

Comparison of efficacy of sodium hypochlorite with sodium perborate in the removal of stains from heat cured clear acrylic resin

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ABSTRACT

Background: Acrylic resin bases attract stains and odor producing organic and inorganic deposits. The use of chemical denture cleanser soaks is the most popular method of denture cleansing. **Aim:** To compare the efficacy of 2 different denture cleansers in removing tea, coffee, turmeric and paan stains from heat cured clear acrylic resins. **Materials and Methods:** Two hundred heat cured clear acrylic samples were prepared. The samples were divided into four groups and stored in tea, coffee, turmeric and paan at 37°C for 10 days. Stained samples were subjected to immersion in the commercially available denture cleansers sodium perborate (Clinsodent), sodium hypochlorite (VI-Clean) and distilled water (control). Optical density (OD) values were measured before and after 20 minutes and 8 hours of immersion in the cleansers. The data were analyzed statistically using Fischer's test (one way ANOVA) and multiple comparisons were done by Bonferroni test. **Results:** Both Clinsodent and VI-clean were found to be least effective in removal of coffee stains and best for removing turmeric stains. **Conclusion:** It is necessary for the dental professional to ensure that the denture wearing public knows how to select the appropriate denture cleanser so as to improve denture home care protocol.

KEY WORDS: Acrylic resin, dental cleansers, sodium hypochlorite, sodium perborate, stain removal efficacy

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INTRODUCTION

A removable prosthesis serves to replace missing or lost natural teeth and their associated structures to a great extent. Since most dentures nowadays are made with acrylic resin teeth and denture base material of polymethylmethacrylate type of resin (PMMA resin), it is always better to use a cleaning method in which strong abrasive action is not present. The reason being, these acrylic resin bases attract stains and odor producing organic and inorganic deposits. Such unclean dentures often produce a strong repulsive odor commonly called as "denture breath".^[1] Sensing this requirement, many commercial denture cleansers are currently available and each one claims to be efficient. Mainly paan (with or without tobacco), tea, coffee and turmeric stains along with bacterial plaque accumulates

on the dentures in an average Indian patient despite attempts to produce a self cleaning design for dentures. The habit of daily intake of beverages like coffee, cocoa and oral rinses like chlorhexidine several times a day also tends to stain and discolor resin.^[2] Both the concentration and the period of exposure of the staining agents in beverages may affect the pigmentation of resin.^[3] Adequate cleaning of a well polished denture with hand soap and a properly designed denture brush is the current denture cleansing method recommended by the American Dental Association.^[4] The use of chemical denture cleanser soaks is the second most popular method of denture cleansing and these are commercially available as alkaline peroxides, alkaline hypochlorite, dilute organic or inorganic acids, disinfectants and enzymes. These products generally contain antimicrobial agents such as hypochlorite or

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Joseph: Compare efficacy of denture cleansers in removing stains from acrylic resins

oxidizing agents that kill the microorganisms present in denture plaque.^[5]

Despite the claims made by the manufacturers of these commercial denture cleansers, the efficacy of these cleansers remains questionable. Although a few studies have been cited in the literature^[6] comparing the antimicrobial activity of popular denture cleansing agents, the materials used were not Indian formulations. In the past, the function of denture cleansers has been to remove deposits and stains from dentures. With the present knowledge of the role of microorganisms in the etiology of denture stomatitis, more emphasis is being placed on the ability of denture cleansers to sanitize dentures. An ideal denture cleanser should thus fulfill many requirements, including the ability to remove both organic and inorganic deposits together with any associated stain. A plethora of denture cleansers are available, with claims for their various efficacies, the composition of which remains a closely guarded secret in most cases.

The present study has been undertaken to compare the efficacy of two popular denture cleansers in removing the stains induced by tea, coffee, turmeric and paan on the heat cure clear acrylic resin specimens.

MATERIALS AND METHODS

The following equipments were used in the study –

- Spectrophotometer, i.e. Thermo Spectronic 10 UV from Genesys (UV-VIS), Pittsford, New York [Figure 1]
- Julabo SW1 Incubator (Switzerland) for maintaining temperature at $37 \pm 1^\circ\text{C}$, Kavo Dental Flask and clamp, Germany,
- Acrylizer unit, Kavo, Germany,
- Brass mold [Figure 2] for standardization of sample size ($10 \times 50 \times 2\text{mm}$).

