PAPER

THE IMPACT OF PARTIAL-FAT SUBSTITUTIONS WITH DOUM (*HYPHAENETHEBAICA*) DREGS ON THE QUALITY CHARACTERISTICS OF BEEF PATTIES

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ABSTRACT

The present investigation aimed to evaluate the impact of partial substitution of kidney fat (10, 20, 30, 40 and 50%) with equal amounts of doum dregs on the quality attributes of beef patties. Doum dregs contain mainly crude fiber (59.6 g/100 g DM) followed by the total carbohydrate content (35.0 g/100 g DM). Water and fat absorption capacities of doum dregs were 2.07 g and 2.51 mL/g of the sample, respectively. Raw and cooked beef patties formulated with different levels of doum dregs had significantly ($p \leq 0.05$) higher moisture, ash, fiber and carbohydrate contents as compared to control samples (Without doum dregs incorporation). Both cooked and uncooked beef patties manufactured with 10% doum dregs had the lowest content of fat 8.02 and 8.08%, respectively. The lowest energy contents were observed for both uncooked (150.60 kcal/100g) and cooked (179.0 kcal/100g) beef patties supplemented with 10% of doum dregs. Reductions in cholesterol content in cooked burgers supplemented with various levels of doum dregs varied from 8.42 to 33.48%. Significant($p \leq 0.05$) improvements in cooking properties were observed for beef patties incorporated with doum dregs. Sensory evaluation results indicate that the highest overall acceptability scores were recorded for those samples formulated with 2, 4 and 6% of doum dregs.

Keywords: doum, fiber, burger, fat, dregs

1. INTRODUCTION

Consumption of meat in developing countries has been constantly growing from a humble average annual per capita consumption of 10 kg in the 1960s to 26 kg in 2000 and it will reach about 37 kg in 2030, according to estimates of Food and Agriculture Organization (FAO, 2007). Beef burgers are among the food that have attractiveness, ready-to-serve foods despite their failure to appear on everybody's plate due to their high fat, trans fatty acids, saturated fatty acids which can lead to obesity, type 2 diabetes and coronary disease (YILMAZ and GEÇGEL, 2007). Studies demonstrated that these diets caused significant elevation in the levels of low-density lipoprotein cholesterol (LDL), which clogs the arteries (ZORAIDA *et al*., 2011). Nowadays there are increased demands for healthier meat products that hold high dietary fiber and low fats. Epidemiologic studies have provided consistent evidence that dietary saturated fat intake has been associated with the risks of cardiovascular disease (MODI *et al*., 2003). Recent researches have been focused on the positive effects of using vegetarian sources to enhance nutritional and quality properties of meat products. (KUMAR and SHARMA, 2004). Meat extenders are non-meat components, which are added into meat products for technical, nutritional and economic reasons (MANSOUR, 2003). Moringa seed flour in beef patties (AL-JUHAIMI *et al*., 2016), wheat flour in buffalo meat burgers (MODI *et al*., 2003), as well as potato flakes in beef patties (ALI *et al*., 2011) have been applied as extenders. Dietary fiber rich meat products are excellent meat substitutes due to their potential nutritional and functional impacts. Dietary fiber intake through meat incorporated with fruits, vegetables and grains is linked with decreases in plasma and LDL cholesterol; decrease the hazard of major dietary problems such as obesity, diabetes, heart diseases and gastrointestinal disorders (SCHNEEMAN, 1999).

The doum palm (*Hyphaenethebaica*) belongs to the family *Palmae* and subfamily *Borassoideae*. Doum fruit, a desert palm native to Egypt, sub- Saharan Africa and West India; is commonly called “African doum palm” or ginger bread palm (DOSUMU *et al*., 2006). Doum fruits contain high levels of protein and minerals. SALIH, 1991 reported that the fruit of doum contains 7.0% ash, 15.0% crude fiber, 0.5% fat, and 3.2% crude protein. Minerals were found to be 0.13%, 0.18%, 0.09% and 3.02% for Ca, Mg, Na and K respectively. Doum powder was used for preparing cake, frozen yoghurt, fermented milk and ice-cream (SELEEM, 2015, ABD EL-RASHID and HASSAN 2005). However, there are, to our knowledge, no sound published data about the use of doum fruit dregs in food products; therefore, the major objective of the current investigation was to evaluate the impact of partial substitution of kidney fat (10, 20, 30, 40 and 50%) with equal amounts of doum dregs on the quality characteristics of beef patties.

