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ORIGINAL ARTICLE

Arabic Coffee as a Potential Alternative to Black Coffee in the Post-Bleaching Period: An in-vitro Study

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Abstract

Objective: To investigate the effect of Arabic coffee on bleached teeth in comparison to black coffee. **Material and Methods:** Forty teeth (sound maxillary or mandibular premolars with no carious lesions) were randomly selected into 4 groups (A, B, C and D). One group (A) did not receive bleaching and was incubated in saline. The second group (B) was bleached and then incubated in saline. The last two groups were bleached and were immersed in either Arabic coffee (C) or black coffee (D). Color recording of the samples was always carried out as near to their mid-buccal surfaces as possible using VITA Easyshade Advance System. Color measurements were carried out using a digital spectrophotometer at baseline and after short-term and long-term immersion. Data were subjected to two way ANOVA and T-test. The level of significance was set at was set at 0.05. **Results:** Results show that immersion in Arabic coffee resulted only in significant reduction in the b* color value upon long-term immersion (i.e. a reduction in the yellow hue). Black coffee on the other hand resulted in significant: reduction in lightness, increased red tint and increased yellow hue altogether. **Conclusion:** The use of Arabic coffee did not deteriorate color, with the only significant change being the reduction of yellowish hue. Arabic coffee could be an alternative to black coffee after bleaching.

Keywords: Tooth Bleaching Agents; In Vitro Techniques; Coffee.

Introduction

Dental bleaching is the procedure of application of whitening material onto the surfaces of teeth to render them whiter, with the aim to reduce the yellowish hue and increase lightness. Dental bleaching has received more attention in recent years along other restorative and esthetic procedures like dental implantation [1-5] and porcelain veneers [6,7]. This is readily distinguished and encouraged by the increasing interest and wide coverage from mass media [8]. Different bleaching systems with many reported complications and side effects are available including in-office approach, which is performed by the dentist, and at-home bleaching [9,10].

The main materials used for dental bleaching are hydrogen peroxide for in-office bleaching and carbamide peroxide for at-home bleaching [11]. In-office bleaching utilizes a source of light or laser to activate the agent [12]. There are variable reports on the effectiveness of each of them depending on the concentration of the agent, application time, number of applications and the activating agent [12,13]. The use of other materials such as chlorine dioxide has also been reported [14].

Many procedures are carried out or advised to potentiate effectiveness of the procedure such as: implementation of proper oral hygiene practices including tooth brushing, adding an at-home bleaching session at 6-12 months following initial bleaching procedure, use of sodium bicarbonate with or without ordinary tooth brushing and the use of whitening tooth pastes [15-17].

Many potential side effects exist following bleaching procedures such as: tooth sensitivity, variation of micro-hardness of enamel and related dental fillings [18-20]. However, the single most worrying complication for the dentist and patient is relapse of treatment [21-24]. Relapse of treatment can also be termed staining or re-staining. This can happen upon the exposure of bleached teeth to staining agents such as coffee, tea, wine and spices.

Ingestion of coffee is one of the most frequently encountered staining factors [19,25]. The extent of relapse following exposure to coffee can depend on: concentration of the solution, degree of roasting of coffee beans, frequency of ingestion, quantity consumed, exposure and contact of tooth surfaces to ingested coffee [19,26]. Efficacy of bleaching and lack of recurrence, like other treatment modalities in dentistry will reflect on patient acceptance and satisfaction [27-29].

Arabic coffee contains lesser amounts of coffee in a mixture that includes added spices such as cardamoms, cloves, ginger and saffron. Coffee beans receive little roasting and has a greenish-beige color. It is characterized by its lighter color compared to ordinary black coffee. Up to our best knowledge, this material has never been reported or tested as a possible staining agent after dental bleaching. Consequently, its use as a potential alternative to black coffee can be investigated based on the fact that lesser amount of mildly roasted coffee could result in less staining of teeth and hence can be used as a successful alternative for ordinary black coffee.

