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RESEARCH ARTICLE

The Effects of Cereal and Legume Flours on the Quality Characteristics of Beef Patties [1]

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Summary

The effects of cereal and legume flours (wheat, barley, oat, rye, rice, corn, soy, chickpea and yellow lentil flours) on the physical, chemical, and sensory properties of beef patties were investigated. Meat patties were prepared using beef, beef back fat, and spices. Each of the flours was added to each formulation instead of beef back fat at the level of 5%. Effects of the cereal and legume flours (CLFs) on pH, proximate composition, cooking yield, diameter reduction, and sensory properties of beef patties were studied. The effects of CLFs on the protein and fat values of raw and cooked beef patties were found to be significant. However, CLFs increased yield, moisture, and fat retention and decreased diameter reduction values. Oat flour increased moisture retention, odour, texture, flavour and overall acceptability values of the cooked beef patties the best. Among the legume flours, chickpea flour had higher performance on the sensorial properties of beef patties. However, yellow lentil flour decreased sensory scores significantly.

Keywords: *Beef, Beef patties, Cereal, Legume, Patty*

Tahıl ve Baklagil Unlarının Sığır Eti Köftelerinin Kalite Özellikleri Üzerindeki Etkileri

Özet

Tahıl ve baklagil unlarının (buğday, arpa, yulaf, çavdar, pirinç, mısır, soya, nohut ve sarı mercimek) sığır eti köftelerinin, fiziksel, kimyasal ve duyusal özellikleri üzerindeki etkileri araştırılmıştır. Et köfteleri, sığır eti, sığır kabuk yağı ve baharat kullanılarak hazırlanmıştır. Her bir formülasyonda, farklı unlar %5 oranında sığır kabuk yağı yerine kullanılmıştır. Tahıl ve baklagil unlarının sığır eti köftelerinin, pH, nem, yağ, protein, pişirme verimi, çap küçülmesi ve duyusal özellikleri üzerindeki etkileri araştırılmıştır. Tahıl ve baklagil unlarının, ham ve pişmiş sığır eti köftelerinin protein ve yağ değerleri üzerindeki etkileri önemli bulunmuştur. Bununla birlikte, tahıl ve baklagil unları, köftelerin, pişirme verimini, nem değerlerini ve yağ tutma değerlerini artırırken, çap küçülmesi değerlerini azaltmıştır. Unlar arasında yulaf unu, nem tutma değerlerini, koku, tekstür, lezzet ve genel kabul edilebilirlik değerlerini en fazla artıran un olmuştur. Sığır eti köftelerinin duyusal özellikleri üzerinde nohut ununun performansı, diğer baklagil unlarına kıyasla daha yüksek bulunmuştur. Bununla birlikte, sarı mercimek unu duyusal skorları önemli derecede düşürmüştür.

Anahtar sözcükler: *Sığır eti, Sığır eti köftesi, Tahıl, Baklagil, Köfte*

INTRODUCTION

Meat and meat products are preferred by consumers in terms of nutritional and sensory properties. The amount of fat in formulations of meat products is an important factor for product quality, technological properties and health. The desirable sensory characteristics of juiciness and mouth feel of meat patties are associated with fat level [1]. Reduction in fat adversely affects the textural and sensorial characteristics of meat products [2]. Proteins, modified starches, gums, and cereal and legume flours are used to reduce the adverse effects of fat reduction [1,3-7]. They can increase moisture and fat retention capability of meat products, thus increasing the juiciness and improving brittleness meat products.

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The type and the amount of non-meat ingredients in formulations of meat products are the most important factors for product quality, technological properties and health [8-10]. Formulations of meat patties may include one or more cereal and legume products. Cereal flours are used widely in ground meat products as a binder or extender. Some of them, such as oat flour, increase moisture and fat retention in beef patties [11]. Oat products such as oat bran and oat fiber in meat patties increased moisture retention and bran improved mouth feel [1]. However, recent studies of ground meat products have focused on legume flours [6,12,13]. Some of the legumes, such as lentils and chickpeas, are rich in protein and starch content [14,15]. Lentil and chickpea flours can be used in meat products as coating materials or extenders [14,15]. However, soy products have been widely used in meat products for many years because of their higher protein content and the functional properties of their proteins.

