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Meat Fat Replacement with Olive Oil

Basem Mohammed Al-Abdullah[1,*], Khalid M. Al-Ismail[1], Khaled Al-Mrazeeq[1], Malak Angor[2] and Radwan Ajo[2]
[1]*Department of Nutrition and Food Technology, Faculty of Agriculture, University of Jordan, Amman,*
[2]*Al- Huson University Collage, Al- Balqa Applied University, Al-Huson, Jordan*

1. Introduction

The consumption of convenience foods in the restaurants such as beef or chicken burgers is increasing in Jordan. Burger is a meat product prepared from minced lean meat, with or without addition of other ingredients. The total fat content must not exceed 15% (JS: 1334/2002). In Jordan, burgers are prepared from two main meat sources: beef or chicken. Many efforts have been made to improve the quality and stability of burgers because consumer demand for healthy fast food has rapidly increased in the recent years.

Complete or partial replacement of burger fat with oil rich in monounsaturated fatty acids, such as olive oil may improve the oxidative stability of chicken burger and the nutritional value of beef burger. Another approach that can be followed to improve the quality of beef burgers is the partial replacement of beef meat with chicken meat.

This study aimed at:

1. Studying the effect of partial replacement of beef tallow and chicken fat with olive oil on some chemical and sensory properties of a freshly prepared and stored burger.
2. Studying the effect of partial replacement of beef tallow and meat with chicken meat and fat (50:50) on some chemical and sensory properties of a freshly prepared and stored burger.
3. Studying the effect of grilling on some chemical and sensory properties of a freshly prepared and stored burger formulations.

Five burger formulations were prepared and studied during storage and after grilling at 75°C for 20 minutes. These formulations were: beef, chicken, mixed beef and chicken (50:50), beef with olive oil and chicken with olive oil.

The effect of storage and grilling was evaluated by determining cooking loss by using weight differences between raw and cooked burgers, thiobarbituric acid reactive substances (TBARS) (Faustman, *et al.*, 1992), fatty acid profile using GLC analysis; fatty acid methyl esters (FAMEs) of the burger samples were prepared according to Chritopherson and Giass (1969) method, cholesterol and 7-ketocholesterol; cold saponification and extraction was

* Corresponding Author

carried out according to the method used by Sander, *et al.* (1988) and the trimethylsilyl derivatives (TMS) of cholesterol and cholesterol oxides were carried out according to the method used by Pie, *et al.* (1990).

2. Moisture, fat and protein content

The moisture, fat and protein contents for both beef burger treatments before grilling, were about 65.50%, 15.11%, and 18.20%, respectively. The moisture, fat and protein contents of both chicken burger samples before grilling were about 66.50%, 15%, and 17.50%, respectively.

The moisture loss percentage of the freshly prepared treatments due to grilling was between 20.37-25.62%, and fat loss was between 18.85-21.51%. On the other hand, the increase in protein contents was (96-116%) of the burger samples. Moisture and fat contents of the grilled samples were lower than those of raw samples, while protein content was higher. This is mainly due to the loss of water and fat.

3. Oxidative rancidity measured by TBARS test

The initial TBARS values of the beef sample expressed as mg malondialdehyde/kg meat, were about two times greater than those of chicken sample. These results reflect the quality of the raw materials, which in the case of beef, it already had a high initial degree of peroxidation. Inappropriate storage conditions of meat, together with the action of light, oxygen and the presence of myoglobine probably accelerated oxidation.

Characterisic	Time of storage (month)	*Treatment**				
		Beef	Chicken	Mixed	Beef with olive oil	Chicken with olive oil
Raw	0	$_{b}2.26^{a}$	$_{b}1.21^{c}$	$_{b}2.09^{b}$	$_{b}2.27^{a}$	$_{b}0.74^{d}$
	1	$_{a}2.71^{d}$	$_{a}3.00^{c}$	$_{a}2.59^{e}$	$_{a}5.07^{b}$	$_{a}5.23^{a}$
	3	$_{a}2.62^{a}$	$_{b}1.20^{c}$	$_{b}2.13^{b}$	$_{b}2.59^{a}$	$_{b}0.77^{d}$
Grilled	0	$_{b}0.57^{d}$	$_{b}5.09^{a}$	$_{b}2.10^{c}$	$_{c}0.38^{e}$	$_{b}3.76^{b}$
	1	$_{a}1.09^{d}$	$_{a}7.04^{b}$	$_{a}3.68^{c}$	$_{a}0.91^{e}$	$_{a}7.99^{a}$
	3	$_{a}1.03^{d}$	$_{c}4.53^{a}$	$_{c}1.53^{c}$	$_{b}0.79^{e}$	$_{c}3.12^{b}$

