



Research Article

# Evaluating the effect of natural, industrial juices and beverage on orthodontic bonding composite (in-vitro study)

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**Abstract:** Background: Dental erosion is a common oral condition which results due to consumption of high caloric and low pH acidic food such as carbonated drinks and fruit juices. It is expected that these food types can cause irreversible damage to dental hard tissues and early deterioration of the dental restorations. So, this study aimed to evaluate and compare the erosive potential effects of orange fruit juice and Miranda orange drink on the microhardness of an orthodontic composite material. Materials and methods: Thirty discs with a thickness of 2 mm and a diameter of 10 mm were prepared from orthodontic bonding composite. The prepared discs were equally divided into three groups (n=10). Microhardness analysis was carried out both prior to and subsequent to immersion cycles. The microhardness of the specimens underwent evaluation subsequent to immersion in the beverages for durations of 6 hours (equivalent to one day) and 42 hours (equivalent to seven days). Microhardness measurements at baseline, one day, and one week were performed utilizing the Vickers microhardness testing. Statistical analyses were carried out using repeated measure one way ANOVA test and Bonferroni post-hoc test with a level of significant  $p < 0.05$ . Results: The micro hardness of composite exposed to the selected soft drinks was significantly decreased ( $p < 0.05$ ). Conclusions: Natural, industrial orange juices and Miranda can affect the micro hardness of composite. The beverage effect on the orthodontic composite based on the type of juice and the exposure time to these beverages.

**Keywords:** Orthodontic bonding composite, Orange fruit juice, micro hardness, Atomic force microscope, Miranda orange, Erosion

## Introduction

Over the last few decades, there was a drastic decrease in the prevalence of dental caries world-wide which has been accompanied by a remarkable increase in the incidence of non-carious lesions such as dental erosion<sup>(1)</sup>. Dental erosion was defining as an irreversible loss of dental hard tissue by a chemical process without the involvement of microorganisms and is due to either extrinsic or intrinsic sources<sup>(2)</sup>. Intrinsic causes like recurrent vomiting. Extrinsic causes include acidic substances, beverages, medication and environmental exposure to acidic agents<sup>(3)</sup>. With increase in the consumption of soft drinks and fruit juices, the prevalence of dental erosion seems to have increased presumably<sup>(4)</sup>.

Most people think that the consumption of soft drink and fruit juices is not as harmful as generally believed. However, a number of serious health issues were reported to be associated with regular

consumption of soft drinks. The inherent acids and sugars have both acidogenic and cariogenic potential resulting in dental caries and enamel erosion and might affect dental restorations as well<sup>(5)</sup>.

Dental erosion was a reason for restoring teeth. A suitable restorative material should have features such as acceptable mechanical properties, protection against tooth decay, easy use in the clinic, aesthetics, and maintaining the inherent properties in the oral environment<sup>(6)</sup>. Therefore, the use of composites has increased due to the ability to bond to the tooth structure, meet aesthetic needs, and improve mechanical properties in restorative dentistry<sup>(7)</sup>. Composite resins consist of four main parts, including organic polymer matrix, non-organic filler particles, coupling agent, and initiator-accelerator system<sup>(8)</sup>.

In the oral environment, it can be assumed that saliva, food components, beverage and interaction among these materials can degrade and age dental restorations. The chemical environment in the oral cavity may have a critical influence on the *in vivo* degradation of composite resins<sup>(9)</sup>. The longevity of dental restoration depends on durability of the material and its properties such as hardness and wear resistance<sup>(10)</sup>. Hardness was defined as the resistance of a material to indentation. Surface hardness correlates well to compressive strength, and abrasion resistance<sup>(11)</sup>.

Children and adults are large consumers of non-alcoholic beverages; thus, these substances have a significant effect on restorative materials<sup>(12)</sup>. Numerous studies have been conducted on the effect of various beverages, especially alcoholic beverages, carbonated drinks, and orange juice on the mechanical properties of tooth-colour materials, including glass ionomers and composites<sup>(13)</sup>. However, little is known about the effects of these materials on Orthodontic Bonding Composites.