The materials used in the study were-

- Dental carving wax,
 - Model plaster / dental stone,
 - Clear heat cure acrylic material (DPI),
 - Two denture cleansers [Figure 3]
1. Clinsodent powder from ICPA Health Products Ltd Ankleshwar, which contains sodium perborate and acts by liberating nascent O_2
 2. VI-clean denture cleanser liquid from Vishal Pharma Ltd. Ahmedabad, which contains sodium hypochlorite and exerts bleaching action.

The different stains used in the study were [Figure 4]

- Brooke Bond Taaza tea leaves
- Golden Blend Laxmi coffee

- Turmeric roots powdered and
- Paan beeda mixture.

Method employed

Two immersion type denture cleansers (mentioned above) with different chemical compositions were selected and sample solutions were prepared according to the manufacturer's instructions (1 teaspoon in 200 ml of water). Distilled water was used as control.

The samples were fabricated as follows.

Dental carving wax was melted in a standard brass mold of length 50mm, thickness 2mm and width of 10mm for each group so as to fit into the cuvette or specimen carrying chamber of the spectrophotometer. These wax patterns were flaked in dental flasks with plaster of Paris and dental stone. After wax elimination, packing was done with clear, heat cure acrylic resin and after trial closure, the final closure was done. They were then bench cured for 30 minutes and then subjected to a curing cycle of one and half hours. The samples were then deflaked, trimmed and polished using progressive grits of sandpaper, finally ensuring that the dimensions of $50 \times 10 \times 2\text{mm}$ were maintained. After finishing and polishing, the samples were stored in distilled water at $37 \pm 1^\circ\text{C}$ for 24 hrs so as to rid them of any residual monomer present. The baseline optical density of each of the unstained samples was then determined prior to staining for future comparison so as to eliminate samples with porosities. Following this method, 240 heat cured, clear acrylic samples were obtained, of which 40 were used for the pilot study to determine the required quantity of staining agents to produce adequate staining in 200 ml of distilled water. The absorption maximum (λ_{max}) i.e. the wavelength at which the spectrophotometer (UV-VIS) light is sensitive to each specific staining media was also determined. The pH of each stain was also determined. This was done using a pH indicator Indikrom Litmus paper with a specific pH range of 2.0 – 7.5 [Table 1].

The remaining 200 samples were used for the actual study. The samples were then divided into 4 batches of 50 each (200) and suspended in aqueous staining agents of turmeric, tea, paan (tobacco) and coffee for 10 days at $37 \pm 1^\circ\text{C}$ in an incubator (so as to simulate *in vivo* conditions).

The stains were changed on a daily basis with fresh ones so as to prevent any microbial colonization and to maintain a uniform concentration. The specimens were then washed and air-dried for two hours. At this point the optical density (i.e. the baseline reading) of the stained samples was measured for future comparison after immersion with denture cleansers.

Joseph: Compare efficacy of Denture Cleansers in removing stains from acrylic resins



Figure 1: Showing spectrophotometer used in the study

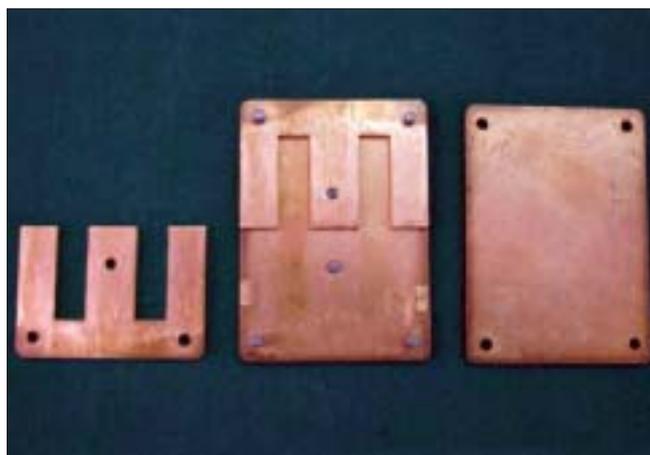


Figure 2: Showing brass mold for standardization of sample size (10 x 50 x 2mm)



Figure 3: Showing two denture cleansers used in the study (Clinsodent powder and VI-clean denture cleanser liquid)



Figure 4: Showing different staining agents used in the study

All the stained specimens were then suspended in two freshly prepared denture cleansers along with 40 stained samples in distilled water (as control) for a period of 20 minutes (so as to simulate in between meals immersion) and 8 hours (simulating overnight immersion) correspondingly. They were then removed, air dried and evaluated for the efficacy of stain removal of the denture cleanser, by measuring the optical density (at the various corresponding λ max of each stain) of the treated specimen by using a spectrophotometer. This process was repeated for the various stains separately and the mean values obtained. From this, the baseline optical density of the previously stained specimens for each stain was determined for standardization and comparison.

