acrylic		
	*T.F. control	**C.M.S	***O.O	T.F	C.M.S	O.O
No.	10	10	10	10	10	10
Mean	18.45980	16.03710	16.67270	17.28050	15.74440	15.58040
SD	2.25763	2.01808	2.76212	2.21166	2.26798	2.21176
SE	0.71393	0.63817	0.87346	0.69939	0.71720	0.69942

***T.F= Tin-Foil , **C.M.S= Cold-Mold Seal , ***O.O= Olive Oil**

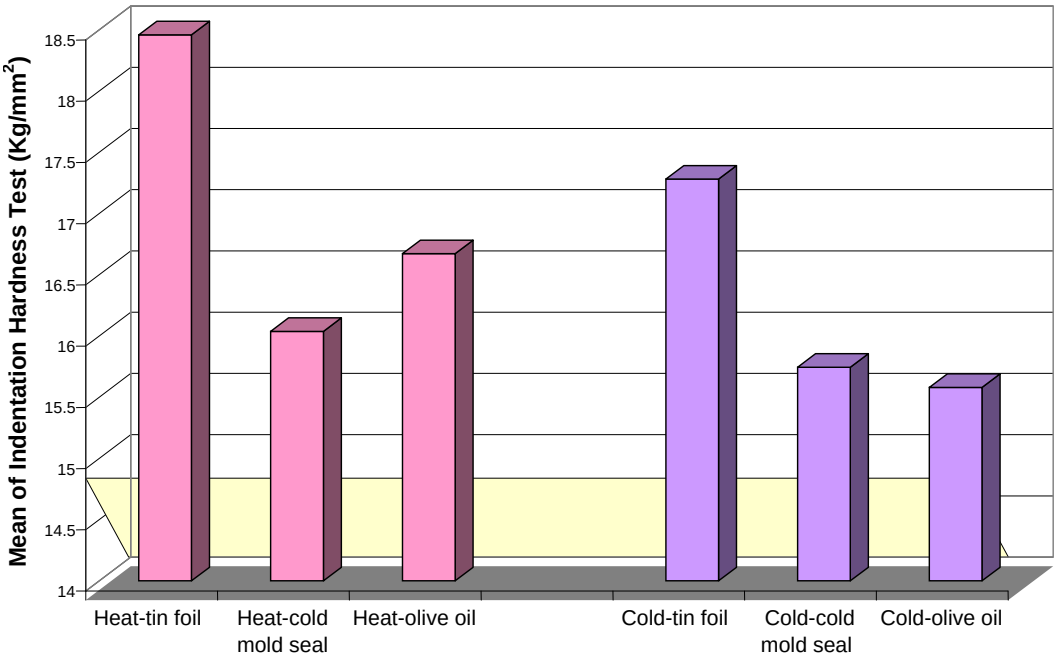


Figure (7): Showsthe Mean Values for Indentation Hardness (Kg/mm^2) of Heat and Cold-Cured Acrylic Resins Denture Base as Influenced by Different Types of Separating Media.

Table (3): ANOVA by LSD (LeastSignificant Difference) for Indentation Hardness of Heat and Cold-Cured Acrylic Resins DentureBase as Influenced by Different Types of Separating Media. ANOVA=S

Groups		Heat-cured acrylic			Cold-cured acrylic		
		*T.F. control	** C.M.S	*** O.O	T.F	C.M.S	O.O
Heat-cured acrylic	T.F.		S	N.S	N.S	S	S
	C.M.S			N.S	N.S	N.S	N.S
	O.O				N.S	N.S	N.S
Cold-cured acrylic	T.F					N.S	N.S
	C.M.S						N.S
	O.O						

P<0.05 = S= Significant, P>0.05= N.S=Non Significant
***T.F= Tin Foil, **C.M.S= Cold-Mold Seal, ***O.O= Olive Oil**

Transverse Strength Test Results:

Mean values, standard deviation (SD) and standard error (SE) are presented in table (4) andfigure (8) for transverse strength test.

