Tikrit Journal for Dental Sciences 11(2) (2023) 232-239
https://doi.org/10.25130/tjds.11.2.9

Tikrit Journal
for
Dental Sciences
https://tjds.tu.edu.iq
ISSN:2073-1213

Evaluation of Effect the Incorporation of The Virgin Coconut Oil on Thermal Conductivity of Heat-Cure Acrylic Soft Denture Lining Materials

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Keywords:
Thermal conductivity; Virgin coconut oil; Soft denture liner.

Article Info.:

Article History:
Received: 25/12/2022
Received in revised form: 17/1/2023.
Accepted: 19/1/2023
Final Proofreading: 19/1/2023
Available Online: 1/12/2023

Citation: Mohammed AQ, Jaber MA. Evaluation of Effect the Incorporation of The Virgin Coconut Oil on Thermal Conductivity of Heat-Cure Acrylic Soft Denture Lining Materials. Tikrit Journal for Dental Sciences 2023; 11(2): 232-239.
https://doi.org/10.25130/tjds.11.2.9

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Abstract

Background: The main disadvantage of soft liners is the low thermal conductivity between the denture base and soft liner material.

Aim: The present study aims to estimate the impact of adding virgin coconut oil (1.5% vol and 2.5% vol) to a soft acrylic liner material in a thermal conductivity test.

Material and Methods: For this project, we did 30 pieces of acrylic soft liner material. The specimens were divided into three groups: 10 control group specimens that only contained the soft liner material, 10 specimens mixed with virgin coconut oil at a volume of 1.5% with the soft liner material, and 10 specimens mixed with virgin coconut oil at a volume of 2.5% with the soft liner material. Equipment in the Technologies, Department used to conduct thermal conductivity tests. 40mm diameter and 2.5mm thickness thermal conductivity specimens were prepared.

Results: Using static analysis, data showed that the soft liner with the highest thermal conductivity contained virgin coconut oil at a volume of 2.5% compared to the soft liner containing virgin coconut oil at a volume of 1.5%, and the control group, the results revealed $p < 0.01$.

Conclusion: Thermal conductivity is increased when virgin coconut oil (2.5% by volume) is incorporated into the soft acrylic liner material.

Introduction:

Soft polymers fill the gap between hard prosthetic materials and the wearer's mucosa. They help protect the mucosa from damage, inflammation, and swelling by distributing pressure in an even manner over the entire area covered by the restoration. Furthermore, they prevent deformed oral mucosa from protruding through the restoration [(1).] One of the main disadvantages of using heat-sensitive soft acrylic liners is their low thermal conductivity. Patients are aware of this important feature of these liners, which detracts from their acceptance of their prosthesis. Additionally, it has a significant impact on the secretions produced by the parotid glands as well as the health of the nearby mucosal tissues. Recently, improvements have been made to dentures to improve heat conductivity and lessen the sense of foreign bodies in older individuals. High heat conductivity dental materials also protect oral tissues and raise patient satisfaction [(2).] Fluid leaks between a patient's prosthetic arm and its base can cause complications for long-term adhesion. Additionally, failure of the liners to stick to each other is a significant drawback in clinical settings. This lapse in connective tissue allows bacteria to colonize the area and form plaque on surrounding surfaces [(3).] People have used soft liners as antifungal agents for the treatment of denture stomatitis and for preventing Candida albicans infection [(4).] Many people consider medicinal plants to be a potential source for new antibacterial and antifungal compounds. People also use herbal extracts such as those found in flax, ginger, neem and tea plants. These extracts are used as effective therapeutic agents [(5).] Oils are intricate blends of several volatile chemicals taken from botanicals. Recently, they have been credited with possibly curing oral infections caused by bacteria. Because they are organic, oils have strong antioxidant and antibacterial properties and can combat a variety of pathogens [(5).] Virgin Coconut Oil (VCO) is frequently used in skin and hair cosmetics since it has a low-calorie content. Due to its high metabolic activity, coconut oil provides energy and prevents weight gain in the diet. It enhances the body's ability to absorb vitamins via the stomach, strengthens the immune system, lowers the risk of arteriosclerosis and cardiovascular disease, and blocks carcinogens [(6).] Virgin Coconut Oil consist of the Stearic acid, Caporic acid, Myrestic acid, Capric acid, Palmitic acid, and Caprylic acid, there is approximately 18.9% of VCO is made up of saturated fatty acids, while Olic acid, Linoleic acid, and Linolenic acid are unsaturated fatty acids [(7)] . Indonesia is reputed to use virgin coconut oil frequently, known as VCO. It is created from fresh coconut meat and has several advantages, such as not having a flavor or smell and not irritating the mouth. Additionally, it has been demonstrated that VCO, which is less expensive than other oils and readily available, greatly lowers gingival index and plaque [(8)]**.** A thermal acrylic carrier has been combined with the potent antifungal Virgo Coconut Oil, or VCO, to provide a natural medicine delivery method for Candida albinos [(9)]**.** This study examined the effects of virgin coconut oil on thermal conductivity when combined with a soft acrylic denture liner.

