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ARTICLE

# Evaluation of the Quality of Beef Patties Formulated with Dried Pumpkin Pulp and Seed

M. Serdaroğlu*, H. S. Kavuşan, G. İpek, and B. Öztürk

Food Engineering Department, Engineering Faculty, Ege University, 35100 Bornova, Izmir, Turkey

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***Corresponding author :** M. Serdaroğlu
Food Engineering Department, Engineering Faculty, Ege University, 35100 Bornova, Izmir, Turkey
Tel: +0090-532-2370436
E-mail: meltem.serdaroglu@ege.edu.tr

**Abstract** The objective of this study was to investigate quality attributes of beef patties formulated with dried pumpkin pulp and seed mixture (PM). Four different meatball formulations were prepared where lean was replaced with PM as C (0% PM), P2 (2% PM), P3 (3% PM) and P5 (5% PM). Utilization of PM decreased moisture and increased ash content of the patties. Incorporation of 5% PM (P5) increased the pH value of both uncooked and cooked patties compared to C group. Increasing levels of PM increased water-holding capacity. No significant differences were found in cooking yield and diameter change with the addition of PM. Incorporation of PM increased fat and decreased moisture retention of the samples. a* values were decreased with PM addition, where L* values did not differ among treatments and b* values were similar in C, P3 and P5 samples. Textural properties were mostly equivalent to control samples with the incorporation of PM even at higher concentrations. The addition of PM did not significantly affect any of the sensory scores tested. These results indicated that utilization of PM presents the opportunity to decrease the amount of meat besides to improve healthier profile without causing negative changes in physical, chemical and technological quality of beef patties.

**Keywords** beef patty, meat replacer, pumpkin, pumpkin pulp, pumpkin seed

## Introduction

Meat has been known as a source of high biological value protein including all essential amino acids in adequate proportions, as well as it involves many valuable nutrients like long chain n-3 fatty acids, bioactive hydrolysates, connective tissue components, nucleotides, conjugated linoleic acid and antioxidants, thus unique status of meat in the diet is indisputable (Jiang and Xiong, 2016; Olmedilla-Alonso et al., 2013; Young et al., 2013). However, there is a strong evidence that high consumption of processed meat products is directly related to cardiovascular diseases, type-2 diabetes, obesity and some cancer types (Cashman and Hayes, 2017; de Smet and Vossen, 2016; Shan et al., 2017), moreover recently WHO International Agency for Research on Cancer has classified the consumption of red meat as carcinogenic to humans (Apostolidis and McLeay, 2016). As consumers have become increasingly more health conscious, foods including meat products with decreased levels of fat, salt, cholesterol as well as enriched with dietary fiber has become more and more popular (Yang et al., 2007). Enhancement of meat and meat products with vegetables, fruits and their fibers could reduce production costs and improve the technological and nutritional quality of the products.

Fruits and vegetables occupy an important role in human nutrition as they provide essential minerals, vitamins, dietary fiber and phenolic compounds that are natural antioxidants (Grigelmo-Miguel et al., 1999). Besides, the relevance of fruits and vegetables in the processing of meat products relates to their functional properties such as water binding, fat emulsification, and improves cook yield, textural and sensory properties. A variety of plant sources such as guava powder (Verma and Sahoo, 2000), pepper puree (Yıldız-Turp et al., 2007), kimchi powder (Lee et al., 2008), plum puree (Yıldız Turp and Serdaroğlu, 2010), date paste (Sánchez-Zapata et al., 2011), flaxseed and tomato paste (Melendres et al., 2014) and apricot pomace (Purma-Adıbelli and Serdaroğlu, 2017) have been used as fat replacers, binders and extenders in formulation of various meat products.

