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THE EFFECT OF RED LENTIL FLOUR ON THE QUALITY CHARACTERISTICS OF BEEF BURGERS OBTAINED FROM TWO DIFFERENT ANATOMICAL REGIONS

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Abstract

The study was carried out to evaluate the quality of four beef burgers from two different anatomical regions (round and hind shank) that were manufactured in the USV Iasi Meat Processing Workshop. The technological process of obtaining the four types of burgers had as a specificity the addition of red lentil flour in two proportions (5 and 10%) and the adjustment of the proportions of added fat according to the level of added lentil flour (35 and 15% fat). The obtained products were evaluated physicochemically for color, chemical composition, cooking, and sensory parameters to determine the perception of the attributes appearance, aroma, juiciness, tenderness, aftertaste, and off-flavor. Samples with higher percentages of red lentil flour showed lower lightness, lower heat treatment losses, and less diameter reduction. The same samples demonstrated better water retention capacity after cooking, though the type of raw materials used also had an impact on this parameter. According to the sensory evaluation, the addition of lentil flour in combination with the fat content resulted in improved textural attributes (juiciness and tenderness) and the samples showed high acceptability.

Key words*: beef burgers, beef round, beef hind shank, quality parameters red lentil flour.*

INTRODUCTION

Meat and meat products are generally recognized as essential foods in the human diet due to their nutritional properties, which include proteins with high biological value, essential fatty acids, fat-soluble vitamins, minerals, and bioactive compounds (Yilmaz Önal et al., 2021). However, despite these elements that give it its nutritional potential, meat is deficient in carbohydrates, especially non-starch polysaccharides such as fiber (Câmara et al., 2020; Mehta et al., 2015). Furthermore, the fat (especially saturated fat) and cholesterol content of meat contribute to its unfavorable reputation (Salejda et al., 2022). Nowadays, consumer concern for health has increased, with choices being oriented towards meat products with beneficial health properties (Kambarova et al., 2021). For these reasons, more and more research has been done to study ways to improve meat products by adding plant-based materials, thus obtaining functional products. Functional foods are those foods that, in addition to nutritional intake, benefit the body's biological functions, improve overall health, and reduce the risk of certain diseases (Illippangama et al., 2022; Kausar et al., 2019).

Fibre intake in the body is achieved through the consumption of cereal products, legumes, fruits and vegetables in sufficient quantities to reach the recommended dietary fiber intake of 25-30 g per day (Amine et al., 2003; Mann, 2007; Miller, 2021; Vasyukova & Lyubimova, 2022). However, most people do not reach the recommended dietary fiber intake, since due to rapid urbanisation and dietary style changes, people consume more processed, fast food, high cholesterol and high-calorie snacks (Zaini et al., 2020).

Hence, the meat industry is constantly looking for solutions to meet consumer demands related to health, quality of life and sustainability, with the addition of plant fiber in meat products being some of the ways to improve quality both from a nutritional point of view and shelf life (through the antioxidant properties of the fiber sources used) (Fernández-López et al., 2021; Pame et al., 2022; Salejda et al., 2022). Moreover, the introduction of a plant fiber source in meat products leads to improved technological properties through improved cooking yield, reduced fat and salt content, and improved texture and structural properties (Kambarova et al., 2021; Kausar et al., 2019; Kim & Paik, 2012).

Lentil (*Lens culinaris*) is a high-protein legume (20.6 - 31.4%) and is an excellent source of essential amino acids (except methionine and cystine), fiber (11% in green and 31% in red), minerals and bioactive compounds (Bayomy & Alamri, 2022; Hajas et al., 2022; Oduro-Yeboah et al., 2022). The use of lentil flour in various food products such as bakery products, dairy products, and meat products has attracted the attention of producers and consumers due to its balanced nutritional composition and functional properties (solubility, gelation, emulsification, foaming) (Argel et al., 2020; Romano et al., 2021).

Burgers are minced meat products with high consumer acceptability and are frequently consumed. In the formulation of these products, binding agents and elements that increase water-holding capacity are currently being used to improve the cooking yield and juiciness of the product (Shariati-Ievari et al., 2016).

The study carried out followed the effect of adding lentil flour in proportions of 5 and 10% in the manufacture of four experimental batches of beef burgers derived from two different anatomical regions (beef round and shank), correlated with the proportion of fat added (15% and 35%), on the sensory and physicochemical characteristics of the batches studied.

MATERIALS AND METHODS

The study was carried out in the Meat Processing Workshop and the Meat and Meat Products Technology Laboratory of the Faculty of Agriculture of the University of Life Sciences in Iasi.

