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An In-Vitro Comparison of Wettability of Heat Polymerized Acrylic Denture Base Resin with Commercially Available Artificial Saliva and Traditional Natural Compounds

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Keywords

heat cure acrylic resin, artificial saliva substitute, aloe vera, sesame oil, turmeric oil.

Abstract

Purpose: To compare wettability of heat polymerized acrylic denture base resin with commercially available artificial saliva and traditional natural compounds

Materials and methods: 40 heat cure acrylic resin specimens were made from converting wax specimens. Specimens were divided into group of 10 for control group media [WET MOUTH] and 30 for experimental group [aloe vera, turmeric oil, sesame oil]. Advancing receding contact angle were measured using digital goniometer. Angle of hysteresis values were obtained from difference of advancing and receding contact angle. Data were collected and statistical analysis was performed.

Results: Aloe vera juice, Sesame oil, and Turmeric oil shows higher contact angle hysteresis value, which shows better wettability on heat polymerized acrylic denture base resin compare to control group media- artificial saliva substitute. angle of hysteresis mean values for wet mouth=1.74, aloe vera =2.14, turmeric oil= 2.71, sesame oil=2.51.

Conclusion: Wettability was found more on heat polymerized acrylic denture base resin by Turmeric oil and Sesame oil followed by Aloe vera juice and WET MOUTH. The Control group showed poor wettability compared to the experimental group.

1. Introduction

The sufficient amount of retention and stability should be provided for the success of complete denture.^{1,2} Saliva influences on the physical factors affecting the retention and they are atmospheric pressure, adhesion, cohesion and, interfacial surface tension.^{2,3} Sufficient retention obtained when saliva wet the denture surfaces adequately.^{4,5} This ability of saliva to flow or wet the surface of denture is called as wettability, which is observed and measured by the contact angle.⁶

In various systematic diseases, dryness of mouth [xerostomia] is a common sign.⁷ Xerostomia cause denture wearing difficult because it makes the problem in functioning and retaining the dentures.⁸ To overcome these problems, generally, salivary substitutes and denture adhesives are used. Denture retention mainly affected by salivary mucins due to its rheological properties. Hence, artificial saliva substitutes made up of carboxymethylcellulose or mucin based, with xylitol or sorbitol, and salts at concentrations same as human saliva, should be used.⁹ The functioning properties of saliva substitutes should be equivalent to human saliva when used intraorally with dentures.

Artificial saliva and denture adhesives are chemical products, which may cause psychological discomfort to the patient while using intraorally. Also, artificial saliva having some common side effects such as abnormal taste, difficulty in swallowing and speech and in some rare case it cause digestive problems.¹⁰ And, most commonly used commercially available denture adhesive, when overused is known for its zinc toxicity, which may cause copper depletion, neurological problems such as numbness, tingling sensation in hand, and difficulties with balance and walking.¹¹

Due to side effects and psychological discomfort due to chemical based oral care products, people are increasingly attracted to traditional practices. Nowadays, there are various natural, traditional, and consumable compounds like Turmeric, Aloe vera, Sunflower oil, Sesame oil, Coconut oil, Olive oil, etc known for their antimicrobial properties and have almost no side effects.^{12,13,14}

Above-mentioned natural compounds are known for their beneficial properties for oral and general care of the body. Some are also known for their use in

dentistry, but the wettability of these compounds to acrylic denture base resin is not known. So, the main aim of present in vitro study is to compare the wettability of artificial saliva and natural compounds to heat cure acrylic denture base resin, so we can use them as a saliva substitute and denture adhesive.

2. Materials and Methods

In the present in-vitro study wettability of heat polymerised acrylic denture base [figure 1] resin was measured with commercially available artificial saliva (WET MOUTH) [figure 2] and traditional natural compounds like Aloe vera juice, Turmeric oil and Sesame oil [figure 2]. Study was conducted in the Department of Prosthodontics at College of Dental Sciences and Research Centre, Bopal, Ahmedabad. Wettability was tested at Nanotechnology centre, Dharamsinh Desai University, Nadiad.