2. MATERIALS AND METHODS

Doum palm (*Hyphaenethebaica*) fruits were purchased from the local market in Giza, Egypt, washed with tap water several times, cut into small pieces, and dried in an electric air draught oven (Isotemp Oven, Fisher Scientific) at 50°C for 24 hours. Fresh lean beef meat and kidney fat were obtained from Metro Market, El Haram St., Giza Governorate, Egypt.

2.1. Methods

2.1.1 Preparation of doum dregs

Dried and crushed pieces of doum fruits were ground in an electric grinder (Braun Model 1021), passed through a 150µm mesh sieve. Doum powder was soaked in tap water (1: 20 *w/v*) and kept in a refrigerator at 4°C for 48 hours. The extract was passed through a single layer of muslin cloth to filter out the solid materials. The solid dregs were dried in an electric air draught oven (Isotemp Oven, Fisher Scientific) at 50°C for 24 hours. The dried dregs were packed in clean, dry glass containers and stored at 4°C for further use. Five replicates of doum samples were subjected to chemical analysis

2.1.2 Preparation of beef patties:

The fresh lean beef meat and kidney fat portions were individually ground in meat grinder equipment (Moulinex - ME605131). The ground lean beef (5% lipids), kidney fat (89% lipids), doum fiber and ice flakes have been used for the formulation of beef burgers (Table 1). The control samples contain 65% of lean beef meat and 20% of beef fat. Five levels of fat portions (10, 20, 30, 40 and 50%) were partially replaced by equal amounts of doum dregs. Ground beef meat and the other ingredients were blended together by hand, then ground finally in meat grinder meat with 0.5 cm plate, and formed into beef burgers (100 g weight, 12 mm thickness and 100 mm diameter). Formulated burgers were placed on plastic foam plats, wrapped with 10 microns polyethylene film and kept in freezer at -25°C until further analysis. Five replicates of each beef burger formula were subjected to chemical analysis.

2.1.3 Cooking procedure

Frozen burgers were cooked by using electric grill (Kumtel, Turkey) for 6 min on each side to ensure that the internal temperature of 70±5°C measured at the centre of beef patty using a digital thermometer, model 16454, Pyrex-Accessories Robinson Knife Company, China.

Table 1. Beef patties formulated with various levels of doum fibers

Fat replacement treatment*	Lean beef (g)	Kidney fat (g)	Doum dregs (g)	Ice flakes (g)
Control	65	20	0	10
10%	65	18	2	10
20%	65	16	4	10
30%	65	14	6	10
40%	65	12	8	10
50%	65	10	10	10

*All treatments were formulated with 2 g salt, 1.5 g spices mixture, 1 g sugar, 0.2 g tripolyphosphate, 0.3 g ascorbic acid. Doum fiber was rehydrated with water, doum fiber /water (1:2, w/v).

2.2. Analytical methods

2.2.1 Proximate analysis of doum dregs

The moisture, ash, protein, crude fibre, and fat contents of doum dregs were assessed using the official methods described by AOAC (2005, Methods 930.15, 923.03, 976.05, 962.09 and 920.85, respectively). Total carbohydrate was calculated by difference.

2.2.2 Functional properties of doum dregs

The absorption capacities of water and oil were determined according to the procedures described by SOSULSKI (1962) and SOSULSKI *et al*. (1976), respectively, and the results were expressed as grams of water or milliliters of corn oil bound with one gram of doum dregs flour. Emulsifying and foaming capacities were determined according to the methods of NETO *et al*. (2001) and LAWHON *et al*. (1972), respectively.

2.2.3 Proximate composition and caloric values of beef patties

Moisture (oven drying method) (Methods 930.15), protein (N × 6.25) (Method 920.152), fat (ether extraction with Soxhlet apparatus) (Method 991.36.), ash content (Method 923.03) and crude fibre contents (Method 962.09) were determined using the official methods described by AOAC (2005). Carbohydrate contents were calculated by difference. Total caloric (Kcal/100g sample) were calculated according to MANSOUR and KHALIL (1999), as follow, for fat (9 kcal g^{-1}), protein (4.02 kcal g^{-1}), and carbohydrates (3.87 kcal g^{-1}).

