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Effect of Lamb Fat Replacement with Olive Oil in Water Emulsion on Quality and Storage Stability of Beef Meatballs

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BEEF meatballs were made with 0.0, 25, 50, 75, and 100% replacement of lamb fat by an olive oil in water emulsion. The technological, physicochemical properties, composition, fatty acid profile as well as storage stability at -20°C for 4 months of these products were studied. The results indicated that emulsion stability was increased and cooking loss was lowered with increasing the lamb fat replacement in meatballs by olive oil emulsion. Also both oleic and linoleic acids of the olive oil emulsion meatballs lipid fraction were increased with view changes in it's oxidation stability during frozen storage. The acceptance and sensory properties of meatballs were not impact by the different ratio of lamb fat replacement. Total cholesterol was reduced while the total energy value from fat content of these products did not affect due to such replacement. Results confirmed that meatballs with healthier lipid profile can be prepared using olive oil emulsion.

Key words: Meatballs, Olive oil emulsion., Cholesterol, Fatty acids profile

Introduction

The increasing public preoccupation with personal health and fitness turned the attention of nutritionists to investigate the role of the various fats in the maintenance of health and reduction of risk of chronic diseases such as heart diseases, cancer, hypertension, obesity. diabetes,...etc, in addition to the effect of fat substitutes and replacers on overall fat requirement, consumption and health. Nutritionists recommended 30% level or lower of calories as fat with the intake of saturated fat not to exceed 10% of the total energy and the remaining (20%) can be divided equally between monounsaturated (MUFA) and polyunsaturated fats (Mc-laughlim et al., 2005) .

Meat and meat products represent an important position in human diet due to their content of high quality protein, essential amino acids, minerals and B-group vitamin. In last years , the consumers became aware of the health risks of animal fat due to high content of saturated fatty acids , triglycerides, cholesterol, gallstone, and it's relation with blood pressure and cardiovascular diseases. (Suelem Lima.da siliva et al., 2019). So that the animal lipids in quantitative and qualitative terms become recently among the bioactive components which have received more attention to the development of potential meat based functional foods including frankfurter, pate, sausage, meatballs and other meat products which their normally contain goat or lamb fat (Salcedo-Sandorval et al., 2013).

Partial or complete replacing of the animal fats with plant or marine oils, which have fatty acids profiles agree more with health recommendation, decreases saturated fatty acids (SFA) and increases both monounsaturated (MUSFA) and polyunsaturated fatty acids (PUSFA) in meat products. Olive, cotton seed, corn, soybean and peanut oils have been used as partial substitutes for meat fats (Luruena-Martinez et al., 2004). Delgado – Pando et al. (2010) suggested a healthier lipid combination based on mixing suitable levels of oils of olive, linseeds, and fish then used it in preparing functional low fat frankfurter.

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Generally the methods which can be used to incorporate the selected healthier oils in meat products include direct addition as lipid oils or as interesterified solids, or in a capsulated form or pre-emulsified form or as apart of plant ingredients. Among these methods, pre-emulsion procedure is the good selection to stabilize, the oils in meat products. In this method a non meat protein emulsifier such as sodium casinate, soy protein isolate or whey proteins, is used to stabilize and immobilize the oils in meat protein matrix, reduce separation of bulk oil from the meat products and also to leave more of meat protein available. By this way meat products will be stable during processing, storage and consumption. (Djordjevic et al., 2004). Oil in water emulsion adds as fat ingredient., Delgado-Pando et al. (2011) stated that because konjac glucomannan, a natural polysaccharide from the Amorphophallus konjac tubers, has a good water retention capacity, gelling and thickening properties as well as good health effects (reducing cholesterol, insulin and glucose levels, having satiating and laxative actions, it was used as a fat substitute in preparing low fat meat frankfurter bologna sausage.

