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ARTICLE

Effects of Beef Fat Replacement with Gelled Emulsion Prepared with Olive Oil on Quality Parameters of Chicken Patties

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Abstract

The objective of this study was to investigate the effect of using gelled emulsion (olive oil 46%, inulin 9%, gelatin 3%) as fat replacer on some quality parameters of chicken patties. For this purpose GE, prepared with olive oil, gelatin and inulin was replaced with beef fat at a level of 0%, 25%, 50%, 100% (C, G25, G50, G100). In this study syneresis, thermal stability, centrifuge and creaming stability of gelled emulsion were analyzed. Chemical composition, technological paramerers (cooking yield, water holding capacity, diameter reduction, fat and moisture retention) and textural and sensory properites were evaluated in comparision to control patties. High thermal stability was recorded in GE (93%), also creaming stability results showed that GE protected its stability without any turbidity and separation of the layer. The complete replacement of beef fat with GE showed detrimental effect on all investigated cooking characteristics except fat retention. Replacement of beef fat with GE at a level of 50% resulted similar cooking characteristics with C samples. Color parameters of samples were affected by GE addition, higher CIE b* values observed with respect to GE concentration. The presence of GE significantly affected textural behaviors of samples ($p<0.05$). Our results showed that GE prepared with inulin and olive oil is a viable fat replacer for the manufacture of chicken patty.

Keywords gelled emulsion, chicken patty, reduced fat, olive oil, inulin

Introduction

Although fat is an important component in meat products, the demand for low-fat meat products formulated with healthier lipid sources has greatly increased since high fat intake, especially saturated fats, is associated with obesity, cardiovascular and chronic diseases (AHA, 1996). Since fat contributes texture and flavor to meat products, reducing fat content in formulation may alter product quality; products with less fat content is firmer, more rubbery, less juicy, darker in color and more costly (Keeton, 1994). Since meat products with healthier lipid profile are increasingly demanded owing to consumer interest, pre-emulsions constitute an innovative approach in low-fat product formulations. Pre-emulsions provide a great opportunity to incorporate healthier vegetable oils to meat systems for increasing mono and polyunsaturated fatty acid content since adding vegetable oils directly to product formulation can have technological problems and quality loss in meat products.

Modified or structured oils which have solid-like properties can be used while replacing solid fat with liquid oils, for this purpose, different methods such as struc-

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tured emulsions (simple, gelled and double emulsions), interesterification, and organogelation have been used (Alejendre *et al.,* 2016; Öztürk *et al.,* 2017; Pintado *et al.*, 2015a; Poyato *et al.*, 2014; Serdaroğlu *et al.,* 2016a; Zetzl *et al.*, 2012). Gelled emulsions prepared with healthy oils were found a good option to achieve nutritionally improved meat products (Pintado *et al.*, 2015*a*). Moreover, GE could be more suitable alternative than simple oil-in water (O/W) emulsions to achieve better characteristics such as higher water holding capacity, better texture and lower cooking loss (Poyato *et al.*, 2014).

Previous studies have shown the potential of GE which contains a variety of bioactive compounds and healthy oils for use as healthier fat replacers in meat product formulations. Gelled emulsions which were incorporated with healthy oils (olive, linseed, fish and sunflower seed oil) and gelling agents (carrageenan, gelatin, alginate, chia flour and inulin) have been used in different products such as frankfurters (Delgado-Pando *et al.*, 2011; Herrero *et al.*, 2017; Pintado *et al.*, 2015a; Pintado *et al.*, 2016; Salcedo-Sandoval *et al.,* 2015), dry fermented sausages (Alejandre *et al.*, 2016) and pork patties (Poyato *et al.*, 2015) as fat replacer.

Among the variety of meat products, burgers and patties have great importance since they are common products sold as ready-to-eat and fast food consumption, easy to prepare at home, and it is possible to easily modify composition to improve their nutritional properties. In this regard, many researches have been carried out with different methods to improve nutritional quality specially in burger and patties (Afshari *et al.*, 2017; Guedes-Oliveira *et al.*, 2016; Hur *et al.*, 2008; López-López *et al.*, 2010; López-López *et al.*, 2011; Poyato *et al.*, 2015; Rodriguez-Carpena *et al.*, 2012; Serdaroğlu *et al.*, 2005; Serdaroğlu, 2006a; Serdaroğlu, 2006b).

