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Color evaluation of acrylic resin denture base material impregnated with Fluconazole antifungal drug

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Abstract
Background: Several health problems are associated with wearing dentures mainly related to fungal and bacterial aggregation on their surfaces. Several antifungal drugs have been tested to be combined with the acrylic resin material for alleviating such problems. The objective of this study was to evaluate color properties of the acrylic denture material as a result of Fluconazole antifungal drug impregnation.
Methods: A total of 20 samples were prepared from clear heat-cured acrylic resin. They were divided into two groups (experimental and control) with 10 specimens each. The acrylic resin specimens were finished and analyzed optically by color sensor module for Red, Green, Blue values. The data were then analyzed statistically for significant differences.
Results: The results showed there was a significant difference in red color between the groups with higher proportion associated with the control group. There was also a significant difference in green color between the groups with higher proportion associated with the control as well. However, there was no statistically significant difference in blue color proportion between the groups.
Conclusions: The study showed that Fluconazole impregnation with acrylic resin denture base material could affect the shade color of the resin which might have a significant impact on the esthetics of the restoration.

Keywords: acrylic resin; PMMA; Fluconazole; drug impregnation

Introduction
Acrylic resin is one of most frequently used biomaterials in medical applications [1-3]. Their main application in dentistry is for making oral prostheses and dentures that partially or completely restore the dentition [4, 5]. Because of their intra-oral use, they are susceptible to biofilm formation and fungal attack [6]. One of the main health issues associated with denture in the oral cavity is denture stomatitis that is associated with *Candida* species, particularly *Candida albicans* [7-9]. There was several research experiments were conducted on fighting the attack of *Candida* biofilms which included several disinfecting solutions for periodic overnight denture cleaning, using resistant coatings on dentures, and incorporating antifungal drugs with the acrylic resin denture base material for constant intra-oral elution [10-12]. Denture stomatitis is a condition that results from poor oral hygiene by denture wearers which leads to formation of visible plaque coating on the denture surface that later on simulates local inflammatory reactions in the contacting oral tissues, and then produces erythema hyperplasia[13]. It was proven by some literature that acrylic resin material provides constant release of loaded compounds serving as a successful drug delivery system [14]. Several findings showed that the same setting can be employed into oral applications in the form of drug delivery dentures [15, 16]. Fluconazole is one of the antifungal drugs that have been used for treatment of superficial and systemic fungal infections[17]. It has been used for treating skin infections for more than 35 years, and due to its large molecular size and hydrophobicity it became bioavailable for oral use as well [18]. Fluconazole elution from acrylic resin material was proved to be successful for certain doses and certain duration of time [19]. Moreover, precise percentage of drug loaded was recommended so the restoration can perform its intended function with reasonable mechanical sustainability [20].
Esthetics of the dental prosthesis is a critical factor for patient acceptance and the success of the restoration. Patient satisfaction is sometime difficult to achieve without having a prosthesis that is fit, comfortable, and esthetically acceptable [21]. Although technical skills are importance to simulate the anatomical features of the restoration, adopting the proper coloring is also necessary [22]. The purpose of this study was to evaluate the acrylic resin color properties when loaded with fluconazole antifungal agent for intra-oral drug elution, and how significant the shade changes after loading procedure.

Materials and Methods

Sample preparation

The study samples were prepared from heat-cured acrylic resin polymer (Veracril, Colombia). The study samples were divided into two groups, control and experimental, with 10 specimens for each group. Fluconazole powder (PYXUS PHARMACEUTICALS PVT. LTD, India) was added to the acrylic powder at the mixing stage for the experimental group samples with drug percentage of the powder mix of 10% as recommended by the literature[20]. Stone molds were prepared and the acrylic mix was added and the mold was clamped tightly. The curing procedure was conducted in a waterbath as recommended by the manufacturer. The specimens were then finished and cleaned to be ready for evaluation.

