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The Effect of Coca Cola Drink on the Impact Strength and Surface Roughness of Acrylic Denture Base

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Abstract

Background: Despite the development of many denture base material like chrome-cobalt, fluid and plastic material but the heat cure polymethylmethacrylate considered as the most widely used denture base material. The aims of this study to evaluate and compare the impact strength and surface roughness of heat cured denture base resin after immersing in coca-cola drink for two and four weeks. **Methods:** A total number of 40 samples were prepared, 30 samples for impact strength test and 10 samples for surface roughness test. The samples were divided into three group; A (control), B (2 weeks immersed in coca cola drink), and C (4 weeks immersed in coca cola drink). **Result:** Data analyzed by using SPSS software with ANOVA test indicated a non significant differences between the different tested groups, however the samples that were immersed in coca cola drink for 4 weeks revealed non dramatic increase in surface roughness, while the samples that were immersed for 2 weeks showed a non dramatic decrease in the impact strength. **Conclusions:** The coca cola drink non significantly caused dropping in the tested properties in comparison to the control group.

Key Words: Impact strength, surface roughness, heat cured resins, coca-cola.

تأثير مشروب الكوكا كولا على قوة الصلابة و خشونة سطح قاعدة الاكريليك

الخلاصة:

الخلفية: على الرغم من تطوير العديد من المواد الأساسية مثل مادة الكروم-كوبالت ، والمواد السائلة والبلاستيكية ، إلا أن مادة polymethylmethacrylate المعالجة الحرارية تعتبر الأكثر استخداماً على نطاق واسع لصنع قاعدة الطقم. وتهدف هذه الدراسة إلى تقييم ومقارنة القوة التصادمية و خشونة السطح لراتنج قاعدة أسنان المعالجة حرارياً بعد غمسها في شراب الكولا كولا لمدة أسبوعين وأربعة أسابيع. الطريقة: تم تحضير عدد إجمالي من 40 عينة ، 30 عينة لاختبار قوة التصادمية و 10 عينات لاختبار خشونة السطح. تم تقسيم العينات إلى ثلاث مجموعات. ١ (السيطرة) ، ب (مغمورة لأسبوعين في مشروب الكولا كولا) ، و ج (مغمورة لاربعة أسابيع في شراب الكولا كولا). النتيجة: أظهرت البيانات التي تم تحليلها باستخدام برنامج SPSS مع اختبار ANOVA إلى وجود اختلافات غير مهمة بين المجموعات المختلفة التي تم اختبارها ، إلا أن العينات التي تم غمرها في مشروب الكوكا كولا لمدة 4 أسابيع كشفت عن زيادة غير مهمة في خشونة السطح ، في حين أن العينات التي تم غمرها لمدة أسبوعين أظهر انخفاض غير مهم في قوة التصادم. الخلاصة: إن مشروب الكوكا يشرب الكولا تؤثر بشكل ملحوظ في الخصائص المختبرة مقارنة بالمجموعة الضابطة.

الكلمات المفتاحية: قوة التصادمية ، خشونة السطح ، راتنج المعالجة الحرارية ، مشروب الكوكا كولا.

1. INTRODUCTION

In 1937 polymethyl methacrylate was introduced by Dr. Walter, Wright¹ and the Vernon brothers. but the material at that time was lacking to good esthetic, mechanical strength and other physical properties, thanks to the chemical properties of the PMMA and its ease of processing that allows huge modifications to take place and changes several properties of this material to reach acceptable esthetics, mechanical and physical properties. [8, 11] Since that time polymethyl methacrylate resin polymers undergo several modifications to improve the construction of denture bases, now a day 95% of all dentures are made from polymethyl methacrylate polymers. [8, 9] The presence of Saliva and Oral fluids and the oral consumption of the individuals have their effect on the denture base and teeth. Variations of PH and temperature of fluids and foods have been considered to change some properties of

the denture base materials . These fluids have a tendency to interfere or weakened the chains which are already formed by means of polymerization. [8]