Material and Methods

This is an in-vitro study. Sample size and methods were followed by prior study [30]. A total of 40 extracted teeth were obtained from dental clinics of Oral Surgery at College of Dentistry, Taibah University. Selected teeth were sound maxillary or mandibular premolars with no carious lesions. Excessively dark or light teeth or teeth with narrow buccal surfaces were excluded. All attached periodontal tissues were removed prior to cleaning with a rotary brush mounted on a slow-speed handpiece. Teeth were then rinsed with distilled water and stored in saline at room temperature.

Teeth were randomly selected out of a box into 4 groups: A, B, C and D. The plan for the work in this study is illustrated in Table 1.

Table 1. Study plan for the samples in different test groups.

Step 1 Creating Groups	**Step 2** Baseline	**Step 3** Treatment	**Step 4** 1st Incubation (15 Mins)	**Step 5** Washing	**Step 6**	**Step 7** 2nd Incubation (6 Days)	**Step 8**	**Step 9**
A (N=10)	**First Color Recording**	No Bleaching	Saline	Washing With Distilled Water For 15 Seconds	**Second Color Recording**	Saline	Washing With Distilled Water For 15 Seconds	**Third Color Recording**
B (N=10)		Bleaching	Saline			Saline		
C (N=10)		Bleaching	Arabic Coffee			Arabic Coffee		
D (N=10)		Bleaching	Black Coffee			Black Coffee		

Colors of teeth in all groups were registered prior to the start of treatment procedure. Color recording of the samples was always carried out as near to their mid-buccal surfaces as possible using VITA Easyshade Advance System (VITA Zahnfabrik, H. Rauter GmbH & Co. KG, Säckingen, Germany). Color was registered in terms of its CIE L*a*b* color values. Color was registered for each group: at baseline prior to bleaching, after 15 mins of immersion in saline or corresponding staining solution and after 6 days of immersion in a freshly prepared quantity of its original solution. Bleaching was carried out using: In-office Opalescence Xtra Boost 40% bleaching agent (Ultradent Product Inc, Utah, USA). This chemically activated bleaching agent was prepared according to manufacturer's instructions by mixing the liquid and powder components. A 0.5-1 mm thick layer of the resulting gel was then applied immediately to the buccal surfaces of the planned test-samples using a dispenser tip. The gel was allowed to stay onto the surfaces of the samples for 20 mins, then it was rinsed-off with water. The procedure was repeated three times at the same sitting.

Arabic coffee was prepared according to manufacturer's instructions by dissolving a 3gm sachet of Nescafe Arabiana (LOTTE-Nestle Co. Ltd., Chungbuk, Republic of Korea) in 100ml of boiling water. Black coffee was prepared by dissolving one sachet (3gm) of Nescafe Classic Coffee (Sede Central de Nestle Espana, S.A, Barcelona, Spain) per 200 ml of boiling water.

Statistical Analysis

Statistical analysis was carried out using IBM-SPSS version 21 (IBM Corp., Armonk, NY, USA). Data was checked to be normally distributed and ANOVA was used to explore significant

differences between the groups. As different groups were of matching size, Tukey HSD was used as a post hoc test. When the number of samples was less than 3, two-sample t-test was used.

Ethical Aspects

Ethical approval was obtained from Research Ethics Committee at Taibah University College of Dentistry under the number: TUCDREC 20170323AlNuman.

Results

Means and standard deviations of CIE L*, a* and b* values for all groups are listed in Table 2. It shows the mean CIE L*, a* and b* values of the 3 recordings in all the groups. Results in Table 2 shows that baseline color data of the 4 groups are not homogenous with statistically significant differences between the groups. This effect is mostly due to lower L* and a* values of group C as illustrated in Figures (1, 2 and 3). Therefore, comparisons between the groups will be avoided.

