Ann. For. Res. 66(1): 2372-2381, 2023
ISSN: 18448135, 20652445

EFFECT OF ARTIFICIAL SALIVA ON THE MECHANICAL CHARACTERISTICS OF GLASS IONOMER CEMENT ENHANCED WITH ECO-FRIENDLY MATERIAL

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Abstract

Restoration of cervical tooth lesions involving just root cementum, or at the CEJ involving enamel and dentin cavity borders, has been found to be successful using glass ionomer cements. Its ability to stick to tooth structure and release fluoride is their principal benefit, and this has significant cariostatic value for populations with a high prevalence of caries. The limited mechanical resistance of glass ionomer cements prohibits their employment in larger flaws when compared to adhesively retained resin composite materials as alternative therapeutic methods. The goal of this research was to examine the potential of tiny particles of date seeds (DS) to strengthen regular glass ionomer cement. The 3 wt.% powder component of GIC includes ground up date seeds. A sample controlled for the absence of date seed powder was made from ground glass. Mechanical parameters, including as compressive strength (CS), Vickers micro hardness (VH), and impact strength, were evaluated for DS-reinforced glass ionomer cement (IS). Adding 3 wt.% DS reinforcement to GIC considerably increased micro hardness and compressive strength in comparison to the GIC control sample. However, the results showed that the impact strength dropped with increasing DS %, which was caused by the DSP's brittle behavior in the synthetic saliva. The results showed that the mechanical properties of glass ionomer cement in artificial saliva may be improved with the addition of date seeds powder as reinforcement.

Keywords: Compressive Strength, Date Seeds, Eco-friendly material, Glass Ionomer Cement, Impact strength, Micro-hardness.

1. Introduction

Glass ionomer cement (GIC) is a type of water-based material that hardens in 2-10 minutes after mixing to form a putty-like paste via the acid-powder ratio of particular composition where action between a polyalkenoic acid and a fluoroalumino silicate glass to form cements. Since dental silicate cement has been widely utilized in clinical applications since its discovery at the turn of the century, it stands to reason that GIC would eventually emerge as a natural progression (Wilson 1972, Nicholson 1998).

Because of its many benefits, including its direct attachment to tooth structure and base metals, glass ionomer cement (GIC) has become the material of choice (Van 2002, Smith 1999) benefits against tooth decay because of fluoride emission (Wilson and Nicholson 1993) minimizes micro leakage at the tooth-enamel interface as a result of minimal shrinkage, is thermally compatible with enamel and dentin, and exhibits biological compatibility and low cytotoxicity (Davidson 1999, Mount 1994). (McLean 1994, Culbertson 2006).

GIC, on the other hand, are brittle and have poor mechanical qualities such low fracture toughness, fracture strength, and wear resistance. Because of these drawbacks, its application as a dental filling is restricted to certain situations (Lohbauer 2009). Many studies attempted to improve its mechanical properties by tailoring a variety of its physical characteristics. Forcing-phase components such metal particles, fibers, and ceramics were the primary focus of this area of study. To ensure the mechanical qualities, several researchers have worked on their creation using various strategies or methodologies. The most well-known of these approaches is the incorporation of metals, ceramics, and polymers, or at least certain components or compounds thereof (Rahman 2014, Sari 2014). Montmorillonite clay, zirconia, glass fibers, hydroxyapatite (HA), bioactive glass particles, and casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) are among the materials used in these endeavors to create additional micro particles (Moshaverinia 2011).

According to research (Abdallah 2016), adding 1, 2, or 5% (w/w) myrrh to glass ionomer cement significantly degrades the mechanical qualities of the cement. The effect of basalt fibers on the mechanical characteristics of commercial GICs was studied (Bao X. 2019). Basalt fibers were shown to greatly improve the GIC's mechanical properties, with the best results being achieved at a mass fraction of 7 wt. % and a fiber diameter of 2 mm.

Reinforcing particles made from date seeds (DS) have been employed in polymer composites with good results. Date seeds added to HDPE have been the subject of multiple research efforts (HDPE). Polyethylene polymers have also used date seed nanoparticles as fillers. The use of organic date seed nanoparticles (DSN) as fillers in a polymer matrix material (PET) was studied to create better polymer Nano composites. The investigations showed that the mechanical characteristics of the polymer composite reinforced with date seeds particles were significantly improved (Elkhouly 2021). Despite these advantages, there has been no research conducted or papers written about the use of date seeds to enhance GICs. The objective of this research was to determine how the mechanical properties of artificial saliva (compressive strength [CS], micro-hardness [MH], and impact strength [IS]) were affected by adding 3 wt.% of date seed powder micro particles size to conventional glass ionomer cement.

