J. Food and Dairy Sci., Mansoura Univ., Vol. 9 (7): 263 - 271 , 2018

Improvement of some Functional and Nutritional Characteristics of the Beef Burger Using Marjoram Herb

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ABSTRACT

Fortification of food products with herbal plants to improve their functional and nutritional properties has currently found great effort. Therefore, the present study was designed to characterize the marjoram herb and using it in preparation of beef burger to improve their functional and nutritional properties. Also, the effect of marjoram herb on the oxidative stability of prepared burgers was studied. In addition, Marjoram herb was partially substituted of beef meat by different levels (1.5, 2.5 and 3.5 %), then compared to the control. The results cleared that the marjoram herb contained high protein, ash and fibers contents, where the values were 11.2, 29.0 and 18.5 %, respectively. Moreover, Total phenolic compounds content of the marjoram herb were 19.28 mg as chlorogenic acid equivalent/g. Addition of marjoram herb to beef burger led to improve of the cooking properties such as increase of water holding capacity (WHC), decrease of cooking loss and shrinkage during cooking. In addition, reduce the cost of production of beef burger without significant differences in its sensory properties. Furthermore, marjoram improved the oxidative stability of beef burger, where the peroxide and thiobarbituric acid values of burgers stored at -18 °C for 14 days decreased with the increasing of the marjoram levels. Based on these results, we can recommend that, fortification of beef burger with marjoram herb can improve its nutritional and functional properties.

Keywords: *Marjoram, phenolic compounds, antioxidant activity, storage and beef burger*

INTRODUCTION

Marjoram (*Origanum majorana*) belongs to the Lamiaceae family, genus Origanum with about 360 species and it is a perennial herb or under shrub with sweet pine and citrus flavors. Marjoram herb is considered one of the main crops for increasing Egypt income from foreign currency (El-Eshmawiy *et al.*, 2009). The fresh or dried marjoram leaves and their essential oil are extensively used in the food manufacturing as a food ingredient, a herbal tea, flavoring, coloring, nutritional and natural preservatives (Holley and Patel, 2005).It is a popular spice used for centuries as a remedy for many diseases and as a cuisine matter (Matkowski and Piotrowska, 2006).In particular, sweet marjoram herb holds equal to 3% volatile oil, tannins, steroids, flavonoid glycosides and triterpenoids such as oleanolic and ursolic acids (Vagi *et al.*, 2002).These diverse extracts of marjoram hold anti-inflammatory, antioxidant and antimicrobial effects (Heo *et al.*, 2002).

During storage, quality characteristics of the product decline because of microbial growth and lipid oxidation, where lipids oxidation is control for reduction in food quality as well as alterations in flavor (Aguirreźabal *et al.*, 2000).Andrés *et al.,*(2017) stated that the microbial growth and lipid oxidation are the main causes of quality degradation in meat products. Lipid oxidation can yield an extensive range of breakdown products which can be responsible off-odours and flavours in meat products. Proteins are also susceptible to oxidative reactions, which can damage protein functionality (Lund *et al.*, 2011).

In recent years, the use of natural plant preservatives to raise the shelf-life of foodstuff is promising technology since they derived substances have antimicrobial and antioxidant properties. Several spices, herbs and their extracts have been added in a variety of foods to improve their shelf-life and sensory characteristics (Burt, 2004).

Replacement of meat with other non-meat ingredients has been practiced between processed meat industries. This replacement is done too many reasons such as, health or economic purposes and quality. For example, the replacement of constituents from animal source with that of plants has been applied in food manufacturing (Egbert and Payne, 2009).

According to our knowledge, there is no studies were done regarding to use the marjoram in burger industry. Therefore, the current study was focused on characterization of marjoram herb in addition to incorporation of marjoram in formulation of beef burger to improve their functional and nutritional properties. Moreover, the effect of marjoram on the storage stability of prepared burgers was also studied.

MATERIALS AND METHODS

Materials:

The marjoram herb was obtained from Desert Research Center, Cairo, Egypt. All ingredients used in preparation of burger were purchased from the local market of Kafr El-Sheikh city, Egypt. Chemicals and reagents were obtained from El-Gomhoria Company for Chemicals and drug, Tanta, Egypt. All the rest reagents and chemicals used were of analytical grade.

Methods:

The marjoram herb dried in oven at 50 ºC for 30 h, then milled in a hammer mill (Moulinex Odacio 3). The powder passed through 50 mesh cell sieve.

Proximate chemical composition of marjoram herb and burgers:

The moisture, ash, crude fat, crude protein, and crude fiber contents of the marjoram were determined according to (AOAC, 2011). The available carbohydrates were calculated by difference as follows:

Carbohydrates (%) = 100 - (crude fiber + crude protein + crude ash + crude fat)

Energy value of marjoram herb:

Energy value of marjoram was designed as described by AOAC, (2011), where one g protein gives 4.27 Kcal, one g lipid gives 9.02 Kcal and one g of carbohydrates gives 4.10 Kcal.