Pumpkin (*Cucurbita maxima*) is a cultivar of a squash plant that is rich in carotene (*β*-carotene, α-carotene), lutein, pectin, vitamins (A, B1, B2, and C), minerals (Fe, Ca, Na, K, Mg, and P), dietary fiber and other substances beneficial to health (Azevedo-Meleiro and Rodriguez-Amaya, 2007; de Escalada Pla et al., 2007; González et al., 2001; Jun et al., 2006; Lee et al., 2010; Murkovic et al., 2002; Sojak and Głowacki, 2010). Pumpkin seeds are rich source of proteins (24 to 36.5%) and highly unsaturated oil (31.5 to 51%), minerals (Al-Khalifa, 1996; Asiegbu, 1987; El-Adawy and Taha, 2001; Nyam et al., 2009; Rezig et al., 2012; Yoshida et al., 2004). Although there have been a few studies regarding the incorporation of raw or dried pumpkin sourced ingredients like pumpkin flour (Ammar et al., 2014) and pumpkin pulp (Verma et al., 2015; Zargar et al., 2014) in meat product formulations, no study has addressed the utilization of pumpkin pulp and seed mixture in beef products so far. The aim of our study was to investigate the effects of replacing lean meat with pumpkin powder mix (dried pumpkin pulp + pumpkin seed) on physical, chemical and sensory properties of beef patties.

## Materials and Methods

### Materials

Fresh and non-damaged whole pumpkins and pumpkin seeds were purchased from a local market in Izmir and stored at 4ºC until used. The spices and breadcrumbs used in beef patty formulations were supplied from Bağdat Spices Co. (Turkey). Post-rigor beef as boneless rounds (moisture 72%, fat 4.30%, protein 20.97%, ash 2.73%) and beef fat were supplied from a local butcher in Izmir. Muscles were trimmed of visible fat and connective tissues and stored at 4ºC with fat until used. All chemicals used in the trial were of analytical grade.

### Preparation of pumpkin mix

The pumpkins were washed with tap water and peeled. The seeds were removed and the rest was sliced into 2 mm thickness. The slices were then dried at 65ºC for 2.5 h in thermostat vacuum oven (Townson & Merker Ltd., UK). The dried pumpkin slices and the purchased seeds were milled separately in kitchen-type chopper (Conti CMD-201, Italy), then mixed to obtain homogenous pumpkin blend (ratio of 1:1 pumpkin flour to seed flour). The final mixture had 42.38% total sugar, 25.92% protein, 10.18% moisture, 16.45% oil and 5.07% ash. The pH value of PM was recorded as 5.77.

### Production of beef patties

Four different beef patties were formulated with 0% (C), 2% (P2), 3% (P3) and 5% (P5) pumpkin mix (PM), which is presented in Table 1. Lean meat and beef fat were minced separately through a 3 mm plate grinder (Arnica, Turkey). PM and other additives (breadcrumbs, salt, black pepper, cumin and onion powder) were added and all ingredients were mixed for 12 min until a homogeneous distribution was seen. The mixture was then portioned with round molds (d:80 mm, h:1 cm). After shaping, the patties were cooked on an electrical grill (SBG-7110, Sinbo, Turkey) at 180°C until core temperature reached to 73°C. The samples were finally cooled and stored at 4°C prior to analysis.

Table 1. Formulation of beef patties (g)

| Treatments[1)] | Lean meat | Fat | Breadcrumbs | Spice mix | Salt | Water | Pumpkin mix | Total |
|---|---|---|---|---|---|---|---|---|
| C | 864 | 180 | 72 | 54 | 18 | 12 | 0 | 1,200 |
| P2 | 840 | 180 | 72 | 54 | 18 | 12 | 24 | 1,200 |
| P3 | 828 | 180 | 72 | 54 | 18 | 12 | 36 | 1,200 |
| P5 | 804 | 180 | 72 | 54 | 18 | 12 | 60 | 1,200 |

[1)] C: beef patties formulated without pumpkin mix; P2: beef patties formulated with 2% pumpkin mix; P3: beef patties formulated with 3% pumpkin mix; P5: beef patties formulated with 5% pumpkin mix.
Spice mix: 0.25% ground black pepper, 0.75% ground cumin, 3.5% onion powder.

## Methods

### Proximate analysis and pH

Moisture and ash content of the patties were analyzed following AOAC (2012) procedures. Protein content was determined using an automatic nitrogen analyzer (FP 528 LECO, USA) based on the Dumas method. Fat content was determined according to Flynn and Bramblett (1975). All proximate analysis was performed in triplicate. pH value of samples was measured three times by using a pH-meter (WTW pH 3110 SET 2, Germany) equipped with a penetration probe.

### 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 (W1), 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 cheese cloth and centrifuged at 1,400 rpm for 15 min and weighed again (W2). Water-holding capacity (WHC) was calculated from the equation below:

$$\%\,WHC = 1 - \frac{T}{M} \times 100 = 1 - \frac{(W1 - W2)}{M} \times 100$$

where T is water loss after heating and centrifugation and M indicate total moisture content of the sample.