2. Materials and Methods

2.1. Materials and Samples Preparation

The seeds were cleaned with pure water and dried for a full day in the air. The seeds were dried in an oven at 70 degrees Celsius for 24 hours to remove any remaining moisture. After that, a high-speed multi-functional crusher (rotating speed 22000 r/min) was used to crush and mill the seeds for 5 hours. The DS-reinforced GIC were produced using DS weight fractions of 0 and 3 wt. % by replacement from GIC powder. The die was made from (Silicon).

A conventional glass-ionomer powder from (Shanghai Rongxiang Dental Material Company Ltd, China) with a particle size of about >500 μm was blended with different proportions of date seeds powders, Figure 1 shows Conventional GIC and date seeds powder.

Ann. For. Res. 66(1): 2372-2381, 2023
ISSN: 18448135, 20652445

Powders were produced by manually combining the date seeds powder in concentrations of 3 (wt. /wt.) with the glassy ionomer powder for a period of ten minutes. All experiments were conducted alongside a control group using unmixed powder. The powder to liquid (P/L) ratio for the glassy ionomer cement utilized in each one of the prepared samples was 20 grams per 15 liters by weight; the samples were preserved in deionized water and artificial saliva according to the formulation given by (J. Klimek 1982), for one day, seven days and one month, Table 1 shows the composition of artificial saliva.

Figure1. Conventional GIC and date seeds powder

Table1. Composition of artificial saliva

The composition	Concentration (g/l)
KCl	1.27
NaCl	0.58
KH_2PO_4	0.33
Na_2HPO_4	0.34
CaCl	0.17
NaSCN	0.16
NH_4C1	0.16
urea	0.2
glucose	0.03
mucin	2.7
ascorbic acid	0.002

The artificial saliva renewed every day. Artificial saliva and immersed samples are shown in figure 2.

Figure2. Artificial saliva and immersed samples

2.2. Mechanical Properties Measurements

2.2.1. Hardness

For examining the GIC material's durability with and without the DS reinforcement, 6 disk-shaped samples were created using a silicon mold with interior dimensions of diameter (20 mm) and (5 mm) thickness. These samples were then stored in artificial saliva for 24 hours. Utilizing a micro-indentation device (Micro Hardness Tester, HVS-1000, LARYEE TECHNOLOGY CO., LTD), the Vickers hardness numbers (VHN) were determined, through the application of a force of 0.245 N to the specimens for a period of ten seconds. After the load is removed, a microscope is used to measure the lengths of the two diagonals left by the indenter on the surface of the material. This allows the average diagonal to be determined. Figure 3 illustrated the hardness device.

Figure3. Hardness test device

2.2.2. Compression Strength

Compression strength is an important design factor in the manufacture of the materials, where failure can occur as a result of weakness in the durability.it is described as the ultimate strength, which a rigid substance can resist under a vertical pressure, thus its unit is N/mm^2. This test is considered to be distractive, where the load is applied usually by a hydraulic power. In this study, compression test has been conducted using the hydraulic press universal tester (Top-load/Crush) shown in figure 4. The universal testing machine was used to measure the samples' compressive strength (Cs) (Mpa) at 0.5 mm/min cross - head speed. The universal testing machine was used to measure the specimens' compressive strength (Cs), which was determined using the equation below:

$$CS = \frac{4F}{\pi d^2} \quad (1)$$

Where CS is the compressive strength in (Mpa), F is the load at fracture in (N), and d is the diameter of the sample in (mm).

Figure4. Compression test device

2.2.3. Impact Strength

The Charpy impact analysis and the Izod impact test are commonly utilized to evaluate a material's resistance to impact. The Charpy and Izod tests utilize more energy than is needed to break a sample that is being evaluated. These tests use devices that have a framework similar to a pendulum. This technique can be used for high-altitude weight drops. The Charpy impact test equipment, which was designed by an American company (Testing Machine INC, AMITYVILE, New York), was employed throughout this experiment to assess the impact strength. Figure 5 illustrate an impact device that may shatter samples using a variety of hammers, each of which has a unique energy level and size (for example, 2, 5, 30, or 45 Joules).

The impact strength (IS) was expressed as the absorbed energy per sample cross-section upon fracture and calculated using the Equation below:

$$\mathrm{IS} = \frac{\mathrm{E}}{\mathrm{wh}} \quad (2)$$

Where E is the power required for breaking the test sample (J), and A is the area of the sample (mm^2). Scanning electron microscopy was used to characterize the effect of DS on the GIC structure.