Physical properties of marjoram herb:

Protein - water fat coefficient (PWFC), Protein - water coefficient (PWC) and water-protein coefficient (WPC) values were estimated as stated by Tsuladze, (1972) as follows:

PWC = % Protein (WW) / % Water

PWFC = % protein (WW) / (% water + % fat (WW)).
WPC = % water /% protein (WW).

Feder value was estimated according to the method described by Pearson, (1970) as follows:

Feder value = % Water / % Organic Non-fat.

Where: **% Organic Non-fat= 100 – (% fat + ash + % moisture)**

Identification and quantification of amino acids:

The amino acids of marjoram was determined according to the method of Duranti and Cerletti, (1979).

Preparation of burgers:

Four burger formulations were prepared in Food Technology Department, Faculty of Agriculture, Kafrelsheikh University according to Yousefi *et al.*(2018) with some modifications by replacing the beef meat with three different levels (1.5, 2.5 and 3.5 %) of marjoram herb. All ingredients were mixed together in a blender, to ensure uniform distribution of the added ingredients, and the resulting paste was added to minced beef and mixed with marjoram in a separate blender. This mixture was formed by a commercial burger maker into disc pieces of 50 g and a thickness around one cm and diameter around nine cm to obtain burger.

Sensory evaluation of burgers:

Sensory properties of raw and cooked burgers fortified by different levels of marjoram were evaluated as described by Meilgaard *et al.*, (2007).

Determination of total phenolic compounds of burgers:

Total phenolic compounds were extracted by the method of Nara *et al.*, (2006).Burger samples (1.5 g) were mixed with absolute methanol (20 ml). The mixture was shaking on a mechanical shaker for 24 h at room temperature. After that, the mixture was filtrated and the supernatants obtained were stored till needed. The total phenolics content of extracts were determined spectrophotometrically using Folin-Ciocalteu reagent according to the method described by Bonoli *et al.*, (2004). An aliquot of the extract (0.1 mL) was diluted with distilled water to 5 mL in 10 mL volumetric flask, then 0.5 mL of Folin-Ciocalteau reagent was added after 3 min, one mL of saturated sodium carbonate (Na_2CO_3) solution was added. The volume of mixture was completed to 10 mL with distilled water. After incubation for 1 h, the absorbance was measured at 725 nm by PG Instruments T80 UV/VIS Spectrophotometer. The amount of phenolics was expressed as mg chlorogenic acid equivalent/ 100 g burger.

Determination of antioxidative capacity of burgers using DPPH assay:

Anti-oxidative capacity of burger extracts were estimated using DPPH assay as designated by Binsan *et al.*, (2008)with a slight modification. One mL of 0.15 mM (2,2-diphenyl-1-picryl hydrazyl (DPPH) in 95% ethanol) was added to one mL extract. The mixture was mixed vigorously and stored in the dark at room temperature for 30 min. The absorbance of the mixture was measured at 517 nm using PG Instruments T80 UV/VIS Spectrophotometer. The activity was expressed as mM TE/ 100g burger.

Cooking properties of burgers:

Cooking loss:

The cooking loss of the prepared burgers was measured using the formula of Akwetey and Knipe, (2012)as follows:

$$\%\ \text{Cooking loss} = \frac{\text{Weight of raw burger (g)} - \text{Weight of cooked burger (g)}}{\text{Weight of raw burger (g)}}\ \%100$$

Cooking yield and moisture retentions:

Cooking yield and moisture retention were calculated as reported by Aleson-Carbonell *et al.*, (2005) according to the following equations:

% Cooking yield = Weight of raw burger (g)/ Weight of cooked burger (g) × 100

% Moisture retention = moisture of raw burger /moisture of cooked burger × 100

Shrinkage and the thickness increase measurements:

The percentage of burger shrinkage and the thickness increase was studied according to equations planned by Berry, (1992) as follows:

$$\%\ \text{Shrinkage} = \frac{\text{Diameter of uncooked sample (cm)} - \text{Diameter of cooked sample (cm)}}{\text{Diameter of uncooked sample (cm)}}\ \%100$$

$$\%\ \text{Thickness increase} = \frac{\text{Thickness of cooked sample (cm)} - \text{Thickness of raw sample (cm)}}{\text{Thickness of cooked sample (cm)}}\ \%100$$

Physiochemical properties of burgers:

pH value:

The pH value of burgers was estimated according to Tan *et al.*, (2007) with a slight modification. 10 g of burgers were weighed into a conical flask (50 mL) and 20 mL of deionized water was added. Samples were homogenized for 30 seconds and the pH value of homogenate was determined using a pH meter (Mettler toledo FE20/EL20, Shanghai, China) calibrated using three buffers (pH 4, 7 and 9).

