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Original Research

Color Stability of Various Denture Base Resins After Exposure to Different Coloring Agents – An In vitro Study

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ABSTRACT

Aim: The purpose of this study is to evaluate the colour variation of samples prepared with various denture base materials i.e. heat cure (Compression moulding) self cure, light cure and microwave (Regular) methods and subjecting them to three different food colouring agents (Erythrosine, Tartrazine, Sunset yellow).

Materials and Methods: 120 wax patterns were fabricated from metal die of dimensions 65×10.5×12mm (ADA Specification 1567). Prepared specimens were stained with erythrosine, Tartrazine & sunset yellow. These specimens were placed in artificial saliva with food colorants & placed in incubator at 37°c. Specimens were washed under distilled water and dried before measuring colour variation on 10, 20, and 30 days of immersion. Color variation of samples were measured using spectrophotometer

Results: According to the statistical results obtained colour stability was more for heat cure material followed by microwave, light cure and self cure. Among the food colorants used samples placed in Sunset yellow were more stable followed by Tartrazine and Erythrosine.

Conclusion: The results of the present study concluded that there was statistical significant colour change in erythrosine, Tartrazine and sunset yellow solutions. Microwave and heat cure samples showed highest colour stability followed by light cure and self cure.

INTRODUCTION

Complete and removable partial dentures are fabricated using acrylic resin because of its low cost and relative ease of manipulation. Apart from the other properties of acrylic resin, developing its colour to match with the colour of oral mucosa and teeth makes it the material of choice for its universal application in denture prosthesis. Denture base has to be in contact with various food materials and beverages in the oral cavity. Acrylic resin material is likely to absorb various contaminants and is also subjected to sorption, a process of absorption and adsorption of liquids is dependent on environmental conditions.[1,2]

In human mouth dentures act as an optimal environment for adhesion and multiplication of pathogenic and non-pathogenic organisms. The rate at which bio film accumulates depends upon salivary composition, dietary intake, surface texture, porosity of denture base material and denture- cleansing regimen adopted by wearer.[3] Acrylic resin constitutes organic materials and it is likely to undergo deterioration of its colour and translucency. The discoloration or deterioration of colour pose an aesthetic problem and critically viewed on the point of acceptance from the patient's side challenging the prosthodontic workability and skill.[4,5]

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Color change is an indicator of aging or damage to dental materials1 and can be ass\essed by colorimetry, which is based on the digital expression of the color perceived from the object.[6] Two of the color systems were used to assess chromatic differences i.e. Munsell color system and the standard Commission International de l'Eclairage (CIE L*a*b*) color system. The American Dental Association (ADA) recommends the use of the CIE L*a*b* system. According to this system, all colors in nature are obtained through the blending of 3 basic colors, namely, red, blue, and green, in certain proportions. This technique is widely used by researchers in dentistry to study the color of dental materials.[7]

Color stability is a required characteristic of denture base resins, and it may provide important information on the serviceability of these materials.[8]

Polyzois et al determined the color stability of 4 VLP hard direct denture reline materials by immersing them in coffee and tea. After 30 days, color changes (ΔE) ranged from 1.1 to 17.8. The tea solution exhibited more staining capacity than did the coffee solution.[9]

Imirzalioglu et al studied the color stability of 2 AP soft denture liners and 3 HP soft denture liners after accelerated aging in a weatherometer (QUV Accelerated Weathering Tester; Q-Lab, Cleveland, Ohio). Color changes (ΔE) ranged from 0.92 to 104.03. The AP soft denture liner showed a significantly greater color change than the HP soft denture liner.[10]

Hersek et al determined the color stability of 5 HP denture base acrylic resins in 3 food colorants. The CIE L*a*b* system and NBS (National Bureau of Standards)-defined units were used to evaluate the color differences. The color changes exhibited by all specimens after 6 months were at clinically acceptable levels (<3.0 NBS units).[11]

The color stability of denture base acrylic resins and hard direct reline acrylic resins, when exposed to food colorants, has been widely reported. However, little information is available on the influence of various artificial coloring agents on color stability. So the purpose of this study was to assess the color variation of different denture base materials after immersion in various coloring agents (Erythrosine, Tartrazine, Sunset yellow).

Materials and Methods

70 rectangular wax patterns were prepared of dimensions 65×12×3.5mm (According to ADA spec. No 12). Moulds were fabricated by placing the patterns in metallic flasks with dental stone .After setting of stone, flasks were separated. Wax was removed and stone mold was cleaned. Heat cure acrylic resin is manipulated packed & pressed into mold according to manufactures instructions. After acrylization specimens removed from moulds and immersed in distilled water at 37ºc for 48 hrs for residual monomer elimination. Finishing and polishing was done with 180, 220, 400 grit abrasive papers.