In Egypt, olive oil is one of the popular product and an important component of the Egyptian diet due to it's high amount of monounsaturated fatty acid (MUFA), more than ~ 65% oleic acid. The virgin olive oil is also rich in antioxidants and substance called squalene. The latter component has antiflammatery properties, slows blood clot formation, reduces cholesterol and enhances, the uptake of omega3 fatty acids (n-3 FA) by cells of body (Ciriminna et al., 2016). Also, meatballs is one of the common grilled beef meat product. During it's preparation in a commercial scale nearly 25% saturated lamb fat is usually added to gain the cooked product pleasant flavor (Giese,1996).

To produce healthy beef meatballs product low in saturated fats and with a good keeping quality. This study was carried out to replace 0.0,25,50, 75 and 100% of the added lamb fat with an olive oil in water emulsion using soy protein isolate as protein emulsifier. The influence of such replacing on the technological and physicochemical properties, chemical composition and fatty acids profile, as well as storage stability at -20 °C for 4 months was studied.

Materials and Methods

Materials

Brazial frozen imported back rip boneless beef (from local market) , fresh lamb fat, fresh onion, refined fine iodized common salt, spices blend mixture (Cinnamon-white, red and black pepper, thyme, sage, nutmeg, rosemary and cardamom) of El Motaheda, Co., soy protein isolate (90% protein content) of Imtenan .Co., virgin extra olive oil with 0.8% acidity, koshala, Co., polyethylene bags, foam plates (22x17cm) were obtained from local market , Alexandria city , Egypt. All reagents and chemicals used in this study were an analytical grade.

Methods

Technological methods

Meatballs preparation: Frozen meat was thawed at room temperature (22 ± 3°C) for 4-5 hr, dressed by removing their surrounded fat layers, cut into 10 cm thickness portions then minced 2 times through 5mm plate of Luska meat chopper .To the result minced meat ,4% of chopped fresh onions ,1% salt 2% spices mixture , and 1% cold water were added and well mixed. Lamb fat was trimmed to remove inedible parts, cut into small pieces, chopped through 3 mm mincer then mixed well.

An oil-in-water emulsion was prepared with 52:2.4: 42, olive oil, soy proteins isolate, and water (w/w/w) respectively as described by Delgado-Pondo et al. (2010). This emulsion was prepared the day before using and stored at 3°C. Five different types of beef meatballs were formulated as follows: control sample containing 75% meat blend, 25% lamb fat and 0 % olive oil water emulsion, four samples containing the same amount of meat blend, 75,50,25,0.0% of meat lamb fat in addition to 25,50,75 and 100% of an olive oil on emulsion as a fat replacer of meat low fat. These samples were referred as R25, R50, R75 and R100, respectively. Each formula was well mixed, shaped into balls with approximately 30 g. weight then placed on a foam plate, packed inside poly ethylene bags, stored at -20° C for 4 months and subjected monthly for analysis. Cooking of meatballs was properly done in an oven (Modermob-Fresh) for nearly 30 min. at 180°C.

Cooking loss: Cooking loss of meatball was measured by calculating the weight difference before and after cooking, as mentioned above using the following equation:

Cooking loss (%) = (weight of fresh meatballs – weight of cooked meatballs)/weight of fresh meatballs ×100

Emulsion stability: Emulsion stability and total fluid release (TFR) of meatballs were determined according to method of Carballo.et al., (1996) and expressed as % of initial sample weight . In this method 25 g fresh meatball was placed in a 50 mL closed centrifuge tube, centrifuged for 5 min at 3000 rpm. heated in a water bath for 30 min at 70 °C ,removed centrifuge tube cover and left stand upside down for 30 min. to release the exudate onto a tube that had been previously weighed . Water fluid (WL) was determined as weight loss after heating the total release fluid for 16 h. at 105 °C and expressed as % of initial sample weight. Fat fluid (FL) was calculated as the difference between total fluid release (TFR) and WL.

Analytical method

Physicochemical properties: The colour values lightness (L*), redness (a*) and yellowness (b*), of fresh meatballs were evaluated using a Hunter Lab Ultra Scan, VIS model, colorimeter (USA). The instrument was standardized during each sample measurement with a black and white tail (L*= 94.1 ,a*= 1.12, b* =1.26). Five reading of each colour index of Hunter scale (L*, a*,b*) were recorded (Santipanichwing & Suphantharika, 2007).