The phenomena that responsible for the soluble substances leached out during storage in water and in the oral fluids termed solubility. This phenomena cause deleterious changes in the denture base material. These changes may include mechanical and physical changes such as swelling and plasticization consequently and softening, and chemical changes such as oxidation and hydrolysis. [7, 8, 13] The carbonated drinks like Pepsi and coca cola are the most newly produces popular drinks with consumers drinking more than 1.8 billion beverage servings each day . [2] The effect of these various beverages has not been studied in detail in the past. Keeping this as a background this in vitro study is proposed

2. MATERIALS AND METHODS

2.1. PREPARATION OF TEST SAMPLES

For impact strength test thirty samples were prepared, each sample had dimensions of $80 \pm 2 \times 10 \pm 0.2 \times 4 \pm 0.2$ mm (Figure 2.6) according to ISO 179-1: 2010. The specimens were conditioned at least 16 hours at 23 ± 2 °C and 50 ± 5 % relative humidity according to ISO 291:2008 Plastics - Standard atmospheres for conditioning and testing. Figure 1

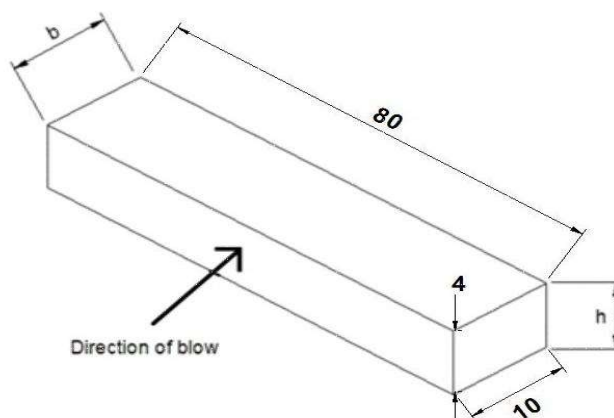


Figure 1: Specimen dimensions for impact strength test

For surface roughness test, ten samples were prepared in total. Each square sample had dimensions of $50 \times 50 \times 3$ mm. The excessive flash was cut using a cutting disk then

tungsten carbide bur was used to bring the samples to the required dimensions. The samples then finished with stone bur until no sharp edges nor irregularities were detected, after that they were polished with 900 grade sand paper for 15 minutes then with 1200 grade sand paper for the same time to get a well polished surface.

After that the samples were polished and placed for 300s in an ultrasonic cleaner that is filled with distilled water to allow removal of impurities that was created during finish and polishing before starting the test.

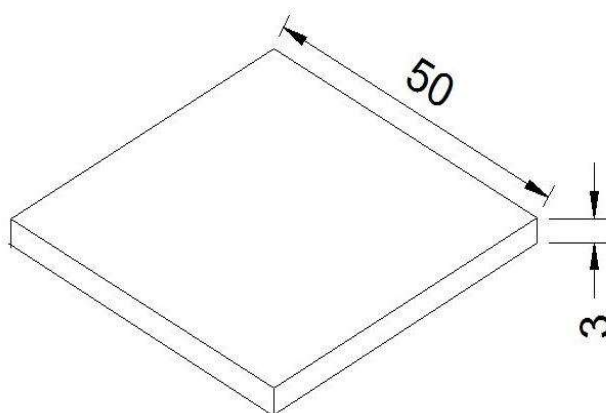


Figure 2: Surface roughness sample

Metal mold with former dimensions were used to make impact strength and surface roughness samples. These molds were flaked in a bronze mold, after that the powder and liquid of acrylic resin were mixed in a ratio of 3:1 by volume according to manufacturer's instructions. Then the mixed PMMA was packed into the molds by compression molding technique with 2 bar/pressure. Samples of resin inside the flasks were placed in a water bath, the temperature of the water was 25 C, the automatic water bath heater turned on until it reached 70 degree centigrade, the flasks remain immersed at that temperature for 45 minutes, after that the heater turned off. Once the water cooled and it's temperature reached 25C the flasks removed and opened and the samples were removed from the flasks.

