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PRODUCTION LOW-FAT BEEF BURGER BY USING GUM ARABIC AS FAT REPLACER

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ABSTRACT: ***The chemical composition, phenolic compounds and antioxidant activity of Gum Arabic (GA) were studied, as were physical, chemical, cooking and sensory properties of low-fat beef burger manufactured by replacing its fat content with different levels (0.0, 5, 10, 15 and 20%) of GA. The results of chemical composition of GA indicated that the total dietary fiber was the major compound (89.89%) and the other components were minor such as protein (2.02%), ash (3.99%), and ether extract (4.10%). The present study showed that antioxidant activity of GA extracted by water (73.30%) was higher than extracted by ethanol (70.87%). All chemical compositions (moisture, fiber, protein, ash and total carbohydrate contents) of uncooked and cooked low-fat beef burger manufactured by replacing its fat content with different levels of GA were increased, except ether extract content was decreased. However, replacing process increased ($P \leq 0.05$) significantly of both water holding capacity and feder value, it was decreased ($P \leq 0.05$) significantly of plasticity, protein water coefficient and protein-water-fat coefficient of low-fat beef burger. Cooking properties were affected by replacing fat with GA whereas, cooking yield was increased ($P \leq 0.05$), and on the other side cooking loss, shrinkage and diameter reduction were significantly ($P \leq 0.05$) decreased. Sensory evaluation of low-fat beef burger showed the level replacement 5 and 10% of GA produced beef burger similar with control with little changes also 15 and 20% replacement gave a fair low-fat beef burger.***

Key word: ***Gum Arabic, beef burger, antioxidant activity, chemical and physical properties.***

INTRODUCTION

Gum Arabic is edible biopolymer obtained as exudates of mature tress of *Acacia senegal* which grow principally in the Africa region of Sahel in Sudan. The exudates are a non-viscous liquid, rich in soluble fibers, and its emanation from the stems and branches usually occurs under stressful conditions such as draught, poor soil fertility, and injury (Williams and Philliphs, 2000). Gum Arabic is a branched-chain, complex polysaccharides, either neutral or slightly acidic, found as a mixed of calcium, magnesium, potassium salt of a polysaccharide acid (glucuronic acid). Gum Arabic has been claimed to act an antioxidant, and to protect against experimental hepatic-, renal and cardiac toxicities (Ali *et al*., 2009). Gum Arabic also considered in folk medicine to treat diabetes mellitus. The plant has been shown to exhibit antibacterial, anti-filamentary, vasoconstrictor actions, antihypertensive, antispasmodic activities, inhibitory effect against hepatitis virus, cytotoxic activities and antioxidant activity (Gilani *et al*., 1999 and Malviya *et al*., 2011).

Food manufactures have responded to consumer demand and there has been a rapid market growth of products with a

healthy image (Liu *et al*., 2007). One of the major trends is to reduce the fat content of traditional dressing foods, which has led to popular "reduced fat", "light", "low fat", or "fat free" versions of these traditional products. However, as a food component, fat contributes to the flavor, appearance, texture and shelf life of food products. Therefore, it is difficult to imitate traditional product quality when preparing reduced-fat foods. Thus, to establish the formulation of reduced-fat products, it is necessary to use a combination of non fat ingredients with different functional roles to replace the quality attributes lost when fat is removed. Thus to establish the formulation of the low fat products, food technologists have focused their efforts essentially on fat replacers (Liu *et al*., 2007). The reduced of fat and calorie derived from the use of fat replacers is a nutritional approach to prevent many chronic diseases (i-e cardiovascular disease, hypertension, obesity ………), thus providing beneficial health effect (Lim *et al.,* 2010). Biopolymers, such as gums, starches and proteins are often incorporated into fat-reduced products to provide some of these functional attributes (Mun *et al*., 2009).

In recent years, health concerns about fat consumption and changes in consumer's preferences have led to extensive research on low-fat foods (Carrapiso, 2007). The popularity of hamburger lies in it is favorable a sensory characteristics practicality and high content of protein with high biological value, vitamins and minerals (Ramadhan *et al.,* 2011). This research aimed to study the active ingredients of GA and investigate the effect of partial replacing of fat content with GA on the physical, chemical and sensory evaluation of low-fat beef burger.

MATERIALS AND METHODS

Materials:

Gum Arabic:

Gum Arabic (*Acacia senegal*, Hashab) in powder form was obtained from Samandal Company for Export and Import, Sudan.

Beef meat and other ingredients:

Lean beef, kidney fat and other ingredients (spices mixture, salt, dried onion and dried garlic) were obtained from local market at Tanta City, Egypt.

