RESEARCH ON RHEOLOGICAL PROPERTIES AND NMR SPIN-SPIN RELAXATION TIME OF HIGH-PRESSURE MINCED PORK

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The purpose of the research is to establish the nature of the influence of high pressure on the rheological properties and NMR spin-spin relaxation time of minced pork treated with high pressure.

Main research results. Storage modulus (G′) is a key index for rheology properties of meat proteins, which is correct with the elastic behavior of the solid-like components and directly affects the gel properties of meat batter. We obtained the following experimental data about the effects of G′ on raw batters with soy protein isolate treated by different pressures from 20 °C to 80°C in Fig. 1.

All the curves of the changes on G′ were similar, and they had a typical curve of dynamic rheology with three phases caused by meat proteins denaturation during heating. Firstly, the initial G′ value was increased from 8.22 kPa to 18.50 kPa with the increase of pressure, the result indicated that HPP processing could induce the denaturation of meat proteins and soy protein isolate, and form a weakened gel structure, which led to the G′ value to increase.

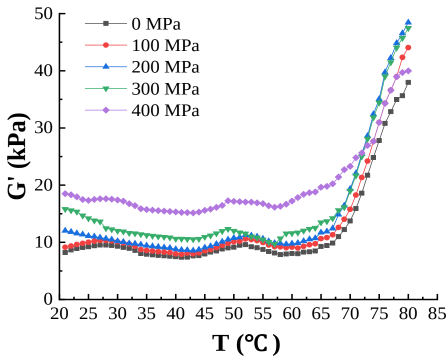

Fig. 1 The changes in storage modulus (G', kPa) of cooked batters with soy protein isolate treated by different pressures

After that, due to the pork back-fat melting and the protein unfolding with increasing the temperature, the G′ value was slightly decreased from 20 °C to 41 °C (0.1 and 100 MPa), and 43 °C (200, 300 and 400 MPa), respectively. In the second phase, because of the protein-protein interactions and weak gel formation, the G′ values of 0.1 and 100 MPa were slowly increased from 42 °C to 52 °C, the 200 MPa was slowly increased from 44 °C to 52 °C, while the 300 MPa and 400 MPa were slowly increased from 44 °C to 49 °C, respectively. Immediately, the G′ values of 0.1 MPa. 100 MPa and 200 MPa were slowly decreased from 53 °C to 58 °C, while 300 MPa and 400 MPa were slowly increased from 50 °C to 57 °C, respectively. The different changes were caused by the different pressures, because the myosin has partial denaturation when the pressures were 300 MPa and over. The other, some researchers reported that soy protein isolate and HPP processing combined can decrease the pre-gel effects produced by the denaturation of myosin tails. Thus, HPP processing and added soy protein isolate could lower the change in G′ values, which are caused by the denaturation of the myosin tails. In the third phase, a rapid increase in G′ value was occurred from approximately 58 °C to 80 °C, that implying the viscous sol was transformed into an elastic gel. In addition, the differences were possible caused by the denaturation of β-conglycinin (7S), it is present in the proportion of 27% of total soy protein isolate content, and the denaturation temperature is about 68 °C. Herein, the techno-functional properties of β-conglycinin was affect by the different pressures, such as the water and fat holding capacity of soy protein isolate were increased after the HPP treatment. The G′ values at 80 °C of 0.1, 100, 200, 300 and 400 MPa were 37.97, 44.05, 48.44, 47.47 and 39.99 kPa, respectively. It is well known that the G′ values were higher, the gel was firmer.

The effects of initial relaxation time and peak ratio of cooked batters with soy protein isolate treated by different pressures are shown in Fig. 2.

