Material Density of Composite hydroxyapatite Bovine Bone-Borosilicate formed by Compaction and Sintering Techniques

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Abstract. Hydroxyapatite Ca10 (PO4) 6 (OH) 2 is a calcium compound whose chemical composition is similar to human bone minerals. In this study, hydroxyapatite was formed into a composite material by adding borosilicate (borax and silica). For the formation of this composite material, the Hydroxyapatite borosilicate composition has been adjusted, namely: 90:10, 85:15, 80:20, 75:25, 70:30 wt.%. The samples were made with different compacting forces, namely 5 KN, 15 KN, and 25 KN with a sintering temperature of 800 °C. The lowest density value is found in the composition 75:25 wt.%, The compacting force is 5 KN with a value of 0.002436 gr / mm3. The decrease in the density value is influenced by the composition and compaction force applied. The greater the borosilicate composition, the lower the density. Meanwhile, the greater the compacting force applied, the density will increase.

1. Introduction
Bone is an active tissue that is metabolically undergoing continuous growth by two processes, namely bone formation (formation) and absorption (resorption). This process depends on the activity of osteoclasts, osteoblasts, and osteophytes [1]. The need for reconstructive of bone is continuously increasing. Now, over 500,000 bone graft procedures are performed annually. The estimated cost of these procedures approaches US$ 2.5 billion per year. Therefore, there is still a constant need to search for material implant for tissue engineering [2]. To replace and repair bone, a material similar to human bone is needed. Human bones contain a compound called hydroxyapatite. One source of the hydroxyapatite material is beef bone [3]. Hydroxyapatite (HA) has the molecular formula Ca10(PO4)6(OH)2 is included in the calcium phosphate compound family. Hydroxyapatite is used because of its excellent biocompatibility with hard tissues [4]. Hydroxyapatite bio ceramics are successfully used as material implants as they are chemically similar with the inorganic constituent of biological hard tissue. HAP is also a potential implant material due to its excellent osteon conductive properties [5]. The biocompatibility of hydroxyapatite to the mineral of the bone has made hydroxyapatite a potential in material implant. Application of hydroxyapatite in
critical bone defects has further evolved in tissue engineering with the using cell, scaffold and various growth molecules [6]. Utilizing human bones, hydroxyapatite compounds need to be formed into a composite by adding other elements, by compaction and sintering processes [3]. This sintering will result in changes in the microstructure, including an increase in density values, grain growth, and shrinkage of composite mass [7]. The sintering temperature will improve the bonds present in the material and its density. This effect can be seen on the microstructure and mechanical properties indicated by the grain size, hardness and modulus which will increase with the higher temperature [8]. Density is the value of bone density. Bone density will be affected by the composition, compacting and sintering temperature during manufacture. This factor affects bone density. Bone density ultimately affects bone strength. Bone that has high density will experience fewer fractures and vice versa [9].

This study will examine the density value of the hydroxyapatite-borosilicate composite as a candidate for implant material.

2. Methodology

This research was conducted by mixing the bovine bone hydroxyapatite material with borosilicate material as a composite constituent. The mixing process is carried out using ball milling with the number of balls of 25 pieces with a ball diameter of 10 mm with a rotating speed of 200 rpm for 60 minutes. The mixed bovine-borosilicate hydroxyapatite powder was formed according to the composition by being compacted with a compressive force of 5 KN, 15 KN and 25 KN. In order for the fusion process to occur and the emergence of a mechanical bond in the composite, the sintering process was carried out at a temperature of 800°C for 3 hours.

3. Result and Discussion

After measuring the density, the density value of Hydroxyapatite-Borosilicate was obtained with a compaction force of 5 KN, 15 KN and 25 KN with a temperature of 800 °C.

![Figure 1. Effect of composition on density values](image)

Figure 1 shows the relationship between composition and density values, starting from the composition of 90:10% wt. with a density value of 0.003732 gr/mm3, then decreasing the density value until the composition of 75 :25 wt.% 0.002436 gr/mm3. The decrease in density in influenced by the density size of each powder. From the material data, it is known that hydroxyapatite powder has a greater density than borosilicate powder. So that the mixing of hydroxyapatite with borosilicate which is done by ball milling process causes changes in density. The more borosilicate compositions were shown to reduce the density of the hydroxyapatite-borosilicate composites.
Effect of composition on density values

4. Conclusion
The highest density value is found in the compacting force of 25 KN with a composition of 90:10 Wt.% With a density value of 0.003732 gr/mm³. While the lowest density value is found in the 5 KN compacting force with a composition of 75:25 wt. % of 0.002436 gr/mm³

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