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Improving the physico-chemical and sensory characteristics of camel meat burger patties using ginger extract and papain

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ABSTRACT

The objective of the current study was to include tenderizing agents in the formulation of camel meat burger patties to improve the physico-chemical and sensory characteristics of the product. Camel meat burger patties were processed with addition of ginger extract (7%), papain (0.01%) and mixture of ginger extract (5%) and papain (0.005%) in addition to control. Addition of ginger, papain and their mixture resulted in significant ($P < 0.05$) increase of the collagen solubility and sensory scores (juiciness, tenderness and overall acceptability) with significant ($P < 0.05$) reduction of the shear force values. Ginger extract resulted in extensive fragmentation of myofibrils; however, papain extract caused noticeable destructive effect on connective tissue. Moreover, ginger and papain resulted in improvement of the lipid stability of treated burger patties during storage. Therefore, addition of ginger extract and papain powder during formulation of camel burger patties can improve their physico-chemical and sensory properties.

1. Introduction

Consumer demand for fast foods has been increased rapidly in recent years due to drastic changes of life style. Meat burger patty is one of the most popular meat products that are under extensive consumption as fast meals especially in Arab countries. The most common meat raw material that is extensively used for production of burger patties is beef. The increasing price of the beef as raw meat materials required for manufacture of meat products has encouraged the food processors to evaluate the possibility of utilization of other low cost and high quality meat source such as camel meat especially in Asian and African countries where camel meat is available and considered more efficient than the other farm animals in the production of meat. The total number of camels in the world is about 25 million and the worldwide market for camel products has a prospective of ten billion dollars per year (Mirzaei, 2012). A camel carcass can provide a substantial amount of meat for human consumption. There is a high demand for camel meat to be used in meat products even in societies not rearing camel. The low fat content with relatively high polyunsaturated fatty acids, high moisture contents, high proportion of good quality proteins rich in essential amino acids, low level of cholesterol and high level of vitamins especially vitamin B complex makes camel meat a healthy food for humans (Kadim, Mahgoub, & Purchas, 2008). Moreover, the high water holding capacity of this meat is giving it a good processing properties (Babiker & Yousif, 1990) that can be recommended as an important raw material for production of many meat products (Farouk & Bekhit, 2013).

Although camel meat may be considered as a valuable raw material for formulation of meat products, a most important trouble associated with this meat is its higher connective tissue content which makes it a tougher kind of meat (Kadim et al., 2008). This is mainly because camel meat usually comes from old animals that have served other functions in their life or at the time that their labor performance and milk yield decline (Wilson, 1998). The high amount of connective tissue makes the camel meat a challenging raw material for production of acceptable meat product. Therefore, various methods have been established to tenderize camel meat to be suitable for further processing of different products.

The process of meat tenderization is recognized to be enzymatic in nature and involves endogenous proteolytic systems of meat itself which are responsible for tenderization during natural aging. However, when tenderization is desired to be enhanced, plant or microbial enzymes can be added (Lantto et al., 2010). Treatments by proteolytic enzymes are popular methods for meat tenderization and the most widely used exogenous enzymes in meat tenderization are the plant enzymes papain, bromelain and ficin as well as bacterial collagenase (Kang & Rice, 1970; Stanton & Light, 1987). Recently, proteolytic enzyme derived from ginger rhizome (*Zingiber officinale Roscoe*) and fruits of *Cucumis trigonus Roxb* plant has been reported to be effective for tenderization of tough meat from culled animals (Garg & Mendiratta, 2006; Naveena & Mendiratta, 2004; Naveena, Mendiratta, & Anjaneyulu,

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2004). Exogenous proteases are capable of digesting connective tissue and muscle proteins (Grzonka, Kasprzykowski, & Wiczk, 2007). Besides tenderizing properties, antioxidant characteristics of ginger extract have been reported by different workers (Lee, Kim, & Ashmore, 1986; Kim & Lee, 1995; Mendiratta, Anjaneyulu, Lakshmanan, Naveena, & Bisht, 2000).

Most of the previous studies conducted on the usage of plant derived proteolytic enzymes were directed to tenderization of fresh meat, however, the use of these enzymes for improving the characteristics of these meat when incorporated as raw material in meat products are limited. Therefore, the goal of the current study was to include tenderizing agents in the formulation of camel burger to improve the physico-chemical and sensory characteristics of the product. On the other hand, meat processors are concerned about the quality characteristics of processed products under storage. Therefore, prepared camel burger patties were stored at −18 °C for 3 months (shelf-life of burger) and the quality characteristics were assessed post-processing. This work may encourage meat processors to use camel meat for production of high quality meat products.

