JAP&T
TPA-Timisoara

Available online at http://journal-of-agroalimentary.ro

Journal of Agroalimentary Processes and Technologies 2021, *27* (1), 1-8

Journal of Agroalimentary Processes and Technologies

Effect of fat level and type of legume flours on the quality characteristics of sheep meatballs

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Abstract

The effect of legumes flour (lentil and chickpea) and different fat levels (10, 15 and 20%) on chemical, physical and sensory evaluations of sheep meatballs were investigated. No significant differences were found in pH values of meatballs formulated with different types of legume flours and fat levels. Significant differences were found in moisture content of cooked sheep meatballs formulated with lentil and chickpea flours with different fat levels. While, significant differences were found in fat content between controls, meatballs formulated with lentil and chickpea flour and 10% fat. Meatballs formulated with chickpea flour had the highest a* value. Control groups had the lower cooking yield (58.98%), while the highest found in meatballs formulated with lentil flour and 10% fat (75.60%). No significant differences were found in water retention of meatballs formulated with chickpea and lentil. Generally, Meatballs formulated with chickpea flour and 15% fat recorded the highest score of sensory attributes.

Keywords: legumes flour, fat level, sheep meatballs, quality characteristics

1. Introduction

Meat and meat products can be formed into more "healthier food" by adding ingredients considered beneficial for health or by reducing components that are considered harmful [1]. Recent studies have focused on healthier effects of high fat intake and found that consumption of meat products with high fat level is associated with increasing risk of cardiovascular diseases and some types of cancers such as colon, breast and prostate [2, 3]. This resulted in increased demand for healthier meat products with low fat levels. On the other hand, studies showed that decreasing the fat level in meat products, results in reducing tenderness, juiciness, flavor, dark color and overall product acceptability [4-6]. In this respect, food researchers increased their efforts to improve meat products formulations to meet the consumer demands for healthier low fat meat products without negative effects on the products quality attributes.

Non-meat proteins are the most valuable ingredients that can be used in meat processing to improve the quality of meat products to meet the consumer demands for healthy low fat meat products. Various types of non-meat proteins such as cereal and legume flours have been used either alone or combined with other ingredients such as starches and gums in formulation of low fat meat products as extenders and binders [7]. Recent studies have focused on adding legumes flour on meat products formulations and its effect on quality properties [8-11].

Therefore, the aim of the present study was to evaluate the effects of using legume flours (chickpea and lentil) in sheep meatballs prepared with different levels of fat (10, 15 and 20%) on the quality characteristics of sheep meatballs.

2. Materials and methods

2.1. Materials

2.1.1. Preparation of legumes flour

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Legumes: chickpea (*Cicer arietinum* L., 9g protein, 27g carbohydrates, and 3g fat and 164 kcal calories/100g) and lentil (*Lens culinary*, 9g protein, 20g carbohydrates, and 1g fat and 116 kcal calories/100g).

2.1.2. Chickpea flour preparation

Chickpea were soaked in distilled water (1:3 w/v) at room temperature (25 ±3ºC) for 12hr and cooked in boiling water (100 ºC) in the ratio of 1:5 until they became soft (45 min). Cooked seeds were dried in electric oven (70 ºC) for 30 min.

2.1.3. Lentil flour preparation

Lentil seeds were soaked in distilled water (1:2 lentil to water) at room temperature (25 ±3ºC) for 2 hr and cooked for (20min) in boiling water (100 ºC) in the ratio of 1:5. Cooked lentil was dried in electric oven (70°C) for 1 h.

Cooked legume seeds were separately ground to get fine flour by using an electric mill (Moulinex, Type: DPA2 and Ref. DPA2417/0 G-0614-R. France).

2.1.4. Meatball preparation

Fresh sheep meat was obtained from local butcher in Giza, Egypt. Bones and all knives –separable fat were removed and all subcutaneous fat and inter-muscular fat were used as the fat source. Lean and fat were separately ground through a 3mm plat meat grinder (K-R-SU, Model: KMG1700. China). This minced meat was divided into 5 parts. Control treatment was formulated with 20% fat 0% flour. The other treatments were prepared with two levels of fat (10% and 15%) and two types of legume flours (chickpea and lentil). The following ingredients were added to the each part: onion powder, black pepper, spices mix and salt as shown in Table 1. 2kg batches of each formulation were mixed by hand for (2 min) until a homogenous mix was obtained and then processed into proper shape of meatballs (25±2g) by hand. Samples were placed in plastic foam meat trays, packed in polyethylene bags and frozen at -20ºC±1 until further analysis.

