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Effect of regenerated cellulose fiber on the physicochemical properties and sensory characteristics of fat-reduced emulsified sausage

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ABSTRACT

The purpose of this study was to assess the effects of regenerated cellulose (RC) fiber on the quality and sensory characteristics of fat-reduced emulsified sausages. The pork back fat contents of traditional emulsion sausage were reduced from 30% to 20% by the supplementation of RC fiber with the concentrations of 0, 0.4%, 0.8% and 1.2%. The results indicated that reformulated sausage with RC fiber had significant effects on approximate composition, color, emulsion stability, texture, lipid oxidation, apparent viscosity and sensory evaluation. The treatments with RC addition showed a significant reduction in fat content and lipid oxidation compared to control samples ($P < 0.05$). With the levels of RC increased, the fat-reduced sausages had higher L* values, enhanced emulsion stability, increased the raw meat batter viscosity and improved texture including hardness, gumminess and chewiness ($P < 0.05$). The highest score for overall acceptability was the emulsified sausage containing 0.8% RC fiber. It is concluded that 20% fat emulsified sausage with incorporation of 0.8% RC fiber can be effectively to reduce fat content without deteriorating the quality and sensory characteristics.

1. Introduction

Fat is well known to play an important role in improving the quality of the emulsified meat product (Kim et al., 2010). Fat contributes to improve the stability of the meat emulsion system, reduce cooking losses, provide flavor as flavor precursor, enhance texture and provide the product suitable hardness and juiciness mouth feel (Matsuishi, Igeta, Takeda, & Okitani, 2004; Yoo, Kook, Park, Shim, & Chin, 2007). The animal fat content of traditional emulsion sausages could be as high as 30% (Choi et al., 2009). However, many studies have indicated that the intake of animal fat is associated with many chronic diseases such as hypertension, cardiovascular disease, diabetes and obesity (Oezvural & Vural, 2008; Vickery & Rogers, 2002). Therefore, the production of fat-reduced meat products has become an important direction for food industry. Thus, it is a challenge to food processors to reduce the fat content of meat products while maintaining or improving the quality and sensory property of fat-reduced meat products.

In recent years, many researches have reported that meat products could be manufactured by adding some functional ingredients as fat substitutes. These practices could offset the adverse influence of the modified formulation and thus maintain product characteristics (Giese, 1992; Zhang, Xiao, Himali, Lee, & Ahn, 2010). For example, dietary fiber from different sources has been added to meat products as mean to replace fat such as pineapple fiber (Henning, Tshalibe, & Hoffman, 2016) and cellulose fiber (Bastianello Campagnol, dos Santos, Wagner, Terra, & Rodrigues Pollonio, 2012). The dietary fiber provides technological functions such as enhancing water-binding capacity and improving texture without affecting organoleptic quality.

However, the insoluble fiber is defective due to its poor water retention and imbalanced distribution which may lead to the rough mouth feel of meat products. These characteristics prevent the application of dietary fiber in food industry. Thus the modification of insoluble fiber to improve water-soluble property, water holding capacity and dispersion has become an important research field (Yamazaki, Murakami, & Kurita, 2005; Yang, Ma, Wang, & Zheng, 2017). The regenerated cellulose (RC) is derivative from microcrystalline cellulose (MCC) and could be produced by a modification method of acid dissolution and water regeneration. Compared to MCC, RC possesses gel properties, high water-binding capacity and emulsion stability (Hu, Xing, et al., 2016). In addition, the gel-like RC has a similar appearance and mouth feel to the animal fat and hardly interacts with other nutrients (Jia et al., 2013). Therefore, RC is recognized as the potential fat substitute directly to replace the fat in meat products. However, there were no previous studies to investigate the effects of gel-like RC as fat substitute on the quality of emulsified sausages. The objective of this study was to assess the effect of fat-reduced emulsified sausage on

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approximate composition, color, emulsion stability, texture property, lipid oxidation, sensory quality and apparent viscosity by adding different levels RC fiber at 0%, 0.4%, 0.8% and 1.2%.

2. Materials and methods

2.1. Process of RC preparation

The RC fiber was prepared using the method of Jia et al. (2013) with some modification. The 4 g of commercial MCC (Linghu Xinwang Chemical Company, Huzhou, China) and the 16 mL deionized water were mixed following with the addition of 160 mL of 85% food grade phosphoric acid. The ratio of MCC to deionized water and phosphoric acid was 1:4:40 (g/ml/ml). A homogeneous cellulose suspension was obtained by stirring. Then cellulose suspension was incubated with shaker at a rate of 150 rpm for 24 h at 4 °C to obtain a clear and viscous solution. The viscous cellulose solution was diluted with deionized water and the ratio of MCC to diluted deionized water was 1:50 (W:V, g/ml). The resulting cellulose suspensions presented a white emulsion suspension and centrifuged at 16,500 g for 20 min. The washing and the centrifugation process were repeatedly carried out until the pH was constant at 6 to 6.5.

The 5.00 g RC fiber was placed in an evaporating dish and weighed. Then they were dried in a drying oven (DGG-9240A, Senxin Company, China) at 105 °C until constant mass for about 3–4 h. After cooled to room temperature they were weighted again. Then the RC fiber concentration was calculated and the three groups of data were averaged. The final concentration of the gelatinous cellulose was 4.43%.