Statistical analysis

The values obtained were statistically analyzed using SPSS software version 13.0. Mean and standard deviations were estimated from the samples for each

Table 1: Results of pilot study showing the required quantity of staining agents to produce adequate staining in 200ml of distilled water, the absorption maximum (λ max) and the pH of each stain

Staining agent	Minimum quantity required for adequate staining	λ max (nm)	pH
Tea	15 gm in 200 ml (boiled for 10 min)	295	3.5
Coffee	15 gm in 200 ml (boiled for 10 min)	290	3.0
Turmeric	0.5 gm in 200 ml (boiled for 10 min)	422	5.5
Paan	25 gm (3 packets approx.) in 200 ml (fine paste made by grinding in a mixer)	293	7.0

stain groups (baseline reading). Mean values were compared by one-way ANOVA – Fischer's test for the group comparison. The multiple comparisons were done by Bonferroni test which was employed to identify the significant groups at 5% level keeping the baseline reading as the dependent variable. The comparison was done for individual stains, period wise for each denture cleanser. In the present study, $P < 0.05$ was considered as the level of significance.

RESULTS

The mean baseline optical density values of the stained samples, after the spectrophotometric analysis at their respective λ_{max} are shown in Table 2. The results showed that coffee followed by tea, then turmeric and finally paan had optical density values in the respective descending order. These mean values were then analyzed using the ANOVA (Fischer's Test) between the stain groups and it was found to be very highly

significant for staining (i.e. $P = 0.001$, where $P < 0.05$).

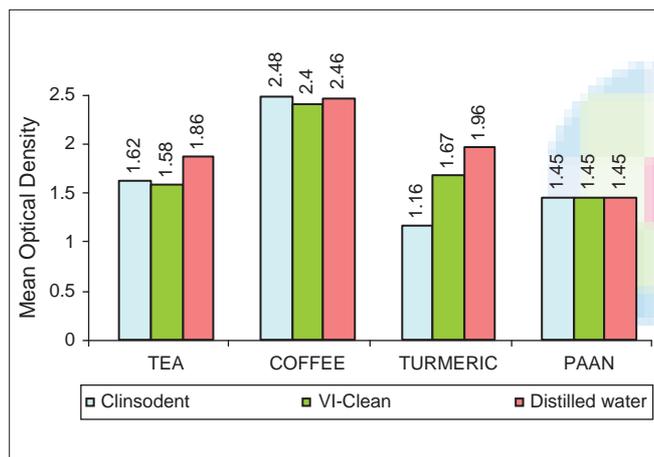
The mean optical density values of heat cured acrylic stained samples after immersion in the denture cleansers for 20 minutes are depicted in Graph 1. The results showed that samples immersed in Clinsodent solution had the least optical density for turmeric stain followed by paan, then tea and finally coffee. For the samples immersed in VI-clean, the least optical density values were for paan followed by tea, turmeric and then coffee.

Table 2: Mean averages and standard deviations of optical density values of heat cured acrylic samples after staining with various staining agents and before immersion in denture cleanser at their respective λ_{max}

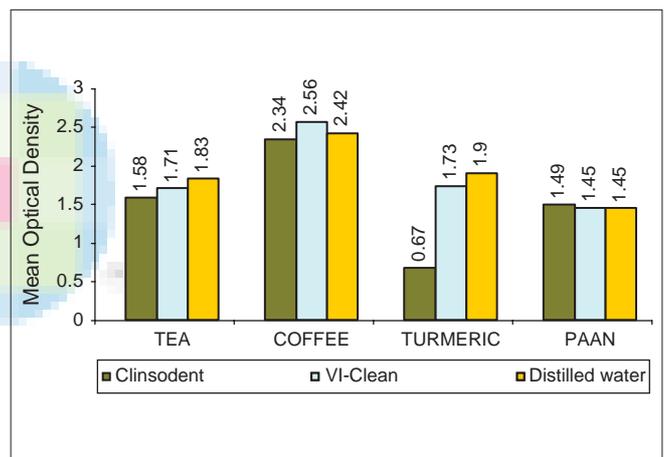
Stains	N	Optical density at λ_{max} Mean \pm SD	F	P*
Tea	30	2.163 \pm 0.44325	23.64	0.001 vhs
Coffee	30	2.499 \pm 0.19587		
Turmeric	30	1.968 \pm 0.28749		
Paan	30	1.4613 \pm 0.06981		

