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Evaluation of the color stability of heat cure denture base acrylic resins in different staining solution – an in Vitro Study

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Abstract

Context: The most important property of esthetics is color. Clinical studies have demonstrated that discoloration of the denture base polymers may be caused by intrinsic and extrinsic factors. Intrinsic factors involve chemical changes of the material because of the oxidation of amine accelerator .Extrinsic factors include staining by adhesion or penetration of colorants as a result of contamination from exogenous sources like tea, coffee, nicotine etc.

Aims: The present study was done to determine color stability of 5 different brands of heat cure denture base resins in different staining solutions.

Methods and Material: Five heat cure denture base resins used were DPI, Lucitone, Trevelon, Ashvin & Pyrax. 1400 samples.70 samples from each brand were immersed in solutions of tea, coffee ,tobacco ,turmeric and artificial saliva (control) .The optical density was evaluated at 15 days,1 month and 3 months time interval. After 15 days of immersion 23 samples from each group were taken out from each solution and evaluated for optical density using visible spectrophotometer. Next after the period of 1 month 23 samples were evaluated and at the end of 3 months 24 samples were evaluated. The results of evaluating optical density were noted down and statistical analysis was carried out

Results: Results revealed that Lucitone(Mean value-0.864) showed least change in optical density while Pyrax showed maximum change(Mean value-1.746).Tea solution showed maximum staining potential (Mean value-1.561)while turmeric had minimum staining potential(Mean value-0.670). Intensity of the stains was maximum at the end of 3 months.

Conclusions: It can be concluded that the heat cure denture base resin specimens were color stable when immersed in artificial saliva and staining was noticed after their immersion in various staining solutions. Lucitone out of the entire tested heat cure denture base resin brand showed mininimum of staining. Thus it had maximum color stability.

Keywords: Acrylic staining, Spectrophotometer, Heat cure discoloration.

Introduction: In modern day dentistry, a large emphasis is laid over esthetics. Today, prostheses are made with perfect precision and so as to accurately fit and match the surrounding oral structures. As color is one of the most desirable properties of an esthetic restorative material, maintenance of the matched colour for the entire length of its service life may determine the success or failure of the material.[1]

Humans consume food that has a high quantity of food colorants. Indian food is particularly known to have a very high quantity of ingredients which have a high staining capacity. Also, use of various oral hygiene aids and medicated oral rinses containing chlorhexidine have been found to cause yellow-brown discoloration of teeth as well as artificial restorative materials like denture resins, restorative resins and porcelain. [1]

Color stability is the ability of any dental material to be able to retain its original color. The oral cavity has a dynamic environment. With the continuous presence of micro flora, saliva and frequent intake of colored food (chromatogens), the color stability of an esthetic material may become compromised. However, the property of colour stability of esthetic dental materials is often ignored over other physical and mechanical properties while making a choice.[1]

Different factors can be responsible for affecting the colour stability of dental materials. Discoloration of materials may be caused by intrinsic or extrinsic factors. Intrinsic factors involve chemical changes of the material. In denture base resins, cause of such chemical discolouration has been attributed to the oxidation of amine accelerators. These tertiary amines contribute to discoloration by a change in hue from whitish to yellow appearance. Extrinsic factors of discoloration include staining by adhesion or penetration of colourants from exogenous sources like coffee, tea, nicotine etc.[1]

Discoloration may result from several factors. Impurities, incorporated during manufacturing or manipulation, can lead to color changes. Most materials used for treatment restorations are subject to sorption, a process of absorption and adsorption of liquids dependent upon environmental conditions. Should a contacting solution be pigmented, discoloration is possible.[2] Stain accumulation, water sorption, dissolution of the ingredients, degradation of intrinsic pigments and surface roughness are the factors which might contribute to discoloration of dental materials after long term use.

Since the mid 1940s, the majority of denture bases have been fabricated using poly (methyl methacrylate) resins. Such resins are resilient plastics formed by joining multiple methyl methacrylate molecules or “mers. Pure poly methacrylate is colorless, transparent solid to facilitate its use in dental applications.The polymer may be tinted to provide almost any shade and degree of translucency. Its colour and optical properties have proven adequate for dental applications.[3]

There are several types of denture base acrylic resins; heat-polymerized acrylic, autopolymerized , and visible-light polymerized are often used for prosthetic purposes.