### Cooking procedure and cooking measurement

Three samples for each replication were examined for all cooking measurements. Beef patties were cooked on electrical grill for 7 min of each side (until the internal temperature was reached to 73°C). Percent cooking yield was determined by calculating weight differences for samples before and after cooking (Murphy et al., 1975) and calculated according to the equation below:

$$Cooking\ Yield\ (\%) = \left(\frac{Cooked\ beef\ patty\ weight}{Uncooked\ beef\ patty\ weight}\right) \times 100$$

The fat retention value represents the amount of fat retained in the product after cooking. Fat retention was calculated according to Murphy et al. (1975) by using the equation as follows:

$$Fat\ Retention\ (\%) = \left(\frac{(Cooked\ weight) \times (\%Fat\ in\ cooked\ beef\ patty)}{(Uncooked\ weight) \times (\%Fat\ in\ uncooked\ beef\ patty)}\right) \times 100$$

The moisture retention value represents the amount of moisture retained in the cooked product per 100 g of sample and was determined according to El-Magoli et al. (1996) according to the equation below:

$$Moisture\ Retention\ (\%) = \left(\frac{\%\ Yield \times \%Moisture\ in\ beef\ patty}{100}\right)$$

The change in beef patty diameter (measurements were taken using calibers) was calculated as

$$Reduction\ in\ beef\ patty\ diameter\ (\%) = \left(\frac{Uncooked\ beef\ patty\ diameter - Cooked\ beef\ patty\ diameter}{Uncooked\ beef\ patty\ diameter}\right)$$

The change in beef patty thickness (measurements were taken using calibers) was calculated as

$$Reduction\ in\ beef\ patty\ thickness\ (\%) = \left(\frac{Uncooked\ beef\ patty\ thickness - Cooked\ beef\ patty\ thickness}{Uncooked\ beef\ patty\ thickness}\right)$$

### Color measurement

Color parameters of lightness (CIE L*- value), redness (CIE a*- value), and yellowness (CIE b*- value) were measured using a portable colorimeter (CR-200, Konica Minolta, Japan) with D65 illuminant setting and $10^0$ standard observer from four different locations.

### 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 (2.5 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), springiness (distance of the sample recovers after the first compression as mm), cohesiveness (ratio of active work done under the second compression curve to that done under the first compression curve as dimensionless), gumminess (the strength of internal bonds making up the body of the sample as N) and chewiness (the required work to masticate the sample as N·mm).

### Sensory evaluation

Sensory evaluation was performed by an untrained panelist group of 10 members from Food Engineering Department, Ege University. Samples were cooked in electrical grill (SBG-7110, Sinbo, Turkey at 180°C) for 7 min each side (until the internal temperature was reached to 73°C) and served warm to panelists with randomly coded numbers. Panel members were asked to evaluate the samples for appearance, color, texture, juiciness, flavor and overall acceptability. Samples were evaluated by using a 9-point hedonic scale (1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much, 9=like extremely). Water and bread were served to clean the mouth between the samples.

### Statistical analysis

One-way Analysis of Variance (ANOVA) was used to determine significant differences between beef patty formulation groups using the IBM SPSS for Windows 21.0. The data was analyzed using General Linear Model (GLM) procedure, least squares differences (LSD) were utilized for comparison of mean values among formulations and Duncan's multiple range test was performed to identify significant differences between treatments, at a confidence interval of 95%.

