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# THE EFFECT OF ADDING SOME CHEMICAL MATERIALS ON THE COMPRESSIVE STRENGTH AND SURFACE HARDNESS OF DENTAL STONE

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**ABSTRACT**-*To determine the effect of some chemical materials on the compressive strength and surface hardness of dental stone.* ***Material and Methods:*** *three types of chemical materials (rosin, nigella stavia oil and sodium lauryl sulfate) were incorporated into three kinds of type III dental stone (Zeta, Elite and Dental stone) at four concentrations (0.5%, 1%, 1.5% and 2%).The collected data of compressive strength and surface hardness were subjected to the descriptive analysis (mean and stander deviation), student T test (to evaluate the difference between standard and experimental groups) and one way analysis of variance (ANOVA) (to show if there are significant differences among experimental groups).* ***Results****: revealed that the incorporation of these chemical materials into each type of dental stone resulted in changing their evaluated physical properties; this change varies with the type, concentration of the added chemical material and type of dental stone being used.* ***Conclusion:*** *The highest values of compressive strength and surface hardness were recorded with the addition of rosin into each of Zeta, Dental stone (at a concentration of 1%) and Elite stone (at a concentration of 1.5%). Also the addition of nigella sativa stone oil increases in the compressive strength and surface hardness of Zeta and Dental stone when this materials added at a concentration of 1% and at a concentration of 0.5%when it is added to Elite.*

**Key words:** rosin, negellia stavia oil, sodium lauryl sulfate, compressive strength, surface hardness, gypsum products.

## 1. INTRODUCTION

Successful die materials should have Good strength and hardness to withstand normal laboratory and clinical handling. Recently, many attempts have been made to enhance the properties of gypsum products through the addition of chemical materials [(1-9)]. Schnieder and Taylor (1984)[(10)] found that the addition of gypsum hardener solution produce a significant increase in the compressive strength of dental stone. Where as the addition of a liquid dispersing agent and a microcrystalline additives to type IV dental stone increases the wet compressive strength[(11)]. Breault *et al* (1998)[(12)] suggested that the substitution of 10% of gauging water with 5.25% solution of sodium hypochlorite results in a significant increase in the compressive strength and surface hardness of dental gypsum products . While, Twomey *et al* (2003)[(13)] found that the wet compressive strength of dental stone increases with the addition of 1.5% calcium hypochlorite. Al-Shakhily (1995)[(7)] found that the incorporation of 0.5% chlorhexidine significantly increased the compressive strength of dental stone. Al-Sadi *et al* (1996) and Abdelaziz *et al* (2002a)[(14,15)] reported that the addition of 1% gum arabic and 0.132% calcium hydroxide into dental stone significantly improved the surface hardness without being adversely affecting other surface properties.

This study aimed to evaluate the effect of adding some chemical materials (rosin, nigella stavia oil and sodium lauryl sulfate) on compressive strength and surface hardness as follow:

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1. Testing the change in compressive strength and surface hardness of the dental stone before and after the addition of chemical materials.
2. Comparing the resultant values of compressive strength and surface hardnes of dental stone (after the addition of chemical materials) with that of plaster (negative control) and the properties of die stone (positive control).

## 2. MATERIALS AND METHODS

Three types of dental stone (type III) (Zeta,Seienor,industria zingardi s.r.l.Ligure Italy, Elite, Zhermack SPA-45021.Badia Poesine, Italy and Dental stone, China Meheco co.P.R. China)) were used in this study into which three types of chemical materials were added (rosin(R), nigella stavia oil (NSO) and sodium lauryl sulfate (SLS)). In addition these chemical materials will be added into one type of plaster(Al-Ahliya co. for gypsum industries Lid) as –ve control and into type IV dental stone(Silky rock ,Type IV,Whip-mix Grop.Louisville,U,S,A) as +ve control. The chemical materials were added to the powder of dental stone in four percentages (0.5%, 1%, 1.5%, and 2%)..Mixing procedure employed in the preparation of all the test specimens followed the ADA specification No. 25 for gypsum products (1975)[16]. Each lest was repeated five times and the average value taken as a mean value for that test. Measuring of the compressive strength was done by using Instron testing machine (Soil test, Inc., Evanston.ILL,USA). While surface hardness test was done by using Microhardness yester (Rockwell Hardness tester, Wolpert,Germany).

## 3. RESULT AND DISCUSSION

The mean values for the tested compressive strength give (275, 77.75, 275.75, 231.7, 250 kg/cm²) for the silky rock, plaster, zeta, elite and dental stone respectively. The surface hardness give mean values 107.75, 20, 72, 63, 78 for the silky rock, plaster, zeta, elite and dental stone respectively.