Cereal and legume flours can cause differences in the physical, chemical, and sensorial characteristics of beef patties. Therefore, in this study, the effects of using nine different cereal and legume flours instead of beef fat on some quality parameters of beef patties were investigated.

MATERIAL and METHODS

Patty Preparation

Beef (*semimembranosus)* and beef fat pieces (2-3 cm^3 in size) were mixed and minced in a grinder (Tefal, Le Hachoir 1500, France). This minced meat was divided into 10 parts. Five percent minced beef fat on the basis of patty formulation was added to the first part and then minced in a grinder. However, each of the remaining 9 parts was minced again in a grinder. Five percent of cereal or legume flours were added to these remaining parts on the basis of patty formulation. The following ingredients were added to the each part: 1.5% salt, 1.2% red pepper, 0.3% black pepper, 0.3% cumin, and 1.7% onion powder. One kg of each formulation was then kneaded for 10 min by hand to obtain uniform meatball batter. Then, each 25 g of batter was shaped with silicone moulds into 1.4 cm thick and 4.8 cm diameter circular-shaped patties. The patties were cooked on a preheated electric grill (Philips HD4417, Philips, Amsterdam, the Netherlands) for 4 min on each side. The core temperature of patties was reached to 74°C during cooking. Core temperature was measured a digital thermometer with a penetration probe (Testo 926, Testo AG, Lenzkirch, Germany). Five meat patties were used for the analysis of each treatment.

Determination of the pH

Ten grams of sample was homogenized in 100 ml distilled water and the pH was measured using a pH meter (Orion 3-star, MA, USA) equipped with temperature probe as outlined by Ockerman [16].

Determination of the Proximate Composition

Moisture, fat, and protein were determined according to AOAC [17]. Protein was determined as crude protein using the Kjeldahl method. Fat was determined as crude fat using the Soxhelet extraction.

Determination of the Cooking Yield

Cooking yield was determined as follows:

$$Cooking\ Yield\ (\%)\ = \frac{w_1 \times 100}{w_0}$$

where w_0 is the weight of patties before cooking and w_1 is the weight after cooking.

Determination of the Moisture and Fat Retention

Moisture and fat retention were determined as follows:

$$Moisture\ retention\ (\%) = Cooking\ yield\ x\ \frac{\%\ moisture\ in\ cooked\ patties}{\%\ moisture\ in\ raw\ patties}$$

$$Fat\ retention\ (\%) = Cooking\ yield\ x\ \frac{\%\ fat\ in\ cooked\ patties}{\%\ fat\ in\ raw\ patties}$$

Determination of the Diameter Reduction

Diameter reduction was calculated as follows:

$$Diameter\ Reduction\ (\%)\ = \frac{(d_0 - d_1) \times 100}{d_0}$$

where d_0 is the diameter of patties before cooking and d_1 is the diameter after cooking.

Sensory Analysis

The cooked beef patties were cooled to room temperature and served in a random order. Water and bread were served after each sample to remove traces of the previous sample from mouth. Ten trained panelists (academic staff of Adıyaman University, Food Process, Food and Beverage, and Cookery Departments) who were selected and trained according to Yetim and Kesmen [18] assessed the sensory properties using a hedonic scale for the appearance, color, brittleness, odor, flavor, and overall quality. The values in the scale indicated the following range of reactions: 1: dislike extremely to 9: like extremely.

Statistical Analysis

Two replicates were performed for this study. The data were subjected to analysis of variance (ANOVA), and the results were expressed as mean ± standard deviation (SD). When there were differences among the samples, the differences were compared by Duncan's multiple-range test at the levels of $P<0.01$ and $P<0.05$ using a software (SPSS, Chicago, IL, USA).

RESULTS

The Proximate Composition and pH Values of Raw Meat Patties

The effects of different cereal and legume flours on the pH and moisture values of raw beef patties were not found to be significant ($P>0.05$, *Table 1*). Moisture and pH values of raw beef patties were changed between 59.18-60.59% and 5.59-5.78, respectively. The effects of differences in the cereal and legume flours on the fat and protein values of raw meat patties were found to be significant ($P<0.01$). As shown in *Table 1*, CLFs decreased fat values. The lowest fat value was found with rice flour. However, of all the cereals and legumes, oat increased fat content of raw beef patties the most. The highest protein content was found with soy flour. Wheat, rye, and rice flour decreased the protein values of raw beef patties.

