Dental Staining Associated with Various Types of Coffee

Aseel K Alhindi[1], Afnan A Nassar[2]*, Rahaf K Jarwan[1], Raghad M Iskandar[1], Shahad O Bashihab[1] and Nada A Abdelaleem[3]

[1]Dental Intern Department of Dentistry, Umm Al-Qura University, Saudi Arabia

[2]Assistant Professor Department of Preventive Dentistry, Division of Public Health, Umm Al-Qura University, Saudi Arabia

[3]Assistant Professor Department of Restorative Dentistry, Umm Al-Qura University, Saudi Arabia

*Corresponding Author: Afnan A Nassar, Assistant Professor Department of Preventive Dentistry, Division of Public Health, Umm Al-Qura University, Saudi Arabia.

Abstract

Introduction: Teeth staining is one of the biggest concerns among people who care about aesthetics. Coffee consumption is linked to teeth staining because it can cause teeth discoloration in many ways. One of the widely acknowledged theories claims that acidic drinks can add more roughness to the surface of enamel, making it more susceptible to stain.

Objectives: This paper aimed to assess the degree of staining associated with different types of commonly consumed coffee and the effect of coffee temperature.

Methods: Sixty extracted human teeth were assigned to six different groups, then their roots were sealed using three barrier layers. The baseline shades were measured using a colorimeter. The teeth in each group were immersed in a different type of coffee. The groups were further subdivided into hot coffee groups and cold coffee groups. The teeth were immersed for 12 days, after which the change in colour (ΔE) was measured.

Results: The ΔE scores of all groups were > 3.3, which is considered unfavourable. All the teeth that were incubated in cold temperature showed no significant difference in staining among the different types of coffee. The teeth that were incubated in hot solutions showed significant staining in the sweetened coffee (P = 10.4) and Turkish coffee (P = 16.2) in comparison to the other coffee types. The remaining types of coffee (Arabic, instant and latte) showed a minimum degree of staining almost matching the ΔE of the control group. The addition of sugar to coffee can worsen staining. In contrast, the addition of milk or water reduces staining.

Conclusion: Turkish coffee and sweetened coffee have the highest degree of staining; the higher the temperature of the coffee the greater the dental staining.

Recommendations: The study recommends drinking sugar-free coffee; moreover, the addition of milk or water can decrease the amount of staining.

Keywords: Dental Staining; Coffee; Sweetened Coffee; Turkish Coffee

Introduction

   Coffee consumption has been growing immensely in the past few years. Earlier this year, the Ministry of Commerce and Investment of Saudi Arabia reported that the number of coffee shops exceeded 126,000 [1]. The Saudi Customs Authorities also reported that Saudis spent more than 850,000 USD daily on coffee [2]. This shows how drinking coffee has become an integral part of people's lives. Coffee

can be served in various ways and it has a big impact on the oral environment. It was found to have an anti-periodontitis effect [3]. It also significantly protects against alveolar bone resorption in male adults and it inhibits the formation of caries [4]. People who consume sugar-free coffee daily were found to have lower decayed, missed and filled teeth (DMFT) scores than people who consume coffee with sugar [5]. One study suggested that coffee might accelerate orthodontic movement [6].

However, tooth staining is a common problem with regular coffee drinking. Staining is the discolouration and the change in opacity and tinge of teeth [7]. Shade is one of the most important visual characteristics of the dentition. The majority of people prefer lighter shades as it directly improves their appearance and positively influences other people's overall judgement of their personality [8]. The shade of a person's teeth is significantly affected by staining. Extrinsic staining is a type of discolouration that affects teeth that is influenced by an individual's daily dietary and hygienic habits, resulting in superficial colour change and gradual wear of enamel exposing the underlying darker dentin; this could occur within the tooth as a result of chemical interactions or overlying the enamel in the pellicle layer [9]. Dental staining occurs through precipitation of the coloured particles within the pellicle layer. These particles then react chemically with the surface of the tooth. While the nature of this reaction is not clear, many theories have suggested that stains usually produce a brownish hue [10]. They can also result from aging, smoking and the consumption of coffee, tea and wine [11].

