Effects of replacing beef fat with pre-emulsified pumpkin seed oil on some quality characteristics of model system chicken meat emulsions

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Abstract. In this study, the effects of adding pumpkin seed oil (PSO) in water emulsion to model system chicken meat emulsions (MSME) on product quality and oxidative stability were investigated. MSME were produced by replacing 25% (P25) and 50% (P50) of beef fat with PSO-in-water emulsion (PSO/W) while control treatment was prepared with only beef fat. Addition of PSO/W to the formulation resulted in significant differences in chemical composition and pH values of both raw and cooked MSME treatments. The use of PSO/W produced significant improvements to emulsion stability, oxidative stability and cooking yield of MSME. It was determined that the use of PSO/W formulation results in decreased total expressible fluid values and increased cooking yields of the emulsions. It was observed that the highest cooking yield and the lowest total expressible fluid were found in the sample containing 50% PSO/W. It should be a feasible strategy to produce fat-reduced meat products with healthier lipid profiles by using PSO/W.

1. Introduction

Fat has an important role in meat products; it helps emulsion stabilization, improves binding properties, water holding capacity and cooking yields as well as provides sensorial characteristics such as juiciness [1,2]. However, diets with high animal fat contents have been related to increased obesity, cardiovascular disease and coronary heart disease due to their high saturated fatty acid and cholesterol contents [3,4,5]. Thus, the meat industry has begun to work on reformulation strategies to produce healthier meat products by decreasing saturated fatty acids, decreasing cholesterol and adding natural antioxidants. One of these strategies is using formulations with vegetable oils, since they are free of cholesterol and have a higher ratio of unsaturated to saturated fatty acids than animal fats [6,7,8]. However, the use of vegetable oils directly in product formulation can cause technological problems and quality loss in meat products [9]. Therefore, pre-emulsions constitute an innovative approach in low-fat product formulations since they can be used in fat reduction processes, beneficially modifying fatty acid profiles, masking off flavors and improving the sensory properties of products [10,11,12].

Pumpkin seed oil (PSO) is rich in bioactive compounds such as polyunsaturated (linoleic and linolenic) fatty acids, β-carotene, lutein, β-tocopherol, chlorophyll and phytosterols, and it is widely used in salads around the world, especially in Hungary, Slovenia and Austria. Due to its color and
foaming problem, PSO cannot be used in manufacturing processed foods or processes such as frying [13].

To the best of our knowledge, no research has been performed regarding utilization of PSO in meat model systems or meat products. Therefore, the objective of this study was to investigate the effect of using PSO in oil-in-water emulsion as a fat replacer on the technological characteristics and oxidative stability of model system chicken meat emulsions.

2. Materials and Methods

The pumpkin seed oil-in-water (PSO/W) emulsion was prepared according to Poyato et al. [14] with modifications. The aqueous phase was prepared with the mixture of egg white powder (5 g/100 g) and water (45 g/100 g). The oil phase (50 g/100 g) was added to the aqueous phase after both phases were heated separately to 55°C. After the emulsification process (6000 rpm, Ultra-Turrax® T25basic), the emulsion was cooled to room temperature and PSO/W was kept under refrigeration (4°C) until use. Three different model system chicken meat emulsions (MSME) were prepared following the procedure described by Cofrades et al. [15] with modifications (table 1). One contained only beef fat (C), two other MSME were prepared by replacing 25% (P25) and 50% (P50) of beef fat with PSO/W. Chicken breast meat and beef fat were passed through a grinder with a 3-mm plate (Arnica, Turkey). The minced meat was homogenized for 1 min in a kitchen-type mixer (Tchibo, Germany) which was placed in cooling bath (2°C). Fat or PSO/W, half of the ice, plus salt and sodium tri-polyphosphate (STPP) were added and mixed for 1 min. The other half of the ice was added and mixed again for 2 mins. Portions of each emulsion (approximately 25 g) were placed in Falcon tubes (50 ml), which were hermetically sealed then centrifuged at 4500 rpm at 4°C for 1 min to eliminate any air bubbles. Samples were heat-treated for 30 min in a water bath at 70 °C, then cooled to room temperature for further analyses.

| Table 1. Formulation (%) of MSME1 |
|-----------------------------------|
| Samples<sup>a</sup> | Meat (%) | Beef fat (%) | PSO/W<sup>b</sup> (%) | Water (Ice) (%) |
|------------------------|----------|--------------|------------------------|-----------------|
| C                      | 68       | 20           | -                      | 10              |
| P25                    | 68       | 15           | 5                      | 10              |
| P50                    | 68       | 10           | 10                     | 10              |

<sup>a</sup> Samples contain: 1.5% salt and 0.5% STPP.
<sup>b</sup> Sample denomination: C: %100 beef fat.
P25: 75% beef fat + 25% PSO/W.
P50: 50% beef fat + 50% PSO/W.