## Results and Discussion

### Chemical composition and pH

Chemical composition and pH values of uncooked and cooked beef patties are presented in Table 2. Moisture, protein, fat and ash content of uncooked samples ranged between 57.78-61.13%, 17.50-18.35%, 18.24-20.91% and 2.73-2.95%, respectively. The values for cooked samples were in the range of 55.83-59.71%, 20.18-21.33%, 17.35-20.26% and 2.76-2.95, respectively. Significant changes were obtained in most of the chemical parameters of both uncooked and cooked samples ($p<0.05$). Moisture content was lower in raw samples containing 5% PM (P5) ($p<0.05$), which could be due to the increase in solid material content. No significant differences were obtained in moisture content of other uncooked treatments. The decrease in moisture content of cooked samples were more visible, where all the samples with PM had lower moisture compared to C samples ($p<0.05$). P3 and P5 samples had lower moisture content compared to P2 samples ($p<0.05$). Similar to our results, López-Vargas et al. (2014) reported that, the moisture content fell with the addition of passion fruit albedo in raw and cooked burgers. However, Zargar et al. (2014) found significant increases in moisture percent of chicken sausages formulated with pumpkin pulp, that could be due to higher moisture present in the fresh pumpkin. Protein content of all samples were similar to each other in both cooked and uncooked products. Fat content was similar in raw C, P2 and P3 samples, while P5 samples had higher fat content compared to P2 and P3 ($p<0.05$). The higher fat content of P5 samples could be attributed to high levels of oil in the pumpkin mix. It was found that all cooked samples with added PM had higher fat content compared to C samples without PM ($p<0.05$). Cooked beef patties with added PM showed higher ash content compared to C samples ($p<0.05$), probably due to high mineral content of pumpkin mix. In contrast to our results, Ali et al. (2017) found that fish burger formulated with mashed pumpkin and mashed potato showed higher moisture and lower protein, fat and ash contents than control groups.

pH values of beef patties were between 5.67-5.71 and 5.86-5.92, for uncooked and cooked samples, respectively. Incorporation of 5% PM (P5) increased the pH value of both uncooked and cooked patties compared to C group ($p$<0.05). P3 samples had lower ($p$<0.05) and P2 samples had similar pH values compared to C samples in cooked treatments. Similarly, some authors reported an increase in pH values of meat burgers formulated with different fiber types (Gök et al., 2011; Sayas-Barberá et al., 2011). Contrarily, López-Vargas et al. (2014) found that passion fruit albedo addition decreased pH value compared to control samples in raw burgers which could be attributed to the acid nature of the ingredient, while in cooked burgers the presence of fruit albedo did not modify the pH values. Therefore, the acidity and alkalinity of the raw material incorporated in the meat product formulation is crucial for ultimate pH value and thereby functional characteristics of the product.

**Table 2.** Chemical composition and pH of cooked and uncooked beef patties

| Treatments[1)] | | Moisture (%) | Protein (%) | Fat (%) | Ash (%) | pH |
|---|---|---|---|---|---|---|
| Uncooked beef patties | C | 60.46$^{a}$ ± 0.59 | 17.50 ± 0.39 | 19.30$^{ab}$ ± 0.36 | 2.73$^{b}$ ± 0.03 | 5.67$^{b}$ ± 0.01 |
| | P2 | 61.04$^{a}$ ± 1.15 | 17.61 ± 0.05 | 18.48$^{b}$ ± 1.20 | 2.86$^{ab}$ ± 0.09 | 5.68$^{b}$ ± 0.02 |
| | P3 | 61.13$^{a}$ ± 1.77 | 17.89 ± 0.32 | 18.24$^{b}$ ± 1.61 | 2.74$^{b}$ ± 0.04 | 5.67$^{b}$ ± 0.01 |
| | P5 | 57.78$^{b}$ ± 1.14 | 18.35 ± 0.78 | 20.91$^{a}$ ± 0.74 | 2.95$^{a}$ ± 0.09 | 5.71$^{a}$ ± 0.01 |
| Cooked beef patties | C | 59.71$^{a}$ ± 0.42 | 20.18 ± 2.22 | 17.35$^{b}$ ± 1.94 | 2.76$^{b}$ ± 0.04 | 5.89$^{b}$ ± 0.01 |
| | P2 | 58.69$^{b}$ ± 0.37 | 20.26 ± 0.44 | 18.18$^{a}$ ± 0.67 | 2.87$^{a}$ ± 0.07 | 5.89$^{b}$ ± 0.05 |
| | P3 | 56.46$^{c}$ ± 0.36 | 20.32 ± 0.70 | 20.26$^{a}$ ± 0.45 | 2.95$^{a}$ ± 0.02 | 5.86$^{c}$ ± 0.02 |
| | P5 | 55.83$^{c}$ ± 1.64 | 21.33 ± 1.51 | 19.92$^{a}$ ± 1.71 | 2.90$^{a}$ ± 0.05 | 5.92$^{a}$ ± 0.01 |

[1)]C: beef patties formulated without pumpkin mix; P2: beef patties formulated with 2% pumpkin mix; P3: beef patties formulated with 3% pumpkin mix; P5: beef patties formulated with 5% pumpkin mix.
Data are presented as the mean values of replications ± standard deviation. abc: Means with the different letter in the same column are significantly different ($p$<0.05).

