Original Article

DOI: 10.7860/JCDR/2024/66964.19334

Dentistry Section

Colour Stability of Two Different Denture Base Resins and the Efficacy of Two Denture Cleansing Agents after Tea and Coffee Staining: An In-vitro Study

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ABSTRACT

Introduction: In dentistry, colour is one of the most important dimensions of aesthetics. Due to the diverse food habits in India, stains accumulate on dentures. Various denture cleansing agents such as Fittydent and Clinsodent are widely used, emphasising the importance of patient oral hygiene.

Aim: To evaluate the colour stability of heat-cure activated acrylic denture base resins {Dental Products of India (DPI) and Trevalon} after staining with tea and coffee, subsequently treated with Clinsodent, Fittydent, and distilled water (control group) as cleansing agents.

Materials and Methods: This in-vitro study was conducted at Swargiya Dadasaheb Kalmegh Smruti Dental College and Hospital, Nagpur, in the Department of Prosthodontics, Crown and Bridge, and Implantology in collaboration with Indorama, Nagpur, Maharashtra, India, over a period of approximately 90 days (August-October 2017). Total 120 samples were prepared in-vitro study using custom-made brass metal discs measuring 10 mm by 2 mm. Trevalon and DPI heat-cure acrylic denture base resins were used for sample preparation. Baseline colour stability values were established after immersing the samples in distilled water at 37°C for 24 hours. The samples were then stained for eight hours, followed by immersion in different cleansing agents and distilled water for 12 hours. This process was repeated every 24 hours for 60 days, with the staining and cleansing agents replenished daily. Colour measurements were taken at baseline, 15th, 30th, 45th, and 60th days. Statistical analysis involved t-tests and one-way Analysis of Variance (ANOVA).

Results: The DPI denture base resin exhibited a highly significant ΔE (change in energy) at 45 days (p=0.0001), while Trevalon showed significance at 60 days (p=0.0079). The difference in means was statistically significant using t-tests for independent samples, and the variance-measure analysis indicated statistical significance in the means of ΔE. The comparison of the three cleansing agents at 60 days was statistically obtained using one-way ANOVA.

Conclusion: Dental Products of India (DPI) showed more colour variation than Trevalon. Tea showed a higher staining than coffee. Staining intensity increased over time, peaking at 45 days and stabilising thereafter. Clinsodent is better than Fittydent in removing stains.

Keywords: Clinsodent, Colourimeter, Fittydent, Polymethylmethacrylate denture base resin, Stains

INTRODUCTION

In dentistry, edentulism detoriates the patient physical and psychological health. Therefore heat-cure acrylic denture base resins are commonly utilised due to their cost-effectiveness, good mechanical properties, and ability to replicate the colour and contour of oral tissues. In India, diverse food habits contribute to the accumulation of stains on dentures. Such stains can be due to commonly used beverages like tea and coffee are common culprits, causing discolouration and plaque accumulation. Stain accumulation, incomplete polymerisation, water sorption, ingredient degradation, intrinsic dye dissolving, and surface roughness are factors responsible for denture discolouration. Diet and oral hygiene also play crucial roles in this process [1,2].

Thus, the, denture wearers must adhere to a stringent denture cleansing regimen to prevent biofilm formation on denture surfaces [3]. The most commonly practiced method involves denture cleansing with a toothbrush and dentifrice or soap due to its simplicity, cost-effectiveness, and proven efficacy in removing organic deposits [4]. However, brushing with dentifrices can significantly impact the wear and roughness of restorative and prosthetic materials [5]. Colourimetric measurements allow for the objective comparison of colour changes in materials, eliminating subjective interpretations of visual colour assessments [6].

Hollis et al., measured the colour stability using a spectrocolourimeter of three different denture base resins (light-polymerised Eclipse, heat-polymerised Lucitone 199 Heat, and autopolymerised Lucitone 199 Repair) after staining with coffee, cola, or grape juice and soaking in commercial denture cleansers such as Polident and Efferdent in the United States [7].

The present study aimed to evaluate the in-vitro colour stability of two commonly used denture base resins in India after staining with tea and coffee, using different cleansing agents like Clinsodent and Fittydent, with distilled water as a control. The proposed null hypothesis suggests that there will be no colour change in the two denture base resins after staining with tea or coffee, followed by exposure to Clinsodent and Fittydent, and distilled water at various time intervals.

