

THE PHASE COMPOSITION OF BIOCERAMIC PROTECTIVE LAYERS OF HEALTHY AND PATHOLOGICAL HATCHING HEN'S EGGS

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Abstract. *In this article we show results of structural characteristics of bioceramic protective eggshell layer of hatching eggs, which consists of calcium carbonate in different crystalline forms. We have experimentally proved that negative factors of environment, genetic factors and mistakes connected to birds holding technology lead to changes at phase composition of eggshell calcium carbonate that, in turn, can influence the essential characteristics of developing embryos.*

Key words: *hens, hatching eggs, calcite, X-ray diffraction, eggshell.*

Urgency of problem: Eggshell is a unique bioceramic composite material that has the characteristics like high density and solidity, certain mechanical flexibility and high gas permeability and moisture permeability [1, 2]. These physicochemical characteristics of bioceramic material of eggshell are determined by synergic action of two components – inorganic component consisting of crystalline calcium carbonate (CaCO_3), and organic “minor” component (specific peptides, glycoproteins, lipids, stains and etc) [3,4].

General function of eggshell is gas permeability regulation for embryo in period of incubation, providing of barrier qualities against pathogenic microflora of environment, and it also takes part at fluid and temperature balance maintenance at embryo development zone [1]. Forming of such multicomponent biocomposite like eggshell takes place during a small time period, and the influence of many factors (like “internal factors” – genetic, consequences of diseases, and environmental factors like holding and feeding conditions of birds) leads to bioceramic structural failure, which, in turn, provide the failure of above-mentioned physiological function [5].

In spite of the fact that O. Bordunova and co-authors use one of the approaches of structural failure correction of bioceramic layer of eggshell – technology “Artificial cuticle” [6], designed and introduced by O. Bordunova, that helps to prevent physiological consequences of negative factors before and during the incubatory period, the details of failure processes have not been studied enough. In particular, we don't have enough information about changes of crystalline forms of calcium carbonate at eggshell thickness because of negative factors action. The importance of this research is that known crystalline forms (polymorphous modifications) of calcium carbonate, in particular calcite, vaterite, aragonite, differ from each other by physicochemical parameters (hardness by Moos scale, density), morphological and structural characteristics. The last, in its turn, cause increase (decrease) gas and steam eggshell permeability, protective qualities against pathogenic microflora, integral and local strength of eggshell. Detailed knowledge about eggshell's bioceramic layer formation process let us improve technology “Artificial cuticle” [6].

Task of research: Research objective was to study the direction of changes of morphological parameters of crystalline structure of bioceramic protective layer of eggshell of hens' hatching eggs (crystalline form of calcium carbonate as basic constituent of eggshell) due to influence of environmental negative factors, genetic factors and mistakes at birds' holding technology.

Material and methods: In research we used eggs from Rod Island Red hens, Poltava Clay Chicken breed, Birkivska Barvysta (Colorful) at the beginning of productive period at the age of 8 months (30 eggs from every breed). Experimental farm “Borky”; hatcher “Universal 55”. X-ray diffractive experiments were conducted on automatic diffractometer ДРОН-4-07 (НВП «Буревестник», Russia, www.bourevestnik.spb.ru). Automatic system ДРОН-4-07 based on microprocessor monitor, which controls goniometer ГУП-9 and sends information on PC in digital form. We used emanation $\text{CuK}\alpha$ (wave length 0,154 nanometer), focusing by Breggu-Brentano 0-20 (20 – breggur corner). Experimental results were sent to program package of experiment support DifWin-1 (Limited Liability Company (LLC) “Etalon PTS”, Russia) for pre-assessment of the results. Identification of crystalline phases was performed using the software package Crystallographica Search-Match (Oxford Cryosystems, www.crystallographica.co.uk) with imposed restrictions on the elemental composition of samples by comparing experimental results with PDF-2 database cards and subsequent manual sampling.