Specimen fabrication

Wax blocks were fabricated from joining two wax sheets (PYRAX- modelling wax sheet) with the help of a glass slab, scale, BP blade, and handle. Wax specimens first made 2-3mm larger than the final actual size of testing specimen which was kept 20×15×2 mm (length × width × thickness) after finishing. Converting of wax blocks [figure 3] to heat cure acrylic resin block [figure 4] done with conventional flasking in denture flask with type II and type III gypsum product (dental plaster and dental stone). Polishing was not done on one surface to replicate the tissue surface of the denture. Total 40 specimens from heat polymerized acrylic denture base resin (Dental Products of India) were fabricated and divided into four groups: 10 samples for control group [artificial saliva]30 samples for Experimental group [10 per each media]

Storage of specimen: Specimens washed with distilled water to remove any residual monomer and then stored in sterile distilled water for 24 hours. After that, the resin drying of samples done in the oven at 44 degrees C for approximately 30 min and then samples were cooled to 22 degrees C by the air conditioner.

Testing of specimen

Contact Angle Measurements:

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Both the advancing and receding contact angles were measured on acrylic samples with the help of a digital contact angle goniometer.

The sterilized syringe was filled with testing liquid. The digital goniometer system permits standard amount of fluid to be used on the specimen for testing. Adequate precautions were kept in mind not to touch the testing [unpolished tissue] surface of the sample. High-speed camera of digital goniometer system records the changes in the drop contour which has

been dispensed onto the testing surface. Measurement of the advancing contact angle with digital camera [figure 6] is measured when the liquid drop forms when dispensed on the dry specimen surface, after advancing contact angle measurement liquid drop is drawn backward and receding contact angle is measured after the liquid has receded from the surface. The contact angle of hysteresis was measured from the difference in advancing and receding contact angle value ($\Theta_A - \Theta_R$).

Table 1: denotes the mean value, standard deviation and minimum and maximum value of advancing contact angle of heat polymerised acrylic resin with four different media which included control group [WET MOUTH] and experimental group [Aloe vera, Sesame oil, Turmeric oil].

Table 1: Advancing contact angle measurement mean values								
	Group	No	Mean	SD	Maximum	Minimum	95% confidence interval for mean	
							Lower bound	Upper bound
Advancing angle	WET MOUTH	10	67.45	5.176	76.31	60.76	63.74	71.15
	Aloe vera	10	49.26	6.855	56.92	38.50	44.35	54.16
	Sesame oil	10	22.25	3.85	28.25	17.79	19.49	25.00
	Turmeric oil	10	26.25	2.67	28.78	19.96	24.34	28.16

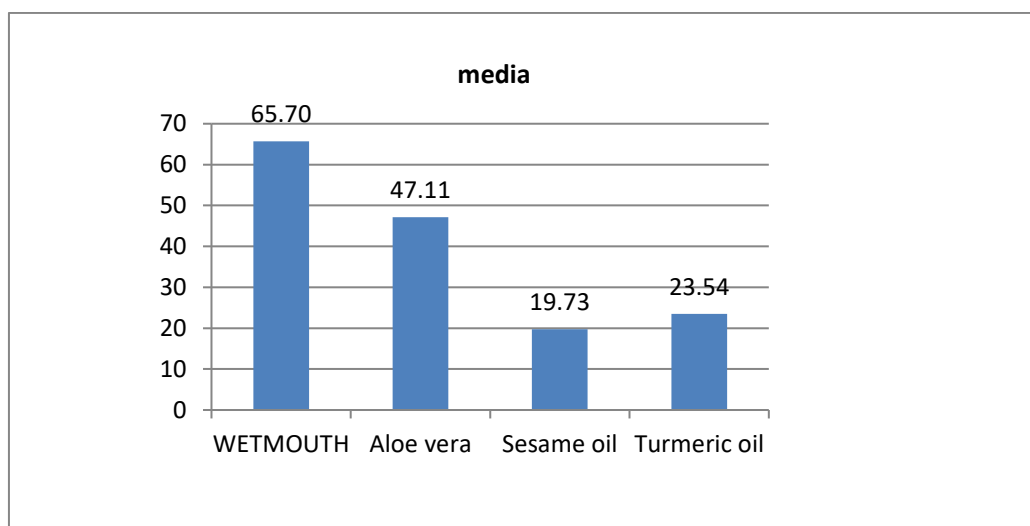
Table 2: denotes the mean value, standard deviation and minimum and maximum value of receding contact angle of heat polymerised acrylic resin with four different media which included control group [WET MOUTH] and experimental group [Aloe vera, Sesame oil, Turmeric oil].