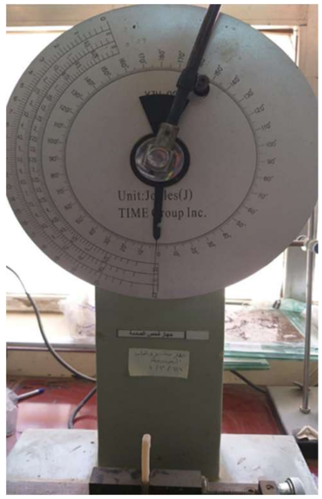

Figure5. Impact test device

3. Results and Discussions

3.1. Hardness Test

Each sample's Vickers Micro Hardness value is displayed in Figure 6 below. After 24 hours in the artificial saliva solution, there is a little shift, as depicted in Figure 6, when DSP is added to GIC. It didn't matter which DSP was utilized, but the GIC-DSP had higher micro hardness measurements on the surface than the GIC control sample. Hardness was measured by indentation and found to be somewhat lower for the GIC-DSP sample at 3 wt.% of DSP compared to the GIC control sample. This could be because the cement itself was weaker, making it less resistant to indentation. This is in agreement with the theory that surface hardness can be increased by incorporating DSP micro particles into GIC (Elkhouly 2020). Because this micro particle has likely been chemically damaged by the acid and is capable of interacting in an acid-basic reaction to participate in the GIC setting, a higher percentage of DSP may harden the bulk of the cement. Moreover, the cement bulk's hardening improves the material's hardness by increasing its resistance to indentation.

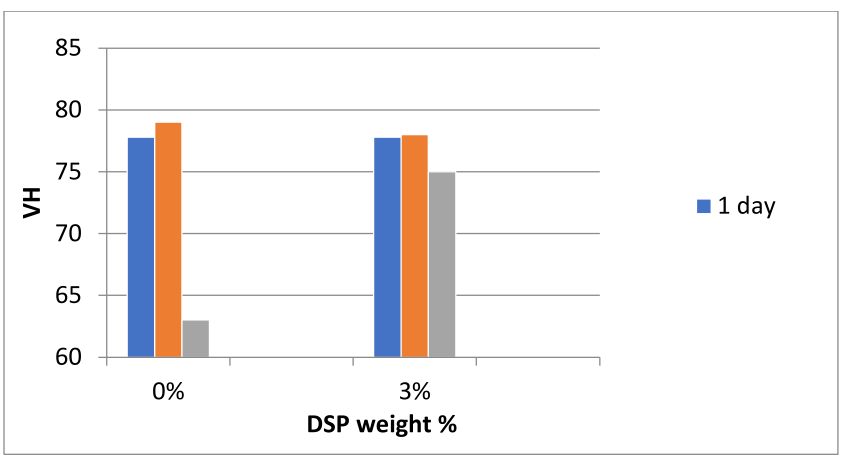

Figure6. Hardness of GIC samples with different percentage of DSP after (1, 7 and 30 days) in artificial saliva solution.

3.2. Compressive Strength

Compressive strength is a common metric used to evaluate a material's resilience to squeezing or squeezing pressures. Figure 7 displays the compressive strength results of the tested GIC and GIC-DSP with 3 percentages of DSP. Figure 7 displays the dramatic increase in compressive strength between the GIC-DS micro-particles and the GIC control sample. One possible explanation for this distinction is the higher percentage of DSP micro-particles, or date seeds powder, that was combined alongside the glass powder to create the GIC substance. Furthermore, the inclusion of these DSP micro-particles aids in the improvement of the GIC material by filling in the spaces between the GIC glass particles and providing additional bonding sites for the polyacrylic polymer (Abdallah 2016). This is because cross-linked DSP is more robust and durable than cement made from glass ionomers by acid-base reactions alone.
Restoration materials with a high fluoride release typically have subpar mechanical properties. Hence, it may not be as suitable as a material with a lower fluoride release, especially in load-bearing places (Xu and J. O. Burgess 2003). Although the glassy ionomer produces a large number of ions at first, this quantity rapidly decreases by day two and levels off by day seven. Similar to what happens during the preparation reaction (Paschoal 2011, Gandolfi 2006) when fluoride is liberated from glass particles upon reaction with a polyalkenoate acid (Wiegand 2007). This means Figure 7 demonstrates that the DSP micro-particles' ability to block fluoride release and boost compressive strength leads to much higher values for GIC-DSP than for the GIC control sample.