Heat-activated materials are used in fabrication of nearly all denture bases. The resin systems includes powder and liquid components.The powder consists of prepolymerized spheres of poly(methyl methacrylate) and a small amount of benzoyl peroxide. The benzoyl peroxide is responsible for starting the polymerization process and is termed the initiator. Poly (methyl methacrylate) is a transparent resin of remarkable clarity; it transmits light in the ultraviolet range to a wavelength of 250 nm.[3]

The liquid is predominantly nonpolymerized methyl mathacrylate with small amounts of hydroquinone. Hydroquinone is added as an inhibitor and it prevents undesirable polymerization or “setting” of the liquid storage.Glycol dimethacrylate is commonly used as the cross linking agent.[3]

The color and appearance of denture teeth is certainly an important property of a denture; however, the color and appearance of the denture base cannot be overlooked. Color stability is one of the most important clinical properties for all dental materials, and color changes are indicators of aging or deterioration of the materials.

Denture cleansers are widely used to prevent colonization by Candida albicans and related Candida species,and to prevent plaque accumulation. Daily use of denture cleansers can affect the physical and mechanical properties of denture base materials. The study done by Guang Hong et al[4] showed that the influence of denture cleansers on the color stability of denture base acrylic resins varies according to the type of denture cleanser used.

Common food colorants used in beverages, beverage powders, jellies, jams, candies, puddings, icecreams and many other food formulations are erythrosine,tartrazine and sunset yellow. Nur Hersek et al[5] have shown that long term exposure of food colorants like erythosine,tartrazine can also lead to discoloration of denture base resins

Study done by Tsun Ma et al[6] concludes change in color and surface roughness is significantly less with use of chemical disinfectants.

Tea is an infusion of the leaves of the camellia sinensis plant,and is the most widely used beverage in the world. It can be useful in treating headaches and decreases the risk of myocardial infarction, osteoporosis, kidney stones, obesity but its excessive consumption is not recommended. Consumption of coffee has its own health benefits too. It may reduce risk of developing gall stones, kidney stones and colorectal cancer but it may be considered as a risk factor for coronary heart diseases.[7,8]

Tobacco consists of nicotine and tar which can cause erosion of the polished surface and result in staining.

A study done by s v singh, priyanki aggarwal[9] gives evidence that beverages such as tea, coffee, turmeric solution significantly increase the development of stains on enamel and acrylic resin. Also the habitual intake of fermented food caused discoloration of denture base acrylic resins.[10]

Materials And Methodology

The study materials includes five heat cure denture base resins (DPI®, Trevalon®, Lucitone® ,Pyrax® and Ashvin®)and four staining solutions(Tea, Coffee, Tobacco, Turmeric).Artificial saliva was used as a control group.

Fabrication of specimen

A standardized metal die of dimension 10×10×mm and 0.5 mm thickness was prepared for the fabrication of specimen at Gujarat Industrial Development Corporation, Vadodara .Fabrication of samples was done at Manubhai Patel Dental College, Vadodara.

The metal die was flasked in dental flask to create a mould space. These moulds were packed with different heat cure denture base resins in dough stage (fig-1, fig-2) and cured in UNIDENT® acryliser following short polymerization cycle according to manufacturer's instructions.

Fabrication of 280 samples each for DPI®, Trevalon®, Lucitone®, Ashwin® & Pyrax® were fabricated in the similar manner. Samples were checked for any type of porosities. After processing, the specimens were finished using NO 2000 silicon carbide paper to a final thickness of 0.5mm and polished using acrylic polishing bur and pumice.(fig-3)

Exclusion Criteria: Samples having porosity, improper thickness and inadequate polymerization.

Inclusion Criteria: Samples with 0.5mm thickness, smooth polished surface with the necessary dimensions.

Thus specimens were divided into five groups :-

Group 1-DPI®

Group-2-Pyrax®

Group 3-Trevalon®

Group 4-Ashwin®

Group 5- Lucitone®

These samples were then immersed in 4 staining solutions and artificial saliva. Each group sample was divided into 5 subgroups as follows:-

S1-Artificial saliva

S2-Coffee

S3-Turmeric

S4-Tea

S5-Tobacco.

70 Samples from each group were immersed in each subgroup.

Preparation of staining solutions

Four staining solutions and artificial saliva were prepared for immersion of samples. These were tea solution, coffee solution, tobacco solution and turmeric solution (FIG-4).Artificial saliva was prepared in Department of Biochemistry M S University, Vadodara.