Moisture, protein and ash contents of raw and cooked MSME treatments were determined by AOAC methods [16]. Fat content was evaluated according to Flynn and Bramblet [17], pH values of emulsions were measured by using a pH-meter (WTW pH 3110 set 2, Germany) equipped with a penetration probe. Emulsion stability, recorded as total expressable fluid (TEF), and water holding capacity (WHC) were determined according to Hughes et al. [18]. The weights of meat emulsions before and after cooking were recorded and the cooking yield calculated. Lipid oxidation on days 0, 1 and 4 of storage was evaluated by the TBA method as described by Witte et al. [19]. The data were analyzed by one-way ANOVA using the SPSS software version 20. Differences among the means were compared using Duncan’s Multiple Range test. A significance level of p<0.05 was used for evaluations.
3. Results and Discussion

Table 2. Chemical composition and pH values of raw and cooked MSME treatments.

|             | Raw MSME                  | Cooked MSME               |
|-------------|---------------------------|---------------------------|
|             | Moisture (%) | Ash (%) | Fat (%) | Protein (%) | pH | Moisture (%) | Ash (%) | Fat (%) | Protein (%) | pH |
| C           | 62.05 ± 0.44b        | 14.6 ± 0.08 | 18.77 ± 0.97a | 16.29 ± 0.46b | 6.06 ± 0.01a | 60.23 ± 0.96c | 1.51 ± 0.06 | 15.44 ± 0.70b | 19.77 ± 0.78 | 6.17 ± 0.02b |
| P25         | 64.66 ± 1.20ab       | 15.3 ± 0.05 | 16.74 ± 0.65b | 16.93 ± 0.93ab | 6.02 ± 0.01a | 62.54 ± 0.87b | 1.41 ± 0.18 | 16.07 ± 0.65a | 19.85 ± 0.26 | 6.20 ± 0.01a |
| P50         | 65.91 ± 0.42ac       | 13.9 ± 0.10 | 15.04 ± 0.72c | 17.56 ± 0.35c | 5.96 ± 0.01b | 64.28 ± 0.47a | 1.48 ± 0.06 | 15.18 ± 0.47b | 19.91 ± 0.21 | 6.17 ± 0.01b |

Data are presented as the mean values of 3 replications ± SD.

abc: Means with different letters in the same column are significantly different (p ≤ 0.05).

Chemical compositions and pH values of raw and cooked MSME treatments are shown in table 2. Replacing beef fat with PSO/W showed an increasing effect on moisture and protein contents of raw MSME (p<0.05), since PSO/W contributed water and protein (egg white powder) to the formulation. The fat content of raw MSME decreased with respect to the incremental addition of PSO/W (p<0.05), while no significant differences were observed in ash content (p>0.05). Addition of PSO/W decreased the pH values of raw MSME because of lower pH value of PSO [20].

The highest moisture content was found in P50 after cooking (p<0.05), probably the result of the lower TEF of this treatment. Protein and ash contents of cooked MSME treatments were similar (p>0.05). Addition of PSO/W to the formulation showed significant effects on fat content and pH values of cooked MSME. The highest fat content was found in P25 (p<0.05). The fat content of MSME with added PSO/W (P25 and P50) was more or less constant in raw and cooked MSME treatments; this could be the result of higher emulsion stability of these formulations.

Table 3. MSME characteristics.

|          | WHC (%)    | TEF (%)   | Cooking Yield (%) |
|----------|------------|-----------|-------------------|
| C        | 93.84±0.20 | 12.26±0.46c | 86.64±1.11c       |
| P25      | 94.35±0.15 | 9.98±0.23b  | 89.47±1.11b       |
| P50      | 94.37±0.48 | 7.73±1.59c  | 92.65±0.75a       |

Data are presented as the mean values of 3 replications ± SD.

abc: Means with different letters in the same column are significantly different (p≤0.05).

The aim of adding pre-emulsified fat or oils is having stable characteristic in meat products. WHC, cooking yield and emulsion stability (TEF%) results of MSME are shown in table 3. WHC of the MSME formulations were similar (p>0.05). PSO/W addition to formulations showed significant effect on emulsion stability of treatments (p<0.05). The highest TEF% values were found in C treatment while replacing beef fat with PSO/W showed a decreasing effect on TEF% values of MSME treatments (p<0.05). Cooking yield depends on the ability of the protein matrix to stabilize both fat and water molecules [5]. The lowest cooking yield was observed in C treatment and higher cooking yields were found when beef fat was replaced with PSO/W (p<0.05). The higher protein content of
P25 and P50 treatments could be the reason for their higher cooking yields and more stable emulsions, since more protein could have entrapped water and fat molecules in the system. It is well-known that emulsifiers are amphiphilic in their native state in emulsions because of their hydrophilic and hydrophobic interactions [21]. Another reason for the lower TEF% values and higher cooking yields in P25 and P50 formulations may be due to the amphiphilic properties of egg white powder in PSO/W.