## Water holding capacity and cooking properties

WHC and cooking properties of beef patties formulated with different levels of PM are given in Table 3. WHC of beef patties varied between 75.30-79.80%, where significant differences were found among treatments ($p$<0.05). Increased amounts of PM had a significant effect on WHC, where P5 samples had higher WHC compared to C and P2 samples ($p$<0.05). The high dietary fiber content of pumpkin could be the most probable reason to increase WHC of the samples. According to the literature findings pumpkin seed flour contains 22.40 g dietary fiber in 100 g dry matter (Naves et al., 2010) while pumpkin flour contains 27.4% total dietary fiber (Minarovičová et al., 2017). Ammar et al. (2014) stated that 1 g of pumpkin flour has the ability to hold 7.01 g of water that it could be used as a thickening agent in formulation of many foods. They found that WHC of meatball samples contained pumpkin flour were significantly higher than meatball samples contained date seed powder or wheat germ.

Yield, in meat and meat products, is associated with fat and water retention (Aleson-Carbonell et al., 2005). According to Kastner and Felício (1980), grinding of meat during burger processing results in a tender product due to the breakdown of the myofibrils and connective tissue, which, however, promotes weight loss during the cooking process. Cooking yield of the samples changed between 87.88-89.90%. No significant differences were found in cooking yield and diameter change of the treatments, this result showed that PM could compensate for the decrease in the meat amount in the formulation without loss of any technological quality. This finding could also present a good option for ensuring the healthy profile of the product as well as reducing product costs. Ammar et al. (2014) reported that the highest cooking yield was noticed for meatballs formulated with pumpkin flour compared to meatballs formulated with date seed powder and wheat germ, which could be due to pumpkin flour was able to hold more excess water. In contrast to these findings, a significantly decreasing trend was observed by Zargar et al. (2014) in the cooking yield of chicken sausages with increasing levels of pumpkin pulp. The differences in our results could be associated with utilization of dried pumpkin ingredients instead of fresh ones, that resulted in good retention of fluids in the meat matrix. Mendiratta et al. (2013) observed no significant differences in cooking yields of control and vegetable (carrot, radish and capsicum) incorporated mutton nuggets. The differences in the cooking yield of the products could be related to water absorption degrees of the non-meat ingredient used.

**Table 3. Water holding capacity and cooking properties of beef patties**

| Treatments[1)] | Water holding capacity (%) | Cooking yield (%) | Change of thickness (%) | Change of diameter (%) | Fat retention (%) | Moisture retention (%) |
|---|---|---|---|---|---|---|
| C | $75.30^{b} \pm 1.37$ | $87.94 \pm 2.79$ | $59.72^{a} \pm 8.67$ | $12.39 \pm 2.41$ | $69.53^{c} \pm 2.14$ | $54.32^{a} \pm 1.59$ |
| P2 | $75.59^{b} \pm 0.85$ | $87.88 \pm 1.42$ | $36.15^{bc} \pm 7.21$ | $11.35 \pm 1.33$ | $86.74^{b} \pm 7.47$ | $51.57^{b} \pm 0.73$ |
| P3 | $77.22^{ab} \pm 0.99$ | $89.90 \pm 1.34$ | $21.05^{c} \pm 9.12$ | $11.65 \pm 2.52$ | $99.33^{a} \pm 7.57$ | $50.25^{b} \pm 1.07$ |
| P5 | $79.80^{a} \pm 3.13$ | $88.20 \pm 0.42$ | $43.14^{ab} \pm 12.24$ | $11.20 \pm 1.25$ | $84.09^{b} \pm 6.93$ | $49.24^{b} \pm 1.23$ |

[1)]C: beef patties formulated without pumpkin mix; P2: beef patties formulated with 2% pumpkin mix; P3: beef patties formulated with 3% pumpkin mix; P5: beef patties formulated with 5% pumpkin mix.
Data are presented as the mean values of replications ± standard deviation. abc: Means with the different letter in the same column are significantly different ($p$<0.05).