To the best of our knowledge, no research has been performed regarding utilization of GE prepared with gelatin and inulin as beef fat replacers in chicken patties. Therefore, the aim of this study was to evaluate the effect of using gelled emulsion as fat replacer on some quality parameters of chicken patties.

Material and Methods

Raw material

Chicken breast and beef fat were purchased from a local market. Extra virgin olive oil was supplied from Taris Co. (according to the specifications of the supplier, it was consisted of 70.98% oleic acid (C18:1), 12.46% palmitic acid (C16:0), 11.4% linoleic acid (C18:2), 2.66% stearic acid (C18:0), 0.5% linolenic acid (C18:3) and 2243 ppm total sterol), oil phase emulsifier polyglyserol polyricinoleate (PGPR) was obtained from Çağdaş Chemicals Co. (Turkey). Gelatin was purchased from Sigma-Aldrich. Inulin powder (Ash Content: 0.05-0.15% Glucose: 0-1.6% Sacarose: 1.05-3.05% Dry Matter Content: 93-70.97% Carbohydrates: 94.90% Inulin: 88-92% Fructose: 1.2-3.2%) was obtained from BENEO-Orafti.

Gelled emulsion preparation

Gelled emulsion was prepared according to the method described by Poyato *et al.* (2014) with modifications. The oil phase (50 g/100 g emulsion) containing the PGPR as surfactant (6.4 g/100 g oil), was added to the aqueous phase containing 3 g gelatin/100 g emulsion and 9 g inulin/100 g emulsion and homogenized. Both phases were previously heated separately to 55°C on a hot plate stirrer. After the homogenization process (6000 rpm, Ultra-Turrax® T25basic, UK), the emulsion was cooled to room temperature. The GE was kept for 12 h at 4°C until being used in chicken patties.

Experimental design and preparation of chicken patties

Four different chicken patties were formulated as indicated in Table 1. In control samples (C) 20 g/100 g of beef fat was added, whereas in the three experimental batches different percentages, 25% (G25), 50% (G50) and 100% (G100), of beef fat were substituted with gelled emulsion. Salt (2 g/100 g) was added to all formulations. Fat content of all samples were set as 20% (beef fat, GE or both). Chicken breast and beef fat were minced through a 3 mm plate grinder (Turkey), separately. Ground meat, fat source (beef fat and/or GE), and salt mixed in food processor for 2 min (Germany) and chicken patties were formed with the appropriate tool (d:9 cm, h:1.5 cm). During preparation of chicken patties the temperature of the mixture was kept below 10°C. After forming, the samples were cooked in electric oven (Turkey) at 180°C until core temperature reached to 73°C. Samples were cooled to room temperature and analyses were performed.

Methods

pH

pH value of GE and chicken patties were measured in

Table 1. Formulations of chicken patties

Sample[a]	Chicken breast meat (g)	Beef fat (g)	Gelled emulsion (g)	NaCl (g)
C	1170	300	-	30
G25	1170	225	75	30
G50	1170	150	150	30
G100	1170	-	300	30

[a]Sample denomination: C: Control 100% beef fat.
G25: 75% beef fat + 25% GE; G50: 50% beef fat + 50% GE; G100: 100% GE.

triplicate by using a pH-meter (WTW pH 3110 set 2, Germany) equipped with a glass penetration probe.

Color

Color parameters of GE and cooked chicken patties were measured using a digital colorimeter (Chromameter CR 400, Minolta, Japan) to obtain the color coordinates lightness (CIE L*), redness (CIE a*) and yellowness (CIE b*).

Syneresis

Syneresis (S) was measured in triplicate according to Bot *et al.* (2014). A sample was cut in half in the tub, and one of both halves was removed. The weight of the half-filled 100 mL tub [W_1] was determined and the tub is sealed again. The tub was stored for 4 h at 25°C. Subsequently, the lid was removed and the sample was weighed again [W_2]. The value should be almost equal to W_1, and was used as a check only. Then all fluid was removed from the tub and inside the tub was wiped with paper tissue, and the weight of the tub was determined again [W_3]. Finally, the sample was removed from the tub, and the empty tub was weighed [T]. The stability against syneresis of the samples was calculated by using the following equation: Syneresis = $(W_1 - W_3) / (W_1 - T)$

Gelled emulsion stability

Centrifugation and thermal stability of GE were determined. Centrifugation stability was measured after the preparation of GE to observe any phase separation after centrifugation at 1400 rpm for 3 min (Serdaroğlu *et al.*, 2016b). Creaming stability was measured according to Gu *et al.* (2005) in samples stored at 4°C for 7 d. Serum layer separation was observed and measured to express creaming stability as a percentage of initial sample height. Thermal stability, in terms of water and fat binding properties was measured in GE according to Surh *et al.* (2007). For thermal stability test, the tubes containing 25 g of the GE was hermetically sealed and heated in a water bath (70ºC/30 min). Afterwards, they were then opened and left to stand upside down (for 50 min) to release the separated fat and water onto a plate. The stability of emulsions after heating (thermal stability) or storage (creaming stability) were recorded in terms of phase separation and expressed as a percentage of initial sample height. These parameters were determined in triplicate.

