WPI-PECTIN-COMPLEXES AS NOVEL TOOLS TO STRCUTURE MEAT PRODUCTS

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Abstract – There is considerable interest in using structural design principles such as complex coacervation to develop functional foods in order to combat overweight and obesity. This paper describes the effect of biopolymer complex addition that are composed of whey protein isolate (WPI) and sugar beet pectin on structural and sensory properties of fat reduced emulsion type sausages. Firstly, biopolymer particles with various biopolymer ratios (WPI:pectin 2:1, 5:1, 8:1) were prepared by complex coacervation under acidic conditions (pH 4). Secondly, biopolymer particles generated were heated (80°C, 20 min) to induce covalent bonds between oppositely charged biopolymers. Thirdly, a standard recipe was used to incorporate heat-treated complexes into emulsion type sausages (50% pork meat, 12.5% pork fat, 12.5% biopolymer complexes, 25% water) as fat replacer. Results obtained by texture profile analysis and CLSM indicated that biopolymer particles having a high protein content were readily incorporated into the meat protein matrix. These observations were confirmed by a sensory evaluation. The results suggest that biopolymer particles generated by complex coacervation have the potential to be used as fat replacer in emulsion type sausages.

Key Words – Emulsion type sausages, Fat replacer, Structure and texture.

I. INTRODUCTION

There is a growing interest in the development of healthy and nutritional food products that combat high energy intakes, overweight, and obesity [1]. In recent years, the food, pharmaceutical, cosmetic, and health industry utilize biopolymer particles composed of proteins and polysaccharides for a wide variety of applications [2, 3]. In particular, biopolymer particles have gained interest as fat replacer and texture modifier in foods. As such, it was shown that texturized proteins in meat analogues significantly impact their sensory properties [4]. Both, proteins and polysaccharides such as milk proteins and pectins are generally recognized as safe (GRAS), have a high nutritive value, and can be used as thickening, gelling, or stabilizing agents.

In general, complexes between milk proteins and pectins are formed by attractive forces acting between oppositely charged biopolymers. Recently, stable biopolymer particles with sizes between 200 and 2000 nm were produced in aqueous solutions, whereas molecular (e.g. concentration, chain stiffness, charge density) and environmental factors (e.g. pH, ionic strength, temperature) determine their size and internal structure [2, 5].

The objective of the current study was investigate the use of biopolymer complexes as potential texture modifier and fat replacer in meat products. Therefore, emulsion type sausages enriched with biopolymer complexes were produced, whereas the biopolymer ratio was varied between 2:1 and 8:1. We hypothesized that biopolymer complexes having a high protein content were readily incorporated into the meat protein matrix due to strong protein-protein interactions. Initially, mixed whey protein isolate (WPI) and sugar beet pectin solutions were adjusted to pH 4 leading to complex formation. Biopolymer particles were then heat-treated and subsequently mixed into the meat batter to obtain fat reduced emulsion type sausages. Both, single WPI and beet pectin solutions were used as control samples.

II. MATERIALS AND METHODS

Materials

Whey protein isolate (WPI 895) was obtained from Fonterra (Auckland, New Zealand). As stated by the manufacturer, the composition of the WPI was 93.9% protein (69.2% β-lactoglobulin, 14.2% α-lactalbumin), 4.7% moisture, 0.3% fat, 0.4% carbohydrates, and 1.5% ash. Sugar beet pectin (Betapec RU 301) was donated by Herbstreith & Fox KG (Neuenbürg, Germany). According to the manufacturer, the degree of esterification was 55%.

Preparation of WPI-pectin-complexes (coacervates)

Aqueous biopolymer solutions were prepared by dispersing powdered whey protein isolate and sugar beet pectin in double-distilled water. The pH was adjusted to 7. After complete hydration, stock biopolymer solutions were mixed at various protein-to-pectin ratios (2:1, 5:1, 8:1), whereas the total biopolymer concentration was 12.5%. Single protein and pectin solutions having the same biopolymer concentration were used as control samples. Subsequently, hydrochloride acid was added to induce complex formation at pH 4. All complexes generated were heated at 80°C for 20 min. Before sausage production, the pH of the complex dispersions was set to a pH value of 5.8 to avoid pH-induced impacts on the sausage formation.