MATERIALS AND METHODS

This in-vitro study was conducted at Swargiya Dadasaheb Kalmegh Smruti Dental College and Hospital, Nagpur, in the Department of Prosthodontics, Crown and Bridge, and Implantology in collaboration with Indorama, Nagpur, Maharashtra, India, over a period of approximately 90 days (August-October 2017). The study received approval from the Institutional Ethical approval board with reference number (SDKS/PG/syn/prostho3/7/2015).

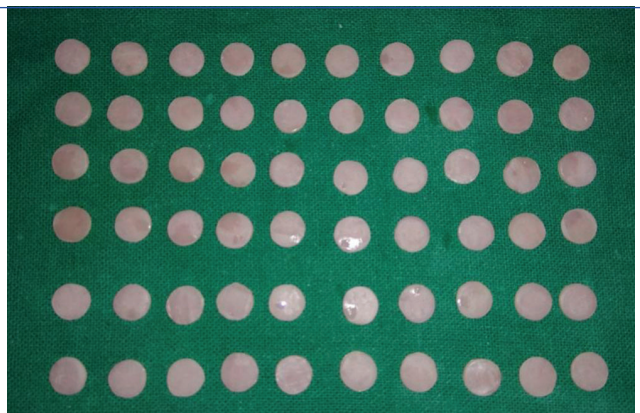
Inclusion and Exclusion criteria: Finished and polished samples measuring 10×2 mm were used for the study. Samples with processing errors leading to porosity, dimensional changes, or rough surfaces were excluded.

Study Procedure

Heat-polymerised acrylic resin test samples were prepared using a custom-made brass metal disc measuring 10 mm by 2 mm in dimensions and grouped accordingly [Table/Fig-1]. Six circular discs were placed in each flask before the initial set of dental stones (Kalstone, Kalabhai Karson India Private Limited, Mumbai) in the base flask (Varsity flask Jabbar and Company), exposing their superior surface. Metallic discs were retrieved from the flask to obtain mold spaces for preparing the test specimens. The heat-activated monomer and polymer were mixed and set aside until reaching the final (dough) stage for packing. After polymerisation, the resin samples were recovered after overnight bench cooling and deflasking. A finishing and polishing procedure was performed, and each specimen was numbered using a carbide bur. Digital vernier calipers were used to measure each sample.

[Table/Fig-1]: Custom-made brass metal disc.

Total 120 (60 of each) of Trevalon (Dentsply India Pvt. Ltd., Gurugram) and DPI (Dental Products of India, Mumbai) denture base resin materials were prepared [Table/Fig-2]. The samples were preserved at 37°C for one day, and the baseline colourimetry values were measured using a Hunter Lab colourimeter (D25 M Optical Sensor, Reston, Virginia, USA) for each sample.



[Table/Fig-2]: Prepared test specimens for Group Trevalon (Dentsply India Pvt. Ltd., Gurugram).

Different beverages were prepared for staining. The tea solution (Taj Mahal Brooke Bond, Hindustan Unilever Ltd., Mumbai) was made using four tea bags in 1000 mL of boiled distilled water, cooled, and poured into 60 beakers containing samples of DPI and Trevalon [8]. The coffee solution (Nescafe Classic, Nestle India Ltd., New Delhi) was made using 100 mg of instant coffee in 1000 mL of purified water and poured into 60 beakers containing samples of DPI and Trevalon.

Total 30 samples of each PMMA denture base resin were immersed in the tea and coffee staining substrates, respectively, each day for eight hours [Table/Fig-3] [7].

[Table/Fig-3]: Trevalon samples immersed in tea and coffee.

Two denture cleaning agents, Clinsodent and Fittydent, were used for immersionas test specimens [Table/Fig-4], with distilled water serving as the control. Clinsodent powder was mixed with 100 mL of distilled water in a beaker, and samples of each DPI and Trevalon heat-activated resin were soaked in the solution. A Fittydent tablet was dissolved in 100 mL of distilled water in a beaker, and DPI and Trevalon heat-activated resin samples were soaked in the solution. After eight hours of immersion in tea and coffee, the samples were washed with purified water and then placed in the denture cleansing agents and water for 12 hours at room temperature, with distilled water as the control [7].

