EFFECTS OF PARTIAL BEEF FAT REPLACEMENT WITH GELLED EMULSION ON THE FUNCTIONAL AND QUALITY PROPERTIES OF MODEL SYSTEM MEAT EMULSION

M. Serdaroğlu*, B. Nacak, M. Karabıyıkoğlu, G. Keser

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

*meltem.serdaroglu@ege.edu.tr

Abstract- The objective of this study was to investigate the effects of partial beef fat replacement with gelled emulsion which prepared with olive oil on functional and quality properties of model system meat emulsion. Model system meat emulsions were prepared as follows: C: 100% beef fat; G30: 70% beef fat + 30% gelled emulsion; G50: 50% beef fat + 50% gelled emulsion; G100: 100% gelled emulsion. Inulin and gelatin were used as gelling agents. No significant differences were recorded in chemical composition (p>0.05). Adding gelled emulsion decreased the pH with respect to increase in emulsion concentration(p<0.05). Results show that partial replacement up to 50% with gelled emulsion could be used for improving emulsion stability, cooking yield and water holding capacity (p<0.05). Emulsion added samples had higher L* and b* values while lower a* values. The presence of an emulsion gel significantly affected textural behaviors of samples.

Key Words – fat replacement, model system meat emulsion, O/W gelled emulsion

I. INTRODUCTION

The use of emulsion based systems to achieve nutritionally improved meat products is one of the current approaches in meat industry. Healthier lipid profile is one the most important goals and using edible oil containing emulsion gels could be good option for reformulation strategies [1].

One of the main problems of fat replacing is maintaining the technological, rheological and sensory properties of meat product [2]. For this reason, emulsion gels could be better option than O/W emulsions to achieve better characteristics such as higher water holding capacity [3,4,5].

The objective of this study was to evaluate how does replacing beef fat with gelled emulsion affect functional and quality properties of model system meat emulsions.

II. MATERIALS AND METHODS

The gelled emulsion was prepared according to the method described by Poyato et al. [6]with slight modifications. The oil phase (50 g/100 g emulsion) containing the polyglyserol polyricinoleate (PGPR) as surfactant (6.4 g/100 g oil), was added to the aqueous phase (3 g gelatin/100 g emulsion and 9 g inulin/100 g emulsion) and homogenized. Both phases were previously heated separately to 55°C. After the homogenization process (6000 rpm, Ultra-Turrax® T25basic), the emulsion was cooled to room temperature.

Table 1. Formulation (%) of MSME

Samples[a]	Meat (g)	Beef fat (g)	O/W gelled emulsion[b] (g)	Water (Ice) (g)
C	227.5	35	-	87.5
G-30	227.5	24.5	22.44	75.56
G-50	227.5	17.5	37.39	67.61
G- 100	227.5	-	74.79	47.71

All of our samples also contaions: 7 g NaCl, 1.75 g STTP, 0.05 g $NaNO_3$

a Sample denomination: C: Control %100 beef fat; G30: 70% beef fat + 30% gelled emulsion; G50: 50% beef fat + 50% gelled emulsion; G100: 100% gelled emulsion.

b Olive oil-in-water emulsion gel prepared with inulin, gelatin and PGPR.

Four different model system meat emulsions were formulated (Table 1) and prepared following the procedure reported by Cofrades et al. [7] with slight modifications. One contained beef fat (Control samples- C) , three of MSME were prepared by replacing beef fat %30, 50, 100 emulsion gels contain olive oil (G-30, G-50, G-100). Lean beef and beef fat were passed through a grinder with a 3 mm plate (Arnica, Turkey). The meat was homogenized for 1 min in kitchen type mixer (Tchibo, Germany) was placed in cooling bath (2 °C). Fat or gelled emulsions, half of ice, curing ingredients were added and mixed for one min. The other half of ice was added and mixed again for 2 mins.. Portions of each meat system (approximately 25 g) were placed in Falcon tube (50 ml), which were hermetically sealed then heated for 30 min in a water bath at 70 °C. Samples were cooled to room temperature and analyzed.