It is worth noting that studies have found that coffee will only cause significant staining when the exposure to it is high and repeated. Otherwise, the discolouration is negligible so discolouration would only be relevant in people consuming coffee on a daily basis [12]. Discolouration produced by coffee is more difficult to remove than other types of extrinsic stains, including smoking stains [13].

In a study done on the colour stability of denture teeth to assess staining following immersion in decolorating agents, instant coffee showed the highest rate of staining in comparison to the other denture teeth materials used [14]. Coffee was found to affect the colour of teeth as well as tooth restorations. A study was done in Saudi Arabia to evaluate the effect of four different types of coffee on the microhardness and colour stability of composite material. Espresso showed the greatest discolouration and Arabic coffee showed the least effect [15]. To the best of our knowledge, no previous studies have evaluated the effect of sugar, milk and artificial agents added to coffee or the effect of temperature in relation to teeth staining.

Aims and Objective

This research study aimed to compare the degrees of staining of enamel with different types of commonly consumed coffee. The study had three objectives: 1) to evaluate the effect of coffee on teeth staining, 2) to measure the difference between the degree of staining with various coffee types and 3) to assess the effect of coffee additives on tooth colour and identify the correlation between coffee temperature and staining. This research will also improve dentists' knowledge about coffee staining enabling them to advise their patients on its effect.

Materials and Methods

This case-control experimental study (*in vitro*) assessed enamel staining with various types of coffee as well as the effect of additives and temperature. Extracted intact maxillary or mandibular permanent teeth were used (n = 60). Teeth with caries, signs of enamel wear and dental anomalies were excluded from this study [16]. Ethical approval was obtained from Ethical Research Committee at Umm Al-Qura University. Approval No. (HAPO-02-K-012-2021-02-544).

Specimen preparation

The roots of 60 extracted teeth were covered with three different barrier layers:

1. Three layers of clear water-resistant varnish covered the whole root ensuring apical seal.

2. Melted wax was used to completely coat the root area and it was retained until it dried.

3. Finally, the roots were sealed with aluminium foil.
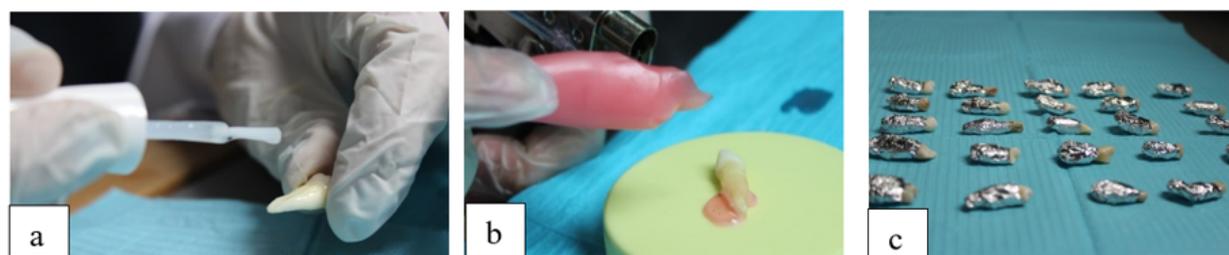
Figure 1: (a) Teeth coated with three layers; (b) Wax melted over the roots; (c) Aluminium foil as the last seal of clear varnish.

The teeth were stored in 37°C deionized water [17] until they were used.

Each group of teeth was immersed in a different type of coffee (Turkish black coffee, sweetened black coffee, latte, Arabic coffee, instant coffee). While the teeth in the control group were immersed in saline.