Gross chemical composition:

Moisture, crude protein, ether extract, ash and crude fiber were determined according to AOAC (2005). Total dietary fiber content was calculated by differences subtracting protein; ash and ether extract content from the total mass of 100g as reported by Sabah El-Kheir *et al.* (2008).

Determination of total phenolics content (TPC):

Total phenolic content was determined by the Folin-Ciocalteu method according to Arabshahi-Delouee and Urooj (2007). Total phenolic content expressed as Gallic acid equivalent (g/ 100g dry weight).

Separation and identification of phenolic compounds by using HPLC:

Phenolic compounds of GA ethanol extract was separated and identified by HPLC apparatus (Type: Shimadzu LC-6A model) in Central Laboratory of Food Tech. Res. Inst., Agric. Res. Center, Giza, Egypt according to the method of Goupy *et al*. (1999) under the following conditions: Column: Water-Bondapack C18 column (250 × 4.6 mm) and as SCL-6A system controller; the solvent system used was a gradient of A (CH3COOH

2.5%), B (CH3COOH8%) and C (acetonitrile). The solvent flow rate was 0.7 ml/ min and separation was performed at 35°C; injection volume: 20 µl; detector: UV-visible spectrophotometer SPD- 6 AV (Leicestershine LE17 5BH, UK); phenolic compounds were assayed by external standard calibration at 280 nm and expressed in µg/ L-1 equivalent (+)-catechin.

Evaluation of Antioxidant activity of extracts (AA):

The antioxidant activity was evaluated by 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging method according to the procedure of Lee *et al*. (2003). The antioxidant activity was expressed as the percentage of decline of the absorbance relative to the control, corresponding to the percentage of DPPH that was scavenged. Scavenging activity was calculated as follows:

DPPH radical-scavenging activity (%) =
[(A control – A sample)] / (A control)] × 100
Where, A is the absorbance at 515 nm .

IC50 values, which correspond to the concentration of Gum Arabic extracts that caused a 50% neutralization of DPPH, were calculated from the plot of percent DPPH scavenging versus concentration.

Preparation of beef burger:

Beef burger samples were formulated according to Aleson-Carbonell *et al.* (2005) from fresh lean beef and kidney fat and the ingredients were tabulated in Table (A).

The lean beef and kidney fat sources were separately ground in 5-mm plate in meat grinder (Braun multi – Quick system 100 2k) and then the water, salt and spice mixture were added and mixed with ground meat and fat for 4min. The mixture was divided into five proportions. The first proportion was served as control. For each treatment the mixture was mixed individually by rehydrated GA at different levels 5, 10, 15 and 20% (fat weight basis), and then mixed again for 5min to create homogenate mixture. Patties were placed on plastic foam meat trays, wrapped with polyethylene film and kept frozen at (-18˚c) until further analysis.

The beef burger samples were grilled on an electrical hot plate at 180˚c for 5 min, Khalifa (2011).

Table (A): Ingredients for prepared beef burger containing GA at different levels (g/100g).

Ingredients	Gum Arabic levels (%)				
	0	5%	10%	15%	20%
Beef meat	65.00	65.00	65.00	65.00	65.00
Beef fat	15.00	14.25	13.50	12.75	12.00
Water	10.50	10.50	10.50	10.50	10.50
Spice mixture	2.50	2.50	2.50	2.50	2.50
Dried onion	2.50	2.50	2.50	2.50	2.50
Dried garlic	2.50	2.50	2.50	2.50	2.50
Salt	2.00	2.00	2.00	2.00	2.00
Gum Arabic	0.00	0.75	1.50	2.25	3.00

Physical properties and feder value:

Water holding capacity (WHC) and plasticity:

Water holding capacity (WHC) and plasticity were measured using the method of El-Seesy (2000) using the following equation:

Free water (%)

$$= \frac{(\text{Total surface area} - \text{meat film area,mm})(6.11)}{(\text{Total moisture (mg) in meat sample})} \times 100$$

WHC (%) $= 100 - \text{free water}$

Plasticity (cm^2) = Meat film area (Internal area)

Texture indices:

Protein water coefficient (PWC) and protein-water-fat coefficient (PWFC) were calculated according to Tsolaze (1972) using the following equations:

$$\text{PWC} = \frac{\%\ \text{protein}}{\%\ \text{water}}$$

$$\text{PWFC} = \frac{\%\ \text{protein}}{\%\ \text{water} + \%\ \text{fat}}$$

Feder value:

Feder value which is used for assessing one of the quality attributes in meat was calculated according to Pearson (1991) using the following equation:

$$\text{Feder value} = \frac{\%\ \text{water}}{\%\ \text{organic non fat}}$$

Where % organic non fat =

100 – (% Moisture + % Fat + % Ash)

Cooking characteristics:

Texture profile analysis:

Texture was determined in Food Technology Research. Institute, Agricultural Research Center Giza-Egypt, by a universal testing machine (Cometech, B type, Taiwan) provided with software. An Aluminum 25 mm diameter cylindrical probe was used in a "Texture Profile Analysis" (TPA) double compression test to penetrate to 50% depth, at 1 mm/s speed test. Hardness (N/cm^2), gumminess (N/cm^2), chewiness (N/cm^2), cohesiveness (ratio), springiness and resilience were calculated from the TPA graphic. Both, springiness were calculated from the TPA graphic as described by Bourne (2003).

