Effects of using chia (Salvia hispanica L.) mucilage and different cooking procedures on quality parameters of beef patties

Ö Yüncü1, H S Kavuşan1 and M Serdaroğlu1

1 Ege University, Engineering Faculty, Food Engineering Department, Bornova, İzmir, Turkey

E-mail: ozlemm_yuncu@hotmail.com

Abstract. This study was carried out to investigate the effects of chia (Salvia hispanica L.) mucilage (CM) as a fat replacer in grilled or pan-fried beef patties. For this purpose, beef fat was replaced by CM at levels of 0, 25, 50, and 75%. The use of CM and cooking method affected cooking-related parameters. Cooking yield was lower in pan-fried patties, while the addition of CM increased the cooking yield. Moisture retention, shrinkage, changes in diameter, and thickness of grilled patties were improved compared to the pan-fried samples. The addition of CM increased moisture retention, while shrinkage values decreased. Results of our investigation revealed that CM retarded oxidative changes in pan-fried patties. Textural parameters and sensory properties of samples were not negatively affected by the addition of CM.

1. Introduction

In recent years rising attention has been paid to specific types of healthy and beneficial food ingredients since consumers are becoming more health-conscious about the food in their diet [1]. Although meat and meat products occupy an important role in human nutrition as they provide valuable nutrients, such as proteins, vitamins, and minerals, they also contain saturated fat and cholesterol that are risky for cardiovascular diseases and some cancer types. From this point of view, the meat industry has attempted to develop low-fat meat products with desired properties by utilizing non-meat proteins, hydrocolloids, and replacing animal fat with plant/seed oils [1, 2].

Chia seeds contain significant amounts of dietary fiber (18-30%), protein (15-25%), natural antioxidants (tocopherol and polyphenols), vitamins, and minerals, and also, the seeds are good sources of omega-3 and omega-6 [3]. Moreover they increase the satiety index and have protective effects against cardiovascular diseases, diabetes, and cancer. A variety of chia forms such as seed [3, 4, 5] and flour [6, 7, 8] have been used as fat replacers, binders and extenders in comminuted meat products. The incorporation of chia seeds into various meat products retarded the progression of lipid oxidation [3, 4, 5]. It has been also observed that water holding capacity, cooking yield, and the amount of polyunsaturated fatty acids increased by the addition of chia flour to chicken nuggets [8] and fish burger [9]. However, some studies have shown that chia seed and flour caused undesirable sensory quality. The increasing amount of the chia flour/seeds decreased sensory acceptability in terms of texture, internal appearance, and flavor [4, 5, 6, 7]. When chia seeds are soaked in water, transparent and clear mucilaginous substances rapidly exude around the seeds. Mucilaginous seeds constitute mainly xylose and glucose together with uranic acid, glucuronic acid, galacturonic acid, arabinose, and galactose [10].
Chia mucilage (CM) is known to have both emulsifying agents and water-retaining properties. It has therefore become a promising fat substitute in bakery products [11]. However, to the best of our knowledge, limited research has been done on using CM in gel and powder forms as a pork fat substitute in model system pork emulsion, in which researchers reported that CM in powder form increased hardness and decreased elasticity; however, in gel form, it enhanced the textural properties [10]. Therefore, the aim of this study was to investigate the effects of utilization CM on chemical composition, lipid oxidation, technological and sensory quality characteristics of pan-fried and grilled beef patties.

2. Materials and methods

Post-rigor beef as boneless rounds and beef fat was kindly donated by MIGROS TRADE INC. Non-damaged whole chia seeds were purchased from a local market. Chia mucilage was prepared according to methods developed by Câmara et al. [10] and Brütsch et al. [12]. Chia seeds were downscaled and mixed with distilled water (1:10) and mixed on a magnetic stirrer at 45°C for 15-20 minutes to achieve full hydration. The viscous solution was centrifuged at 4100 rpm for 15 minutes to remove the excessive water. The water phase accumulated in the upper layer of the tubes was separated to obtain the CM to use in beef patty formulation as a fat substitute. CM was added to the patty formulation by replacing 0%, 25%, 50%, and 75% beef fat, and the following ingredients were added per kg meat mixture (Table 1); salt and spice mix (cumin, black pepper, and onion powder). The minced meat was mixed with beef fat and/or CM and other ingredients in a kneading machine (Mateka, Turkey) until a homogeneous mixture was obtained, then the patties were shaped by using a round metal mold (d:80 mm, h:1 cm). Subsequently, shaped patties were cooked by using two different cooking methods.