The values of transverse strength varied according to the types of separating media that are used. The highest mean transverse strength value was obtained in heat-cured acrylic resin denture base and tin-foil separating media (control group) (82.194700). While the lowest mean transverse strength value was obtained in cold-cured acrylic resin denture base and cold - mold seal separating media (66.638800).Table (5) represents one way ANOVA by LSD multiple compression test,

showed that there was a significant difference at (P<0.05) between different types of separating media, except for a non- significant difference at (P>0.05) between heat-cured acrylic resin-tin foil separating media (control group) and heat-cured acrylic resin- olive oil separating media. Heat-cured acrylic resin-cold mold seal separating media and heat-cured acrylic resin-olive oil separating media.Cold-cured acrylic resin-cold mold seal separating media and cold-cured acrylic-olive oil separating media.

Table (4): Mean and Standard Deviation, Standard Errors for Transverse Strength of Heat and Cold-Cured Acrylic Resins Denture Base as Influenced by Different Types of Separating Media.

Statistics	Heat-cured acrylic			Cold-cured acrylic		
	*T.F. control	**C.M.S	***O.O	T.F	C.M.S	O.O
No.	10	10	10	10	10	10
Mean	82.194700	79.542100	80.289000	70.528700	66.638800	67.374800
SD	1.569889	3.061168	2.701482	0.962814	1.962930	2.771643
SE	0.496442	0.968026	0.854284	0.304469	0.620733	0.876471

***T.F= Tin-Foil , **C.M.S= Cold-Mold Seal , ***O.O= Olive Oil**

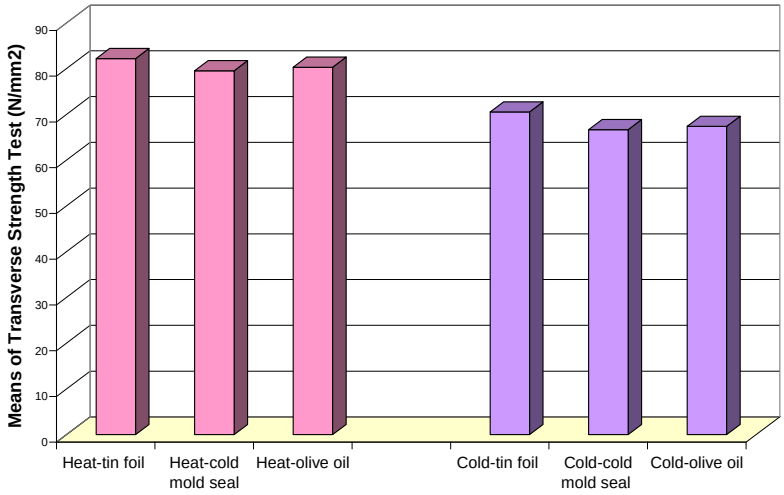


Figure (8): TheMean Values forTransverse Strength (N/mm^2) of Heat and Cold-Cured Acrylic Resins Denture Base as Influenced by Different Types of Separating Media.

Table (5): ANOVA by LSDLeastSignificant Difference for Transverse Strength of Heat and Cold-Cured Acrylic Resins Denture Base as Influenced by Different Types of Separating Media.

ANOVA=S

Groups		Heat-cured acrylic			Cold-cured acrylic		
		*T.F. control	** C.M.S	*** O.O	T.F	C.M.S	O.O
Heat-cured acrylic	T.F.		S	N.S	S	S	S
	C.M.S			N.S	S	S	S
	O.O				S	S	S
Cold-cured acrylic	T.F					S	S
	C.M.S						N.S
	O.O						

P<0.05 = S= Significant, P>0.05=N.S= Non Significant
T.F= Tin Foil, C.M.S= Cold –Mold Seal, O.O=Olive Oil

DISCUSSION

Among other factors coefficients, separating medium must be used, due to its effect on the mechanical properties of the processed acrylic denture base materials. In the present study, olive oil is used as a separating medium in the process of curing both heat and cold-cured acrylic resins denture base.

