A novel fat modification strategy in fermented sausages by incorporation of gelled emulsions with fig seed oil

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Abstract. Gelled emulsion (GE) systems are one of the novel proposals for reformulation of meat products with healthier profiles. In this study, the quality of fermented sausages formulated with fig oil seed-in-water GE as partial or total beef fat replacers were studied. Control sausages (C) consisted of 100% beef fat, whereas GE treatments were formulated by replacing 50% (G1) or 100% (G2) of beef fat. Total replacement of beef fat with GE (G2 sausages) did not change 2-Thiobarbituric acid reactive substance (TBARS) levels in the sausages, whilst G1 sausages containing 50% GE had the highest TBARS levels among the sausages. In general, TBARS levels tended to increase at the end of the storage. The highest total carbonyl content was measured in C sausages with 100% beef fat; however, the final carbonyl contents of the sausages were not different. All sensory parameters were within acceptable ranges; color scores were higher in G2 sausages than in C sausages, and the rest of the sensory characteristics were similar to each other. Finally, it was concluded that utilization of gelled emulsion systems consisting of fig seed oil GE as beef fat replacers has good potential to enhance the chemical and sensory quality of fermented sausages.

1. Introduction

In our modern world, consumers mostly associate meat with a negative image as a high-fat and unhealthy food, and thus, an important goal for the meat industry is to suggest novel fat modification strategies to satisfy consumer needs. In this regard, today, an important goal for the meat industry is to develop novel lipid modification strategies. Incorporation of gelled emulsion (GE) systems in meat product formulations could be counted as one of the novel approaches in lipid modification that ensures both suitable product yield and healthier composition. A GE is defined as “an emulsion with a gel-like network structure and solid-like mechanical properties” [1]. Although oil-in-water emulsions have been widely used for lipid modification, GEs could be a better option to mimic functional and sensory characteristics of the animal fat used in most of the currently consumed meat products [2]. Although some studies have indicated that utilization of gelled emulsions had positive effects on emulsified meat products [2-5], the impacts of GEs in the formulation of fermented meat products have not been yet extensively studied.

Fig seed oil is a healthy fruit oil that highly contains oleic, linoleic, and linolenic fatty acids and is produced from an important exotic fruit, fig, which is a good source of dietary fibers, minerals, and
polyphenols [6]. In this study, we aimed to investigate the effects of fig seed oil-in-water GE systems as beef fat replacers on oxidative and sensory quality of fermented Turkish sausages (sucuk).

2. Materials and Methods

Fresh boneless post-rigor beef (M. semitendinosus), beef fat, and other ingredients were purchased from a local market in Izmir, Turkey. Cold-pressed fig seed oil was kindly donated by Egesia Co. (Aydın, Turkey). GE system was prepared using the method of Pintado et al. [3] with modifications. Fig seed oil (52.5 g/100 g emulsion) was emulsified with the aqueous phase (47.5 g/100 g emulsion) containing 41.8 g water/100 g emulsion, 5 g egg white powder/100 g emulsion, and 0.7 g microbial transglutaminase/100 g emulsion. After the emulsification process, the emulsion was cooled to room temperature and then cold-set for 12 h at 4°C.

In the experimental design, each sausage treatment was adjusted to an initial total lipid content of 20%. Control (C) sausages consisted of 100% beef fat, whereas GE treatments were formulated by replacing 50% (G1) or 100% (G2) of the beef fat. Beef muscles and beef fat were separately minced through a 3 mm plate grinder (Arnica, Turkey). All ingredients (salt, saccharose, sodium nitrite, ascorbic acid, starter culture, cumin, garlic powder, sweet red pepper, and black pepper) were added to the treatments and homogeneously mixed. After stuffing into natural casings, the sausages were held at 22.5°C and 60% relative humidity (RH) for 3 h and 23°C and 88% RH until the pH reached 5.4 in a fermentation chamber (Wisd, South Korea). After fermentation, the sausages were ripened at 20-21°C and 80-85% RH until the moisture content reached 40%.

Oxidative stability of the sausages was analyzed by determining 2-Thiobarbituric acid reactive substances (TBARS) value [7] and total carbonyl content [8] throughout the 28 days of storage at 4°C. A sensory panel was carried out by 25 members using a 9-point hedonic scale (ranging from “like extremely” as 9 to “dislike extremely” as 1) to assess appearance, color, texture, flavor and overall acceptability of the sausage groups. Data were analyzed by One-Way Analysis of Variance (ANOVA) and Duncan’s Post-Hoc tests using the SPSS software for Windows (IBM, USA).