Grouping of the specimens

The 60 teeth were divided randomly into six groups (A, B, C, D, E and G); each group was furtherly divided into two subgroups (Hot:1 and Cold:2). The tubes were labelled as A1, A2, B1, B2, C1, etc., giving a total of five teeth for each subgroup, which were numbered from 1 to 5. The teeth were stored in specimen tubes. The shade of each tooth was recorded prior to immersion (baseline) with a colorimeter [16]. Vita Easyshade Advance 4.0 was used to determine the shades; the results are recorded in figure 2.
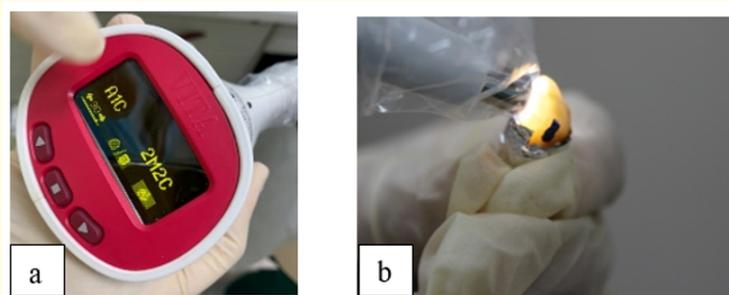
Figure 2: (a) Vita Easyshade Advance 4.0; (b) Recording of the shades prior to immersion.

Figure 3: (a) Grouping of teeth prior to incubation.

Preparation of the immersion media

The immersion media were prepared as follows:

- Group A: Turkish coffee (brand name: Kurukahveci Nuri Toplar) was prepared according to the manufacturer's instructions by adding 5g of ground coffee to 65g of boiling water.

- Group B: Latte (milk and coffee) was prepared according to the manufacturer's instructions using Starbucks ground Pike's Place Medium Roast; 115g of espresso was brewed and then added to 177 ml of milk.

- Group C: Arabic coffee was prepared by adding 3g Nescafé Arabiana to 100 ml water [16].

- Group D: Instant coffee was prepared according to the manufacturer's instructions by adding one package (11.7g) of Nescafé 3-in-1 coffee to 180 ml of water.

- Group E: Sweetened black coffee was prepared by adding 3g of coffee to 200 ml of water [16] with the addition of 12g of sugar.

- Group G (Control): Normal saline was used as the control group.

The immersion media were changed daily for 12 days to ensure the freshness of the coffee.

All six groups were divided into two subgroups yielding a total of 12 tubes, which were incubated at 70°C and 10°C [18] to evaluate the effect of temperature. The teeth were kept in the immersion media for 12 days to represent consumption over one year. One day of immersion was equal to one month of consumption [19].

After 12 days, the teeth were again assessed for colour change (ΔE) using Vita Easyshade Advance 4.0. The ΔE for each tooth was recorded as the degree of colour change.

Results

In this study, the ΔE after immersion was measured. ΔE scores > 1 and < 3.3 are considered to be clinically acceptable, and only detected by specialists. ΔE > 3.3 is perceived by general public and is clinically unacceptable [15,20]. In the study sample, the ΔE ranged from 1.4 to 28.0. Table 1 which represents the values of ΔE for the hot and cold immersions. Table 1 also shows that the most of the ΔE values are in the clinically unfavourable range, while the digits in bold font are clinically acceptable values for ΔE.

Tooth #	△ Control	△ Sweetened	△ Instant	△ Arabic	△ Latte	△ Turkish
Hot Immersion (70°C)						
1	6.5	10.4	1.8	1.4	11.8	16.2
2	6.1	21.5	7.5	7	4.6	4.7
3	6.1	6.5	7.8	3	3.4	16.7
4	6.6	10.6	7	2.6	15.7	28
5	7.2	17.4	1.6	6.1	3.2	14.9
6	12.6	7.9	13.5	2.7	7.7	14.3
Cold Immersion (10°C)						
1	6.2	6.4	3.4	5.1	8.6	7.1
2	6.5	2.3	1.9	10.5	7.5	3.2
3	2.6	11.2	14.4	6.1	3.8	15
4	6.1	4.3	7.6	4.7	7.8	6.3
5	6.4	4.2	3.4	7.8	9.3	10.3
6	3.1	5.9	8.4	4.3	4.8	10.6

Table 1: *The ΔE values for each type of coffee and for each both types of immersion.*

The staining related to hot coffee and cold coffee was analysed to compare the different types of coffee. Moreover, the effect of various types of coffee additives on teeth discolouration was investigated. ANOVA (Kruskal-Wallis test) for one-way independent samples was used for the analysis.