Artificial saliva was prepared by dissolving following constituents in 1000ml of distilled water.(FIG-05)

Disodium hydrogen phosphate (0.26gm)

Sodium chloride (70gm)

Sodium dihydrogen phosphate (0.20gm)

Potassium chloride (1.20gm)

Sodium bicarbonate (1.50gm)

Bovine serum albumin (100gm)

Coffee solution was prepared by dissolving 7.5 gm coffee powder (Nescafe®) in 500 ml of boiling water. Tea solution was prepared by dissolving 7.5 gm tea powder(Brooke Bond®) in 500 boiling water .Turmeric solution was prepared by dissolving 10 gm of turmeric powder in 500ml of boiling water.Tobacco solution was prepared by mixing 30 gm of tobacco leaves in 500ml of water

Artificial saliva was used as the control group and all four staining solutions were mixed with artificial saliva to simulate the oral conditions. Artificial saliva was added after the cooling of staining solutions:-

Artificial saliva (control group) - 990ml

Artificial saliva(660ml) + tea solution(330ml) - 990ml

Artificial saliva(660ml) + coffee solution(330ml) - 990ml

Artificial saliva(660ml) + turmeric solution(330ml) - 990ml

Artificial saliva(660ml) + tobacco solution(330ml) - 990ml

Immersion & evaluation of specimens and staining procedure

Then 70 samples from each brand of heat cure acrylic resin were immersed in each staining solution and artificial saliva. The samples were then incubated at 37°C in an incubator to maintain the diffusion coefficient of heat cure denture base resins (diffusion

coefficient=$1.08\times10^{12)}$ and stored at the Department Of Oral Pathology, Manubhai Patel Dental College, Vadodara. The optical density was evaluated at 15 days, 1 month and 3months interval as per the requirement of study. The solutions were replaced every 10 days with fresh ones to prevent microbial growth. (fig-06)

After 15 days of immersion 23 samples from each group were taken out from each solution and evaluated for optical density using visible spectrophotometer.

Next after the period of 1 month 23 samples were evaluated and at the end of 3 months 24 samples were evaluated for optical density using a visible spectrophotometer.

The visible spectrophotometer (Systronics 166®) at Dept of Microbiology &Biotechnology Gujarat University, Ahmedabad was used to evaluate optical density of the samples .Since the spectrophotometer reads only liquid readings, the stains in the samples were leached out using 30%H_2O_2 and collected in a test tube for evaluation. The frequency of the spectrophotometer was set at 490nm as the frequency of 490nm is considered to be appropriate for the staining of black-brown to yellow stains. (fig 07).