Each value is the mean of three replicates.
* Values within the same column with different subscripts denote significant differences ($p \leq 0.05$) between storage times according to LSD.
** Values within the same row with different superscripts denote significant differences ($p \leq 0.05$) between the treatments according to LSD.

Table 1. Thiobarbituric acid reactive substances values (TBARS) expressed as mg malondialdehyde /kg meat for the raw and grilled burger samples during storage time.

It can be observed that TBARS values increased during the first month.The increase was higher in the chicken sample and those with olive oil than those of beef sample.These results might be explained by the fact that the fatty acids of these samples have higher degree of unsaturation when compared with those of beef.

Melton (1985) reported that oxidized flavors were detectable at TBARS numbers of 0.3-1.0 in beef or pork, 1or 2 in chicken, and higher than 3 in turkey. The TBARS values obtained in this study, remarkably exceeded these ranges. So it can be assumed that these high values of TBARS could be attributed to oxidation as well as other interferences.

On the other hand, decrease in TBARS values noticed at the end of storage period were 85, 60, 47, 18 and 3% for chicken with olive oil, chicken, beef with olive oil, mixed and beef treatments, respectively. This behavior may be ascribed to the combination of aldehydes with other compounds and to the loss of volatile aldehydes (Severini, *et al*., 2003).

Different trends were observed on the effect of grilling on TBARS values, since TBARS values decreased in both beef samples, whereas they increased in both chicken samples. This finding may be attributed to the fact that chicken fat contains higher levels of PUFA, which are prone to higher level of oxidation.

4. Cholesterol and cholesterol oxides

It was evident that cholesterol content of the raw and grilled chicken sample was about 39% higher than those of beef sample. This is due to the use of chicken skin which contains high level of cholesterol in chicken burger. Mixed meat samples had cholesterol content which was about 15% lower than chicken and 18% higher than those of beef.

Substitution of the added beef and chicken fat with olive oil resulted in a considerable decrease in cholesterol contents. The reduction in beef and chicken samples was about 53% and 58%, respectively

Characteristic	Time of storage (month)	*Treatment				
		Beef	Chicken	Mixed	Beef with olive oil	Chicken with olive oil
Raw	0	$_{a}333.87$	$_{a}462.10$	$_{a}391.67$	$_{a}157.70$	$_{a}193.43$
	1	$_{a}331.27$	$_{a}461.67$	$_{a}390.66$	$_{a}156.61$	$_{a}193.03$
	3	$_{a}331.30$	$_{a}460.27$	$_{a}390.47$	$_{a}155.73$	$_{a}192.00$
	**Means	$^{c}332.15_{a}$	$^{a}461.35_{a}$	$^{b}390.93_{a}$	$^{e}156.68_{a}$	$^{d}192.82_{a}$
Grilled	0	$_{a}331.73$	$_{a}460.13$	$_{a}390.27$	$_{a}156.47$	$_{a}191.13$
	1	$_{a}330.23$	$_{a}459.37$	$_{a}389.30$	$_{a}154.92$	$_{a}191.07$
	3	$_{a}330.93$	$_{a}459.11$	$_{a}389.13$	$_{a}154.67$	$_{a}190.28$
	**Means	$^{c}330.96_{a}$	$^{a}459.54_{a}$	$^{b}389.57_{a}$	$^{e}155.35_{a}$	$^{d}190.83_{a}$

Each value is the mean of three replicates.
* Values within the same column with same subscripts are not significantly ($p > 0.05$) different according to LSD.
** Values within the same row with different superscripts denote significant differences ($p \leq 0.05$) between treatments according to LSD, whereas values within the same column with same subscripts denote no significant ($p > 0.05$) differences among raw and grilled samples according to LSD.

Table 2. Cholesterol content (mg/100 g fat) for the raw and grilled burger samples during storage.