2.2.4 Cholesterol assay

The content of cholesterol was determined according to the previous procedures described by TURHAN *et al*. (2007). Petroleum ether was used to extract the fats from 5 gm of beef burger samples. The petroleum ether was removed by evaporation at 50°C. The extracted fat was weighed and subjected to saponification using aqueous ethanolic KOH solution. The mixture solution was allowed to cool at ambient temperature, and 10 mL of petroleum ether was added. The mixture was shaken vigorously for 1 min. After the layers have separated, the ether layer was transferred into clean test tube, then the ether solvent was evaporated at 50°C. Acetic acid saturated with ferrous sulfate and concentrated sulfuric acid were added to develop the chromophore for colorimetric analysis. The absorbance was then measured at 490 nm against the reagent blank.

2.3. Determination of cooking properties

2.3.1 Cooking yield

Cooking yield percentage was determined by calculating weight differences for samples before and after cooking according to the procedures described by KHALIL (2000).

2.3.2 Fat retention

The fat retention value represents the amount of fat retained in the product after cooking. Fat retention was measured according to the procedures described by KHALIL (2000).

2.3.3 Moisture retention

The moisture retention was measured according to the equation described by KHALIL (2000).

2.4. Sensory evaluation of cooked patties

Sensory evaluation of cooked beef burgers was conducted according to AL-JUHAIMI *et al*. (2016). Each sample of the six formulas was evaluated by ten of trained judges who are belonging to Food Technology Research Institute, Agriculture Research Center, Giza, Egypt. All judges had previous experience in quality attributes. Judges were both male and female in the age range of 25-40 years old. Cooked patties were cut into 2 equal-sized parts and served randomly to each panelist at 50ºC. Three cut of each formulated beef burger samples were served to the panelist. Samples were evaluated in three sessions (each session with two formulas). The panelists were asked to evaluate the appearance, taste, juiciness, flavour and overall acceptability of beef patties using 10-point hedonic scale, where (10 = I like extremely, 1 = I dislike extremely). Cups of drinking water were provided for judges to clean their mouth between samples.

2.5. Statistical analysis

Results were expressed as the average of values±standard deviation (SD). Results were analyzed of variance (ANOVA) ($P \leq 0.05$). Results were analyzed by Excel (Microsoft Office 2007) and SPSS software Version 18.0 (SPSS Inc., Chicago, IL, USA).

3. RESULTS AND DISCUSSIONS

3.1. Proximate composition of doum (*Hyphaenethebaica*) dregs

Table 2 shows the proximate composition of doum (*Hyphaenethebaica)* dregs. Moisture content of dried doum dregs was 6.36%. Moisture content and water activity are key factors affecting the storage, shelf life, and safety of foods (AHMED and ALI, 2015). Low levels of fat and protein (0.39 and 1.69%, respectively) were detected in doum dregs. Doum dregs had adequate amounts of ash 3.32 g/ 100g DM. Doum dregs contain mainly crude fiber (59.6 /100 g DM) followed by the total carbohydrate content (35.0/100 g DM). Doum palm fruit is one of important sources, which supplies human with carbohydrates, fibers, and anti-hypertension compounds (DOSUMU *et al*., 2006). The high level of fiber in doum fruit make it as a potential ingredient for production of bakery products for improving their nutritive value, as well as their contributions to prevent the gastrointestinal problems beside its relevant role as natural anti-cancer agent (COIMBRA and JORGE, 2011).

3.2. Functional properties of doum (*Hyphaenethebaica*) dregs

The investigations of the functional characteristics of raw materials provide an advanced knowledge for their potential use in food products (AHMED and ALI, 2015). Table 2 shows water absorption, oil absorption, emulsifying and foaming capacities of doum (*Hyphaenethebaica*) dregs. Water absorption capacity (WAC) of doum dregs was 2.07 g of H_2O/g of doum dregs. The hydrophilic constituents such as carbohydrate and crude fiber in doum dregs may have contributed to the high water absorption capacity of the dregs.

This finding indicates that the doum dregs can be used as water binding agent in food processing industries. Fat absorption capacity (FAC) of doum dregs was 2.51 mL of oil/g of sample. This finding indicates that doum dregs could be useful in formulation of foods such as sausages and bakery products. Emulsifying activity determines the capacity of substrate to form oil-in-water emulsion. The emulsifying capacity (mL /g) of dried doum dregs was 19.20. Functional characteristics influenced by the ability of dietary fiber to bind with oil and water as well as gel-forming ability. BORDERIAS *et al*. (2005), reported that the addition of dietary fiber agents into fish-based products enhanced the functional properties of these products. Doum dregs have a poor foaming capacity. The foaming capacity (%) of dried doum dregs was 9.10. The low levels of protein in doum dregs accounted for the low foaming capacity of doum dregs. The ability of the flours to form foam depends on the presence of the flexible molecules of protein that may reduce the surface tension of water (SATHE *et al*., 1982).