Shrinkage:

Shrinkage percentage was calculated as described by American Meat Science Association (1995) as follows:

% Shrinkage

$$= \frac{(\text{Raw thickness} - \text{Cooked thickness}) + (\text{Raw diameter} - \text{Cooked diameter})}{(\text{Raw thickness} + \text{Raw diameter})}$$

Diameter reduction:

Changes in beef burgers diameter was calculated by Gök *et al.* (2011) using the following equation:

% Diameter reduction

$$= \frac{(\text{Uncooked diameter} - \text{Cooked diameter})}{\text{Uncooked diameter}} \times 100$$

Cooking loss:

Cooking loss of the beef burger was calculated according to American Meat Science Association (1995) using the following equation:

Cooking loss (%)

$$= \frac{[\text{Raw sample weight (g)} - \text{Cooked sample (g)}]}{\text{Raw sample weight (g)}}$$

Cooking yield:

Cooking yield of the beef burger was determined by measuring the weight of three burgers for each treatment/batch Gök *et al.* (2011) and calculating weight differences for burgers before and after cooking, as follows:

Cooking yield (%)

$$= \frac{\text{Cooked weight (g)}}{\text{Raw weight (g)}} \times 100$$

pH value:

The pH value of samples was measured using the method described by Bloukas *et al.* (1997) using electronic electrode of digital pH-meter (JENCO 608 U.S.A).

Organoleptic evaluation:

Cooked burger samples were subjected to sensory evaluation directly for color, texture, taste, tenderness, appearance and overall acceptability by trained panel consisted of twenty members of Food Technology Research Institute (FTRI) selected from laboratory staff. Hedonic scale rating 1-10 points (1 = dislike very much; 10=like very much) to assess the differences Smith *et al.* (1973). Panelists evaluated of cooked burger samples which were offered at the same time in specific area of sensory test without special lighting. Water was provided for rinsing purposes.

Statistical analysis:

Statistics on a completely randomized design were performed with the analysis of variance (ANOVA) procedure in SPSS (Version 16.0, SPSS Inc., Chicago, IL) software. Duncan's multiple range test ($p>0.05$) was used to detect differences among mean values SPSS (2009).

RESULTS AND DISCUSSION

Chemical composition of Gum Arabic:

Results of gross chemical composition of GA are show in Table (1). The GA contain a great amount of total dietary fiber, it represents about 83.41 % of total chemical composition on wet weight and about 89.89 % on dry weight basis. Also, GA contain a small amounts of ether extract and ash, which represent about 3.70 and 3.80 % on wet weight and about 3.99 and 4.10 % on dry weight, respectively while protein content recorded the lowest amount of chemical composition, it represent about 1.87 and 2.02 of total chemical composition on wet and dry weight basis, respectively. The results of ash, lipid and total dietary fiber are in full agreement with that obtained by Sabah El-Kheir *et al.* (2008); Nasir *et al.* (2012); Dauqan and Abdullah (2013) and Abd El-Shakour (2014). Whereas, protein content is agreeing with the results of Daoub *et al.* (2016), but lower than that obtained by Abd El-Shakour (2014). Al-Assaf *et al.* (2005) stated that the chemical composition of GA can vary with it is source, the age of trees which it was obtained, climatic condition and soil environment.

Table (1): Chemical composition of Gum Arabic (g/ 100g).

Constituents	Percentage of constituents	
	On wet weight basis	On dry weight basis
Moisture	7.22	-
Protein	1.87	2.02
Lipids	3.70	3.99
Ash	3.80	4.10
Total dietary fiber*	83.41	89.89

* Calculated by differences as the flowing equation; 100- (moisture+ protein+ lipid+ ash).