*One-way ANOVA (Fischer's test) was used to calculate the P-value

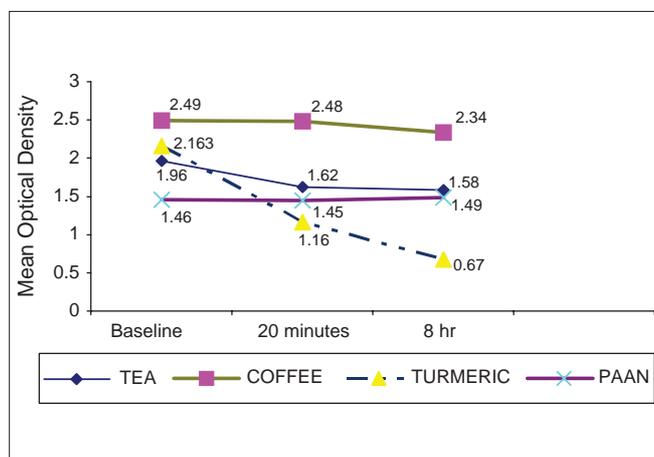
The mean of optical density values of heat cured acrylic samples after immersion in the denture cleansers for 8 hours is depicted in Graph 2. The results showed that samples immersed in Clinsodent solution had the least optical density for turmeric stain followed by paan, then tea and finally coffee. For the samples immersed in VI-clean the least optical density was for paan, followed by tea, turmeric and then coffee. There was no significant change in the optical density values for the control samples immersed in distilled water.



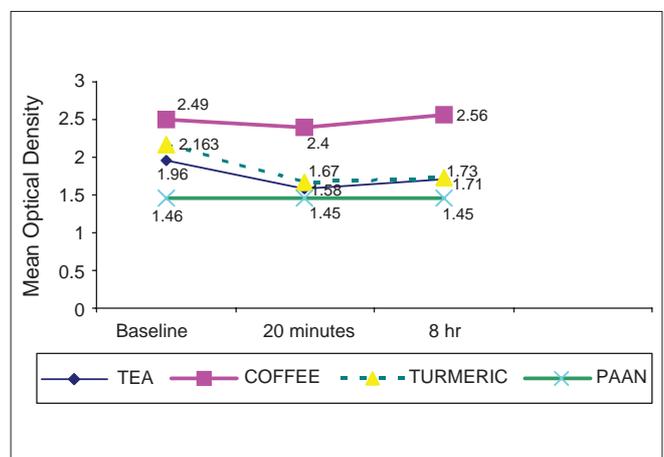
Graph 1: Comparison of mean optical density among different stains after 20 minutes