Texture Profile Analysis (TPA) of fresh meatballs was performed using TA-XT 2 Texture meter (Texture Pro CT3 V1.2, Brookfield, Middleboro, USA) as described by Yuan & Chang (2007). Meatballs sections (20 mm in diameter, 20 mm in height) were axially compressed to 40% of their original height. Force time deformation cures was obtained during applying a 5 kg load cell, at a 1mm/s cross head speed. The following texture attributes were calculated hardness, cohesiveness, springiness and chewiness.

Chemical analysis

Moisture, protein and ash contents of beef meatballs were determined according to the AOAC (2000). Bligh and Dyer (1959) method was used to determined fat. Thiobarbituric acid (TBA) was calorimetrically estimated according to Park et al. (2007) using UV-VIS Spectrophotometer Laxo alpha 1102 , suit and expressed as mg malonaldehyde per kilogram sample . The pH was determined using pH meter type MVX100 Beckman (USA) at room temperature (22 ± 3°C) as described in AOAC (2000).

Extracted lipid of meatballs was esterified and fatty acids analysis were determined according to Taga et al. (1984) method using gas liquid chromatography (GLC) a Toxichron GLC, model B-5 800-1, equipped with FID detector (PE Auto System XL). 180x0.3 cm. column of DEGS on Chromos orb W, nitrogen carrier gas at a flow rate of 40 mL/min., 185 °C. as an iso thermal temperature.

The atherogenic index (AI) and Thrombogenic index (TI) were computed according to Ulbricht and Southgate (1991) as a ratio between some saturated and unsaturated fatty acids using the following equations:

AI = (C12: 0 + 4 x C14: 0 + C16: 0) / (MUFA + n−3 PUFA + n−6 PUFA)

TI = (C14: 0 + C16: 0 + C18: 0) (0. 5 x MUFA + 0:5 x n−6 PUFA

+ 3 x n−3 PUFA + n−3 PUFA /n−6 PUFA)

Cholesterol level of fresh beef meatballs was estimated using the mothed of Liese et al. (1952) with some simple modification using 2g of sample, 4 ml of 50% aqueous KOH solution and 6 ml of ethyl alcohol to extract total lipids in a falcon tube. Tube was stoppered, well shaken, and kept in a water bath at 37-40 °C for 55 min. After cooling to room temperature, 10 ml. of petroleum ether was added and well mixed with the content of tube, then 5 ml. of distilled water was added, vigorously shaken for 1 min and centrifuged at 2000 rpm for 5 min, to break emulsion and form two clear layers. A suitable aliquot of the petroleum ether layer was transferred to a small dry bottle the petroleum ether was evaporated in a water bath at 60 °C with blowing a weak stream of air into a bottle. After cooling to room temperature, the bottle was mixed with the Liebermann-Burchard reagent, stoppered with clean dry corks and left for 30 min. in dark for color development. The optical density of sample was recorded against the blank in a photoelectric calorimeter at 620 nm. using UV-VIS spectrometer Laxo alpha 1102.

Microbiological methods

Ten grams of beef meat ball were blended with 90 ml of sterilized peptone water for 2 min, in sterilized glass jar of blender. Appropriate dilution was prepared for enumeration using standard microbiological pour plate technique and the recommended culture Plate count agar medium Oxide (2002) used for enumerating the Total Viable Count (TVC) after incubating at 35-37°C for 48 hr.

Sensory evaluation

Colour, texture, taste, odour and overall acceptability of cooked beef meatballs were organoleptically evaluated using 10 trained panelists from, Food Science and Technology Department, Faculty of Agriculture, Alexandria University. They were asked to rate their acceptability of cooked burgers products according to nine point scale, ranging from 9= like extremely to 1= dislike extremely as described by Meilgaard et al. (1999).