2.2. Methods

2.2.1. Chemical analysis

Moisture content of cooked sheep meatballs was determined gravimetrically at 105°C in an oven according to AOAC [12]. Fat contents of raw and cooked sheep meatballs samples were estimated by Soxhlet extraction by using petroleum ether [12].

2.2.2. Physical analysis

pH of raw sheep meatballs was measured using a digital pH-meter Jenway 3310 conductivity and pH meter as described by Hood [13].

Meatballs samples were cooked in a preheated electric oven for 15 min. Each sample was sheared for three times at different positions by using Instron Universal Testing Machine (Model: 2519-105, USA). The shearing machine was adjusted at crosshead speed of 200 mm/min and load 1 kg Newton. The average shear force calculated from three obtained results (kg/f).

2.2.3. Cooking measurements

Meatballs were roasted in a preheated oven for 15 min. All cooking measurements were carried out on three replicates of each treatment. Cooking yield percent was determined by calculating weight deference of samples before and after cooking. The cooking yield and fat retention of meatballs were determined according to Murphy et al. [14] as follows:

Cooking yield (%) = (Cooked sample weight) / (Uncooked sample weight)×100

Fat retention (%) = [(Cooked sample weight)×(% Fat in cooked sample)] / [(Raw sample weight)×(% Fat in raw sample)] ×100

Moisture retention was determined according to El-Magoli et al. [15] using the following equation:

Moisture retention (%) = [%Cooking yield×% Moisture in cooked sample] / 100

Raw and cooked samples were measured for diameter as described by Berry [16] using the following equation:

Shrinkage in diameter (%) = [(Uncooked sample diameter) – (Cooked sample diameter)] / (Uncooked sample diameter) ×100

2.2.4. Color measurement

Color of raw meatballs was measured by Chroma meter (Konica Minolta, model CR 410, Japan) calibrated with a white plate and light trap supplied by the manufacturer. Color was expressed using the CIE L, a, and b color system [17]. A total of three spectral readings were taken for each sample on different locations. Lightness (L*) (dark to light), the redness (a*) values (reddish to greenish) and the yellowness (b*) values (yellowish to bluish) were estimated.

Table 1. Sheep meatballs formulated with different legume flours and fat levels

Ingredients (%)	Control	CF		LF	
	20%	10%	15%	10%	15%
Meat	77	72	67	72	67
Fat	20	10	15	10	15
Legume flour	-	15	15	15	15
Onion powder	0.5	0.5	0.5	0.5	0.5
Black pepper	0.3	0.3	0.3	0.3	0.3
Spices mix	0.2	0.2	0.2	0.2	0.2
Salt	2	2	2	2	2

CF= Chickpea Flour, LF= Lentil Flour

2.2.5. Sensory evaluation

Meatballs samples were subjected to organoleptic evaluation as described by A M S A [18]. Ten trained panel assessed the sensory attributes using a 9-point hedonic scale, as follows: 8-9 very good, 6-7 good, 4-5 fair, 2-3 poor and 0-1 very poor. The mean scores of the obtained results of organoleptic evaluation were then statistically analyzed.

2.2.6. Statistical analysis

Analysis of variance (ANOVA) was used to test the obtained data using the general linear modeling procedure [19]. The used design was one way analysis. Duncan's multiple tests [20] were applied for comparison of means and the significance was defined as $P<0.05$.

3. Results and discussion

3.1. pH value, moisture and fat

Results of pH values of raw sheep meatballs, moisture and fat percent of cooked meatballs are given in Table 2. No significant differences were found in pH values of meatballs formulated with different types of legume flours and fat levels. On the same bases, Zaki [11] found that pH values of low fat sheep meatballs formulated with 10% chickpea and blackeye beans flour were not significantly different. Likwise, Kilincceker et al [10] found that the effects of lentil and chickpea flours on pH values of chicken meatballs were not significant. Zaki [21] indicated that no significant differences were found in chicken burgers containing different types of flour. Kurt and Kilincceker [9] found that no significant differences were found in pH value of beef patties formulated with different types of cereal and legume flours. Also, Serdaroglu [22] reported that fat level and oat flour not significantly affected on pH values of beef patties. Serdaroglu and Degirmencioglu [23] found the same results.

