EFFECT OF HIGH HYDROSTATIC PRESSURE ON SAUSAGE BATTERS

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SUMMARY

Sausage meat batter having varying levels of meat, fat, water, salt, and phosphate were subjected to high pressure treatment (500 - 3800 bar / 5 min.) just before cooking. Pressures of 1000 - 2000 bar for 5 min. at approximately 10° C increased the cooking yield and improved the texture of low-salt and low-phosphate frankfurter-type sausages, especially those having low-fat and/or high added water contents, which otherwise had very unacceptable (soft and mushy) texture. With the application and release of pressure, there might be reorientation of some or all of the meat proteins that leads to increased cooking yield and firmer texture in low-salt and low-phosphate sausages. In formulations with higher salt and/or phosphate levels, pH of the sausage batters increased and also the meat proteins became more negatively charged thereby probably limiting the effect of high pressure on protein aggregation. At above 2000 bar, the effect was negative which could be due to the denaturation of meat proteins as shown by the DSC analysis of sausage batters, and also by the higher pH values and lower protein solubility values of sausage batters.

Introduction

Meat batter is better described as a highly viscous, protein sol with suspended fat particles (Whiting, 1988). It is necessary to dispense/solubilise the highly organized myofibrillar proteins in order to convert meat tissues into functional meat batters. This is usually achieved by chopping the meat in optimal concentrations of salt and phosphate. Only after an appropriate sol is formed, can the meat batter be thermally gelled to form a product with the desired texture.

Although the research about the effect of high hydrostatic pressure (HHP) on food systems dates back to the early part of this century, it is only recently that the food industry (especially the Japanese) has renewed the interest in the use of HHP because of its beneficial effect on food preservation and texture (Hayashi, 1989). Considerable work has also been done on meat and muscle proteins with the main emphasis being on the tenderness of meat (Macfarlane, 1985).

There have also been few studies carried out on the effect of HHP on meat protein functionalities. It was shown that HHP (1000 - 1500 bar) promotes the solubilisation of meat proteins in saline solution (Macfarlane 1974; Macfarlane and McKenzie, 1976). When pressure treated (200-1500 bar) myosin at pH 6.0 was subsequently heated, its gelling properties were improved (Suzuki and Macfarlane, 1984). All these studies, however, were carried out on model systems and not extended to normal meat production formulations. The present study was therefore conducted to see the effect of HHP (as a pre-treatment before cooking) on frankfurter-type sausage formulations with varying levels of meat, fat, salt, and phosphate.

Materials and methods

Sausage manufacture

Pork shoulders (48 h postmortem) and pork back fat were obtained from a local meat packing plant. All the visible fat and connective tissue was removed from the pork shoulders which was then ground using a 3 mm plate. Pork back fat was also ground using the same plate. Sausage batters (8 kg batches) were conventionally prepared using different levels of meat (50-60%), fat (0-25%), cured salt (1.5-1.8%), sodium diphosphate(0.5-3.0 g/kg meat and fat), and spices depending upon the formulation. These prepared batters were filled into 18 mm cellular peel-off casings and formed into 12 cm links. The raw sausage links were vacuum packed (6 links/each pack) before being subjected to high pressure treatment. Vacuum packed sausage links were subjected to pressure treatment (0-3800 bar/5 min/~ 10° C) with a National Forge High Pressure equipment (8.5 l / 0-4000 bar). Cold water (1-7° C) was used as the pressurising medium. After pressurisation, sausage links were removed from plastic bags and cooked with Rational Combisteam type C11 (program 1) or Autotherm type 6249 (Program 2). After cooking, sausages were chilled (4° C for 16 h), peeled, and vacuum-packed. All the experiments were replicated three times.

Program 1 (Rational Combisteam - type C11)

Temp. (° C)	Humidity (%)	Time (min)
55	60	20
65	60	30
75	100	25

Program 2 (Autotherm - type 6249)

	Temp. (° C)	Humidity (%)	Time (min)
Warming	50	60	17
Drying	55	37	7
Steam smoking	68	--	10
Steam cooking	72	--	12
Showering	--	--	5

Analysis of Raw Meat Batters

pH was measured directly in control and pressurized meat batters using Beckman pH meter (Model 40) fitted with a glass electrode (model 39533). Each measurement was duplicated.

Protein solubility was measured on meat batters (meat 60%, fat 5%, ice 35%, salt 1.5%, and phosphate 0.5g/kg of meat fat) and also minced meat samples using the methods of Steinmann and Fischer (1993). Ten grams of sample was homogenized with 90 ml of 2% NaCl solution using Omni mixer at top speed for 1 min. Homogenates were centrifuged at 30 000 g for 10 min. at 4° C. Supernatants were analyzed for protein content and results were expressed as percent of total protein content of the meat batters. Each measurement was duplicated.

Protein denaturation of meat batters (50% meat, 48% ice, and 2% salt) subjected to 1000, 2000, 3000, and 3800 bar pressure for 5 min. was studied using DSC analysis. A sample of about 650 mg was sealed in the sample cell of Micro-DSC system (SETARAM, France) and heated from 10 to 90° C at a heating rate of 1° C / min. Water was used as reference material. Denaturation of meat proteins was observed in calorimetric metric curves and the enthalpies were calculated. Each measurement was duplicated.

Analysis of Cooked Sausages

Cooking yields were calculated from the weights taken before and after cooking. %yield = Weight after cooking, cooling and peeling/weight of raw product X 100.