The cold coffee immersion results showed that there was no statistically significant difference in staining across all types of coffee (P = .502), as presented in table 2. For the cold coffee immersion, the mean ΔE in the Turkish coffee increased by around 21%.

Coffee types	Mean (SD) ΔE
Turkish	8.75 (4.10)
Latte	6.97 (2.18)
Arabic	6.42 (2.36)
Instant	6.52 (4.63)
Sweetened	5.72 (3.05)
Control	5.15 (1.79)

Table 2: *Mean and standard deviation (SD) of ΔE for the cold immersion of different types of coffee.*

For the hot coffee immersions, a notable difference in staining was observed among the different types of coffee (P = .007), as presented in table 3. With the exception of the sweetened coffee and Turkish coffee groups, all the teeth submerged in hot coffee showed a similar degree of ΔE. The ΔE value increased by about 60% for the Turkish coffee. For the sweetened coffee, the increase in ΔE was 52%. The remaining types of coffee (Arabic, instant and latte) showed a minimum degree of staining almost matching the ΔE of the control group. The teeth in the Arabic coffee group showed the least amount of staining. A significant difference was seen between the Arabic coffee and both the sweetened coffee and Turkish coffee. The P-value was 0.01 when Arabic coffee was compared to Turkish coffee, which had the lowest P value in the pair-wise comparison analysis.

Coffee types	Mean (SD) ΔE
Turkish	15.80 (7.43)
Latte	7.73 (5.08)
Arabic	3.80 (2.21)
Instant	6.53 (4.42)
Sweetened	12.38 (5.83)
Control	6.58 (0.45)

Table 3: *Mean and S) of ΔE in the hot immersion of different types of coffee.*

Another analysis was run to compare the ΔE of the same type of coffee to assess the effect of temperature on staining. The Mann-Whitney test for unpaired non-parametric data was used. Although a significant difference in ΔE was found for sweetened coffee when it was subjected to hot/cold temperatures (P = .026), the outcome for all the other types of coffee was found to be non-significant.

Discussion

This study was conducted to assess ΔE (degree of colour change) in natural teeth associated with the consumption of different types of coffee as well as the effect of additives and temperature.

This study found that about 90% of the teeth demonstrated clinically unfavourable staining (ΔE > 3.3) after immersion. However, no significant difference was observed between all six groups when the teeth were immersed in cold coffee. Only two (sweetened, Turkish) of the six groups immersed in hot coffee exhibited a statistically significant difference in staining: Group A1 (hot Turkish coffee) and Group E1 (hot sweetened black coffee). Several other studies reported a similar outcome [15,21]. In a previous study, colour stability evaluation revealed that the highest staining was observed with Turkish coffee in comparison to other types of coffee [21]. It has been verified that Turkish coffee had the highest ΔE score due to the nature of its coffee molecules which cling to surfaces and are eventually absorbed [15]. The higher ratio of ground coffee-to-water in Turkish coffee increases the number of staining particles, thus, enhancing the staining.

The discolouration associated with sweetened coffee was found to be higher than most of the other types of coffee. This finding confirmed the results reported in previous studies [22,23]. In an evaluation of sugar's ability to enhance staining, it was found that adding sugar to tea and coffee resulted in more tooth pigmentation [21]. This could be explained by the adhesive properties of sugar that helps the stained particles adhere to the surface of the tooth and eventually cause more severe staining [23].