### The Effect of Chemical Additives on the Compressive Strength of Dental Stone:

Incorporation of different chemical materials (rosin, nigella sativa oil and sodium lauryl sulfate) into each of the three types dental stone produced different effects on their compressive strength Table (1).

**Table 1.** The Effect of chemical additive on the Compressive strength of dental stone

| % | Zeta +R | Elite+R | Dental stone+ R | Zeta+NSO | Elite+NSO | Dental stone+ NSO | Zeta+SLS | Eite+SLS | Dental stone+ SLS |
|---|---|---|---|---|---|---|---|---|---|
| 0.5% | 302.7* | 235 | 257 | 275.5 | 286.5* | 250 | 226.88* | 214.2* | 224.5* |
| 1% | 327* | 249.7* | 259* | 285.5* | 252.25* | 252 | 222.25* | 150* | 213* |
| 1.5% | 324.5* | 287* | 254.2 | 259* | 241.5* | 230.5* | 117.25* | 95.75* | 164.7* |
| 2% | 271 | 220* | 229* | 229* | 218* | 229* | 113* | 43* | 156.2* |
| Control | 275.7 | 231.75 | 250 | 275.75 | 231.75 | 250 | 275.75 | 231.75 | 250 |

R: Rosin, NSO: Nigella Sativa Oil, SLS: Sodium Lauryl Sulfate,
*Statistically Significant from control sample at $p<0.05$

The highest compressive strength value was recorded with the addition of rosin to each of the three types of dental stone.

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Statistical comparison between the mean of each of testing groups and that of control by using student T test analysis showed that with the addition of rosin, there is a statistically significant increase in the compressive strength to reach its maximum when rosin added at a concentration of 1% to each of Zeta and Dental stone at ($t= 34.326, 15.588, p<0.05$) respectively. Whereas the maximum significant increase in the compressive strength of Elite stone was achieved when rosin added at a concentration of 1.5% at ($t=32.467, p<0.05$). This increase in the compressive strength of the experimental dental stones was followed by a reduction in the compressive strength when 2% rosin was added

However this reduction was not statistically significant in Zeta stone at ($p<0.05$). While, a significant reduction in the compressive strength has been achieved when rosin added at a concentration of 2% to each of Elite and Dental stone at ($t=8.485, 16.267, p<0.05$) respectively, but it remained within the accepted level of ADA specification No.25 in 1975 (210 Kg/Cm²).

The addition of nigella sativa oil results in a statistically significant increase in the compressive strength of Zeta stone when this material added at a concentration of 1% at ($t=4.565, p<0.05$) and at a concentration of 0.5% when it is added to Elite at ($t=21.372, p<0.05$). Whereas there is a non-statistical significant increase in the compressive strength of Dental stone when nigella sativa oil added at a concentration of 1%. This increase in the compressive strength of dental stones is followed by a reduction in the compressive strength to be statistically significant at ($t=44.9, t=8.32, t=25.7, p<0.05$) when nigella sativa oil added at a concentration of 2% to Zeta, Elite and Dental stone respectively. However, this reduction is not less than the accepted limit of the ADA specification No.25 in 1975 (210 Kg/Cm²).

The addition of sodium lauryl sulfate results in a reduction of compressive strength for each of the three types of dental stone, which was statistically significant at ($p<0.05$). This reduction is directly related to the concentration of the sodium lauryl sulfate being added.

Statistical comparisons revealed that there is a statistical significant difference in the effect of the three chemical additives on the compressive strength of the experimental dental stones at ($f=2628.7, f=4702.8, f=947.36, p<0.05$) respectively.

From Figure (1) we can note that although the addition of rosin and nigella sativa oil increase the compressive strength of the experimental dental stones, but the increase is not large enough to reach the compressive strength of +ve control.