In the stone mold obtained self cure material was placed and allowed to cure. Samples were obtained and final finish and polishing was done.

Microwave denture base samples were prepared by placing them in specialised flasks (ceramic flasks). Microwave denture base material was placed on the stone mold and kept in microwave for about 5-7 minutes. After curing the obtained samples were finished and polished.

Light cure denture base samples were prepared by using light cure denture base material (primobase TP 100 primotec). Rectangular shaped samples were prepared and placed in light curing chamber for about 8-10

minutes. After curing the obtained samples were finished and polished.

Test samples were randomly divided into 7 groups. 12 sets of solutions were prepared for each colorant, as three different materials were to be tested and a control group was taken as distilled water. 10 samples of each group were soaked in each solution of different food colorants and named as “E” for Erythrosine, “T” for Tartrazine and “Y" for Sunset Yellow. Three grams of each colour was taken in separate conical beaker and 100 ml of distilled water was added to each beaker. To stimulate natural oral environment, artificial saliva was added about 50 ml in each beaker. Before soaking it in colour solution one acrylic sample was taken from each group randomly and Initial Base Value reading was recorded. This reading was considered as control group value. These values were obtained by testing in computer controlled UV-Visible Spectrophotometer Hitachi U-3210.

After 10th day each group of samples were taken out of the coloured solution. The samples were washed in distilled water and dried with tissue paper. The samples were then ready for obtaining the readings. Spectrophotometer contains tungsten bulb emitting light, which gives source of light to the testing specimen. The light passes through the samples & the readings were recorded in computer as nm verses time graph on the monitor. This procedure has to be repeated for 20th and 30th day for all the acrylic samples. The beaker was closed with aluminum foil and kept in the incubator at a temperature of 37°C ± 1°C.

Figure 1: Self cure denture base material

Figure 2: Heat cure denture base material

Figure 3: Microwave cure denture base material

Figure 4: light cure denture base material

Figure 5: flasking of samples

Figure 6: Flasking of microwave samples in ceramic flasks

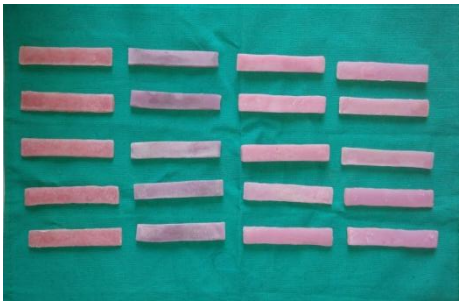


Figure 7: Acrylic samples

Figure 8: Acrylic samples placed in different coloring solutions

Figure 9: light curing unit

Figure 9: Spectrophotometer

RESULTS

The data collected for the change in colour was evaluated and compared for the different groups using One-way Analysis of Variance and Bonferroni (post hoc) test.

Table 1 and Graph 1 shows the mean values and standard deviations (SD) of the color change (Δ E) of heat cure denture base material in erythrosine, tartrazine, and sunset yellow solutions depicts that heat cure denture base samples stained more in sunset yellow followed by

Tartrazine and erythrosine after 10, 20 and 30 days which was not statistically significant

Table 2 and Graph 2 shows the mean values and standard deviations (SD) of the color change (Δ E) of self cure denture base material in erythrosine, tartrazine, and sunset yellow solutions depicts that self cure denture base samples stained more in sunset yellow followed by erythrosine and Tartrazine after 10, 20 and 30 days which is not statistically significant.

Table 3 and Graph 3 shows the mean values and standard deviations (SD) of the color change (Δ E) of microwave cure denture base material in erythrosine, tartrazine, and sunset yellow solutions depicts that microwave cure denture base samples stained more in sunset yellow followed by erythrosine and Tartrazine which is not statistically significant after 10, 20 and 30 days.

Table 4 and Graph 4 depicts that light cure denture base samples stained more in sunset yellow followed by Tartrazine and erythrosine after 10 days. Light cure denture base samples stained more in Sunset yellow followed by Erythrosine and Tartrazine after 20 and 30 days which is not statistically significant.