Characteristic	*Treatment**				
	Beef	Chicken	Mixed	Beef with olive oil	Chicken with olive oil
Raw	$_{c}50.12^{a}$	$_{a}70.82^{a}$	$_{b}59^{a}$	$_{e}23.78^{a}$	$_{d}29^{a}$
Grilled	$_{c}38.76^{b}$	$_{a}56^{b}$	$_{b}45.42^{b}$	$_{e}17.77^{b}$	$_{d}23^{b}$

Each value is the mean of three replicates.
* Means in the same row with the different subscripts denote significant differences among treatments of burger ($p \leq 0.05$) according to LSD.
** Means in the same column with different superscripts denote significant differences among raw and grilled burger samples ($p \leq 0.05$) according to LSD.

Table 3. Cholesterol values (mg/100g burger) for the raw and grilled burger samples.

Storage time and grilling did not affect cholesterol contents of all treatments, calculated on the fat basis (mg cholesterol/100g fat).

However, cholesterol content calculated on the burgers basis (mg cholesterol/100g burger) showed lower cholesterol in grilled samples compared to the raw one. The reduction was about 23, 21, 23, 25 and 21% for beef, chicken, mixed, beef with olive oil and chicken with olive oil samples, respectively. This reduction might be due to the loss of fat during cooking.

7-ketocholesterol was used in this study as a tracer of the degree of cholesterol oxidation, because of its fast and continuous formation at levels relatively high with respect to the other oxidation products (Park and Addis, 1985). moreover, the chromatographic peak of 7-ketocholesterol does not overlap with other peaks of cholesterol oxides products and components of food matrices (Rodriguez-Estrada, *et al.*, 1997).

In this study, there was no detectable amount of 7-ketocholesterol in all raw and grilled samples, indicating that storage and grilling did not affect the stability of cholesterol against oxidation. This could be explained by the fact that grilling conditions were not severe, since the maximum temperature of grilling was about 75°C and the time of grilling did not exceed 20 minutes. Cholesterol shows high oxidation stability at temperature below 100°C (Kyoichi, *et al.*, 1993). Furthermore, the grilling machine permitted low oxygen level to be in contact with burger during grilling because the upper part of the grill was closed and directly came into contact with the burgers.

5. Fatty acids profile

The effect of formulation, grilling and storage period on SFA, MUFA and PUFA contents of the burgers was observed. As expected, fatty acid composition of burgers reflected the fatty acid composition of the tissues and the fat used for their manufacturing.

It is well known that SFA are considered as a primary cause of hypercholesterolemia, and MUFA provide the body of essential fatty acids and decrease LDL cholesterol in the body (Mattson and Grundy, 1985). On the other hand, the addition of beef meat and fat to chicken burger enhanced its oxidative stability by increasing SFA by 32% and decreasing PUFA content by 34%, approximately. PUFA are easily prone to oxidation generating short chain compounds that deteriorate the sensory properties of the meat products.

Fatty acid	Treatment									
	Beef		Chicken		Mixed		Beef with olive oil		Chicken with olive oil	
	Raw	Grilled	Raw	Grilled	Raw	Grilled	Raw	Grilled	Raw	Grilled
Myristic C14:0	1.36	1.34	0.58	0.53	0.88	0.76	0.25	0.24	0.29	0.22
Palmitic C16:0	34.78	31.79	26.71	26.58	30.69	28.87	16.71	15.42	17.25	14.45
Palmitoleic C16:1	1.01	1.48	4.72	4.62	3.02	3.73	0.81	1.11	2.68	3.34
Stearic C18:0	22.36	20.57	6.13	6.00	12.61	10.48	10.21	8.93	5.86	4.81
Oleic C18:1	37.72	39.65	42.84	42.88	39.93	42.88	58.84	63.32	59.92	65.37
Linoleic C18:2	1.81	3.1	17.82	17.81	11.60	12.03	8.63	8.94	11.97	11.94
Linolenic C18:3	0.35	0.96	1.10	0.88	0.79	0.83	0.86	0.89	1.26	0.93
Arachidic C20:0	0.04	traces	0.02	traces	0.02	traces	0.03	traces	0.01	traces

Each value is the mean of three readings of fatty acids after samples formulation.

Table 4. Means values of fatty acids profile (g/100g fat) for the raw and grilled burger samples after formulation.