Table 2. Proximate composition and some functional properties of doum (*Hyphaenethebaica*) dregs (n= 5)[a].

Parameters	Mean±SD	Functional property	Mean±SD
Moisture (%)	6.36±0.95[a]	Water absorption capacity (g of H_2O/g of sample)	2.07±0.11
Fat (%)	0.39±0.02	Fat absorption capacity (mL of oil/g of sample)	2.51±0.16
Protein (%)	1.69±0.15	Emulsifying capacity (mL /g)	19.20±0.96
Ash (%)	3.32±0.31	Foaming capacity (% vol. increase)	9.10±0.87
Crude fiber (%)	59.6±3.08		
Carbohydrates[b] (%)	35.0±2.85		

[a]Values are means±SD of three determinations
[b]By difference.

3.3. Effect of the addition of different levels of hydrated doum dregs on chemical composition of raw and cooked tested beef burgers

The proximate composition of the uncooked and grilled patties as influenced by adding different levels of doum dregs as fat replacer is shown in Table 3. The results indicate that beef patties incorporated with various levels of doum dregs were significantly higher ($P \leq 0.05$) in moisture content than those of control. Moisture content of uncooked beef patties ranged from 60.55 to 67.09%. The lowest ($P \leq 0.05$) content of moisture was recorded for control beef burgers (without doum dregs incorporation). Moisture of uncooked beef patties was gradually and significantly increased with increasing the levels of doum dregs. Beef patty formulated with 10% doum dregs significantly ($P \leq 0.05$) recorded the highest moisture content followed by those formulated with 8% doum dregs. The high content of fiber in doum dregs powder indicates the potentiality of use this powder as a good source of dietary fibre, which plays an important role in increasing water absorption capacity (WAC). The high WAC of fibers encourages their use as a functional ingredient in food formulations, in order to reduce syneresis and dehydration during the storage process, to modify texture and viscosity and to reduce energetic content of food products (BESBES *et al*., 2008). Similar trend was observed for cooked beef patties. In this regard, cooking process caused significant decreases in moisture content of beef patties. During cooking process, the moisture content of beef patties has been lost by evaporation (ALI *et al*., 2011). Moisture content was decreased by cooking process that in turn leads to increase the percentage of protein and dietary fiber in the cooked samples (TURHAN *et al*., 2007). The highest decreases in fat and moisture content were observed for cooked control sample (without doum dregs incorporation), however the lowest reductions of moisture content were observed for those samples incorporated with 10 and 8% of doum dregs. These findings indicate that the incorporation of different levels of doum dregs into beef patties resulted in retention of more moisture during cooking due to a high water-binding capacity of doum fibers. Addition of doum fiber reduces drip and evaporation which resulting in significant increases in the moisture content of cooked patties, these increases in moisture content of beef patties increased significantly ($p \leq 0.05$) as the level of doom dregs inclusion was increased. Incorporation of dietary fiber into meat batters caused significant increases in the viscosity of these products, which was effective in retaining water in the meat products (YUN-SANG *et al*., 2015). Fat content of uncooked beef patties ranged from 8.08 to 19.10%. The highest level of fat was recorded for uncooked control sample (without doum dregs incorporation). Beef patties formulated with various levels of doum dregs had significantly ($P \leq 0.05$) the lower levels of fat than control samples (without doum dregs incorporation). Fat content decreased proportionally with increasing the level of doum dregs used in raw beef patty formulation. Beef burger samples incorporated with 10% and 8% of doum dregs had the lowest ($P \leq 0.05$) content of fat (8.08 and 9.33%, respectively). Similar results were showed by AL-JUHAIMI *et al*. (2016) for low-fat beef patties formulated with different levels of moringa seed flour, and by TURHAN *et al*. (2000) for beef patties incorporated with okara. Cooking process caused marked decreases in fat content, while, the lowest decreases of fat content were observed for beef burgers incorporated with different amounts of doum dregs. These findings are in good agreement with those obtained by MANSOUR and KHALIL (1999) who reported that low-fat patties retained more fat during cooking than higher fat patties. In this regard, KIRCHNER *et al*. (2000) noted that more fat was lost at the 15% fat level than at the 5% fat level in beef burger samples. No significant differences ($p \geq 0.05$) were recorded for protein contents among raw beef burger samples. Cooking process caused significant increases in protein contents of beef burger samples. Loss of moisture during grilling process could leads to concomitant increase in the protein content (BASSEY *et al*, 2014). Crude protein contents for cooked beef burger samples were significantly higher ($p \leq 0.05$) than raw samples (Table 3). However, no statistically significant differences in protein content were observed among the cooked beef burger samples.