Research results. In figure 1 depicts diffractogram of powder, obtained from fertilized egg's bioceramic eggshell layer, prepared for incubation (Poltava Clay), which meets the standard requirements noted in Technical Requirements "Hatching Eggs of Hens. Technical Requirements" after V. Breslavets and others (Code UKHД 636.52/58.637.4.082.47467.120.20). Location and intensity of the lines in the diffraction pattern indicate that the phase of calcium carbonate at eggshell thickness is calcite (trigonal syngony, perfect cleavability all along the rhombohedron, low hardness).

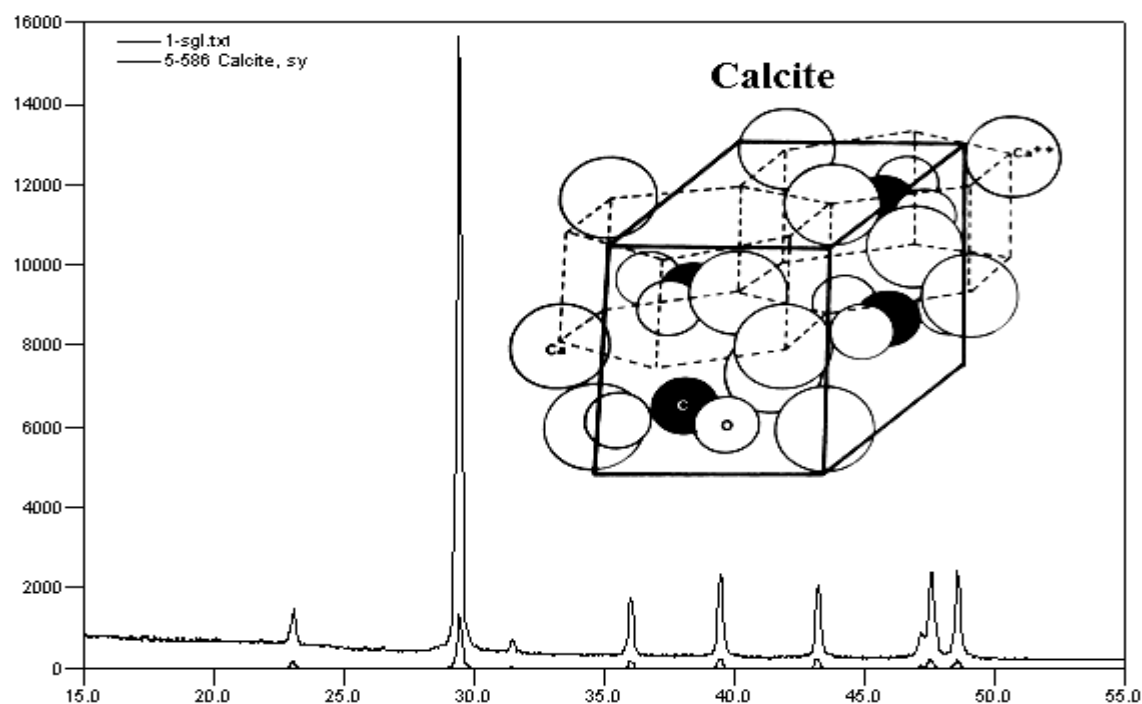


Figure 1. Phase composition of bioceramic eggshell layer of hen's eggs (Poltava Clay); hereinafter on the vertical axis we show relative intensity, and on the horizontal axis the angle of 2θ is shown.