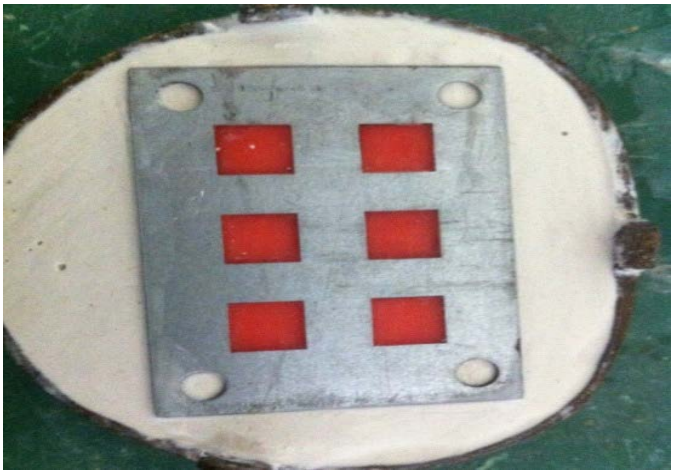

Fig 1: Preparation of mould space

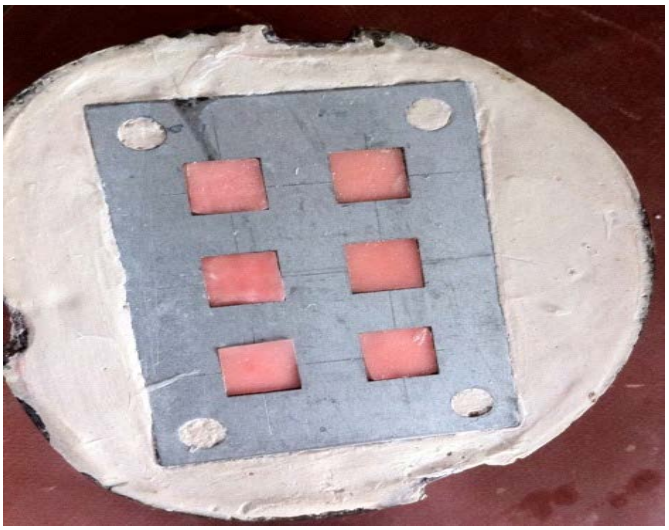

Fig 2: Packing of various resins

Fig 3 : Finished and polished Specimen

Fig 4 : Staining Components

Fig 5 : Artificial Saliva Solution

Fig 6 : Immersion of Specimen in staining solution

Fig 7 :Systronic spectrophotometer

Result

Table - 1 demonstrates the mean value of the optical densities of different heat cure denture base resin in various solutions at 15 days, 1 month and 3 months. It shows the highest mean value for Ashvin® (0.9322 & 1.4352) at 15 days and 3 months interval respectively. It also demonstrates the lowest mean value of Trevalon® (0.4980) for 15 days and for Lucitone® (1.1959) for 3 months.

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
15 Days	DPI	92	.7559	.53990	.05629	.6441	.8677	.02	1.99
	TREVALON	92	.4980	.51217	.05340	.3920	.6041	.02	1.83
	LUCITONE	92	.6799	.45240	.04717	.5862	.7736	.07	1.90
	PYRAX	92	.7972	.52151	.05437	.6892	.9052	.05	1.91
	ASHVIN	92	.9322	.54595	.05692	.8191	1.0452	.08	1.93
	Total	460	.7326	.53282	.02484	.6838	.7815	.02	1.99
1 Month	DPI	92	.9899	.58479	.06097	.8688	1.1110	.10	1.99
	TREVALON	92	.7558	.55637	.05801	.6405	.8710	.07	1.90
	LUCITONE	92	.7177	.54106	.05641	.6057	.8298	.06	1.92
	PYRAX	92	3.0651	14.39124	1.50039	.0848	6.0455	.11	99.00
	ASHVIN	92	.9458	.60360	.06293	.8208	1.0708	.10	1.96
	Total	460	1.2948	6.48970	.30258	.7002	1.8895	.06	99.00
3 Months	DPI	92	1.3982	.44582	.04648	1.3058	1.4905	.22	1.93
	TREVALON	92	1.3657	.38063	.03968	1.2868	1.4445	.22	1.89
	LUCITONE	92	1.1959	.42197	.04399	1.1085	1.2833	.20	1.79
	PYRAX	92	1.3768	.34357	.03582	1.3057	1.4480	.29	1.99
	ASHVIN	92	1.4352	.41481	.04325	1.3493	1.5211	.31	1.97
	Total	460	1.3543	.40964	.01910	1.3168	1.3919	.20	1.99

Table 1(A) shows a highly significant p-value (0.00) of different heat cure denture base resin for 15 days and 3 months time interval.

		Sum of Squares	df	Mean Square	F	P-value
15 Days	Between Groups	9.415	4	2.354	8.859	.000
	Within Groups	120.894	455	.266		
	Total	130.309	459			
1 Month	Between Groups	365.459	4	91.365	2.192	.069
	Within Groups	18965.900	455	41.683		
	Total	19331.359	459			
3 Months	Between Groups	3.147	4	.787	4.846	.001
	Within Groups	73.874	455	.162		
	Total	77.021	459			

Table - 2 compares different heat cure denture base resins in various time intervals. During 15 days time interval there is significant difference found in the mean value in comparison of Trevalon® with Ashvin® and. 3 months interval showed significant difference in mean value of Lucitone® when compared with Ashvin®. It depicts that Lucitone® had the maximum color stability at the end of 3 months and Pyrax® the least.