Statistics analysis

The obtained data were statistically analyzed by ANOVA and differences among mean values were processed by LSD test using SAS (Release. 9, SAS Institute, NC, and USA). Mean values were reported and significance was defined at P>0.05.

Results and Discussion

Proximate composition and cholesterol content

As shown from the results in Table 1 the different levels of olive oil emulsion used to replace lamb fat in beef meatballs caused slight changes but not significant in proximate composition of this product. The moisture content was ranged from 66.81 to 68.78%, while crude protein, crude fat and ash levels were varied from 64.35 to 64.54, 25.37 to 25.75% and 8.2 to 8.65 respectively on dry weight basis in the different samples. In 100% lamb fat beef meatballs, the protein was mainly from meat raw material. In case of the samples containing olive oil emulsion, the protein was mostly of meat raw material in addition to soy protein isolate. This is may be cause the slight increase of protein in such samples than control one. Also, the type of oil in such products was a combination of animal fat and olive oil, vegetable oil. The animal fat was mainly lamb fat with a lower level and constant amount of beef meat fat in control product. The ash sources in these samples include beef meat, soy protein isolate and other's added constant ingredients to formulate such product. Presence of soy protein isolate may be the cause of slight rise in ash content in products containing olive oil water emulsion. The fat content in the different meatballs products in this study was nearly agreed or met with that mentioned in the specification of the Egyptian Standards No (1973/2005) for Frozen Balls (2005) (Egyptian Organization for Standardization and Quality Control , 2005).

According to Suelem Lima da Silva et al. (2019) problems of replacing animal fat with vegetables ones are the increase rate of lipid oxidation and reduction in some technological and sensory quality of meat products , Fagundes et al. (2017) replaced 50% of animal fat of burger by oleogel from canola oil . They found that nutritional and technological quality improved and sensory characteristics did not impact by such replacement. Significance reduction in cholesterol content of beef meatballs was observed with the replacing lamb fat with olive oil water emulsion (Table 1). Reduction of cholesterol was 8.14, 9.53, 10.69 and 11.45% at 25, 50, 75 and 100% lamb fat replacing with olive oil in beef meatballs. This important nutritional effect. Suelem Lima da Silva et al (2019) found that Bologna type sausages prepared with 25,50, 75 and 100% replacement of pork back fat by oleogel made from pork skin, water and high oleic sunflower oil contained less than 10% cholesterol than control.

TABLE 1. Effect of lamb fat replacement by olive oil emulsion on proximate composition and cholesterol content of beef meatballs.

Component%	Meatballs				
	Control	R25%	%R50	R75%	R100%
Moisture(%) *	66.81	68.76	68.78	68.78	68.76
Crude * protein (%)	64.35	64.48	64.54	64.52	64.50
Crud fat (%)*	25.75	25.37	25.42	25.41	25.42
Ash(%)*	8.20	8.65	8.60	8.62	8.61
Cholesterol (mg/100)	43.12[a]	39.61[b]	39.01[b]	38.51[b]	38.18[b]

LSD of cholesterol at P>0.05 =2.0689

*No significance. Control meatballs with 25% lamb fat . R 25 %,R50%,R75% and R100% replacing of lamb fat by olive oil emulsion, respectively

Fatty acid profile and fat energy content

Table 2 summarizes the fatty acid profile (g/100g) and total energy (Kcal/100g) of the meatballs fat. Palmitic acid (C16:0) and stearic acid (C18:0) represented the main saturated fatty acids in meatballs. Both acids were higher in control sample than other's ones. This was due to the gradually reduction in total saturated fatty acids (SFA) in such product with increasing the replacement ratio of olive oil emulsion. This reduction in SFA was 18.7, 23.7, 30.9 and 43.1% in R25, R50, R75 and R100% meatballs, respectively. Stearic acid (C18:0) showed higher reduction than palmitic one in these samples especially in R75% and R100% products. The same notice was also mentioned by Asuming Bediako et al. (2014) and Suelem Lima da Silva et al. (2019) who studied the replacement of prok fat by high oleic sunflower oil in sausages.