Table 4. TBA values of MSME treatments during storage (mg malondialdehyde/kg product).

|          | Day 0            | Day 1            | Day 4            |
|----------|------------------|------------------|------------------|
| C        | 0.63±0.02a,X     | 0.61±0.02a,X     | 0.69±0.02a,Y     |
| P25      | 0.52±0.01b,X     | 0.48±0.01b,Z     | 0.63±0.02b,X     |
| P50      | 0.47±0.02c,X     | 0.49±0.01b,X     | 0.34±0.03c,Y     |

Data are presented as the mean values of 3 replications ± SD.

abc: Means with different letters in the same column are significantly different (p≤0.05).

XYZ: Means with different letters in the same row are significantly different (p≤0.05).

Lipid oxidation can have negative effects on the quality of meat and meat products since they can cause sensory attribute (color, texture, odor and flavor) and nutritional quality changes. TBA values of MSME treatments during 4-days storage are shown in table 4. The oxidative status of MSME is strongly influenced by the type of fat/oil used in the formulation. The lower TBA values were found when beef fat was replaced with PSO/W (p<0.05) and this trend was observed during the storage period (p<0.05). The lower TBA values in P25 and P50 could be the result of adding pre-emulsion, which provided a protective effect from lipid oxidation and also added an oil with antioxidant properties to the formulations [22]. There was a slight decrement in TBA values of P50 treatment on day 4, probably due to the result of decomposition of malondialdehydes by bacterial processes [23,24] or further oxidation of malondialdehydes to other products [25,26]. Although the highest TBA values were found in C treatment during storage, these oxidation values were below 1.0 (mg malondialdehyde/kg product), which is the accepted limit for rancidity in meat products [27,28].

4. Conclusion
The results of this study indicated that replacement of beef fat with pumpkin seed oil-in-water emulsions significantly affected chemical composition and pH values of raw and cooked MSME treatments. PSO/W addition to the formulations resulted lower total expressible fluid values, higher cooking yield and higher oxidative stability during storage. Our study showed that meat products with a healthier lipid profile could be manufactured by using pumpkin seed oil in pre-emulsions.