Another strategy for changing fatty acid profile of meat products rather than meat mixing is the replacement of animal fats by vegetable oils. Olive oil is a vegetable oil whose MUFA content is high. The MUFA, PUFA and SFA contents were about 72%, 10% and 13%, respectively. The addition of olive oil in place of beef and chicken fat changed the fatty acids composition of the beef and chicken burgers. The decrease in SFA of beef sample was about 54%, whereas the increase in MUFA and PUFA contents was about 54% and 33.9%, respectively, of their original contents in beef fat. On the other hand, the increase in MUFA was about 32%, whereas the decrease in SFA and PUFA contents was about 30% of their original contents in chicken fat. The decrease in SFA contents in these burger samples was due to the decrease in myristic, palmitic and stearic acid contents, while the increase in MUFA was due mainly to oleic acid, since the addition of olive oil decreased the palmitoleic acid contents. The increase in PUFA content of beef sample was mainly due to the increase in linoleic and to a less extent to the increase in linolenic content.

MUFA and PUFA contents showed gradual and significant decrease for all treatments during storage period, especially at the end of storage. This may be due to the oxidation of unsaturated fatty acids.

In the case of PUFA, the decrease in their contents of beef with olive oil was lower than in beef with tallow (≈ 47%), while chicken samples showed reverse trend, since the decline in PUFA contents of chicken was about 8% compared to 22% in chicken with olive oil.

Charac-teristic	Time of storage (month)	*Treatment**									
		Beef		Chicken		Mixed		Beef with olive oil		Chicken with olive oil	
		Raw	Grilled	Raw	Grilled	Raw	Grilled	Raw	Grilled	Raw	Grilled
SFA	0	$_{a}58.54^{a}$	$_{a}53.70^{b}$	$_{a}33.42^{a}$	$_{a}33.11^{b}$	$_{a}44.20^{a}$	$_{a}40.11^{b}$	$_{a}27.20^{a}$	$_{a}24.61^{b}$	$_{a}23.40^{a}$	$_{a}19.48^{b}$
	1	$_{a}58.28^{a}$	$_{a}53.75^{b}$	$_{a}33.50^{a}$	$_{a}33.25^{b}$	$_{a}44.57^{a}$	$_{a}40.24^{b}$	$_{a}26.93^{a}$	$_{a}24.90^{b}$	$_{a}23.61^{a}$	$_{a}19.50^{b}$
	3	$_{a}58.89^{a}$	$_{a}53.63^{b}$	$_{a}33.76^{a}$	$_{a}33.57^{b}$	$_{a}44.61^{a}$	$_{a}40.49^{b}$	$_{a}27.13^{a}$	$_{a}24.92^{b}$	$_{a}23.72^{a}$	$_{a}19.73^{b}$
MUFA	0	$_{a}38.73^{b}$	$_{a}41.13^{a}$	$_{a}47.56^{a}$	$_{a}47.50^{a}$	$_{a}42.95^{b}$	$_{a}46.69^{a}$	$_{a}59.65^{b}$	$_{a}64.43^{a}$	$_{a}62.60^{b}$	$_{a}68.71^{a}$
	1	$_{b}38.11^{b}$	$_{b}39.99^{a}$	$_{b}45.87^{a}$	$_{b}45.76^{a}$	$_{b}41.70^{b}$	$_{b}46.02^{a}$	$_{b}56.90^{b}$	$_{b}63.46^{a}$	$_{b}60.19^{b}$	$_{b}67.72^{a}$
	3	$_{c}35.35^{b}$	$_{c}36.50^{a}$	$_{c}35.17^{b}$	$_{c}40.60^{a}$	$_{c}36.58^{b}$	$_{c}38.72^{a}$	$_{c}47.22^{b}$	$_{c}54.50^{a}$	$_{c}50.59^{b}$	$_{c}57.52^{a}$
PUFA	0	$_{a}2.16^{b}$	$_{a}4.06^{a}$	$_{a}18.92^{a}$	$_{a}18.69^{a}$	$_{a}12.39^{b}$	$_{a}12.86^{a}$	$_{a}9.49^{b}$	$_{a}9.82^{a}$	$_{a}13.26^{a}$	$_{a}12.87^{a}$
	1	$_{b}1.53^{b}$	$_{b}2.47^{a}$	$_{b}17.82^{b}$	$_{a}18.55^{a}$	$_{b}11.93^{a}$	$_{b}11.42^{b}$	$_{b}7.29^{a}$	$_{b}7.93^{a}$	$_{b}12.59^{b}$	$_{a}12.77^{a}$
	3	$_{c}1.15^{b}$	$_{b}2.69^{a}$	$_{b}17.64^{b}$	$_{a}18.42^{a}$	$_{c}11.29^{a}$	$_{c}10.79^{b}$	$_{c}5.94^{b}$	$_{b}7.77^{a}$	$_{c}10.34^{b}$	$_{b}12.02^{a}$

