Effect of bone age and anatomy on the variability of the bovine bone by-product by Terahertz Time-Domain spectroscopy and Energy-Dispersive X-ray microanalysis

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ABSTRACT

Bone is an important by-product of the meat and dairy livestock. Currently it is disposed through incineration or valorised in pet food, despite its low nutritional value. However, thanks to its biological and mechanical properties, bone can be valorised in multiples domains demanding for bio-based products, such as packaging and insulation materials, as well as biomaterials, electrical energy production, fertilisers, *etc*. Successful valorisations routes of bone need a comprehensive characterization of the possible variability of the physical-chemical properties of the tissue with major biological parameters, such as the age and the anatomy of the bone itself. In this study, the variability of bovine bones was assessed through the Terahertz Time-Domain spectroscopy (THz-TDS) and the energy dispersive X-ray microanalysis (EDXMA). The bone optical properties, such as the refractive index and the absorption coefficient, and the main bone minerals, *i.e.* calcium and phosphorous, were determined for adult bovine femurs and tibias, in the age range of 93 – 120 months. Proteoglycans content was also assessed. Clustering analysis was then carried out by unsupervised statistical tools (Principal Component Analysis (PCA) and Agglomerative Hierarchical Clustering (AHC)). Results showed that the considered bones can be clustered in two different classes, represented by each anatomy, and that the anatomy is most significant than age. The goodness-of-clustering was significant (AHC *Silhouette* index > 0.5) yet the strength of clustering was low (AHC *Silhouette* index < 0.75). The bone refractive index determined by THz-TDS increased with age and was higher for femur but and the cluster of tibias was more homogeneous than the cluster of femurs. Hence, the THz radiation showed to be a useful and non-destructive tool to assess bone variability and optical properties; it could be applied to the predict bone components extractability as well as in bone characterisation for medical purposes.

Keywords: agro-food by-products, bones, variability, terahertz radiation, optical properties, terahertz time-domain spectroscopy.