The Proximate Composition and pH Values of Cooked Meat Patties

The use of cereal and legume flours instead of fat did not change the pH and moisture values of cooked beef patties significantly. The effects of CLFs on the fat and protein values were found to be significant ($P<0.01$). They decreased the fat and moisture values of cooked beef patties. The highest and the lowest fat values of cooked patties were found in the control group and with rice flour, respectively (*Table 2*). Of all CLFs, lentil flour increased fat values the most. However, significant differences ($P>0.05$) were not

Table 1. *Proximate composition and pH values of raw beef patties*
Tablo 1. *Ham sığır eti köftelerinin nem, yağ, protein ve pH değerleri*

Fat and Flours	pH	Moisture (%)	Fat (%)	Protein (%)
Beef fat	5.61±0.14	59.85±0.45	16.95±0.15 ^{d}	18.05±0.11^{ab}
Wheat	5.59±0.04	60.04±0.41	13.64±0.18 ^{b}	17.97±0.14 ^{a}
Barley	5.63±0.05	59.86±0.41	13.38±0.39^{ab}	18.28±0.03^{bc}
Oat	5.65±0.04	59.18±0.24	13.82±0.04 ^{c}	18.47±0.10^{cd}
Rye	5.64±0.01	59.75±0.62	13.78±0.43^{bc}	18.01±0.04 ^{a}
Rice	5.62±0.02	60.59±0.50	12.62±0.44 ^{a}	18.00±0.16 ^{a}
Corn	5.62±0.03	59.93±0.78	13.23±0.41^{ab}	18.58±0.17 ^{d}
Soy	5.78±0.02	59.84±0.35	13.47±0.18^{ab}	20.07±0.05 ^{f}
Chickpea	5.67±0.02	60.07±0.44	13.39±0.46^{ab}	18.49±0.10^{cd}
Lentil	5.65±0.01	60.07±0.37	13.52±0.31 ^{b}	18.89±0.03 ^{e}
SL	NS	NS	S	S

SL: *significance level,* ***NS:*** *non-significance,* ***S:*** *significance, Mean values within a row followed by different letters are significantly (P<0.05) different. Values are means ± SD*

Table 2. *Proximate composition and pH values of cooked beef patties*
Tablo 2. *Pişmiş sığır eti köftelerinin nem, yağ, protein ve pH değerleri*

Fat and Flour	pH	Moisture (%)	Fat (%)	Protein (%)
Beef fat	5.75±0.04	54.44±0.63	15.36±0.54 ^{c}	25.04±0.82^{d}
Wheat	5.73±0.01	55.07±0.36	14.15±0.59^{ab}	22.07±0.81^{ab}
Barley	5.75±0.04	55.20±0.54	14.29±0.17^{ab}	21.92±0.66^{ab}
Oat	5.76±0.04	55.61±0.41	14.00±0.41^{ab}	22.07±0.13^{ab}
Rye	5.78±0.05	55.50±0.18	14.06±0.30^{ab}	21.56±0.22^{ab}
Rice	5.77±0.04	54.46±0.75	13.70±0.09 ^{a}	23.09±0.18^{bc}
Corn	5.77±0.08	54.96±0.92	14.12±0.17^{ab}	21.32±0.80^{a}
Soy	5.88±0.06	54.68±0.64	14.40±0.02^{ab}	24.34±1.02^{cd}
Chickpea	5.83±0.11	54.85±0.77	14.47±0.10^{ab}	22.65±0.66^{ab}
Lentil	5.84±0.13	54.88±0.50	14.67±0.15^{bc}	22.18±0.52^{ab}
SL	NS	NS	S	S

SL: *significance level,* ***NS:*** *non-significance,* ***S:*** *significance, Mean values within a row followed by different letters are significantly (P<0.05) different. Values are means ± SD* found between the effects of CLFs, with the exception of rice and lentil flours in terms of fat content.

The highest and the lowest protein values of cooked beef patties were found with the control and corn flour, respectively *(Table 2)*. The increasing fat loss increased protein values of the control group. However, significant differences ($P>0.05$) were not found between the effects of CLFs, with the exception of rice, corn and soy flours in terms of protein content.

Cereal and legume flours increased the cooking yield of beef patties significantly *($P<0.01$, Table 3)*. CLFs applications decreased the diameter reduction values of cooked beef patties. These values in the beef patties were lower with corn, rye, and rice flours.

