RESEARCH ARTICLE

# Color Stability of Coated Stainless Steel Arch wires Measured by Visible Spectrophotometer (An *In-Vitro* Study)

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## Abstract

Background: Aesthetic archwires are used to overcome the aesthetic problems of stainless steel wires but the color of the coating layer can be changed with time when exposed to oral environments. The aim of this study was to evaluate the degree of color change of different aesthetic archwires from different companies and under different coloring solutions. Materials and Methods: 150 samples of coated archwires from 3 companies (Highland, G&H and Dany) were immersed 5 solutions (artificial saliva, turmeric, tea, coffee and Miranda) to evaluate the degree of color changes after 7, 14 and 21 days using visible spectrophotometer. Data were collected and analyzed using ANOVA and post hoc Turkey's tests. Results: Turmeric solution caused high color change in contrast to Miranda solution. Aesthetic archwires from Highland company showed the highest degree of color change than archwires from other companies. Conclusions: Turmeric solution produced more discoloration than other solutions and the effects of these solutions are related to different chemical compositions of those solutions.

**Keywords:** *Aesthetic arch wires, Staining drinks, Turmeric, Tea, Coffee, Miranda.*

## Introduction

With increasing number of adult patients seeking orthodontic treatment, the demand for aesthetic orthodontic appliances has increased dramatically, creating a need for the so-called invisible orthodontic appliances like Invisalign[1], and lingual braces[2]. However, aesthetics of fixed labial appliances has also evolved by inclusion of ceramic brackets[3], aesthetic ligatures and tooth colored archwires[4-5-7]. The color stability of esthetic arch wires during orthodontic treatment is clinically important. Any staining or discoloration or change in the aesthetic of patient will affect the cooperation and the acceptance to his treatment.

Color instability of these arch wires and exposure of the underlying metal is also often reported. It has been found that 25% of coating is lost in 33 days intra-orally; therefore, the arch wires become aesthetically degraded[8]. Coatings improve aesthetics but have some disadvantages.

The color tends to change with time like other aesthetic orthodontic products. This color change is either internal or external [9]. External discoloration can be caused by food dyes and colored mouth rinses, the type of coating material and its surface roughness play decisive roles in the extent of the discoloration caused by diverse substances[10]. The daily consumption of tea, coffee and cola drinks promotes discoloration of these archwires[11]. So this study was planned to compare the color stability of three aesthetic arch wires along with the use of artificial saliva, black tea, Miranda, coffee and turmeric.

## Materials and Methods

Epoxy-coated stainless steel arch wire arch wires with a dimension of 0.019×0.025 inch were selected from three different companies (Highland metals, G&H orthodontic and Dany). A total of one hundred fifty segments (50 samples from each company) were prepared by cutting the preformed arch wires into two parts and placing ten parts of the coated archwires segments from each company in several solutions including: artificial saliva, black tea, Miranda, Coffee, Turmeric solution.

The solutions were replaced regularly to prevent the precipitation and change in concentration as follow:

- Black tea and coffee (three times daily)

- Miranda (two times daily)

- Turmeric (one time daily)

The color change was assessed using a visible spectrophotometer (Figure 1) after numbering the specimens of each subgroup from 1 to 10 for each solution by the marker which could not be removed by the solutions. The samples were incubated in distilled water in glass container at 37°C for 24 hours using incubator. Baseline measurement was done to measure the light reflection of each specimen by visible spectrophotometer at visible wavelengths started from 300-700nm at 10nm intervals. Color measurements will be repeated after 7 days (T1), 14 days (T2), and 21 days (T3) of immersion in the solution. Before each measurement, samples were removed from the solution (Figure 2) and rinsed with distilled water for 5 minutes. Excess water on the surfaces was removed with tissue papers and then left to dry.
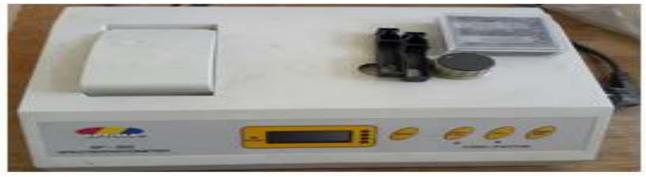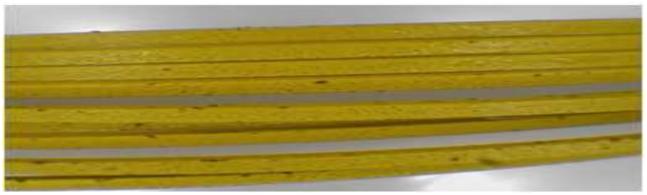