Table 2. Means and standard deviations of CIE L*a*b* values for all groups according to incubation time

Treatment		N	L		a		b	
	Time		Mean	SD	Mean	SD	Mean	SD
Group A (No Bleaching)	1. Baseline	10	85.90	2.396	-1.20	1.776	21.60	7.587
	2. After 15 mins	10	85.47	3.055	-.97	1.794	21.37	8.440
	3. After 6 days	10	85.49	2.938	-1.03	1.740	21.29	8.205
Group B (Bleaching and Saline)	1. Baseline	10	87.52	5.331	-2.04	2.068	21.34	6.424
	2. After 15 mins	10	84.68	6.192	-1.88	1.838	19.29	7.215
	3. After 6 days	10	86.75	6.444	-2.93	2.304	16.55	5.258
Group C (Bleaching and Arabic Coffee)	1. Baseline	10	80.87	6.738	-.16	1.440	27.11	3.747
	2. After 15 mins	10	79.51	5.436	-.67	.919	24.73	3.759
	3. After 6 days	10	83.14	7.368	-1.68	2.056	20.32	7.769
Group D (Bleaching and Black Coffee)	1. Baseline	10	87.56	7.651	-2.62	2.388	22.23	7.443
	2. After 15 mins	10	82.30	5.256	-2.15	1.721	17.56	6.483
	3. After 6 days	10	77.78	6.400	2.09	1.652	30.56	4.408

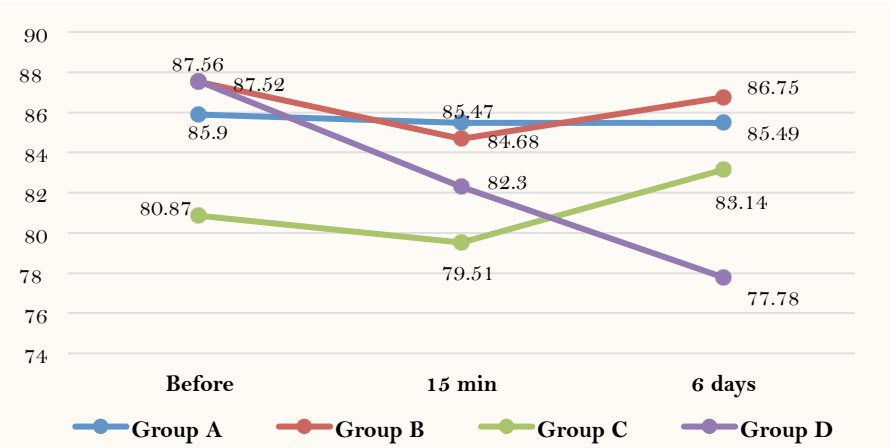

Figure 1. L* values for specimens in different groups.

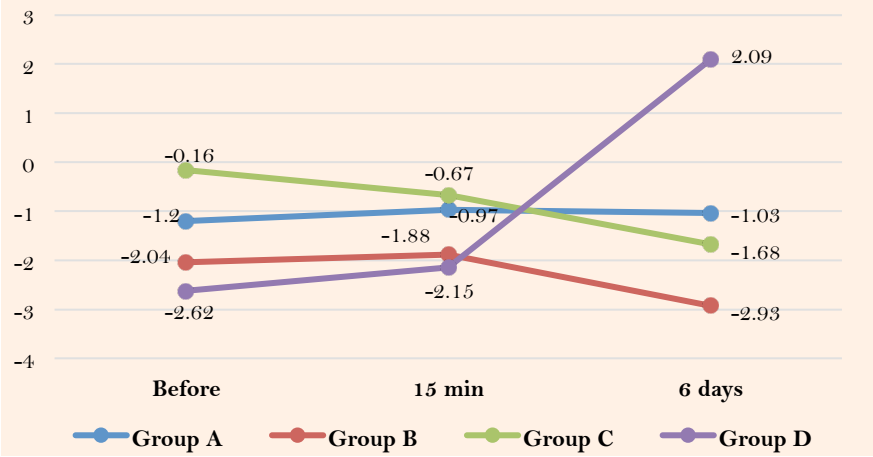

Figure 2. a* values for specimens in different groups.