Surface micro hardness of restorative materials is an important feature for predicting mechanical properties such as abrasion resistance<sup>(8)(11)</sup>, thus studies that examine the micro hardness of materials are important. The aim of this study was to investigate the erosive potential of natural, industrial juices and beverage on the micro-hardness of composite materials (bonding).

## Subjects and Methods

### Sample size:

The sample size for this study was determined by using G power 3.1.9.7 (Program written by Franz-Faul, Universität Kiel, Germany) with power of study=95%, with 3 groups, three-time intervals, under all these conditions, sample size is about 10 samples for each group. This sample size was also computed on a previous study by Hashemikamangar et al<sup>(14)</sup>.

### Mold fabrication:

A clear acrylic sheet (Perspex Cell Cast Acrylic, Clairvaux les Lacs France) which was 15 cm in width, 20 cm in length, and 2 mm in thickness was used to fabricate the mold. The samples measurements were designed by using a computer's software (AutoCAD 2019) to design the samples. Then, the cutting was done by a CNC or computer numerical control.

#### Samples fabrication:

A total 30 disks of Orthodontic Bonding Composite (3M Unitek, Transbond XT, adhesive kit orthodontic bonding, USA) were prepared using molds of 10 mm diameter and 2 mm height. This dimension was also used by a previous studies on composite<sup>(14,15)</sup>. The material was managed according to the manufacturer's instructions. The mold was placed on a transparent celluloid strip (Torvm, Russia) and glass slide (Artedent, China) then the composite material was placed into the mold space using a plastic instrument. The mold, with composite material, were held between two glass slides and covered with a transparent celluloid strip. The glass slides were held firmly during setting to avoid the presence of air bubbles and to obtain a smooth surface<sup>(1)</sup>.

The material was photo-polymerized using LED light curing unit (Maximum curing intensity 2300 mw/cm<sup>2</sup>, Eighteeth, Changzhou City, Jiangsu Province, China) The intensity of curing light was 1600 mw/cm<sup>2</sup> and it was rechecked periodically via curing light meter (AP-C11, Septa, Guangdong, China) before usage<sup>(16)</sup>.

Light activation was carried on for 20 seconds on both sides by applying the tip of the light probe directly against the glass slide at right angle. Polymerizing against a glass surface is a method commonly used by researchers to produce a standardized surface finish for testing and was preferred to exclude air from the composite surface and thereby minimizing oxygen absorption which produce an oxygen inhibited layer<sup>(14)</sup>.

#### Soft drinks preparation:

The natural orange juice (pH= 3.4) was made by a juicer. According to U.S. Department of agriculture, it contains calories, fat, sodium, carbohydrate, fiber, suger, protein, vitamin C, potassium. Rani Fruit Drink Orange (pH= 4) was used, made in Iraq by Al Injaz for beverage filling and manufacturing company LTD, according to manufacturer, it contains Water, Sugar, Orange Juice made from concentrate (Min 10%), Citric Acid, Pectin, Natural Orange Flavour. Mirinda Orange (pH= 2.8) produced by Baghdad soft drinks company, Baghdad, Iraq, under instructions from Pepsico Inc, according to manufacturer, it contain carbonated water, crystalline sugar, citric acid, stabilizers, sodium benzoate, natural flavour, colour, ascorbic acid.