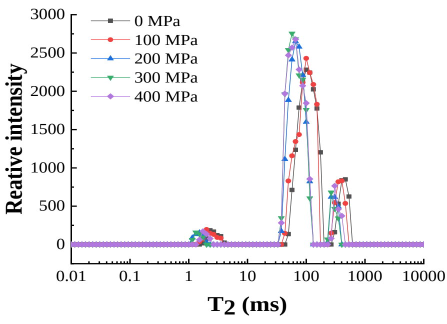

Fig. 2 Curves of relaxation time (T_2) in cooked batters with soy protein isolate treated by different pressures

The proton transverse relaxation time and peak ratio (T_2) can provide the information to evaluate the distribution and mobility of water in the cooked batter. Three peaks of T_{2b}, T_{21} and T_{22} are observed from 0.01 ms to 10000 ms in the inversion map of the nuclear magnetic intensity, and they are named bound water, immobilized water and free water respectively. The relaxation population of T_{2b} is centered at approximately 0-10 ms, it is assigned to water tightly associated to protein and macro-molecular constituents through the hydrogen bonding to polar groups. The relaxation population of T_{21} is located at 35-100 ms, it is represented to intra-myofibrillar water and water within the protein structure, indicating this water is loosely bound in the sol matrix. Opposite, T_{22} corresponds to extra-myofibrillar water and centered at approximately 100-350 ms.

Compared with the 0.1 MPa, the initial relaxation times of T_{2b}, T_{21} and T_{22} were quicker ($P < 0.05$) in the cooked batter treated by different pressures, implying that the water in the cooked batters treated by different pressures was tied closer. In addition, the samples of 200 and 300 MPa had the shortest initial relaxation times of T_{2b}, T_{21} and T_{22} ($P < 0.05$) among the treatments.

Conclusions. The result indicated that the cooked batters treated by 200 MPa and 300 MPa had good gel structure, this was in agreement with the result of cooking yield and texture properties. All the peak ratios of T2b in the cooked batters were not significant differences ($P > 0.05$). The samples of 200 and 300 MPa had the largest peak ratio of P21 and the smallest peak ratio of P22, meanwhile, the samples of 0.1 MPa and 100 MPa had the smallest peak ratio of P21 and the largest peak ratio of P22. We suggested the main reason is possible that the solubility of myofibrillar protein was increased, more hydrophobic residues and sulfydryl groups of raw batter were exposed when treated by HPP processing, which was favour of forming good structure and enhancing water holding capacity. The other reason is that due to the protein-protein interaction at pressure 400 MPa and above were formed at the expense of protein-water interactions and caused the aggregation, which could decrease the solubility of myofibrillar protein. Thus, excessive pressures led to the gel structure being worse and more water moving, causing the free water to increase and the immobilized water to decrease.

List of used literature

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THE PROCESS OF FERMENTATION IN INSTALLATIONS FOR BIOGAS PRODUCTION

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One of the ways of utilization of agricultural waste is biogas technologies, which make it possible to obtain highly effective organic fertilizers and energy in the form of biogas together with the solution of the environmental problem [1,2]. The biogas plant makes it possible to process various types of organic raw materials into fertilizers and energy.

The analysis of existing studies [2,3] shows that the development of biogas plants goes in two directions.

The first is a rational simplification and, accordingly, a reduction in the price of those installations, during the use of which the production of biogas is not the main goal compared to the requirements of ecological safety of the environment and production of highly effective organic fertilizers. These developments are usually offered for use in small farms.

The second direction is the creation of modern high-performance complete biogas plants based on the latest improved designs of bioreactors, modern automated technological process control systems, highly efficient thermal, electrical and technological equipment.

Since the decomposition of organic waste occurs due to the activity of certain types of bacteria, the environment has a significant impact on it [2]. The amount of gas produced largely depends on the temperature: the warmer it is, the greater the rate and degree of fermentation of organic raw materials.

Anaerobic fermentation in a bioreactor is a complex and unstable process, it is affected by both external and internal factors: [2,3]:

• external temperature;
• internal temperature of the environment;
• alkalinity of the environment, pH;
• the presence of inhibitor substances;
• fractional composition of the substrate and its humidity and