Textural measurements of sausages were done using an Instron Universal Testing Machine type 1140. For frankfurter-type sausages, 2.5 cm long samples were sheared with W-B shear using cross-head and chart speeds of 100 mm/min. Each measurement was replicated 10 times.

Results

Raw Meat Batters

There was no change in pH up to 1000 bar but pH was higher at 2000 bar and above indicating denaturation of meat proteins (Table 1). Protein extractability values show that up to 1000 bar, there was no change (in meat) or slight decrease (in meat batter). However, at 2000 bar and above, protein extractability decreased significantly. This again confirms that pressures above 2000 bar denatures the meat proteins thereby limiting their functionalities. These results are further confirmed by the DSC analysis of raw meat batters. Enthalpy values (Table 2) show that meat proteins start to denature at pressures of 2000 bar and above.

Frankfurter-type sausages

Full-fat (25 %) sausages with low-salt (1.5 %) levels

Two types of sausages were made with the same amounts of lean meat (50 %), fat (25 %), water (25 %) and salt (1.5 %) but one had lower levels of phosphate (0.5 g / kg of meat and fat) whereas the other had normal levels of phosphate (3.0 g / kg of meat and fat). In sausages with low-phosphate levels, pressurisation resulted in slightly higher cooking yields and much firmer samples with the highest increases at 1000 - 2000 bar (Table 3). However, pressurisation had no influence on the sausages with normal phosphate levels.

Low-fat (7 %) sausages with low-salt (1.5 %) levels

Three types of sausages were made with the same amounts of lean meat (60 %), fat (5 %), water (35 %) and salt (1.5 %) but differed in phosphate levels i.e with no phosphate, low phosphate (0.5 g / kg of meat and fat) and normal phosphate (3.0 g / kg of meat and fat) levels. In sausages having no or lower phosphate contents, pressurisation resulted in higher cooking yields and firmer texture with the highest values being at 2000 bar (Table 4). In sausages having normal phosphate content, pressurisation had no influence on the cooking yield although the texture was slightly firmer.

Low-fat (7 %) sausages with normal salt (1.8 %) levels

Three types of sausages were made with the same amounts of lean meat (60 %), fat (5 %), water (35 %) and salt (1.8 %) but differed in phosphate levels i.e with no phosphate, low phosphate (0.5 g / kg of meat and fat) and normal phosphate (3.0 g / kg of meat and fat) levels. In sausages with no or normal phosphate contents, pressurisation had no beneficial effect on the cooking yield but sausages were firmer in texture with maximum values being at 1000 and 2000 bar (Table 5). However, in sausages with low-phosphate content, pressurisation at 1000 and 2000 bar resulted in higher cooking yields besides making the sausages firmer.

Low-fat (7 %) and full-fat (25 %) sausages with low-salt and - phosphate levels

From the previous formulations, both low-fat and full-fat formulations with low-salt (1.5 %) and low-phosphate (0.5 g / kg of meat and fat) levels were again tested but this time with normal levels of spices, ascorbate and dextrose, and cooked with a different cooking program (No. 2). The results indicate (Table 6) that pressurisation resulted in higher cooking yields and firmer sausges but the effect was more pronounced in low-fat sausages.

Discussion

These results clearly indicate that pressurisaion was beneficial in increasing the cooking yields and improving the texture of sausges having low levels of salt and phosphate. The effect, however, was much more pronounced in low-fat (7 %) formulations than in full-fat (25 %) formulations. Generally, it can be concluded that optimum pressure range lies in between 1000 and 2000 bar depending on the formulation and cooking conditions. At above 2000 bar, the effect was negative. This could be related to the fact that pressures above 2000 bar denatured the meat proteins as shown by the DSC analysis, and also by the higher pH values and lower protein solubility values.

The reason for the positive effect of pressurisation at 1000 and 2000 bar in low-salt and low-phosphate formulations is far from clear. Previous studies (Macfarlane, 1974; Macfarlane and McKenzie, 1976) showed that pressurisation (1000 - 1500 bar) increased the solubilisation of meat proteins in saline solution. However, Macfarlane and McKenzie (1976) noted that at low concentrations of KCl, solubilisation of myosin from suspensions of myofibrils was not increased.

Suzuki and Macfarlane (1984) observed that pressure (200 - 1500 bar) treated myosin at pH 6.0 had improved gelling when it was subsequently cooked. They suggested that the alteration in heat setting properties was due to depolymerisation, under pressure, of myosin filaments accompanied by a conformational change of the monomer so that it reaggregated in a different manner upon the release of pressure. Therefore, with application and then release of pressure, there might be a reorientation of some or all of the meat proteins that leads to increased cooking yield and firmer texture in low-salt and low-phosphate formulations. In meat systems with higher salt and/or phosphate levels, pH of the meat batters increase and also the proteins become more negatively charged thereby limiting the effect of high pressure on protein aggregation. Suzuki and Macfarlane (1984) also observed in myosin model systems that high pressure improved the gelling of myosin at pH 6.0 but not at 7.0.

Without some processing aid or some additives, it is not possible to obtain good texture in meat products when the salt and phosphate contents are low. This study shows that high pressure could be used as processing aid to improve the cooking yield and texture of low-salt and low-phosphate meat products, especially those having low-fat and/or high added water contents. Also, as the pressures needed are only about 1000 - 2000 bar, the processing costs will not be very expensive. However, depending on the formulation, further work has to be done to optimise pressure, temperature and time, and also cooking conditions.

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