Sensory Properties

The effects of cereal and legume flours on the sensory parameters were found to be significant ($P<0.01$) with the exception of texture scores. The appearance and colour scores with wheat, barley, oat, rye, rice, corn and chickpea flours were significantly higher than those of the control, soy, and lentil flours *(Table 4)*. The lowest colour score was found with lentil flour.

Odour scores with wheat, oat, rye, rice, corn and chickpea flours were found to be higher (Table 4). There were also no significant differences between them. The effects of cereal and legume flours on the flavour scores were found to be significant. The oat, rice, and wheat flours increased overall quality scores more than did other cereal and legume flours *(Table 4)*. However, lentil flour significantly decreased the scores of sensory parameters. Overall quality scores of CLFs, with the exception of soy and lentil, were higher than those of beef fat.

DISCUSSION

95% of the formulations of beef patties had the same content. Therefore, the difference in the rates of protein contents of raw beef patties may be caused from protein

Table 3. *Physical and chemical properties of cooked beef patties*
Tablo 3. *Pişmiş sığır eti köftelerinin fiziksel ve kimyasal özellikleri*

Fat and Flours	Yield (%)	Moisture Retention (%)	Fat Retention (%)	Diameter Reduction (%)
Beef fat	76.22±2.95 ^{a}	69.33±2.96 ^{a}	69.17±5.71 ^{a}	21.91±064 ^{c}
Wheat	87.70±1.32 ^{b}	80.44±1.19 ^{bc}	91.07±6.40 ^{b}	18.42±0.60 ^{b}
Barley	87.72±2.28 ^{b}	80.90±2.33 ^{bc}	93.76±6.25 ^{b}	18.13±0.45 ^{b}
Oat	88.84±2.06 ^{b}	83.48±2.21 ^{c}	90.07±4.96 ^{b}	17.93±0.01 ^{b}
Rye	87.63±1.86 ^{b}	81.39±1.16 ^{bc}	89.54±6.64 ^{b}	17.34±0.37 ^{ab}
Rice	84.92±2.76 ^{b}	76.34±2.91 ^{b}	92.26±6.85 ^{b}	17.52±0.58 ^{ab}
Corn	87.18±2.74 ^{b}	79.94±2.80 ^{bc}	93.17±6.96 ^{b}	16.56±0.59 ^{a}
Soy	85.82±2.58 ^{b}	78.41±2.82 ^{bc}	91.77±3.85 ^{b}	18.18±0.37 ^{b}
Chickpea	86.80±2.62 ^{b}	79.27±2.92 ^{bc}	93.89±6.70 ^{b}	18.13±0.59 ^{b}
Lentil	86.66±0.40 ^{b}	79.17±0.12 ^{bc}	94.09±2.69 ^{b}	17.97±0.37 ^{b}

Mean values within a row followed by different letters are significantly (p<0.05) different. Values are means ± SD

Table 4. *Sensory properties of cooked beef patties*
Tablo 4. *Pişmiş sığır eti köftelerinin duyusal özellikleri*

Fat and Flours	Appearance	Colour	Odour	Texture	Flavour	Overall Quality
Beef fat	5.30±0.57 ^{a}	5.80±0.57 ^{ab}	6.50±0.00 ^{bc}	6.20±0.14 ^{a}	6.40±0.00 ^{bc}	6.05±0.07 ^{b}
Wheat	7.20±0.57 ^{b}	7.60±0.57 ^{d}	7.05±0.35 ^{c}	7.05±0.07 ^{a}	6.95±0.21 ^{cd}	7.20±0.42 ^{c}
Barley	6.75±0.07 ^{b}	6.95±0.07 ^{bcd}	6.40±0.42 ^{bc}	6.40±0.71 ^{a}	6.45±0.35 ^{bc}	6.65±0.35 ^{bc}
Oat	7.10±0.57 ^{b}	7.10±0.28 ^{cd}	7.45±0.35 ^{c}	7.15±0.49 ^{a}	7.40±0.14 ^{d}	7.40±0.28 ^{c}
Rye	6.85±0.78 ^{b}	7.15±0.21 ^{d}	6.90±0.28 ^{c}	7.05±0.07 ^{a}	6.60±0.00 ^{bcd}	6.75±0.49 ^{bc}
Rice	7.05±0.35 ^{b}	6.95±0.78 ^{bcd}	6.55±0.49 ^{c}	6.95±0.35 ^{a}	6.70±0.28 ^{bcd}	7.35±0.35 ^{c}
Corn	6.80±0.14 ^{b}	7.00±0.14 ^{bcd}	6.75±0.21 ^{c}	6.35±0.49 ^{a}	6.25±0.07 ^{bc}	6.50±0.00 ^{bc}
Soy	5.55±0.64 ^{a}	5.85±0.64 ^{abc}	5.50±0.57 ^{ab}	6.05±0.64 ^{a}	5.95±0.49 ^{b}	5.80±0.42 ^{ab}
Chickpea	7.00±0.71 ^{b}	7.20±0.85 ^{d}	6.90±0.71 ^{c}	6.70±0.42 ^{a}	6.55±0.07 ^{bcd}	6.75±0.35 ^{bc}
Lentil	5.45±0.49 ^{a}	4.80±0.42 ^{a}	4.75±0.49 ^{a}	5.15±1.20 ^{a}	4.50±0.85 ^{a}	5.00±0.71 ^{a}