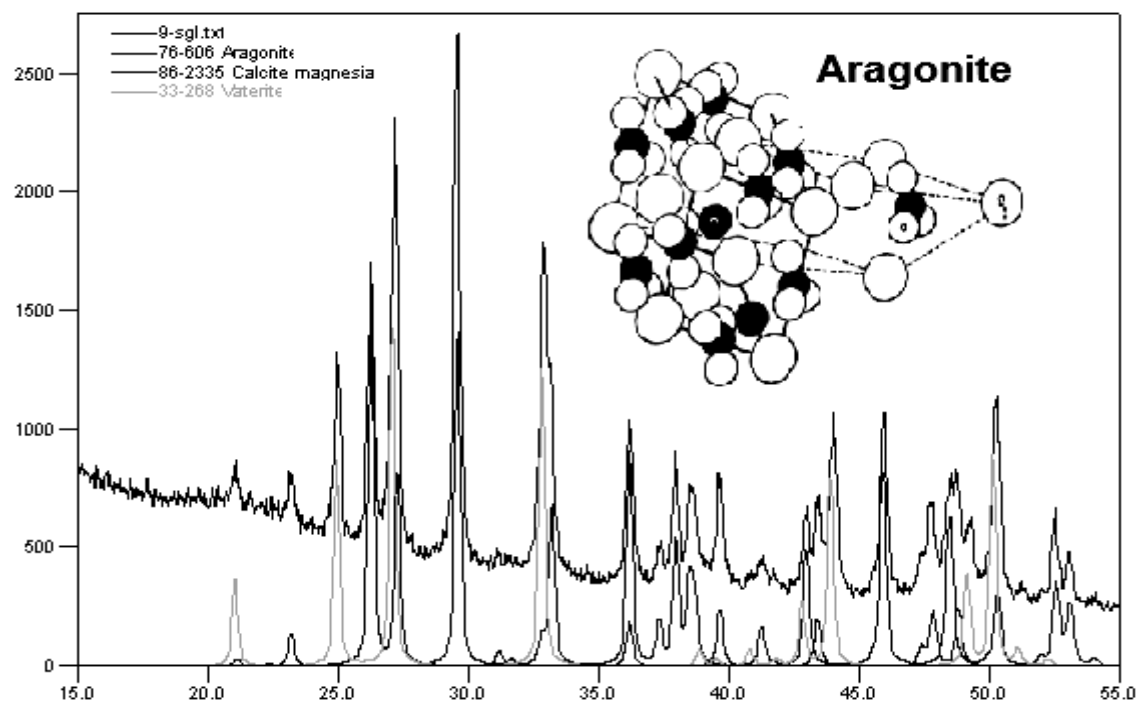


Figure 2. Phase composition of bioceramic eggshell layer of hen's egg (Poltava Clay); very small, irregular-shaped (specimen from obtuse end).

