PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH
FERHAT ABBAS UNIVERSITY, SETIF 1

جامعة سطيف 1
UNIVERSITY OF SETIF 1

FACULTE DES SCIENECES
DEPARTEMENT DE ¨PHYSIQUE

Master's Thesis

To obtain a Master's degree in Materials Physics

Valorization of animal waste to extract hydroxyapatite for medical applications

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Had been presented on 28/06/2026 to the responsible jury

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2025/2026

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Abstract: This thesis investigates the valorization of bovine bone and eggshell waste as sustainable precursors for biomaterial production, with particular focus on hydroxyapatite and calcium oxide. Bovine bone powder and eggshell powder were prepared through cleaning, grinding, thermal treatment, and calcination, followed by structural, chemical, and thermal characterization using XRD, XRF, FTIR, TGA/DSC, and particle size analysis. The results show that calcination improves phase purity, crystallinity, and thermal stability, while bovine bone-derived powders produce a hydroxyapatite phase close to biological apatite. Eggshells, mainly composed of calcium carbonate, were successfully converted into calcium oxide after thermal decomposition, confirming their potential as a low-cost calcium source for biomaterial synthesis. This work highlights the environmental and biomedical value of animal waste and supports their use in orthopedic, dental, and tissue engineering applications.

Résumé : Cette mémoire étudie la valorisation des déchets d'os bovins et de coquilles d'œufs comme précurseurs durables pour la fabrication de biomatériaux, avec un intérêt particulier pour l'hydroxyapatite et l'oxyde de calcium. Les poudres d'os bovin et de coquilles d'œufs ont été préparées par nettoyage, broyage, traitement thermique et calcination, puis caractérisées par XRD, XRF, FTIR, TGA/DSC et analyse de la taille des particules. Les résultats montrent que la calcination améliore la pureté de phase, la cristallinité et la stabilité thermique, tandis que les poudres issues d'os bovins donnent une phase d'hydroxyapatite proche de l'apatite biologique. Les coquilles d'œufs, principalement composées de carbonate de calcium, ont été transformées avec succès en oxyde de calcium après décomposition thermique, ce qui confirme leur potentiel comme source peu coûteuse de calcium pour la synthèse de biomatériaux. Ce travail met en évidence l'intérêt environnemental et biomédical de ces déchets animaux et soutient leur utilisation dans les domaines orthopédique, dentaire et du génie tissulaire.

الملخص

تبحث هذه المذكرة تثمين نفايا ت عظام الأبقار وقشور البيض بوصفها مصادر مستدامة لتحضير المواد الحيوية، مع التركيز بشكل خا ص على الهيدروكسي أباتيت وأكسيد الكالسيوم. تم تحضير مسحوق عظام الأبقار ومسحوق قشور البيض من خلال التنظيف والطحن والمعالجة الحرارية والتكليس، ثم تم ت دراستها باستخدام تقنيات TGA/DSC و FTIRو XRFو XRD وتحليل حجم الجسيمات .وقد أظهرت النتائج أ ن التكليس يحسن نقاء الطور ودرجة التبلور والاستقرار الحراري، كما أ ن المساحيق المستخلصة من عظام الأبقار أعطت طور الهيدروكسي أباتيت القريب من الأباتيت البيولوجي . أما قشور البيض ، فهي تتكون أساسًا من كربونات الكالسيوم، وقد تم تحويله بنجاح إلى أكسيد الكالسيوم بعد التحلل الحراري، مم يؤكد إمكانية استخدامها كمصدر منخفض التكلفة للكالسيو م في تحضير المواد الحيوية. يبرز هذا العمل القيمة البيئية والطبية الحيوية لهذه النفايا ت الحيوانية ويدعم استخدامها في التطبيقات العظمية وطب الأسنان وهندسة الأنسجة.