Significant increases in fiber and ash content in raw and uncooked beef patties formulated with hydrated doum dregs (Table 3). Fiber content of cooked beef burgers supplemented with 6, 8 and 10% of doum dregs were about 7.25, 8.47 and 8.55 times as high as that in control samples (without doum dregs incorporation).

Statistically the highest ash contents were recorded for cooked samples incorporated with 8 and 10% of doum dregs, however, the lowest value was recorded for control samples (without doum dregs incorporation). This finding could be attributed to the presence of high amounts of fiber and ash in doum dregs. Doum palm fruit (*Hyphaenethebaica*) powder packs a health punch of dietary fiber and minerals (ABD EL-RASHID and HASSAN, 2005). Low amounts of carbohydrates (0.22 -1.0%) were recorded for control beef burger samples and those samples incorporated with different levels of doum dregs (Table 3). With increasing the consumer awareness on food safety systems, and health concerns, there is a rapidly increased demand for the reduction of saturated fats in meat products and its substitution by non-meat substrates, such as dietary fibers, polysaccharides and other non-carbohydrate components. (FUENTES-ZARAGOZA *et al*., 2010). Dietary fibers poss more of advantages such as inhibiting hydrolysis, digestion and absorption in the human small intestine, improving fecal bulk, enhancing colonic fermentation, reducing postprandial blood glucose, and decreasing pre-prandial cholesterol levels (KTARI *et al*., 2014).

Table 3. Chemical compositions of raw and cooked beef patties formulated with different levels of doum dregs (n= 5)[a].

Parameter	Doum fiber level (%)						
	0	2	4	6	8	10	LSD at.05*
Raw beef patties							
Moisture (%)	60.55±0.87[d]	62.09±0.95[cd]	63.48±1.51[bcd]	64.98±1.19[abc]	66.00±2.23[ab]	67.09±1.64[a]	2.62
Fat (%)	19.10±0.66[a]	16.51±0.58[b]	14.10±1.08[c]	11.27±1.06[d]	9.33±0.63[e]	8.08±0.81[e]	1.47
Protein (%)	18.01±0.65[a]	18.12±0.43[a]	18.15±0.86[a]	18.35±0.96[a]	18.61±1.12[a]	18.71±1.01[a]	1.54
Ash (%)	1.86±0.02[d]	1.89±0.04[d]	2.09±0.08[c]	2.35±0.03[b]	2.69±0.04[a]	2.70±0.05[a]	0.08
Crudefiber (%)	0.26±0.02[e]	1.06±0.08[d]	1.68±0.04[c]	2.46±0.10[b]	2.68±0.12[a]	2.71±0.09[a]	0.14
Carbohydrates[b] (%)	0.22±0.01[d]	0.33±0.02[c]	0.50±0.05[b]	0.59±0.08[b]	0.69±0.02[a]	0.71±0.08[a]	0.09
Cooked beef patties							
Moisture (%)	53.80±0.91[c]	54.10±1.58[c]	55.62±1.32[bc]	57.4±2.351[abc]	58.70±2.27[ab]	59.89±1.08[a]	2.98
Fat (%)	17.94±0.91[a]	16.92±0.92[a]	14.23±0.63[b]	11.52±1.23[c]	9.34±0.84[d]	8.02±0.74[d]	1.59
Protein (%)	25.21±0.45[a]	25.31±0.28[a]	25.37±0.38[a]	25.43±0.46[a]	25.54±0.49[a]	25.6±0.61[a]	0.81
Ash (%)	2.21±0.02[b]	2.13±0.05[ab]	2.28±0.08[ab]	2.32±0.08[ab]	2.38±0.11[a]	2.40±0.09[a]	0.15
Crude fiber (%)	0.36±0.07[e]	1.18±0.06[d]	1.83±0.09[c]	2.61±0.14[b]	3.05±0.12[a]	3.08±0.06[a]	0.17
Carbohydrates[b] (%)	0.48±0.02[d]	0.36±0.03[c]	0.67±0.05[b]	0.71±0.05[b]	0.99±0.08[a]	1.00±0.07[a]	0.09

[a]Values are means±SD of three determinations.
Means followed by the same letter are not significantly different (p≤0.05).
[b]By difference.
*Least significant difference at p≤0.05 according to Duncan's multiple-range test.