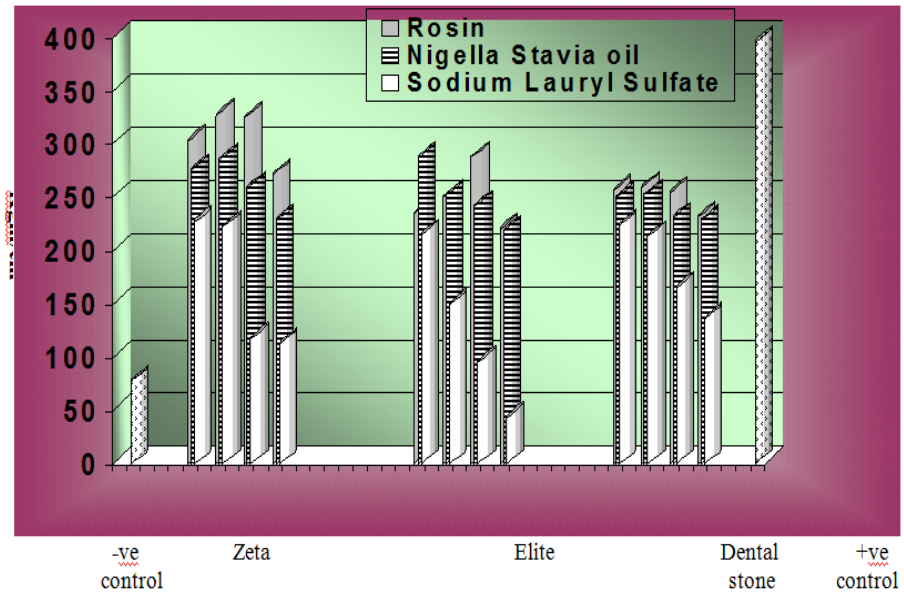


**Figure 1.** The Effect of Chemical Additives on the Compressive Strength of Dental Stones.

While the addition of sodium lauryl sulfate to each of the three types of dental stones decrease their compressive strength. However, it remains more than the compressive strength of –ve control except that when sodium lauryl sulfate added to Elite stone at 2% concentration.

**The Effect of Chemical Additives on the Surface Hardness of Dental Stone:**

The change in the surface hardness as a result of the incorporation of the chemical materials into the experimental dental stones is recorded in terms of the change in the Rockwell hardness number as listed in Table (2). The highest surface hardness is achieved with the addition of rosin to each of the three types of dental stone.

**Table 2.** The Effect of chemical additive on the Surface hardness of Dental Stones.

| % | Zeta +R | Elite+R | Dental stone+ R | Zeta+NSO | Elite+NSO | Dental stone+ NSO | Zeta+SLS | Eite+SLS | Dental stone+ SLS |
|---|---|---|---|---|---|---|---|---|---|
| 0.5% | 89.5* | 67* | 82* | 73 | 68* | 79 | 55* | 57* | 74* |
| 1% | 92* | 68* | 83* | 76* | 64 | 81* | 50* | 40* | 44* |
| 1.5% | 90* | 69* | 79.5 | 65* | 62.5 | 76 | 40.75* | 35.5* | 27* |
| 2% | 68* | 59* | 76* | 60* | 54* | 75* | 35* | 22* | 20.25* |
| control | 72 | 63 | 78 | 72 | 63 | 78 | 72 | 63 | 78 |

R: Rosin, NSO: Nigella Sativa Oil,SLS: Sodium Lauryl Sulfate,
* Statistically Significant from control sample at $p<0.05$

The mean of each of the testing group compared to that of the control using T test analysis. The result shows that the addition of rosin to each of the three types of dental stone result in an increase in the surface hardness; the greatest increase achieved when rosin is added at a concentration of 1% to each of Zeta and Dental stone types at ($t=36.373$, 15.00, $p<0.05$) and at a concentration of 1.5% when it is added to Elite at ($t=3.307$). This is followed by a reduction in the surface hardness to produce a significant reduction in the hardness when rosin is added at a concentration of 2% to Zeta, Elite and Dental stone at ($t=3.806$, $t=12.124$, $t=9.00$, $p<0.05$). The addition of nigella sativa oil to each of the three types of dental stone result in the same effect as rosin.

While, the addition of sodium lauryl sulfate result in a statistically significant reduction of the surface hardness of the three types of dental stone being used at ($p<0.05$) and this reduction is directly proportional to the concentration of sodium lauryl sulfate being used.

One-Way analysis of variance showed that there is a statistically significant difference in the surface hardness of the three types of dental stone when they are blended with each of the chemical additives as compared with that of the control specimens at ($f=1753.5$, $f=759.64$, $f=1949.11$, $p<0.05$) .

On comparing the effect of chemical materials on the surface hardness of experimental dental stones Figure (2), we can note that, despite the increase in the surface hardness associated with the addition of rosin and nigella sativa oil, it not reached the surface hardness of +ve control. While, the addition of sodium lauryl sulfte reduced the surface hardness of the experimental stones but it not less than that of -ve control.