[Table/Fig-4]: Trevalon samples immersed in clinsodent, fittydent and distilled water.

Out of the 120 samples, 80 samples of DPI and Trevalon denture base resins, after staining with tea and coffee, were immersed in Clinsodent and Fittydent denture cleansing agents, with 40 samples placed in distilled water as the control group [Table/Fig-5]. Each day, new solutions were prepared for immersing the specimens for 60 days. The 120 samples were tested on day 0, 15th day, 30th day, 45th day, and 60th day using Hunter's Lab colourimeter [Table/Fig-6].

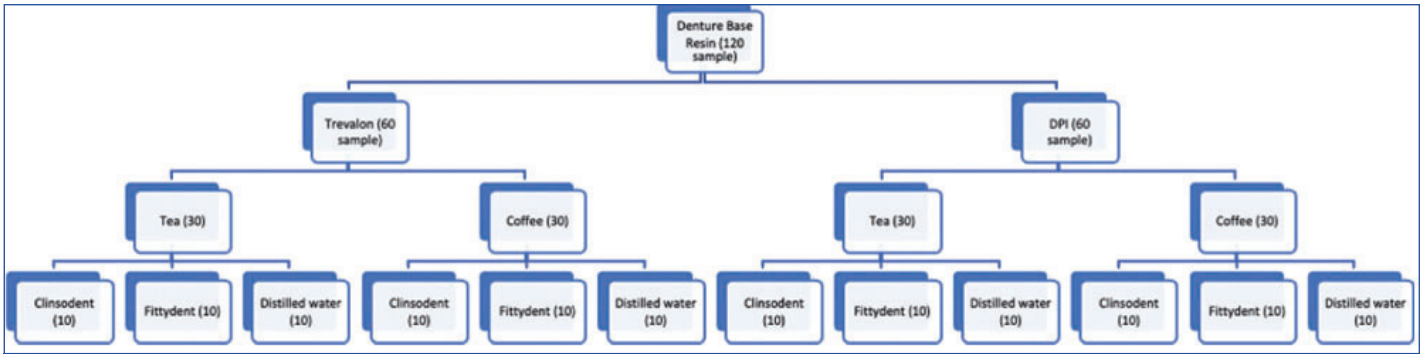
The mean and standard deviations of the colour change (E) were obtained using the Commission Internationale de l'Eclairage L* a* b* (CIELab) system, which is a uniform three-dimensional system for determining colour changes. The CIELab system is widely used for determining chromatic differences and is more advantageous than the Munsell colour system.

Colour changes were calculated for each specimen using the formula: $\Delta E^* = \{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2\}^{1/2}$. In this formula, L* represents lightness and darkness on a scale of 0 (black) to 100 (white), a* and b* represent chromatic scales, with positive a* corresponding to red and negative a* corresponding to green, and positive b* corresponding to yellow and negative b* corresponding to blue [9].

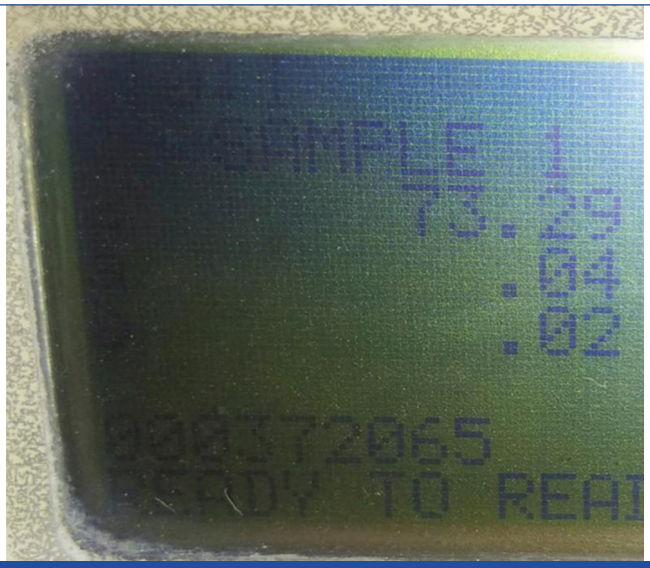
In conclusion, the colour change of the samples was measured at various time points using the CIE Lab system. Statistical analysis was performed to assess the effectiveness of different denture cleaning agents in removing tea and coffee stains from the denture base resin materials. The results of the study will provide valuable information for dental professionals in selecting appropriate cleaning agents for maintaining the aesthetics of dentures.