The reduction in diameter is the result of the denaturation of meat proteins with the loss of water and fat (Besbes et al., 2008; Farouk et al., 2000; López-Vargas et al., 2014). The change of thickness determined in beef patties was between 21.05-59.72%. It was found that the thickness of all of the samples were changed after the cooking operation as expected. The change of thickness varied with different levels of added PM ($p$<0.05). C and P5 treatments had higher thickness change compared to P2 and P3 samples ($p$<0.05). This finding could be attributed to the stabilizing properties of PM, which restricted the distortion of the patties during cooking. However, in increased concentrations PM could have a reverse impact that might increase the changes of thickness and thereby increase shrinkage and negatively affect the acceptability of the product. Therefore, the levels of PM more than 5% could lead to textural cracking of the product, probably due to the increased solid material and decreased moisture content. The change of diameter in treatments was recorded between 11.20-12.39%, no significant differences were obtained between treatments. Therefore, it could be concluded that PM inclusion provided an equivalent diameter reduction to control samples regardless of the level added.

Keeping fat within the matrix of meat products during cooking and storage is necessary to ensure sensory quality and acceptability (Anderson and Berry, 2001). Fat retention of beef patties was between 69.53-99.33%. Control patties showed the lowest fat retention among samples ($p$<0.05). This result indicated that incorporation of PM lead to an increase in fat retention of the samples. Maximum fat retention was found in P3 samples ($p$<0.05), this showed that the average amount of PM showed the best performance among PM treatments in holding fat in the matrix upon cooking. Previously, pumpkin flour was reported to have 1.69 g oil/g sample oil binding capacity by Ammar et al. (2014), meaning that pumpkin ingredients could adequately support the ability to keep fat in the structure of the product during heat treatment. Our results were in concordance with the findings of López-Vargas et al. (2014) who found that fat retention of pork burgers formulated with passion fruit albedo was higher than in control pork burgers. Similarly, Ergezer et al. (2014) reported that the addition of breadcrumbs and potato puree with level of 10% and 20% increased the fat retention values of meatballs compared to control samples. Similar results were also obtained by Yıldız-Turp and Serdaroğlu (2010) in beef patties formulated with plum puree.

Moisture retention of beef patties were between 49.24-54.32%. Addition of PM decreased moisture retention of samples compared to C samples, regardless of the added amount ($p<0.05$). This finding is in contrast to WHC of the samples, where the ability to hold water was increased in the samples formulated with 5% PM, as mentioned previously. This result is in line with total moisture content of the samples, where significant loss in moisture was obtained with added PM. Therefore, the likely reason in decrement of moisture retention could be the lower moisture content of the products formulated with PM. Contrary to our findings, Selani et al. (2015) stated that beef burgers formulated with pineapple by-product showed higher moisture retention than conventional treatments, due to the property of the fiber to hold water and this resulted in products with higher percentages of moisture retention.

## Color

The excess amount of non-meat ingredients added to meat product formulations could lead to undesirable changes in color. Color parameters of beef patties are shown in Table 4. L*, a* and b* values were within the range of 39.26-40.92, 8.52-14.14 and 9.66-12.38, respectively. No significant differences were obtained in L* values of the samples. Although some of the non-meat ingredients, especially flours could lead a pale color in beef products, it was found that use of PM did not affect the lightness of the samples. Similarly, Selani et al. (2015) found no significant differences between L* values of beef burgers with the addition of pineapple, passion fruit or mango byproducts. In contrast, López-Vargas et al. (2014) reported that in pork burgers, L* values increased when passion fruit albedo was added, while the effect of cooking on the L* values showed that only the control sample was affected. They stated that the L* behavior of cooked burgers with fruit albedo was attributed to the white components in the raw material. a* values of the samples were significantly affected by the addition of PM ($p<0.05$), regardless of the added amount. The highest a* values were measured in C samples ($p<0.05$), probably due to the control samples containing only minced beef which has high amount of myoglobin, as well as due to the color of PM itself. The lowest b* values were measured in P2 samples ($p<0.05$), whilst b* values of other treatments did not show significant differences. This result showed that utilization of 2% PM could cause a decrement in yellowness of the product, but more than this concentration b* values were similar to control samples. Selani et al. (2015) reported that in beef burgers the treatments with the higher levels of pineapple by-product showed significant reduction in a* values, while the treatments with mango by-product promoted the greatest change in b* value, compared to conventional treatments.