Preparation of coacervate-enriched emulsion type sausages

Two approaches were utilized to prepare emulsion type sausages as shown in Figure 1: control (process A) and coacervate-enriched sausages (process B). Sausages were manufactured from 50% pork meat, 25% pork fat, and 25% water. Meat and fat were separately passed through a meat grinder (3 mm endplate, type WD-114, Seydelmann KG, Stuttgart, Germany). Meat was added to a bowl chopper (type K64 VA-K, Seydelmann KG, Stuttgart, Germany) and half the water (as ice), 1.8% nitrite-enriched curing salt (NCS), and 0.1% sodium di-phosphate were added. The mix was chopped until a temperature of 2°C was reached. Minced fat, 0.05% ascorbic acid, and 0.5% of a spice blend was added, whereas the meat batter was further processed until a temperature of 10°C was reached. Subsequently, the ice water remaining was added to achieve a temperature of 6°C.

For the addition of biopolymer particles, a portion of the processed meat or sausage mix (5 kg) was transferred to a bowl chopper (type K20 Ras, Seydelmann KG, Stuttgart, Germany) and biopolymer dispersions were added and mixed for 105 sec. The meat batter did not exceed a temperature of 10°C. Afterwards, the meat batter was filled in plastic casings (inline coated cellulose casing, type Nano Top, 60 mm diameter, Kalle, Wiesbaden, Germany). The filled casings were thermally processed for 90 min at 76°C and subsequently stored at 2°C prior to analysis (Figure 1).

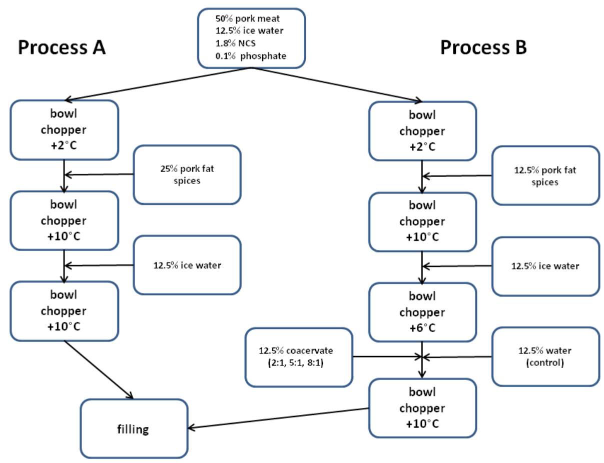

Figure 1. Preparation of emulsion type sausages without (Process A) and with biopolymer particles (Process B).

Sample analysis

Water, protein, and fat content of sausages were analyzed according to the AOAC methods [6]. Water binding capacity of the raw meat batters was determined gravimetrically after a heat treatment (45 min at 98°C). Firmness of sausage slices was measured in an Instron 1011 texture analyzer. Photographic images were taken under defined conditions with a Pentax K5. CLSM images were taken to visualize the microstructure. Color of sausage cross sections was captured in the CIE L*a*b* color space with a Konica Minolta chromameter CR-200 (Illumination at D_{65}). Sausage slices were evaluated by a trained panel (n = 20) regarding firmness and taste. Results were analyzed with statistical software SAS 9.3 from SAS institute (Cary, USA).

III. RESULTS AND DISCUSSION

The data obtained after chemical analysis of all emulsion type sausages containing coacervates are shown in Table 1. Moreover, the pH (6.0 - 6.1) and a_w-values (0.966 - 0.974) of the sausages was not affected by the addition of biopolymer particles. However, water binding capacity (WBC) significantly increased when biopolymer particles were utilized instead of pork fat.

Table 1 Water, fat, and protein content of emulsion type sausages containing coacervates (WPI:pectin ratio) or biopolymer solutions.