2.2 Testing procedure

A total number of 30 samples were prepared from heat cured PMMA for impact strength test. And 10 sample from same material for surface roughness test. These impact strength samples were subgrouped in to three groups; group A the control group (10 samples), group B the number of samples were same as group A and were immersed in coca cola drink for two weeks, and the last one group C with same sample quantity as former groups but were immersed in coca cola drink for one month. Regarding surface roughness samples they were first place in distilled water for 24 hours, after that they were tested for surface roughness then the same samples immersed in coca cola drink for two weeks and tested again and replaced in the drink for another two weeks, finally the same samples were removed from the drink and tested lastly for the surface roughness

The samples were immersed in coca-cola drink for the mentioned times and kept in a tight seal plastic jar, the drink was daily replaced to keep it's freshness.

For impact strength test a Charpy type digital impact tester was used to determine the impact strength figure 3. For testing the acrylic samples, a pendulum of one joule was installed on impact tester. Before starting the procedure, a test was performed without the sample to check for air friction. The air friction value was reduced from impact strength value for each sample. The procedure was followed according to ISO 179-1:2010 for the un notched specimen. After that, the sample was fractured and reading was recorded.



Figure 3: Charpy type digital impact tester

The Charpy impact strength of un notched specimens was calculated in KJ/m^2 using the below formula:

$$a_{cu} = \frac{Ec}{h.b} \times 10^3 \text{ (ISO 179-1:2010)}$$

Where:

Ec is the corrected energy, in joules, absorbed by breaking the test specimen;

h is the thickness, in millimeters, of the test specimen;

b is the width, in millimeters, of the test specimen.

For surface roughness test a portable contact profilometer (Qualitest TR-200) (Figure 4) was used to measure arithmetical average (R_a) of the samples, measured in μm . Surface roughness was measured in three different areas in the same direction for each sample then the average was taken to be used for statistical analysis.

The samples for group B and C before testing were conditioned in distilled water for 24 hours to remove any residue of the drink



Figure 4: Portable surface roughness tester

3. RESULTS

The results were analyzed using Statistical Package for Social Sciences (SPSS, version 23). One-way ANOVA with Tukey's Honest Significant Difference (HSD) was performed to determine if there is a statistically significant difference between the two groups when compared to control. . For statistical analysis, significant level $\alpha = 0.05$ was considered.

The results for surface roughness test showed that the specimens immersed in coca-cola drink for different periods did not revealed a statistically significant difference as illustrated in Table 1, however the samples that were immersed in coca cola drink for 4 weeks showed increase in the surface roughness by about 5% as shown in Figure 5.

Table 1: Descriptive statistics and comparisons of each group with control group for surface roughness.

		Mean (Ra)	SD	ANOVA P value
2 weeks	4 weeks	9.963	0.982	0.395
	Control			0.848
4 weeks	2 weeks	10.412	0.861	0.395
	Control			0.300
Control	2 weeks	9.863	1.533	0.848
	4 weeks			0.300

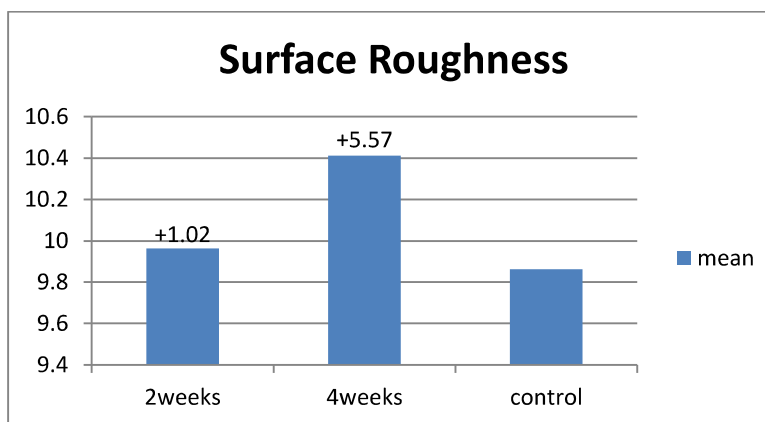


Figure 5: Mean values for Surface roughness

Regarding impact strength test similar to the former test also did not reveal statistically significant difference among the tested groups, however the samples that immersed in the coca cola drink for 4 weeks showed higher value in contra verse to those which immersed for 2 weeks showed the lowest Impact strength Figure 6.