Separation and identification of phenolic compounds of GA by using HPLC:

Fractionation and identification of total phenolic compounds of GA ethanol extract by using HPLC are given in Table (2). Data revealed that total phenolic compounds content of GA was 1449.35 mg/100g. This result is in full agreement with those obtained El-Tobgy (2019), who found that total phenolic content of dried exudates (gum) from *Acacia senegal* purchased from Aswan city was 1.526 g/100g. HPLC chromatogram reveled that GA extract contain several phenolic acids: hydroxybenzoic acid (i.e, gallic, benzoic, vanillic and salycilic) and hydroxycinnamic acids (i.e cinnamic, caffeic and P.coumaric acid). Besides these phenolic acids, many phenolic compounds were also found i.e. Pyrogallol, Catechein, epicatechein, catechol and derivatives of phenolic acids.

GA extract contains catechein as a predominant phenolic compound recording 445.21 mg/100g, followed by epicatechein (108.08 mg/100g) and gallic acid (161.45 mg/100g). These three components represent more than 50% of total phenolic compounds (54.28%), another four components: pyrogallol, vanillic acid salycilic acid and catechol recording 93.42, 91.85, 77.12 and 69.42 mg/100g, respectively which represent 22.89% of total phenolic compounds. The other seven components represent about 22.83%. The present findings are in complete agreement with study conducted by El-Tobgy (2019), who found that catechein, epicatechein and gallic acid the predominant compounds in GA.

Table (2): Identification of phenolic compound of sample (mg/100g) by HPLC of Gum Arabic.

Phenolic compounds	(mg/100g)
Gallic acid	161.45
Pyrogallol	93.42
Catechein	445.21
Epicatechein	180.08
Quinic acid	3.98
Catechol	69.42
3-methoxybenzoic acid	40.54
Tannic acid	10.31
Benzoic acid	40.09
Caffeic acid	1.94
Vanillic acid	91.85
p-Coumaric acid	7.54
Cinnamic acid	5.27
Salycilic acid	77.12
Other compounds	221.13
Total phenolic compound	1449.35

Antioxidant activity of GA extracts:

The results obtained from the DPPH radical experiments were expressed as the percentage of decline of the absorbance relative to the control are presented in Table (3). The DPPH radical scavenging activity of water extract and 50% ethanolic extract were 73.30 and 70.87 %, respectively. The results are higher than that reported by El-Tobgy (2019), who revealed that the DPPH free radical scavenging activity of GA purchased from Aswan was 66.707 %. The IC50 of GA water extract and ethanolic extract were 18.27 and 22.39 mg/ml, respectively. The value of IC50 of water extract was lower than IC50 of ethanolic extract; this may be due to the differences in phenolic content of water extract and ethanolic extract.

Chemical composition of beef burger:

The results of chemical composition of both uncooked and cooked beef burger manufactured by replacing fat content with different levels (0.0, 5, 10, 15 and 20%) of GA are shown in Table (4). Moisture content of uncooked and cooked beef burger was increased (P ≤ 0.05) gradually as a function of increasing the percentage of GA replacement level to beef burger. Beef burger manufactured without any addition of GA (control) had the lowest (P ≤ 0.05) significantly value of moisture content in both raw and cooked beef burger. Also, the moisture content of beef burger samples determined after cooking process were lower than that of raw beef burger. The decrements of moisture content of cooked beef burger due to cooking and evaporation of moisture during cooking process. The increment of moisture content may be due to the capability of GA rich with fiber to hold more water via preparation and cooking process. These results are in agreement with Choi *et al.* (2016) they stated that, dietary fiber sources has the capacity to hold three or four times its weight of water.

Protein content of the fat replaced uncooked and cooked beef burger was increased (P ≤ 0.05) significant as the replacement levels increased of GA. The same trend was noticed by Hussein *et al.* (2015), who found that the protein content of law fat sausage prepared with fat replacer increased by increasing substitution ratio.

Fat content of control uncooked and cooked beef burger had higher (P ≤ 0.05) amount of fat than that of other treatments. Furthermore, fat content of all beef burger containing GA with different levels as fat replacer decreased (p ≤ 0.05) significantly with increasing of replacement level of GA. Mansour and Khalil (1997) and Gad (2019) reported that there were significantly decreased in fat content for beef burger with added wheat dietary fiber and GA.

Table (3): Antioxidant activity of GA extracts.

Property	Solvent extract	
	Aqueous	Ethanol (50%)
DPPH (%)	73.30	70.87
IC50 mg/ml	18.27	22.39

DPPH: 1,1-diphenyl-2-picrylhydrazyl
IC50: correspond to the concentration of Gum Arabic extracts that caused a 50% neutralization of DPPH.

