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Determination of Electrical Properties of Fish Eggs toward Electrical Sex Reversal

The present study proposes calculations of electrical parameters to be used for electrical sex reversal technique using Hen-egg model. In the case of tilapia's egg, its actual shape is an asymmetrical prolate spheroid with a short prolate spheroid bottom and a more elongate prolate spheroid at the top with a common equator rather than a symmetrical prolate spheroid. The two semi-minor axes (b, c) are set to equal one another. The ratio between the semi-major (a) and semi-minor axes is 1.3. To analyze the implicit value of electrical breakdown transmembrane potential for electropermeabilization, polarization of the egg was assumed to be the same over the whole egg volume. In the case of the egg possessing a single dielectric shell, it was analyzed as the equivalent tri-phases of RC-circuit using three pairs of resistors and capacitors to represent the conductive and capacitive properties of the egg's shell, the inner part of the egg and the suspending medium, respectively. The complex specific impedances of each compartment of the egg were finally analyzed. The threshold transmembrane potential for electroporation of tilapia's egg is also evaluated. This approach allowed us to calculate the precise value of electrical properties of tilapia's eggs when they were being induced in transient electric field. The essential parameters calculated from the model were rates of occurrence new pores on membrane surface Nc, resealing pores Nd (Nc/Nd=1.0), time dependent function of pore density with respect to pore diameter size N(r,t), membrane surface area Am= 1-2 μm2, membrane capacitance Cm=1-15 nF.m-2, initial pore radius of the maximum R(max)(400 nm) and the minimum R(min) (250 nm), membrane surface energy = 1-10 mJ.m-2 and membrane including shell thickness of each layer (d), respectively. It should be noted that the latter parameter was evaluate through histological technique which was employed to examine a cross-sectional view of electroporated eggs. We found that the shell thickness of tilapia's egg of O.niloticus was d=5.60.1±μm (SD) (including 8 nm of the plasma membrane layer). To achieve electroporation, the threshold of the induced transmembrane potential TMP was also calculated using the surface tension of the shell of J.m-2 where permittivity of the shell was 10ε0. This yielded a critical TMP of 211 mV for the plasma membrane and 5.60 V for the whole shell, values which are in reasonable agreement with the experimental results.

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