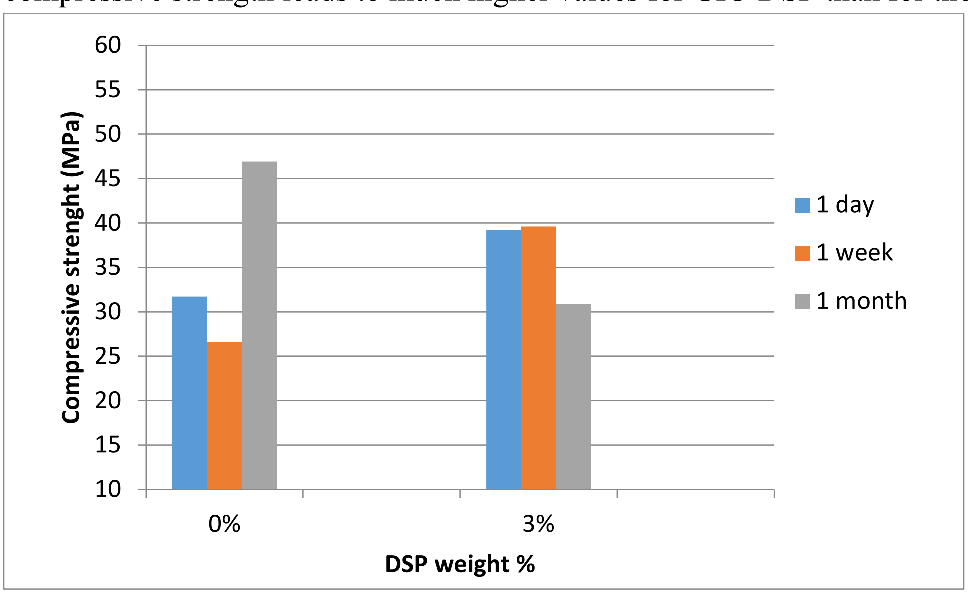

Figure7. Compression Strength of GIC with various percentage of DSP during immersion in artificial saliva for (1, 7 and 30 days).

3.3. Impact Strength

Figure 8 shows the values of sample impact strengths. After being submerged in fake saliva for 24 hours, the impact strength of the GIC-DSP samples did not change from that of the GIC control sample. And since the additive works as impurities in regular GIC, it has been shown that the impact strength values of GIC-DSP decrease when added to GIC.

Although Impact Strength may represent the mechanical energy required to fracture a repair, it is not considered an intrinsic attribute because it is impacted by test parameters and sample geometry (Zappini 2003). Yet, this investigation's results are consistent with those of a prior study (Thomaidis 2013).

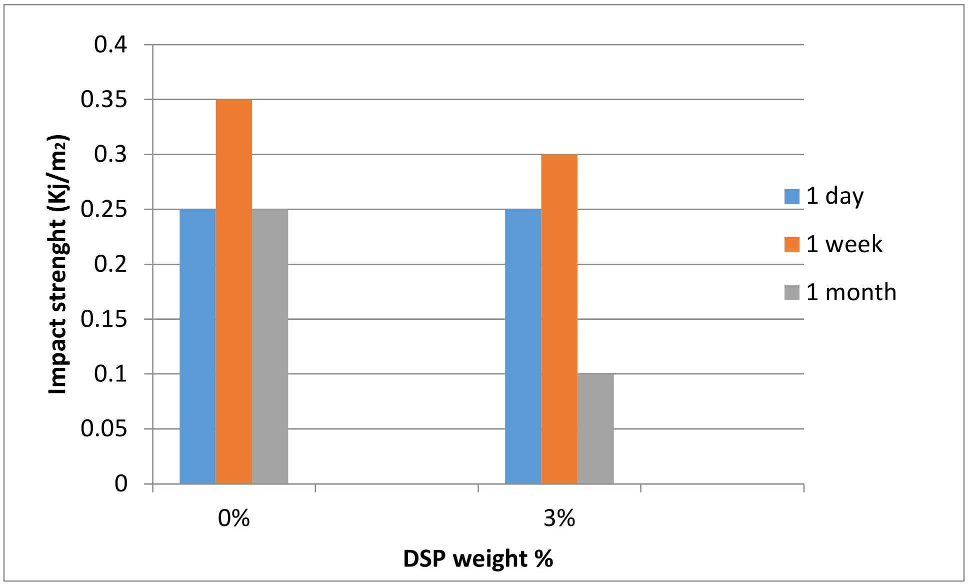

Figure8. Impact strength of the various DSP reinforcement GIC

4. Conclusion

Using date seed powder micro particles as reinforcement materials, this research looked into how adding dates could improve the strength of Glass Ionomer Cement. The micro particle powder from date seeds was added to glass ionomer cement at a weight percentage of 3. Principal findings could be outlined. The inclusion of DSP micro particles improves the GIC's mechanical properties, including as its compressive strength and hardness, albeit this effect is attenuated at 3%. After being submerged in saliva for a week, the GIC-DSP sample with a DSP weight percent of 3 wt.% exhibited greater compressive strength. In addition, the hardness of the GIC-DSP samples was enhanced in comparison to the GIC control sample. In addition, the brittle behavior of DSP in the artificial saliva resulted in a drop in the impact strength values of the GIC-DSP after it was added at a weight percentage of 3%.

Abbreviations

DS	Date Seeds
GIC	Glass Ionomer Cement

ACKNOWLEDGMENT

The authors would like to thank the Department of Materials Engineering – College of Engineering, Mustansiryiah University for supporting this work.

Conflict of interest

There are no conflicts of interest regarding the publication of this manuscript.

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