Water-holding capacity:

The water-holding capacity (WHC) of burgers was measured according to the method adapted by Troy *et al.*, (1999).The WHC was calculated depending on the following equation:

$$\%\text{WHC} = \frac{\text{Weight of sample before centrifugation (g)} - \text{Weight of sample after centrifugation (g)}}{\text{Initial moisture content of the sample (g)}}\ \%100$$

Oil uptake:

The oil content of raw and cooked burgers was determined using the soxhlet extraction method (AOAC, 2011).The oil uptake (%) was calculated according to the following equation:

$$\textbf{Oil uptake (\%)} = o_f - o_r / o_r \times 100$$

Where: o_f **is the oil content of cooked burger and** o_r **is the oil content of raw burger expressed as dry matter.**

Texture:

The texture measurement of raw and cooked burgers was measured using a texture analyzer as outlined by Ngadi *et al.*(2007).

Effect of marjoram on the storage stability of prepared burgers:

Four formulations of burgers were stored at – 18 °C for 14 days and evaluated each seven days by the following parameters.

The change in the pH values:

pH value of burgers was measured at 0, 7 and 14 days storage as described above.

The change in the total bacterial count:

Raw burger formulations stored at -18°C were evaluated for total bacterial count to determine the shelf life at 0, 7 and 14 days according to the pour-plate method (Difco, 1977).

Determination of the lipid oxidation of stored burgers:

Peroxide value (PV):

Peroxide value (PV) of oil extracted from the burger was measured using the method outlined by Leonard *et al.*, (1987).

Thiobarbituric acid (TBA):

TBA assay was performed according to the method of Nirmal and Benjakul, (2009) and TBA value was expressed as mg malondialdehyde (MDA)/kg burger.

Statistical analysis:

All results were studied to analysis of variance by one-way ANOVA by Sigma Stat (v.3.5. Systat Software Inc.). The significant variance between the means of treatments was estimated at the $P \leq 0.05$ level by Duncan's new multiple range test (Steel and Torrie, 1981).

RESULTS AND DISCUSSION

Proximate chemical composition and quality attributes of marjoram herb:

The chemical composition of marjoram herb was determined on dry weight basis and the data are shown in Table (1). The results reported that marjoram herb contained 11.2, 9.2, 29.01, 18.5 and 32.09 % for crude protein, fat, ash, crude fibers and total carbohydrates (by difference) on dry weight, respectively. These data are nearly with those of USDA, (2009); El-Ghany and Nanees, (2010) and Hafez, (2012).Where, El-Ghany and Nanees,(2010) reported that the chemical composition of marjoram leaves was16.21% ash, 12.34% protein, 66.73% total carbohydrate and 19.69% fiber on dry weight, while Hafez,(2012) found that, marjoram contained 5.66, 5.62,12.80, 3.75, 19.52and72.18% for moisture, ash, crude protein, fat, crude fibers and carbohydrates, respectively.

These slight differences may be depending on the origin and conditions of agriculture. It is also noticed from the same Table that the marjoram herb can be considered as a rich source for both the crude protein and fibers. Data outlined in Table (1), show some quality attributes of marjoram such as PWC, PWFC, WPC and feder value where the values were 1.02, 0.55, 0.98 and 0.18 respectively, these results are related to the percentage of protein and moisture. With respect to the energy value of marjoram, it showed energy value (268.69 Kcal/100g). According to USDA (2009), every 100 *g* of marjoram contains energy value (271kcal). Moreover, marjoram showed a high phenolic content (19.28 mg as chlorogenic acid equivalent/ g marjoram) (Table 1).

Table 1. Proximate chemical composition and quality attributes of marjoram herb.

Parameters		Moisture	Crude Protein	Fat	Ash	Crude fibers	Total carbohydrates
Chemical composition	DW	9.9 ±1.1	11.20 ±1.2	9.20 ±0.8	29.01 ±1.7	18.5 ±1.4	32.09 ±2.1
Quality attributes	PWC	PWFC	WPC	Feder value	Energy value (Kcal/100g)	Total phenolics (mg chlorogenic acid / g)	
	1.02	0.55	0.98	0.18	268.69	19.28	

Where: **DW, Dry Weight basis; PWC, Protein Water Coefficient; PWFC, Protein Water Fat Coefficient and WPC, Water Protein Coefficient.**

The amino acids content of marjoram herb:

The amino acids composition of marjoram leaves was presented in Table (2). The results displayed that the predominant essential amino acids of marjoram herb protein were in this order leucine, valine, lysine, phenylalanine, threonine, isoleucine and tyrosine with values 0.71, 0.53, 0.49, 0.46, 0.42, 0.38 and 0.35 %, respectively. Whereas, it considered a poor source of cystine 0.1%, hisitidine 0.19 % and methionine 0.19 %. As shown in the same Table, glutamic and aspartic were the predominate of non-essential amino acids which reached 1.27 and 0.96 % followed by arginine and alanine with 0.68 and 0.56 % respectively. While, proline, glycine, and serine represented 0.49, 0.46 and 0.42 %, respectively.