Table 2: Receding contact angle measurement mean values								
	Group	No	Mean	SD	Maximum	Minimum	95% confidence interval for mean	
							Lower bound	Upper bound

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Receding angle	WET MOUTH	10	65.70	4.76	75.89	60.31	62.29	69.11
	Aloe vera	10	47.11	7.78	56.36	34.50	41.54	52.68
	Sesame oil	10	19.73	3.52	24.57	15.04	17.21	22.25
	Turmeric oil	10	23.54	2.58	26.58	18.56	21.69	25.39

Graph 2: Mean receding contact angle values of denture base materials in various media



Graph 1: Mean advancing contact angle values of denture base materials in various media

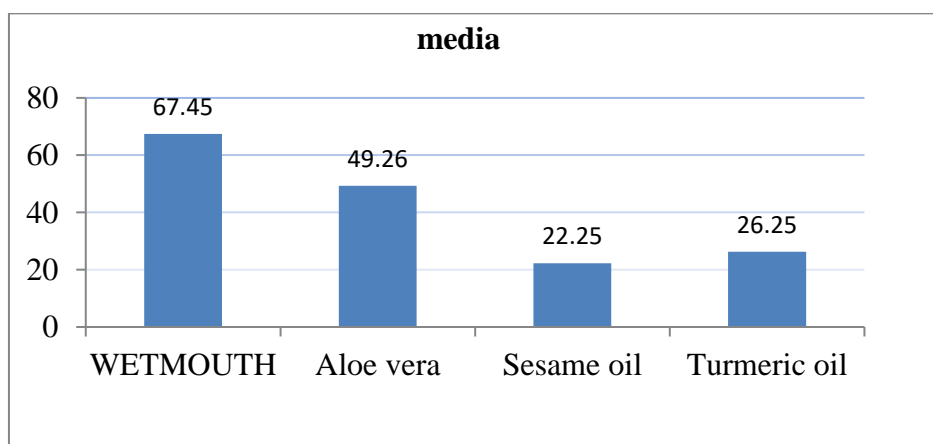
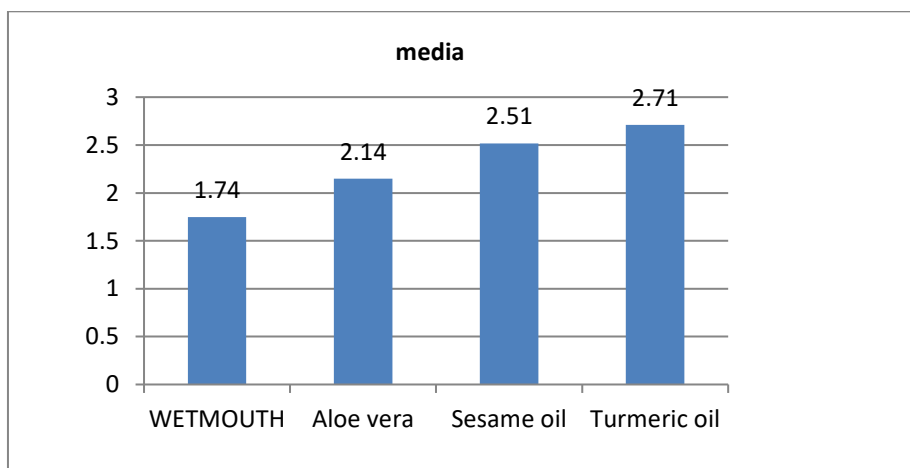


Table 3: denotes the mean value, standard deviation and minimum and maximum value angle of hysteresis of heat polymerised acrylic resin with four different media which included control group [WETMOUTH] and experimental group [Aloe vera, Sesame oil, Turmeric oil].