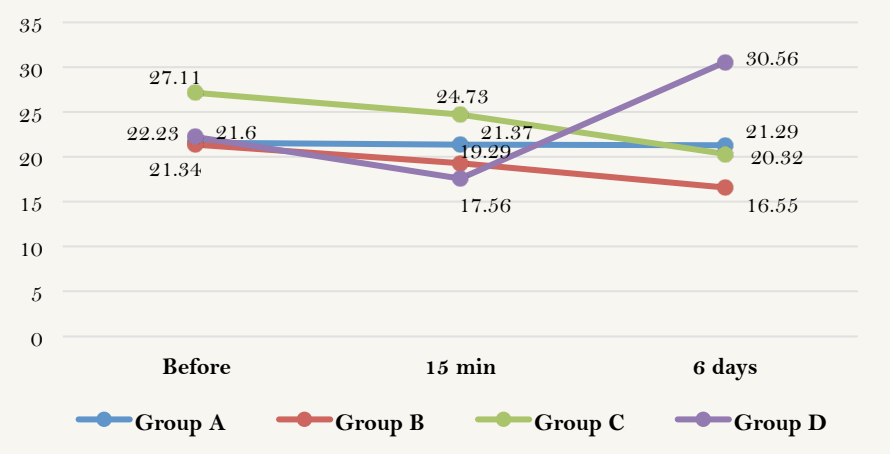

Figure 3. b* values for specimens in different groups according to time of measurement.

Table 3 shows comparison between groups regarding baseline data of L*, a* and b*. Table 4 shows some statistically significant differences in L*, a* and b* values when compared to each other. Table 4 shows effect of short term and long-term incubation in respective solutions. These did not result in statistically significant variations in L*, a* or b* values in Group A and B ($p>0.05$). However, b* values in Group C, were significantly reduced upon long-term incubation in Arabic coffee ($p=0.023$).

Table 3. Comparison of baseline L*, a* and b* values of the groups.

Time	Group vs Group		L	A	B
			p-value	p-value	p-value
Baseline	A	B	0.526	0.311	0.930
		C	0.051	0.211	0.065
		D	0.515	0.088	0.831
	B	C	0.010*	0.025*	0.053
		D	0.987	0.484	0.764
	C	D	0.010*	0.004*	0.101

*Statistically significant.

Table 4. Significant differences in L*, a*, b* values within groups according to time of color measurement.

Groups	Time	Time	L p-value	a p-value	b p-value
A	1. Baseline	2. After 15 mins	0.866	0.781	0.938
		3. After 6 days	0.872	0.837	0.917
	2. After 15 mins	3. After 6 days	0.994	0.942	0.979
B	1. Baseline	2. After 15 mins	0.267	0.847	0.489
		3. After 6 days	0.763	0.283	0.107
	2. After 15 mins	3. After 6 days	0.418	0.206	0.355
C	1. Baseline	2. After 15 mins	0.594	0.538	0.422
		3. After 6 days	0.374	0.068	0.023*
	2. After 15 mins	3. After 6 days	0.157	0.224	0.138
D	1. Baseline	2. After 15 mins	0.041*	0.570	0.116
		3. After 6 days	0.000*	0.000*	0.006*
	2. After 15 mins	3. After 6 days	0.078	0.000*	0.000*

*Statistically significant.

Results in Group D on the other hand, show that exposure to black coffee will produce statistically significant differences in L*, a* and b* values, with significant differences between L* values at baseline and after 15 mins of incubation (p=0.041) and between baseline after 6 days of incubation (p=000). a* values varied significantly between baseline and after 15 mins (p=0.000) and between: after 15 mins and 6 days of incubation (p=0.000). b* values similarly, significantly varied between: baseline and after 6 days of incubation (p=0.006) and between: 15 mins of incubation and 6 days of incubation (p=0.000). Variation in the values of either L*, a* and b* between short term staining and long term staining indicate cumulative staining effect, that significantly worsens overtime (Table 4).

Means and standard deviations of ΔE for all groups are listed in Table 5. Figure 4 show ΔE values for all groups on short-term and long-term staining. The values of ΔE indicate the overall color change irrespective of the individual trends of its components (i.e. L*, a* and b*). Table 5 shows that in Group A, surface wetting of the samples after incubation in saline without bleaching resulted in small ΔE value indicating small change in color. This color difference is greater than the 0.3 threshold for the human eye. However, long-term incubation in saline resulted in a more but small and insignificant change in color (p=1.000).