Dependent Variable	(I) Company	(J) Company	Mean Difference (I-J)	Std. Error	P-value	95% Confidence Interval	
						Lower Bound	Upper Bound
15 Days	DPI	TREVALON	.25783*	.07600	.007	.0497	.4660
		LUCITONE	.07598	.07600	.855	-.1322	.2841
		PYRAX	-.04130	.07600	.983	-.2495	.1668
		ASHVIN	-.17630	.07600	.140	-.3845	.0318
	TREVALON						
		LUCITONE	-.18185	.07600	.119	-.3900	.0263
		PYRAX	-.29913*	.07600	.001	-.5073	-.0910
		ASHVIN	-.43413*	.07600	.000	-.6423	-.2260
	LUCITONE						
		PYRAX	-.11728	.07600	.535	-.3254	.0909
		ASHVIN	-.25228*	.07600	.009	-.4604	-.0441
	PYRAX						
		ASHVIN	-.13500	.07600	.389	-.3431	.0731
1 Month	DPI	TREVALON	.23413	.95192	.999	-2.3729	2.8412
		LUCITONE	.27217	.95192	.999	-2.3349	2.8793
		PYRAX	-2.07522	.95192	.189	-4.6823	.5319
		ASHVIN	.04413	.95192	1.000	-2.5629	2.6512
	TREVALON						
		LUCITONE	.03804	.95192	1.000	-2.5690	2.6451
		PYRAX	-2.30935	.95192	.110	-4.9164	.2977
		ASHVIN	-.19000	.95192	1.000	-2.7971	2.4171
	LUCITONE						
		PYRAX	-2.34739	.95192	.100	-4.9545	.2597
		ASHVIN	-.22804	.95192	.999	-2.8351	2.3790
	PYRAX						
		ASHVIN	2.11935	.95192	.172	-.4877	4.7264
3 Months	DPI	TREVALON	.03250	.05941	.982	-.1302	.1952
		LUCITONE	.20228*	.05941	.006	.0396	.3650
		PYRAX	.02130	.05941	.996	-.1414	.1840
		ASHVIN	-.03707	.05941	.971	-.1998	.1256
	TREVALON						
		LUCITONE	.16978*	.05941	.036	.0071	.3325
		PYRAX	-.01120	.05941	1.000	-.1739	.1515
		ASHVIN	-.06957	.05941	.768	-.2323	.0931
	LUCITONE		*				
			*				
		PYRAX	-.18098*	.05941	.021	-.3437	-.0183
		ASHVIN	-.23935*	.05941	.001	-.4021	-.0766
	PYRAX						
			*				
		ASHVIN	-.05837	.05941	.863	-.2211	.1043

Dependent Variable	(I) Company	(J) Company	Mean Difference (I-J)	Std. Error	P-value	95% Confidence Interval	
						Lower Bound	Upper Bound
15 Days	DPI	TREVALON	.25783*	.07600	.007	.0497	.4660
		LUCITONE	.07598	.07600	.855	-.1322	.2841
		PYRAX	-.04130	.07600	.983	-.2495	.1668
		ASHVIN	-.17630	.07600	.140	-.3845	.0318
	TREVALON						
		LUCITONE	-.18185	.07600	.119	-.3900	.0263
		PYRAX	-.29913*	.07600	.001	-.5073	-.0910
		ASHVIN	-.43413*	.07600	.000	-.6423	-.2260
	LUCITONE						
		PYRAX	-.11728	.07600	.535	-.3254	.0909
		ASHVIN	-.25228*	.07600	.009	-.4604	-.0441
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		ASHVIN	-.13500	.07600	.389	-.3431	.0731
1 Month	DPI	TREVALON	.23413	.95192	.999	-2.3729	2.8412
		LUCITONE	.27217	.95192	.999	-2.3349	2.8793
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		ASHVIN	.04413	.95192	1.000	-2.5629	2.6512
	TREVALON						
		LUCITONE	.03804	.95192	1.000	-2.5690	2.6451
		PYRAX	-2.30935	.95192	.110	-4.9164	.2977
		ASHVIN	-.19000	.95192	1.000	-2.7971	2.4171
	LUCITONE						
		PYRAX	-2.34739	.95192	.100	-4.9545	.2597
		ASHVIN	-.22804	.95192	.999	-2.8351	2.3790
	PYRAX						
		ASHVIN	2.11935	.95192	.172	-.4877	4.7264
3 Months	DPI	TREVALON	.03250	.05941	.982	-.1302	.1952
		LUCITONE	.20228*	.05941	.006	.0396	.3650
		PYRAX	.02130	.05941	.996	-.1414	.1840
		ASHVIN	-.03707	.05941	.971	-.1998	.1256
	TREVALON						
		LUCITONE	.16978*	.05941	.036	.0071	.3325
		PYRAX	-.01120	.05941	1.000	-.1739	.1515
		ASHVIN	-.06957	.05941	.768	-.2323	.0931
	LUCITONE		*				
		PYRAX	-.18098*	.05941	.021	-.3437	-.0183
		ASHVIN	-.23935*	.05941	.001	-.4021	-.0766
	PYRAX						
		ASHVIN	-.05837	.05941	.863	-.2211	.1043

Table - 3 demonstrates mean value of the staining potential for different staining solutions. It can be seen that the maximum staining was caused by tea solution

(mean value 1.561) and the minimum staining was caused by turmeric solution (mean value 0.670).