Significant differences were found in moisture content of cooked sheep meatballs formulated with different types of legume flours and fat levels. Regardless of legume type, meatballs formulated with 15 % fat showed the higher moisture content than that formulated with 10% fat. The highest moisture content was found in control sample and the lowest content found in meatballs formulated with lentil flour and 10% fat. Serdaroglu and Degirmencioglu [23] found that the moisture content of cooked meatballs ranging from 52.3 to 58.5%. Also, Serdaroglu [22] reported that addition of flour increasing the moisture content of beef patties at all fat levels.

Data of fat content showed that no significant differences were found in meatballs of control, meatballs formulated with chickpea and lentil flour with 10%fat. Meatballs formulated with lentil flour with 15%fat had the lowest fat content. Kurt and Kilincceker [9] reported that no significant differences were found in fat content of beef patties formulated with different types of cereal and legume flours. On the same bases, Serdaroglu [22] showed that addition flour significantly change the fat content of beef patties.

Table 2. pH values, moisture and fat contents of sheep meatballs

Meatballs formulation		Parameters		
Type of flour	Fat level	pH	Moisture %	Fat %
Control	20%	5.75±0.22	51.18±0.42^{a}	10.72±0.11^{a}
CF	10%	5.75±0.13	48.81±0.27^{c}	10.29±0.02^{a}
	15%	5.75±0.09	49.45±0.48^{b}	9.56±0.34^{b}
LF	10%	5.76±0.16	47.88±0.03^{d}	10.64±0.38^{a}
	15%	5.71±0.15	49.23±0.16^{bc}	8.61±0.15^{c}
SEM		0.08	0.18	0.13

$^{a-d}$ means within the same column with different superscripts letters are different ($p<0.05$).
CF= Chickpea Flour, LF= Lentil Flour. Means ± standard deviation. SEM: standard error of means.

3.2. Color measurements

Color measurements of raw sheep meatballs formulated with different fat levels and types of flour are shown in Table 3. No significant differences were found in L* value of meatballs samples. It can be noticed that type of flour and fat level did not significantly affected on a* value of meatballs samples. Also, a slight significant was found in b* values between meatballs samples. Similarly, Serdaroglu et al [24] found that a slight significant differences in L* value of meatballs formulated with lentil, chickpea flour and control groups.

No significant differences were found in b* values among low fat meatballs formulated with chickpea and lentil flour. Serdaroglu [22] found that fat level did not significantly affected on a* or b* values of beef patties formulated with different levels of fat. The same results were found in chicken meatballs formulated with different flours by Kilincceker [25].

3.3. Cooking yield, moisture retention and fat retention

Cooking yield, moisture retention and fat retention of cooked meatballs formulated with different fat levels and legumes flour are shown in Table 4. Data showed that control samples had the lowest cooking yield while, the meatballs formulated with legume flours showed the highest cooking yield. No significant differences were found in cooking yield% of meatballs formulated with chickpea flour at any fat level. Ikhlas et al [26] indicated that using various type of flours in formulation of meatballs resulting in increasing in the cooking yield. Motamedi et al [27] reported that hamburger prepared with different levels of lentil and chickpea flour showed significant differences in cooking yield, hamburger of control group showed the lowest cooking yield while, samples prepared of lentil and chickpea were the highest in cooking yield. Zaki [21] found that chicken burger of control group showed the lower cooking yield than that formulated with different types of flour.

No significant differences were found in water retention among meatballs formulated with chickpea and lentil flour, while control samples recorded the lowest percent. Similarly, Kurt and Kilincceker [9] reported that no significant differences were found in water retention of beef patties formulated with different types of cereal and legume flours. Also, Serdaroglu [22] found that all beef patties containing flour showed higher moisture retention than control one. These may be due to the increased of fat content in control group.