Color change due to wetting the surface with saline was more pronounced in Group B. Color change upon short term incubation in saline (mean ΔE= 34.16) was higher than the long term color change after 6 days of incubation in saline (mean ΔE= 20.46) the difference between the short term color change and the long term color change was not significant (p=0.570).

In Group C immediate effect of incubation in Arabic coffee (i.e. 15 mins) did not produce large color change (mean ΔE= 23.36), however, the color change after 6 days of incubation relative to the original basic color was large (mean ΔE= 116.86) the difference in color between short-term staining and long-term staining was significant (p=0.000).

Incubation in black coffee produced the highest color changes both on short-term staining (mean ΔE= 53.53) and long-term staining (mean ΔE= 156.93). The difference between short term staining and long term staining was significant (p=0.000).

Table 5. Means and standard deviations of ΔE values* in all groups after short-term and long-term staining.

Group	Time	N	Mean	SD	ΔE difference	p-value
A	After 15 mins	10	3.94	6.040	0.006**	1.000
	After 6 days	10	3.94	5.719		
B	After 15 mins	10	34.16	43.111	13.704	0.570
	After 6 days	10	20.46	14.114		
C	After 15 mins	10	23.36	22.615	-93.504	0.000**
	After 6 days	10	116.86	71.574		
D	After 15 mins	10	53.53	42.497	-103.401*	0.000**
	After 6 days	10	156.93	116.387		

*ΔE values were always calculated relative to basic color values; **Statistically significant.

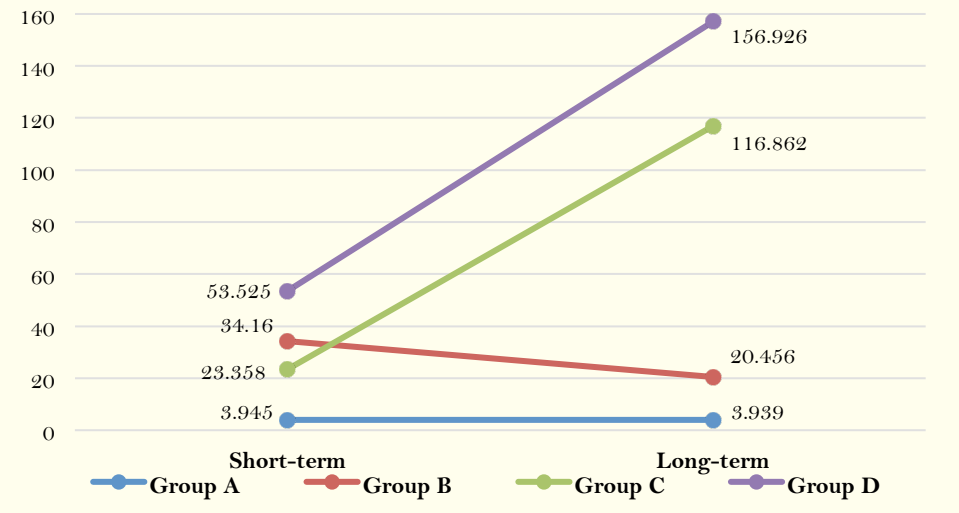

Figure 4. ΔE values for specimens in different groups after short-term and long-term staining. Black coffee resulted in highest ΔE values.

Table 6 shows comparisons of mean ΔE values according to treatment method in all groups. There were no significant differences between mean ΔE values for all the groups after 15 mins incubation except for Groups 1 and Group 4 (p=0.043). Long term staining (i.e. after 6 days of incubation) resulted in significant differences in ΔE values between following group pairs: Groups A and C (p=0.000), Groups B and C (p=0.000), Groups A and D (p=0.000), Groups B and D (p=0.000). There were no significant differences between Groups C and D either after short term or long term staining indicating the change in color in the two groups is comparable (Table 6).

Table 6. Comparison of mean ΔE values according to treatment method.