Graph 2: Comparison of mean optical density among different stains after 8 hours



Graph 3: Comparison of mean optical density for different periods - Clinsodent



Graph 4: Comparison of mean optical density for different periods - VI-clean

Table 3: Multiple comparisons using bonferroni test

Stains	Dental cleanser	(I) Time	(J) Time	Mean difference (I-J)	P
Turmeric	Clinsodent	Baseline	20 minutes	0.7100	0.001 vhs
			8 hr	0.7462	0.001 vhs
		20 minutes	8 hr	0.0362	1.000
Tea	VI-clean	Baseline	20 minutes	0.5079	0.001 vhs
	Clinsodent	Baseline	20 minutes	-0.5438	0.001 vhs
			8 hr	0.3878	0.001 hs
			8 hr	-0.3989	0.001 vhs
		20 minutes	8 hr	-0.1201	1.000
		20 minutes	8 hr	0.1449	0.624
	Distilled water	Baseline	20 minutes	0.1979	0.974
	VI-clean	Baseline	20 minutes	-0.3915	0.006 hs
			8 hr	0.2329	0.611
		8 hr	-0.5513	0.001 vhs	
	20 minutes	8 hr	0.035	1.000	
	20 minutes	8 hr	-0.1598	0.902	
Paan	Clinsodent	Baseline	20 minutes	0.3034	0.290
		Distilled water	Baseline	20 minutes	-0.5175
			8 hr	0.8001	0.001 vhs
			8 hr	-0.4742	0.012
		20 minutes	8 hr	0.4967	1.000
		20 minutes	8 hr	0.0433	1.000
Coffee	VI-clean	Baseline	20 minutes	-0.197	0.001 vhs
	Clinsodent	Baseline	20 minutes	1.1306	1.000
			8 hr	-0.2511	0.001 vhs
			8 hr	1.0893	1.000
		20 minutes	8 hr	-0.0541	1.000
		20 minutes	8 hr	-0.0413	0.03 sig
	Distilled water	Baseline	20 minutes	-0.5245	0.001 vhs
	VI-clean	Baseline	20 minutes	0.9722	0.072
			8 hr	-0.4639	0.001 vhs
			8 hr	0.9766	1.000
			20 minutes	8 hr	0.0606
	20 minutes	8 hr	0.0044	0.001 vhs	
Distilled water	Baseline	20 minutes	1.0385	0.001 vhs	
		8 hr	1.0358		
		20 minutes	8 hr	-0.0027	1.000

Table 3 depicts the multiple comparisons among denture cleansers for individual stains and the period wise (i.e. 20 minutes and 8 hours) changes in optical density (by calculating the mean differences) and applying the Bonferroni test using the baseline readings as the dependent variable.

The results [Graphs 3 and 4] show that, for 20 minutes as well as eight-hour immersions, both Clinsodent and VI-clean were least effective for removal of coffee stain and best for removing of turmeric stain.

DISCUSSION

A major cosmetic concern for denture wearers is the stains which accumulate on their dentures which in turn aids in the propagation of denture stomatitis. Therefore this study was undertaken to deal with this concern, by employing a standardized scientific approach in analyzing the efficacy of stain removal of immersion type denture cleansers. These stains result from various processes including the ingestion of colored foodstuffs, tobacco and beverages like coffee, tea etc. The earlier study was done by Gispin and Caputo^[7] using tea, coffee and grape solution as the staining agents. They found grape solution to have a higher staining potential, owing to the increased pH. Yannikakis *et al.*,^[3] studied the staining effect of coffee and tea on six brands of resins used in fabrication of provisional restoration. Coffee solution exhibited more staining than tea solution. Seven days of immersion resulted in perceptible color change in all brands of resin. The stains on the acrylic resin samples used in this study relate to the dental stains seen commonly *in vivo* and were therefore thought to be clinically relevant.

In the present study, heat cured clear acrylic samples of dimensions 10 mm in width by 50 mm in length by 2 mm in thickness were fabricated, which is in contrast with the dimensional specifications given by the ADA specification No. 12 for denture base polymer.^[8] The samples were fabricated to this specification in order to fit into the spectrophotometer cuvette slot used for this study.

Coffee and tea stained samples had maximum residual stains present, after both 20 minutes and eight-hour immersion as compared to turmeric and paan stained samples. To see the difference in the staining solution, the pH testing was done and it was found that coffee has a pH of 3.0 followed by tea at 3.5, turmeric at 5.5 and paan at 7.0. This indicated the influence of the acidic nature of coffee and tea on the clear acrylic samples, possibly eroding the polished surface layer and facilitating more stain uptake. This finding is in accordance with the result of Gispin and Caputo^[7] who claimed the same while using grape as a staining solution (being highly acid). On the other hand turmeric and paan were towards the alkaline side of pH scale, explaining the lesser degree of staining with these stains.

Although the most widely used method of denture cleansing seems to be the usage of soap and brush, with increasing age, a large number of geriatric patients (who form the majority of complete denture wearers) have a loss of manual dexterity and are handicapped, hence being unable to accomplish denture cleansing effectively.

Conventional alkaline peroxide soak type denture cleansers are by far more widely used by the public than others to clean their dentures. The usage of immersion type of cleansers helps them to keep the dentures clean and devoid of any deposits. Keeping this in perspective, two immersion type denture cleansers (Clinsodent powder and VI-Clean liquid), commonly available in the south Indian market were chosen to test for their efficacy in stain removal.