| Treatments | Beef meat (%) | Beef fat (%) | Chia mucilage (%) | Salt (%) | Spice mix (%) |
|------------|---------------|--------------|-------------------|----------|--------------|
| Grilled    |               |              |                   |          |              |
| CG0        | 76            | 20           | -                 | 2        | 2            |
| CG25       | 76            | 15           | 5                 | 2        | 2            |
| CG50       | 76            | 10           | 10                | 2        | 2            |
| CG75       | 76            | -            | 20                | 2        | 2            |
| CG0        | 76            | 20           | -                 | 2        | 2            |
| Pan-fried  |               |              |                   |          |              |
| CF0        | 76            | 20           | -                 | 2        | 2            |
| CF25       | 76            | 15           | 5                 | 2        | 2            |
| CF50       | 76            | 10           | 10                | 2        | 2            |
| CF75       | 76            | -            | 20                | 2        | 2            |

Moisture contents of the patties were determined by the AOAC method [13] and fat content was calculated by a method stated by Flynn and Bramblett [14]. All proximate analysis was performed in triplicate. The cooking yield, moisture retention [15] and fat retention were calculated by weight differences for patties before and after cooking [16] and calculated according to these equations below:

\[
\text{Cooking yield} \% = \frac{(\text{Cooked patty weight})}{(\text{Uncooked patty weight})} \times 100
\]

\[
\text{Moisture retention} \% = \frac{\text{(%Yield x %Moisture in cooked patty)}}{100}
\]

\[
\text{Fat retention} \% = \frac{(\text{Cooked weight}) \times (\% \text{Fat in cooked patty})}{(\text{Raw weight}) \times (\% \text{Fat in raw patty})} \times 100
\]

Reduction of patty diameter (measurements were taken using calibers) and change in thickness were calculated as:

\[
\text{Reduction of diameter} \% = \frac{(\text{Uncooked patty diameter} - \text{Cooked patty diameter})}{(\text{Uncooked patty diameter})} \times 100
\]

\[
\text{Change in thickness} \% = \frac{(\text{Uncooked patty thickness} - \text{Cooked patty thickness})}{(\text{Uncooked patty thickness})} \times 100
\]

Beef patty dimensional shrinkage was calculated according to following equation:
Texture profile analysis (TPA) was performed five times for each treatment using a texture analyzer (TA-XT2, Stable Micro Systems, UK). Oxidative stability of beef patties was analyzed by determining 2-thiobarbituric acid reactive substances (TBARS) [17]. Sensory properties of patties were evaluated in terms of appearance, color, texture, juiciness, oiliness, flavor and general acceptability (1: not like, 9: extremely like). Data was analyzed by ANOVA and Duncan’s Post-Hoc tests using SPSS 23 software.

3. Results and discussion

Moisture and fat contents of samples are given in Figure 1. For both cooking methods, moisture content increased and fat content decreased with the addition of CM (p<0.05). While there were no differences between 25%, 50%, and 75% substitution of beef fat with CM in grilled patties, using more than 50% CM in pan-fried patties significantly reduced the fat content (p<0.05).

Cooking characteristics such as cooking yield, moisture, and fat retention, diameter reduction and shrinkage are some of the most important factors for the meat industry to predict the behavior of burger-type meat products during cooking. Cooking characteristics are given in Table 2. Interaction between cooking method and CM level significantly affected cooking yield and moisture retention (p<0.05). In grilled patties, cooking yield and moisture retention were improved by the effect of CM, and therefore, CG25 and CG75 treatments had the highest cooking yield and moisture retention. The incorporation of more than 50% CM made it possible to hold more water in the meat matrix. The lowest cooking yield in samples with 100% beef fat incorporated might be attributed to the excessive fat separation and water release during cooking. This result showed that cooking yield of patties increased by the addition of CM due to its high dietary fiber (34.4%) and protein (16-20%) content. According to Herrero et al. [7], in frankfurters, chia flour gel emulsion can increase moisture and fat binding properties. Patties formulated with 50% CM showed the highest thickness change, CG50 and CF50 patties showed similar effects on diameter reduction, but nevertheless, in CG75 and CF75, the cooking method was found to be significant. Swelling of chia in meat protein matrix resulted in patties swelling up during the cooking process, so the flat shape of patties changed to ridged up. Researchers found no effects of cornflour levels in meatball diameter changes [18]. Denaturation of meat proteins with the release of water and fat means the patties tend to shrink during the cooking process. CM levels and cooking methods affected shrinkage, as increasing the CM level significantly decreased the patty shrinkage (p<0.05). In grilled patties, shrinkage values at all CM levels were lower than the control treatment. Pan-frying resulted in similar shrinkage values in CF0 and CF25 treatments, but shrinkage values decreased with 50% and 75% replacement levels.