Mean values within a row followed by different letters are significantly (p<0.05) different. Values are means ± SD contents of the flours. Protein rates in the beef patties were increased with cooking process associated with loss of moisture. Of all CLFs, soy flour increased the protein values of raw and cooked beef patties at the best. The protein content of soy flour and the increasing fat and moisture loss in cooked beef patties may play an important role in increasing the protein values of cooked beef patties.

Although there is no statistically significant difference between the beef patties with CLFs, oat flour increased cooking yield the most compared to other CLFs. This result might be due to the highest moisture retention of cooked patties with oat flour *(Table 3)*. Cooking yield in meat patties primarily depends on moisture and fat retention. As shown in Table 3, the use of cereal and legume flours instead of fat increased the moisture and fat retention of cooked meat patties significantly ($P<0.01$). In particular, the effect of oat flour on the moisture retention was found to be the greatest. However, the moisture retention values for rice flour in beef patties were found to be lower compared to other CLFs *(Table 3)*. Serdaroglu [11] reported that oat flour can be used in beef patties as an extender in order to provide higher fat and moisture retention. Giese [1] reported that oat products such as oat bran and oat fibre increased moisture retention of low-fat meat products. Talukder and Sharma [8] reported that oat bran showed a greater effect on water-holding capacity than did wheat bran in chicken meat patties. Moreover, the protein and starch content of cereals and legumes may affect moisture and fat retention of cooked beef patties. During the cooking process, proteins form a gel matrix which can retain some components inside it [19,20]. Meat and non-meat protein interactions may also affect gel properties.

During the cooking process, gel formation and changes in the moisture and fat retention may affect the size and shape of the meat patties [21]. Alakali et al.[21] reported that shrinkage in patties during heating is caused by muscle protein denaturation, water loss and melted fat drainage. In particular, corn flour significantly decreased the diameter reduction values. This effect of corn flour might be due to its starch and protein content and gel formation properties. Starch may play an important role in improving low-fat meat patties [4, 21]. Moreover, thermally denatured proteins formed irreversible strong gels [19] that may be responsible for the size and shape of the products [23,24]. Ziegler and Acton [19] reported that heat treatment allows protein-protein interactions, which cause a stronger protein matrix.

Colour scores were found to be higher with wheat, chickpea, and rye flours. This difference might be due to the effects of the cooking process on the colour pigments. The lowest odour score was found with lentil flour. The differences in the odour scores of beef patties might be affected the flour sources and their usage levels.

Rye, rice, chickpea, wheat, and oat flour increased flavour scores of beef patties more compared to beef fat. As shown in *Table 4*, flavour scores increased the most with oat flour and decreased with lentil flour. Giese [1] reported that oat bran was used to improve mouth feel of low-fat cooked meat patties. Moreover, Pszczola [25] reported that oat bran imitated fat in low-fat meat products. Cereal and legume flours might affect the flavour of beef patties because of their different flavour characteristics. Moreover, the cooking process might affect these flavour differences.

Cereals and legumes used in this study with the exception of lentil flour, have improved the quality of beef patties. Although lentil flour had a positive effect on the physical and chemical properties of beef patties, it had a negative effect on the sensory scores. Among the cereal flours, oat has a high potential for use in beef patties. Moreover, among the legume flours, chickpea flour had higher performance in beef patties.

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