Abstract

Tooth enamel is the hardest and most resistant highly mineralized inorganic component in mammalian bodies that significantly affects both the life quality and expectancy of an individual. Its specific qualitative properties are given by the biomineralization process responsible for its formation. In this process the mineralization of hydroxyapatite (HAp), the only inorganic phase composing the mammalian hard tissues, is controlled by activity of enamel-forming cells ameloblasts and their products. Over the past years, the studies of enamel matrix proteins, their structure, composition and function has become the prevalent field of experimental investigation. However, unique enamel qualities, which enable the teeth to withstand high pressure and stress demands, cannot be accurately assessed without the thorough systematical study of its mineral compound.

In this thesis, I focus on the crystallographic and compositional characteristics of enamel hydroxyapatite and their influence on the mechanical properties of teeth. Obtained results are discussed in context of developmental and adaptation dynamics of mammalian species. The main aspect of the work is to extend our knowledge about the protein–mediated mineralization process from the perspective of inorganic compound and its contribution to the unique characteristics of the tooth.

Special attention is devoted to the proper sample preparation technique for X–ray powder diffraction analysis. It is demonstrated that the inappropriate treatment of specimen causes formation of extra phases. Moreover, the used preparation technique might affect the microstructural properties of the hydroxyaptatite crystals, especially the length of crystallites. I propose that the manual disintegration technique using a piston to crack the tooth into fragments, subsequent separation of potential enamel fragments under an optical microscope, and a final confirmation of the purity of enamel using a scanning electron microscope is the most suitable separation technique. This approach enables yielding the most reliable data for biomineralization–focused research.

In the second project presented in the thesis, micro– and macro–structural changes are correlated with mechanical properties variations during the maturation stage of amelogenesis in selected parts of a miniature pig's tooth. The crystallization and maturation processes start at the boundary of enamel and dentine beneath the future cusp at the anterior part of the tooth. It then spreads toward the roots following the border line of enamel and dentine, surface and posterior parts of the tooth. The late secretory and early maturation stage is characterized by the formation of enamel prisms. During that period, the crystallites gradually thicken. The late maturation stage is associated with a development of interprismatic enamel, abrupt decrease in amount of lattice imperfections in the crystal structure, and rapid settling of the final mechanical properties. The delayed formation of interprismatic enamel is an essential adaptive pattern of a swine developmental dynamics.

I further studied the qualitative characteristics of swine dental enamel (i.e. degree of surface wear, chemical composition variations, and microstructural and mechanical properties) and their relationship to the duration of crystallization developmental process and the age dependency. The results suggest that the longer the crystallization process, the bigger crystallite sizes with lower amount of lattice distortions are formed. This aspect has a significant influence on the final mechanical behaviour of the tooth. Moreover, the inner structure of crystals seems to be immutable with age of the animal.

In summary, a set of these data provides a reliable basis for a multifactorial analysis of functional correlates of particular crystallographic variables and their odontogenetic and phylogenetic representation. The results illustrate that the crystallographic characteristics of enamel hydroxyapatite are a significant contribution to the final qualitative enamel characteristics and they must be taken into account in the studies of biomieralization processes.