Clinsodent contains sodium perborate, which is a peroxide type of denture cleanser. When dissolved in water, it forms a solution of hydrogen peroxide. This type of cleanser combines alkaline detergents to reduce surface tension and chemicals which release oxygen from the solution. The oxygen bubbles exert a mechanical cleansing effect. VI-Clean contains sodium hypochlorite, as an active ingredient. When dissolved in water, it cleanses by a bleaching action as a result of the release of chloride ions into the solution.

The immersion time of 20 minutes was chosen to determine whether optimum stain removing action takes place within this period, as has been recommended by some manufacturers in the past for 'in between meals immersion' and supported by a study by Russell and Elahi^[9] according to which 10 minutes soaking time was sufficient. Eight hrs of immersion time was chosen to simulate the 'overnight soaking' of dentures in the cleansing solutions as recommended by the manufacturers of the denture cleanser used in this study.

The optical density values were measured at the respective absorption maximum (λ max) for different stains to check the extent of staining and the stain removing ability of denture cleansers, which is in contrast to the study by Tulsi and Sabita,^[10] where the optical density was measured without measuring the absorption maximum of the stains.

The present study is an *in vitro* test which is accelerated as compared with clinical conditions. The results showed significant color change in acrylic resin within 10 days of immersion in tea, turmeric, coffee and paan stains. Also the study was done keeping the samples in darkness at $37 \pm 1^\circ\text{C}$ in an incubator to simulate natural oral conditions as suggested by Thakral *et al.*,^[2] and Jagger *et al.*^[6]

The results revealed that Clinsodent was least effective for removal of coffee stain and best for removing turmeric stain at both 20 minutes and eight hours of destaining durations. This can be explained by the acidic nature of coffee stain in comparison

to turmeric and paan which could have influenced the uptake of more stains by the acrylic samples, as a result of dissolution of polished surface layer. This is supported by the results found by Hutchins and Parker^[11] that the effervescent tablets are not effective in removal of denture surface deposits.

On the other hand VI-Clean was least effective for removal of coffee stain and best for removing paan stain at both 20 minutes and eight hours of destaining durations. As inferred from the above results, coffee stain was found to be the most difficult to be cleaned by both the cleansers. The mean difference of optical density values between 20 minutes and eight-hour immersion for coffee stained acrylic sample in cleansers was more for VI-clean than that for Clinsodent, indicating that VI-clean has better cleansing activity than Clinsodent. Similar results have been shown by Jagger *et al.*,^[6] where a denture cleanser with sodium hypochlorite was used and was found to be a better cleanser than Boots Denture Cleaning Powder. For the control (distilled water) was found to cause small degree of stain removal which may be due to the increased temperature, causing increased water uptake by the materials and leaching out of few soluble components of the stains from the denture materials as stated by Gupta *et al.*^[12]

Limitations of the study

1. The individual stains were taken and scrutinized separately; this is not possible in the patient's dentures as there is a multifactorial influence in staining of dentures.
2. Micro porosities present in denture samples could have an effect on absorption of the stains, though all samples were finely polished and visually checked for porosity prior to testing.
3. The denture samples used here were clear ones, so the whitening effect could not have been perceived as much as it would have in colored acrylic used for denture fabrication.

Further scope of the study

1. This study can be extended further into a clinical study to prove the efficacy of denture cleansers. Thus it would be more significant clinically.
2. The whitening (bleaching) effect of the presently studied denture cleansers can be further analyzed using colored samples on prolonged immersion.
3. The stained samples can be subjected to further analysis by reflection spectrophotometry using cie lab system.

SUMMARY AND CONCLUSIONS

From the results obtained the following conclusions were drawn,

1. Of the stains studied, coffee was found to have the

Joseph: Compare efficacy of Denture Cleansers in removing stains from acrylic resins

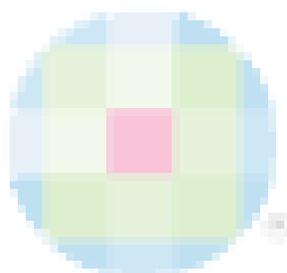
maximum staining capacity and the most difficult to be cleansed by both the denture cleansers.

2. VI-clean denture cleanser was found to be more effective in removing stains used in this study as compared to Clinsodent.

Thus, it is necessary on the part of the dental professional, to ensure that the denture wearing public knows how to select the appropriate denture cleanser so as to improve denture home care protocol.

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