Sensory properties of burgers:

Data presented in Table (3) show the sensory properties of raw and cooked burger samples prepared with different levels of marjoram herb. Results indicate that there were no significant variances at $p \leq 0.05$ for color, texture, flavor and overall acceptability between raw burgers fortified by marjoram and the control burger. Moreover, there were also no significant differences at $p \leq 0.05$ for the same properties between cooked burgers fortified with marjoram and the control burger. Therefore, supplemented burger with marjoram till 3.5 % could be suggested to be made as burger with good quality suitable sensory quality characteristics.

Table 2. Amino acids content (% on dry weight basis) of marjoram herb.

Essential amino acids	(%)	Non–Essential Amino acids	(%)
Leucine	0.71	Aspartic	0.96
Isoleucine	0.38	Serine	0.42
Lysine	0.49	Glutamic	1.27
Phenylalanine	0.46	Glycine	0.46
Hisitidine	0.19	Alanine	0.56
Tyrosine	0.35	Arginine	0.68
Valine	0.53	Proline	0.49
Therionine	0.42	Cystine	0.1
Methionine	0.19		
Total	3.72	Total	4.94

Table 3. Sensory evaluation of raw and cooked beef burgers fortified by different levels of marjoram herb.

Formulations		Sensory properties					
		Color	Taste	Odor	Texture	Appearance	Overall Acceptability
Raw	RB0	8.6 ±0.19[a]	ND	7.1 ±0.30[a]	7.8 ±0.83[a]	8.1 ±0.67[a]	8.4 ±0.66[a]
	RB1	7.7 ±0.28[a]	ND	7 ±0.23[a]	7.6±0.79[a]	7.5 ±0.74[a]	7.9 ±0.93[a]
	RB2	7.6 ±0.21[a]	ND	7.1 ±0.24[a]	7.6 ±1.1[a]	7.5 ±0.43[a]	7.8 ±0.39[a]
	RB3	7.6±0.33[a]	ND	7.3±0.51[a]	7.7±1[a]	7.6±0.33[a]	7.8±0.50[a]
Cooked	CB0	8.2 ±0.14[a]	7.7 ±0.92[a]	7.6 ±0.32[a]	7.8 ±0.23[a]	7.9 ±0.45[a]	8.2 ±0.78[a]
	CB1	8.2 ±0.19[a]	7.7 ±0.84[a]	7.7 ±0.44[a]	7.8±0.81[a]	7.9 ±0.48[a]	8.2 ±0.22[a]
	CB2	7.7 ±0.43[a]	7.6 ±0.56[a]	7.9 ±0.66[a]	7.9 ±0.13[a]	8.0 ±0.39[a]	8.1 ±0.34[a]
	CB3	7.6±0.23[a]	7.6±0.65[a]	8.1±0.43[a]	8.0±0.41[a]	8.0±0.47[a]	8.0±0.45[a]

Where: **Means within column with different letters are significantly different at $p \leq 0.05$. RB0, raw burger without marjoram (control); RB1, raw burger fortified with 1.5 % marjoram; RB2, raw burger fortified with 2.5 % marjoram and RB3; raw burger fortified with 3.5 % marjoram; CB0, cooked burger without marjoram (control); CB1, cooked burger fortified with 1.5 % marjoram; CB2, cooked burger fortified with 2.5 % marjoram and CB3; cooked burger fortified with 3.5 % marjoram and ND, not determined.**

Chemical composition of burgers:

The moisture, fat, protein, ash and carbohydrates contents of the raw and cooked control and fortified burgers with different levels of marjoram (1.5, 2.5 and 3.5 %) were cleared in Table (4). The results show that the control of raw burger (RB0) contained 58.10 % moisture, 70 % protein, 17.70 % fat, 8.65 % ash and 3.65 % carbohydrates, while the control of cooked burger (CB0) contained 51.70 % moisture, 70 %protein, 18.78 % fat, 7.70 % ash and 3.52 % carbohydrates. From the tabulated data, it could be noticed that the moisture content of raw burgers decreased as the percentage of marjoram significantly increased. These observation was in the line with Al-Juhaimi *et al.*, (2016), who stated that the moisture content of beef patties fortified with moringa seed flour was decreased when the level of moringa flour increased. Moreover, Alakali *et al.*(2010) reported that an increase in bambara groundnut seed flour reductions the moisture content of beef patties. In contrast, the moisture content of cooked burgers increased gradually (but still lower than that of raw) as the percentage of marjoram increased.

Sheridan and Shilton (2002) reported that the fat and protein contents of raw burgers had a trend like that of moisture. The decrease of fat and protein contents in raw burgers may be associated to the decrease in amount of beef meat, and this is good to have burger with low fat content and rich in vegetarian protein. On the other hand, the cooking process caused significantly increases in fat content which may be related to the oil used in frying process. A like observation has been reported by Dzudie *et al.*(2002) for beef patties prepared with common bean flour and in buffalo meat patties prepared using different legume flours (Modi *et al.*, 2004).