Moisture, protein and ash contents of samples were determined to AOAC [8].Fat content was evaluated according to Flynn and Bramblet, [9].pH value of emulsion was measured by using a pH-meter (CR-400, Konica Minolta, Japan) equipped with a penetration probe.Emulsion stability (ES) and water holding capacity weredetermined according to Hughes et al. [10].Jelly and fat seperation (JFS)of MSME was measured in triplicate according to Bloukas and Honikel [11]. Syneresis was determined by Poyato [6]. The weights of meat emulsions before and after cooking were recorded and the cooking yield calculatedaccording to Serdaroğlu et al. [12]. Colour of model system meat emulsions was measured using a digital colorimeter (Chromameter CR-400,Minolta, Osaka, Japan).The texture (TPA) was measured using a Universal TA-XT2 (Stable Micro Systems, Haslemere, UK) texture analyzer.The data was 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<0.05was used for evaluations.

III. RESULTS AND DISCUSSION

Chemical composition and pH values of MSME treatments are presented in Table 2. Emulsion gels showed no effect on moisture, ash and lipid contents (p>0.05).while showed significant differences among samples on protein content(p<0.05). Beef fat replacement by olive oil could reduce the pH values of MSME were between 5.95 and 6.06. There were slight decrease in pH with the increase in emulsion concentration (p<0.05).

Table 2 Chemical composition and pH values of MSME treatments

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	pH
C	68.34± 1.25	3.01± 0.03	10.99± 0.69	15.328± 0.36^{ab}	6.06± 0.02^{a}
G30	68.12± 1.05	3.07± 0.06	11.17± 0.62	15.028± 0.35^{b}	5.97± 0.01^{b}
G50	67.73± 1.31	3.06± 0.03	11.24± 0.42	14.002± 0.17^{c}	5.96± 0.01^{b}
G100	66.99± 1.24	3.05± 0.03	10.42± 0.69	15.776± 0.05^{a}	5.95± 0.01^{b}

Data are presented as the mean values of 3 replications ± SD. abc: Means with the different letter in the same row are significantly different (p≤0.05).

The typical O/W meat emulsions, if oil volume is not too high and has a low-viscosity continuous phase, show liquid-like flow behaviour while emulsion gels could be defined as a emulsion with two charactheristic: a gel-like network structure and solid-like mechanical properties [1].

For gelled emulsion one of the most important objectives is keeping syneresis minimum levels. In our study syneresis value is 41.69% which is higher than Poyato et al.[6]. WHC results of MSME are shown in Table 3. The lowest WHC result was found in G100 (p<0.05) while the result of C samples, G30 and G50 were found similar and did not show significant difference (p>0.05). Results showed that gelled emulsions, depend on concentration, could be better option to improve water holding capacity of meat products as Poyato et al. [6] suggest. Jelly and fat separation (JFS) is the total liquid release at certain temperature [12]. The lowest JFS was found in G30 and showed no significant difference with G50. The highest JFS was found in G100 which is similar to C samples (p>0.05) and showed significant difference with G30 and G50 (p<0.05). The aim of producing emulsion is having stable characteristic in meat products. Emulsion stability results of MSME are shown as total expressible fluid (TEF %) and expressible fat (EFAT %) in Table 3. The highest TEF% and EFAT% values were found in G100 treatment (p<0.05) where beef fat was completely replaced with olive oil. G30 and G50 samples had the highest stability but no significant difference was found with C samples (p>0.05). Similar results were found by

Delgado-Pando et al. [13] where konjac gel was used as gelling agent. Having high amount of unsaturated fatty acid in system may reduce emulsion stability because of their low melting point [14]. When O/W or W/O/W emulsions are prepared before meat product manufacture and added as fat ingredient, more protein source is needed in meat systems[15]. Increasing olive oil concentration more than 50% while protein amount is constant could be another reason of low emulsion stability results in G100.

Cooking yield results also show similarity with WHC results. The lowest yield was found in G100 ($p<0.05$) with respect to decrease in WHC and increase in TEF%. The higher results were found in G30 and G50 while no significant differences were found between ($p>0.05$). The proportional relationship between process yield and gelatin level contributes to the reduction of water losses. It has been reported that WHC decreased when gelatin concentration increased up to optimum point [16]. Thus, using gelatin and inulin in gelling process could help to improve cooking yield and emulsion stability resulst. Also it has been reported that using pre-formed emulsion could be another reason to reduce cooking losses[17].

