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Effects of *Zingiber Offcianille* Essential Oil on Compressive Strength of Fluorescent Orthodontic Adhesive

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Abstract

Aims: This study aimed to evaluate the compressive strength of a fluorescent orthodontic adhesive modified by the incorporation of different concentrations of *Zingiber officinale essential oil.* **Materials and Methods:** Compressive strength test groups consisted of the control group, orthodontic adhesive modified with 1% *Zingiber Officinale* essential oil, and 2% groups, (5 specimens for each group). Cylindrical rubbery molds were utilized to fabricate the study specimens; their diameter was three millimetres while their height was six millimetres, each specimen was constructed by utilizing an incremental approach. Each layer of Fix fluorescent orthodontic adhesive was about 2 mm level, the curing light was applied for 20 seconds. A universal testing apparatus with a cross-head velocity of 1 millimetre/ minute was used to assess the compressive strength. Statistical comparisons were conducted at $p < 0.05$. **Results:** The compressive strength of the control group was higher than orthodontic adhesive modified with 1%, and 2% *Zingiber Officinale* essential oil, but no statistically significant differences were shown among them. **Conclusion:** The current study concluded that compressive strength reduced after incorporation of *Zingiber Officinale* essential oil with orthodontic adhesive, however, no evident differences were noticed.

تأثير الزيت العطرى لنبتة الزنجبيل على القوة الانضغاطية للمادة اللاصقة لتقويم الأسنان

الملخص

الأهداف: كان هدف الدراسة تقييم مقاومة الإنضغاط لمادة لاصق تقويم الأسنان المعدل عن طريق دمج تراكيز مختلفة من زيت الزنجبيل العطري. **المواد وطرائق العمل:** تتكون مجموعات اختبار مقاومة الانضغاط من المجموعة القياسية ،مجموعة لاصق تقويم الأسنان المعدل بنسبة 1٪ من زيت الزنجبيل العطري ، و 2٪ ، (5 عينات لكل مجموعة). تم استخدام قوالب مطاطية أسطوانية لتصنيع عينات الدراسة ، وكان قطرها حوالي ثلاثة مليمترات بينما كان ارتفاعها حوالي ستة مليمترات باستخدام طريقة تدريجية ، حيث كان مستوى كل طبقة من لاصق تقويم الأسنان حوالي 2 ملم، حيث تم تطبيق ضوء المعالجة على فترة 20 ثانية.استُعمل بعدها جهاز قياس مقاومة الإنضغاط صيني المنشأ لقياس مقاومة العينات بسرعة 1 ملم لكل دقيقة، تم بعدها إجراء التحليل الإحصائي لتحليل نتائج التجربة. **النتائج:** المجموعة القياسية كانت أعلى من مجموعة اللاصق التقويمي المعدل بنسبة 1٪ ، 2٪ من زيت الزنجبيل الأساسي العطري ، ولكن لم تظهر فروق ذات دلالة إحصائية بين مجموعات الدراسة. **الإستنتاجات:** تم ملاحظة الإنخفاض في قيم مقاومة الانضغاط للاصق التقويمي المعدل في جميع التراكيز المستخدمة من زيت الزنجبيل العطري.

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INTRODUCTION

In contemporary society, orthodontic therapy is widely used, however, it may have unfavourable side effects, such as dental caries, periodontal disease, root resorption, tooth devitalization, and TMJ dysfunction [(1)]. Dental biofilms have been linked to serious dental problems such as decalcifications, periodontitis, gingival inflammation, and carious lesions. The oral microbiota is changed by orthodontic appliances and compromised dental hygiene [(2)]. Additionally, even in the early stages of demineralization, caries in the anterior teeth compromise the aesthetic improvement brought on by orthodontic therapy [(3)]. This resulted in the invention of various antibacterial orthodontic bonding technologies that exhibit antibacterial properties [(4)]. Essential oils could be promising antibacterial alternatives because of their non-synthetic origin, broad-spectrum antibacterial effects relatively low toxicity, and accessibility at an economical cost, if they are supported by scientifically established research [(5 & 6)].

Brackets are de-bonded after active orthodontic treatment and any remaining adhesive is removed by various methods such as mechanical methods, chemical solvents, ultrasonic scalars, and lasers. Among these techniques, the mechanical one is still the most commonly utilized in clinical practice [(7)]. It is still challenging for any orthodontist since resin remnants can collect dental plaque, stain the teeth, and the subsequent elevated risk of caries, as a result, numerous devices and techniques have been developed to find a relatively safe, reliable and efficient way to remove orthodontic adhesive residues following the de-bonding of orthodontic attachments [(7)].

From a clinical point of view, current literature has shown that UV light might assist orthodontists in viewing fluorescent adhesives since they allow for more effective removal of the residues after de-bonding, additionally, this method shortens the time needed to complete the process of removing the adhesive remains [(7)].

The highest vertical compressive force a material can withstand before fracture is known as compressive strength [(8)]. Compressive strength is a key component of the mastication process and as most masticatory stresses are compressive, it is important to evaluate the longevity of dental restorations and adhesives under similar circumstances [(9)].