**Figure 1: Visible spectrophotometer**



**Figure 2: Discolored aesthetic arch wire segments**

## Statistical Analyses

The data were analyzed using SPSS (Statistical Package of Social Science version 24, IBM Co., New York, USA). The statistical analyses included:

- Descriptive statistics including mean, standard deviation, maximum and minimum values.
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- Inferential statistics: including: One-way analysis of variance (ANOVA) to test any statistically significant difference among groups followed by post hoc Turkey's high significant difference (HSD) to test any statistically significant differences between each two groups

## Results

Table 1, 2 and 3 showed the descriptive statistics and comparison between the degree of color absorption and effect of different solution of coated arch wires after 7, 14 and 21 days of immersion respectively. The results revealed that the most causative solution on color change were the Turmeric and tea solutions among brands and durations. Generally, arch wires from Highland company had the highest degree of color change followed by Dany and G& Hand the amount of color change increased with increased immersion time.

Turkey's HSD test (table 4) showed that the difference between each two groups of the study as followed:

- For artificial saliva, there is no significant difference between Highland and G&H after 21 days of arch wires immersion.

- For the Turmeric solution, there are high significant differences among all groups for all duration of arch wire immersion.

- High significant differences have also been found between groups of Coffee solution except between Highland and G&H after 7 days and between Highland and Dany after 14 and 21 days of immersion.

- For the Tea solution, there were no significant differences between most groups except for Dany with Highland and G&H with high significant differences between them.

- The least effective solution was Miranda for all arch wires and among all durations with no significant differences between groups except for Dany with Highland and G&H with Highland where there were significant differences between them.

## Discussion

The visible spectrophotometer did not give any readings for the artificial saliva during the first two readings (after 7 and 14 day) with minimum readings after 21 days of arch wire immersion.

All solutions altered the final color of the arch wire specimens. In an ascending order, staining of the test specimens was as follows: artificial saliva, Miranda, tea, coffee and turmeric. The present study showed differences in the degree of color changes for different types of aesthetic arch wires from different companies and under the same solutions and this may be due to different chemical and physical compositions of the aesthetic arch wires which need further researches to explore the accurate causative agents. The highest degree of color change was recorded with turmeric solution because of the high content of the gold-yellow coloring agent (curcumin) [12]. The variation between the reading of coffee and tea solution was related to the compositions of these solutions.

The caffeine content was differed between coffee and tea being high in coffee (70 mg in 237 ml.) as compared to its contents in tea (40 mg in 237 ml.)[13,14]. The least degree of color change was found with Miranda solution due to the presence of ascorbic and citric acids that may have cleaning effect as compared to tea and coffee that have some precipitation which increased the staining effect and these results were agree with different local studies [15-16].

## Conclusions

- Turmeric solution had the highest effect on color change.

- The amount of color change increased with increasing immersion time.

- Coffee solution produced discoloration more than tea which may be related to the amount of caffeine materials.

- Miranda has the least effect due to the cleaning effect of acidic content.

