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鲜虾卸压超冷速冻过程中的热变化和冰晶形态

Study on thermal behavior and ice crystal formation in pressure shift freezing of shrimp

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中文摘要:

冷冻过程中样品的热变化和冰晶形态是反映冷冻方法对产品品质影响的重要特征，为了开发高品质的冷冻虾产品，研究了鲜虾在卸压超冷冷冻过程中的热变化和冰晶结构形态，分析了冷冻过程中温度变化和冰晶的截面积、当量直径、圆度和拉伸度，以及其粒径分布，并与传统冷冻法进行了比较。空气冷冻、液体浸没冷冻、卸压超冷速冻（100，150和200 MPa）形成的冰晶截面积依次分别为：5 002.47，901.79，2 851.93，1 364.42和597.36 μm2；圆度分别为0.73，0.86，0.87，0.90和0.85；拉伸度分别为2.11，1.65，1.54，1.55和1.58。试验结果表明：空气冷冻结冰所需时间最长（154 min），形成较大且不规则的冰晶，对虾肉组织造成不可逆破坏；液体浸没冷冻速率相对较快（5.9 min），形成的冰晶比空气冷冻的小；200 MPa的卸压超冷速冻形成的冰晶颗粒最小最均匀，冰晶形成时间最短（2.1 min），能最大限度地保持虾的品质。研究结果为卸压超冷速冻在虾的产业化生产应用中提供参考。

英文摘要:

Abstract: In order to investigate the production of high valued shrimp frozen by different methods, fresh shrimp (Penaeus monodon) were frozen either by pressure shift freezing (PSF) at 100 MPa (-8.4℃), 150 MPa (-14℃) and 200 MPa (-20℃) or by air blast freezing (ABF) at -20℃ and liquid immersion freezing (LIF) at -20℃. Thermal behavior and ice crystal formed in the freezing process are characterized as indicators of the fitness of the freezing methods on shrimp, therefore, the temperature and phase transformations of the shrimp samples were recorded during different freezing processes, and the microstructures of ice crystals formed were analyzed for cross-section area, equivalent diameter, roundness and elongation, ice size, shape, and location. These factors were evaluated and compared in different freezing processes. The mean (±standard deviation) cross-section area of ice crystals were: 5 002.47±2655.13, 901.79±392.23, 2 851.93±1429.96, 1 364.42±397.66 and 597.36±216.49 μm2 for the shrimp samples subjected to air blast freezing, liquid immersion freezing and three levels of pressure shift freezing at 100, 150, and 200 MPa, respectively, as compared with that of the muscle fibers (6.23±1.71 μm2). The roundness of the ice crystals formed in different freezing processes was: 0.73±0.10, 0.86±0.09, 0.87±0.10, 0.90±0.06 and 0.85±0.07 for shrimp, respectively, while the roundness of the muscle fibers was 0.95±0.09. The elongation of the formed ice crystals in shrimp samples were 2.11±0.58, 1.65±0.41, 1.54±0.34, 1.55±0.29 and 1.58±0.36, respectively, while the elongation of the fresh muscle was 1.52±0.25. Air blast freezing, which finished the ice formation process within 154 min, created larger and irregular ice crystals, which resulted in severe and irreversible damage to shrimp muscles and caused degradation of the value of the shrimp. Liquid immersion freezing produced smaller ice crystals than air blast freezing and finished the freezing process at a higher speed within 5.9 min. The quick process created finer ice crystals than air blast freezing, while the ice crystals were less regular than that of the pressure shift freezing (PSF) processes. Pressure shift freezing created a better ice crystal with a smaller cross-section area, higher roundness and lower elongation, especially at a higher pressure level within the pressure range of 0.1-200 MPa. The ice crystals formed in the PSF process were distributed all over the sample. What's more, the complete ice formation time was the shortest (2.1 min) for PSF at 200 MPa, -20℃ of all freezing methods in this study. Microscopic images clearly showed that the muscle fibers were well maintained in the PSF treated shrimp tissues as compared with traditional freezing methods. The area-cumulative distribution indicated that the ice crystals in the frozen shrimp created by 200 MPa PSF were the best, with smaller size, regular shape, and good distribution. The results achieved in this research provides a better understanding of the SF process of shrimp and are useful technical support for the application of PSF in shrimp preservation. PSF was concluded to be a promising freezing method for producing frozen shrimp.

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