Table (4): Chemical composition of beef burger (on dry weight basis):

Treatments	Components (%)											
	Moisture	Protein	Ether extract	Ash	Crude fiber	*T.C	Moisture	Protein	Ether extract	Ash	Crude fiber	*T.C
	Uncooked beef burger						Cooked beef burger					
Control	59.98^{e} ±0.16	43.20^{e} ±0.11	38.23^{a} ±0.20	2.64^{c} ±0.14	2.88^{e} ±0.22	15.93^{c} ±0.23	40.77^{d} ±0.67	35.85^{e} ±0.44	33.31^{a} ±0.24	5.33^{e} ±0.23	4.53^{e} ±0.27	25.51^{d} ±0.44
Beef burger 5% GA	63.61^{d} ±0.10	45.03^{d} ±0.38	36.08^{b} ±0.50	2.73^{c} ±0.13	4.35^{d} ±0.15	16.16^{bc} ±0.27	46.22^{c} ±0.08	37.48^{d} ±0.40	29.71^{b} ±0.20	6.16^{d} ±0.16	6.10^{d} ±0.09	26.65^{c} ±0.37
Beef burger 10% GA	64.32^{c} ±0.03	46.06^{c} ±0.40	34.32^{c} ±0.20	2.92^{bc} ±0.20	6.74^{c} ±0.24	16.70^{b} ±0.31	47.40^{b} ±0.35	38.15^{c} ±0.50	27.27^{c} ±0.21	7.05^{c} ±0.21	8.45^{c} ±0.13	27.53^{b} ±0.46
Beef burger 15% GA	65.30^{b} ±0.39	46.35^{b} ±0.30	33.00^{d} ±0.70	3.07^{ab} ±0.07	7.85^{b} ±0.34	17.58^{a} ±0.36	50.51^{a} ±0.09	39.17^{b} ±0.17	25.16^{d} ±0.11	7.79^{b} ±0.19	9.56^{b} ±0.11	27.88^{ab} ±0.23
Beef burger 20% GA	66.49^{a} ±0.35	47.33^{a} ±0.30	31.69^{e} ±0.19	3.26^{a} ±0.25	9.51^{a} ±0.10	17.72^{a} ±0.42	50.07^{a} ±0.20	40.13^{a} ±1.35	23.35^{e} ±0.14	8.42^{a} ±0.30	11.12^{a} ±0.11	28.10^{a} ±0.19

Each value is an average of three determinations ± standard deviation.

Values followed by the same letter in columns are not significantly different at $P<0.05$.

*T. C: Total carbohydrates were calculated by differences.

Ash content percentage of uncooked and cooked beef burger was increased (P ≤ 0.05) significantly as a function of increasing the percentage of GA replacement level to beef burger. This increment may be due to high ash content of GA in comparing with that of control beef burger. Ash content of reduced-fat chicken patties samples containing wheat sprout was higher than those of control patties Choi *et al.* (2016).

Crude fiber content was significantly (P ≤ 0.05) increased by increasing fat replacement levels of GA. This increment may be due to high crude fiber content of GA. Data of the present study are in agreement with those found by Hussein *et al*. (2015) and Mwove *et al*. (2016). The ratios of fat replacers increased the total carbohydrates of beef burger was increased with a significant (P ≤ 0.05) difference in comparison with control beef burger. Also, the results revealed that, cooked beef burger have percentages of moisture, ether extract and protein lower than uncooked beef burger with significant (P ≤ 0.05) differences between samples. Meanwhile, the opposite were found in case of ash, crude fiber and total carbohydrate increased, this also was probably due to the moisture loss during cooking process Mansour and khalil, (1997) and Gad (2019).

Physical properties and feder value of beef burger:

Data in Table (5) showed the physical properties of beef burger containing GA with different levels. Water holding capacity (WHC) was increased (P ≤ 0.05) significantly with increasing the replacement level. The highest WHC was observed in both 20% and 15% replacement level (63.50% and 63.42%, respectively) followed by 10% (62.32%) and finally 5% (60.51%), while WHC for control beef burger was 56.33%. This result is probably due to the ability of GA to absorb large amounts of water. Generally, this finding agrees well with those reported by Mahmoud *et al. (*2017). The values of protein water coefficient (PWC) and protein water fat coefficient (PWFC); which are considered as indices for tenderness of the prepared beef burger, were decreased (P ≤ 0.05) gradually with the increasing of GA levels comparing to control sample. These decrements relate to the increase occurred in moisture content. These results were in agreement with those published by Bessar (2008). Also, plasticity (cm^2) value of beef burger enriched with different levels of GA is decreased (P ≤ 0.05) gradually with increasing the replacement level of GA. These results agreement with those published EL-Refai *et al*. (2011) and Shalaby *et al*. (2015). Also, feder value; which is used for assessing the physical properties of meat products, was 1.6033 for control sample of burger. Feder values of burger increased (P ≤ 0.05) gradually with increasing the replacement level of GA. All values of feder values were kept under 4.0. According to Pearson (1991), the feder number in good quality product should not exceed 4.0. These increments in feder number may be due to the increase in water content as a result to increase GA which content high amount of dietary fiber.