**Table 1: Descriptive statistics and comparison the degree of color absorption after 7 days of immersion**

| Media | Arch wires | Descriptive statistics | | | | Comparison | |
|---|---|---|---|---|---|---|---|
| | | Mean | S.D. | Min. | Max. | F-test | p-value |
| Turmeric | Highland | 0.690 | 0.012 | 0.674 | 0.702 | 127.883 | 0.000 |
| | G & H | 0.615 | 0.017 | 0.600 | 0.641 | | |
| | Dany | 0.522 | 0.020 | 0.503 | 0.555 | | |
| Tea | Highland | 0.314 | 0.015 | 0.293 | 0.335 | 29.140 | 0.000 |
| | G & H | 0.297 | 0.011 | 0.281 | 0.311 | | |
| | Dany | 0.350 | 0.004 | 0.344 | 0.355 | | |
| Coffee | Highland | 0.497 | 0.009 | 0.489 | 0.510 | 253.324 | 0.000 |
| | G & H | 0.492 | 0.007 | 0.485 | 0.500 | | |
| | Dany | 0.408 | 0.005 | 0.400 | 0.411 | | |
| Miranda | Highland | 0.124 | 0.013 | 0.110 | 0.141 | 8.257 | 0.006 |
| | G & H | 0.113 | 0.013 | 0.100 | 0.132 | | |
| | Dany | 0.160 | 0.027 | 0.120 | 0.190 | | |

**Table 2: Descriptive statistics and comparison the degree of color absorption after 14 days of immersion**

| Media | Arch wires | Descriptive statistics | | | | Comparison | |
|---|---|---|---|---|---|---|---|
| | | Mean | S.D. | Min. | Max. | F-test | p-value |
| Turmeric | Highland | 0.818 | 0.018 | 0.800 | 0.844 | 548.861 | 0.000 |
| | G & H | 0.681 | 0.002 | 0.679 | 0.684 | | |
| | Dany | 0.578 | 0.008 | 0.570 | 0.588 | | |
| Tea | Highland | 0.389 | 0.008 | 0.380 | 0.400 | 15.184 | 0.001 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | G & H | 0.359 | 0.008 | 0.350 | 0.371 | | |
| | Dany | 0.406 | 0.021 | 0.390 | 0.440 | | |
| Coffee | Highland | 0.587 | 0.005 | 0.581 | 0.592 | | |
| | G & H | 0.521 | 0.113 | 0.395 | 0.612 | 1.199 | 0.335 |
| | Dany | 0.548 | 0.029 | 0.520 | 0.590 | | |
| Miranda | Highland | 0.205 | 0.016 | 0.190 | 0.230 | | |
| | G & H | 0.190 | 0.008 | 0.182 | 0.201 | 44.411 | 0.000 |
| | Dany | 0.251 | 0.006 | 0.244 | 0.260 | | |

**Table 3: Descriptive statistics and comparison the degree of color absorption after 21 days of immersion**

| Media | Archwires | Descriptive statistics | | | | Comparison | |
|---|---|---|---|---|---|---|---|
| | | Mean | S.D. | Min. | Max. | F-test | p-value |
| Artificial saliva | Highland | 0.019 | 0.001 | 0.017 | 0.020 | | |
| | G & H | 0.018 | 0.007 | 0.011 | 0.028 | 4.216 | 0.041 |
| | Dany | 0.011 | 0.004 | 0.007 | 0.017 | | |
| Turmeric | Highland | 0.978 | 0.042 | 0.910 | 1.020 | | |
| | G & H | 0.850 | 0.024 | 0.820 | 0.880 | 91.019 | 0.000 |
| | Dany | 0.704 | 0.027 | 0.680 | 0.750 | | |
| Tea | Highland | 0.491 | 0.008 | 0.480 | 0.500 | | |
| | G & H | 0.458 | 0.003 | 0.455 | 0.460 | 22.215 | 0.000 |
| | Dany | 0.488 | 0.013 | 0.470 | 0.500 | | |
| Coffee | Highland | 0.687 | 0.009 | 0.680 | 0.699 | | |
| | G & H | 0.702 | 0.013 | 0.690 | 0.720 | 39.044 | 0.000 |
| | Dany | 0.626 | 0.019 | 0.600 | 0.650 | | |
| Miranda | Highland | 0.342 | 0.041 | 0.299 | 0.390 | | |
| | G & H | 0.318 | 0.019 | 0.299 | 0.350 | 1.013 | 0.392 |
| | Dany | 0.331 | 0.011 | 0.320 | 0.350 | | |