Sample	Fat (%)	Water (%)	Protein (%)
Control (Standard)	21.3 ± 0.3	65.4 ± 0.2	11.1 ± 0.0
Control (Water)	12.8 ± 0.3	74.2 ± 0.2	11.7 ± 0.1
Control (WPI)	11.2 ± 0.0	71.5 ± 0.4	14.1 ± 0.1
Control (Pectin)	11.8 ± 0.2	69.1 ± 0.6	10.5 ± 1.2
Coacervate 2:1	12.1 ± 0.1	71.5 ± 0.3	12.7 ± 0.1
Coacervate 5:1	12.2 ± 0.3	71.7 ± 0.5	13.3 ± 0.1
Coacervate 8:1	12.6 ± 0.3	71.6 ± 0.3	13.4 ± 0.1

Moreover, the results showed that the addition of biopolymer complexes impacts the microstructure of emulsion type sausages. CLSM images taken demonstrated that the biopolymer particles interrupt the protein matrix of the sausages leading to a softer texture.

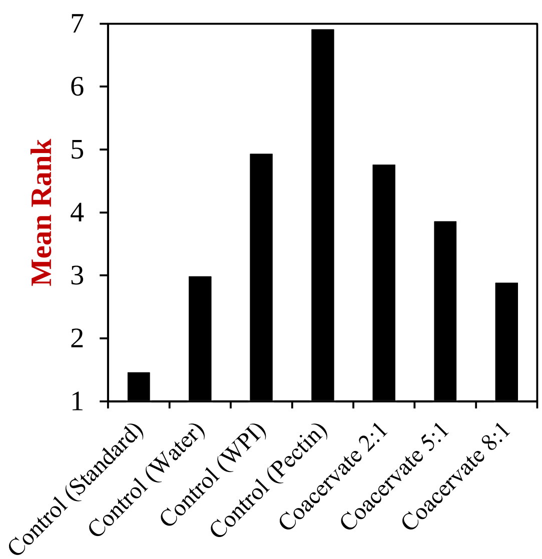

Figure 2. Rank sum of emulsion type sausages containing biopolymer particles (n = 20; 1 = most firm, 8 = most soft).

The sensory panel evaluated the firmness and overall appearance of sausage slices in a rank order test (Figure 2). It was demonstrated that higher protein concentrations incorporated in biopolymer particles increased the firmness of the sausage. However, coacervate-enriched sausages were still softer than the control samples - a fact that was confirmed by texture profile analysis (Figure 3).

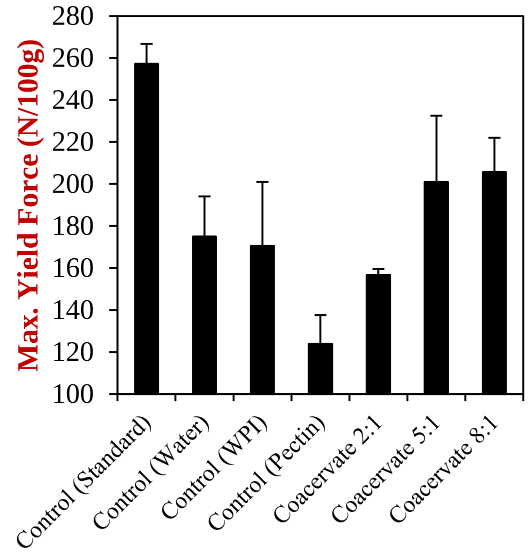

Figure 3. Max. yield force of emulsion type sausages containing biopolymer particles (WPI:pectin ratio).

IV. CONCLUSION

The study has shown the biopolymer particles composed of whey protein isolate and sugar beet pectin have the potential to be used as fat replacer in emulsion type sausages. In particular, increasing protein concentrations within the biopolymer complexes seem to be included in the meat protein matrix. However, further investigations are needed in order to optimize the dosage level or fat replacement. In addition, biopolymer particles might be also utilized as fat replacer or texture modifier in other meat products such as raw fermented sausages. As such, this study is a first step into this direction.

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