In the present study, Arabic coffee resulted in mild staining. This finding was consistent with the results reported in other studies [15,16]. It can be explained by the nature of Arabic coffee, which is diluted with higher amounts of water and has a much lower amount of coffee than other types of coffee, resulting in decreased staining [15]. Another study also concluded that Arabic coffee had a noticeable impact on diminishing the yellowish hue of natural teeth immersed in Arabic coffee, resulting in less staining than the control group over a few days [16]. This is similar to our findings where the mean ΔE was lowest for the teeth immersed in hot Arabic coffee.

A very recent study evaluated tooth staining in coffee containing dairy products and compared it to milk-free coffee [24]. It concluded that the addition of milk to coffee lessened staining, and it recommended consuming milk-containing coffee to decrease the possibility of discolouration [24]. These recommendations support the results reported in the present study. The staining in the teeth in the latte group

was mild in comparison to the Turkish coffee and sweetened coffee groups. This finding could also be due to the reduced concentration of coffee in the latte group, which ultimately leads to reduced staining.

The teeth in the instant coffee group had lower ΔE values. This finding was consistent with the results reported in a similar study that used Nescafé instant coffee to estimate its discolouring potential [25]. That study also found no statistical significance in the ΔE for the instant coffee group and the control group.

When evaluating teeth staining under the influence of temperature, the present study found that the ΔE values were higher for hot coffee than cold coffee. The effect of temperature in enhancing pigmentation is supported by recent literature. One study investigated the difference in the colour change associated with coffee and concluded that staining due to the consumption of coffee was directly proportional to its temperature [18]. Another study investigated this phenomenon through immersion of composite material in distilled water and demonstrated that more stains were produced at 60°C than at 37°C. This also explains the slight difference in discolouration in the present study when the teeth were immersed in saline (control group); the teeth in the hot saline control group had higher ΔE values than the teeth in the cold saline control group.

Conclusion

To the best of our best knowledge, this study is the first to investigate different types of coffee in relation to temperature changes on non-bleached natural human teeth rather than dental materials. All the investigated coffee types displayed clinically unfavourable staining; however, only sweetened coffee and Turkish coffee showed a statistically significant difference in the ΔE values. The remaining types of coffee (Arabic, instant and latte) showed a minimum degree of staining almost matching the ΔE of the control group. The teeth in the Arabic coffee group had the least amount of staining. Increasing the temperature of coffee worsen the staining as did adding sugar to the coffee. In contrast, the addition of milk and water reduced the amount of staining. Based on this study's findings, it is recommended that people drink sugar-free coffee and add milk or water to decrease the staining.

Recommendations and Limitations

This *in vitro* study was conducted over a short period of time (12 days). Extracted intact permanent teeth were used and immersed in six different types of coffee at different temperatures (hot and cold). While these circumstances closely resemble the environment of the oral cavity, they are not a true reflection of it. The authors recommend investigating coffee staining (*in vivo*) on human intact dentition; doing so will give a more accurate representation of the actual environment of the oral cavity. We also recommended studying more types of coffee and different additives commonly used by the people in the community being investigated.

Authorship

The authors contributed in this paper, as follows:

Dr. Nada Abdelaleem: hypothesis, study design, data collection, supervision, and review of the written paper.

Dr. Afnan Nassar: study design, data analysis, results, supervision, and review of the written paper.

Dr. Aseel Alhindi, Dr. Rahaf Jarwan, Dr. Raghad Iskandar and Dr. Shahad Bashihab: data collection, data analysis and writing the paper.

Ethical Approval

Ethical approval was obtained from Ethical Research Committee at Umm Al-Qura University. Approval No. (HAPO-02-K-012-2021-02-544). Date (2/2/2021).

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Bibliography

1. M AlMahraq. "126 thousand cafes attracting teenagers". Al-watan newspaper (2020).

2. A AlMesbahi. "How much do the citizens of Saudi Arabia spend on coffee each year?". Okaz newspaper (2019).

3. T Machida., *et al*. "Severe periodontitis is inversely associated with coffee consumption in the maintenance phase of periodontal treatment". *Nutrients Journal* 6.10 (2014): 4476-4490.