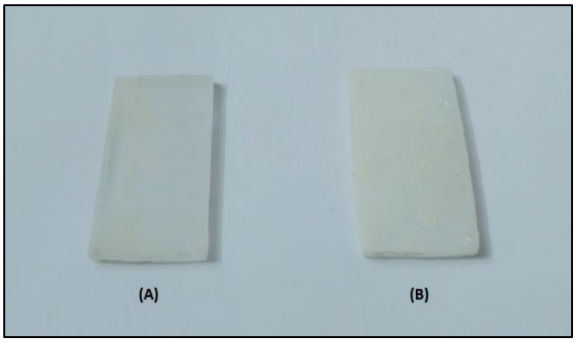

Fig 1: Representative specimens (A = Control, B = Experimental)

Optical and statistical analysis

The specimens were analyzed for colors values using a color recognition sensor (TCS230, China) that gives data regarding proportions of Red, Green, and Blue in each specimen. The system setup composed of the color sensor connected to Arduino Uno microcontroller that was programmed to process the data received from the sensor and view them through Arduino IDE software in form of three values based on basic colors (Red, Green, and Blue) as shown in Figure(2) [23]. The examination was started by tacking the baseline values of a white background which were constant (Red=80, Green=82, and Blue=58). When values increase it means less color proportion or in other word more lightness or whiteness is associated with the color. Each specimen was examined and the data was obtained and saved for statistical analysis. After data collection, statistical analysis was conducted using IBM SPSS software for significant difference. Independent sample T test was performed between the groups for each color.

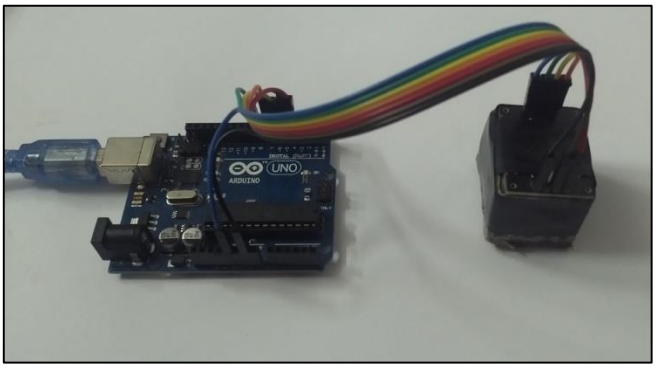

Fig 2: Color recognition setup

Results

The descriptive statistics data for color proportions were illustrated in Table (1) as well as the independent T test results. With regards to red color data, the mean values showed that redness is higher in the control group than the experimental groups which is then confirmed by the T test with statistically significant difference (P-value<0.05) Figure(3).

Table 1: Descriptive and Independent Sample T test results for the study groups (units in bytes)

		N	Mean	Std. Deviation	Std. Error Mean	Minimum	Maximum	Sig.
Red	Control	10	113.60	3.565	1.127	108	119	0.012
	Drug-loaded	10	116.90	1.101	0.348	115	119	
Green	Control	10	119.10	2.885	0.912	114	124	0.048
	Drug-loaded	10	121.40	1.838	0.581	117	123	
Blue	Control	10	89.80	3.084	0.975	85	94	0.157
	Drug-loaded	10	91.80	2.974	0.940	85	94	

Regarding green color data, there was also a significant difference between the groups with higher green color intensity in the control group than the experimental as shown in Figure (4). However, there was no statistically significant difference in blue color intensity between the control and experimental group (P-value>0.05) despite the difference in mean values as shown in Figures (5-7).

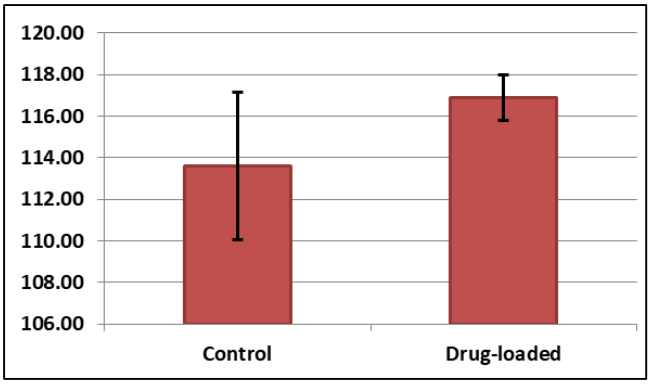

Fig 3: Red color mean values (units in bytes)

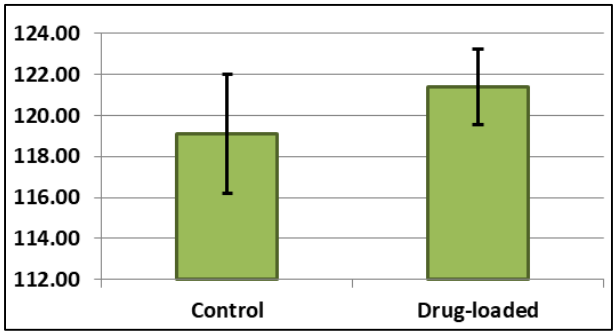

Fig 4: Green color mean values (units in bytes)