Formulation of sheep meatballs with different types of legume flours and fat levels had a significant effect of fat retention of meatballs. Control samples with 20% fat had the lower fat retention than that formulated with legume flours. Also, data showed that regardless of legume flours, meatballs formulated with 10% fat showed the higher fat retention than samples formulated with 15%. In this regard, Serdaroglu [22] found that beef patties of control samples with 20% fat had the lowest fat retention values. In addition, beef patties formulated with 10% fat showed the highest value of fat retention.

Table 3. Color parameters of raw sheep meatballs

Meatballs formulation		Parameters		
Type of flour	Fat level	L*	a*	b*
Control	20%	49.47±2.33	8.95±0.38^{ab}	8.52±0.04^{b}
CF	10%	50.79±1.00	9.42±0.56^{a}	9.22±0.22^{ab}
	15%	50.58±1.31	9.12±0.66^{ab}	10.36±1.07^{a}
LF	10%	50.13±0.55	8.23±0.38^{b}	9.43±0.91^{ab}
	15%	49.77±0.87	8.36±0.18^{b}	9.23±0.52^{ab}
SEM		0.78	0.26	0.39

Means within the same column with different superscripts letters are different ($p<0.05$).
CF= Chickpea Flour, LF= Lentil Flour. Means ± standard deviation. SEM: standard error of means.

Table 4. Cooking yield, moisture retention and fat retention of cooked sheep meatballs

Meatballs formulation		Parameters		
Type of flour	Fat level	Cooking yield %	Moisture retention %	Fat retention %
Control	20%	58.98±0.88^{c}	30.18±0.52^{b}	37.53±0.92^{d}
CF	10%	71.78±1.91^{b}	35.03±0.82^{a}	69.48±2.67^{b}
	15%	71.92±1.38^{b}	35.56±0.88^{a}	46.99±0.69^{c}
LF	10%	75.60±0.73^{a}	36.19±0.37^{a}	85.06±4.23^{a}
	15%	71.90±1.59^{b}	35.39±0.80^{a}	45.49±1.81^{c}
SEM		0.78	0.40	1.40

$^{a-d}$ means within the same column with different superscripts letters are different ($p<0.05$).
CF= Chickpea Flour, LF= Lentil Flour. Means ± standard deviation. SEM: standard error of means.

Based on the present data meatballs formulated with lentil flour and 10% fat had the highest fat retention. Serdaroglu et al [24] indicated that low fat meatballs containing lentil flour had the higher fat retention than meatballs formulated with chickpea flour; they found a significant correlation between cooking yield, moisture retention and fat retention.

3.4. Reduction in diameter, cooking loss and shear force values

Reduction in diameter, cooking loss and shear force values of cooked sheep meatballs are given in Table 5. The results of reduction in diameter revealed that all meatballs treatments tend to shrink in diameter during cooking process. Addition of legumes flour significantly affected the reduction in diameter. Formulated meatballs with legume flours were lower in diameter reduction than control one at all fat levels. Zaki [11] reported that low fat meatballs supplemented with legume flours showed the lowest reduction in diameter, while control sample recorded the highest loss in diameter. Kurt and Kilincceker [9] found that beef patties containing lentil flour is better in diameter reduction than that containing chickpea flour. Also, Serdaroglu et al [24] found the same results.

Jayasinghe et al. [28] showed that the diameter reduction was significantly higher in control nuggets but samples containing flours had the lower reduction in diameter percentages. Similarly, Kilincceker [8] found that chicken meatballs formulated with chickpea and wheat flour were lower in reduction in diameter than control samples.

Table 5. Diameter reduction, cooking loss and shear force values of cooked sheep meatballs

Meatballs formulation		Parameters		
Type of flour	Fat level	Diameter reduction %	Cooking loss %	Shear force(kg/f)
Control	20%	26.98±2.45^{a}	41.07±0.90^{a}	3.06±0.65
CF	10%	19.03±2.07^{b}	28.21±1.91^{b}	3.52±0.56
	15%	18.61±1.00^{b}	28.07±1.38^{b}	3.83±0.95
LF	10%	14.30±1.50^{c}	24.39±0.73^{c}	3.15±0.24
	15%	18.68±1.20^{b}	28.09±1.59^{b}	4.09±0.97
SEM		0.99	0.79	0.41

$^{a-c}$ means within the same column with different superscripts letters are different ($p<0.05$). CF= Chickpea Flour, LF= Lentil Flour. Means ± standard deviation. SEM: standard error of means.