Time	Group vs Group (I)	(J)	N	ΔE difference between groups I-J	p-value
After 15 mins	Group A	Group B	10	-30.216	0.213
		Group C	10	-19.414	0.422
		Group D	10	-49.581*	0.043**
	Group B	Group C	10	10.802	0.655
		Group D	10	-19.365	0.423
	Group C	Group D	10	-30.167	0.214
After 6 days	Group A	Group B	10	-16.518	0.494
		Group C	10	-112.924*	0.000**
		Group D	10	-152.988*	0.000**
	Group B	Group C	10	-96.406*	0.000**
		Group D	10	-136.470*	0.000**
	Group C	Group D	10	-40.064	0.100

*ΔE values were always calculated relative to basic color values; **Statistically significant.

Discussion

Some researchers did not consider coffee to be a potent staining solution compared to wine for example [31,32]. However, as the consumption of wine is not widespread in Middle Eastern communities, the effect of other staining agents including coffee becomes more importance.

Black coffee staining solutions were prepared by dissolving the sachet in a quantity of hot water more than that used for the preparation of Arabic coffee. This was done according to manufacturer's instructions. This is probably because black coffee sachets contain more ground coffee compared to Arabic coffee. Arabic coffee contains many spices as well. Moreover, in black coffee sachets, the coffee is darkly roasted necessitating the addition of more water to dilute it to taste.

This in-vitro study utilized extracted teeth that are supposed to be darker than vital teeth. However, no attempt was made to compare results of this study to the range of color norms of vital teeth. Results were drawn strictly from comparisons made within groups.

Original baseline mean CIE L*, a* and b* values (Table 2) indicate that specimens in the three groups are having markedly variable lightness (mean L*= 80.87-87.56), a negative a* value indicating a greenish tint and positive b* value well above 21.34 indicating a clear yellowish hue.

Original baseline data were widely variable as there were significant differences in L* and a* values between the following group pairs: B-C and C-D (Table 3). This makes subsequent comparisons between groups impossible for these values. Such color variations in colors between groups if found despite random selection of samples into different groups are consistent with tooth color variations between teeth, even in the same patient.

Saline incubation without bleaching resulted in minute variations of lightness and the yellow hue. However, green hue tended to decrease. These variations were not significant with $p>0.05$. On the other hand, bleaching followed by saline incubation resulted in slight reduction of lightness after

15 mins of saline incubation. After 6 days of incubation lightness insignificantly increased, without reverting to original baseline value. Initial "a" values indicated a green hue, this was reduced after 15 mins of saline incubation, but slightly increased after 6 days. Initial b values indicated a yellowish hue that was reduced after 15 mins and further reduced after 6 days of saline incubation.

Variations of L, a and b measurements when compared to baseline measurements were non-significant after 15 mins or 6 days. Variations were also not significant when measurements after 15 mins were compared to those after 6 days ($p>0.05$).

General effect of Arabic coffee incubation indicated lower lightness after 15 mins ($p=0.594$) but it increased insignificantly after 6 days. Green hue increased with short and long term incubation. Yellow hue on the other hand was reduced on short term and long-term incubations.

Variations in measurements of L*, a* and b* at various stages of the study were non-significant when compared to each other ($p>0.05$) except for the measurements of "b" values when long-term staining was compared to its considerably higher value at baseline ($p=0.023$). This indicates a lower potential for Arabic coffee to alter elements of tooth color. The significant reduction of the b value on long term staining points to a reduction in the yellowish hue and is considered therefore beneficial.

Black coffee incubation produced significant reduction in lightness after 15 mins of incubation ($p=0.041$), and more pronounced reduction at 6 days of incubation ($p=0.000$). Green hue was insignificantly reduced on short-term staining ($p=0.570$) but was significantly reduced after long-term staining ($p=0.000$). Yellow hue was initially insignificantly reduced on 15 mins ($p=0.116$), but was significantly increased after 6 days of incubation ($p=0.006$). The b* values (or the yellow hue in this instance) were significantly different when measurements after short-term staining were compared to those after long-term staining ($p=0.000$). In-brief, black coffee resulted in significantly reduced lightness and greenish tint but significantly increased yellowish hue.

Results of delta E are not as useful as the study of individual color elements as ΔE is an amalgamated expression of the three values of the CIEL*a*b*. Any variation in ΔE will only be beneficial if net change included an increase in lightness and a reduction in yellowish and greenish hues.