Table 1: The mean values and standard deviations (SD) of the color change (Δ E) of heat cure denture base material in erythrosine, tartrazine, and sunset yellow solutions

Type	Time period		Mean	Median	SD	P-value	Inference
Heat cure	10	Erythrosine	3.42	3.1	0.22	0.28	NS
		Tartarizine	3.45	3.6	0.41		
		Sunset	3.87	3.4	0.4		
	20	Erythrosine	3.69	4.5	0.2	0.2	NS
		Tartarizine	3.67	4.7	0.61		
		Sunset	3.99	4.6	0.16		
	30	Erythrosine	3.71	5.1	0.16	0.31	NS
		Tartarizine	3.79	5.6	0.77		
		Sunset	4.12	5.2	0.34		

Graph 1: Schematic representation of color change (Δ E) of heat cure denture base material in erythrosine, tartrazine, and sunset yellow solutions

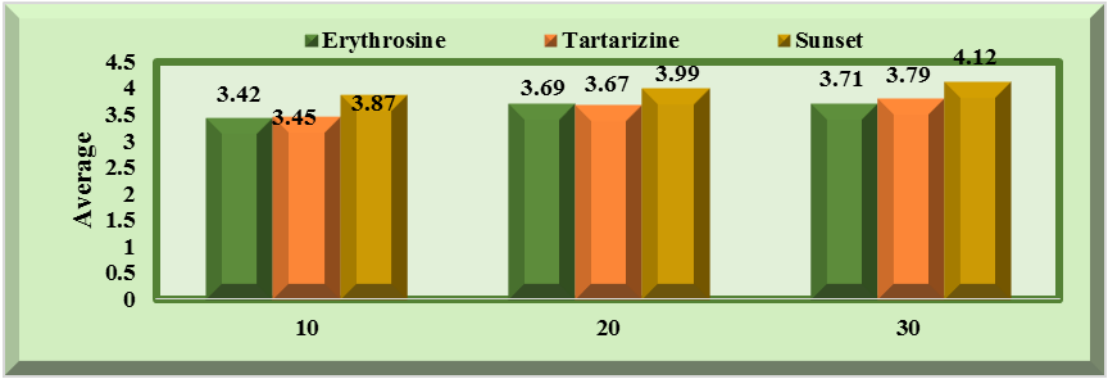


Table 2: The mean values and standard deviations (SD) of the color change (Δ E) of self cure denture base material in erythrosine, tartrazine, and sunset yellow solutions

Type	Time period		Mean	Median	SD	P-value	Inference
Self-cure	10	Erythrosine	3.92	2.9	0.35	0.43	NS
		Tartarizine	3.83	3.3	0.34		
		Sunset	3.97	3.1	0.24		
	20	Erythrosine	4.13	4	0.27	<0.05	S
		Tartarizine	3.99	3.7	0.4		
		Sunset	4.19	4.2	0.34		
	30	Erythrosine	4.23	4.6	0.22	0.08	NS
		Tartarizine	4.06	5.1	0.79		
		Sunset	4.42	5.1	0.32		

Graph 2: Schematic representation of color change (Δ E) of self cure denture base material in erythrosine, tartrazine, and sunset yellow solutions.

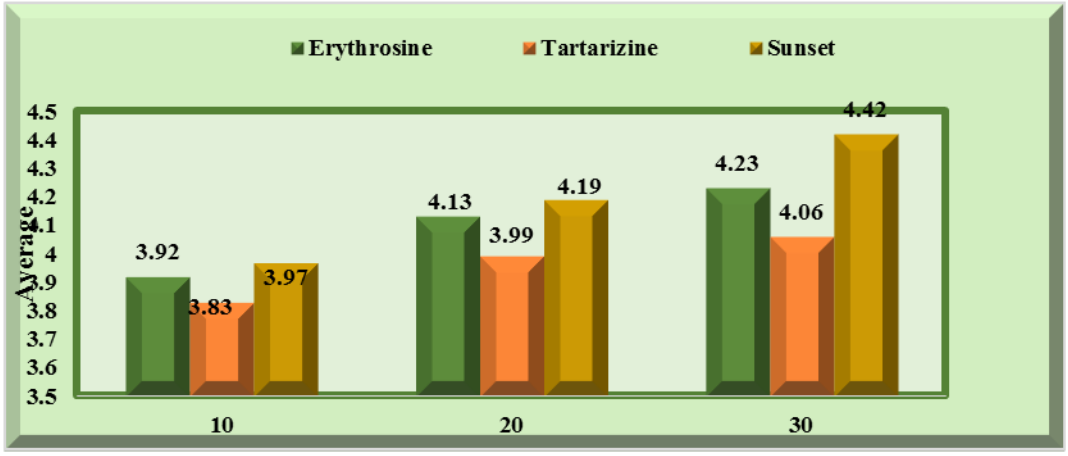


Table 3: The mean values and standard deviations (SD) of the color change (Δ E) of microwave cure denture base material in erythrosine, tartrazine, and sunset yellow solutions