Zingiber officinale rhizome contains gingerol and shogaol, which have antibacterial capabilities against the anaerobic bacteria that cause periodontal disease in the mouth [(6)]. The *Streptococcus mutans* may have been eliminated because *Zingiber officinale* fractions suppressed the activity of many bacterial enzymes critical in biological mechanisms such as cell growth, intra-cellular and extra-cellular polysaccharide development, and even glycolysis actions [(6, 10)].

According to our best knowledge, no study was conducted to assess the compressive strength of the orthodontic adhesive that was modified by incorporating ZO. The null hypothesis is that there is no significant difference in compressive strength after incorporating ZO in orthodontic adhesive.

MATERIALS AND METHODS

Preparation of Modified Adhesive

The ethical clearance was obtained from the Research Ethics Committee of the College of Dentistry, University of Mosul in 2022 (UoM.Dent / H.DM. 51/22). The prepared ratios of the modified orthodontic adhesive with ZO essential oil (Sigma-Aldrich, St. Louis, Missouri, USA) (Fig. 1) were done by using an electrical sensitive balance (Kern, Germany). Two concentrations of 1% and 2% were prepared in a weight-to-volume ratio; a micropipette (DRAGON lab, Shandong, China) was utilized for the ZO essential oil aspiration. The mixing of the modified Fix orthodontic adhesive (Maquira, Maringá, Brazil) was done at room temperature about (22 Cº ± 3) by utilizing a plastic spatula and a sterile glass slab [11]. To achieve a uniform and homogenous consistency, we mixed the products for around 60 seconds in a semi-dark location, the mixture was then spread out on a surface to reduce porosity [4, 11 & 12]. Dimetacrylate resins and essential oils both have a hydrophobic characteristic, making it simple to mix them to create homogeneous material [4]. The ZO-modified adhesive was then transferred to a sterilized disposable syringe, and a piece of tape of a dark colour was used to protect the mixture from direct light exposure [11]. In addition to the control group, the concentrations of the essential oil were chosen as follows: A group of 10 µL ZO essential oil in 1gm of Fix orthodontic adhesive and another group of 20 µL ZO essential oil in 1 gm of Fix orthodontic adhesive.

Figure (1): *Zingiber officinale* essential oil.

Evaluation of Compressive Strength

Specimens were constructed for each group of compressive strength using a cylindrical rubber cast with (3 and 6) millimetres of diameter and height respectively then sealed with a mylar strip. By utilizing a gradual application method, Fix fluorescent orthodontic adhesive was deposited into the rubbery transparent mold. Each layer was then exposed to light for 20 seconds using a Woodpecker light-curing machine (Woodpecker, China) [12]. At every 2 millimetres layer, the light activation was accomplished [12]. The specimens (Fig. 2) were taken out of the rubber cast and photoactivated on the bottom and the four outer sides for an additional 20 seconds [12].

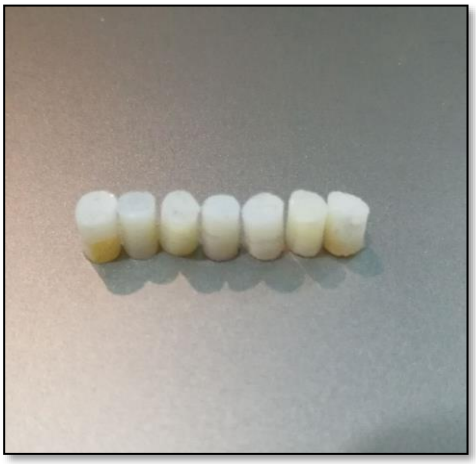

Figure (2): Specimens of Compressive-Strength test

Following 24 hours of storage in distilled water, the specimens were tested for resistance to compression stresses by utilizing a (Gester) universal testing apparatus with a cross-head speed of 1 millimetre per minute, as indicated in (Fig. 3) [13]. Utilizing the curve of stress-strain, the applied force was exerted in a perpendicular direction to the centre of the specimen's upper and lower surfaces, until the sample was fractured, at which point the peak force necessary to crush each sample was registered in Newtons. Using the given formula, the compressive strength was estimated in MPa:

Compressive Strength= $4\ P/\pi\ D^2$. Where D is the sample diameter, while P is the applied stress at the fracture point [14].

Figure (3) Compressive Strength Measurement by the Universal Testing Machine.

RESULTS

The assessment of data normality of distribution has shown that most data along compressive strength study groups were normally distributed, Table (1).

Table (1): Shapiro-Wilk test for data distribution along the study groups.

Variables	Statistic	*p*- valve
Compression Control	0.81	0.100
Compression 1% ZO	0.97	0.896
Compression 2% ZO	0.90	0.453

*Significant at $p < 0.05$.

The descriptive data included the mean, standard deviation, minimum and maximum values of the compressive strength study groups. The results revealed that the control group had the highest compressive strength mean value, followed by orthodontic adhesive modified with 1% ZO essential oil after while the 2% group showed the lowest mean value of the compressive strength as shown in Table (2).

Table (2): Descriptive Statistics of compressive strength study groups.