Chemical composition

Moisture and ash contents of raw and cooked chicken patties were determined according to AOAC method (2012). Protein content of the samples was determined using an automatic nitrogen analyzer (FP 528 LECO, USA) based on the Dumas method. Fat content was analysed according to Flynn and Bramblet (1975).

Water holding capacity

The ability of the uncooked product to retain moisture was determined in triplicate according to Hughes *et al.* (1997) with modifications. 10 g batter was weighed (W_1), placed into glass jars and heated in 90°C water bath for 10 min. After cooling to room temperature, the samples were wrapped in cotton cheesecloth and centrifuged at 1400 rpm for 15 min and weighed again (W_2). Water-holding capacity (WHC) was calculated from the equation below:

$$\mathrm{WHC}(\%) = \left(1 - \frac{W_1 - W_2}{M}\right) \times 100$$

M: Total moisture content of the sample

Cooking yield

The weights of chicken patties before and after cooking were recorded and the cooking yield was determined by calculating weight differences for samples before and after cooking.

$$\text{Cooking yield}(\%) = \left(\frac{\text{Weight of the cooked patty}}{\text{Weight of the raw patty}}\right)$$

Moisture and fat retention

The moisture retention value represents the amount of moisture retained in the 100 g cooked product and was determined according to an equation described by El-Magoli *et al.* (1996).

$$\text{Moisture retention(\%)} = \frac{(\%\ \text{Yield} \times \%\ \text{Moisture in cooked patty})}{100}$$

Fat retention was examined according to Murphy *et al.* (1975) and calculated as follows:

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

Diameter reduction

The diameter of each chicken patties were measured before and after cooking with a digital caliper. Change in the chicken patties' diameters were determined using the following equation (Modi *et al.*, 2004):

$$\text{Diameter reduction(\%)} = \left[\frac{\text{Raw patty diameter} - \text{Cooked patty diameter}}{\text{Raw patty diameter}}\right] \times 100$$

Texture profile analysis

Texture profile analysis (TPA) was performed five times for each treatment using a texture analyzer (TA-XT2, Stable Micro Systems, UK). Samples (1.5 cm × 2 cm × 2 cm) were taken and compressed to 50% of their original height with a crosshead speed of 5 mm/s and 50 kg load cell. The parameters calculated from the force and time curves were hardness (maximum force required for the initial compression as N), cohesiveness (ratio of active work done under the second compression curveto that done under the first compression curve as dimensionless), springiness (distance of the sample recovers after the first compression asmm), gumminess (the strength of internal bonds making up the body of the sample as N) and chewiness (the required work tomasticate the sample as N × mm).

Sensory analysis

Three sessions were conducted for sensory evaluation. In each session, sensory evaluation of cooked patties was performed by ten panelists who are post-graduate students in Food Engineering Department of Ege University. Chicken patties were labelled with 3-digit random numbers and served in random order to assessors in individual booths. A nine-point scale was used where 1 represented = dislike extremely and 9 = like extremely. The patties were served as warm (~38°C), sugar and salt free bread and water were used to clean the palate between samples. Panelist evaluated for appearance, texture, oiliness, flavor, and overall acceptability.

Statistical analysis

One-way analysis of variance (ANOVA) was used to evaluate the statistical significance ($p<0.05$) of the effect of chickern patties formulations, using the SPSS for Windows statistical package program (IBM, version 21.0, USA). The data was analyzed by using general linear model procedure (GLM). Least square differences (LSD) were used to compare mean values of formulations and significant differences ($p<0.05$) between chicken patties formulations were identified by Duncan multiple test.