Materials and Procedures:

Samples grouping

This study can utilize the acrylic soft lining material from Vertex in the Netherlands, and virgin coconut oil from Nature Way Dent in the Philippines. The thirty specimens of acrylic soft liner materials, the specimens were categorized to three groups, ten specimens of acrylic soft liner materials with no incorporation (control group), ten soft lining material's specimens with the coconut oil's merging with volume of 1.5%, and ten specimens of acrylic soft liner materials with the coconut oil's merging with volume of 2.5%.

Virgin coconut oil incorporation to the soft liner materials

The experimental specimens were constructed by combining two different concentrations of the virgin coconut oil (1.5%, and 2.5% by volume) into liquid material with a soft lining. The virgin coconut oil's volume was decreased the soft lining liquid material's volume to achieve accuracy of the P/L ratio, [9, 10] as shown in Table (1).

Add the necessary amount of virgin coconut oil (VCO) together with the liquid materials to a dry, clean, soft-lined glass jar and thoroughly homogenize the mixture using a probe sonicator operating at 120 W and 60 kHz 20-second graph [11]. Following instructions from the manufacturer, the powdered soft liner material is added to the initial mixture quickly. This is then mixed until smooth.

Thermal conductivity test:

A plastic specimen with a 40mm diameter and 2.5mm thickness is cut into a disc shape using a laser cutting device from CNC materials [12, 13]. As shown in Fig. (1: A, B).

Specimen preparation

This study incorporated a collagen-derived acrylic liner material that was mixed with and added to VCO. All samples were sealed inside bags before mixing, curing and stripping them. Headaches and overheating were mitigated by cooling all thermal conductivity samples in an ice bath, then polishing them according to conventional techniques after fabrication [13]. Thermal conductivity samples were kept at 37°C for 48 hours in an Iraqi incubator to accomplish this. This was put into practice in accordance with ADA Specification No. 12, 1999.

Testing procedure

In the Fig. (2) test procedure, Lee disk apparatus is used. This thermally conductive device consists of three copper disks, including C and B, with holes that accommodate thermometers. The specimen was placed between the copper discs A and B. the sixty watt electrical plate heater was placed between discs (B and C). The power to the heater was switch on after securing the clamp screw in order to hold all the discs together. A transformer was utilized to monitor 0.25 A current and 6 V voltage provided to the heater at surroundings temperature (18 °C). When the heater was switch on the temperature in disc (C, and B) start to increase more than disc A, and this due to the existence of the specimen that act as an isolator. Record the heater's temperature readings after tightening the clamping screws that hold all the pucks together. After stabilizing at equilibrium for 30 minutes, calculate thermal conductivity by using equations [13, 14]:

$$e = \frac{I.V}{a_A T_A + as\,\frac{T_A + T_B}{2} + 2aH\,\frac{T_B + T_C}{2} + a_B T_B + a_C T_C}$$

e : Each temperature loss in seconds and the variance between pane and ambient temperature.

I : Current Through Heater (Amps)

V : Indicates the voltage in the heater (volts)

a_A, a_B, a_C : Interpret the surface area of disk A, B or C in m^2

as : Average sample surface in m^2

aH : Average heated area m^2

T_A, T_B, T_C : Explains the temperature of disks A, B , C in °C (Celsius).