STATISTICAL ANALYSIS

The data were statistically evaluated using Statistical Packages for Social Sciences (SPSS) version 25.0 software. A student's t-test was employed for independent variables, with a confidence level of 99%. One-way Analysis of Variance (ANOVA) was used to determine differences between the means of independent groups.



[Table/Fig-5]: Sample distribution.



[Table/Fig-6]: Reading of a specimen.

RESULTS

For DPI, tea stained more than coffee in Clinsodent and Fittydent at 15, 30, 45, and 60 days. Staining significantly increased over time for both tea and coffee, with a p-value <0.0001 [Table/Fig-7]. Similar results were seen for Trevalon. Staining was more with tea compared to coffee at 60 days for Trevalon samples in both Clinsodent (p=0.0181) and Fittydent (p=0.0294) solutions [Table/Fig-8].

For tea stained samples dipped in distilled water, the mean colour change at 15 days was 3.21±0.17 for DPI and 5.45±0.87 for Trevalon (p-value <0.0001). At 60 days, the mean colour change was 11.78±1.52 for Trevalon and 9.98±0.59 for DPI, with a statistically insignificant difference (p=0.0774). The colour change of samples stained with tea was higher in Trevalon compared to DPI in both Clinsodent and Fittydent solutions at 60 days [Table/Fig-9]. Similarly,

Beverage	Cleansing agent	Time				p-value*
		15 days	30 days	45 days	60 days	
Tea	Clinsodent	4.15± 0.95	8.91± 0.72	9.69± 0.76	9.66± 1.08	<0.0001 (HS)
Coffee	Clinsodent	3.96± 0.44	7.07± 0.64	8.67± 0.65	10.82± 1.16	<0.0001 (HS)
p-value**		0.5989 (NS)	0.0003 (S)	0.0227 (S)	0.0517 (NS)	
Tea	Distilled water	3.21± 0.17	7.06± 0.22	11.76± 1.02	9.98± 0.59	<0.0001 (HS)
Coffee	Distilled water	4.08± 0.33	8.20± 0.22	8.65± 1.03	11.02± 1.32	<0.0001 (HS)
p-value**		<0.0001 (HS)	<0.0001 (HS)	0.0001 (S)	0.0701 (NS)	
Tea	Fittydent	4.20± 0.35	7.07± 0.21	10.11± 0.91	9.84± 0.71	<0.0001 (HS)
Coffee	Fittydent	3.42± 0.63	6.92± 0.38	9.25± 0.91	13.28± 1.72	<0.0001 (HS)
p-value**		0.0201 (S)	0.1714 (NS)	0.1151 (NS)	<0.0001 (HS)	

[Table/Fig-7]: Mean and standard deviation for colour change (ΔE) at different time intervals with respect to baseline according to beverages and cleansing agents for denture base resin DPI.
*Using repeated measure ANOVA; **Using t-test for independent samples; S: Significant; NS: Not significant; HS: Highly significant

Beverage	Cleansing agent	Time				p-value*
		15 days	30 days	45 days	60 days	
Tea	Clinsodent	4.97± 0.35	8.62± 0.60	11.74± 0.97	14.25± 2.95	<0.0001 (HS)
Coffee	Clinsodent	4.81± 0.45	8.70± 0.43	11.40± 0.74	11.58± 0.55	<0.0001 (HS)
p-value**		0.3833 (NS)	0.7873 (NS)	0.5029 (NS)	0.0181 (S)	
Tea	Distilled water	5.45± 0.87	9.11± 0.77	10.68± 1.03	11.78± 1.52	<0.0001 (HS)
Coffee	Distilled water	4.85± 0.65	8.75± 0.61	11.54± 1.07	11.92± 0.95	<0.0001 (HS)
p-value**		0.1238 (NS)	0.286 (NS)	0.1299 (NS)	0.823 (NS)	
Tea	Fittydent	4.67± 0.37	8.59± 0.48	11.31± 0.98	11.71± 0.93	<0.0001 (HS)
Coffee	Fittydent	5.49± 0.76	9.05± 0.52	11.28± 1.07	10.72± 0.94	<0.0001 (HS)
p-value**		0.0218 (S)	0.0929 (NS)	0.9368 (NS)	0.0294 (S)	