3. Results and Discussion

Lipid oxidation is one of the main causes for physical, sensory and nutritional quality deterioration in muscle foods. Since fermented meat products have relatively high lipid content, oxidation reactions could lead to changes in their chemical and/or sensory qualities. Analysis of TBARS is the most common method to determine the malonaldehyde concentration of meat products. TBARS values of the sausage groups are presented in Figure 1a. Initial TBARS values were between 1.064-2.104 mg malonaldehyde/kg sausage, indicating that oxidation reactions could occur during the fermentation and ripening periods. The results throughout the storage period showed that 100% replacement of beef fat with GE did not significantly change the oxidative stability of the sausages. Meanwhile, G1 sausages containing 50% GE had the highest TBARS values among the sausages during storage (P<0.05). This result showed that the amount of GE incorporated into the formulation did not have a decisive impact on lipid oxidation. Lower TBARS values in G2 sausages could arise from the more protective effect of GE against oxidation when incorporated solely, compared to incorporation as a mixture of beef fat and GE (G1 sausages). In general, TBARS values of the sausages tend to increase at the end of the storage due to the propagation of lipid oxidation secondary products (P<0.05). Wang et al. [9] reported that the replacement of pork back-fat with camellia oil gels decreased TBARS values of Harbin sausages significantly. In another study, it was found that lipid oxidation parameters showed higher susceptibility to oxidation in fermented sausages formulated with inulin línseed oil GE compared to conventional sausages [9]. Those results implied that the composition and characteristics of the unsaturated lipids in GE systems could be a determinative factor for oxidation level.

In recent years, protein oxidation of muscle foods has become a trending topic since the alterations in the proteins could cause many types of quality problems. One of the most noticeable modifications in oxidized food proteins has been highlighted as the generation of carbonyl compounds [11]. Initial carbonyl contents of the sausages (Figure 1b) were between 0.147-0.817 nmol/mg protein, and the
The highest carbonyl contents were found in C sausages with 100% beef fat ($P<0.05$). This data indicates that protein oxidation reactions in GE sausages could proceed more slowly during fermentation and ripening of the sausages. Although some fluctuations were observed in total carbonyl content of the sausages during storage, carbonyl contents mostly increased after 21 days ($P<0.05$). Nevertheless, the final carbonyl contents of the sausages were not statistically different. Overall results indicated that incorporation of GEs with fig seed oil showed promising impact on retarding lipid and protein oxidation during cold storage of fermented sausages.

Since animal fat is a crucial ingredient that effects flavor, mouthfeel, and texture of the meat products, modification of lipid composition could greatly alter the sensory characteristics. Therefore, assessment of sensory quality is necessary for products where animal fat is replaced with alternative lipid sources. Sensory scores of the fermented sausages are presented in Figure 2. Appearance, color, texture, flavor and overall acceptability of the sausages ranged between 6.10-7.11, 6.11-7.39, 5.17-6.00, 5.39-6.72, and 5.67-6.44, respectively. The results showed that all sensory parameters were within acceptable ranges. Color scores were higher in G2 sausages than in C sausages ($P<0.05$), indicating that panelists preferred the sausages formulated with 100% GE in terms of visual appearance. The rest of the sensory features were statistically similar to each other. The data is a good indicator of the promising effects of fig seed oil GE systems on sensory quality. In a similar study, it was reported that sensorial aspects of reduced-fat beef patties with microalgal oil gelled emulsions were similar to control patties with pork back fat [12]. Concordantly, Glisic et al. [10] found that fermented sausages formulated with inulin linseed oil GE were acceptable regarding all sensory attributes.
Figure 2. Sensory scores of fermented sausages. C: control sausage sausages formulated with 100% beef fat as lipid phase, G1: sausages formulated with 50% beef fat + 50% GE as lipid phase, G2: sausages formulated with 100% GE as lipid phase.

4. Conclusion
The present study indicates that fig seed oil GE systems in fermented sausages present favorable impacts in terms of oxidative stability and sensory scores. Utilization of this GE system showed that total fat replacement might be possible, since the GE system was able to maintain lipid and protein oxidation in the sausages at desired levels. Moreover, 100% GE sausages had better sensory scores than control sausages and sausages containing a mixture of GE and beef fat. Consequently, these fig seed oil GE systems could be used as novel animal fat replacers to develop healthier meat product formulations without altering chemical and sensory quality.

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