Table 3: Angle of hysteresis mean values								
	Group	No	Mean	SD	Maximum	Minimum	95% confidence interval for mean	
							Lower bound	Upper bound
Angle of hysteresis	WET MOUTH	10	1.74	1.87	6.55	0.37	0.4	3.08
	Aloe vera	10	2.14	1.81	5.52	0.22	0.85	3.44
	Sesame oil	10	2.51	1.36	5.45	0.66	1.54	3.49
	Turmeric oil		2.71	1.12	5.27	1.4	1.9	3.51



Graph 3: Mean Angle of hysteresis values of denture base materials in various media

3. Results:

Data obtained was statistically analysed and tabulated to obtain following results-

As data from table 1 suggests, mean advancing contact angle of experimental group medias [mean for Aloe vera=49.26, Sesame oil= 22.25, Turmeric oil= 26.25] are lower compare to control group media [mean for wet mouth= 67.45]. Results from table 2

showed, mean receding contact angle of experimental group medias [mean for Aloe vera=47.11, Sesame oil= 19.73, Turmeric oil=23.54] are lower compare to control group media [mean for WET MOUTH=65.70] As shown in table 3, the mean angle of hysteresis value for the control group [WET MOUTH] were least [mean = 1.74] compare to experimental group media, Aloe vera juice, Sesame oil, and Turmeric oil. Among the experimental group, Turmeric oil shows the highest mean angle of hysteresis [mean =2.71],

followed by Sesame oil [mean =2.51] and Aloe vera juice [mean=2.14].

Based on statistical analysis experimental group media - Aloe vera juice, Sesame oil, and Turmeric oil shows higher contact angle hysteresis value, which shows better wettability on heat polymerized acrylic denture base resin compare to control group media-artificial saliva substitute [WET MOUTH].

The results of this study for Aloe vera juice are supported by the study done by Mohsin AH, in this study they found that the wetting ability of Aloe vera saliva substitute was better to compare to aqwet artificial saliva substitute.

4. Discussion

According to various studies, adhesion between the saliva molecules with palatal mucosa and denture base and cohesion within saliva molecules play an important role in the physical mechanism of denture retention.¹⁶ Stanitz suggested that retentive force is a because of the surface tension of saliva, which is dependent on liquid film thickness, contact surface, and liquid-denture contact angle.¹⁶ Stanitz described the mechanism of adhesion between saliva- palate-denture base system and given the formula:

$$F = 2\gamma a/H.$$

Where, F identified as the "film pressure" resulting from the pressure drop across the concave meniscus of the liquid at the edge of the plates. H is the thickness of the liquid layer, a is the area between the plates and γ is the surface tension of the liquid.

The film pressure and the retentive force increase as the surface tension increases and as the film thickness decreases. Due to presence of pressure inside a fluid film surrounded by a meniscus is lower than the pressure of the surrounding medium, the atmospheric pressure. Because of this difference in pressure, it provides a retentive force. The magnitude of this force has been calculated for parallel plates separated by a film of saliva, and it has been suggested that this force is responsible for complete denture retention.¹⁸ Due to the dynamic relationship between the denture base and underlying tissue, whenever the denture base moves against tissue, viscosity of interposed saliva film thickness resist that movement and provides sufficient

retention. This is how all the physical factors are affected by saliva.¹

Xerostomia is a frequent annoying condition for complete denture wearer patients, as it causes ulceration, discomfort in wearing a complete denture, difficulty in eating, swallowing, and speaking with the denture, burning sensation and makes the total unhealthy oral environment. xerostomia treatment for a complete denture patient's includes use of artificial saliva substitute is helpful to relieve symptoms and wearing of a denture and sometimes denture adhesive to retain denture.^{17,18}