[Table/Fig-8]: Mean and standard deviation for colour change (ΔE) at different time intervals with respect to baseline according to beverages and cleansing agents for denture base resin Trevalon.
*Using repeated measure ANOVA; **Using t-test for independent samples; S: Significant; NS: Not significant; HS: Highly significant

Denture base resin type	Levels	15 days	30 days	45 days	60 days	p-value*
DPI	Clinsodent	4.15± 0.95	8.91± 0.72	9.69± 0.76	9.66± 1.08	<0.0001 (HS)
Trevalon	Clinsodent	4.97± 0.35	8.62± 0.60	11.74± 0.97	14.25± 2.95	<0.0001 (HS)
p-value**		0.0255 (S)	0.3417 (NS)	<0.0001 (HS)	0.0007 (S)	
DPI	Distilled water	3.21± 0.17	7.06± 0.22	11.76± 1.02	9.98± 0.59	<0.0001 (HS)
Trevalon	Distilled water	5.45± 0.87	9.11± 0.77	10.68± 1.03	11.78± 1.52	<0.0001 (HS)
p-value**		<0.0001 (HS)	0.0003 (S)	<0.0001 (HS)	0.0774 (NS)	
DPI	Fittydent	4.20± 0.35	7.07± 0.21	10.11± 0.91	9.84± 0.71	<0.0001 (HS)
Trevalon	Fittydent	4.67± 0.37	8.59± 0.48	11.31± 0.98	11.71± 0.93	<0.0001 (HS)
p-value**		<0.0001 (HS)	0.09392 (NS)	<0.0001 (HS)	0.0001 (S)	

[Table/Fig-9]: Mean and standard deviation for colour change (ΔE) at different time intervals with respect to baseline according to denture base resin type and cleansing agent for beverage type tea.
*Using repeated measure ANOVA; **Using t-test for independent samples; S: Significant; NS: Not significant; HS: Highly significant

for coffee-stained samples in Clinsodent, the mean colour change at 15 days was 3.96±0.44 for DPI and 4.81±0.45 for Trevalon. At 60 days, the mean colour change was 11.58±0.55 for Trevalon and 10.82±1.16 for DPI (p=0.0860) [Table/Fig-10].

Denture base resin type	Levels	15 days	30 days	45 days	60 days	p-value*
DPI	Clinsodent	3.96± 0.44	7.07± 0.64	8.67± 0.65	10.82± 1.16	<0.0001 (HS)
Trevalon	Clinsodent	4.81± 0.45	8.70± 0.43	11.40± 0.74	11.58± 0.55	<0.0001 (HS)
p-value**		0.0004 (S)	<0.0001 (HS)	<0.0001 (HS)	0.0860 (NS)	
DPI	Distilled water	4.08± 0.33	8.20± 0.22	8.65± 1.03	11.02± 1.32	<0.0001 (HS)
Trevalon	Distilled water	4.85± 0.65	8.75± 0.61	11.54± 1.07	11.92± 0.95	<0.0001 (HS)
p-value**		0.0053 (S)	0.0208 (S)	<0.0001 (HS)	0.0974 (NS)	
DPI	Fittydent	3.42± 0.63	6.92± 0.38	9.25± 0.91	13.28± 1.72	<0.0001 (HS)
Trevalon	Fittydent	5.49± 0.76	9.05± 0.52	11.28± 1.07	10.72± 0.94	<0.0001 (HS)
p-value**		<0.0001 (HS)	<0.0001 (HS)	0.0002 (S)	0.0011 (S)	