2. Materials and methods

2.1. Experimental design

A three replicate based experiment (three independent replicates at different times) was carried out to investigate the effect of incorporating ginger extract (7%), papain (0.01%) as well as mixture of ginger extract 5% and papain 0.005% during formulation of camel burger patties on the physico-chemical and sensory characteristics of prepared product. Moreover, the prepared burger patties at each replicate were stored at −18 °C for 3 months and examined monthly for sensory quality, pH, thiobarbituric acid and total volatile base nitrogen).

2.2. Enzymes preparation

Readily available papain enzyme powder from standard firm (Loba Chemie, Mumbai, India) was used. The recommended concentration was dissolved in distilled water just before application. Fresh ginger rhizome (*Z. officinale Roscoe*) was purchased from a local supermarket. The rhizome was peeled, sliced and blended with equal quantity of chilled distilled water for 1–2 min. The slurry was then filtered with four layers of muslin cloth and the filtrate was collected as the crude ginger extract. This crude extract was used as a source of proteolytic enzymes in subsequent application to meat.

2.3. Preparation of burger ingredients

Five fresh chucks and hump fat of ~8 years old female camels (*Camelus dromedarius*) were obtained from 5 animals, 1 h after slaughter from a slaughter house (Cairo, Egypt). The meat and fat were rapidly transported to the laboratory wrapped in polyethylene bags where they were stored at 4 °C overnight before use. Sodium tripolyphosphate and seasonings mix were obtained from Loba Chemie, Mumbai, India. Moreover, the sodium chloride and starch were obtained from a local market at Cairo, Egypt.

2.4. Products formulation

A base batter was prepared by using a simple traditional formulation as follows: 65% lean camel meat, 17% hump fat, 1.8% sodium chloride, 11% water, 5% starch, 0.3% sodium tripolyphosphate and 0.05% seasonings mix. Four formulas were prepared from the base batter by addition of ginger extract at rate of 7% to the 1st formula, papain at a rate of 0.01% to the 2nd formula; mixture of ginger extract (5%) and papain (0.005%) to the 3rd formula and the 4th formula was left as control without addition of any tenderizing ingredient. The levels of ginger and papain used in this study were based on a preliminary experiment to choose the concentration that gives a good tenderizing effect beside the previous studies. The percentage of the extracts was calculated as *v*/*w* of the whole formula.

2.5. Burger processing and storage

Three independent replicates for each burger formula were processed. For each replicate, the cooled camel meat and fat were ground through a 4.5-mm plate grinder (Seydelmann NW 114 E; Stuttgart, Deutschland, Germany). The ground meat and fat were mixed together with water, salt, starch, polyphosphates and seasonings. The mixture was divided into the following four treatment groups: the 1st group treated with ginger extract at rate of 7% (*v*/*w*), the 3rd group was treated with ginger extract 5% (*v*/*w*), while 2nd and 4th groups were left at this step without any treatment. After overnight storage at 4 °C, papain powder at rate of 0.01% (*w*/w) was added to the 2nd group, papain powder at rate of 0.005% (*w*/w) was added to the 3rd group (treated with ginger extract 5%), however, the 4th group was left without any treatment as control. Therefore, 4 formulas were prepared; the 1st one was treated with ginger extract 7% and stored overnight at 4 °C, the second one was treated with papain 0.01% added instantly, the 3rd one was treated with mixture of ginger extract 5% (stored overnight at 4 °C) plus papain 0.005% added instantly, however, the 4th formula was kept without any treatment (control). Afterward the mixture of each formula was mixed by hand for 5 min. A commercial burger maker with 9-cm internal diameter was then used to shape this mixture into burger patties of approximately 75 g and 1-cm thickness. Thirty burger patties were prepared from each formulation for each replicate. The patties were placed in plastic packaging films, held at −40 °C for 30 min and then placed in plastic containers and stored at −18 °C for 3 months. For each replicate, samples were withdrawn from each formula for analysis at 2nd day (0-time) and monthly.

2.6. Burger patties analysis

The proximate chemical analysis, collagen solubility, shear force, color values, cooking loss and moisture and fat retention values were determined at 0-time only. However, pH, thiobarbituric acid, total volatile base nitrogen values and sensory attributes were determined at 0-time and every month for 3 months. Burgers were thawed in a chiller at 4 °C before analysis.

2.6.1. Proximate composition analysis

Moisture, protein, fat and ash contents of burger patties from different formulas were determined for each replicate after the processing according to the method of AOAC (2000). For determination of moisture contents (g % sample), 3 g of sample were dried at 100 °C until constant weight was obtained. Protein content (g % sample) was determined according to the Kjeldahl method of analysis. For conversion of nitrogen into crude protein, a factor 6.25 was used. Fat (g % sample) was determined by 6-cycle extraction with petroleum ether in a soxhlet apparatus and calculating the weight loss. Ash was determined by ignition at 500 °C for 5 h (g % sample). Moreover, the proximate chemical analysis was conducted for cooked burger patties. The cooking was performed in a convection oven (Heraeus, D-63450 Hanau, Germany) adjusted at 180 °C to an internal temperature 75 °C and the cooking temperature was monitored by a needle thermocouple probe attached to a previously calibrated hand-held thermometer (Hanna HI 985091–1; Pasadena, TX, USA).