3.4. Energy content (Kcal) of uncooked and cooked beef burgers incorporated with various levels of doum dregs

Table 4 illustrates the amount of energy of uncooked and cooked beef burgers incorporated with various levels of doum dregs. Generally, Energy content of cooked and uncooked beef patties decreased when fat content decreased or level of doum dregs increased (Table 4). The highest energy content (264.65 and 245.15 kcal/100g, respectively) was recorded for control samples (full fat) in uncooked and cooked patties. Lipids in diet are the source of energy, fat-soluble vitamins and essential fatty acids as well as improve the flavor and texture of food products. On the other hand, fat supplies the body with approximately more than double the calories of protein and carbohydrates (PAPADIMA and BLOUKAS 1999). The lowest energy values were observed for both uncooked (150.60 kcal/100g) and cooked (179.0 kcal/100g) beef patties supplemented with 10% of doum dregs. These findings indicate that incorporation of doum dregs caused significant (p ≤0.05) reductions in energy values. Reduction rates in energy content of uncooked beef burger supplemented with different levels of hydrated doum dregs ranged from 9.15 to 38.56%. While, it varied from 3.49 to 32.36% for cooked patties compared with their control samples. The reduction of caloric energy was associated with the reduction of fat content (MANSOUR, 2003; ALI *et al.*, 2011).

Table 4. Energy content (Kcal) and Cholesterol content (mg/100 g, dry weight basis) of raw and cooked beef patties formulated with different levels of doum dregs (n= 5)[a].

Trait	Doum dregs level (%)						LSD at.05*
	0	2	4	6	8	10	
Energy content (Kcal)							
Raw beef patties	245.15±046[a]	222.70±0.36[b]	201.79±0.68[c]	177.47±0.81[d]	161.41±0.62[d]	150.60±0.6[f]	1.34
Cooked beef patties	264.65±0.49[a]	255.41±0.43[a]	232.64±0.39[b]	208.64±0.59[c]	190.56±0.49[d]	179.00±0.46[e]	7.59
Cholesterol content (mg/100 g, dry weight basis)							
Raw beef patties	189.76±1.25[a]	170.41±2.05[b]	154.12±1.89[c]	146.91±1.12[d]	145.39±0.93[d]	140.14±2.01[e]	2.85
Cooked beef patties	219.50±3.18[a]	201.00±2.11[b]	183.20±0.97[c]	168.15±0.88[d]	150.02±1.13[e]	146.13±1.07[f]	3.14

[a]Values are means±SD of three determinations.
Means in the same row with different letters are significantly different (p≤0.05).
*Least significant difference at p≤0.05 according to Duncan's multiple-range test.

3.5. Cholesterol content (mg/100 g, dry weight basis) of raw and cooked beef patties formulated with different levels of doum dregs

Table 4 shows the cholesterol content of uncooked and cooked samples. Control samples had significantly higher (P≤0.05) cholesterol content than beef patties formulated with different levels of doum dregs. Cholesterol concentration of uncooked control sample (full fat) was about 1.11, 1.23, 1.29, 1.30 and 1.35 times as high as that in uncooked beef patties formulated with 2,4,6,8 and 10% of doum dregs, respectively. Cholesterol concentrations of beef patties decreased (p ≤ 0.05) significantly with reducing fat levels or increasing the level of doum dregs (Table 4). The lowest cholesterol content (140.14, mg/100 g, dry weight basis) was observed for uncooked beef patties formulated with 10% of doum dregs as fat replacer. MANSOUR and KHALIL (1999) showed that the content of cholesterol of cooked and uncooked samples significantly decreased with addition of wheat fibers. CANDOGAN and KOLSARICI (2003) showed also that reducing fat content in frankfurters from 17.0% to 3.0% resulted in a significant reduction in cholesterol content varied from 50 to 56%. Cooking process caused significant (p ≤ 0.05) increases in cholesterol content of beef patties. Cooked control samples had significantly (p ≤ 0.05) the highest amount of cholesterol (219.50 mg/100 g, dry weight basis). The levels of cholesterol were markedly higher in cooked beef meat samples compared with the fresh beef samples, and these increases may be attributed to the loss of moisture content, which varies depending on the different cooking methods, leading to variation in cholesterol levels (BADIANI *et al*., 2002; TURHAN *et al*., 2007). In the respect, the transmission of cholesterol from the adipose tissue to muscle as a result of the cooking process represents a strong explanation for the higher cholesterol content in the cooked samples than fresh. Particularly when the fat found in high amounts in the subcutaneous or intramuscular tissues (BADIANI *et al*., 2002). Here again, cholesterol content of cooked patties decreased significantly with increasing the level of fat substitutes (doum dregs). MANSOUR and KHALIL (2007) reported that the cholesterol content of cooked beef burger samples markedly decreased with addition of wheat fibers. The concentration of cholesterol of cooked samples which incorporated with various levels of doum dregs were gradually reduced from 201mg/100 g DW in beef burger samples blended with 2% to 146.13 mg/100 g DW in those samples blended with 10% of doum dregs, this means that the decreases in cholesterol content in cooked beef patties formulated with various levels of doum dregs varied from 8.42 to 33.48%. Dietary fibers act as potential therapeutic agents against cardiovascular diseases. They exert this action by acting as lowering agent of hyperlipidemia and hypocholesterolemia (BULLOCK *et al.*, 1995).