Table 3. MSME Characteristics

Sample	WHC	TEF (%)	EFAT (%)	Cooking Yield (%)
C	95.905± 0.16 ^{a}	9.141± 0.28 ^{b}	4.467± 0.67^{a}	90.292± 0.61 ^{b}
G30	96.165± 0.25 ^{a}	8.352± 0.68 ^{b}	3.989± 0.55^{a}	92.461± 0.56 ^{a}
G50	96.186± 0.17 ^{a}	7.514± 1.66 ^{b}	3.869± 0.59^{a}	91.903± 0.67 ^{a}
G100	93.494± 0.09 ^{b}	13.342± 1.35 ^{a}	5.267± 0.72^{b}	83.281± 0.61 ^{c}

Data are presented as the mean values of 3 replications ± SD. abc: Means with the different letter in the same row are significantly different ($p\leq0.05$).

The color parameters of the MSME were shown in Table 4. As the results show that L* values of MSME were affected by formulation. The highest L* values was found in G100 ($p<0.05$) with while L* values showed no differences below 30% replacement of beef fat. The highest a* value and the lowest b* value was observed in treatment C samples($p<0.05$). Increase in emulsion concentration caused decrease in a* and increase in b* values but no signifant effect was observed between MSME treatments ($p>0.05$). Another reason for increment of L* values could be modifying larger animal fat globules with much smaller olive oil globules which reflect more light and animal fat globules [6].

Table 4. Colour (L*, a*, b*) of MSME treatments

Sample	L*	a*	b*
C	51.36±0.86 ^{c}	10.54±1.07	8.09±0.33 ^{a}
G30	54.94±1.04^{b}	9.30±0.54	10.37±0.62 ^{b}
G50	58.32±0.91 ^{a}	9.24±0.75	10.69±0.55 ^{b}
G100	60.38±3.40 ^{a}	9.64±1.23	10.73±0.49 ^{b}

Data are presented as the mean values of 3 replications ± SD. abc: Means with the different letter in the same row are significantly different ($p\leq0.05$).

Except C samples (Table 5), increase in emulsion concentration showed lower values in hardness, gumminess and chewiness values due to replacing beef fat with olive oil.It has been reported that adding gelled emulsion, depend on concentraion, could improve hardness values [6]. Significant differences were recorded in hardness values ($p<0.05$) while emulsion concentration showed no differences on springiness values ($p>0.05$) in all treatments. Cohesiveness values of G30 and G50 showed significant differences with C samples and G100 ($p<0.05$). Gumminess and chewiness values of C samples and G30 showed significant differences with other groups ($p<0.05$) while G100 had the lowest values ($p<0.05$).

Table 5. Texture profile analysis of MSME treatments

Sample	Hard ness	Springi ness	Cohesi Veness	Gummi Ness	Chewi Ness
C	13.25± 0.60^{b}	0.81± 0.17	0.85± 0.08^{ab}	12.6± 0.35 ^{a}	11.92± 0.49 ^{a}
G30	15.77± 0.83^{a}	0.95± 0.03	0.87± 0.03^{a}	11.94± 0.35 ^{a}	11.09± 0.75 ^{a}
G50	10.06± 0.22 ^{c}	0.95± 0.04	0.89± 0.03^{a}	9.04± 0.49 ^{b}	8.5± 0.80 ^{b}
G100	3.71± 0.07 ^{d}	0.94± 0.04	0.81± 0.05^{b}	3.01± 0.26 ^{c}	2.86± 0.37 ^{c}

Data are presented as the mean values of 3 replications ± SD. abc: Means with the different letter in the same row are significantly different ($p\leq0.05$).

IV. CONCLUSION

The results of the study showed that partial replacement of beef fat with gelled emulsion could be used for improving water holding capacity, emulsion stability and cooking yield when replacement level is up to 50%.Also, adding gelled emulsion could increase L* and b* values while a* values decrease. Significant effects were found on TPA values with respect to emulsion addition level.