**Table 4. Color parameters of beef patties**

| Treatments[1)] | L* | a* | b* |
|---|---|---|---|
| C | 40.45 ± 0.84 | $14.14^{a}$ ± 2.83 | $12.25^{a}$ ± 0.76 |
| P2 | 39.58 ± 1.87 | $10.57^{b}$ ± 1.22 | $9.66^{b}$ ± 0.75 |
| P3 | 39.26 ± 0.44 | $9.70^{b}$ ± 1.23 | $11.85^{a}$ ± 0.46 |
| P5 | 40.92 ± 1.11 | $8.52^{b}$ ± 0.95 | $12.38^{a}$ ± 1.50 |

[1)]C: beef patties formulated without pumpkin mix; P2: beef patties formulated with 2% pumpkin mix; P3: beef patties formulated with 3% pumpkin mix; P5: beef patties formulated with 5% pumpkin mix.
Data are presented as the mean values of replications ± standard deviation. abc: Means with the different letter in the same column are significantly different ($p<0.05$).

## Texture profile analysis

The texture of cooked meat is generally considered to be affected by heat-induced changes in connective tissue, soluble proteins and myofibrillar proteins (Zayas and Naewbanij, 1986). In comminuted meat products, textural properties are closely related to the functionality of muscle proteins and the presence of non-meat ingredients. The results of texture profile analysis of the patties could be seen in Table 5. Hardness, springiness, cohesiveness, gumminess and chewiness of the samples were between 7.80-9.97 N, 0.34-0.51 mm, 0.31-0.35, 2.67-3.49 N and 2.89-5.07 N·mm, respectively. Most of the samples formulated with PM showed equivalent textural parameters to control samples without PM. Hardness value of P2 samples was higher than C samples ($p<0.05$), while the values were similar in C, P3 and P5 samples. Lower springiness values were measured in P3 and P5 compared to C ($p<0.05$), but the results were similar in C and P2. Cohesiveness values were in parallel with springiness, thus addition of more than 2% PM reduced the springiness and cohesiveness of beef patties ($p<0.05$). Chewiness values of PM treatments were similar to control, but P2 samples had higher chewiness than P3 and P5 samples ($p<0.05$). The findings showed that generally replacement of lean with PM could compensate for the changes in textural attributes. López-Vargas et al. (2014) found that hardness and chewiness values of pork burgers formulated with albedo-fiber powder were increased with the increasing fiber amount, while springiness and cohesiveness of the samples did not show significant differences and gumminess was increased with only addition of 5% powder. The textural parameters of the products could show differences according to the natural structure and the amount of the non-meat ingredient and the amount of replaced meat in the formulation.

**Table 5. Texture profile analysis of beef patties**

| Treatments[1)] | Hardness (N) | Springness (mm) | Cohesiveness | Gumminess (N) | Chewiness (N·mm) |
|---|---|---|---|---|---|
| C | $7.80^{b} \pm 0.55$ | $0.46^{a} \pm 0.42$ | $0.35^{a} \pm 0.00$ | $2.76^{b} \pm 0.2$ | $4.11^{ab} \pm 0.45$ |
| P2 | $9.97^{a} \pm 0.44$ | $0.51^{a} \pm 0.11$ | $0.35^{a} \pm 0.02$ | $3.49^{a} \pm 0.11$ | $5.07^{a} \pm 0.93$ |
| P3 | $8.75^{ab} \pm 0.98$ | $0.36^{b} \pm 0.02$ | $0.32^{b} \pm 0.01$ | $2.90^{b} \pm 0.30$ | $3.72^{b} \pm 0.49$ |
| P5 | $8.62^{ab} \pm 1.57$ | $0.34^{b} \pm 0.01$ | $0.31^{b} \pm 0.01$ | $2.67^{b} \pm 0.47$ | $2.89^{b} \pm 0.56$ |

[1)]C: beef patties formulated without pumpkin mix; P2: beef patties formulated with 2% pumpkin mix; P3: beef patties formulated with 3% pumpkin mix; P5: beef patties formulated with 5% pumpkin mix.
Data are presented as the mean values of replications ± standard deviation. abc: Means with the different letter in the same column are significantly different ($p<0.05$).