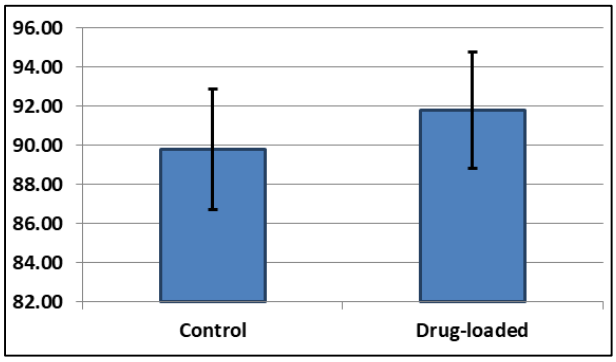

Fig 5: Blue color mean values (units in bytes)

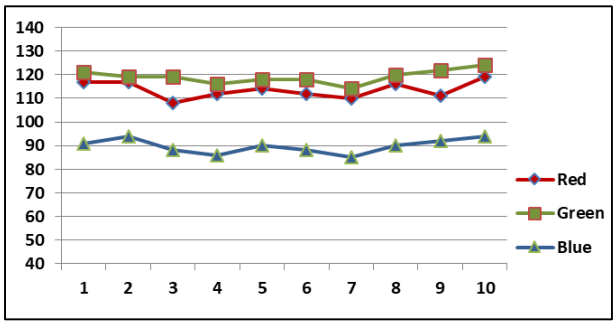

Fig 6: Control samples data (units in bytes)

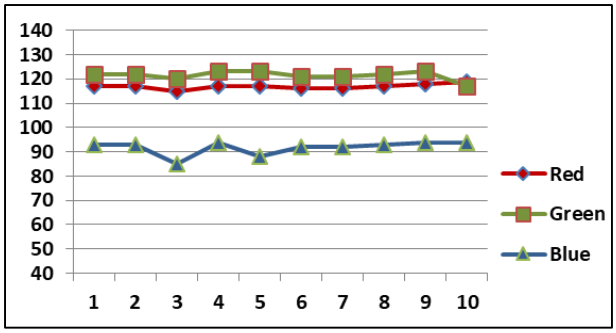

Fig 7: Experimental samples data (units in bytes)

Discussion

The two main key factors for a successful dental prosthesis are to perform the intended function and to restore patient esthetics. For many patients, oral hygiene is difficult to be maintained. Therefore, several studies examined the possibility to incorporate antimicrobial drugs within the denture material to overcome this issue. Fluconazole as well as other drugs was confirmed to be successfully eluted from acrylic resin material without interfering with the polymerization reaction of the polymer or suffering from deterioration during polymerization. Yet this drug impregnation effect of the color and shade of the acrylic resin material is not clearly confirmed. This study was conducted to evaluate the impact of fluconazole impregnation on the esthetics of the dental restoration.

The study samples were analyzed optically by measuring three color parameters (RGB models) in terms of proportions and intensity [24]. The three parameters data were analyzed for each specimen as they represent the basic ingredient of the visible shade color of the acrylic surface. Values of individual colors were analyzed statistically for significant difference. The red color showed significant difference between the groups where the experimental group samples showed less redness than the control samples. There was also a significant difference between the groups in the green color proportion which was less in the experimental samples than the control samples. However, blue color proportion showed no statistically significant difference between the groups although the experimental groups showed higher mean value. From visual observation and inspection, a noticeable difference can be detected in terms of shades of the clear acrylic resin. The control specimens were quite transparent while the experimental specimens were translucent. This could significantly affect the shades of the acrylic prosthesis and thereby affect its esthetics. This difference could be attributed to the color of Fluconazole powder which constitutes 10% of the acrylic resin powder. The study result comes in agreement with a study conducted by Kotanidis and associate, they concluded that reinforcing acrylic resin material with silica nanoparticles could affect the optical properties of the acrylic resin material [25]. The color, particle size, and type of the incorporated material could play major roles in the color of the final restoration whether this incorporation is resulting in mechanical reinforcement or drug delivery capability. In case of drug impregnation, color change could take place as the drug is being eluted from the acrylic material as normally intended. More studies are highly recommended in this subject.

Conclusion

This study was conducted to evaluate color change of acrylic resin as a result of Fluconazole impregnation within the polymer. The results showed that only two color proportions were changed which were the red and green that might have a noticeable effect on the shade of the dental restoration which may affect the esthetics at some point. Continuing examination of the denture color as it delivers the drug with time is highly recommended for future work.

Conflict of interest

1. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors
2. The Author declares that there are no conflicts of interest.

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