REFERENCES

1. Dickinson E. (2013). Stabilising emulsion-based colloidal structures with mixed food ingredients. Journal of the Science of Food and Agriculture 93: 710–721.
2. Tye, R. J. (1991). Konjac flour: properties and applications. Food Technology, 45: 86-92.
3. Poyato, C., Astiasaran, I., Barriuso, B., Ansorena, D. (2015).A new polyunsaturated gelled emulsion as replacer of pork back-fat inburger patties: Effect on lipid composition, oxidative stability andsensory acceptability. LWT - Food Science and Technology 62: 1069-1075.
4. Pintado, T., Herrero, A. M., Ruiz-Capillas, C., Triki, M., Carmona, P., & Jimenez-Colmenero, F. (2015). Effects of emulsion gels containing bioactive compounds on sensorial, technological and structural properties of frankfurters. Food Science and Technology International.
5. Pintado, T., Ruiz-Capillas, C., Jimenez-Colmenero, F., Carmona, P., & Herrero, A. M. (2015). Oil-in-water emulsion gels stabilized with chia (Salvia hispanica L) and cold gelling agents: technological and infrared spectroscopic characterization. Food Chemistry 185: 470-478.
6. Poyato, C., Ansorena, D., Berasategi, I., Navarro-Blascol, & Astiasaran, I. (2014). Optimization of a gelled emulsion intended to supply u-3 fatty acids into meat products by means of response surface methodology. Meat Science 98: 615-621.
7. Cofrades, S., López-López, I., Solas, M. T., Bravo, L., & Jiménez-Colmenero, F. (2008). Influence of different types and proportions of added edible seaweeds on characteristics of low-salt gel/emulsion meat systems. Meat Science, 79, 767–776.
8. AOAC, (2012). Official Methods of Analysis, Latimer, G.W. (Ed.), 19th ed. Association of Official Analytical Chemists, Gaithersburg, MD, USA.
9. Flynn, A.W. and Bramblett, V.D. (1975). Effects of frozen storage cooking method and muscle quality and attributes of pork loins. Journal of Food Science 40:631–633.
10. Hughes, E., Confrades, S., Troy, D.J. (1997). Effects Of Fat Level, Oat Fibre And Carrageenan On Frankfurters Formulared With 5, 12 And 30% Fat. Meat Science 45: 273-281.
11. Bloukas I., Honikel K. O. (1992). The influence of additives on the oxidation of pork back fat and its effect on water and fat binding in finely comminuted batters. Meat Sci. 32:31–43.
12. Serdaroğlu, M., Öztürk, B., Urgu, M. (2016). Emulsion characteristics, chemical and textural properties of meat systems produced with double emulsions as beef fat replacers. Meat Science, 117:187-195.
13. Delgado-Pando, G., Cofrades, S., Rodríguez-Salas, L., Jiménez Colmenero, F. (2011). A healthier oil combination and konjac gel as functional ingredients in low-fat pork liver pâté. Meat Science 88: 241-248.
14. Martín, D., Ruiz, J., Kivikari, R., & Puolanne, E. (2008). Partial replacement of pork fat by conjugated linoleic acid and/or olive oil in liver pâtés: Effect on physicochemical characteristics and oxidative stability. Meat Science, 80, 496−504.
15. Freire, M., Bou, R., Cofrades, S., Solas, M. T., Jimenez-Colmenero, F. (2015). “Double emulsions to improve frankfurter lipid content: impact of perilla oil and pork backfat’’, DOI 10.1002/jsfa.7163.
16. Yasin, H., Babji, A. S., Ismail,H. (2016). Optimization and rheological properties of chicken ball as affected by k-carrageenan, fish gelatin and chicken meat. LWT - Food Science and Technology 66: 79-85.
17. Asuming- Bediako, N., Jaspal, M.H., Hallett, K., Bayntun, J., Baker, A., Sheard, P.R. (2014). ‘’Effects of replacing pork backfat with emulsified vegetable oil on fatty acid composition and quality of UK-style sausages’’, Meat Science 96: 187–194.