References
[1] McAfee A J, McSorley E M, Cuskelly G J, Moss B W, Wallace J M W and Bonham M P 2010 Red meat consumption: An overview of the risks and benefits Meat Sci. 84(1) 1–13
[2] Rodriguez Furlan L T, Padilla A P and Campderros M E 2014 Development of reduced fat minced meats using inulin and bovine plasma proteins as fat replacers Meat Sci. 96 762–8
[3] Ö兹vural E B and Vural H 2008 Utilization of interesterified oil blends in the production of frankfurters Meat Sci. 78 211-6
[4] Sanchez-Zapata E, Daaz-Vela J, Perez-Chabela M., Perez-Alvarez J and Fernandez-Lopez J 2013 Evaluation of the effect of tiger nut fibre as a carrier of unsaturated fatty acids rich oil on the quality of dry-cured sausages Food Bioprocess Tech 6 1181–90.
[5] Kumar Y, Kairam N, Ahmad T and Yadav D N 2016 Physico chemical, microstructural and sensory characteristics of low-fat meat emulsion containing aloe gel as potential fat replacer Int. J. Food Sci. Tech. 51(2) 309–16
[6] Muguerza E, Gimeno O, Ansorena D and Astiasaran I 2004 New formulations for healthier dry fermented sausages: a review *Trends Food Sci. Tech.* 15 452–7
[7] Choi Y S, Choi J H, Han D J, Kim H Y, Lee M A, Kim H W and Kim C J 2009 Characteristics of low-fat meat emulsion systems with pork fat replaced by vegetable oils and rice bran fiber *Meat Sci.* 82 266–71
[8] Afshari R, Hosseini H, Khaksar R, Mohammadifar M A, Amiri Z and Komeili R 2015 Investigation of the effects of inulin and b-glucan on the physical and sensory properties of low-fat beef burgers containing vegetable oils: Optimization of formulation using d-optimal mixture design *Food Technol. Biotechn.* 53(4) 436–44
[9] Beriaia M J, Gómez I, Petri E, Insausti K and Sarriès M V 2011 The effects of olive oil emulsified alginate on the physico-chemical, sensory, microbial, and fatty acid profiles of low-salt, inulin-enriched sausages *Meat Sci.* 88(1) 189–97
[10] McClements D J, Decker E A, Park Y and Weiss J 2009 Structural design principles for delivery of bioactive components in nutraceutical and functional foods *Critical Review of Food Science and Nutrition* 49 577–606
[11] Dickinson E 2011 Double emulsions stabilized by food biopolymers *Food Biophys.* 6 1–11
[12] Cofrades S, Antoniou I, Solas M T, Herrero A M and Jimenez-Colmenero F 2013 Preparation and impact of multiple (water-in-oil-in-water) emulsions in meat systems *Food Chem.* 141(1) 338–46
[13] Murkovic M, Hillebrand A, Winkler J, Leitner E and Pfannbauser W 1996 Variability of fatty acid content in pumpkin seeds (*Cucurbita pepo* L.) *Z Lebensm Unters Forsch.*, 203 216-19
[14] Poyato C, Astiasaran I, Barriuso B and Ansorena D 2015 A new polyunsaturated gelled emulsion as replacer of pork back-fat in burger patties: Effect on lipid composition, oxidative stability and sensory acceptability *LWT-Food Sci. Technol.* 62 1069-75
[15] Cofrades S, López-López I, Solas M T, Bravo L and Jiménez-Colmenero F 2008 Influence of different types and proportions of added edible seaweeds on characteristics of low-salt gel/emulsion meat systems *Meat Sci.* 79 767–76
[16] AOAC 2007 *Official methods of analysis* 18th Ed. AOAC International Association of Official Analytical Chemists Gaithersburg MD USA
[17] Flynn A W and Bramblett V D 1975 Effects of frozen storage cooking method and muscle quality and attributes of pork loins *J Food Sci* 40 631–33
[18] Hughes E, Cofrades S and Troy D J 1997 Effects of fat level, oat fibre and carrageenan on frankfurters formulated with 5, 12 and 30% fat *Meat Sci.* 45 273-81
[19] Witte V C, Krause, G F and Bailey M E 1970 A new extraction method for determining 2-thiobarbituric acid values of pork and beef during storage *J. Food Sci.* 35 582–5
[20] Al-Okbi S Y, Abdou D, Hamed T E, Alaa A, Hosam S, El-Alim A and Mahmoud D 2017 Enhanced prevention of progression of non alcoholic fatty liver to steatohepatitis by incorporating pumpkin seed oil in nanoemulsions *J. Mol. Liq.* 225 822–32
[21] Viljanen K 2005 Protein oxidation and protein-lipid interactions in different food models in the presence of berry phenolics *Doctoral dissertation* University of Helsinki Department of Applied Chemistry and Microbiology p 36
[22] Öztürk B, Uruğ M and Serdaroğlu M 2017 Egg white powder-stabilised multiple (water-in-olive oil-in-water) emulsions as beef fat replacers in model system meat emulsions. *J. Sci. Food Agr.* 97 2075–83
[23] Casaburi A, Aristoy M C, Cavella S, Di Monaco R, Ercolini D and Toldra F 2007 Biochemical and sensory characteristics of traditional fermented sausages of Vallo di Diano (Southern Italy) as affected by the use of starter cultures *Meat Sci.* 76 295–307
[24] Fregonesi R P, Portes R G, Aguiar A M M, Figueira L C, Gonçalves C B, Arthur V, Lima C G, Fernandes A M and Trindade M A 2014 Irradiated vacuum-packed lamb meat stored under refrigeration: Microbiology, physicochemical stability and sensory acceptance *Meat Sci.* 97(2) 151–5
[25] Georgantelis D, Ambrosiadis I, Katikou P, Blekas G and Georgakis S A 2007 Effect of rosemary extract, chitosan and α-tocopherol on microbiological parameters and lipid oxidation of fresh pork sausages stored at 4°C *Meat Sci.* 76 172–81

[26] Azizkhani M and Tooryan F 2014 Antioxidant and antimicrobial activities of rosemary extract, mint extract and a mixture of tocopherols in beef sausage during storage at 4°C *J. Food Safety* 35 128–36

[27] Ockerman H W 1976 *Quality control of post mortem muscle and tissue* Vol. 4 Columbus USA Department of Animal Science Ohio State University (Available at: https://kb.osu.edu/.../QUALITY%20CONTROL%20OF%20POST%20MORTERM%20MUSCLE%20TISSUE%20Vol.4.pdf)

[28] Yıldız-Turp G and Serdaroğlu M 2008 Effect of replacing beef fat with hazelnut oil on quality characteristics of sucuk – A Turkish fermented sausage *Meat Sci.* 78(4) 447–54