Total phenolic content and antioxidant activity of raw beef burgers

Table (5) shows that the addition of marjoram which has high polyphenols content caused a significant increase at $p \leq 0.05$ in total phenolics content of fortified burgers compared to unfortified one. The results showed that, there was a dramatically relationship between additives of marjoram and phenolics content of burger where, increasing the marjoram levels leading to increase the total phenolics content.

The highest total phenolics content was obtained at addition of dried marjoram leaves to burger, where the value was 406.29 and the lowest total phenolics content (189.14 mg/100 g) were recorded for control burger. This observation was in agreement with those reported by Mahmoud *et al.*(2017), who reported that the addition of orange peel to burger increased the total phenol content. Therefore, the addition of marjoram to burger improved the antioxidant activity compared to control burger, where the values were 13.39, 18.98, 28.30 and 34.45 mM TE/ 100 g for RB0, RB1, RB2 and RB3, respectively (Table 5). Therefore, supplemented burger with marjoram till 3.5 % could be suggested to be produced as burger with a good source for bioactive compounds for food possessing.

Table 4. Chemical composition (dry weight) of raw and cooked burger fortified with different levels of marjoram.

Formulations		% Moisture	% Protein	% Fat	% Ash	% Carbohydrates
Raw	RB0	58.1±1.2[a]	70.0±0.89[a]	17.70±0.88	8.65±0.17[a]	3.65±0.09[d]
	RB1	57.9±1.1[a]	66.5±1.1[a]	16.57±0.44	8.74±0.23[a]	8.19±0.17[c]
	RB2	56.4±1.3[b]	61.25±1.3[b]	15.13±0.32	8.81±0.27[a]	14.81±0.23[b]
	RB3	55.6±1.2[b]	57.75±1.1[c]	14.40±0.22	9.18±0.19[a]	18.67±0.27[a]
Cooked	CB0	51.7±0.90[b]	70.0±1.4[a]	18.78±0.51	7.70±0.23[a]	3.52±0.04[a]
	CB1	53.6±0.93[a]	63.0±1.0[ab]	18.93±0.32	7.85±0.12[a]	10.22±0.12[b]
	CB2	54.3±1.2[a]	59.5±1.0[b]	19.44±0.77	8.11±0.10[a]	12.95±0.23[a]
	CB3	55.5±1.0[a]	57.30±1.3[b]	19.75±0.78	8.45±0.14[a]	14.5±0.17[a]

Where: **Values are means of triplicate samples (±SD). RB0, raw burger without marjoram (control); RB1, raw burger fortified with 1.5 % marjoram; RB2, raw burger fortified with 2.5 % marjoram and RB3; raw burger fortified with 3.5 % marjoram; CB0, cooked burger without marjoram (control); CB1, cooked burger fortified with 1.5 % marjoram; CB2, cooked burger fortified with 2.5 % marjoram and CB3; cooked burger fortified with 3.5 % marjoram.**

Table 5. Total phenolic contents (mg as chlorogenic acid equivalent/ 100 g) and antioxidant capacities (mM Trolox /100 g) of raw beef burgers fortified with different levels of marjoram.

Formulations	Total phenolics (mg chlorogenic acid equivalent/ 100 g)	DPPH (mM Trolox /100 g)
RB0	189.14±3.4	13.39±0.9
RB1	210.10±4.2	18.98±0.8
RB2	254.86±3.9	28.30±2.1
RB3	406.29±6.2	34.45±3.3

Where: RB0, raw burger without marjoram (control); RB1, raw burger fortified with 1.5 % marjoram; RB2, raw burger fortified with 2.5 % marjoram and RB3; raw burger fortified with 3.5 % marjoram.

Cooking properties of burgers:

The cooking properties of fortified and non-fortified burgers are presented in Table (6).The results showed that, the addition of marjoram herb to burgers affected cooking properties of the burgers. The cooking yield was increased in burgers with an increase in the marjoram level compared to control. The cooking yield was increased from 96.50 % for CB0 to 97.05, 98.90 and 99.20 % for CB1, CB2 and CB3 burgers fortified with 1.5, 2.5 and 3.5 % marjoram, respectively. These results are in agreement with Aleson-Carbonell *et al.*, (2005); Naveena *et al.*, (2006); Besbes *et al.*, (2008); Alakali *et al.*, (2010); Al-Juhaimi *et al.*, (2016), who reported similar results for the cooking yield in patties formulated with lemon albedo, finger millet flour, pea and wheat fiber concentrate, bambara groundnut seed flour and moringa seed flour, respectively. They explained this observation by the ability of these materials to the fat and water retention capacity and capability to keep moisture and fat in the patty matrix. As apparent in Table (6), the addition of marjoram improved the moisture retention of cooked burgers, where they were increased with the increase of marjoram level compared to control. The increase in moisture retention of the patties may be caused to the increases in the water absorption capacity of protein and the gelatinization of starch during cooking process in addition to the swelling of the fiber (Modi *et al.*, 2004).This result is important since high water retention positively influences properties of meat products such as juiciness and texture.

