Effects of hen age and egg storage conditions on the quality and protein composition of the vitelline membrane

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Abstract
The egg vitelline membrane is a protein-based structure surrounding the yolk. In table eggs, it contributes to protect the egg from bacterial contaminations, and it enables the separation of egg white and yolk after egg breaking, thanks to its mechanical properties. The quality of the vitelline membrane is thus of high interest for the egg and egg products industries. Various factors, such as egg storage conditions (duration, temperature) and the age of laying hens, can adversely affect the quality of this membrane. It is also noteworthy that, for sustainability reasons, the production period of commercial hens is lengthening considerably (from 70-80 to about 100 weeks of age), which may have further negative consequences on egg and vitelline membrane quality at the end of the laying cycle. In this context, the aim of this study was to investigate the effects of both hen age and storage conditions on the physical and biochemical properties of the vitelline membrane. Eggs from hens aged 32-34 (peak of lay), 71-73 (late laying period) and 94-99 (very late laying period) weeks were stored for up to 28 days at 4°C or 20°C. Several quality parameters were measured on these eggs: yolk mass, yolk index (height/diameter ratio), deformation and breaking strength of the vitelline membrane. In parallel, vitelline membrane samples were collected to analyze their protein composition by SDS-PAGE and mass spectrometry (GeLC-MS/MS). As expected, the four quality parameters studied were significantly altered by both hen age and storage time. Storage temperature also had a significant effect on these parameters, with the exception of yolk mass, which did not change between 4°C and 20°C. Interestingly, no interaction between hen age and storage conditions was observed in our conditions. The protein profile of solubilized vitelline membranes was also altered, especially during storage at 20°C. At least 219 proteins were identified by mass spectrometry in the collected samples. The label-free quantification revealed differential relative abundances for half of these proteins as affected by hen age and/or storage conditions. In conclusion, increasing the production period of laying hens has a negative impact on the mechanical properties of the vitelline membrane, but it does not alter its degradation rate during egg storage. Proteomic analyses of the vitelline membrane allowed the identification of proteins potentially involved in alterations induced by hen age and egg storage.

Keywords
Egg, vitelline membrane, hen age, storage, quality, proteomics