The raw materials used to manufacture the two experimental batches of burgers were purchased from the local food market, as was the red lentil flour used in the formulation of the products. The raw and auxiliary materials required in the technological process to produce 1 kg of product for the four assortments are presented in Table 1. The experimental protocol consisted of two categories of raw materials: beef round and hind shank, two levels of fat (15 and 35%) and red lentil flour (5 and 10%). The other ingredients were added in the same proportions in all samples: salt (2.2%), onion (1.5%), black pepper (1%), mustard (0.5%), chilli (0.2%) and sweet paprika (0.5%).

The raw meat was passed through a grinder through a 0.8 mm diameter sieve. After obtaining the meat paste, burgers of equal size (12 cm diameter and 2.5 cm height), weighing ~200 g were formed, then packed in trays and wrapped in polyethene film. The products were stored under refrigerated conditions (2-4°C) until the proposed analyses were performed.

Table 1. Formulations to prepare the raw beef burgers that included red lentil flour

Batch code	**Ingredients (%)**				
	Beef round	**Beef hind shank**	**Pork backfat**	**Red lentil flour**	**Total**
L1P5	60	-	35	5	100
L2P10	75	-	15	10	100
L3R5	-	60	35	5	100
L4R10	-	75	15	10	100

Chemical characterisation was carried out by determining the proximate chemical composition. Moisture, fat content, and protein were determined using a spectrophotometer (FoodCheck analyzer) using an infrared light source. The physical characterisation of the burger samples consisted of instrumental color determination, evaluation of cooking yield, losses and diameter reduction after heat treatment. The samples' color was determined with the portable Konica Minolta Chroma Meter CR-410, in the three-dimensional CIE color system, measuring the L*, a* and b* color parameters with the D65 illuminant at an observation angle of 10 degrees. The instrument was calibrated on a white calibration plate for standard values before starting the measurements. The cooking yield was calculated according to formula (1). The difference between the sample's weight before and after cooking, as calculated using formula (2), served as the basis for calculating cooking losses. Diameter reduction was determined according to the method presented by do Prado et al. (2019), using formula (3).

$$\text{Cooking yield (\%)} = \frac{\text{weight of cooked sample}}{\text{weight of raw sample}} \times 100 \quad (1)$$

$$\text{Cooking loss (\%)} = \frac{\text{weight of raw sample} - \text{weight of cooked sample}}{\text{weight of raw sample}} \times 100 \quad (2)$$

$$\text{Diameter reduction (\%)} = \frac{\text{raw sample diameter} - \text{cooked sample diameter}}{\text{raw sample diameter}} \times 100 \quad (3)$$

The sensory evaluation of the burger samples was carried out on a group of 58 evaluators aged 21-25, students of the University of Life Sciences of Iasi, in the Sensory Analysis Laboratory of USV Iasi. Six tasting sessions were organized, at the beginning of each session the evaluators were trained on the tasting procedure and on how to complete the sensory evaluation questionnaire. The burgers were previously cooked on a grill for 15 minutes until they reached a temperature of 90°C in the thermal center. The cooked pieces were transversely sectioned into eight portions, which were coded with a three-digit code and distributed to the evaluators for analysis. For each product formulation, evaluators were asked to score from 1 to 10 the following sensory descriptors: appearance, aroma, juiciness, tenderness, after taste and off-flavor.

RESULTS AND DISCUSSIONS

The results obtained for the color parameters (L*, a*, b*) of the burger samples, as well as the p-values of the variation factors and their interactions, are shown in Table 2. The lightness L*, which represents the reflecting diffusivity, measured from 0 (black) to 100 (white), recorded the highest value for sample L3R5 (46.98 ± 1.37). The addition of red lentil flour in the higher proportion resulted in lower lightness in the burger samples ($p < 0.01$). Moreover, the percentage of fat also showed a significant effect ($p < 0.01$) on the lightness of the burger batches. Similar results have also been reported by adding lentil flour to meatballs or coating beef burgers with lentil powder (Serdaroglu et al., 2005; Embaby et al., 2016).

Hence, the lower L* lightness of L2P10 and L4R10 samples can be explained by the addition of a higher percentage of red lentil flour, which is correlated with the lower percentage of fat added in the production process.

Regarding the a* values (redness), a significant influence of the anatomical region of the raw material ($p < 0.001$) as well as the amount of fat in the sample ($p < 0.01$) on this parameter was observed. In this context, samples L1P5 and L2P10, made from beef round, showed a higher intensity of red color compared to samples L3R5 and L4R10.