Results and Discussion

Characteristics of gelled emulsion

Better understanding the behaviour of pre-emulsions in meat systems is important to guarantee the quality of the end product which they are added (Serdaroğlu *et al.*, 2016a). The characteristics of GE are shown in Table 2. The pH of GE was 5.40. CIE L*, CIE a* and CIE b* parameters of GE were recorded as 83.72, 3.14 and 16.29, respectively. Syneresis is an important parameter for emulsions and it effects characteristics of product such as stability and cooking yield. In our study syneresis value is 13.88% which is similar to our previous work (Serdaroğlu *et al.*, 2016a). Interaction of gelatin and inulin with gel matrix helped GE to show stability against centrifugation forces, no phase separation was observed after centrifugation and protected its stability at different temperatures (4°C for 48 h, 25°C for 24 h). High thermal stability was recorded in GE (93%), also creaming stability results showed that GE protected its stability without any turbidity and separation of the layer up to 7 d at 4°C.

Chemical composition and pH

Chemical composition and pH values of raw and cooked samples are presented in Table 3 and 4, respectively. The differences of formulation resulted significant changes in moisture, fat and ash content of raw samples ($p<0.05$) while no effect was recorded in protein content ($p>0.05$). The highest moisture content was found in G100 where beef fat was completely replaced with GE due to the presence of water in GE. Addition of GE showed decreasing effect on fat content of raw samples and met the targeted

Table 2. Gelled emulsion characteristics

Sample	pH	CIE L*	CIE a*	CIE b*	Syneresis (%)	Thermal stability (%)
GE	5.40±0.01	83.72±0.41	3.14±0.22	16.29±0.31	13.88±0.56	93±0.46

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

Table 3. Chemical composition of raw patties

	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	pH
C	58.59^{b}±1.22	18.21±0.78	19.23^{a}±0.40	3.07^{a}±0.04	6.12^{a}±0.3
G25	59.66^{b}±1.29	17.94±0.62	18.21^{b}±0.65	3.06^{a}±0.09	6.08^{b}±0.01
G50	60.72^{b}±0.56	17.95±0.20	15.61^{c}±0.49	2.92^{b}±0.02	6.07^{bc}±0.01
G100	66.74^{a}±0.57	17.67±0.13	11.65^{d}±0.11	2.80^{c}±0.04	6.05^{c}±0.01

Data are presented as the mean values of 3 replications ± SD.
$^{a-d}$Means with the different letter in the same column are significantly different (p<0.05).

Table 4.Chemical composition of cooked patties

	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	pH
C	56.58^{a}±0.31	25.47^{a}±0.36	13.23^{b}±0.73	3.77^{a}±0.04	6.21^{a}±0.01
G25	56.04^{a}±0.39	25.14^{a}±0.28	14.26^{a}±0.17	3.73^{ab}±0.14	6.17^{b}±0.01
G50	55.68^{a}±0.27	25.18^{a}±0.46	14.57^{a}±0.62	3.52^{c}±0.02	6.14^{c}±0.01
G100	54.81^{b}±0.84	26.67^{b}±0.36	12.85^{b}±0.22	3.58^{bc}±0.04	6.14^{c}±0.02

Data are presented as the mean values of 3 replications ± SD.
$^{a-c}$Means with the different letter in the same column are significantly different (p<0.05).

levels, also increasing GE addition more than 25% significantly reduced ash content (p<0.05). pH values of raw samples were found between 6.05 and 6.12, increasing GE concentration (p<0.05) resulted slight decreament in pH since olive oil has lower pH than beef fat.

Cooking process increased pH, protein and ash contents of samples while decreased moisture content due to cooking loss. Addition of GE effected chemical composition and pH of cooked samples (p<0.05). Moisture content of C, G25 and G50 were found similar with each other while G100 had significantly lower moisture content (p<0.05). The highest protein content was observed in G100 as consequence of the high amount of water loss due to heat treatment, and showed significant differences with other samples (p<0.05). Similar findings were observed by Poyato *et al.* (2015) in burger patties. Fat content of C and G100 was found similar with each other and significantly different than G25 and G50 (p<0.05). pH values of cooked samples were found between 6.14 and 6.21.