Table (6) also shows that the addition of marjoram at 3.5 % was reduced the cooking loss compared to control burger followed by concentration of 2.5 %. This enhancement in cooking loss was occurred by the addition of orange peel which is able to bind water and fat, consequently (Rinaudo, 2006; Eldemery, 2010; Mahmoud *et al.*, (2017).Dietary fibers decreased cooking loss because of their high ability to keep moisture and fat in the matrix (Besbes *et al.*, 2008).The percentage of shrinkage was decreased with the marjoram level and differed with the varying levels of marjoram in burgers (Table 6).The control burger showed the highest shrinkage percent, 17.50 %, compared to 8.65, 6.25 and 3.25 % for CB1, CB2 and CB3burgers, respectively. The denaturation of protein meat, water evaporation and drainage of melted fat and juices during cooking process is related to the shrinkage (Alakali *et al.*, 2010; Al-Juhaimi *et al.*, 2016).

Table 6. Cooking properties of burgers fortified with different levels of marjoram.

Formulations	Cooking yield (%)	Moisture retention (%)	Cooking loss (%)	Shrinkage (%)	Thickness increase (%)
CB0	96.50	49.90	3.43	17.50	31.30
CB1	97.05	52.05	2.93	8.65	20.50
CB2	98.90	53.70	1.05	6.25	19.70
CB3	99.20	55.11	0.83	3.65	17.10

Where: CB0, cooked burger without marjoram (control); CB1, cooked burger fortified with 1.5 % marjoram; CB2, cooked burger fortified with 2.5 % marjoram and CB3; cooked burger fortified with 3.5 % marjoram

As in the case of cooking loss and reduction in diameter, the highest thickness increase was observed in the control beef burgers (31.3 %).The thickness increase decreased with increasing the amount of marjoram added, where the burger fortified with 3.5% marjoram had the lowest thickness increase followed by fortified with 2.5 and 1.5 %. These results are in the line with Selani *et al.*, (2015) and Heydari *et al.*, (2016).This action could be attributed to the binding and the stabilizing properties of marjoram herb.

Physicochemical properties of burgers:

Measuring of pH value is important due to its effect on several properties of meat products, for example color, shelf-life, texture and water holding capacity. As shown in Table (7), the replacing of meat with 1.5, 2.5 and 3.5 % marjoram caused a slight decrease in the pH values of raw and cooked burgers compared with pH value of control burgers. Aleson-Carbonell *et al.*, (2005) and Mahmoud *et al.*,(2017) found that, the pH values of burgers fortified with different levels of lemon albedo and orange peel were lower than the control sample, these results may be due to its organic acids content such as citric and ascorbic acids. From the same table, it could be also observed that water holding capacity (WHC) of burgers increased by increasing marjoram level from 1.5 to 3.5 %. WHC values of raw fortified burgers ranged from 85.3 to 99.1% compared to 78.8 % for raw control burger, while in case of cooked burgers, the values were 81.5, 90.0 and 90.2 % for burgers fortified with 1.5, 2.5 and 3.5 % marjoram, respectively compared to 74.9 % for control burger. Water Holding Capacity (WHC) of meat is reflected as one of the essential factors of quality characteristics to determine the chance of using this meat in inducting of meat product. It is responsible for the eating quality, cooking loss, juiciness, tenderness and thawing drip of meat (Mahmoud *et al.*, 2017). This property is affected by two chief reasons, the muscle protein and the level of pH value. Moreover, tenderness directly effects on WHC of meat protein (El-Seesy, 2000).

Table 7. Physiochemical properties of raw and cooked beef burgers fortified with different levels of marjoram.

Formulations	pH		WHC %		Oil uptake %	Texture (lb)
	Raw	Cooked	Raw	Cooked		
B0	6.15	6.21	78.8	74.9	6.10	0.95
B1	6.14	6.21	85.3	81.5	14.24	0.84
B2	6.09	6.17	91.5	90.0	28.48	0.73
B3	6.08	6.14	99.1	90.2	37.15	0.56

Where: **B0, burger without marjoram (control); B1, burger fortified with 1.5 % marjoram; B2, burger fortified with 2.5 % marjoram and B3; burger fortified with 3.5 % marjoram.**

These results showed that there was an improvement in WHC, a juicier product, with increasing concentrations of marjoram for all treatment study. Marjoram had high ability to retain water where, the increasing of marjoram level increased the WHC values which reflect increasing the ability of meat protein to holding water. The increase of WHC can be explained by the increases in the water absorption capacity of protein and the gelatinization of starch at high temperatures, which absorbs water into its granules in addition to the swelling of the fiber (Rodríguez-Ambriz *et al.*, 2008, Ali *et al.*, 2011).In addition to these results, the texture of prepared burgers decreased with increasing of marjoram levels (Table 7). The decrease in the texture of fortified burgers may be related with the replacement of meat muscles with marjoram.