Table 2. Colour parameters for raw burgers

Burger samples	**L*± SD**	**a*± SD**	**b*± SD**
L1P5	46.50 ± 2.01	6.67 ± 0.32	14.52 ± 1.09
L2P10	44.01 ± 1.09	7.31 ± 0.13	14.37 ± 0.44
L3R5	46.98 ± 1.37	5.48 ± 0.44	14.88 ± 0.77
L4R10	44.43 ± 1.35	5.83 ± 0.08	16.22 ± 0.12
p-value			
A (Meat anatomical region)	0.510 ns	**<0.0001** ***	**0.003** **
B (Fat, %)	**0.002** **	**0.001** **	0.076 ns
C (Red lentil powder, %)	**0.001** **	0.098 ns	0.193 ns
AB (Meat anat. reg. x Fat, %)	0.965 ns	0.247 ns	**0.031** *
AC (Meat anat. reg. x Red lentil powder, %)	0.610 ns	**0.009** **	0.569 ns
BC (Fat, % x Red lentil powder, %)	**0.001** **	0.160 ns	0.184 ns

ANOVA Tukey test: ns = $p > 0.05$; * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$

In contrast, the color parameter b* (yellowness) showed higher values in samples L3R5 and L4R10 (14. 88 ± 0.77 and 16.22 ± 0.12, respectively), with the meat anatomical region factor and the interaction meat anatomical region x fat (%) determining distinctly significant ($p<0.001$) and significant ($p<0.05$) differences between experimental burger samples.

The mean values obtained for the chemical composition (± SD) of uncooked and cooked burger samples are shown in Table 3.

The protein content before cooking was significantly different ($p<0.05$) between the four formulations, with the samples with the higher amount of lentil flour and lower fat proportion showing higher amounts of protein. Protein levels showed an increase after heat treatment, with a significant ($p<0.05$) increasing trend only in the L2P10 sample made from beef round with 10% lentil flour. Similar results were obtained by Baugreet et al. (2016) and Serdaroglu et al. (2005) by introducing legume flour into beef burgers and meatballs.

The lipid content identified in the samples analyzed before cooking ranged between 14.06 ± 0.208 (L4R10) and 28.53 ± 0.603 (L1P5), showing significant differences ($p<0.05$) between samples. After cooking, the burger samples showed a fat content ranging from 13.73% ± 0.252 (L2P10) to 26.73% ± 0.153 (L1P5). There was a non-significant increase ($p>0.05$) in fat content for batches made from the beef hind shank, while batches made from beef round lost significant amounts of fat during heat treatment ($p<0.05$).

The moisture content of burger samples was negatively correlated with lipid content, thus samples with 35% added fat had lower amounts of water in the composition compared to samples with 15% added fat. Moreover, following heat treatment, a significant ($p<0.05$) increase in moisture was observed in the samples from beef round, while the experimental batches from hind shank showed statistically insignificant water loss ($p>0.05$).

Table 3. Chemical composition of burgers before and after cooking

Burger samples	Before cooking				After cooking			
	Fat (%)	Moisture % (%)	Protein (%)	Collagen (%)	Fat (%)	Moisture % (%)	Protein (%)	Collagen (%)
L1P5	28.53 ± $0.603^{d,y}$	54.63 ± $0.513^{a,x}$	15.76 ± $0.058^{a,x}$	13.66 ± $0.321^{a,x}$	26.73 ± $0.153^{cd,x}$	55.80 ± $0.100^{a,y}$	16.30 ± $0.000^{a,x}$	14.33 ± $0.058^{a,x}$
L2P10	19.86 ± $0.321^{b,y}$	61.43 ± $0.208^{c,x}$	17.83 ± $0.153^{b,x}$	15.93 ± $0.208^{c,x}$	13.73 ± $0.252^{a,x}$	66.10 ± $0.200^{cd,y}$	19.23 ± $0.058^{b,y}$	17.46 ± $0.115^{b,y}$
L3R5	25.73 ± $0.404^{c,x}$	56.73 ± $0.252^{b,x}$	16.43 ± $0.058^{ab,x}$	14.50 ± $0.200^{ab,x}$	25.93 ± $0.666^{c,x}$	56.50 ± $0.520^{ab,x}$	16.50 ± $0.173^{a,x}$	14.53 ± $0.208^{a,x}$
L4R10	14.06 ± $0.208^{a,x}$	65.83 ± $0.208^{d,x}$	19.10 ± $0.100^{c,x}$	17.30 ± $0.436^{d,x}$	14.50 ± $0.265^{ab,x}$	65.46 ± $0.208^{c,x}$	19.10 ± $0.000^{b,x}$	17.26 ± $0.058^{b,x}$

a, b, c, d - The same superscript letter within the same column means there is no significant difference between any two means ($p>0.05$). x, y, - The same superscript letter within the same row means there is no significant difference between the same parameter analysed before and after cooking ($p>0.05$).