Cooking characteristics

Water-holding capacity (WHC), which is defined as the ability of meat to retain moisture, is one of the most important parameters in determination of emulsion stability. WHC results of samples are shown in Table 5. WHC was found affected by the addition of GE (p<0.05), C and G50 samples showed similar WHC while G100 found the lowest probably due to the lower pH value in this sample. Differences in WHC values can be attributed to the consistence of water in GE. Osburn *et al.* (1999) indicated that the protein gel prepared with connective tissue can be a potential water binder for low-fat meat products and it has also synergistic effect on water binding when myofibrilar proteins are in the system. To obtain this effect, gelatin concentration must be between 0.5-3.0 g/100 g (Stevens, 2010). Also, WHC could be affected by properties

Table 5. Cooking characteristic

	WHC of raw patties (%)	Diameter reduction (%)	Cooking yield (%)	Moisture retention (%)	Fat retention (%)
C	94.17^{a}±0.53	9.52^{a}±1.31	63.12^{a}±0.91	37.83^{a}±0.85	42.62^{d}±2.07
G25	93.31^{b}±0.30	16.25^{b}±1.15	60.52^{b}±0.76	34.16^{b}±0.87	49.62^{c}±1.91
G50	94.10^{a}±0.48	17.62^{b}±1.9	64.06^{a}±0.58	37.07^{a}±0.61	59.83^{b}±2.15
G100	92.79^{c}±0.18	17.64^{b}±1.55	58.95^{c}±0.31	31.25^{c}±0.53	66.20^{a}±0.72

Data are presented as the mean values of 3 replications ± SD.
$^{a-d}$Means with the different letter in the same column are significantly different (p<0.05).

of inulin, in case added inulin has large particles it improves hydration and fat absorption capacity in meat systems (Lopez-Lopez *et al.*, 2010).

Cooking characteristics such as cooking yield, moisture and fat retention, diameter reduction (Table 5) are some of the most important factors for food industry to predict the behavior of products during cooking. The highest cooking yields were observed in C and G50 samples while the lowest was observed in G100 sample ($p<0.05$). It was reported that higher inulin concentration can have negative impact on cooking yield (Afshari *et al.,* 2015). High amount of fat and also having GE in formulation resulted in lower cooking yield, moisture and fat retention in G25 treatment since there is an inverse proportion between fat level and free space between fat cells. It was reported that decreasing free space between fat cells might cause coalescing and leaking of fat from the products (Lopez-Lopez *et al.*, 2011). When gelatin is used at an appropriate concentration in meat emulsions, it acts as a stabilizer; promotes cooking yield, reduces fat and water losses due to its gelling ability. Inulin, as an another constituent of GE, can also absorb liquid in the products and promotes fat retention. Depending on aforementioned properties of gelatin and inulin, beef fat replacement at a level of 50% with GE improved cooking yield and G50 samples showed similarity with control patties. The lowest cooking yield was observed in G100 despite it had the lowest fat level. Having the highest GE addition and the lowest moisture retention result is the probable reason for the lowest cooking yield in G100. Another reason for lower cooking yield could be high gelatin percentage since high level of gelatin could melted out and could not interact with protein in G100.

Moisture retention in ground meat products is an important cooking parameter, since retained moisture in the product effects eating quality. Moisture retention results of samples showed similarity with cooking yield results. The highest moisture retention was found in G50 among GE added samples ($p<0.05$) and showed similarity with C sample. This could explain the fact that in G50 treatment inulin might create hydrogen bounds with water and keep the moisture in the meat matrix. Another possible reason for this phenomena is the interaction of gelatin with inulin and water.

Retaining fat within the matrix of meat products during processing is necessary to ensure sensory quality and acceptability. Improvement in fat retention in GE addedsamples could be attributed to the stabilizing effects of the oil in the established emulsion system.This might be due to the increased concentration of inulin and gelatin by the addition of increasing amount of GE. Inulin might interact with the proteins of patty matrix and reduce migration of fat from products (Anderson and Berry, 2001). The lowest fat retention was found in C sample since it has higher fat content and due to melting of fat globules higher leakage was observed during cooking.

A dimensional change is one of the most important alterations of patties which can be affected by incorporation of new ingredients. Protein denaturation, moisture and fat release of products are some of the main diameter reducing effects during cooking (Soltanizadeh and Ghiasi-Esfahani, 2014). In this research, the lowest reduction in the diameter was observed in C samples and showed significant differences with GE added samples ($p<0.05$). The reason for the higher diameter reduction in GE added samples could be the result of swelling and gel forming characteristics of inulin. Swelling of the inulin and gelatin molecules in meat protein matrix resulted swelling up in patties during cooking and flat shape of patties turn into round. Afshari *et al.* (2015) reported that the highest diameter reduction was observed when inulin (8%) added to low-fat beef burgers.

