CHAPTER V

CONCLUSION AND SUGGESTION

5.1 Conclusion

1. The synthesis of hydroxyapatite from chicken and duck eggshells was successfully carried out through calcination and sintering processes. The main component of both chicken and duck eggshells is calcium carbonate ($CaCO_3$), with a content of approximately 95%, which is subsequently converted into calcium oxide (CaO) through a heating process and further transformed into hydroxyapatite. XRD analysis shows that the formation of hydroxyapatite is indicated by the appearance of characteristic diffraction peaks corresponding to specific crystal planes, while FTIR analysis confirms the formation of the main functional groups of hydroxyapatite, namely phosphate (PO_4^{3-}) and hydroxyl (OH^-). These results indicate that both chicken and duck eggshells have similar potential as calcium sources for hydroxyapatite synthesis.
2. Variations in calcination and sintering temperatures significantly influence the purity and morphology of the formed hydroxyapatite. At a lower temperature of 800°C, the decomposition of $CaCO_3$ into CaO during the second calcination stage was incomplete, resulting in the presence of a secondary phase, whitlockite, which indicates low crystallinity and an unorganized crystal structure. As the temperature increased to 900 °C and 1000°C, crystallinity improved, as indicated by sharper and more intense XRD peaks, leading to the formation of a single-phase hydroxyapatite with up to 100% purity. These results are supported by FTIR analysis, which shows sharper phosphate absorption bands and a reduction of carbonate-related peaks at higher temperatures. Furthemore, the SEM results indicate that at higher temperatures, the particle morphology becomes more homogeneous, denser, and more uniformly distributed, with the highest frequency occurring within the smaller size range of 0-500 nm and an average number particle of approximately 254,619 nm. This suggest that increasing temperature plays a significant role in the decomposition process as well as in densification during crystal growth.
3. Based on hardness testing using the Shore A durometer, the physical and mechanical properties of hydroxyapatite combined with PVA are influenced

by temperature variations. The highest hardness value was observed in the chicken eggshell sample treated at 1000–800°C, with a value of 4.715 MPa, while the lowest value was obtained from the duck eggshell sample at 900–1000°C, with a value of 3.095 MPa. These results indicate that hydroxyapatite–PVA composites exhibit mechanical properties comparable to the range of natural bone strength. The addition of PVA acts as a binding matrix that improves structural homogeneity and enhances stress distribution within the material. Furthermore, XRD results of pellets before and after furnace treatment show that heating improves crystallinity, as indicated by peak sharpening and increased crystallite size, which directly contributes to improved mechanical properties.

5.2 Suggestion

1. It is recommended to investigate different combinations of calcination temperatures, including low-to-high and high-to-low temperature sequences, to obtain optimal hydroxyapatite purity.
2. The use of dopants should be further developed by exploring alternative polymers other than PVA to enhance material properties.
3. The compaction parameters during pellet formation should be further investigated, as material density significantly influences porosity, which in turn results in suboptimal hardness test outcomes.
4. A calcination temperature of 800°C can still be utilized with optimized process control to produce high-quality hydroxyapatite.