Infra-Red Spectroscopy Analysis:

From the infrared spectroscopic analysis of the different materials used in the present study, including (acrylic resins denture base processed

against olive oil as a separating medium, acrylic resins denture base only, and olive oil), showed no differences in the spectrum of the composition of both heat and cold-cured acrylic resins denture base after processing in stone mold lined with olive oil separating media with no changes in the bonds, no additional bonds of olive oil in the processed acrylic resins denture base are detected, that means no reaction between olive oil and acrylic resin denture base (heat and cold), no grafting of olive oil in heat and cold-cured acrylic resins denture base was found after processing[15].

Indentation Hardness:

High values of hardness was obtained in heat – cured acrylic resin processed against tin foil separating media when compared with those samples processed against cold – mold seal and olive oil separating media, similar results was obtained in cold – cured acrylic resin samples, this could be related to that, the hardness of dry specimens are greater than those for wet specimens these results agreed with Parr and Rueggebery[16].

On the other hand, high mean values of hardness was found in heat – cured acrylic resin samples when compared with those samples of cold- cured acrylic resin, Similar results were obtained by many studies[17-19]when they concluded that, in general, heat-cured material is significantly harder than cold-cured material under all conditions. This could be related to the higher amount of residual monomer presented in cold-cured type, which adversely affects the indentation hardness. And olive oil separating media show a comparable result concerning indentation hardness.

There isno statistically significant difference between samples processed against cold-mold seal separating media and those samples processed against olive oil separating media. While there was a significant difference between samples processed against tin foil and cold-mold seal separating media. This could be related to high water sorption which leads to greatest decrease in indentation hardness. This explanation is in agreement with Woelfel et, al.,[20].Their findings were confirmed by Stafford and Smith[21],when they reported that water sorption adversely affects the hardness resistance of PMMA. Also it may be related to porosity, which may decrease the hardness resistance.

Transverse Strength:

The result of the present study showed a high values of transverse strength in all samples of heat-cured acrylic resin denture base with reduced values in cold-cured acrylic resin denture base samples are estimated, Similar results are observed bymany researches[81,22-24]when they concluded that the strength in transverse bending of self-cured acrylic resin is inferior to that of heat-cured materials and recorded approximately 80% of the heat-cured material. This may be related to residual monomer in cold-cured materials, which is affected adversely with transverse strength and olive oil as a separating medium showed comparable result regarding transverse strength.

Furthermore, there is no statistically significant difference between samples processed against cold-mold seal separating media and those samples processed against olive oil separating media. While there was a significant difference between samples processed against tin foil and cold-mold seal separating media for both dental resins**.** These results agreed withFairhurst and Ryge[25]when they concluded that, the use of tin foil substitute as a mold liner for processing self-curing and heat curing denture base resins results in a slight, less strength product than when using tin foil separating media. This may be related to high water sorption of the acrylic denture base material lined tin foil substitute which may be cause of lowering the transverse strength value. Also, it may be related to porosity if it reaches the surface; the transverse strength will be lowered. This explanation agreed withDavenport [26].Whilein other studies[27,28] found no-significant difference between the transverse strength of resin processed in tin foil and that of resin processed in tin foil substitute.

From the present study the following conclusions can be withdrawn:

1. Tin foil is the most ideal type of separating medium for lining molds during the process of both heat and cold-cured acrylic resins followed by olive oil and cold-mold seal separating medium regarding indentation hardness and transverse strength.
2. Infrared spectroscopic analysis shows no changes in the composition of the processed both heat and cold-cured acrylic resins denture base against olive oil separating medium.
3. Comparable results were found between cold-mold seal and olive oil separating medium regarding (indentation hardness and transverse strength) of processed acrylic resins denture base.
4. Finally, from the results obtained, it can be concluded that olive oil forms a satisfactory material for being used as a separating medium of process acrylic resins denture base.

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