Meat freshness estimation - aquaphotomics approach

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Introduction: In recent years the consumers have increased demand for chicken meat, which is fresh, naturally grown and without additives. Incorrect labeling, added water, added salt or sugars and other substances, and thawed chicken meat which is labeled as fresh, are among the most common frauds with chicken meat. The European Regulation states that poultry meat can be labeled “fresh” when the meat has not undergone a freezing process, i.e. when stored at temperatures between -2 and + 4°C until purchase by consumers. Frozen and deep-frozen is the storage of poultry meat at -12°C and -18°C, respectively (EC Reg. 1234/2007). In the case of raw meat, it is accepted as a legal requirement to be applied only one freeze cycle, and after defrosting the meat is subjected to a short (up to a few hours) refrigerated storage before culinary treatment. Re-freezing of the thawed meat is prohibited. It is also forbidden for freeze-thawed meat to be labeled as fresh meat. Such violations are referred as food fraud. A challenge to control by the governmental authorities and for consumers is the lack of a quick, inexpensive, and reliable method of recognizing fresh and freeze-thawed meat. In the current laboratory practice of official meat control, there is a method for destructive determination of the enzymatic activity of muscle juice from the meat. The method is only laboratory-applicable and with very expensive test kits and reagents. Considerable interest for development of instrumental techniques for objective, faster, non-destructive and less expensive assessments of meat quality exists. The aim of the study is investigation of the feasibility of Near Infrared Spectroscopy combined with aquaphotomics approach for discrimination of fresh and freeze-thawed chicken meat.

Methods: An experiment was carried out with 4 fresh breast meats and 20 tenderloins of broiler chickens, purchased from a local meat store. All samples were measured twice - once immediately after purchase and again after frozen at minus 22°C and stored at the same temperature for 20 days, then thawed in the refrigerator at 6°C for 8 hours.

NIR measurements were performed by NIRQuest 512 spectrometer (Ocean Optics, Inc.) in the region 900-1700 nm using reflection fiber-optics probe without destruction or any kind of treatment of the samples. Four or five measurements at different part of the samples were made to minimize any possible effects of structural variation in the samples. A commercial program Pirouette Version 4.5 was used for performing of spectral data processing. SIMCA (Soft Independent Modelling of Class Analogy) method was performed to classify samples. Additionally, aquagrams were calculated, using specific water vibrations, and named water matrix co-ordinates. Aquagram is a radar chart which displays normalized absorbance values at several water bands on the axis originating from the center of the graph. Water matrix coordinates were used for axes (Tsenkova, 2009).

Results and discussion: Differences in absorption spectra of fresh and frozen-thawed poultry breast meat in the region from 900 to 1700 nm existed, which could be explained with the changes that occur in the meat when freezing and thawing and could be used for creation of model for discrimination of poultry meat. The most significand differences were found around 938, 1018, 1310, 1374, in the region 1402-1417, around 1470 and 1584 nm (figure 1).

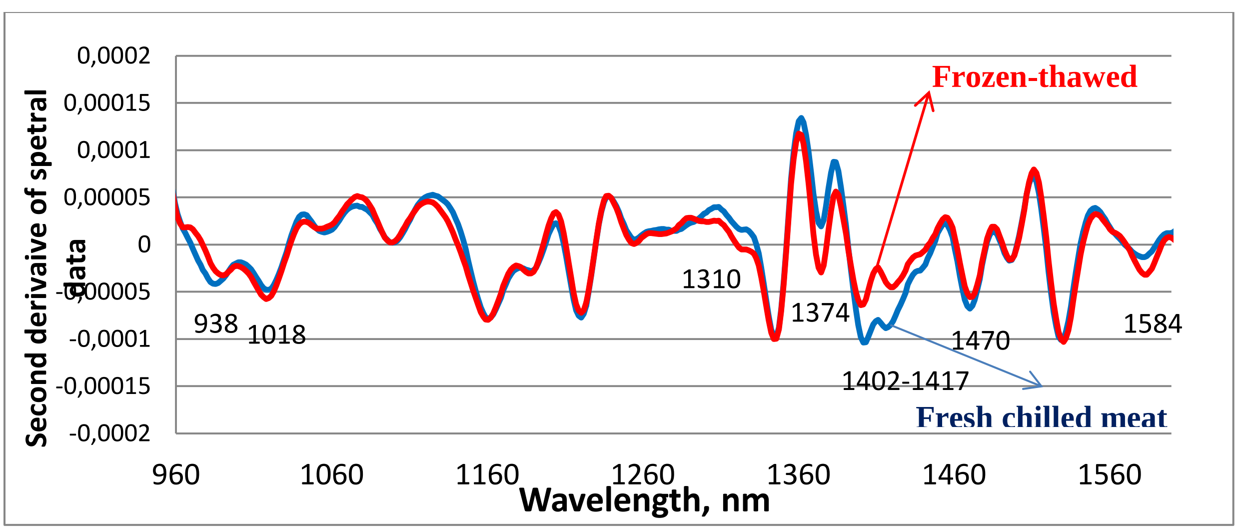

Figure 1. Average second derivative spectra of measured fresh chilled and frozen-thawed meat samples.