## Sensory evaluation

Incorporation of non-meat ingredients in meat product formulations could lead undesired changes in sensory characteristics in case of excessive use or intensive aroma or color of the ingredient added. Therefore, it is important to evaluate the sensory properties of the product and perform necessary regulations in the formulations. Sensory scores of beef patties are illustrated in Fig. 1. Appearance, color, texture, juiciness, flavor and overall acceptability scores were between 7.40-7.70; 7.60-7.80; 7.30-7.90; 6.70-7.60 and 7.20-7.80, respectively, meaning that panelists evaluated all the formulations in acceptable ranges. According to the results, it was found that the addition of PM did not significantly affect any of the sensory scores tested. Only addition of PM at a level of 2% slightly lowered the juiciness scores compared to other samples, which was not statistically significant. The results showed that added PM could compensate for the lean replacement and maintain sensory attributes regardless of the amount used. Therefore, PM could be used even at maximum level without negatively affecting sensory characteristics. Similar to our results, in a study performed by Ammar et al. (2014), utilization of pumpkin flour had no considerable effect on sensory properties of meatballs. Zargar et al. (2014) reported that no significant effect of pumpkin was observed on the appearance, color and flavor scores of the chicken sausages. Consequently, pumpkin ingredients could be noted as alternative non-meat additives in meat products without altering sensory properties, which could be due to neutral aroma and non-intensive flavor of the raw material. Nevertheless, it should be noted that utilization of higher concentrations should be avoided to maintain sensory quality and consumer acceptability of the products.

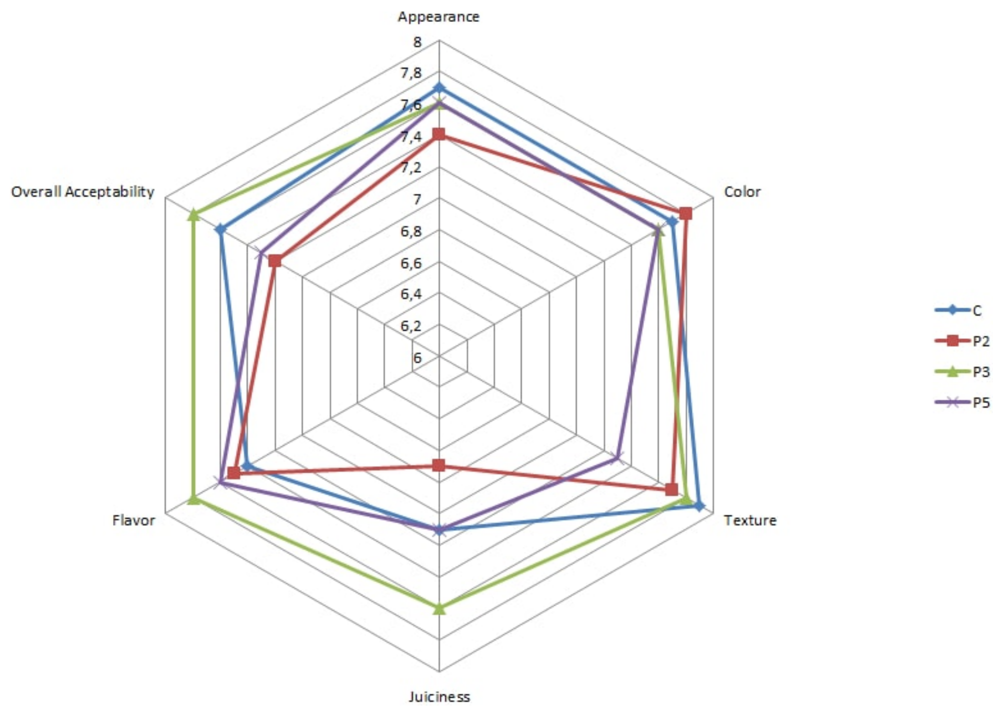


Fig. 1. Sensory scores of beef patties.

## Conclusion

Incorporation of non-meat ingredients in various meat products has long been an important research topic to improve product functionality, provide a healthier profile and reduce costs. Since pumpkin sourced ingredients are economic, healthy and easily produced, utilization of them in meat product formulations could improve quality characteristics and health benefits. Our results showed that incorporation of dried pumpkin pulp and seed mixture present a good option to replace lean meat in beef patties, improving water holding, maintaining cooking properties without causing any unfavorable effects in textural and sensory quality attributes. These are the first findings regarding the usage of PM in beef products, further research should be performed to evaluate different quality attributes of various meat products formulated with pumpkin ingredients.

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