There are two types of saliva substitutes are available. From which mucin based saliva substitutes have proved to show better wettability compared to carboxymethylcellulose-based. But mucin based saliva substitutes made from porcine derivatives, and so it is objectionable to the Indian population. So in India, carboxymethylcellulose based saliva substitutes are most commonly used.⁹ Ideally, saliva substitute should be economical, readily available, soothing, pleasant to taste and smell, and showing favorable wetting to a denture tissue surface. The use of a saliva substitute causes psychological discomfort to the patient due to not having a familiar taste and odour. Also, the viscosity of artificial saliva substitutes makes denture cleansing difficult. And, it is chemical-based, so it makes an uncomfortable situation for patients while swallowing.^{19,20} Denture adhesives can be used particularly to gain sufficient retention, but denture adhesives are again chemical artificial products, which may cause the growth of bacteria and viruses if not used and cleaned properly. Basic composition for denture adhesives are, free carboxyl groups made by the hydration of adhesive like sodium carboxyl-methyl cellulose, methylcellulose, hydroxyl methylcellulose, or polymethyl vinyl-ether maleic anhydride, etc which is responsible for bio adhesion or stickiness. Denture adhesive cannot be used in patients with allergies, poor oral hygiene. Denture adhesives previously were of two types: herbs and synthetics. Herbal type of denture adhesive contains the sap of vegetables, and they were used before 1960. The synthetic type denture adhesive, consists of salts that act as polymers and they are poly(methyl-vinyl-ether) in nature. A synthetic type of adhesive is very well approved and accepted by dentists.²¹

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All these commercial products which are being used for wetting of mouth or denture retention are somewhat having side effects and contraindicated in various conditions. Incorporation of herbal products with them or replacement of artificial products by natural products can be a great invention in the field of dentistry. Various natural products are known for their antibacterial, antifungal, antiviral, palliative, and immunity-boosting effects such as Aloe vera, Sunflower oil, Turmeric oil, Sesame oil, Coconut oil, etc.

Aloe vera can be used for denture adhesive, denture cleaner, and as a saliva substitute, as it is naturally non-toxic, hypoallergenic, and non-irritating. The main component of Aloe vera is acemannan which is a complex mannose carbohydrate, has an inherent stickiness or viscosity. Aloe vera has a soothing, palliative, and moisturizing effect, so it can be implemented as a saliva substitute in dry mouth conditions.¹⁹ Morales-bozo²² performed one randomized control trial to check the effectiveness of Aloe vera containing mouthwash for dry mouth condition and they found that Aloe vera containing mouthwash is effective against xerostomia-associated symptomatology. Aloe vera can be used as denture adhesive because of acemannan polysaccharide, which is mainly composed of glucomannan and is responsible for stickiness. A study done by Julinda M²³, to check incisal bite force with different adhesives in complete denture patient, concluded that the highest adhesiveness incisal bite force value were observed with denture adhesive made from Aloe vera extract compared to denture adhesive made from poly(methyl-vinyl-ether). Aloe vera denture adhesive can give a solid and durable hold which prevents the denture from slipping and sliding. Denture adhesive shows the lubricating or cushioning effect to reduce frictional irritation to the mucosa, for that it required a highly viscous medium which leach out slowly under the denture and prevent further dehydration. The role of Aloe vera as a denture cleanser is due to its bactericidal effect against *Pseudomonas aeruginosa* and its antifungal effects against *Candida Albicans*. The saponins present in Aloe vera have both purging and disinfectant properties, it can also work for soft liners.¹²