Type	Time period		Mean	Median	SD	P-value	Inference
Microwave	10	Erythrosine	3.74	2.8	0.17	0.35	NS
		Tartarizine	3.54	2.9	0.69		
		Sunset	3.99	3.1	0.46		
	20	Erythrosine	3.86	3.8	0.19	0.16	NS
		Tartarizine	3.76	3.5	0.58		
		Sunset	4.11	3.8	0.26		
	30	Erythrosine	3.98	4.2	0.21	0.18	NS
		Tartarizine	3.87	4.9	0.82		
		Sunset	4.23	4.9	0.48		

Graph 3: Schematic representation of color change (Δ E) of microwave cure denture base material in erythrosine, Tartrazine, and sunset yellow solutions

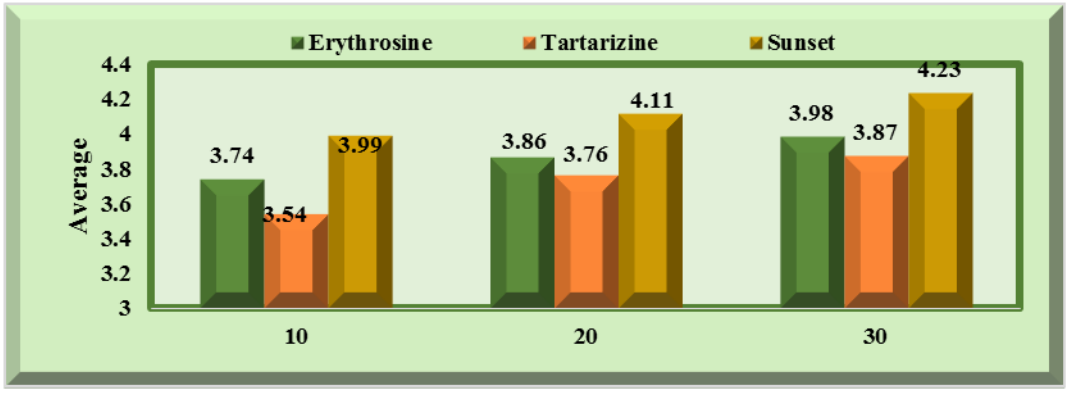
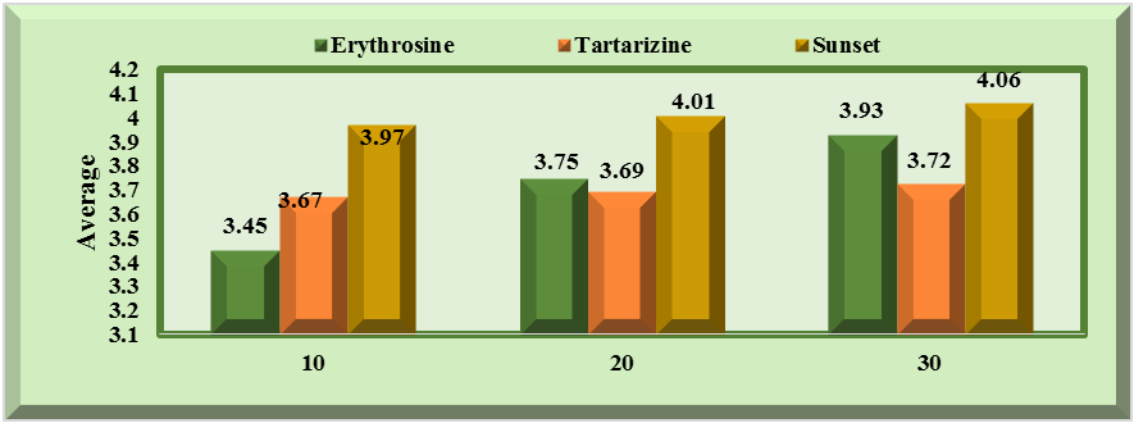


Table 4: The mean values and standard deviations (SD) of the color change (DE) of light cure denture base material in erythrosine, Tartrazine, and sunset yellow solutions

Type	Time period		Mean	Median	SD	P-value	Inference
Light cure	10	Erythrosine	3.45	2.6	0.12	0.48	NS
		Tartarizine	3.67	2.8	0.78		
		Sunset	3.97	2.9	0.55		
	20	Erythrosine	3.75	3.5	0.3	0.25	NS
		Tartarizine	3.69	3.4	0.75		
		Sunset	4.01	3.8	0.3		
	30	Erythrosine	3.93	4.2	0.42	0.39	NS
		Tartarizine	3.72	4.8	1.09		
		Sunset	4.06	4.8	0.54		

Graph 4: Schematic representation of color change (Δ E) of light cure denture base material in erythrosine, tartrazine, and sunset yellow solutions.