Cooking properties and pH value of beef burger:

The results of cooking properties (cooking shrinkage, diameter reduction, cooking yield and cooking loss) and pH values of beef burger manufactured by replacing fat content with different levels of GA are shown in Table (6). Significant (P ≤ 0.05) differences were observed among beef burger control sample and all low fat beef burger formulas prepared with GA for cooking properties. Apparent also from the negative correlation between cooking yield and cooking loss of all samples, however cooking loss of beef burger enriched with different levels of GA is decreased (P ≤ 0.05) with increasing the addition levels since beef burger enriched with GA had cooking loss values lower (P ≤ 0.05) than that of control. This may be related to the fiber content of GA which could influence the cooking loss of the beef burger, since fibers could reduce the water loss during cooking by forming gels as reported by Namir *et al.* (2015).

Table (5): Physical properties and feder value of beef burger.

Treatments	WHC %	Plasticity	PWC	PWFC	Feder value
Control	56.33d ±0.57	4.56a ±0.11	0.289a ±0.006	0.235a ±0.005	1.603d ±0.03
Beef burger 5% GA	60.51e ±0.20	4.41b ±0.16	0.284ab ±0.002	0.231ab ±0.001	1.623d ±0.02
Beef burger 10% GA	62.32b ±0.32	4.23bc ±0.09	0.278b ±0.002	0.228b ±0.002	1.677c ±0.05
Beef burger 15% GA	63.42a ±0.42	4.05cd ±0.07	0.270c ±0.005	0.223c ±0.001	1.777b ±0.05
Beef burger 20% GA	63.50a ±0.20	3.86c ±0.10	0.250d ±0.002	0.212d ±0.008	2.090a ±0.01

Each value is an average of three determinations ± standard deviation.
Values followed by the same letter in columns are not significantly different at P<0.05.
WHC= Water Holding Capacity; PWC= Protein-Water Coefficient; PWFC= Protein-Water-Fat Coefficient.

Table (6): Cooking properties and pH values of beef burger:

Treatments	Cooking loss (%)	Cooking yield (%)	Shrinkage (%)	Diameter reduction (%)	pH
Control	27.44^{a} ±0.11	72.56^{d} ±0.11	19.44^{a} ±0.29	16.84^{a} ±0.09	5.47^{a} ±0.07
Beef burger 5% GA	20.60^{b} ±0.10	79.40^{c} ±0.10	14.50^{b} ±0.08	12.88^{b} ±0.11	5.70^{a} ±0.09
Beef burger 10% GA	19.40^{c} ±0.27	80.60^{b} ±0.27	13.20^{c} ±0.18	12.25^{c} ±0.08	5.70^{a} ±0.13
Beef burger 15% GA	19.25^{c} ±0.21	80.75^{b} ±0.21	12.96^{c} ±0.15	12.12^{cd} ±0.10	5.62^{a} ±0.08
Beef burger 20% GA	18.50^{d} ±0.03	81.50^{a} ±0.03	11.80^{d} ±0.24	12.01^{d} ±0.05	5.48^{a} ±0.23

Each value is an average of three determinations ± standard deviation
Values followed by the same letter in columns are not significantly different at P<0.05

Cooking yield of beef burger enriched with different levels of GA is increased ($P \leq 0.05$) with increasing the addition levels, since beef burger enriched with GA had cooking yield values higher than that of control. Burger containing 20 % (GA) had the highest cooking yield value (81.50%) while control had the lowest value (72.56%). This may be related to the fibers content of GA which could influence the cooking yield of the beef burger, since fibers could reduce the water loss during cooking by forming gels as reported by Rather *et al.* (2016).

Control beef burger sample had a high ($P \leq 0.05$) percentage of shrinkage and diameter reduction after cooking process in a comparison with burger integrated with GA. These results are in conformity with the finding stated by Namir *et al*. (2015) and Gad (2019). The control sample had highest values of shrinkage, diameter reduction and cooking loss (19.44, 16.84 and 27.44 % respectively). On the other hand, using GA at different levels improved the shrinkage, diameter reduction and cooking loss of low fat beef burger in compare with those of high fat beef burger control. These results are in harmony with those of Gibis *et al*., (2015), who reported that less shrinkage, diameter reduction and cooking loss in low-fat lamb patties containing CMC compared with control beef burger.

pH value is one of the most important factors that effect on several properties of meat products, for example color, shelf-life, texture and water holding capacity (El-Abd *et al*., 2003; Simela, 2005 and Hashem *et al*., 2011). No significant ($P \leq 0.05$) differences were noticed in pH among beef burger control (5.47) and that formulated with different replacement levels of GA. These results are similar to those reported by El-Beltagy *et al*. (2007).