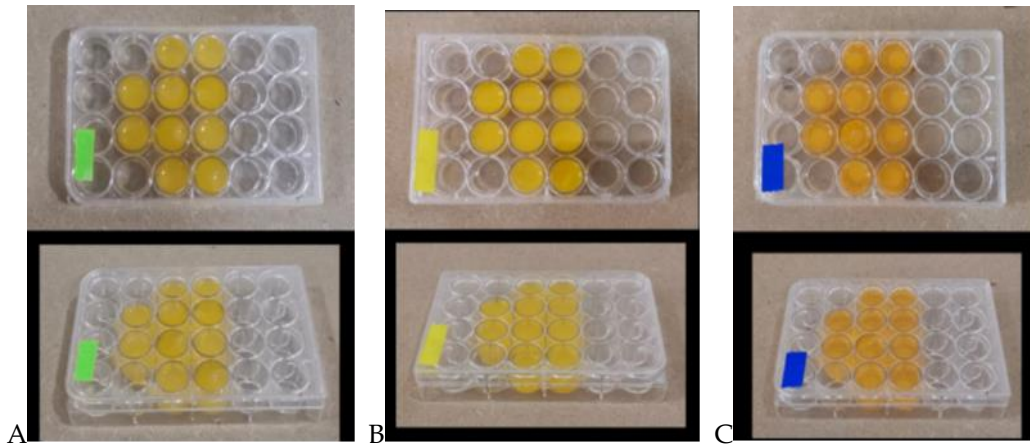
#### Immersion time:

This study was designed to simulate the testing period and period of immersion of a previous study<sup>(15)</sup> who studied the effect of natural and industrial juices on surface micro hardness of micro hybrid and Nano hybrid composites.

#### Sample grouping and immersion procedure:

After separation from the mold, the discs were divided into three groups (n=10 for each group) and placed into flat-bottomed well cell culture plate and immersed in distilled water for 48 hours for primary water absorption and full polymerization process<sup>(15)</sup>. Base line micro hardness was measured for all the specimens using digital Vickers micro hardness tester at a load of 100 gram for 15 seconds. Then the micro hardness of the specimens was measured after 6 h (one day) and 42 h (7 days) being immersed in the drinks<sup>(15)</sup> as seen in (Figure 1).

When not immersed, the specimens were kept in distilled water at 37°. The drinks were used at room temperature in February and were replaced every day to prevent possible interactions, their pH was checked regularly, and no difference was seen in pH during this week.



**Figure 1:** A, Group (1) Natural Orange Juice. B, Group (2) Industrial orange. C, Group (3) Miranda.

Vickers micro hardness test:

The micro hardness measurement was carried out by digital Vickers micro hardness tester (LARYEE, China) in the Metal testing laboratory, Department of Production Engineering and Metallurgy, University of Technology at a load of 100 gram for 15 seconds. For each sample, three readings were obtained; to increase the accuracy of the study; the mean of these three numbers was measured and recorded. Vickers micro hardness test was done using optical microscope, by means of a square based diamond indenter had an included angle of 136° between the opposed faces. The used magnification was X50 (Figure 2).



**Figure 2:** Vickers micro hardness tester.

Determination of the pH values of the drinks:

A pH meter (YINMIK: china pH meter) measures the acidity of an aqueous solution was used. It is in fact the measurement of the amount of H-ions in aqueous solutions. This device was calibrated via buffering solution (4.0, 6.86 and 9.18). The measurement was made by removing the protective cap of the pH meter and rinse the electrode with distill water and dry it with filter paper, turn it ON and immersing the pH electrode in the solution, stir gently and wait around 30 seconds till the reading is stabilized (Figure 3). Between readings, the electrode was washed with distilled water and wiped with cotton pads to avoid of mixture materials <sup>(17)</sup>. Fresh drink are used daily and to insure there was no change in the pH, it was checked every day.



**Figure 3:** Determination of pH value. A, Miranda. B, Industrial orange.

Statistical analysis:

Statistical analyses can be classified into two categories. First, descriptive analysis which includes: (A) Minimum, Maximum, mean and Standard deviation for quantitative variable (Table 1). (B) Graphs: cluster chart bars (Figure 4). Second, Inferential analysis which includes: (A) Shapiro Wilk test (B) Levene test (C) One way ANOVA test to test the difference among various drinks in each time interval (D) General Linear model (Repeated Measure Factorial Analysis of Variance to test the effect of immersion time intervals in each drink (E) Bonferroni post-hoc test. The level of significance at 0.05.