As shown from Table 2, oleic acid (C18:1) was the predominate fatty acid of different meatball samples. A marked rise in this acid was correlated with the rise in the olive oil emulsion replacement. It was 15.4, 22.3, 32.5 and 38.8% in R25, R50, R75 and R100% meatballs respectively. This is mainly due to high level of oleic acid in olive oil emulsion. According to Lopez Huertas (2010) oleic acid reduces the risk of cardiovascular diseases and related factors with these diseases such as obesity, hypertension and cholesterol. Such data confirm the healthier properties of the olive oil emulsion meatballs product.

According to Table 2, linoliec acid (C18:2) is considered the main polyunsaturated fatty acid in meatballs fat. It ranged from 2.79 to 6.72 % in meatball samples. Replacing lamb fat with olive oil low in linoleic acid emulsion caused a marked increase in this acid in meatball samples compared with control. Replacement of 25, 50, 75 and 100% of lamb fat by olive oil emulsion caused an 67.3, 89.9, 120 and 140.8% increasing in linoleic acid (C18:2) level in the fat of meatballs, respectively.

TABLE 2. Effect of lamb fat replacement by olive oil emulsion on Fatty acid profile and fat energy content of meatballs .

Fatty acid (%)	Control	R25%	R50%	R75%	R100%
Myristic acid (C14:0)	2.95	1.93	1.69	1.01	0.67
Palmitic acid (C16:0)	23.73	20.84	20.76	19.22	17.81
Stearic acid (C18:0)	11.69	7.97	8.01	7.23	5.49
C16:1	4.98	2.85	2.39	1.98	2.73
Oliec acid (C18:1)	46.69	53.89	57.15	61.86	64.72
Linoleic acid (C18:2)	2.79	4.69	5.30	6.14	6.72
Linolenic acid (C18:3)	0.10	0.20	0.23	0.31	0.35
Σ SFA	43.39	34.88	33.10	29.97	24.65
Σ MUFA	54.18	59.83	61.10	64.58	67.68
Σ PUFA	2.89	4.86	5.53	6.45	7.07
PUFA / SFA	0.07	0.14	0.17	0.22	0.29
n-6 / n-3	28.40	27.47	22.93	19.53	19.12
Fat energy content (k cal/100g) from:- - Total fat	279.83	276.37	276.82	276.73	276.82
-SFA	394.85	317.36	301.23	272.70	224.31
-MUSFA	493.00	544.46	556.02	587.70	615.90
-PUSFA	26.27	44.21	50.32	58.73	64.32
Atherogenic Index (AI)	0.63	0.44	0.41	0.33	0.27
Thrombogenic Index (TI)	1.33	1.14	0.90	0.76	0.63

Control meatballs with 25% lamb fat .
R 25 %,R50%,R75% and R100% replacing of lamb fat by olive oil emulsion respectively .

Generally, changes in the fatty acids composition resulting from replacement lamb fat by olive oil emulsion caused a lower in saturated fatty acids (SFA), an increase in unsaturated fatty acids(USFA) and this was behind the low ratio of USFA /SFA (0.06 to 0.28). The n-6 to n-3 fatty acid ratio was also reduced due to replacing of lamb fat by olive oil emulsion but still far than that recommended by WHO/FAO, 5-1 n-6 to n-3 ratio. (Allam, 2002). This was mainly due low level of alpha linolenic acid in both lamb fat and olive oil as well as increase in linoleic acid due to the replacement process. Generally consumption of n-3 FAs has been linked with the risk reduction cardiovascular disease, certain type of the cancer, diabetes mellitus, inflammatory disease, multiple sclerosis and clinical depression (Delgado –Pondo et al., 2011)

Also data in Table 2 reveal that the lamb fat replacement by olive oil emulsion caused; (1) a reduction of the contribution of SFA and an increase of MUSFA and PUSFA to total fat energy of meatballs such as increscent was more obvious from MUSFA than PUSFA one, and (2) a reduction in both atherogenic index (AI) and thromboginc index (TI). Such reduction means high levels of antiatherogenic fatty acids, which can protect from coronary diseases. This is one of the beneficial of replacing animal fat with vegetable oils such as olive one (Saygi et al., 2018)