Effect of marjoram on the storage stability of prepared burgers:

The change in the pH value:

The change in pH values of fortified and un-fortified burgers during storage, for 14 days at -18˚C was tested and the results are shown in Figure (1A). At zero time, the pH of control burger (6.15) was higher than burgers fortified with 1.5, 2.5 and 3.5 % marjoram herb, which were 6.14, 6.09, and 6.08, respectively. There was a slight decrease in the pH values of control burgers with progressing of storage period between days 0–14, also minor changes in the pH values of the fortified burgers were found.

The change in the total bacterial count:

Data in Figure (1B) show the total plate counts of fortified and un-fortified burgers. On zero time, the total plate counts of fortified burgers and control ranged between 0 and 10×10^3cfu/g. As the storage period increased from 0 to 14 days, the total plate counts of the prepared burgers were gradually increased, especially for the burger containing 1.5% marjoram and control, where after 14 days of storage at -18 to -20 ˚C, the bacterial count of the unfortified burger increased to 160×10^3cfu/g, which was significantly at $p \leq 0.05$ higher than that of 100×10^3, 80×10^3 and 50×10^3 for the burgers fortified with 1.5, 2.5 and 3.5 % marjoram herb, respectively. This observation is in the line with (Sharaf *et al.*, 2009, Al-Juhaimi *et al.*, 2016).The increase in the total plate count in all studied burgers during storage period might be related to the multiplication of microorganisms (Al-Juhaimi *et al.*, 2016). Finally, the marjoram was more effective in reducing total bacterial counts compared control, this is related to the high content of phenolic content as shown above, where Sousa, (2006) reported that foods rich in polyphenols relate with a wide range of biological properties such as antimicrobial activity.

The lipid oxidation of stored burgers:

The change in the PV

The effect of adding several levels of marjoram on the PV values of prepared burgers stored at -18˚C for 14 days is shown in Figure (2A). The data showed that the PV values of the RB0, RB1, RB2 and RB3 burgers at zero time were 1, 1, 0 and 0 Meq O_2/ kg sample, respectively. Also, data in the same Figure displayed that there was a significant increase at $P \leq 0.05$ in PV values in different samples during storage by different rates and the highest incremental rate was observed in the control sample. The burger fortified with 3.5% marjoram showed the highest significant effect on the lowering PV values than those of fortified sample, followed by burgers fortified with 2.5 then 1.5 % marjoram, respectively.

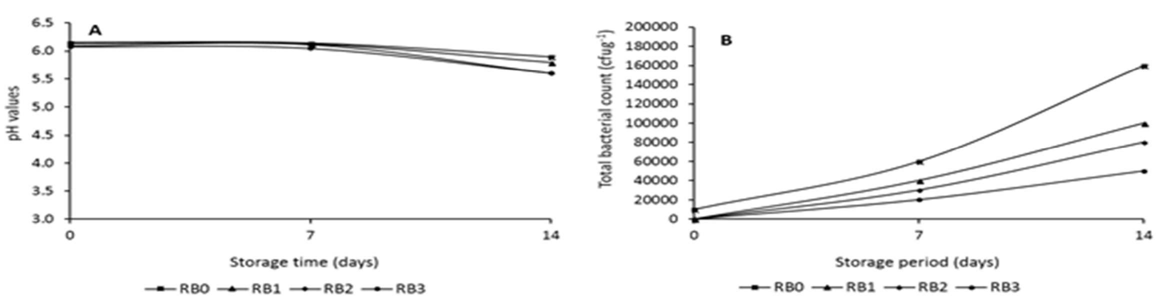

Figure 1. The change in the pH values (A) and total bacterial count (B) of raw burgers fortified with different levels of marjoram during storage at – 18 °C.

Where: **RB0, raw burger without marjoram (control); RB1, raw burger fortified with 1.5 % marjoram; RB2, raw burger fortified with 2.5 % marjoram and RB3; raw burger fortified with 3.5 % marjoram.**

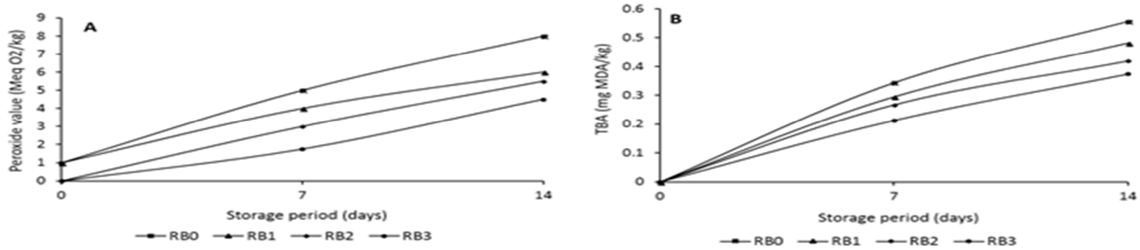

Figure 2. The change in the peroxide values (A) and thiobarbituric acid values (B) of raw burgers fortified with different levels of marjoram during storage at – 18 °C.