## Results

Shapiro Wilk test show that surface micro hardness is normally distributed in all groups ( $p > 0.05$ ). The effect of all 3 beverages was significant on the micro hardness of composite at three periods ( $p < 0.05$ ). Statistical analysis of results using (repeated measured one-way ANOVA) test demonstrated that micro hardness of composite was decreased from baseline to 42hrs in each soft drink with a significant decrease. The decrease was more in Miranda followed by natural orange juice while the least value was for industrial orange juice (Table 1).

**Table 1:** Descriptive and statistical test of surface microhardness of fillings among soft drinks and time intervals

Groups		Baseline	6hrs	42hrs	F	P value*	Effect size
Natural Orange Juice	Minimum	39.500	29.200	27.000	72.970	0.0001	0.849
	Maximum	41.900	36.400	34.900			
	Mean	40.700	33.724	30.740			
	±SD	0.807	2.227	2.647			
Industrial Orange Juice	Minimum	40.000	30.200	28.200	50.654	0.0001	0.796
	Maximum	41.900	37.500	35.400			
	Mean	40.760	34.530	32.370			
	±SD	0.737	2.450	2.507			
Miranda	Minimum	39.500	27.050	25.200	117.539	0.0001	0.900
	Maximum	41.900	33.400	30.900			
	Mean	40.580	31.155	27.812			
	±SD	0.807	2.299	1.789			
F		0.137	5.736	9.702			
P value		0.873^	0.008*	0.001*			
Effect size		0.010	0.298	0.418			

\*=significant at p <0.05, ^=not significant at p>0.05, Leven p value =0.361

Table (2) show multiple pairwise comparisons between immersion time using Bonferroni post hoc test. There was significant difference (significant decrease) between each time with each other. In each time, the lowest surface microhardness was found in Miranda followed by natural orange juice while the highest value was for industrial orange juice with significant difference between soft drinks in 6hrs and 42hrs immersion time.

**Table 2:** Multiple pairwise comparisons of surface micro hardness between phases by soft drinks using Bonferroni post-hoc test.

Groups	Time	Mean difference	P value*
Natural Orange Juice	Baseline	6hrs	-2.389
		42hrs	-5.565
	6hrs	42hrs	-3.176
Industrial Orange Juice	Baseline	6hrs	-1.212
		42hrs	-4.448
	6hrs	42hrs	-3.236
Miranda	Baseline	6hrs	-4.599
		42hrs	-9.197
	6hrs	42hrs	-4.598

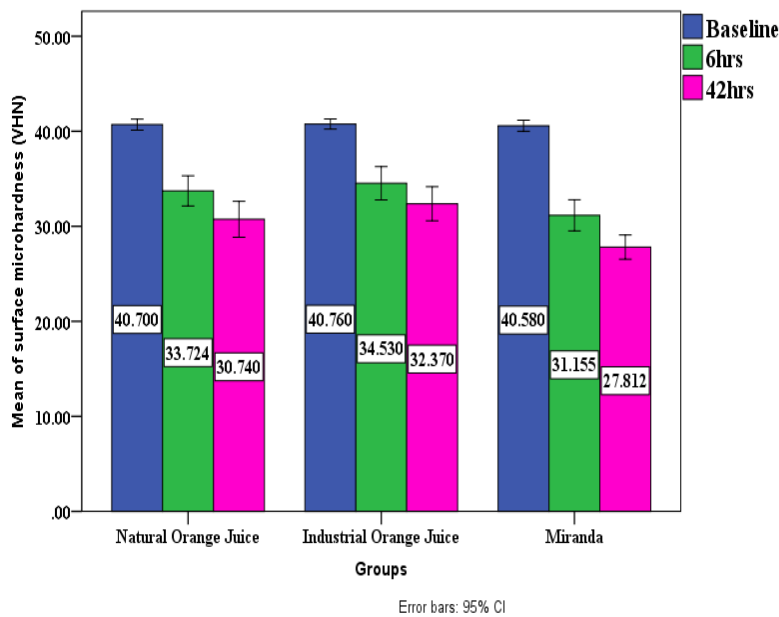
\*=significant at p <0.05

Table (3) shows multiple pairwise comparisons between soft drinks using Bonferroni post hoc test. It revealed a significant difference between each soft drink and other in those immersion times except between natural and industrial orange juices, the results in 6hrs and 42hrs were not statistically significant.