Color

Color is one of the most essential factors on consumer's attitude toward meat and meat products. The color parameters of the samples were shown in Table 6. Results showed that GE addition significantly affected CIE L* and CIE b* values ($p<0.05$) while no effect was observed in CIE a* values. The highest CIE L* value was observed in G50 treatment which kept GE well in the sample matrix, due to lighter color of inulin. Large beef fat droplets absorbed light more than small droplets in GE and that caused the lowest CIE L* value in C samples. Adding GE caused higher CIE b* values as a result of color difference between beef fat and olive oil which has yellowish-green color (Delgado-Pando *et al.*, 2011; Pintado *et al.*, 2015a, Pintado

Table 6. Color (CIE L*, a*, b*) of chicken patties

	CIE L*	CIE a*	CIE b*
C	$72.26^{b}\pm1.88$	0.25 ± 0.07	$16.90^{b}\pm0.85$
G25	$73.28^{ab}\pm2.60$	0.26 ± 0.15	$19.57^{ab}\pm1.62$
G50	$75.75^{a}\pm0.44$	0.29 ± 0.06	$18.37^{ab}\pm0.61$
G100	$72.69^{ab}\pm2.22$	0.30 ± 0.13	$20.51^{a}\pm1.77$

Data are presented as the mean values of 3 replications ± SD.
$^{a-c}$Means with the different letter in the same column are significantly different ($p<0.05$).

Table 7. Texture profile analysis results of chicken patties

	Hardness (N)	Springiness (mm)	Cohesiveness	Gumminess (N)	Chewiness (N×mm)
C	57.29^{a}±2.71	0.89^{b}±0.01	0.80^{a}±0.01	45.65^{a}±2.42	40.77^{a}±1.95
G25	30.83^{b}±1.53	0.87^{b}±0.01	0.77^{c}±0.01	23.94^{b}±1.18	20.83^{b}±1.02
G50	23.22^{c}±2.95	0.78^{c}±0.04	0.74^{d}±0.01	17.25^{c}±2.01	13.41^{c}±1.11
G100	13.86^{d}±1.35	0.94^{a}±0.02	0.82^{a}±0.01	11.47^{d}±1.16	10.77^{d}±1.25

Data are presented as the mean values of 3 replications ± SD.
$^{a\text{-}d}$Means with the different letter in the same column are significantly different (p<0.05).

et al., 2015b; Poyato *et al.*, 2014, Serdaroğlu *et al.,* 2016a).

Texture profile analysis

The results of texture profile analysis (TPA) are presented in Table 7. GE addition affected all of the textural properties of chicken patties (p<0.05), the observed differences in textural parameters can be attributed to the different effcets of inulin and gelatin as well as olive oil. Increasing GE concentration in formulation decreased the hardness, gumminess and chewiness values. Different characteristics and behaviours of beef fat and GE was the probable cause of obtained results in texture parameters. Increasing water percentage could cause softer texture while protein amount is constant (Jimenez-Colmenero *et al.*, 1996).

Besides, the dilution effect of non-meat ingredients in meat protein systems primarily responsible for softer texture. Álvarez and Barbut (2013) studied the effects of inulin and reported that the addition of inulin resulted in a creamy and softer product. Replacing beef fat with GE significantly affected springiness and cohesiveness values (p<0.05) while the lowest springiness and cohesiveness values were observed in G50. Gumminess and chewiness of samples showed similar trend with hardness and all of the treatments showed significant differences (p<0.05).

Sensory analyses

One of the limiting factors for fat reducing strategies is sensory properties due to the functions of fat in meat products. The results of sensory analysis are shown in Fig. 1. In general terms, the scores awarded by the panelists were similar in all the treatments except G100. Replacing all of the beef fat with GE showed negative impact on all investigated sensory characteristics of chicken patties and G100 samples received the lowest scores. Flavor parameter could be affected by the existince of beef fat. Even the beef fat was reduced to half, it gave characteristic flavor to the samples. Negative effects of replacing 100% of the animal fat with GE on sensory characteristics have been reported in other researches (Pintado *et al.*, 2015a, Pintado *et al.*, 2016).

Fig. 1. Sensory properties of chicken patties.

As a result, all the treatments were accepted by panelists in term of overall acceptibility. Besides, these results showed that GE addition up to 50% can be good reformulation strategy to obtain chicken patties similar to original product.

Conclusion

Gelled emulsion was an effective additive as partial beef fat replacer in chicken patties, showing nutritional advantages and judged acceptable by panellists. These formulation strategies improve not only nutritional quality but also technological characteristics of products. Further studies are needed to improve technological characteristics of GE by using various functional ingredients in various meat products such as restructured, and for fermented.

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