Once the value of (e) is obtained, the thermal conductivity can be calculated by the following equation

$$K = \frac{ed}{2\pi\, r^2 (T_B - T_A)}\left[as\,\frac{T_A T_B}{2} + 2a_A T_A \right]$$

K : Thermal conducted is expressed in W/m.C

d : Average thickness of sample in meters

r : Average diameter of sample (m)

r T_A, T_B, T_C : This explains the temperature in °C for discs A, B, and C.

as : Average sample surface in m^2

a_A : Indicates the area of disk A, in m^2.

Results:

The information gathered for the thermal conductivity testing is shown in Table (2). The mean, standard error, standard deviation, and two extreme maximum and minimum values are included for each statistic presented. The outcomes indicated that the unincorporated group (control group) had the lowest average value (0.342 0.031), while the soft liner group with virgin coconut oil at a volume of 2.5% had the highest average value (0.398 ± 0.027) and the soft liner group with virgin coconut oil at a volume of 1.5% had average value of (0.375 ± 0.023). When utilizing the Levene test to explain the equal variances, the outcomes revealed that there were no significant differences among the inspected groups at $P>0.05$, but when using the one-way ANOVA test to analyze ability equality, the results revealed highly significant disparities at $P <0.01$.

Fig.(3) explains the boxplot showing the increase in the mean thermal conductivity values for the acrylic soft liners added to the virgin coconut oil group (2.5 vol%) compared to the other study groups.

The least significant difference test was utilized to compare the thermal conductivity results shown in Table (3). LSD test showed that the control group was significantly different from the soft lining group spiked with (1.5% by volume) virgin coconut oil at $P<0.05$, while the control group was highly significantly different from the soft lining group with (2.5% by volume) virgin coconut oil at $P<0.01$.

Comparisons between the soft pad group supplemented with natural coconut oil 1.5% by volume and the soft pad group supplemented with natural coconut oil 2.5% by volume did not appear to be a non significantly different at $P > 0.05$.

Discussion:

The definition of thermal conductivity is the measurement of how much heat a given volume of material can transport through a specific area in a given amount of time [15].

Low thermal conductivity makes using a prosthetic material made from Polyethylmethacrylate difficult for the patient. Additionally, this material weakens the tissues supporting the prosthesis [16].

It's important to consider thermal conductivity in terms of the size and ratio of thermal-conducting nanoparticles in the base denture powder [2].

The findings of the present investigation appeared that the highest thermal conductivity test average values were revealed for the soft lining group with the addition of (2.5% by vol) of virgin coconut oil, as well as the group of soft lining without incorporation (control group) showed the lowest average values of thermal conductivity test. These results can be seen in Table (2).

Table 3 compares the effects of different coconut oil percentages on a set of soft liners. When comparing a set of soft liners with 1.5% coconut oil, significant differences were shown overall. When comparing a set of soft liners with 2.5% coconut oil, highly significant differences were shown overall once again. Comparisons between all other combinations showed similar results non-significant differences, as can be seen in Table (3). There is speculation that coconut oil could replace plasticizers in the industry of polymer materials due to its potential use as a substitute, since the coconut oil is chiefly composed of medium chain fatty acids which can act as a plasticizers and also works to create heat conductive pathways, although in small amounts, by increased mobility of polymer chain and decreased viscosity of material as in [17].

The findings of research by Hassan and Ali, 2018 agree with the results of this study. They found that adding halloysite nanotubes to a thermal acrylic material increased the material's conductivity.

This result is also in line with results Noori and Jaber's in 2021, incorporating 10% by weight Neem and 10% by weight. Aloe vera powder used in heat acrylic powder for soft denture lining material results in increased thermal conductivity test.

Conclusion:

In this study, virgin coconut oil (2.5% by volume) added to the cushioning material showed improvements in thermal conductivity tests. This is because virgin coconut oil, when mixed with the soft lining material, fills the pores and creates thermally conductive pathways that help transfer heat quickly and smoothly from one side of the sample to the other, increasing the polymer insulation percentage. Virgin coconut oil is used as effective oil and successfully incorporated into soft denture lining materials.

Acknowledgement

I extend my sincere thanks to my supervisor, Dr. Makarem Abdul Rassol, as well as to my family, for helping me complete this work.