Each value is the mean of three replicates.
* Values within the same column with different subscripts are significantly ($p \leq 0.05$) different according to LSD.
** Values within the same row with different superscripts denote significance different ($p \leq 0.05$) among raw and grilled sample according to LSD

Table 5. Effect of formulation, storage time and grilling on fatty acids profile (g/100g fat) of the burger samples.

Grilling significantly decreased SFA, and increased MUFA contents of all samples, except for MUFA contents of chicken sample which remained constant. PUFA contents, in general, increased in most samples, but in some cases there was no clear trend.

6. Cooking loss

Chicken sample with olive oil showed lower cooking loss in weight due to grilling when compared to the corresponding samples without olive oil. This result showed the ability of protein matrix to bind monounsaturated fat. Chicken samples with olive oil had lower cooking loss in weight when compared to beef samples which was due to the highest water holding capacity, lipid capacity and lipid stability of chicken meat rather than beef meat.

Characteristic	Time of storage (month)	*Treatment**				
		Beef	Chicken	Mixed	Beef with olive oil	Chicken with olive oil
Cooking loss%	0	$_{b}49.69^{c}$	$_{b}50.22^{b}$	$_{b}51.30^{a}$	$_{b}50.26^{b}$	$_{b}43.28^{d}$
	1	$_{b}49.86^{c}$	$_{b}50.48^{b}$	$_{b}51.53^{a}$	$_{b}50.21^{b}$	$_{b}43.02^{d}$
	3	$_{a}51.70^{c}$	$_{a}52.63^{b}$	$_{a}53.17^{a}$	$_{a}52.78^{b}$	$_{a}47.39^{d}$

Each value is the mean of three replicates.
* Values within the same column with different subscripts are significantly ($p \leq 0.05$) different according to LSD.
** Values within the same row with different superscripts denote significant differences ($p \leq 0.05$) according to LSD.

Table 6. Percentage cooking loss in weight of burger samples during storage period.

In the mixed treatment we expected that cooking loss value will be between beef and chicken sample values, but unexpected result was obtained, the outcome showed that mixed treatment had the highest cooking loss in weight. More investigation is needed to explain the results.

The highest cooking loss was found after three months of storage which might be due to the weakness of protein matrix to entrap moisture and fat during storage, moreover, this weakness of protein matrix results in decrease of water and lipid holding capacity and stability, which might be due to denaturation of protein during frozen storage.

7. Sensory evaluation

Cooked burgers from each treatment were evaluated by 18 panelists from the sensory evaluation team at the Department of Nutrition and Food Technology. The panelists were both male and female, and were of different ages; they were requested to taste each sample separately without comparing it with other samples. Panelists were familiarized with the questionnaire form used. The samples were evaluated for desirability in appearance, color, tenderness, flavor, juiciness and overall acceptability using a 9-hedonic scale test as described by LARMOND (1991), varying from 9 (like extremely) to 1 (dislike extremely). Pieces of bread and water were used to neutralize the taste between samples.

The sensory evaluation results showed that all the sensory characteristics did not exceed the range like moderately, or fell to dislike slightly. This low score given by the panelists for all samples might be attributed to the fact that the prepared burgers were free of any added ingredients or additives that are usually added to these type of products such as spices, salt, protein derivatives of vegetable origin, dietary fibers, antioxidants, flavor enhancers and other additives which result in enhancing the sensory characteristics and the stability of the meat products.

Since the fat content of all burger treatments was about 15%, these products might contain up to 20-30% of fat to give the desirable succulence and texture.