The differences were biggest around 1400 nm – the region of first overtone of O-H bond of water. To visualize in detail the changes in water absorbance pattern a Aquagram chart are used. The aquagram, calculated using spectral data the same meat samples, measured initially fresh, and after that frozen-thawed meat (figure 2). Aquagram pattern of meat sample after freezing is changed significantly. Aquagram values of frozen sample decreased in the range from 1398 to 1518 nm and increased in the range 1344-1382 nm. Changes in an aquagram showed changes in water configuration in frozen-thawed meat compared to fresh meat. Similar aquagram pattern were found for the rest of the samples.

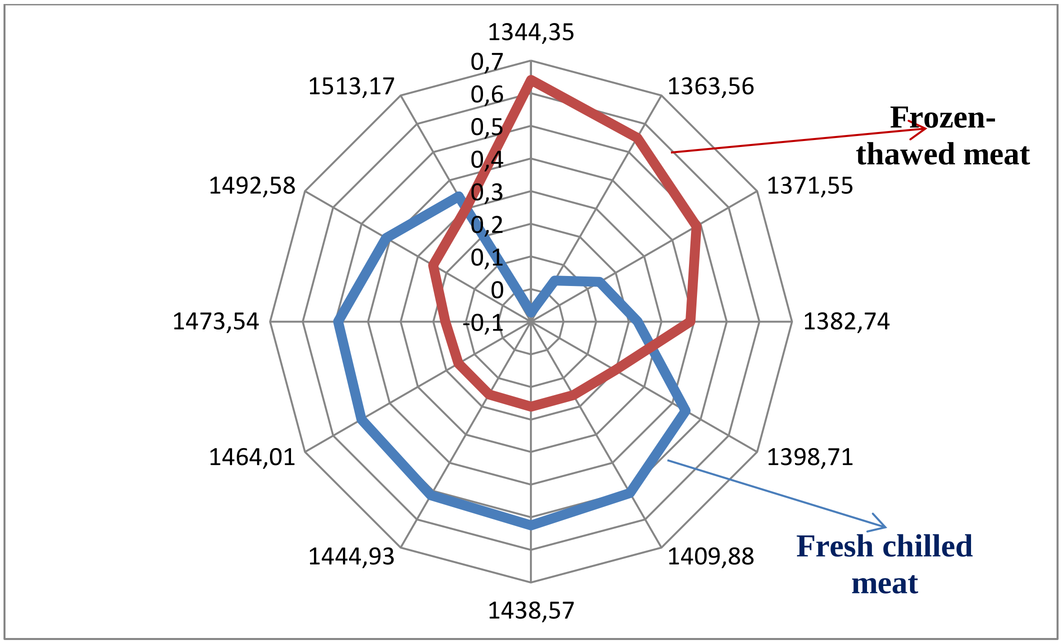

Figure 2. Aquagram of fresh chilled and frozen-thawed meat.

Lean muscle contains approximately 75% water. Water in the meat existed in form of bound, entrapped and free water. Bound water is the water that exists in the vicinity of non-aqueous constituents (like proteins) and has reduced mobility. Entrapped water is another fraction of water that can be found in muscles. It can be easily converted to ice during freezing. Free water is defined as the water whose flow from the tissue is unimpeded. During freezing and thawing of meat, ice crystal growth causes biochemical and physical changes. The latter result in the disruption of cellular organelles and release of their contents into the meat drip juice. These changes lead to changes in water content and proportion of free and bounded water, change of pH, water-holding capacity, protein denaturation, texture and tenderness of the meat (Vieira et al., 2009). At the micro-level, changes lead to oxidative processes and oxidation of lipids and proteins in destroyed cells (Xia et al., 2009).

The differences in near-infrared spectra of fresh and frozen-thawed meat show that variations in the spectra reflect the changes that occur in the meat when freezing and thawing and could be used for creation of model for discrimination of poultry meat. SIMCA models for discrimination of fresh and frozen-thawed meat were developed. The best models were obtained using smoothing and second-derivative transformation of spectral data, which correctly classified 100% of the samples from calibration set. The obtained recognition ratio for validation set was 94.4% for class of fresh meat and 96.8% for class of frozen-thawed meat.

Conclusion: We can conclude from obtained results that NIR Spectroscopy have a potential for discriminating fresh from frozen-thawed poultry meat. The most significant differences in absorption spectra of fresh and frozen-thawed poultry breast meat are connected with changes in water configuration in frozen-thawed meat compared to fresh meat.

References.:

European regulation EC Reg. 1234/2007 Establishing a common organisation of agricultural markets and on specific provisions for certain agricultural products.

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