2.6.2. pH, thiobarbituric acid reactive substances (TBARS) and total volatile base nitrogen (TVBN) values

The pH, TBARS and TVBN values were determined after processing and monthly during storage. For measurement of pH value, five grams from each of the burger patties was homogenized with 20 ml distilled

Table 1
Proximate chemical composition of raw and cooked camel burger patties treated with ginger (7%), papain (0.01%) and mixture of ginger (5%) and papain (0.005%).

Proximate composition	Treatments			
	Control	Ginger (7%)	Papain (0.01%)	Ginger (5%) + papain (0.005%)
Raw burger patties				
Moisture (g %)	63.9 ± 0.8^{ac*}	67.5 ± 0.4^{b}	63.4 ± 0.3^{c}	67.2 ± 1.8^{ab}
Protein (g %)	15.5 ± 0.1^{a}	15.5 ± 0.5^{a}	13.6 ± 0.1^{b}	15.9 ± 1.5^{a}
Fat (g %)	11.8 ± 0.5^{a}	9.6 ± 0.5^{b}	13.4 ± 0.2^{c}	10.6 ± 0.6^{ab}
Ash (g %)	2.6 ± 0.2^{a}	2.5 ± 0.1^{a}	2.6 ± 0.4^{a}	2.6 ± 0.1^{a}
Cooked burger patties				
Moisture (g %)	57.6 ± 1.2^{a}	62.4 ± 0.7^{b}	64.9 ± 0.4^{bc}	65.1 ± 0.4^{c}
Protein (g %)	24.8 ± 0.4^{a}	24.4 ± 0.2^{ab}	23.7 ± 0.3^{b}	21.7 ± 0.3^{c}
Fat (g %)	14.0 ± 1.0^{a}	10.7 ± 0.5^{b}	8.5 ± 0.7^{b}	10.1 ± 0.3^{b}
Ash (g %)	3.4 ± 0.1^{a}	2.3 ± 0.2^{b}	2.7 ± 0.1^{b}	2.7 ± 0.1^{b}

$^{a–c}$Means with different superscripts within the same raw significantly ($P < 0.05$) different.
* Values represent the mean of 3 independent replicates ± SE.

water for 10–15 s (Kandeepan, Anjaneyulu, Kondaiah, Mendiratta, & Lakshmanan, 2009). The pH was measured using a pH meter (Lovibond Senso Direct) with a probe type electrode (Senso Direct Type 330) where three reading for each sample was obtained and the average was calculated. The meter was calibrated every two samples using two buffers 7.0 and 4.0. The thiobarbituric acid reactive substances (TBARS) value was measured by the method outlined by Du and Ahn (2002) and expressed as milligrams of malondialdehyde per kilogram of sample. Moreover, the Total Volatile Base Nitrogen (TVBN, mg/100 g sample) was measured according to the method of Kearsley, El-Khatib, and Gunu (1983) using a macro-Kjeldahl distillation method.

2.6.3. Physico-chemical characteristics

Collagen solubility, shear force, color values, cooking loss, moisture and fat retention were investigated after burger patties processing.

2.6.3.1. Collagen solubility. Collagen solubilities of burger patties were calculated according to the method described by Naewbanij, Dorothy, and Stone (1983) by heating 5 g of the raw burger patty to boiling temperature and holding them for 30 min. The cooked meat was then cut into small pieces and homogenized with 50 ml distilled water at 4 ± 1 °C in a blender for 2 min. The extract was then centrifuged (MLW T5, GRD) at 1500g for 30 min. Aliquots of cooked out juice and centrifugate were hydrolyzed for 18 h and soluble hydroxyproline was calculated.

2.6.3.2. Shear force. For shear force measurement, the burger patties were cooked in a convection oven (Heraeus, D-63450 Hanau, Germany) adjusted at 180 °C to an internal temperature 75 °C. The cooking temperature was monitored by a needle thermocouple probe attached to a previously calibrated hand-held thermometer (Hanna HI 985091–1; Pasadena, TX, USA). Patties were cooled to room temperature. Six core samples of 1.27 cm diameter were removed parallel to patty surface using hand-held coring device. Each core was sheared once with a Warner–Bratzler shear force (WBSF) device attached to an Instron Universial Testing machine (Model 2519 105; Instron Corp., Canton, MA, USA) with a 55-kg tension/compression load cell and a crosshead speed of 200 mm/min. An average shear force value was calculated and recorded for each sample (Shackelford, Wheeler, & Koohmaraie, 2004).