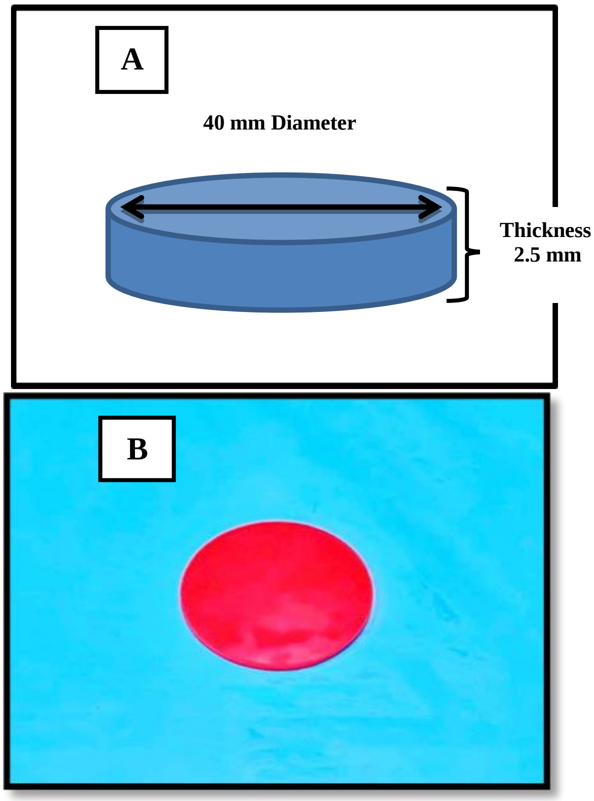

Fig. (1) (A) - Thermal conductivity sample size
(B) - Plastic sample thermal Conductivity

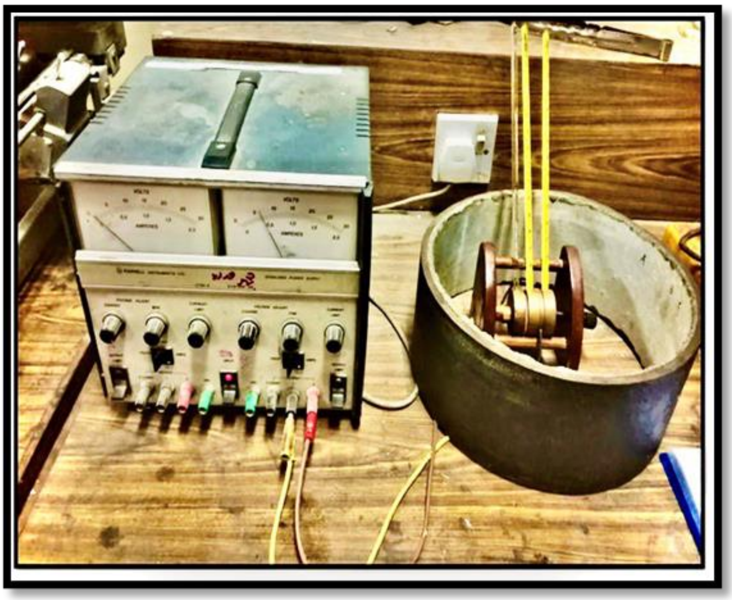

Fig.(2) Thermal conductivity apparatus (Lee disc)