3.6. Effect of replacing fat with different levels of doum dregs on some of cooking characteristics of cooked beef patties

The cooking characteristics of beef patties formulated with different levels of doum dregs are shown in Table 5. Cooking yield of formulated beef patties ranged from 68.53 to 75.84%. Beef patties formulated with different levels of doum dregs had significantly higher ($P \leq 0.05$) cooking yield than control samples. The lowest value (68.53%) of cooking yield was observed for control sample (without doum dregs incorporation). This loss in control beef patties might be attributed to the excessive fat separation and water release during cooking process (TURHAN *et al.*, 2007). At the same time, the highest (75.12 and 75.84%) cooking yields were recorded for those samples incorporated with 8 and 10% of doum dregs, respectively. When fat substitution level increased, the yield of cooking increased (Table 5). These increases in cooking yield may be attributed to the ability of doum fibers to hold moisture and fat during cooking process.

Table 5. Effect of replacing fat with different levels of doum dregs on some of cooking characteristics of cooked beef patties (n= 5)[a].

Doum dregs level %	Cooking yield	Moisture retention	Fat retention
Control (0)	68.53±1.33[a]	60.86±1.77[a]	64.36±1.68[b]
2	70.12±1.41[ab]	61.11±1.24[a]	71.86±1.20[a]
4	72.35±1.12[bc]	63.40±1.32[b]	73.01±0.63[a]
6	73.17±0.95[c]	64.66±0.93[bc]	74.79±1.15[a]
8	75.12±1.36[d]	66.80±0.28[c]	75.20±1.30[a]
10	75.84±0.86[d]	67.70±1.08[c]	75.27±1.66[a]
LSD at.05*	2.11	2.12	2.34

[a]Each value in the table is the mean of three replicates and two determinations were conducted for each replicate.
Means in the same column with different letters are significantly different ($p \leq 0.05$).
*Least significant difference at $p \leq 0.05$ according to Duncan's multiple-range test.

The results of moisture retention of beef patties formulated with doum dregs had the same trend of cooking yield. Moisture retention of cooked beef patties varied from 60.86 to 67.70%. Generally, beef patties with doum dregs had relatively higher values of moisture retention compared to control sample (without doum dregs incorporation). The lowest moisture retention (60.86%) was recorded for control sample. The highest moisture retention values (66.80 and 67.70%) were observed for beef patties incorporated with 8 and 10% doum dregs. These findings plainly indicate that the addition of doum dregs into beef burger formulas leads to increase the moisture retention during cooking process, this finding attributed to the capacity of doum dregs to bind more of water (Table 2). Similar findings were recorded by BULLOCK *et al.*, 1995 for low-fat beef patties formulated with modified food starch, by KHALIL, 2000 for beef burger incorporated with mixtures of

polydextrose, sugar beet, oat fiber, potato starch, and modified corn starch and by ALI *et al*., 2011 for beef patties formulated with potato flaks.
Fat retention of formulated beef patties ranged from 64.36 to 75.27% (Table 5). The lowest (64.36%) value of fat retention was recorded for control samples (without doum dregs incorporation). Similar finding was observed by TORNBERG *et al*. (1989), who reported that fat was more easily separated from higher fat patties during cooking process. Incorporation of various levels of doum dregs (as fat replacer) into beef patties caused significant ($p \leq 0.05$) increases in fat retention values, these increases were gradually and significantly increased with increasing the level of doum dregs. The highest fat retention values (75.20 and 75.27%, respectively) were recorded for beef patties formulated with 8 and 10% of doum dregs. The addition of dietary fibers causes marked increase in fat retention because of their ability to bind more of moisture and fat in their matrix (WAN *et al.,* 2011). In this regard, TORNBERG *et al*. (1989) reported that the dense meat protein matrix of low-fat ground beef prevented fat migration. Similar results were reported by MANSOUR and KHALIL (1999); TURHAN *et al*. (2007), and WAN ROSLI *et al*. (2011) who used high fiber- substrates such as wheat fibers; hazelnut pellicles and corn silk powder respectively to improve the quality attributes of beef patty formulations.