2.2. Manufacture of emulsion sausages

Fresh lean pork meat (moisture 71.63%, protein 21.16%, fat 4.83%) and the back fat of pork (moisture 13.07%, fat 86.37%) were obtained from Yurun Company (Jiangsu, China). The connective tissue and the intramuscular fat of fresh pork muscle were removed. The lean pork and the pork fat were ground through a meat grinder (8 mm diameter) and the ground meat was vacuum packaged and stored at −20 °C until being used to produce emulsified sausages. Five different formulations of emulsified sausages are shown in Table 1. The first group of emulsified sausage as the control formulated with 1 kg lean pork meat and 0.6 kg pork fat so that the sausage contained 30% fat. The other four groups of fat-reduced (20% fat) emulsified sausage prepared with 1 kg lean pork and 0.4 kg pork fat and with different RC fiber levels (0%, 0.4%, 0.8%, 1.2%) were expressed as RC-0%, RC-0.4%, RC-0.8% and RC-1.2%. Firstly, the pork meat was homogenized and ground by a vacuum chopper at 1500 rpm for 30 s. Then salt (1.5%), sodium tripolyphosphate (0.3%), sucrose (0.5%), white pepper (0.24%) and ice water were added and chopped for 30 s at the 3000 rpm. Subsequently, pork back fat or RC were added to the batter and mixed at 3000 rpm for 1 min. Finally, the remaining half of ice water was added and shredded at 3000 rpm for 1.5 min to obtain meat batter. The temperature of meat batter was not higher than 12 °C throughout the whole production process. Part of the raw meat batter was directly placed into the 4 °C for the determination of emulsion stability and apparent viscosity. The rest of the batter was vacuum filled into 25 mm diameter collagen casings and cooked in an 80 °C water bath to the core temperature of 72 °C. After cooling to room temperature, the samples were stored at 4 °C until further analysis within 7 d. The four batches of sausages were replicated at different days and each batch was considered as replication for statistical analysis.

Table 1
Formulation of emulsified sausage with various levels of RC fiber (g/100 g).

Ingredients	Treatments				
	Control	RC-0%	RC-0.4%	RC-0.8%	RC-1.2%
Pork meat	50	50	50	50	50
Pork fat	30	20	20	20	20
Ice water	20	30	21	12	3
RC fiber gel	0	0	9	18	27
Total	100	100	100	100	100
Salt	1.5	1.5	1.5	1.5	1.5
Sugar	0.5	0.5	0.5	0.5	0.5
Sodium tripolyphosphate	0.3	0.3	0.3	0.3	0.3
White pepper	2.4	2.4	2.4	2.4	2.4

Control: Treatment with 30% pork back fat.
RC-0%: Treatment with 20% pork back fat without RC fiber.
RC-0.4%: Treatment with 20% pork back fat with 0.4% RC fiber.
RC-0.8%: Treatment with 20% pork back fat with 0.8% RC fiber.
RC-1.2%: Treatment with 20% pork back fat with 1.2% RC fiber.

2.3. Proximate composition

Compositional analysis including moisture, fat and protein content of emulsified sausages was performed. The moisture content was determined by drying 3 g samples at 105 °C with a drying oven (DGG-9240A, Senxin Company, China) for 12 h. The content of fat was measured following the method of Bligh and Dyer (1959). The protein concentration in the sausages was evaluated with a Kjeldahl nitrogen analyzer (Kjeltec 2300, Foss Company, Denmark). Three samples of each replication were carried out and the average values were used for statistical analysis.

2.4. Color measurement

The color of emulsified sausages was determined using a colorimeter (CR-40, Minolta Camera, Japan) with illuminate C, 8 mm diameter of aperture and 2° standard observer. The colorimeter was calibrated with a white plate ($L^* = 96.86$, $a^* = -0.15$, $b^* = 1.87$) before color measurement. The average of six samples per batch was evaluated. The values of L^* (lightness), a^* (redness) and b^* (yellowness) were obtained from three different areas of sausages.

2.5. Emulsion stability

The emulsion stability was determined according to Gao, Zhang, and Zhou (2015) with some modifications in four replicates for each treatment per batch. Determination of emulsion stability was actually a measurement of water and fat loss in sausages. The 30 g of raw meat batters were placed in centrifuge tubes. In order to remove air bubbles, the samples were centrifuged at 800 g for 5 min at 4 °C. Then the samples were placed into the 80 °C water bath for 20 min and immediately inverted for 60 min at room temperature to release fat and water flow to the plate. Total fluid release (TR) was expressed as the percentage of total liquid released and the initial weight of sample. The water release (WR) was measured by drying the TR at 105 °C for 16 h and expressed as the percentage of dry weight and initial sample weight. The percentage of residual material after drying and the initial sample was considered as the fat release (FR).

2.6. Texture profile analysis (TPA)

For the sausage samples, the TPA was performed according to the method of Gao, Kang, Zhang, Li, and Zhou (2015) with slight modification. Six samples (20 mm height and 25 mm diameter) for each formulation per batch were determined for hardness, springiness, cohesiveness, chewiness and gumminess at room temperature with a texture analyzer by cylindrical probe (P/50) (Stable Micro System, Surrey, UK). Before the analysis, the samples were allowed to stand at 20 °C for 3 h. The conditions were with the post-test speed being 5.0 mm/s, both the pretest speed and test speed being 2.0 mm/s and the strain being 50%.