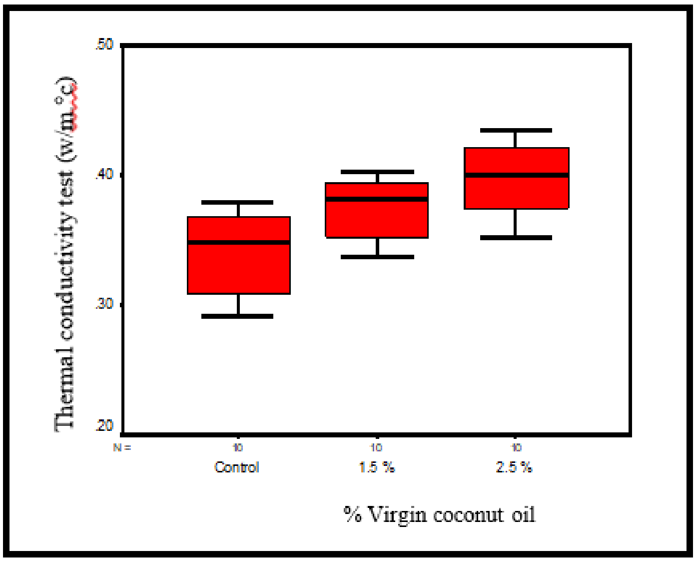

Fig. (3) Box plots for thermal conductivity test

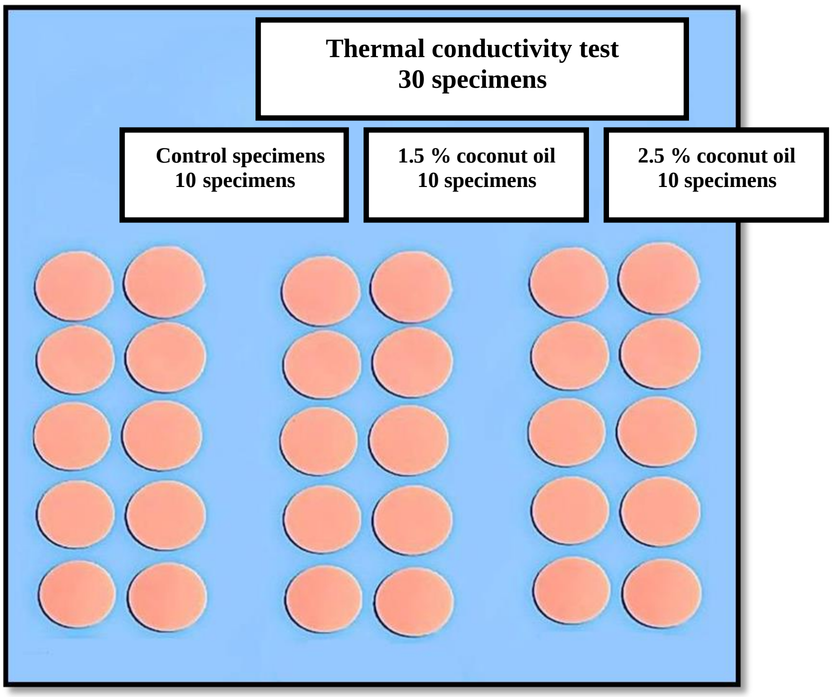

Fig. (4): The all specimens of thermal conductivity test

Table (1): preparation and mixture for soft liner materials (9).

Sample	Soft liner Powder (g)	Soft liner Liquid (mL)	virgin coconut oil (mL)
control	12 g	10 mL	0 mL
1.5% VCO	12 g	9.85mL	0.15 mL
2.5% VCO	12 g	9.75mL	0.25 mL

Table (2): Descriptive statistics for all thermal conductivity tests using Levene and one-way ANOVA Studying group.

Test	Groups	No.	Mean	SD	SE	Min.	Max.	Levene Test	One-way ANOVA Test
Thermal Conductivity test	**Control**	**10**	**0.342**	**0.031**	**0.010**	**0.291**	**0.379**	**p=0.590 (NS)**	**p=0.000 (HS)**
	Soft Lining with Coconut Oil of 1.5%	**10**	**0.375**	**0.023**	**0.007**	**0.337**	**0.403**		
	Soft Lining with Coconut Oil of 2.5%	**10**	**0.398**	**0.027**	**0.009**	**0.353**	**0.434**		

HS: Highly Sig. at p<0.01; NS: Non Sig. at p>0.05

Table (3): The least significant difference test for all thermal conductivity studied groups

(I) Group	(J) Group	Mean Diff. (I- J)	Sig.	C.S. (*)
Control group	Soft liner with Coconut oil of 1.5%	-0.0337	0.010	S
	Soft liner with Coconut oil of 2.5%	-0.0569	0.000	HS
Soft liner with Coconut oil of 1.5%	Soft liner with Coconut oil of 2.5%	-0.0232	0.069	NS
HS: Highly Sig. at p<0.01; S: Sig. at p<0.05 ; NS: Non Sig. at p>0.05				

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