**Table 4: Turkey's HSD test after ANOVA test**

| Media | Archwires | | 7 days | 14 days | 21 days |
|---|---|---|---|---|---|
| Artificial saliva | Highland | G & H | - | - | 0.941 |
| | | Dany | - | - | 0.049 |
| | G & H | Dany | - | - | 0.047 |
| Turmeric | Highland | G & H | 0.000 | 0.000 | 0.000 |
| | | Dany | 0.000 | 0.000 | 0.000 |
| | G & H | Dany | 0.000 | 0.000 | 0.000 |
| Tea | Highland | G & H | 0.074 | 0.012 | 0.000 |
| | | Dany | 0.001 | 0.160 | 0.836 |
| | G & H | Dany | 0.000 | 0.000 | 0.000 |
| Coffee | Highland | G & H | 0.541 | 0.308 | 0.265 |
| | | Dany | 0.000 | 0.644 | 0.000 |
| | G & H | Dany | 0.000 | 0.807 | 0.000 |
| Miranda | Highland | G & H | 0.658 | 0.094 | 0.362 |
| | | Dany | 0.028 | 0.000 | 0.815 |
| | G & H | Dany | 0.006 | 0.000 | 0.708 |

# References

1. Lagravere MO, Flores-Mir C (2005) The treatment effects of Invisalign orthodontic aligners: a systematic review. J. Am Dent Assoc., 136:1724-1729.

2. Ye L, Kula KS (2006) Status of lingual orthodontics. World J. Orthod., 7:361-368.

3. Lee YK (2008) Colour and translucency of tooth-coloured orthodontic brackets. Eur. J. Orthod., 30:205-210.

4. Feu D, Catharino F, Duplat CB, Capelli JJ (2012) Esthetic perception and economic value of orthodontic appliances by lay Brazilian adults. Dental Press J. Orthod., 17:102-114.

5. Elayyan F, Silikas N, Bearn D (2010) Mechanical properties of coated superelastic archwires in conventional and self-ligating orthodontic brackets. Am J. Orthod. Dentofacial Orthop., 137: 213-217.

6. Kusy RP (1998) The future of orthodontic materials: the long-term view. Am J Orthod. Dentofacial Orthop., 113:91–95

7. Kusy RP (1997) A review of contemporary archwires: their properties and characteristics. Angle Orthod., 67:197-208.

8. Li Y, Hu B, Liu Y, Ding G, Zhang C, Wang S (2009) The effects of fixed orthodontic appliances on saliva flow rate and saliva

electrolyte concentrations. J. Oral. Rehabil., 36:781-5. (IVSL)

9. McCabe JF (1985) Anderson's applied dental materials. 6thed. Blackwell Scientific Publications, 9, 43, 46, 65-66, 68.

10. Proffit WR, et al (2013) Contemporary orthodontics. 5th ed. St. Louis: Mosby Company;.

11. Faltermeier A, Rosentritt M, Reicheneder C, Behr M (2008) Discoloration of orthodontic adhesives caused by food dyes and ultraviolet light. Eur. J. Orthod., 30: 89–93.

12. Wang, Ying-Jan, et al (1997) Stability of curcumin in buffer solutions and characterization of its degradation products. J Pharmaceutical Biomed Analysis, 15: 1867-1876.

13. Mc Cusker RR, et al (2006) Caffeine content of energy drinks, carbonated sodas, and other beverages. J. Analytical Toxicol., 30:112.

14. Chin JM, et al (2008) Caffeine content of brewed teas. J Analytical Toxicol 2008; 32:702.

15. Hussein GK, Mohammed SA "Effect of Whitening Toothpastes with Different Whitening Agents on the Color Stability of Orthodontic Clear Elastic Ligatures." International Journal of Medical Research & Health Sciences, 7 (3): 128-134.

16. Noori ZT, Ghaib NH (2016) "Color Stability of Different Aesthetic Arch wires (An In vitro study)." Journal of Baghdad College of dentistry 28(1): 164-168.