DISCUSSION

Complete dentures and removable partial dentures were fabricated using heat-cured acrylic resin because of its low cost, its appearance, and relative ease of manipulation. Color stability is one of the most important clinical properties for all dental materials.[12] Several factors may contribute to the discoloration of dental materials after long-term use. These factors include stain accumulation, water sorption, dissolution of the ingredients, degradation of intrinsic pigments, and surface roughness. It is well-known that beverages such as tea, coffee, wine, and some artificial dyes used in food may increase the discoloration of denture base polymers. To determine and quantify the changes in the color of dental materials, an understanding of colour space and differential colorimetry is required. Current photometric and colorimetric instruments are capable of reliably quantifying the color of acrylic resin specimens.[13]

Pavan Kumar Bohra etal in their study "Colour Stability of Heat and Cold Cure Acrylic Resins" concluded that heat cure acrylic resins are more colour stable than self cure acrylic resins. Tartrazine has the maximum colouring effect while the least colouring effect was observed in sunset yellow.[14]

S V Singh et al in their study "Effect of Tea, Coffee and Turmeric Solutions on the Colour of Denture Base Acrylic Resin used various brands of heat cure denture base acrylic resins" showed statistical significant colour change in tea, coffee and turmeric solution. Among the solutions tested, turmeric showed the highest staining effect on the specimens, followed by tea and later by coffee. [15]

In this study, spectrophotometric measuring techniques were used to determine the color of 4 types of acrylic resin in 3 different test media. Color was expressed in terms of CIE Lab color coordinates. Studies revealed that 'whenever the colorant is more polar and there by more hydrophilic it stains more as denture base resins are hydrophilic attracting more water soluble dyes on the surface'.[16] When color changes of denture base resins with respect to solutions were studied, the least staining was found to be in the sunset yellow solution. The 3 food colorants used in this study have charged and ionisable groups in their chemical structures. They were water soluble azo dyes and stable with heat, alkalis and acids. The polymethyl methacrylate denture base resins were hydrophilic that attracted more water soluble dyes on the surface and staining, which occurs as a result of electrostatic charges.[17]

All the four denture base resin materials used in this study had the same base chemical structures; however, each of them contained small quantities of different cross linking agents and plasticizers, pigments, which may explain the difference in staining properties (hydrophilicity) of resins. There also seemed to be some molecular interactions between colorants and denture polymers that resulted in slight discoloration in acrylic resins. Erythrosine (MW = 879.9) and Tartrazine (MW = 534.4) have 3 electrostatically charged groups on the molecule when ionized; however, sunset yellow contains 2 ionizable groups in the molecule, which may explain why it did not stain as much as the other 2 dyes.[18]

Heat cure denture base material is more resistant to staining because of higher rate of polymerisation, less amount of residual monomer content (0.73-02.10) and high glass transition temperature of polymer.

Microwave resin denture base material is more resistant followed by heat cure because of decrease in polymerisation time i.e. rapid polymerisation, decrease residual monomer content, low processing temperature, uniform and immediate heating of polymer.

Light cure denture base material is next to microwave because of low residual monomer due to its composition consisting of urethane dimethylacrylate matrix with silica filler particles (0.07-0.98), because of its filler particles the molecular weight is high and less porous, higher density and no voids.

Self cure denture base material contains high residual monomer content (2.45-8.52), incomplete polymerisation and more porous structure facilitates diffusion and molecular disintegration of initiator.

CONCLUSION

Within the limitations of this study, all the brands of denture base acrylic resin tested showed statistical significant colour change in Erythrosine, Tartrazine and Sunset yellow solutions. Microwave and heat cure samples showed highest colour stability followed by light cure and self cure. The staining becomes more intense with time i.e. ΔE value for colour change increases with time but the rate does not remain the same as after 10, 20 and 30 days, the value does not increases in the same ratio. So while selecting the brand of denture base material its stability to colorants present in the food taken by the patient should also be an important criteria and the manufacturer should also use some scale which shows the stain resistance.

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