Turmeric has a variety of therapeutic applications in the field of dentistry. The main component of turmeric is curcumin. It can be used as pit and fissure sealant,

mouthwash, subgingival irrigant, local drug delivery system. It is used to treat gingivitis and periodontitis, oral submucous fibrosis, aphthous ulcer, oral lichen planus, and other precancerous lesions. Turmeric is also effective against growth of *Candida Albicans* in complete denture. Alalwan H, in their study found that curcumin is actively promoted aggregation of the cells to affect immature morphological forms, which explains anti-adhesive effects of curcumin.¹⁴

Oil pulling exercise with Sesame oil is known for its local and systematic effect. Sesame oil has an anti-oxidative property that prevents oral mucosa from free radical injury. Oil pulling helps to reduce caries, plaque-induced gingivitis, halitosis, and prevent the growth of *Candida Albicans* in denture wearing patients. It is used in replacement of mouthwash because studies show equal effectiveness of oil pulling and chlorhexidine mouthwash. A study done by Sumaidae RR, check the antifungal action of some traditional original oils such as flax oil, nigella sativa, Sunflower oil, ginger oil and, Sesame oil in relation to nystatin suspension on acrylic resin denture base materials. And, found that all the tested oils are effective antifungal agents.¹³

Wettability plays an important role in complete denture retention. The wetting of any liquid is checked by its tendency to spread on a solid surface. There are various techniques and devices are available to check contact angle. Captive bubble, Wilhelmy plate and Sessile drop methods, etc are known techniques to check contact angle. The digital goniometer and sessile drop method is an easy and widely used to check contact angle.

Generally, a contact angle less than 0 degree is considered favourable and shows good wetting, and considered hydrophilic. Whereas contact angle more than 90 degrees is not favourable and shows poor wetting and is called hydrophobic. Range of the contact angle is generally from 0 to 180 degrees. 0 degree contact angle indicates complete spreading of the drop of the wetting liquid towards the surface. 180 degrees shows poor wetting of the liquid on surface, which creates beading of the drop.⁶

However, the basic requirement for denture retention is the hysteresis value of contact angle. The angle of hysteresis is the difference between advancing and receding contact angle. Advancing contact values are

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higher than the receding contact angle values, and the difference between advancing and receding contact angle $[\Theta_A - \Theta_R]$ values is called as the angle of hysteresis. The greater is hysteresis of the contact angle, the greater will be the wettability.²⁴ The importance of contact angle hysteresis values for denture retention explained by Monsenego and Proust's study. According to them:²⁵

$$F_{\max} = mg \cos \Theta_R / \cos \Theta_A$$

Where, F_{\max} = maximum retentive force of denture, m = mass of the denture, g = gravitational force, Θ_R = receding contact angle, Θ_A = advancing contact angle.

According to this formula, more force is required to dislodge the prosthesis, when the angle of hysteresis values is higher. This shows that wettability is favourable when advancing contact angles are higher than receding contact angle.²⁵

In this present in-vitro study, we compared the wettability of artificial saliva with Aloe vera juice, Turmeric oil, and Sesame oil on heat cure acrylic denture base resin specimens. From a denture retention perspective, we have considered the angle of hysteresis value, to know the wettability of different media. Based on statistical analysis experimental group media- Aloe vera juice, Sesame oil, and Turmeric oil shows higher contact angle hysteresis value, which shows better wettability on heat polymerized acrylic denture base resin compare to control group media- artificial saliva substitute [WET MOUTH].

The results of this study for Aloe vera juice are supported by the study done by Mohsin AH, in their study they observed, the wetting ability of Aloe vera saliva substitute was better to compare to Aqwet artificial saliva substitute.

5. Conclusion:

1.The control group [WET MOUTH] has a higher advancing and receding contact angle, and less values of angle of hysteresis compared to experimental group media [Aloe vera juice, Turmeric oil, Sesame oil].

2.On heat polymerized acrylic denture base resin Turmeric oil and Sesame oil show better wettability followed by Aloe vera juice and WET MOUTH. The

Control group showed poor wettability compared to the experimental group.

3.Based on the high hysteresis value of Turmeric oil and Sesame oil, it would possibly provide better retention.

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