Variables	Mean	SD±	Minimum	Maximum
Control	139.52	22.00	114.10	160.50
Modified with 1% ZO	122.92	18.67	96.70	147.50
Modified with 2% ZO	106.74	26.60	75.00	136.30

The compressive strength measurement unit is Mpa.

The outcomes of the one-way analysis of variance statistical test were shown in Table (3), which revealed that there was no significant difference among the mean values of the research groups for the compressive strength of the current study.

Table (3): One-way analysis of variance (ANOVA) for compressive strength study groups.

	Sum of Squares	DF	Mean Square	F	*p*-value
Between Groups	2686.46	2	1343.23	2.61	0.114
Within Groups	6163.38	12	513.61		
Total	8849.85	14			

*Significant at $p < 0.05$. DF is the degree of freedom.

DISCUSSION

Fluorescent orthodontic adhesives may be a promising solution, from a clinical aspect, according to certain research, orthodontic specialists might detect orthodontic adhesives by using fluorescent chemicals and ultraviolet light, allowing more efficient removal of the remnants after the de-bonding. Additionally, this method shortens the time needed to complete the process of removing the adhesive remnants [(7)]. Studies such as Ribeiro *et al.* [(15)] assessed the removal of adhesive residues as well as the potentially harmful effects on the enamel light by utilizing ultra-violet light and found that the use of fluorescent orthodontic adhesives provides a complete, relatively safe, and more efficient removal of remnants after finishing orthodontic therapy [(16)]. Due to their broad-spectrum antibacterial actions, relative safety for human health, and accessibility at a low cost, essential oils, and their constituents have gained a lot of attention in this respect and are widely used as bactericidal components [(5)]. The methanolic fraction and crude extract of ZO have incredibly high cariostatic potential. Furthermore, its non-toxic nature makes it greatly desirable for the creation of novel materials to combat dental decay [(16)].

The mechanical characteristics of the orthodontic adhesives are crucial to their long-term efficiency in the mouth. The most common type of mechanical force in the oral cavity is compression stress, which occurs when hard tooth tissues are exposed to the highest forces [(17)]. Compressive strength is utilized in in -vitro studies to create forces against materials similar to mastication and chewing forces in the oral cavity [(18)].

In the current study the suggested concentrations were 1%, 2%, and 3%, however, during the pilot study, while working on a 3% concentration it was found that after mixing the resulting modified adhesive did not polymerize after curing for 20 sec, 40 sec, 60 sec and 120 sec. For that reason, concentrations of 1% and 2% were focused on during the experiment.

The results of the current study recorded a reduction in compressive strength after incorporating the ZO essential oil, however, it seems that this reduction is not significant. Nearby to the current study findings, Saleem *et al.* [19] studied the effectiveness of preparing various concentrations of pristine and Se/ZnO nanoparticles which were incorporated in the dental composite manually. The compressive strength test showed that the incorporation of the nanoparticles didn't have a significant impact on the composite-resin compressive strength. Another study demonstrated that when the flowable composite resin was mixed with alcohol, hemostatic elements, artificially-made saliva, or powdered gloves, the compressive strength was decreased at 24 hours as well as 30 days after photo-curing [9]. However, disagreement between these results with the current findings cannot be considered fully due to the different types of composite resin, techniques used, and using agents rather than essential oils.

The present study disagreed with Sherief *et al.* (2021), who found that the addition of cinnamon and thyme essential oils at two different concentrations (5% and 10% concentrations) to glass ionomer cement decreased its compressive strength significantly. It's possible that the essential oils' inability to chemically attach to both the glass and the polyalkenoate matrix caused the micro-porosities of the glass ionomer cement to rise, lowering its compressive strength. Contrarily, it is interesting to notice that when compared to the control Fuji-IX, adding cinnamon oil at a concentration of 5% showed no negative impacts on compressive strength. However, adding 10% cinnamon oil significantly decreased the compressive strength of the glass ionomer cement. However, the present finding is controversial in this study. This may be attributable to the chemical nature of several tested essential oil components [20], and also may be due to the use of a fluorescent orthodontic adhesive in the current study rather than glass ionomer cement.

Composite resin products may exhibit reduced mechanical properties when various antibacterial agents are incorporated [21]. Any substance that reacts with a free radical can affect the polymerization of resin composites and resin-based systems, which happens through free-radical addition polymerizations [22].

Additionally, phenolic acids as well as polyphenols are regarded as free radical searchers. Flavonoids also can demonstrate free radical searchers' effect on free radicals such as hydroxyls, superoxide, and 1,1-diphenyl-2-picrylhydrazyl [23].

In the current work, we met some difficulties such as obtaining the raw materials from overseas which were time-consuming. Despite that, this study tried to make any improvement in orthodontic adhesive by incorporating safe natural product material that has antibacterial and remineralization abilities. Further studies are recommended to assess the effects of ZO in its different forms (essential oil or nano-powder) and concentrations on the orthodontic dental adhesive.

CONCLUSION

Zingiber officinale essential oil incorporation into Fix orthodontic adhesive reduced compressive strength in all utilized concentrations, but no evident differences were noticed.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this manuscript.

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