Mixing of chicken with beef meat enhanced the sensory characteristics of the beef. In general, mixed sample had sensory scores higher than beef sample, and were close to the chicken sample. Mixed formulation was the most stable with respect to the sensory characteristics during the storage period. Freshly prepared mixed formulation samples had appearance and color scores (6.94 and 6.89, respectively) higher than those of the beef and chicken samples.(6.11 and 6.83, respectively for appearance) and (5.67 and 6.61, respectively for color). This may be due to the dilution of the redness color of beef meat as well as the dilution of the yellowness of the chicken meat which resulted in moderate appearance and color between beef and chicken meats (between redness and yellowness), since beef meat contains more myoglobin than chicken.

Appearance and color are related sensory qualities, so this modification in color of the mixed treatment affected the appearance, which in role affected the panelist's evaluation.

Tenderness evaluation of meat and meat products by panelists is correlated mainly with juiciness. Therefore, close scores of tenderness and juiciness of beef chicken and mixed treatments were observed. Tenderness and juiciness scores of the mixed formulations were significantly higher than those of beef, and very close to those of chicken. This indicated that tenderness and juiciness are strongly related to the type of meat more than to other factors.

Characteristic	Time of storage (month)	Treatment				
		Beef	Chicken	Mixed	Beef with olive oil	Chicken with olive oil
Appearance	0	$_{a}6.11^{a}$	$_{a}6.83^{a}$	$_{a}6.94^{a}$	$_{a}6.00^{a}$	$_{a}6.56^{a}$
	1	$_{a}6.06^{ab}$	$_{ab}6.22^{ab}$	$_{a}7.00^{a}$	$_{a}5.33^{b}$	$_{a}5.61^{b}$
	3	$_{a}5.94^{ab}$	$_{b}5.50^{b}$	$_{a}6.83^{a}$	$_{b}4.16^{c}$	$_{a}5.72^{b}$
Color	0	$_{a}5.67^{b}$	$_{a}6.61^{ab}$	$_{a}6.89^{a}$	$_{a}5.88^{b}$	$_{a}6.67^{ab}$
	1	$_{a}5.56^{bc}$	$_{ab}6.00^{ab}$	$_{a}7.00^{a}$	$_{a}5.39^{c}$	$_{a}5.61^{bc}$
	3	$_{a}6.33^{a}$	$_{b}5.11^{b}$	$_{a}6.44^{a}$	$_{b}4.00^{c}$	$_{a}5.61^{ab}$
Tenderness	0	$_{a}4.44^{b}$	$_{a}6.56^{a}$	$_{a}6.10^{a}$	$_{a}4.27^{b}$	$_{a}6.44^{a}$
	1	$_{a}4.55^{b}$	$_{a}6.33^{a}$	$_{a}6.72^{a}$	$_{a}4.50^{b}$	$_{a}6.50^{a}$
	3	$_{a}4.60^{b}$	$_{a}6.22^{a}$	$_{a}6.67^{a}$	$_{a}4.33^{b}$	$_{a}6.17^{a}$
Flavor	0	$_{a}4.94^{b}$	$_{a}6.33^{a}$	$_{a}5.78^{ab}$	$_{a}5.06^{b}$	$_{a}6.06^{a}$
	1	$_{a}5.06^{bc}$	$_{a}5.88^{ab}$	$_{a}6.28^{a}$	$_{ab}4.72^{c}$	$_{a}5.12^{bc}$
	3	$_{a}4.83^{bc}$	$_{a}5.50^{ab}$	$_{a}5.94^{a}$	$_{b}3.94^{c}$	$_{a}5.63^{ab}$
Juiciness	0	$_{a}4.17^{b}$	$_{a}6.44^{a}$	$_{a}6.11^{a}$	$_{a}4.44^{b}$	$_{a}6.17^{a}$
	1	$_{a}4.27^{b}$	$_{a}5.61^{a}$	$_{a}5.67^{a}$	$_{a}4.22^{b}$	$_{a}5.44^{a}$
	3	$_{a}4.44^{b}$	$_{a}5.61^{a}$	$_{a}5.83^{a}$	$_{a}3.56^{c}$	$_{a}5.50^{ab}$
Overall acceptability	0	$_{a}5.38^{b}$	$_{a}6.52^{a}$	$_{a}6.39^{ab}$	$_{a}5.39^{b}$	$_{a}6.10^{ab}$
	1	$_{a}5.00^{c}$	$_{ab}6.06^{ab}$	$_{a}6.50^{a}$	$_{ab}4.44^{c}$	$_{a}5.17^{bc}$
	3	$_{a}5.22^{a}$	$_{b}5.51^{a}$	$_{a}6.00^{a}$	$_{b}3.72^{b}$	$_{a}5.83^{a}$