Texture profile analysis of beef burger:

The results of replacing fat content with GA at different levels on texture profile (hardness, cohesiveness, springiness, gumminess and chewiness) of beef burger are show in Table (7).

Hardness, springiness, gumminess, and chewiness values of cooked beef burger significantly ($P \leq 0.05$) increased with increasing levels of GA. The highest values were noticed in cooked beef burger manufactured with 20 % GA (19.960, 0.793, 9.88 and 7.806 respectively) while, lowest values were noticed in control sample (18.650, 0.730, 8.740 and 6.390 respectively) compared to all samples. Non significant ($P \geq 0.05$) differences were observed with increasing the levels of GA replacer in cohesiveness values of all beef burger samples. The improvement in textural properties may due to the dietary fiber which has abilities of binding water and fat absorption (Choi *et al.,* 2016). Demiric *et al.* (2014) found that addition of xanthan and guar gum to meatballs at 0.5, 1.00 and 1.50% improved the hardness and improved meatballs tissue. Also, Hussein *et al.* (2015) noticed that gumminess and cohesiveness of sausage were significantly increased by reducing fat level or increasing wheat bran or barely as fat replacer levels. Furthermore, the increase in springiness may be due to the gel network formed and increased water held by xanthan gum. On the other hand, the results showed that cohesiveness of cooked beef burger prepared with replace fat with different levels of GA had the opposite trend. The obtained data are consistent with Pereira *et al.* (2011); Yeo *et al.* (2014) and Gad (2019).

Table (7): Texture profile analysis of beef burger.

Treatments	Hardness (N/cm2)	Cohesiveness (ratio)	Springiness (cm)	Gumminess (N/cm2)	Chewiness (N/cm2)
Control	18.650^{c} ±0.35	0.493^{a} ±0.005	0.730^{ab} ±0.010	8.740^{bc} ±0.36	6.390^{b} ±0.17
Beef burger 5% GA	19.060^{bc} ±0.06	0.493^{a} ±0.005	0.730^{ab} ±0.011	8.953^{bc} ±0.33	6.596^{b} ±0.31
Beef burger 10% GA	19.480^{ab} ±0.24	0.473^{a} ±0.015	0.703^{b} ±0.089	9.220^{b} ±0.38	6.460^{b} ±0.58
Beef burger 15% GA	19.910^{ab} ±0.11	0.470^{a} ±0.017	0.780^{ab} ±0.010	9.816^{a} ±0.07	7.656^{a} ±0.12
Beef burger 20% GA	19.960^{a} ±0.93	0.470^{a} ±0.010	0.793^{a} ±0.011	9.886^{a} ±0.39	7.806^{a} ±0.27

Each value is an average of three determinations ± standard deviation.
Values followed by the same letter in columns are not significantly different at P<0.05.
Coh = Cohesiveness; Gum= Gumminess; Che = Chewiness; Spr = Springiness.

Sensory evaluation of beef burger:

Data of sensory properties of beef burger as affected by replacing fat with GA at different levels were listed in Table (8). Significantly (P<0.05) differences were observed in score values of color, taste, tenderness, texture, appearance and overall acceptability among control sample (0% GA level) of burger and that contained 5 and 10, 15 and 20% GA as fat replacer for all sensory characteristics. Sensory characteristics of samples beef burger prepared using GA up to 10% ratio had nearly similar scores in compared with those of control of beef burger. Using of GA at the concentration of more than 10% led to decrease the scores for sensory characteristics of beef burger. The decrements with 20% represent about 18.0, 14.50, 10.70, 12.40, 11.25 and 10.70% of the control, that is mean all ratios of GA replacement can use for manufacture beef burger with overall acceptability more than 87.0% of the control. The highest values were noticed in control beef burger which was 8.80, 9.00, 9.08, 8.70, 8.78 and 9.06 for color, taste, tenderness, texture, appearance and overall acceptability, respectively; while lowest values were noticed in beef burger contained 20 % level GA which were 7.20, 7.70, 8.11, 7.62, 7.88 and 7.91 compared to all samples. These results are in agreement with those obtained by Soncu *et al.* (2015); Kılınççeker and Kurt (2016) and Gad (2019), who revealed that the decrease of appearance, color, flavor, texture and overall acceptability scores decreased with increasing levels of fiber. The obtained results are also particularly agreement with those of Mmove *et al*. (2016), who reported that the level of GA used in extended beef rounds significantly affected in all sensory attributes in cooked beef burger samples.