Table 2: Descriptive statistics and comparisons of each group with control group for impact strength

	Mean	SD	ANOVA P value
2 weeks 4 weeks	20.703	5.746	0.574
control			0.873
4 weeks 2 weeks	21.995	6.338	0.574
control			0.688
Control 2 weeks	21.071	3.504	0.873
4 weeks			0.688

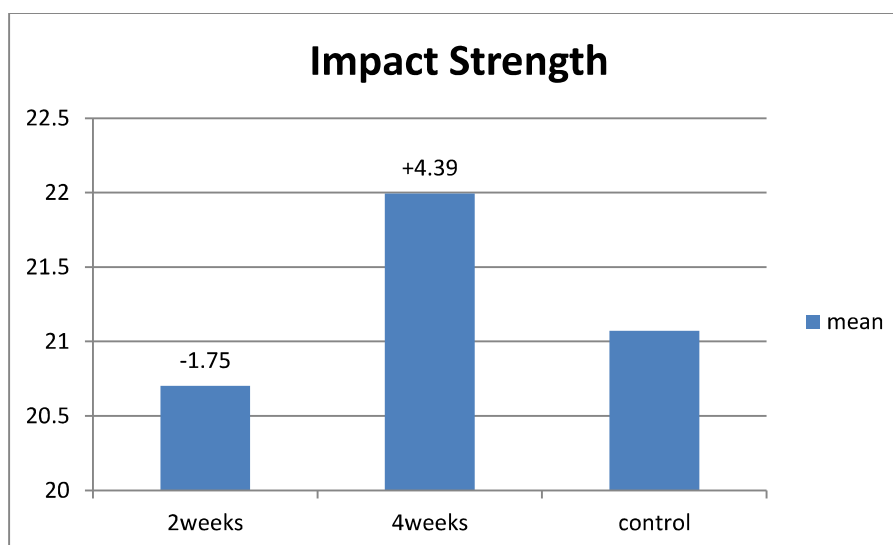


Figure 5: Mean values for Impact strength

4. CONCLUSIONS

When artificial acrylic teeth and denture base are exposed to the oral cavity, they will be in contact with saliva, beverages, and cleaning agents, and such materials are prone to the absorption and adsorption processes to denture base resins. [5, 10,12,15]

It has been shown that certain kinds of foods that are routinely ingested in a human diet can promote surface degradation and changes in other properties of the polymers.[4, 6] However the result showed a nonsignificant difference in the statistical analysis for the tested groups, but there was a slight drop in the impact strength and surface roughness parameters recorded that indicates the influence of carbonated beverage solutions on the denture base resin. The most probably factors is the PH of coca cola which is 2.74 because this drink contains phosphoric acid. [16] The presence of phosphoric acid in the coca cola drink may have to be considered as a causative factor which acts as a plasticizer and causes the changes in the impact strength and surface roughness. [1, 14]

Another possible reason for this drop in the mentioned mechanical properties was may be to the hydrolysis of the bond between molecules by the beverage. The development of stress concentration and entrap of air at the bond interface area weaken the impact strength. This result may be attributed to the acidic nature and basic composition of beverage which cause the hydrolysis of polymethyl methacrylate. [7] The PMMA contain ester group which easily hydrolyze in acidic pH which converts methacrylate to carboxylate and alcohol. The first step in the reaction involves the attachment of oxygen atom of carbonyl group with the proton (acidic hydrogen), in this step, there will be an increase in the electrophilicity of the carbon of the carbonyl group then the attachment of nucleophile (HO) group form carboxylic acid and alcohol. This could be attributed to the decrease in the impact strength.

While the data for the tested properties for group C showed a nonsignificant difference with compare to the group B that immersed in coca-cola for two weeks, this is probably due to that the dissolved surface particles precipitated on the underlying layer and provided more resistance against the acid.

It is known that the composition pH, and polarity of the liquid medium to which the polymers are subjected, as well as the immersion time, are factors that can change its solubility and cause polymer degradation. [4, 6]

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