Means in the same column with the same subscripts denote no significant differences among treatments of burger ($p > 0.05$) according to LSD.
Means in the same row with different superscripts denote significant differences among treatments of burger ($p \leq 0.05$) according to LSD.
Means are the average of 18 reading.

Table 7. Effect of formulation and storage time on sensory evaluation scores for the burger samples.

Sensory scores	Appearance	Color	Tenderness	Flavor	Juiciness	Overall acceptability
Appearance	1.00	0.95*	0.60*	0.79*	0.72*	0.90*
Color	0.95*	1.00	0.59*	0.71*	0.70*	0.85*
Tenderness	0.60*	0.59*	1.00	0.78*	0.96*	0.79*
Flavor	0.79*	0.71*	0.78*	1.00	0.84*	0.92*
Juiciness	0.72*	0.70*	0.96*	0.84*	1.00	0.88*
Overall acceptability	0.90*	0.85*	0.79*	0.92*	0.88*	1.00

* Correlation is significant at the 0.05 level

Table 8. Pearson's correlation coefficients between the sensory scores for the burger formulations.

Substitution of meat fat in beef and chicken samples with olive oil, in general, did not affect the sensory characteristics, since no significant differences were found between the sensory scores of the samples with and without olive oil. Beef with olive oil showed lower sensory scores after three months of storage compared to the beef sample with tallow, whereas the sensory characteristics of the chicken with olive oil remained stable during the storage period.

Although chicken with olive oil treatment showed lower cooking loss compared with the chicken treatment The tenderness and juiciness scores of these two treatments were not significantly different.

Storage time did not significantly affect the sensory evaluation scores of each treatment, except for chicken in which the appearance, color and overall acceptability at the end of storage were lower than the initial values. Appearance, color, flavor and overall acceptability of beef with olive oil also were affected by storage time. This decline in sensory parameters of these samples should be attributed to oxidation

In conclusion, it could be observed that the addition of olive oil did not affect the sensory properties of chicken burger, but it had a slight negative effect on these properties of beef burger, and addition of chicken meat to beef burger improved their sensory properties, which was very close to those of chicken sample. In addition, although, the fatty acid oxidation measured by TBARS of all treatments during storage and by grilling was relatively high, but it didn't affect significantly the sensory properties of their samples.

As a result of this research, it is recommended to introduce olive oil in burgers and other potential meat products to improve their nutritional value and to reduce their cholesterol content, and also to produce burger by mixing chicken and beef meat to enhance the sensory properties of the beef and to improve the oxidative stability of the chicken. However, Further studies are needed to determine the most suitable ratio of chicken/beef meat and fat to be used in burger formulas which give the best chemical and sensory properties.

8. References

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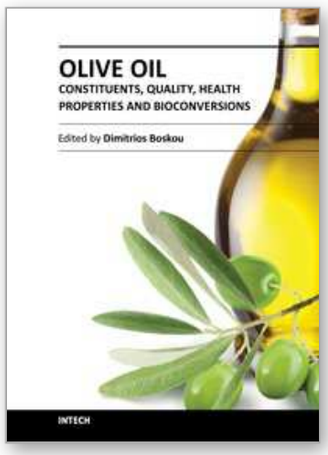
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Olive Oil - Constituents, Quality, Health Properties and Bioconversions

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The health-promoting effects attributed to olive oil, and the development of the olive oil industry have intensified the quest for new information, stimulating wide areas of research. This book is a source of recently accumulated information. It covers a broad range of topics from chemistry, technology, and quality assessment, to bioavailability and function of important molecules, recovery of bioactive compounds, preparation of olive oil-based functional products, and identification of novel pharmacological targets for the prevention and treatment of certain diseases.

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University Campus STeP Ri
Slavka Krautzeka 83/A
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InTech China
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No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

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