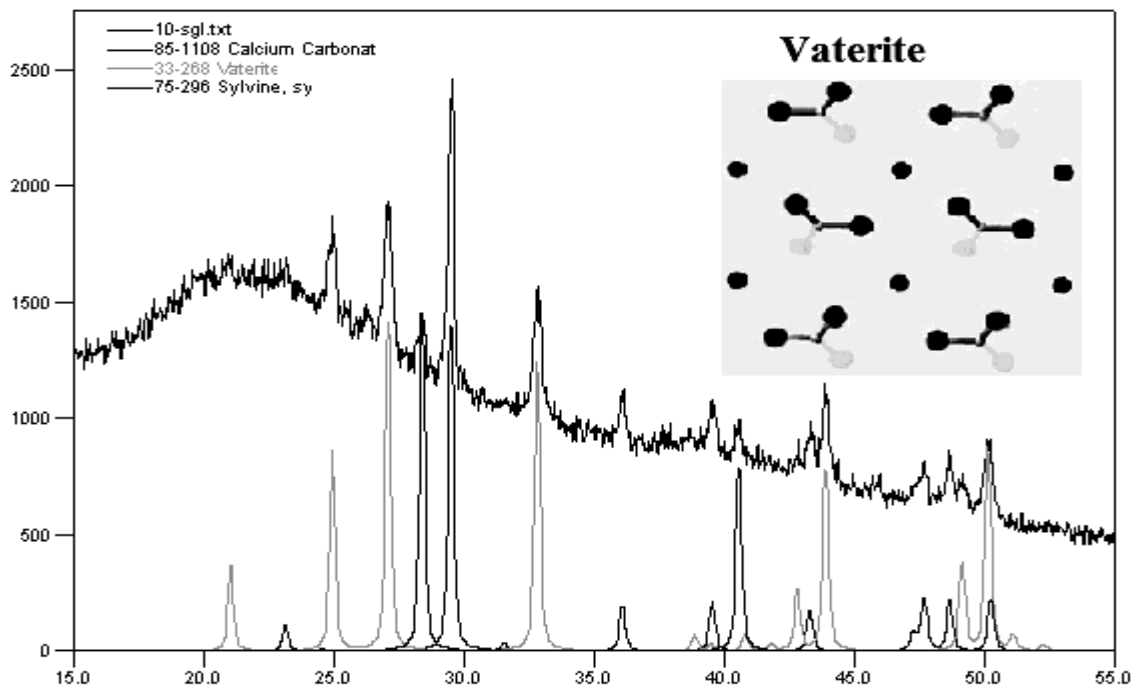


Figure 3. Phase composition of bioceramic eggshell layer of hen's egg (Poltava Clay); very small, irregular-shaped (specimen from central part).

From the diffractograms shown in Figure 2 and 3, we see that morphological defects of eggshell that belonged to a kind of flaws of hatching eggs which are stipulated by genetic factors, also have phase changes – lines peculiar to aragonite and vaterite appear. Aragonite is characterized by rhombic syngony and increased strength; vaterite in turn is characterized by hexagon syngony. Such differences of crystalline forms of calcium carbonate cause different morphology of bioceramic protective layer of eggshell of eggs [7], and it should be noted that eggshell enrichment in aragonite and vaterite leads to general loosening and fragmentation of calcium carbonate layers.

It is established that lack of incubation, entitled "missed abortion" is often accompanied by presence of the phase known as monetite CaHPO_4 (Fig. 4). in diffractograms of powders obtained from the shells of hatching eggs.

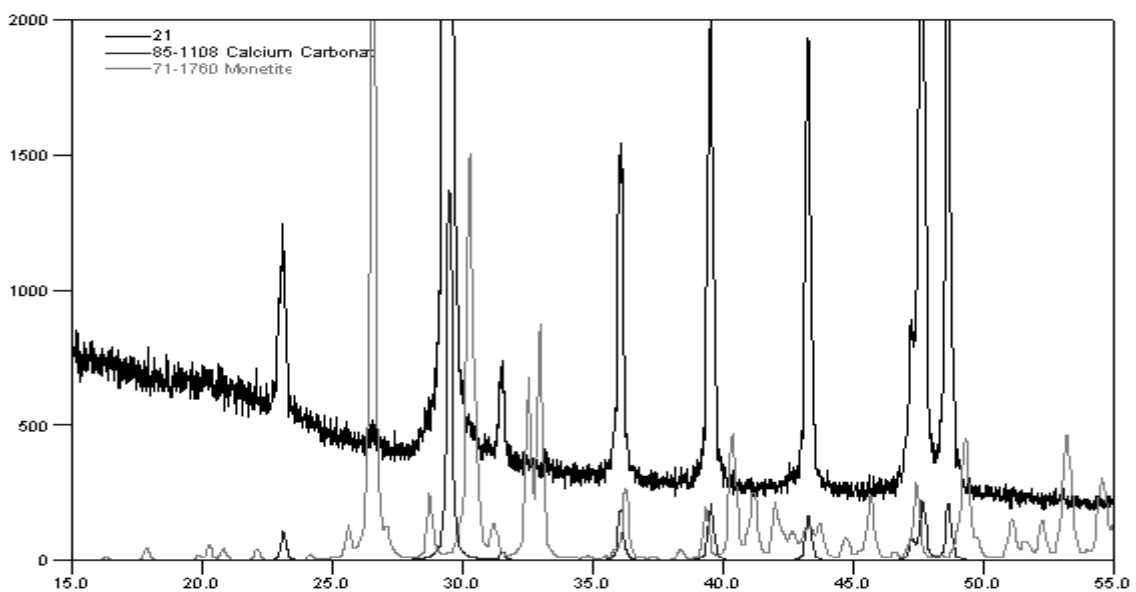


Figure 4. Phase composition of bioceramic eggshell layer of hen's egg (Birkivska barvista) after incubation; lack of incubation - "missed abortion"