Textural parameters of the patties are set out in Table 3. The texture profile of reformulated meat products is a substantial analysis that should be considered due to the various fat sources in the

\[
\text{Shrinkage(\%)} = \frac{(\text{Raw thickness} - \text{Cooked thickness}) + (\text{Raw diameter} - \text{Cooked diameter})}{(\text{Raw thickness} + \text{Raw diameter})} \times 100
\]
In this study, hydrophilic protein and soluble fibers in chia mucilage hold the water and, therefore, caused a soft structure, so in grilled patties with added CM, hardness values decreased (p<0.05). Another probable explanation for this textural behavior could be the emulsifying and gelling properties of CM. However, in pan-fried patties, the same trend was observed up to 75% replacement level (p<0.05). Our results are in line with Fernandez et al. [20], who reported softening in texture when chia flour was added to frankfurter formulation. Interaction between the cooking method and CM significantly affected springiness and cohesiveness values, which confirmed the same similar strength of internal bonds in these samples [21]. In grilled patties, addition of CM had no effect on springiness and cohesiveness, but in pan-fried samples, replacing fat with CM at levels of 50% and 75% increased springiness and cohesiveness. On increasing levels of both in grilled and pan-fried patties, gumminess values showed a general declined trend in treatment patties when compared to controls. The highest chewiness scores were recorded in pan-fried control patties and CF25 samples. Câmara et al. [10] reported similar results for hardness and chewiness in pork emulsions.

| Table 2. Cooking parameters of patties | Table 3. Textural properties of patties |
|---------------------------------------|---------------------------------------|
| **Variances** | **Factor** | **Cooking yield (%)** | **Mixtire retention (%)** | **Fat retention (%)** | **Change in thickness (cm)** | **Reduction of diameter (cm)** | **Shrinkage (%)** | **Variances** | **Factor** | **Hardness (N)** | **Springiness (mm)** | **Cohesiveness** | **Gumminess (N)** | **Chewiness (N x mm)** |
|----------------|--------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------|----------------|--------|-----------------|------------------|-----------------|-----------------|----------------------|
| **Cooking method (A)** | | | | | | | | | | | | | | | |
| Grilled       | 84.79±0.47 | 4.2±1.68 | 57.4±4.65 | 10.6±2.32 | 3.0±0.28 | 3.4±0.21 | 3.4±0.21 | | Grilled       | 9.1±6.23 | 0.1±0.00 | 0.1±0.00 | 1.8±0.25 | 0.1±0.00 | 1.8±0.25 | 0.1±0.00 |
| Pan-fried     | 78.6±1.11 | 47.8±1.17 | 55.2±7.29 | 5.9±0.34 | 7.2±0.32 | 5.3±0.34 | 5.3±0.34 | | Pan-fried     | 35.3±4.10 | 2.1±0.02 | 2.1±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 |
| **Lipid source (B)** | | | | | | | | | | | | | | | |
| 0%             | 84.7±0.47 | 4.2±1.68 | 57.4±4.65 | 10.6±2.32 | 3.0±0.28 | 3.4±0.21 | 3.4±0.21 | | Pan-fried     | 35.3±4.10 | 2.1±0.02 | 2.1±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 |
| 10%            | 84.7±0.47 | 4.2±1.68 | 57.4±4.65 | 10.6±2.32 | 3.0±0.28 | 3.4±0.21 | 3.4±0.21 | | Pan-fried     | 35.3±4.10 | 2.1±0.02 | 2.1±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 |
| 20%            | 84.7±0.47 | 4.2±1.68 | 57.4±4.65 | 10.6±2.32 | 3.0±0.28 | 3.4±0.21 | 3.4±0.21 | | Pan-fried     | 35.3±4.10 | 2.1±0.02 | 2.1±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 |
| 30%            | 84.7±0.47 | 4.2±1.68 | 57.4±4.65 | 10.6±2.32 | 3.0±0.28 | 3.4±0.21 | 3.4±0.21 | | Pan-fried     | 35.3±4.10 | 2.1±0.02 | 2.1±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 |
| 40%            | 84.7±0.47 | 4.2±1.68 | 57.4±4.65 | 10.6±2.32 | 3.0±0.28 | 3.4±0.21 | 3.4±0.21 | | Pan-fried     | 35.3±4.10 | 2.1±0.02 | 2.1±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 |
| 50%            | 84.7±0.47 | 4.2±1.68 | 57.4±4.65 | 10.6±2.32 | 3.0±0.28 | 3.4±0.21 | 3.4±0.21 | | Pan-fried     | 35.3±4.10 | 2.1±0.02 | 2.1±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 |
| 60%            | 84.7±0.47 | 4.2±1.68 | 57.4±4.65 | 10.6±2.32 | 3.0±0.28 | 3.4±0.21 | 3.4±0.21 | | Pan-fried     | 35.3±4.10 | 2.1±0.02 | 2.1±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 |
| 70%            | 84.7±0.47 | 4.2±1.68 | 57.4±4.65 | 10.6±2.32 | 3.0±0.28 | 3.4±0.21 | 3.4±0.21 | | Pan-fried     | 35.3±4.10 | 2.1±0.02 | 2.1±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 |
| 80%            | 84.7±0.47 | 4.2±1.68 | 57.4±4.65 | 10.6±2.32 | 3.0±0.28 | 3.4±0.21 | 3.4±0.21 | | Pan-fried     | 35.3±4.10 | 2.1±0.02 | 2.1±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 |
| 90%            | 84.7±0.47 | 4.2±1.68 | 57.4±4.65 | 10.6±2.32 | 3.0±0.28 | 3.4±0.21 | 3.4±0.21 | | Pan-fried     | 35.3±4.10 | 2.1±0.02 | 2.1±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 |
| 100%           | 84.7±0.47 | 4.2±1.68 | 57.4±4.65 | 10.6±2.32 | 3.0±0.28 | 3.4±0.21 | 3.4±0.21 | | Pan-fried     | 35.3±4.10 | 2.1±0.02 | 2.1±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 | 2.0±0.02 |