Colour, texture and technological properties

Colour

Data in Table 3 showed that replacing of lamb fat by olive oil emulsion caused significant increase in lightness (L*) and yellowness (b*) and decrease in redness (a*) of fresh meatballs. Such changes were gradually increased with increasing the replacement level of lamb fat by olive oil emulsion. Suelem Lima da Silva et al. (2019) also found an rise in Land b value of bologna sausages made with 25,50,75 and 100% replacement of pork back fat by oleogel composed of pork skin, water and high oleic acid sunflower oil. The same observation was mentioned by Fagundes et al., (2017) when replaced 50% of animal fat of burger by oleogel from canola oil .

Texture

In the same table replacing of lamb fat by olive oil water emulsion caused a significant reduction in hardness and did not impact chewiness, cohesiveness and springiness of meatballs. Suelem Lima da Silva et al. (2019) found that bologna type sausage made with 25,50,75 and 100% replacement of pork fat by oleogel made with pork skin, water, high oleic sunflower oil were more in hardness and chewiness compared to the control. They attributed such increases to transform of the collagen of used pork skin to gelatin during cooking. After cooling, gelatin was solidified and formed hard gel.

Technological properties

Emulsion stability and cooking loss

Results in Table 3 show the influence of lamb fat replacement by different levels of olive oil water emulsion in both emulsion stability and cooking loss of meatballs. It can be noticed that both emulsion stability and cooking loss gradually decreased with increasing the lamb fat replacement ratio by olive oil emulsion in meatballs especially at 50,75 and 100% replacement ratio. The reduction in total fluid release was 1.9, 6.4, 8.8 and 10.9% in R25, R50, R75 and 100% sample. Most of the loss in total fluid release was in water fluid. The fat fluid release was significantly higher in control, R25 and R50 thanR75 and R100 meatballs samples. The results of cooking loss were in agreement with that of the total fluid release. It was ranged from 13.35 to 15.01 % and significantly lowers with increasing replacing of lamb fat ratio than 25% with olive oil emulsion. Generally this is an indication to the proper emulsification of olive oil with protein matrix in meatballs. Similar results were stated by Alves et al. (2016) when using soy bean oil in preparing meat emulsion. They reported that the technological quality of such products was improved when using soy bean as a fat substitute.

Storage stability

pH value

After preparing process, the pH value of meatballs varied from 5.55 to 5.58 .Significant gradual rise in pH value of all meat samples was noticed with extending storage period at -20°. Such increase may be due to the weak activity of the proteolytic enzymes during storage. Generally, pH value for all treatment was in the range for this type of product. Such changes were also observed by Alves et al., (2016) who studied the replacement of 80 and 100% of pork fat by pork skin and green banana flour in bologna sausage.

TBA

As mentioned before replacing lamb fat by olive oil emulsion increased the MUFA and PUFA in meatballs. Results in Table 4 indicated that different meatball samples had low TBA value after preparation (0.031 to 0.043) mg malonaldhyde /Kg sample) and significantly changed in the end of 4 month storage at -20°C (0.181 to 0.200).Keeping meatballs in polyethylene bags at low temperature (-20°C) in a deep freezer far from light and oxygen lowered from such changes, no effect on flavor perception for all treatment was mentioned by panelists during sensory evaluation. Suelem Lima da Silva et al. (2019) reported the same notice for TBAR levels of Bologna type sausage made with 25, 50, 75 and 100% replacement of pork fat by oleagel prepared from pork skin, water and high oleic acid sunflower oil.

TABLE 3. Effect of lamb fat replacement by olive oil emulsion on colour, texture and technological properties of beef meatballs.