Table 6. Sensory evaluations of sheep meatballs

Meatballs formulation		Parameters					
Type of flour	Fat level	Appearance	Texture	Juiciness	Flavor	Tenderness	Overall acceptability
Control	20%	4.50±0.53^{d}	3.70±0.48^{d}	3.70±0.48^{d}	3.40±0.52^{e}	4.20±0.79^{c}	3.50±1.18^{d}
CF	10%	6.10±0.74^{b}	6.60±0.52^{b}	6.30±0.48^{b}	7.80±0.42^{b}	5.60±1.07^{ab}	8.40±0.52^{a}
	15%	6.80±0.83^{a}	8.00±0.67^{a}	7.70±0.71^{a}	8.60±0.53^{a}	6.20±0.79^{a}	8.80±0.44^{a}
LF	10%	4.50±0.53^{c}	4.50±0.53^{c}	4.40±0.52^{c}	4.60±0.52^{d}	5.30±0.50^{b}	4.70±0.48^{b}
	15%	4.30±0.67^{cd}	4.80±0.79^{c}	4.30±0.48^{cd}	5.40±0.52^{c}	4.50±0.53c	5.00±0.82^{b}
SEM		0.20	0.19	0.21	0.15	0.24	0.23

$^{a-e}$ means within the same column with different superscripts letters are different ($p<0.05$). CF= Chickpea Flour, LF= Lentil Flour. Means ± standard deviation. SEM: standard error of means.

Data showed that control samples had the highest cooking loss while, the meatballs formulated with legume flours showed the lowest cooking loss. No significant differences were found in cooking loss of meatballs formulated with chickpea flour at any fat level. This results came in accordance with the findings that obtained by Zaki [11, 21]. In addition, Kurt & Kilincceker [9] indicated that use of cereal and legume flours decreased the cooking loss. Based on the present data, the results of cooking loss are in line with data of reduction in diameter of meatballs.

No significant differences were found in shear force values. Meatballs formulate with 15% fat and lentil flour showed the highest shear force value (low tender) while, the control meatballs recorded the lowest value (more tender). These may be due to the high fat content of control group. Serdaroglu et al [24] found that significant differences were found in penetrometer values of low fat beef meatballs containing legume flours. Also, Zaki [11] found that no significant differences were found in share force values of low fat sheep meatballs formulated with 10 % legume flours.

3.5. Sensory evaluation

Results of sensory evaluation of sheep meatballs are given in Table 6. The data revealed that significant differences were found in sensory evaluation of meatballs formulated with different legume flours and fat levels. It can be noticed that meatballs formulated with chickpea flour with 15% fat recorded the highest mean score of sensory attributes, followed by meatballs formulated with chickpea flour and 10%. Meatballs of control and lentil flour had the lowest sensory attributes. Kurt and Kilinççeker [9] found that among legume flours beef patties formulated with chickpea flour had the higher sensory scores while, patties formulated with lentil had the lowest one. Conversely, Serdaroglu et al [24] found the differences in appearance and flavor scores of meatballs formulated with lentil and chickpea flour were not significant, while meatballs of lentil recorded the highest score of overall palatability. Also, Motamedi et al [27] found the same results.

4. Conclusions

Based on the present data, legumes flour (lentil and chickpea) can be successfully used in meatballs formulations at each fat level (10 and 15%). Addition of legume flours improved the physical, chemical and sensory properties of sheep meatballs. Meatballs formulated with lentil flour and 10% fat increased the fat retention, moisture retention% cooking yield and decreased the shrinkage of meatballs. On the other hand, meatballs formulated with chickpea flour at any fat level had the highest score of sensory evaluation.

Acknowledgements. This work was supported by Animal Breeding Department, Animal and Poultry Production Division, Desert Research Center.

Compliance with Ethics Requirements. Author declares that he respect the journal's ethics requirements. Author declares that he have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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