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Impact of some mechanical properties of Room Temperature Maxillofacial Silicone after addition of pomegranate peel powder

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Abstract :

Background : Maxillofacial prosthetic materials must possess optimal physical, esthetic, and biological properties that remain stable over time to ensure patient acceptance and long-term clinical success. Silicone elastomers are the most commonly used materials due to their favourable characteristics; however, their performance remains limited by environmental degradation, particularly from ultraviolet radiation and thermal effects, leading to mechanical deterioration and color instability. Over time, various materials and technologies—including silicone copolymers, polyurethane elastomers, and more recently, three-dimensional (3D) printing with CAD integration—have been explored to enhance the durability, customisation, and esthetic outcomes of facial prostheses.

Aim of the Study : This study aimed to evaluate the effect of incorporating different weight percentages of pomegranate peel powder on the surface hardness of VST-50 room temperature vulcanised (RTV) maxillofacial silicone.

Keywords:

(RTV silicone, maxillofacial prosthetics, pomegranate peel powder, Shore A hardness, natural fillers)

Methodology: Pomegranate peel powder was incorporated into VST-50 RTV maxillofacial silicone at concentrations of 1% and 2% by weight. The Shore A hardness of the prepared samples was measured in accordance with ISO 7619-1:2010 standards. The obtained data were analyzed using both descriptive and inferential statistical methods. A one-way analysis of variance (ANOVA) was performed to determine the significance of differences among the tested groups.

Results: The results demonstrated that the incorporation of pomegranate peel powder increased the hardness of the silicone material. The 2% concentration group exhibited higher Shore A hardness values compared to the 1% group and the control group.

Conclusions: The addition of pomegranate peel powder at concentrations of 1% and 2% by weight improved the mechanical properties, specifically the surface hardness, of VST-50 RTV maxillofacial silicone. This suggests that natural fillers such as pomegranate peel powder may serve as effective reinforcing agents in maxillofacial prosthetic materials.

INTRODUCTION

Facial appearance plays a fundamental role in human interaction, as the face is the primary point of communication with the external environment. In modern society, an acceptable facial appearance has become increasingly important for social integration, employment opportunities, media presence, and personal relationships (1). Consequently, maxillofacial defects—whether congenital, traumatic, or pathological—can have profound psychological and functional impacts on affected individuals. This has led to a growing emphasis on maxillofacial prosthetic rehabilitation as a means to restore both esthetics and function.Among the various materials used in maxillofacial prosthetics, silicone elastomers have emerged as the most widely accepted due to their favorable properties. These include excellent biocompatibility, flexibility, chemical stability, and the ability to closely simulate the texture and appearance of human skin. Despite these advantages, silicone-based materials are not without limitations. One of the major concerns is their susceptibility to environmental degradation, particularly when exposed to ultraviolet (UV) radiation and fluctuating thermal conditions. Such exposure can result in discoloration, loss of elasticity, and deterioration of mechanical properties over time, ultimately affecting the longevity and performance of the prosthesis (2).The mechanical properties of silicone elastomers are influenced by several key factors, including the degree of cross-linking within the polymer network, the molecular weight of the polymer chains, and the incorporation of fillers or additives. Among these, the use of reinforcing fillers has gained considerable attention as an effective strategy to enhance the physical and mechanical performance of silicone materials. Fillers can improve properties such as hardness, tensile strength, tear resistance, and overall durability, making them crucial in optimizing the

clinical performance of maxillofacial prostheses (3).In recent years, there has been an increasing interest in the use of natural, eco-friendly fillers as alternatives to synthetic additives. Agricultural byproducts, in particular, offer a sustainable and cost-effective source of functional materials. Pomegranate (Punica granatum) peel is one such byproduct that has attracted scientific interest due to its rich composition of bioactive compounds, including polyphenols, flavonoids, and antioxidants. These compounds are known for their ability to combat oxidative stress, which plays a significant role in material degradation and biological tissue damage.In addition to their antioxidant properties, pomegranate peels have been reported to exhibit beneficial biological effects, such as reducing hyperpigmentation by inhibiting melanin production and providing protective effects against skin damage. Furthermore, preliminary studies and animal-based research suggest that pomegranate peel extracts may contribute to bone health by reducing bone resorption and promoting new bone formation (3). These multifunctional characteristics highlight the potential of pomegranate peel powder as a novel reinforcing agent in biomaterial applications.Based on these considerations, the incorporation of pomegranate peel powder into silicone elastomers may not only enhance mechanical properties but also improve resistance to environmental degradation. However, limited studies have investigated its effect on the physical properties of maxillofacial silicone materials.Therefore, the aim of the present study was to evaluate the effect of different weight percentages (0%, 1%, and 2%) of pomegranate peel powder on the Shore A hardness of VST-50 room temperature vulcanized (RTV) maxillofacial silicone. Understanding this relationship may contribute to the development of improved maxillofacial prosthetic materials with enhanced performance and durability.