4. N Ng., *et al*. "Coffee consumption and periodontal disease in males". *Journal of Periodontology* 85.8 (2013): 1042-1049.

5. P Namboodiripad and S Kori. "Can coffee prevent caries?". *Journal of Conservative Dentistry* 12.1 (2009): 17.

6. J Yi., *et al*. "Drinking coffee may help accelerate orthodontic tooth movement". *Journal of Dental Hypotheses* 3.2 (2020): 72-75.

7. K Hargreaves., *et al*. "Cohen's Pathways of the Pulp, 11th edition". St. Louis: Elsevier (2016): 96.

8. S Kershaw., *et al*. "The influence of tooth colour on the perceptions of personal characteristics among female dental patients: comparisons of unmodified, decayed and 'whitened' teeth". *British Dental Journal* 204.5 (2008): 1-7.

9. A Watts and M Addy. "Tooth discolouration and staining: a review of the literature". *British Dental Journal* 190.6 (2001): 309-316.

10. M Addy., *et al*. "The comparative tea staining potential of phenolic, chlorhexidine and anti-adhesive mouthrinses". *Journal of Clinical* 22.12 (1995): 923-928.

11. H Eriksen and H Nordbø. "Extrinsic discoloration of teeth". *Journal of Clinical Periodontology* 5.4 (1978): 229-236.

12. R Gupta., *et al*. "Original Article A spectrophotometric evaluation of color changes of various tooth colored veneering materials after exposure to commonly consumed beverages". *Journal of Indian Prosthodontist Society* 5.2 (2005): 72-78.

13. J Bazzi., *et al*. "The effect of at-home bleaching and toothbrushing on removal of coffee and cigarette smoke stains and color". *Journal of the American Dental Association* 143.5 (2012): e1-e7.

14. T Koksal and I Dikbas. "Color stability of different denture teeth materials against various staining agents". *Dental Materials Journal* 27.1 (2008): 139-144.

15. W Awliya., *et al*. "The effect of commonly used types of coffee on surface microhardness and color stability of resin-based composite restorations". *The Saudi Dental Journal* 22.4 (2010): 177-181.

16. S Borzangy., *et al*. "Arabic coffee as a potential alternative to black coffee in the post- bleaching period: an in-vitro study". *Pesquisa Brasileira em Odontopediatria e Clinica Integrada* 18.1 (2018): 1-13.

17. C Worschech., *et al*. "In vitro evaluation of human dental enamel surface roughness bleached with 35 % carbamide peroxide and submitted to abrasive dentifrice brushing". *Brazilian oral Research* 17.4 (2003): 1-7.

18. D Tuncer., *et al*. "Does the temperature of beverages affect the surface roughness, hardness, and color stability of a composite resin?" *European Journal of Dentistry* 7.2 (2019): 165-171.

19. E Ertaş., *et al*. "Color stability of resin composites after immersion in different drinks". *Dental Materials Journal* 25.2 (2006): 371-376.

20. A Elembaby. "The effects of mouth rinses on the color stability of resin-based restorative material". *Journal of Esthetic and Restorative Dentistry* 26.4 (2014): 264-272.

21. K Al-Samadani. "Color stability of restorative materials in response to Arabic coffee, Turkish coffee and nescafe". *Journal of Contemporary Dental Practice* 14.4 (2013): 681-690.

22. A Farag. "Effect Color change of composites after staining and bleaching". *Egyptian Dental Journal* 56.3 (2014): 1785-1796.

23. A Guler., *et al*. "Effects of different drinks on stainability of resin composite provisional restorative materials". *Journal of Prosthetic Dentistry* 94.2 (2005): 118-124.

24. S Kim. "Effects of milk, cheese and strawberry counteracting tooth discoloration induced by coffee or red wine". *International Journal of High School Research* 2.3 (2020): 46-50.

25. M Karadas and N Seven. "The effect of different drinks on tooth color after home bleaching". *European Journal of Dentistry* 8.2 (2014): 249-253.