Story of Young Innovators in Health Sciences

Synthesis of Hydroxyapatite Bio ceramic Varieties Using Eppawala High Grade Rock Phosphate for Biomedical Applications

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Overview of the research or innovation: Sri Lankan rock phosphate deposit situated at Eppawala within North Central Province, is the kind of non-renewable natural resource which contains nearly 34-40% P_2O_5. The International Fertilizer Development Corporation has stated that cadmium and arsenic contained generally in phosphate are present in insignificant levels in this deposit (cadmium composition at 0.0005%), which isn't in a harmful condition to humans. Currently, this natural resource is used mainly as a raw material for the fertilizer industry while there are so many ways to manufacture phosphorus products sustainably. Therefore, it is important to consider inventing and commercializing novel phosphorous findings from the Eppawala rock phosphate deposit. As a result, this study describes innovation of different varieties of hydroxyapatite bio ceramics as value addition to Eppawala High Grade Rock Phosphate.

Hydroxyapatite (HAp) bio ceramic has a close chemical and structural similarity to mammalian hard tissues. It has a hexagonal crystal structure and chemical formula that can be written as $Ca_{10}(PO_4)_6(OH)_2$ with a Ca/P ratio of 1.67. As a bio ceramic, hydroxyapatite can be applied into a variety of orthopedics and dentistry applications such as bone and dental implants, implant coatings for metallic implants, bone tissue engineering, bone void fillers, maxillofacial and dental surgeries, restoration of periodontal defects, edentulous ridge augmentation, endodontic treatments, post teeth bleaching, and toothpaste considering its biomaterial properties.
A recent study converted Eppawala chloroapatite directly into hydroxyapatite using solid state sintering methods, sol gel alcoholic, and acidified techniques by replacing its chlorine positions with hydroxyl groups varying some physiological conditions.

Purpose of the research
Bio ceramics are vividly used in Sri Lankan clinicals for biomedical applications. Most are exported synthetic bio materials; cost higher and have different structural properties compared to human hard tissues. Sri Lanka exports its rock phosphate as raw material for other developed countries without value addition and at a lower price. Our intention in this research is value

addition to Sri Lankan high grade rock phosphate by making advanced bio ceramic material leading to fabricate composites having lots of commercial benefits for biomedical industry around the world via having close chemical and structural similarity to human hard tissues that may lead to improvement of biomaterial properties. Through that, to get much better foreign income into the country and improve living standards among Sri Lankan citizens.

Method(s)
Eppawala High-Grade Phosphate rocks were sort out from the deposit, after removing mud, drying, crushing, ball milling; powdered and sieved apatite was heat-treated and subjected to synthesize hydroxyapatite bio ceramic under the solid state sintering method, sol gel acidified and alcoholic routes. Then synthesized products were characterized under several analytical techniques to confirm the formation of hydroxyapatite and to find out their properties. Cost analysis was carried to find out economic impact of products. Results were compared and contrasted with human hard tissues and commercial products.

Findings: Three types of hexagonal, Hydroxyapatite bio ceramic products named Solid-state sintered Eppawala hydroxyapatite, Sol gel acidified hydroxyapatite and Sol-gel alcoholic hydroxyapatite were successfully invented using Eppawala high-grade rock phosphate. According to X-ray fluorescence results, all products included Ca, P, and O in higher weight percentages and Fe, Al, and Si were present as impurities similarly in bone ash. Solid-state products contained more Ca than Sol-gel products due to the addition of calcium hydroxide base in the solid-state synthesis. X-ray powder diffraction and Fourier-transform infrared spectroscopy results confirmed the formation of hexagonal hydroxyapatite similar to human bones and teeth. Thermogravimetric analysis results have shown that the least amount of weight loss can be found in the novel products than human hard tissues, led to high thermal stability, and good material stability in nature and applications. Analysis of Scanning electron microscopy shows Solid-state products and sol gel alcoholic products consist of micropores improving the osteoconductive property. Sol gel alcoholic product consists of special cylindrical /needle shape, highly crystalline structures. Solid-state hydroxyapatite product gives higher yield than Sol-gel hydroxyapatite products. Solid-state product manufacturing cost is somewhat lower than sol-gel product manufacturing cost. Eppawala fertilizers are available at very cheap prices in the market. The manufacturing cost of novel Eppawala hydroxyapatite types is very less than the import of synthetic hydroxyapatite ceramic for the local biomedical industry. Manufacturing cost for novel bone cement and dental filling materials; reinforcing synthesized product with polymers is also low cost than purchasing commercial bone cement and commercial dental filling materials.

Conclusions: Study concludes at the end of novel three methods; three different varieties of hexagonal hydroxyapatite bio ceramic can be synthesized. All products; contain Ca, P and O in higher amounts and Fe, Al, Si impurities similar to bone ash composition, perform high thermal stability and good material stability. The three products have structural differences; Sol gel acidified products are highly crystalline and both sol gel alcoholic and solid-state products are microporous, improving osteoconductive properties. Overall chemical and structural similarity to human bones and teeth can be found. Therefore, biocompatible than commercial products. Solid-state hydroxyapatite product gives higher yield than sol-gel hydroxyapatite products. Substituting novel products for currently using commercial products will give economic profit

>90%. Introducing these value-added products will earn huge economic benefits for Sri Lankan economy than exporting raw material without value addition as phosphorous fertilizers.

Practical Implications: Novel products can be applied directly as bio ceramic materials for orthopedic and dentistry applications due to their close chemical, structural similarity to human hard tissues. Furthermore, their properties can be improved processing composites via reinforcing with commercially available polymers. Considering better clinical performance, eco-friendliness, and low cost these products can be introduced to the global market with high value.
Novelty: All three novel synthesizing methods and three synthesized hydroxyapatite bio ceramic varieties have obtained patent rights.

Benefit to the society
Invented novel products have close chemical and structural similarity with human hard tissues and made out of natural ingredients than commercial products. Therefore, introducing these value-added products into clinical as a substitute for current commercial products used in clinicals (bone cement and dental filling materials) will not only reduce costs and service charges but will also be healthier than previously used synthetic products.

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