[Table/Fig-10]: Mean and standard deviation for colour change (ΔE) at different time intervals with respect to baseline according to denture base resin type and cleansing agent for beverage type coffee.
*Using repeated measure ANOVA; **Using t-test for independent samples; S: Significant; NS: Not significant; HS: Highly significant

For DPI samples dipped in the cleansing agent Clinsodent, the mean colour change for tea was maximum 9.69±0.76 at 45 days, followed by 9.66±1.08 at 60 days. For Fittydent, the mean colour change for tea was highest at 10.11±0.91 for 45 days, followed by 9.84±0.71 at 60 days. However, for coffee-stained DPI samples, the maximum mean colour change was observed at 60 days for samples dipped in Clinsodent, Fittydent, and distilled water. The difference in mean ΔE across times was highly statistically significant for both tea and coffee-stained samples, with a p-value <0.0001 [Table/Fig-11]. The difference in the mean colour change of Trevalon samples stained with tea across all three cleansing agents at 60 days was statistically significant (p=0.0079), with the highest colour change observed in samples dipped in Clinsodent [Table/Fig-12].

Beverage	Cleansing agent	Time				p-value*
		15 days	30 days	45 days	60 days	
Tea	Clinsodent	4.15± 0.95	8.91± 0.72	9.69± 0.76	9.66± 1.08	<0.0001 (HS)
	Distilled water	3.21± 0.17	7.06± 0.22	11.76± 1.02	9.98± 0.59	<0.0001 (HS)
	Fittydent	4.20± 0.35	7.07± 0.21	10.11± 0.91	9.84± 0.71	<0.0001 (HS)
p-value**		0.0011 (S)	<0.0001 (HS)	<0.0001 (HS)	0.6820 (NS)	
Coffee	Clinsodent	3.96± 0.44	7.07± 0.64	8.67± 0.65	10.82± 1.16	<0.0001 (HS)
	Distilled water	4.08± 0.33	8.20± 0.22	8.65± 1.03	11.02± 1.32	<0.0001 (HS)
	Fittydent	3.42± 0.63	6.92± 0.38	9.25± 0.91	13.28± 1.72	<0.0001 (HS)
p-value**		0.0119 (S)	<0.0001 (HS)	0.245 (NS)	0.0009 (S)	

[Table/Fig-11]: Mean and standard deviation for colour change (ΔE) at different time intervals with respect to baseline according to beverages and denture base resin DPI for cleansing agents.
*Using repeated measure ANOVA; **Using One-way ANOVA; S: Significant; NS: Not significant; HS: Highly significant

Beverage	Cleansing agent	Time				p-value*
		15 days	30 days	45 days	60 days	
Tea	Clinsodent	4.97± 0.35	8.62± 0.60	11.74± 0.97	14.25± 2.95	<0.0001 (HS)
	Distilled water	5.45± 0.87	9.11± 0.77	10.68± 1.03	11.78± 1.52	<0.0001 (HS)
	Fittydent	4.67± 0.37	8.59± 0.48	11.31± 0.98	11.71± 0.93	<0.0001 (HS)
p-value**		0.0541 (NS)	0.2260 (NS)	0.0595 (NS)	0.0079 (S)	
Coffee	Clinsodent	4.81± 0.45	8.70± 0.43	11.40± 0.74	11.58± 0.55	<0.0001 (HS)
	Distilled water	4.85± 0.65	8.75± 0.61	11.54± 1.07	11.92± 0.95	<0.0001 (HS)
	Fittydent	5.49± 0.76	9.05± 0.52	11.28± 1.07	10.72± 0.94	<0.0001 (HS)
p-value**		0.0420 (S)	0.2870 (NS)	0.8320 (NS)	0.0103 (S)	

[Table/Fig-12]: Mean and standard deviation for colour change (ΔE) at different time intervals with respect to baseline according to beverages and denture base resin Trevalon for cleansing agents.
*Using repeated measure ANOVA; **Using One-way ANOVA; S: Significant; NS: Not significant

DISCUSSION

Polymethylmethacrylate is commonly used for denture base fabrication. Denture wearers often face significant issues with denture staining, which can make the prosthesis aesthetically unacceptable [7]. Geriatric patients, with diminished manual dexterity and motor capacity, require a mechanical and chemical cleaning method involving immersion in a denture cleaning agent [7,8].