The properties of the burger samples after cooking are shown in Table 4.

The whole cooking losses ranged from 7.00% (L2P10) to 13.40% (L3R5), and the cooking yield varied inversely with the losses, ranging from 86.60% (L3R5) to 93.00% (L2P10).

Samples L2P10 and L4R10 achieved the highest cooking yields, being the formulations with the lowest fat percentage and the highest red lentil flour.

The lower cooking yields of L1P5 and L3R5 can be attributed to excessive fat separation.

Table 4. Cooking parameters of burger samples

Cooking parameters	L1P5	L2P10	L3R5	L4R10
W_r (g)	0.182	0.200	0.194	0.198
W_c (g)	0.160	0.186	0.168	0.180
D_r (g)	11.5	11.5	11.5	11.5
D_c (g)	9.5	10	9.5	10.8
Cooking loss (%)	12.09	7.00	13.40	9.09
Cooking yield (%)	87.91	93.00	86.60	90.91
Diameter reduction (%)	17.39	13.04	17.39	6.09

W_r - weight of raw sample; W_c - weight of cooked sample; D_r - raw sample diameter; D_c - cooked sample diameter.

A positive correlation can be observed between cooking yield and protein content in the samples. Taking into account the ability of protein to retain fat as well as the fiber intake contained in red lentil flour (with oil binding and oil retaining capacity), the addition of 10% lentil flour resulted in lower cooking losses.

During heat treatment, the products tend to shrink due to the loss of water and fat as well as the denaturation of the contained proteins. The reduction in diameter after cooking was lowest in sample L4R10 (6.09%), while samples L1P5 and L3R5 showed equal values in terms of reduction in diameter (17.39%).

The quality of a food product also includes the consumer acceptance element. In this regard, the burger samples were sensory evaluated on a 10-point scale for attributes such as appearance, aroma, juiciness, tenderness, after taste and off-flavor (Table 5). Based on the individual scores, a mean score was calculated, and an ANOVA test was applied to determine the degree of influence of the variation factors (A, B, C) on the perception of the panel of evaluators. A significant influence of added fat and lentil flour content and the interaction between these factors on the perception of the evaluators was observed.

Texture attributes like juiciness and tenderness improved with the increasing percentage of added lentil flour, while after-taste and off-flavour attributes scored higher for these samples due to the evaluators' perception of a more intense red lentil flavor.

Table 5. Sensory analyses of burger samples

Sensory attributes	L1P5	L2P10	L3R5	L4R10	Significance levels of p-value					
					A	B	C	AB	AC	BC
Appearance	7.16±1.224	8.22±0.850	6.72±1.164	8.31±0.900	ns	***	***	ns	***	***
Aroma	8.76±1.171	8.53±0.991	8.76±1.264	8.27±1.250	ns	*	*	ns	ns	*
Juiciness	8.09±0.996	8.91±0.874	7.82±1.114	8.76±1.246	ns	***	***	ns	***	***
Tenderness	7.56±0.693	8.47±1.236	7.22±1.042	8.07±1.095	ns	***	***	*	***	***
After taste	5.09±1.125	5.73±0.986	5.27±1.250	5.87±1.014	ns	***	***	ns	***	***
Off flavor	5.11±1.481	5.53±0.991	5.38±1.614	5.67±0.977	ns	ns	ns	ns	ns	ns

A = Meat anatomical region; B = Fat, %; C = Red lentil powder, %; ns = not significant ($p > 0.05$); * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$

CONCLUSIONS

The addition of red lentil flour had an impact on the physicochemical characteristics of beef burger samples. Increasing the percentage of red lentil flour decreased the lightness L* of the burger samples while at the same time increasing the intensity of the red color (a* value). The percentage of lentil flour introduced, associated with the amount of fat in the samples, increased the moisture and protein content. Cooking losses were higher for formulations with lower levels of red lentil flour, with the most favorable cooking yield obtained for sample L2P10, made from beef round. The sensory evaluation revealed significant differences in the variation factors of the experimental batches, but the samples showed high acceptability from the evaluators.

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