3.7. Sensory evaluation

Sensory traits for cooked patties are shown in Table 6. Appearance of beef patties formulated with 2, 4 and 6% of doum dregs as fat replacer was substantially higher than those in other formulations and control sample (without doum dregs incorporation). Beef patties with 8 and 10% had significantly ($P < 0.05$) the lowest appearance values (6.20 and 6.10, respectively). Control sample and patties formulated with 2 and 4% doum dregs had significantly the highest value of taste. No significant differences were observed in taste values between control samples and those patties with 2 and 4% doum dregs. Fat plays a good role in foods, it acts as a carrier of flavors and contributes to the strength of food, while the reduction of fat can significantly reduce the overall acceptability, aroma, juiciness and flavor intensity of meat products (KIRCHNER *et al*., 2000).
The taste values decreased gradually with increasing the inclusion percentages of doum dregs to 8 and 10% ($p \leq 0.05$). These decreases may due to the presence of doum flavour. Previous studies have shown significantly lower sensory scores for flavour in beef patties formulated with starch or gums sources (MANSOUR 2003; ALI *et al*., 2011; TURHAN *et al*., 2007).

Table 6. Sensory characteristics of cooked beef patties formulated with different levels of doum dregs (n= 10)[a].

Sensory trait	Doum dregs level (%)						LSD at.05*
	0	2	4	6	8	10	
Appearance	6.30^{c}	6.45^{b}	7.15^{a}	7.20^{a}	6.20^{d}	6.10^{e}	0.07
Taste	7.55^{a}	7.66^{a}	7.60^{a}	7.25^{b}	6.50^{c}	6.30^{d}	0.08
Flavour	6.85^{a}	6.90^{b}	6.82^{c}	6.82^{c}	6.80^{c}	6.75^{d}	0.02
Juiciness	7.87^{ab}	7.90^{b}	7.93^{a}	7.89^{ab}	7.88^{ab}	7.85^{ab}	0.07
Overall acceptability	7.14^{d}	7.22^{c}	7.37^{a}	7.29^{b}	6.84^{e}	6.75^{f}	0.02

[a]Means in a line with different letters are significantly different ($P \leq 0.05$).
*Least significant difference at $p \leq 0.05$ according to Duncan's multiple-range test.

Juiciness values were significantly the higher ($p \leq 0.05$) in beef patties formulated with different levels of doum dregs than control samples (without doum dregs incorporation). Control samples (full fat) had significantly ($p \leq 0.05$) the lowest score (6.87) of juiciness, while, beef patties formulated with 4, 6, 8 and 10% doum dregs had significantly the highest ($p \leq 0.05$) scores were 7.93, 7.92, 7.94 and 7.91, respectively. This finding could be attributed to the ability of doum dregs to hold more of water (Table 3). Beef burgers formulated with white and red beeswings were significantly more tender and juicy than control sample (MANSOUR and KHALIL, 1999).

Beef patties formulated with 2, 4 and 6% of doum dregs were rated higher ($P<0.05$) overall acceptability than control samples (without doum dregs incorporation), while, the lowest scores for acceptability were recorded for those samples formulated with 8 and 10% doum dregs.

4. CONCLUSIONS

The current study shows that addition of different levels of doum dregs (as fat replacer) into beef patties caused marked and significant ($p \leq 0.05$) increases in fiber, ash, cooking yield, moisture and fat retentions of formulated beef patties. The lowest energy contents were observed for both uncooked (150.60 kcal/100g) and cooked (179.0 kcal/100g) beef patties formulated with 10% of doum dregs. The decreases in cholesterol content in cooked beef patties formulated with various levels of doum dregs varied from 8.42 to 33.48%. The sensory evaluation results indicate that the highest scores of overall acceptability were recorded for beef burger samples formulated with 2, 4 and 6% of doum dregs.

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