Abstract

Poultry broiler meat is the second most widely consumed meat in the world and over 53 billion broilers are reared globally to meet the annual protein demand. Day-old chicks are the most important input for broiler farms and successful broiler production, at all scales of operation, critically dependent on the quality and supply of these chicks. Actually, day-old chick supply depends on the percentage of fertile eggs set for incubation and their rate of successful hatching. However, currently about 5-20% of eggs set for incubation are infertile, resulting in reduced hatchability, loss of energy, excessive use of incubator space and increased handling costs. Furthermore, the presence of these infertile eggs or dead embryos in the incubator can harbor and provide a source of pathogenic contamination to live embryos. Thus, early detection of hatching egg fertility would benefits poultry hatchery through: higher hatchability and optimum utilization of incubator space.

Secondly, supply of best quality day-old chicks (determined by post-hatch survivability and growth potential) is considered to be crucial for subsequent broiler performance up to slaughter age. However, the homogeneity in the quality of day-old chicks cohort is frequently compromised by a wide-spread hatch window, which negatively affects the chick's post-hatched performance. Consequently, it is important to control the spread of the hatch window in order to have a batch of chicks with near identical biological age. Since the spread of the hatch window is influenced by the hatching time of individual chicks, early prediction of hatching time can be used to separate eggs into a narrower hatch window. Therefore, need to develop a system for early detection of egg fertility and early prediction of their hatching time, which is currently not available.

Previous researches on incubated fertile hatching eggs suggests that there are early detectable change in growth physiology of hatching eggs such as blood vessels formation after 2 days in incubation and subsequent changes in live embryo. These changes are related to eggs fertility and hatching time. Therefore, monitoring information of embryonic stages can be used to detect hatching egg fertility, as well as to predict their hatching time. In this study, visible light transmission spectroscopy technique was evaluated for it`s potential to monitor embryonic development. To do this,

transmission spectra of brown-shell hatching eggs between incubation day 0 (prior to start incubation) to day 8, at 24 h interval were measured and subsequent hatching time was recorded. Since calciferous shell of egg absorbed most of light below 500 nm, spectral information in the range of 500-750 nm was used to monitor embryonic development.

At first, principal component (PC) analysis was done on spectral data to identify the most effective wavebands that are associated with hatching egg fertility. It was found that fertile and infertile eggs could be discriminated in the spectral range of 575-578 nm after 96 h in incubation. Later, hatching egg fertility classification models were developed using PCs score of selective wavebands combined with *k*-means clustering, linear discrimination analysis (LDA) and support vector machine (SVM) classification algorithms. LDA and SVM models achieved an overall classification accuracy of 100% for both of fertile and infertile eggs, while *k*-means clustering achieved 97% overall accuracy. The results indicate the potential of visible transmission spectra for the detection of hatching eggs fertility. Finally, chick hatching time prediction model was developed based on spectral information combined with partial least squares (PLS) regression methods. Results showed that interval PLS (iPLS) regression model predicts chick hatching time with a RMSEP (root means square error of prediction) value of 3.24 h. This prediction performance is good enough to narrow down the spread of hatch window compared to 24-48 h for current practice.

Above results demonstrate that visible transmission spectroscopy combined with appropriate multivariate methods can be used to develop non-destructive sensing techniques for hatching egg fertility detection as well as early prediction of their expected hatching time. These techniques will enable hatchery managers to ensure higher percentage of fertile eggs in incubation, resulting in higher hatchability, and narrow down the hatch window which resulting in higher percentage of best quality chicks.