**Table 3:** Multiple pairwise comparisons of surface micro hardness between soft drinks by phases using Bonferoni post hoc test.

Time	Groups	Mean difference	P value
6hrs	Natural Orange Juice vs Industrial Orange Juice	-0.806	0.44541^
	Natural Orange Juice vs Miranda	2.569	0.02020*
	Industrial Orange Juice vs Miranda	3.375	0.00314*
42hrs	Natural Orange Juice vs Industrial Orange Juice	-1.630	0.13172 ^
	Natural Orange Juice vs Miranda	2.928	0.00950*
	Industrial Orange Juice vs Miranda	4.558	0.00018*

\*=significant at p <0.05, ^=not significant at p>0.05



**Figure 4:** Comparisons of surface micro hardness between soft drinks.

### Discussion

Most people consider soft drinks and fruit juice use to be relatively harmless; nonetheless, there is a number of health risks linked with regular soft drink consumption<sup>(1)</sup>. Dentistry's main purpose is to improve a person's quality of life, which can be accomplished by preventing disease, reducing pain, improving mastication, improving speech, and improving aesthetics. The development and selection of a bio-compatible, long-lasting, direct filling esthetic restorative material that serves both preventive and restorative purposes has been the main challenge for dentists and material scientists, as many of these objectives require the replacement/alteration of damaged tooth structure. When selecting materials for repairing erosive lesions, acid resistance is an important property to consider<sup>(18)</sup>.

As the longevity of dental restoration depends on durability of the material and its properties such as hardness and wear resistance so micro hardness test was selected for this study. This was achieved by

Vickers technique<sup>(19)</sup>. This study was designed to simulate the testing period and period of immersion of a previous study carried by Meshki and Hoseini<sup>(15)</sup>.

The predicted null hypothesis was disproved by the findings as the tested material showed significant decrease in micro hardness after immersion in the selected soft drinks. Miranda orange was selected as it is highly acidic, with a pH of roughly 2.85, as described by Hamouda<sup>(20)</sup>. The greatest reduction in the micro hardness of Miranda samples could be explained by the tendency of fillers to fall out from resin material and the decomposition of the matrix components when exposed to low pH environment. In addition, filler degradation would produce cracks at the resin– filler interface, which may lead to weakening of the material<sup>(15)</sup>. The results agree with Hamouda<sup>(20)</sup>. However, this result disagree with Yap et al.<sup>(21)</sup> who claimed that after storage in artificial saliva and citric acid, the hardness of the composite increased. This result was due to the specimen preparation process as the specimens were kept in artificial saliva for 24 hours to allow for elution of unreacted components and post cure.

Although fresh orange juice are rich source of vitamins, minerals and dietary fibers that are important for normal growth and development and overall nutritional well-being, these citrus fruits have erosive property due to the presence of citric, malic, tartaric, benzoic, oxalic and succinic acids<sup>(22)</sup>. In our study, orange juice was chosen due to its ready availability and its acidity is considered to be comparable to that of soft drinks. The decrease in micro hardness of composite samples that immersed in natural orange juice may be explained by two reasons, first, juices contain water and water absorption can cause swelling and reduce the frictional forces between the polymerized chains and softening the resin, thus releasing filler particles from the material surface and reducing surface hardness<sup>(23)(15)</sup>. Second, orange juice contains citric acid which shown to be aggressive resin-based restorative materials. The influence of the acidity increasingly dissolves the matrix, thus promoting the dislodgement filler particles and lowering the load resistance of restorative materials<sup>(19)</sup>. This results agree with Tanthanuch et al.<sup>(24)</sup>, however this results disagree with Yesilyurt et al.<sup>(25)</sup>.