MATERIALS AND METHODS

The materials utilized in this investigation are listed in (Table1).

Table 1: The study materials

Material	Manufacturer	Patch number
VST-50 Room temperature maxillofacial silicone elastomer	Factor II Inc., USA	F 15U138R06
Pomegranate peel powder	Local market	N/A

Table 1: The Study Materials

Material	Manufacturer	Patch Number
VST-50 Room temperature maxillofacial silicone elastomer	Factor II Inc., USA	F 15U138R06
Pomegranate peel powder 	Collected and prepared in the laboratory	Not applicable (N/A)

Figure1:The study materials.

A single main group was prepared for the Shore A hardness test and was further divided into three subgroups (n = 10 for each subgroup): a control group (0% pomegranate peel powder) and two experimental groups containing 1% and 2% pomegranate peel powder by weight. Plastic molds were fabricated using a CNC machine, with the base, frame, and cover sections designed to have identical dimensions.According to the manufacturer's

instructions, the VST-50 room temperature vulcanized (RTV) maxillofacial silicone used in this study is a two-component system with a base-to-catalyst mixing ratio of 10:1. For the control group, the base material was first placed into a container on an electronic balance, followed by the addition of the catalyst. The mixture was then subjected to vacuum mixing at 140 ± 10 rpm under a pressure of −0.095 MPa (28 inch Hg).For the reinforced groups, the pomegranate peel powder was initially weighed and placed into the container, followed by the addition of the silicone base. The mixture was vacuum mixed for five minutes before adding the catalyst, after which vacuum mixing was continued for an additional five minutes to ensure homogeneity (4).The silicone mixture was then poured into the Shore A hardness molds, and the mold components were securely assembled using G-clamps. After allowing complete vulcanization for 24 hours, the mechanical properties of the RTV silicone were evaluated in accordance with ASTM D2240-05 (5). The hardness test was conducted using a digital Shore A durometer on specimens with dimensions of 25 mm × 25 mm × 6 mm.

RESULTS

The shore's statistical results Using the one-way ANOVA test, a hardness test revealed a significant increase in the 1% and 2% groups, with P values less than 0.05 (Tables 2).

Table 2: Statistical test of Shore A hardness (IU)

Groups	Minimum	Maximum	Mean	±SD	F	P value
0% Pomegranate peel powder	30.000	34.400	32.200	1.419	5.701	0.118
1% Pomegranate peel powder	31.900	36.000	33.380	1.452		**0.007**
2% Pomegranate peel powder	32.800	36.000	34.120	0.902		0.413

DISCUSSION

Pomegranate peel powder was included because it offered several benefits over other filler types, and many earlier studies had shown that fillers improved the mechanical characteristics of maxillofacial silicone[3].

Pomegranate peel powder acts as a filler that increases crosslink density within silicone, which may be the cause of the increase in hardness values after the addition of 1wt% and 2wt% of the powder. Its uniform dispersion within the elastomeric matrix strengthens the structure, leading to higher hardness values. By strengthening the material's resistance to penetration and indentation, this process can make it more resilient [6].

Intermolecular and interatomic forces determine a substance's flexibility. As these forces rise, the modulus of elasticity rises as well, increasing the hardness of the material [7]. Consequently, increasing the filler percentages causes the fillers to absorb more energy, which raises interatomic tensions and improves hardness [8].

CONCLUSIONS

Several mechanical properties of VST-50 RTV maxillofacial silicone were enhanced by the addition of 1% and 2% pomegranate peel powder.

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