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基于阻抗特性和神经网络的鸡胸肉冻融次数鉴别方法

Classification of chicken breasts with different freezing-thawing cycles by impedance properties and artificial neural networks

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中文关键词: 神经网络 介电特性 品质控制 冻融 阻抗 鸡胸肉

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中文摘要:

为了探究利用肉的介电特性检测冷冻肉品质的可能性，研究了新鲜鸡胸肉和不同冻融次数的鸡胸肉的品质以及阻抗的幅值和相位角变化状况。在0.05～200 kHz频率范围内，选择了16个不同的频率点进行阻抗特性分析。试验结果表明：鸡胸肉阻抗的幅值会随着频率上升而下降，相位角则相反。冷鲜肉与冷冻肉高频段相位角相差一个数量级，低频段阻抗的幅值差异也极显著（P＜0.01）。多次冻融处理后，解冻损失、丙二醛含量上升显著（P＜0.05），pH值变化不明显（P＞0.05）。反复冻融后低频段阻抗幅值降低（P＜0.05），大于50 kHz时，相位角有增大的趋势（P＜0.05），这与正常1次冻结-解冻肉的相位角变化趋势相反。利用径向基函数（radial basis function，RBF）神经网络提取阻抗和幅值信息建立判别模型可以对不同冻融次数的肉进行较为准确的分类。研究结果表明，阻抗测量作为一种冷冻肉快速无损检测方法具有很大的发展潜力。

英文摘要:

Abstract: Electric impedance properties of biological tissue closely relate with their tissue structure. A few published investigations have shown that electric impedance has a rapid detection capability to meat quality. To explore the impedance detection ability for frozen-thawed meat, electric impedance magnitude and phase properties of unfrozen and frozen-thawed chicken breasts subjected to different thawing times were studied. The maximum freezing-thawing circle was three times. Sixteen different frequencies from 50 Hz to 200 kHz and quality parameters like thawing loss, cooking loss, pH value, and TBARS (Thiobarbituric acid reactive substances) of 20 samples of each group were investigated.The impedance of the samples was measured by an LCR electronic bridge at the voltage of 3 V. Copper needle electrodes with a length up to 15 mm and a distance of 15 mm between two electrodes were used. The temperature of the meat was kept within 0-4℃ during the measurement. The location of each test was the same and measurement time was 1-2 sec at every frequency.The experimental results showed that changes in the tissue structure caused by freezing and thawing could be reflected by the impedance magnitude and phase. The impedance magnitude of both fresh and frozen-thawed meat would decrease as the frequencies increased and the impedance magnitude of fresh meat was significantly higher ($P<0.01$) than frozen-thawed meat in the low-frequency range, while the opposite trend was found in the high-frequency range. Those changing trends of impedance are indicators for capacitance characteristics of cell remembrance. Biological tissues are composed of cells that are surrounded by extracellular liquid. The main current flows through the extracellular fluid and the cells are bypassed when low-frequency current is applied to the tissue. The cell membrane acts as an insulator at low frequencies. With the current frequency increases, a part of the current will flow through intracellular fluid through the cell membrane. So, low-frequency impedance of biological tissue is larger than high-frequency impedance.The impedance phase angle of both fresh and frozen-thawed meat would increase as the frequencies increase. Compared with frozen-thawed meat, fresh meat had a higher ($P<0.05$) impedance phase angle in the low-frequency range but a lower ($P<0.05$) value in the high-frequency range. So, the significant difference ($P<0.05$) of high-frequency phase angle and low-frequency impedance magnitude between fresh and frozen-thawed meat would be an ideal index to distinguish those two kinds of meat.After freezing-thawing cycles, low-frequency impedance magnitude would decrease significantly ($P<0.05$), but the difference between two and three times freezing-thawing cycle was not significant ($P>0.05$). High-frequency phase angle would increase ($P<0.05$) which is different with normal frozen processing groups, especially at levels higher than 50 kHz. This impedance phase property of meat with more than one freezing-thawing cycle gives a clear distinction between them and meat with one freezing-thawing cycle. These changes of impedance properties demonstrate that freezing-thawing cycles have a remarkable influence on the structure of cell membrane and lead to a decline of cell membrane capacitance.From the quality aspect, the increasing of freezing-thawing cycles lead to inevitable decline in meat quality. More thawing loss, cooking loss and higher TBARS value are found after freezing-thawing cycles. The precise calculation of the quality by impedance measurement could not be obtained for no accordant significant correlation ($P>0.05$) was found between impedance properties and quality parameters in different groups.Radial Basis Function (RBF) Neural Networks that are built up based on impedance magnitude and phase angle of specific frequencies from 50 Hz to 200 kHz (Total 12 frequencies) could give a solution to estimate the freezing-thawing cycles of meat without complex mathematics modeling, and the prediction accuracy satisfies the requirement. Accuracy of the testing samples of fresh chicken meat was up to 100 percent, one time freezing-thawing cycle samples also had a high degree of distinction from two and three times. These results reflect that electrical impedance measurement is a simple innocuous tool for frozen meat characterization. For improving the measurement accuracy, a dadatabase with a big enough data volume needs to be built in future work.

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