Solution	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
COFFEE	1.386	.203	.988	1.785
TURMERIC	.670	.203	.271	1.068
TEA	1.561	.203	1.163	1.960
TOBACCO	.892	.203	.493	1.291

Table - 4 demonstrates the color stability of various groups in various staining solutions. Lucitone® had the maximum color stability (mean value 0.864) and the Pyrax® had the least color stability (1.746).

Company	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
DPI	1.048	.227	.602	1.494
TREVALON	.873	.227	.428	1.319
LUCITONE	.864	.227	.419	1.310
PYRAX	1.746	.227	1.301	2.192
ASHVIN	1.104	.227	.659	1.550

Discussion

Colour stability is the ability of any dental material to be able to retain its original colour. With the continuous presence of micro flora, saliva and frequent intake of coloured food the colour stability of the esthetic material may be compromised. Further, use of oral hygiene aids and medicated oral rinses containing chlorhexidine have been found to cause yellow brown discoloration of teeth as well as denture base materials. Polymethylmethacrylate (PMMA) or acrylic resin has been successfully used for fabricating denture bases and has favourable physical, mechanical and cosmetic properties and is easy to manipulate with inexpensive equipment. It still has some disadvantages, particularly its colour instability.

Most resin based materials used for prosthetic treatment are subject to sorption, a process of absorption and adsorption of liquid dependent environmental conditions due to which staining may produce colour changes during service in oral environment.Discoloration of the denture base polymers may be caused by oxidation of amine accelerator or by penetration of colored stains.[2,5]

The present study evaluates the colour stability of five different brands of heat cure acrylic resin in staining solutions of coffee,tea,turmeric and tobacco. Fabrication of samples was done using a metal die .The acrylic resin specimen which were to be investigated were immersed into artificial saliva(control group)and above mentioned staining solutions at the time interval of 15 days,1 month and 3 months. A standardized environment was provided by incubating the samples at 37^0C to simulate the oral conditions. The temperature was maintained throughout the study for 3 months time interval so that the diffusion coefficient of heat cured denture base resin is not reduced. (Diffusion coefficient=1.08×10^{-12}).[3]

Optical density was evaluated and it showed that light transmission was more in the artificial saliva (control group) than coffee,tea,turmeric and tobacco solutions. This implifies that extrinsic stains played a major role in discoloration of investigated materials.

The values for all the samples in synthetic saliva were zero.The statistical results showed that amongst the five denture base resins used lucitone had the maximum colour stability followed by trevalon,DPI,ashvin & pyrax.

Limitations of the study

- Discussing the clinical applications of this in-vitro study, it must be considered that the oral environment differs in several ways from in-vitro conditions.
- Factors such as variety of food, thermal and mechanical stresses and their interactions may intensify the discoloration in vivo.
- Further the results cannot be said to simulate oral conditions as the staining was examined in a diet-free medium. The factors like plaque adherence or the effect of dyes in food can further fluctuate the staining tendency.

Moreover the thickness of the specimens (0.5 mm) was according to the laboratory requirements so it enhanced the staining potential.Therfore further in vivo studies are required for a definitive outcome.

Conclusion

Within the limitations of the study it can be concluded that

- The heat cure denture base resin specimens were color stable when immersed in artificial saliva and staining was noticed after their immersion in various staining solutions.
- Lucitone out of the entire tested heat cure denture base resin brand showed mininimum of staining. Thus it had maximum color stability
- Tea solution had highest staining potential followed by coffee owing to the presence of tannic acid and its acidic potential.
- The immersion time period of the specimens (3 months) affected the staining potential.The staining becomes intense with time.

It can be concluded that while selecting the brand of denture base material its stability to colorants present in food taken by the patient should also be an important criteria and the manufacturer should also use some scale which shows stain resistance.

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