Parameter	Meatballs				
	Control	R25%	R50%	R75%	R100%
1-Colour					
Lightness (L*)	44.07[c]	45.46[b]	46.00[b]	46.68[a]	47.63[a]
Redness (a*)	9.73[a]	8.91[a]	8.40[a]	8.11[b]	7.97[b]
Yellowness(b*)	15.30[b]	15.65[b]	16.00[b]	17.08[a]	17.70[a]
2- Texture					
Hardness (g)	272[a]	241[b]	233[b]	229[b]	225[b]
Cohesiveness	0.42	0.41	0.42	0.42	0.42
Springiness (mm)	5.08	5.06	5.06	5.03	5.01
Chewiness (mj)	7.08	6.70	6.30	6.09	6.07
3-Technological properties: Emulsion stability :-1					
a-Fat fluid (FL)	1.41[a]	1.31[a]	1.31[a]	1.09[b]	0.98[b]
b-water fluid (WL) **	12.81	12.64	12.64	11.99	11.69
c-Total fluid release(TFR)* *	14.22	13.95	13.30	12.96	12.67
2- Cookig loss%	15.01[a]	14.21[ab]	13.92[bc]	13.65[c]	13.35[c]

LSD of colour at P>0.05= 1.6046

LSD of hardness at P>0.05= 12.8847

LSD of treatment for FL at P>0.05=0.1736

LSD of treatment for cooking loss at P>0.05=0.9911

No significance **

Control meatballs with 25% lamb fat .

R 25 %,R50%,R75% and R100% replacing of lamb fat by olive oil emulsion respectively

TABLE 4. Effect of lamb fat replacement by olive oil emulsion on frozen storage stability of beef meatballs.

Parameter	Meatball	Storage period (months)				
		0.0	1.0	2.0	3.0	4.0
pH	Control	5.58	5.76	5.80	5.92	6.01
	R25%	5.56	5.78	5.80	5.91	6.05
	R50%	5.55	5.82	5.81	5.88	6.05
	R75%	5.57	5.80	5.80	5.85	6.08
	R100%	5.57	5.80	5.80	5.86	6.07
	Mean	5.56[e]	5.79[d]	5.80[c]	5.89[b]	6.05[a]
TBA(mg malonadhyde/Kg Sample)	Control	0.031	0.046	0.076	0.096	0.200
	R25%	0.036	0.041	0.083	0.095	0.200
	R50%	0.031	0.044	0.080	0.098	0.192
	R75%	0.043	0.052	0.081	0.097	0.192
	R100%	0.034	0.041	0.097	0.102	0.181
	Mean	0.037[e]	0.045[d]	0.083[c]	0.097[b]	0.193[a]
TVC (cfu/g)	Cnotrol	$4.9x10^4$	$3.2x10^3$	$3.0x10^3$	$2.4x10^3$	$2.3x10^3$
	R25%	$4.4x10^4$	$4.0x10^3$	$2.0x10^3$	$2.5x10^3$	$2.1x10^3$
	R50%	$9.0x10^4$	$3.3x10^3$	$3.1x10^3$	$3.0x10^3$	$3.3x10^3$
	R75%	$3.2x10^4$	$3.3x10^3$	$3.2x10^3$	$3.1x10^3$	$3.0x10^3$
	R100%	$3.0x10^4$	$4.8x10^3$	$2.3x10^3$	$3.6x10^3$	$3.0x10^3$

LSD of time at P>0.05 for pH=0.01148 LSD of time at P>0.05for TBA =0.003015
Control meatballs with 25% lamb fat .
R 25 %, R50%, R75% and R100% replacing of lamb fat by olive oil emulsion respectively

Total Viable Count (TVC)

Results in Table 4 clear that the total microbial count of different meatballs samples was low and also slightly reduced with extending storage for 4 months at -20°C . This means that replacement lamb fat with olive oil emulsion had no influence on the microbial count of meatballs.