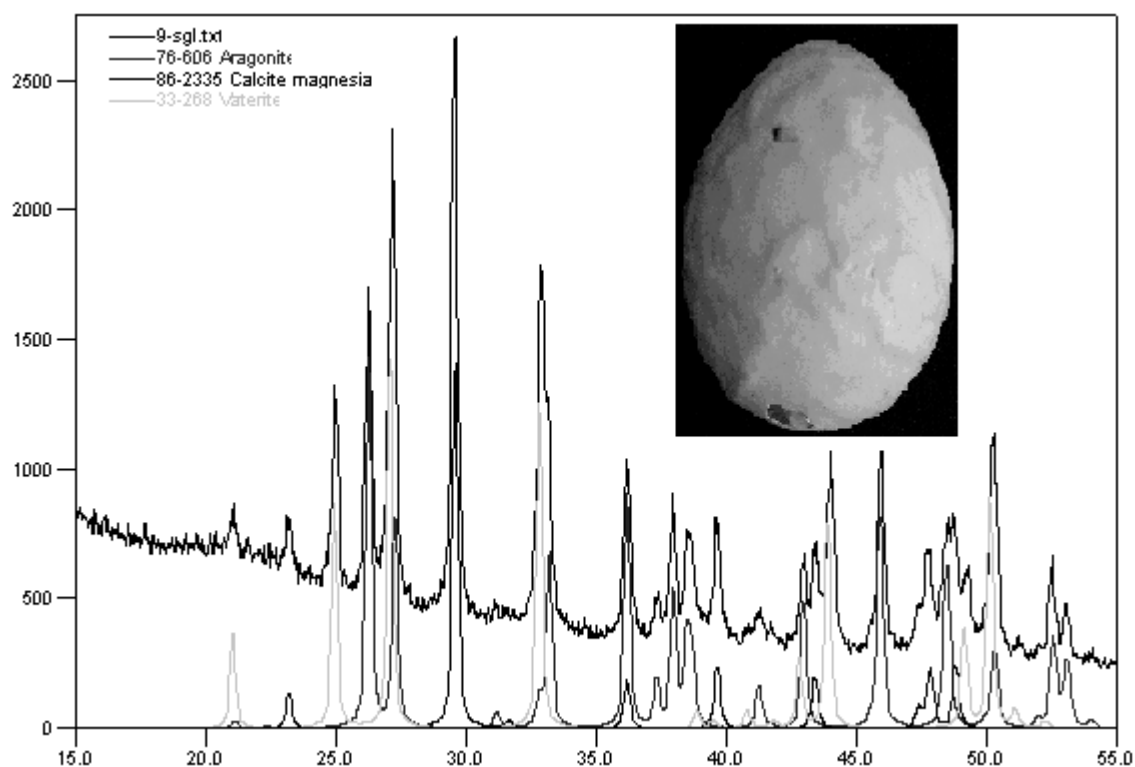


Figure 5. Phase composition bioceramic eggshell layer of hen's egg (Rhode Island Red); eggshell defect

Finally, the combination of such eggshell defect of hatching eggs as roughness coupled with the tumors, growths and mold due to violation of technology leads to gross disruptions in bioceramic layer structure - aragonite, vaterite and magnesium calcite appear instead of typical calcite for quality hatching eggs (Fig. 5).

Conclusions. 1. The analysis of diffractograms obtained on samples of calcium carbonate as the basic inorganic component of eggshell of hen's eggs showed that depending on the conditions for obtaining hatching hen's eggs and due to adverse environmental factors, genetic factors and errors in poultry technology there are significant changes in the phase composition of the eggshell acting as egg's bioceramic protective barrier.

2. Phase composition of eggshell of hen's hatching eggs that meet technical specifications, is presented by specific crystalline form of calcium carbonate - namely calcite. Effects of negative factors of different origin on egg incubation are instead accompanied by other crystalline forms of calcite - aragonite and vaterite, which also leads to a general loosening and fragmentation of calcium carbonate layers with the following negative physiological effects.

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