Discolouration assessment can be done visually or with instruments. Using a measurement instrument eliminates errors due to differences in subjective colour interpretation. A colourimeter was utilised in present study. Measurements obtained from a colourimeter serve the purpose of quantitative analysis and objective comparison of colour changes in materials [9].

The study results indicate that staining intensifies over time, with the colour change value (ΔE) increasing up to 45 days. Water sorption initially softens the polymer resin component by swelling the network, reducing frictional forces between polymer chains. The absorbed moisture acts as a plasticiser, lowering the glass transition temperature (Tg) of the polymerised resins. Water sorption eventually leads to irreversible damage through microcrack formation and hydrolytic degradation of the polymer with scission of the ester linkages and gradual deterioration of the infrastructure of the polymer over time. Once the polar sites in the polymer network become saturated with water, equilibrium is reached between bound and free sites and the water sorption stabilises, intermitting its absorption [10].

Acrylic resin has a tendency to absorb solvent or water owing to the polarity of polymethylmethacrylate molecules. The absorbed solvent diffuses into the polymer network, disrupting polymeric linkages and causing hydrolytic degradation, resulting in a colour change of the acrylic resin [11]. Water sorption saturation in polymeric materials leads to stabilising colour changes. When the polar sites in the polymer network become saturated, equilibrium is reached between the bound and free sites, thereby limiting further water sorption [12].

In present study, coffee caused more staining than tea because tea discolouration is mainly caused by surface adsorption, while coffee staining involves both adsorption and absorption of colourants. Um CM and Ruyter IE reported that the yellow colourants have different polarities, yellow colourants of coffee were less polar and thereby less hydrophilic than yellow colourants of tea [13]. Therefore, the discolouration of tea was easily removed as compared to coffee. Hollis S et al., has evaluated colour stability using beverages such as cola, grape juice and coffee, coffee contains tannic acid (pH6-6.4), which causes its yellow brown colour, and is primary staining

ingredient [7]. Bagheri R et al., measured the pH of tea is 5.38 and of coffee is 5.01, so coffee stains more [14].

Clinsodent and Fittydent, both peroxide-type denture cleaners, were compared. Clinsodent, containing potassium persulfate, sodium perborate, and other ingredients, outperformed Fittydent for stain removal. The hydrogen peroxide solution formed by these cleaners, along with alkaline detergents, aids in mechanical cleaning [15].

Researchers have found that cleansing agents containing sodium perborate with trisodium phosphate are more effective in stain removal than those containing sodium perborate with sodium bicarbonate or water as a control [16].

Limitation(s)

One limitation of present study is that only heat-activated DPI and Trevalon resins were used. Other resins, such as meliodent or lucitone, were not included. Additionally, while two common beverages, tea and coffee, were used for staining, other prevalent staining agents in India like turmeric, tobacco chewing, and paan were not considered. Furthermore, as an in-vitro study conducted under controlled conditions, the presence of multiple colourants simultaneously in the diet, as seen in real-life scenarios, was not accounted for.

CONCLUSION(S)

The study focused on measuring the colour stability of two base denture resins and the effectiveness of various denture cleansing agents after staining with tea and coffee. It was observed that DPI and Trevalon show statistically significant colour changes when exposed to tea and coffee, with Trevalon showing more variation than DPI. Coffee had a greater staining effect on the samples compared to tea. Staining intensity increased over time, with colour change values (ΔE) rising up to 45 days before stabilising. Clinsodent was found to be more effective than Fittydent in removing stains caused by tea and coffee.

To enhance the evaluation of different staining and cleansing agents, future studies could benefit from larger sample sizes. Additionally, conducting studies in patients to assess colour stability may provide further insights into the efficacy of denture materials and cleaning agents.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Aug 10, 2023
- Manual Googling: Oct 20, 2023
- iThenticate Software: Feb 01, 2024 (11%)

ETYMOLOGY: Author Origin

EMENDATIONS: 8

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Aug 09, 2023**
Date of Peer Review: **Oct 14, 2023**
Date of Acceptance: **Feb 03, 2024**
Date of Publishing: **Apr 01, 2024**