A ΔE value of 0.27-0.3 is said to be the least color change detectable by human eye. Thus ΔE as a mathematical expression indicates clinical significance rather than statistical significance. In this study, all ΔE values were measured relative to basic colors of the specimens in each groups base line in their respective media.

All results, including results show ΔE values greater than the reported threshold for human eye detection. However, ΔE values were lowest for Group A measurements (3.94) and highest after incubation in black coffee (53.53). Surprisingly, short-term incubation in saline after bleaching (Group B) produced higher ΔE values (34.16) than incubation in Arabic coffee (23.36) indicating the complexity of the light interactions with the tooth surface after bleaching and the limited color effect and change upon short-term exposure to Arabic coffee.

Long-term incubation also resulted in smallest ΔE values in Group A and highest in Group D. However, ΔE in Group B was lower than Group C (i.e. long-term immersion in Arabic coffee resulted in higher color change than saline incubation after bleaching).

Results of short-term incubation for Groups C and D and long-term incubation for Groups A and B would reflect the reality more in real life as most of the time bleached and unbleached teeth for individuals are in contact with their saliva, while exposure to coffee (and other drinks or even foodstuff) is limited to a short-term exposure. Considering this, the value of Arabic coffee is clearly obvious as a low-staining material for teeth after bleaching.

The incubation of non-bleached teeth in saline resulted in some variations in the elements of color. However, these variations were small indicting perhaps the effect of wetting of the specimens on light properties of the surface. However, interactions of teeth with light after bleaching were more pronounced indicating perhaps an alteration in the chemical composition of the tooth surface. This is supported by the findings of many researchers [11,19].

Many researchers tested bleaching with black coffee as a staining solution [33,34]. No report could be found in the literature for the use of Arabic coffee as a staining medium. Unfortunately, baseline color measurements of Group C (bleaching and Arabic coffee incubation) varied widely compared to the other groups. Although its color measurements were not significantly different than Group A (Table 3), the colors of both groups are clearly not very close to each other (Figures 1, 2 and 3). Basic colors in groups C were the worst in all the groups. Bleaching and short-term incubation brought a* and b* values closer to those of Group A (Figures 2 and 3). Surprisingly, lightness could be brought closer to Group A values after long-term incubation in Arabic coffee (Figure 1).

This study indicated that immersion in saline will result in nearly no color changes for non-bleached teeth. On the other hand, incubation in Arabic coffee resulted in higher lightness (which is a favorable finding), increased greenish (or reduced cyan) and reduced yellowish (also favorable). It is difficult to assess the patient acceptance or satisfaction with reduced cyan and increased greenish tent in light of scarcity of references on the topic.

Other studies reported that similar incubation process using coffee did not produce any significant color change on bleached or control teeth [35]. This is perhaps because in that study, researchers polished the teeth between coffee immersions and before color measurements. In fact, the authors admitted that polishing sessions resulted in "whiteness and lightness" of their test specimens.

It can be noticed that in Group B, long-term effect was reduced lightness and yellowish hue with increased greenish tint. In Group C with the immersion in Arabic coffee, the effect is the same on the yellowish and greenish colors but lightness gets increased. It can be said that Arabic coffee has the same effect of saline incubation after bleaching but the effect on lightness is more favorable. Comparing Arabic coffee to black coffee.

On short-term exposure to these media, there were no significant differences between ΔE values for Groups B, C or D. This indicates that the change in color was similar in the three cases. However, the picture is different for long term staining where ΔE values for group B were significantly different to those of groups C or D. Indicating marked staining on long-term exposure to these media. Short-term staining resulted in smaller ΔE values than long-term exposure. Effect of Arabic coffee on bleached teeth was not reported before in the literature.

Conclusion

Black coffee staining produced significant deterioration of color by reducing lightness and increasing yellow hue. However, green hue was also significantly reduced. Arabic coffee on the other hand, did not deteriorate color values. The only significant change was the reduction in yellow hue, which is clinically favorable. The substitution of Arabic coffee in place of black coffee for teeth after bleaching appears to produce favorable results.

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