Where: RB0, raw burger without marjoram (control); RB1, raw burger fortified with 1.5 % marjoram; RB2, raw burger fortified with 2.5 % marjoram and RB3; raw burger fortified with 3.5 % marjoram.

The change in the TBA

TBA, an indicator of lipid oxidation, was measured as mg of malondialdehyde per kg of burger. Data outlined in Figure (2B) show the TBA values of burgers depending on the levels of marjoram and the storage period. The initial amount of malonaldehyde on day 0 for all prepared burgers was 0 mg/kg of the sample. During the 14 days of storage, lipid oxidation proceeded in the control sample and reached 0.557 mg malonaldehyde/kg burger. The lowest TBA value was obtained in burger fortified with 3.5 % marjoram while, the highest values were recorded with 1.5 % marjoram compared to control samples. Where, the TBA values of burgers produced with 0, 1.5, 2.5 and 3.5 % marjoram were increased to 0.557, 0.482, 0.419 and 0.374 mg malonaldehyde in kg burger after storage 14 days, respectively. It might be because of the increased lipid oxidation and production of volatile metabolites in the presence of oxygen during preparation and storage as well as during aerobic packaging (Goli *et al.*, 2005). The analysis of difference for the TBA data showed that the levels of marjoram were significantly affected on TBA values where, the increasing of marjoram levels let to decrease TBA values compared to the control. These result indicated that lipid oxidation was effectively suppressed by marjoram compared to the control by delayed lipid oxidation during and immediately after formulation of burger. These results support the previous results reported by Soltanizadeh and Ghiasi-Esfahani, (2015), who found that the addition of different concentrations of Aloe vera for beef burgers decreased the TBA values, during cold storage, compared to burger control. Finally, the lower values of PV and TBA values in the fortified burgers compared to the control one may be attributed to the antioxidative effect of the marjoram due to its high phenolic contents which have the ability to scavenge free radicals, thereby reducing the rate of lipid oxidation.

CONCLUSION

The present study showed that the marjoram herb is a good source for protein, fibers and antioxidant compounds. Moreover, using of marjoram herb improved the functional, nutritional and cooking properties, consumer acceptability and storage stability of beef burgers. Sensory properties displayed positive results, since there were no significant differences at $p \leq 0.05$ for colour, odour, texture, flavor and overall acceptability between burgers fortified by marjoram and the control burger.

According to our results, the marjoram herb can be used as functional food with natural antioxidants which are safe and healthy to the consumer, in addition to improve the functional and nutritional properties of meat products.

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تحسين بعض الصفات الوظيفية والتغذوية للبرجر البقرى باستخدام عشب البردقوش

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تدعيم المنتجات الغذائية بالنباتات العشبية لتحسين خواصها الوظيفة والتغذوية وجد حاليا اهتماما كبيرا. ولذلك صممت الدراسة الحالية لتوصيف عشب البردقوش وإضافته لمكونات البرجر البقرى لتحسين خواصة التغذوية والوظيفية. أيضا تم دراسة تأثير عشب البردقوش على الثبات التأكسدى للبرجر المعد,بالإضافة إلى استبدال اللحم البقرى بمعدلات مختلفة من عشب البردقوش (١,٥ – ٢,٥ – ٣,٥ %) مقارنة بالكنترول . أوضحت النتائج أن عشب البردقوش يحتوى على محتوى عالى من البروتين والرماد والألياف الخام حيث كانت القيم ١١,٢ ، ٢٩,٠ و ١٨,٥% على الترتيب. محتوى المواد الفينولية لعشب البردقوش كان ١٩,٢٨ ملجم حامض كلوروجينك/جم .إضافة عشب البردقوش للبرجر البقرى أدى إلى تحسين خواص الطبخ مثل زيادة الاحتفاظ بالماء وانخفاض فاقد الطبخ والانكماش أثناء الطبخ .بالاضافة الى انخفاض تكلفة البرجر البقرى بدون وجود فروق معنوية فى خواصه الحسية, علاوة على ذلك أدى استخدام البردقوش إلى تحسين الثبات التأكسدى للبرجر المخزن على -١٨م° لمدة ١٤ يوم , حيث أدى إلى انخفاض كلا من قيم البيروكسيد و الثيوبارابيوترك بزيادة نسب عشب البردقوش. وبناءً على ما تقدم ، فإنه ينصح بتدعيم البرجر البقرى بعشب البردقوش لتحسين خصائصه الغذائية والوظيفية.