Table (8): Sensory evaluation of beef burger manufactured with different levels of GA.

Treatment	Color (10)	Taste (10)	Tenderness (10)	Texture (10)	Appearance (10)	Overall Acceptability (10)
Control	8.80^{a} ±0.075	9.00^{a} ±0.53	9.08^{a} ±0.08	8.70^{a} ±0.11	8.78^{a} ±0.12	9.06^{a} ±0.09
Beef burger 5% GA	8.47^{b} ±0.26.	8.68b ±0.14	8.91^{ab} ±0.31	8.50^{b} ±0.17	8.77^{a} ±0.11	8.90^{a} ±0.28
Beef burger 10% GA	8.11^{c} ±0.21	8.50^{b} ±0.09	8.70^{b} ±0.16	8.40^{b} ±0.11	8.40^{b} ±0.09	8.60^{b} ±0.13
Beef burger 15% GA	7.80^{d} ±0.07	8.08c ±0.17	8.40^{c} ±0.26	8.40c ±0.09	8.40^{b} ±0.22	8.52^{b} ±0.26
Beef burger 20% GA	7.20^{e} ±0.08	7.70^{d} ±0.12	8.11^{d} ±0.16	7.62^{d} ±0.22	7.88^{c} ±0.09	7.91^{c} ±0.16

Each value is an average of 20 determinations ± standard deviation.
Values followed by the same letter in columns are not significantly different at P<0.05.

From previous results it could be concluded that, GA contain a high amount of dietary fiber and high percentage of phenolic compounds which act as antioxidant substances. The chemical composition of beef burger produced by replacing fat content with GA revealed that, protein and dietary fiber contents were increased with increasing replacement level, while fat content was decreased. The replacing fat content with GA improved the physical properties of low fat beef burger produced by increasing cooking yield and decreased cooking loss, shrinkage and diameter reduction. Cooking profile and sensory evaluation of low-fat beef burger showed that replacing level 5 and 10% gave values nearest to the control sample, also replacing levels 15 and 20% gave a fair product and not bad. So we can recommend using GA as fat replacer for production low-fat products for diabetic, obesity and hypercholestermic people.

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إنتاج بورجر منخفض الدهن باستخدام الصمغ العربي كبديل للدهن

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الملخص العربي

تم دراسة التركيب الكيماوي والمركبات الفينولية والنشاط المضاد للأكسدة للصمغ العربي بالإضافة إلي الصفات الطبيعية والكيماوية وصفات الطبخ والصفات الحسية للبورجر منخفض الدهن الذي تم تصنيعه بإستبدال جزء من المحتوي الدهني بالصمغ العربي بنسب إستبدال (٥، ١٠، ١٥، ٢٠%). وأشارت نتائج التركيب الكيماوي أن الألياف الغذائية هي المكون الأساسي في الصمغ العربي والتي تمثل حوالي (٨٩,٨٩ %) ، والمركبات الثانوية الأخري عباره عن بروتين (٢,٠٢%) والمستخلص الإثيري (٤,١٠%) والرماد (٣,٩٩ %).وأظهرت الدراسة أن النشاط المضاد للأكسدة للمستخلص المائي للصمغ العربي كانت (٧٣,٣٠ %) وكانت أعلي من التي تحصل عليها من المستخلص الكحولي والتي كانت (٧٠,٨٧ %). أدت عملية الإستبدال إلي زيادة النسب المئوية لكل المركبات الكيماوية الرطوبة، الألياف ، البروتين، الرماد، الكربوهيدرات الكلية بإستثناء المستخلص الإثيري الذي حدث له إنخفاض في كلا من البورجر الخام والبورجر المطبوخ والمصنع بإستبدال جزء من المحتوي الدهني بنسب مختلفة من الصمغ العربي. و أدت عملية الإستبدال أيضا إلي زيادة معنوية في القدرة علي الإحتفاظ بالرطوبة وقيمة feder value في حين إنخفضت البلاستيكية ومعامل البروتين والماء ومعامل البروتين والماء والدهن إنخفاضا معنويا في البورجر منخفض الدهن. وقد تأثرت صفات الطبخ بإستبدال الدهن بالصمغ العربي حيث زادت إنتاجية الطبخ زيادة معنوية في حين كان هناك إنخفاضا معنويا في كلا من الفقد في الطبخ والإنكماش وإختزال القطر. وأظهر التقييم الحسي أن مستويات الإستبدال ٥، ١٠% أدت إلي إنتاج بورجر يشابه الكنترول في معظم الصفات الحسية مع فروق بسيطة وأعطت نسب الإستبدال ١٥، ٢٠% بورجر منخفض الدهن مقبولا.

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