Industrial orange juice was chosen for this study as it is a popular brand with a low pH value<sup>(26)</sup>. Composite samples that immersed in industrial orange juice show a significant decrease in surface micro hardness from baseline period. This reduction could be explained by the acidic pH which causes softening of the matrix and destruction of structural ions. This citric acid can enter the resin matrix and release non-reactive monomers and decrease surface hardness<sup>(27)</sup>. The result agrees with Meshki and Hoseini<sup>(15)</sup>.

The findings of this research reveal that in the two periods (6hrs and 42hrs) there was none significant difference between the effect of natural and industrial juices and this agrees Meshki and Hoseini<sup>(15)</sup> who found that both of these juices decrease the surface micro hardness of composites and there was none significant difference between them. According to the research, the abrasive ability of a beverage depends on pH and acidic composition<sup>(28)</sup> and pH of the juices used in this study are extremely near to one another and their main acidic compound was citric acid; this could be a convincing reason for the result. This result agrees with Erdemir et al.<sup>(29)</sup> who found that sports drinks decrease surface hardness due to their low pH and the presence of acidic compounds and there was none significant difference between the effects of beverages due to the close pH of the beverages.



The limitation of this study is that it is an in vitro investigation with limited number of samples, and it does not fully replicate the condition inside oral cavity such as the effects of saliva or the effect of temperature which can cause alterations in certain properties of composites, such as increased color change and decreased Micro hardness<sup>(30)</sup>.

## Conclusion

Within the constraints of this in-vitro study, it can be concluded that natural, industrial orange juices, and Miranda orange significantly worsen the micro hardness of composite resins. These effects are exacerbated with exposure time, so parents of kids who regularly consume these beverages should take this into consideration.

**Conflict of interest:** None

## Author contributions

RSA; study conception and design, data collection. and Methodology. RSA; statistical analysis and interpretation of results. AIS; original draft manuscript preparation. RSA; Writing - review & editing. Supervision. All authors reviewed the results and approved the final version of the manuscript to be published.

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**العنوان: تقييم تأثير العصائر والمشروبات الطبيعية والصناعية على مركب الترابط التقويمي (دراسة مختبرية)**  
**الباحثون: رسل سعد احمد, الان عيسى سليم**  
**المستخلص:**

التآكل هو حالة شائعة تظهر بسبب استهلاك المواد الغذائية الحمضية ذات السرعات الحرارية العالية ومنخفضة الرقم الهيدروجيني مثل المشروبات الغازية وعصائر الفاكهة التي تسبب أضراراً لا رجعة فيها للأنسجة الصلبة للأسنان وتدهور مبيك لحشوات الأسنان. الهدف: الهدف من هذه الدراسة هو تقييم ومقارنة إمكانية التآكل لعصير فاكهة البرتقال وبرتقال ميراندا على الصلادة الدقيقة لمركب الربط التقويمي. المواد والطرق: في هذه الدراسة التجريبية تم أخذ 30 عينة على شكل قرص بسماك 2 ملم وقطر 10 ملم من مركب الربط التقويمي. بعد ذلك ، تم فصل العينات إلى ثلاث مجموعات (ن = 10) ، وتم تقييم صلابتها الدقيقة بعد الغمر في المشروبات لمدة 6 ساعات (يوم واحد) ولمدة 42 ساعة (7 أيام). تم قياس الصلادة الدقيقة للعينات بواسطة اختبار فيكرز للصلابة الدقيقة في الأساس ، بعد يوم واحد وأسبوع من الغمر. تم قياس البيانات عن طريق اختبار ANOVA للقياس المتكرر واختبار Bonferroni اللاحق. كان مستوى المعنوية عند  $>0.05$ . النتائج: انخفضت الصلادة الدقيقة للمركب المعرض للمشروبات بشكل ملحوظ. الاستنتاجات: يمكن أن تؤثر العصائر الطبيعية والصناعية والميراندا على الصلادة الدقيقة للمركب ، والتي تختلف تبعاً لنوع العصير ووقت الغمر.