TBARS values of patties were given in Fig. 2. No differences were recorded in TBARS values of pan-fried patties on the first day of storage. Although some fluctuations were recorded during storage, at the end of the storage, the highest and the lowest TBARS values were recorded for control (0.76 mg MA/kg) and CF25 (0.40 mg MA/kg) samples respectively (p<0.05). CM showed antioxidant effects in pan-fried patties due to its bioactive compounds such as myrcetin, quercetin, rosmarinic acid, caffeic acid etc. [3, 9]. Interaction between the cooking method and CM was significant (p<0.05). TBARS values increased with the addition of CM in grilled patties. The increment in lipid oxidation probably resulted from the high concentration of PUFAs in mucilage. Similar to our results, TBARS values of pork burgers increased with the utilization of chia oil hydro gelled emulsion as a pork fat substitute [22]. However, Zaki [3] reported that TBARS values of patties samples formulated with chia seed were lower than controls formulated with pork fat.
One of the limiting factors for fat-reducing strategies is sensory properties due to the functions of fat in meat products. The purchase intention of consumers depends on not only the safety but also some organoleptic features such as appearance, taste, texture. The sensory scores of the patties are shown in Fig. 3. In general, the cooking method was the most effective factor affecting the sensory properties except juiciness scores (p<0.05). Pan-fried patties had higher scores than grilled ones for all the sensory properties. CM had no effect on sensory properties juiciness (p>0.05). Concerning juiciness, the addition of CM increased juiciness scores. Sensory scores of all experimental groups were above 5. Thus, it could be concluded that all patties were preferred by the consumer, and in fact, that patties formulated with lower beef fat were preferred even more. Even though in some research chia had been reported to decrease sensorial quality [7, 23, 24], in our study, CM had no adverse effect on quality, but rather, improved juiciness.

![Figure 2. TBARS values of patties (mg MA/kg)](image)

**Figure 2.** TBARS values of patties (mg MA/kg)

![Fig. 3. Sensory scores of beef patties](image)

**Fig. 3.** Sensory scores of beef patties

### 4. Conclusion

The results of our investigation revealed that utilization of CM as beef fat replacer improved cooking characteristics. The addition of CM had no negative effects on sensory properties. In general, TBARS values were lower in pan-fried patties than in grilled patties. The results also indicated that CM, as a natural antioxidant, presents the opportunity to prevent oxidation in pan-fried patties, so addition of CM could be a good strategy, both improving technological values and retarding oxidative changes.

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