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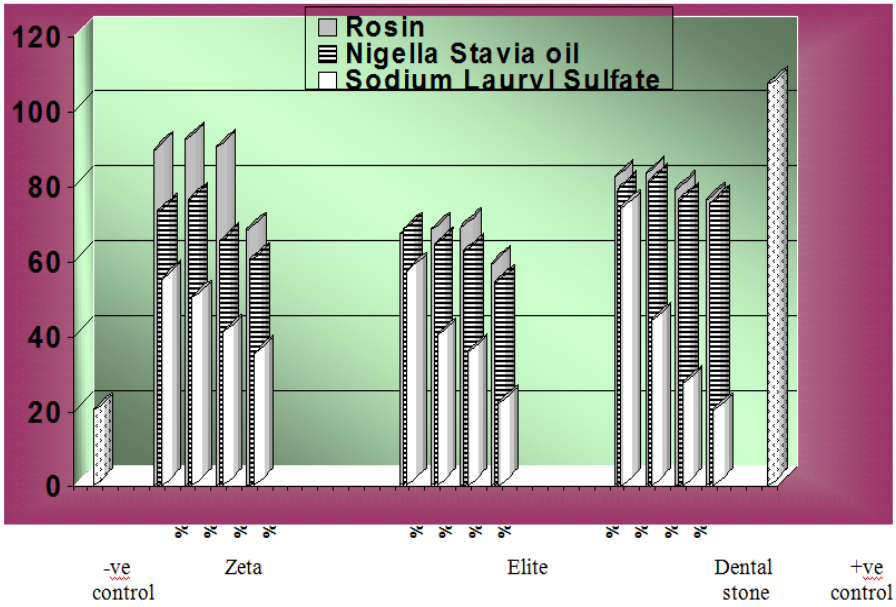


**Figure 2.** The Effect of Chemical Additives on the Surface Hardness of dental stone

## Compressive Strength

According to the results of this study it seems that rosin and nigella stavia oil increase significantly the compressive strength of the experimental dental stones (except that when nigella sativa oil has been added to Dental stone), this increase in the compressive strength may be attributed to the reduction in the water-powder ratio that achieved after the addition of these chemical materials which indicate a denser material, and to the effect of these additives on the chemical structure of the experimental dental stones. El-Tannir and Imam (1969)[17] reported that the basis of physical properties of gypsum is the function of the crystals structure and the crystal rate of formation. However, there is a decrease in compressive strength with increasing the concentration of the added chemical materials (rosin and nigella sativa oil); this may be partially attributed to the action of the added chemical materials as an adulterant and to the reduction in the intercrystalline cohesion [18].

In contrast, to the increase in the compressive strength that is associated with the addition of rosin and nigella sativa oil to the experimental dental stones, a significant reduction in the compressive strength of the experimental dental stones are achieved after the addition of the sodium lauryl sulfate (despite the reduction in the water-powder ratio). It has been reported that the water-powder ratio alone dose not necessarily determine the strength of cast gypsum. So this reduction in the compressive strength could be attributed to the reduction in the intercrystalline cohesion between the crystals or to the change in the chemical composition of these stones after the addition of these chemical materials[19].

## Surface Hardness:

Surface hardness test is very essential factor in evaluating dental stone. It is generally felt that the harder the stone, the better will be the wear resistance and destruction during the fabrication and finishing of the pattern or casting [7]. Several studies have been undertaken to investigate if these properties can be improved by optimizing the set of the cast or by the addition of different kinds of substance into the stone [20 21,7].

In the present study, different types and concentrations of added chemical materials render different results on the surface hardness of the experimental dental stones. Improving the surface

hardness of the experimental dental stones is achieved after the addition of rosin and nigella sativa oil, while the addition of sodium lauryl sulfate resulted in the reduction of the surface hardness.

The effect of chemical additives used in this study on the hardness has been reported to correlate with the effect of these chemicals on the compressive strength. Surface hardness of gypsum products stated to be related to their compressive strength, the higher the compressive strength, the higher being the hardness [(22)]. This is disagreeing with Combe and Smith (1964)[(23)] who reported that there is no clear relation detected between the values of both hardness and compressive strength, since the conditions in the surface layer determine the former.

## 4. CONCLUSIONS

The differences in the examined properties of the dental stone related to the different chemical interactions between the added chemical materials and the calcium sulfate hemihydrate crystals. Incorporating of suitable chemical additives can produce dental stone with superior mechanical properties. The highest values of compressive strength and surface hardness were recorded with the addition of rosin into each of Zeta, Dental stone (at a concentration of 1%) and Elite stone (at a concentration of 1.5%). Also the addition of nigella sativa stone oil increases in the compressive strength and surface hardness of Zeta and Dental stone when this materials added at a concentration of 1% and at a concentration of 0.5%when it is added to Elite.

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