Sensory properties

According to sensory evaluation panelists accepted the different types of cooked meatballs , (Table 5). The degree of the preference of colour, odour, taste, texture and over all acceptability was very good. Also, they showed that storage of such products at -20°C for four months did not impact their acceptability and preference degrees of their sensory qualities. This means that both lamb fat replacements by olive oil emulsion and frozen storage for 4 months had at -20°C no effect on the sensorial properties of meatball products. Suelem Lima da Silva et al. (2019) found that increasing replacing pork back fat by oleogel made of pork skin, water, and high oleic acid sunflower oil than 50% in Bologna type sausage caused a significant decrease in its sensorial properties by panelists.

TABLE 5. Effect of lamb fat replacement by olive oil emulsion on sensory evaluation of beef meatballs during frozen storage.

Storage periode (month)	Meatballs	Colour*	Odour*	Taste*	Texture*	Over all acceptability*
Zero time	Control	8.3	8.3	8.1	8.0	8.3
	R25%	8.3	8.4	8.3	8.2	8.2
	R50%	8.3	8.4	8.2	8.1	8.3
	R75%	8.3	8.3	8.3	8.3	8.4
	R100%	8.3	8.3	8.1	8.2	8.3
After 1 month	Control	8.4	8.2	8.0	8.2	8.1
	R25%	8.3	8.3	8.1	8.3	8.0
	R50%	8.3	8.2	8.1	8.3	8.0
	R75%	8.3	8.2	8.2	8.1	8.0
	R100%	8.3	8.1	8.1	8.1	8.0
After 2 months	Control	8.4	8.2	8.0	8.2	8.2
	R25%	8.3	8.1	8.1	8.3	8.1
	R50%	8.3	8.1	8.0	8.0	8.0
	R75%	8.3	8.1	8.0	8.0	8.0
	R100%	8.1	8.3	8.2	8.0	8.2
After 3 months	Control	8.4	8.2	8.0	8.1	8.1
	R25%	8.2	8.1	8.0	8.0	8.1
	R50%	8.2	8.1	8.0	8.2	8.0
	R75%	8.3	8.1	8.0	8.2	8.1
	R100%	8.3	8.2	8.1	8.0	8.0
After 4 months	Control	8.4	8.2	8.0	8.1	8.0
	R25%	8.1	8.1	8.1	8.2	8.0
	R50%	8.2	8.1	8.1	8.0	8.0
	R75%	8.1	8.0	8.0	8.2	8.1
	R100%	8.1	8.0	8.0	8.1	8.0

* No significance
Control meatballs with 25% lamb fat .
R 25 %,R50%,R75% and R100% replacing of lamb fat by olive oil emulsion respectively .

Conclusion

Results in this study showed the possibility of producing healthier meat products low in cholesterol , with a good fatty acid profile ,technological properties ,storage stability ,sensorial quality and nutritional benefits by partial and /or complete replacement of their contents of animal fat with vegetable oils.

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تأثير إحلال دهن الضآن بمستحلب مائي من زيت الزيتون علي جودة والثبات التخزيني لكفتة اللحم البقري

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تم عمل كفتة اللحم البقري باحلال نسب مختلفة من المستحلب المائي لزيت الزيتون بدلا من الدهن الضاني صفر و ٢٥ و ٥٠ و ٧٥ و ١٠٠ ٪ وتم دراسة الصفات التكنولوجية والفيزوكيميائية وتركيب الاحماض الدهنية والثبات التخزيني خلال فترة التخزين بالتبريد لمدة ٤ شهور علي درجة حرارة ٤ م°. واشارت النتائج الي زيادة ثبات المستحلب وانخفاض فاقد الطهي بزيادة نسبة احلال الدهن بمستحلب زيت الزيتون المائي ، وايضا زيادة كلا من حمض الاوليك واللينوليك وعدم تغيير الثبات التاكسدي للمنتج المحتوي علي المستحلب المائي لزيت الزيتون خلال التخزين . ولوحظ انخفاض نسبة الكوليسترول وعدم تاثر الطاقة الكلية الناتجة من الدهن والنتائج تشير الي ان المنتج المصنع من المستحلب المائي لزيت الزيتون هو صحي اكثر من المنتج المصنع من دهن الضأن.