2.6.3.3. Color evaluation. The color of the surface of raw burger patties was measured using Croma meter (Konica Minolta, model CR 410, Japan) calibrated with a white plate and light trap supplied by the manufacturer. The L* (lightness), a* (redness), and b* (yellowness) values were obtained using CIE standard illuminant D_{65} light source. Color was expressed using the Commission International de l'Eclairage (CIE) L*, a*, and b* color system. The bloom time was 30 min and the observation angle was 10°. Three measurements were taken from each sample surface at each time. The average score of triplicate experiments was recorded, and expressed as CIE lightness (L*), redness (a*), and yellowness (b*) (Shin et al., 2008).

2.6.3.4. Cooking loss. Cooking loss was calculated as outlined by Neel, Reagan, and Mabry (1987). The meat samples were blotted with blotting paper and weighed accurately just before cooking. After cooking, the samples were cooled and wiped with blotting paper and weighed immediately. The cooking loss as a percentage was the difference in weights of the sample before and after cooking.

2.6.3.5. Moisture retention and fat retention. The moisture retention value represents the amount of moisture retained in the cooked product/100 g sample. The percentage of moisture retention was calculated according to the equation of El-Magoli, Laroia, and Hansen (1996). The fat retention value represents the amount of fat retained in the cooked product/100 g raw sample. The percentage of fat retention was calculated according to Murphy, Criner, and Grey (1975).

2.6.4. Sensory analysis

Sensory analysis of camel meat burger patties was performed after processing and monthly during storage. The guidelines of AMSA (1995) were followed during sensory evaluation. For sensory evaluation, 9 experienced panelists (from both sexes in the age range of 30 to 45 years) were chosen from the staff members of the Department of Food Hygiene and Control at Faculty of Veterinary Medicine, Cairo University, Egypt. Panelists were selected on the basis of their experience in sensory evaluation methods and the food products being tested (experienced burger eaters). Moreover, they received a preparatory session related to descriptive profile of sensory attributes (appearance, flavor, juiciness, tenderness and overall acceptability) prior to testing so that each panelist could thoroughly discuss and clarify each attribute to be evaluated. All testing was carried out under controlled conditions (in special room with controlled temperature, free from noise and odor with adequate lightening). Tap water was provided between samples to cleanse the palate. Five beef patties from each formula were cooked at 180 °C in a forced draught oven (Heraeus D-63,450 Hanau, Germany) to a core temperature 75 °C and maintained warm in the oven until testing within 3–8 min (Fernández-López, Jiménez, Sayas-barberá, Sendra, & Pérez-Alvarez, 2006). The cooking temperature was monitored by a needle thermocouple probe attached to a previously calibrated hand-held thermometer (Hanna HI 985091–1; Pasadena, TX, USA). From the center of each burger patty, rectangular pieces of approximately 1.5 cm–2 cm were cut and served at room temperature. Each panelist evaluated three replicates of all formulas in a randomized order and asked to assign a numerical value between 1 and 9 for following attributes: appearance, flavor, juiciness and tenderness where 9 denotes extremely acceptable and 1 denotes extremely unacceptable. At the end of evaluation of the given sample, each panelist was asked to give a score

Table 2
pH values of camel burger patties treated with ginger (7%), papain (0.01%) and mixture of ginger (5%) and papain (0.005%) during storage at −18 °C for 3 months.

Treatments	Storage period (months)			
	0-time	1st month	2nd month	3rd month
Control	5.9 ± 0.03^{ab*}	5.9 ± 0.02^{a}	8.0^{a} ± 0.05^{a}	6.1^{a} ± 0.02^{a}
Ginger (7%)	6.0 ± 0.01^{b}	6.0 ± 0.01^{b}	6.0^{a} ± 0.03^{a}	6.0^{a,b} ± 0.05^{a}
Papain (0.01%)	5.8 ± 0.08^{a}	5.8 ± 0.02^{a}	5.9^{b} ± 0.01^{b}	5.9^{b} ± 0.06^{b}
Ginger (5%) + Papain (0.005%)	5.8 ± 0.02^{a}	5.8 ± 0.03^{a}	5.9^{b} ± 0.01^{b}	5.9^{b} ± 0.05^{b}

$^{a–b}$Means with different superscripts within the same column are significantly ($P < 0.05$) different.
* Values represent the mean of 3 independent replicates ± SE.

Table 3
Thiobarbituric acid reactive substances (mg/kg) values of camel burger patties treated with ginger (7%), papain (0.01%) and mixture of ginger (5%) and papain (0.005%) during storage at −18 °C for 3 months.

Treatments	Storage period (months)			
	0-time	1st month	2nd month	3rd month
Control	0.6 ± 0.05^{a*}	0.6 ± 0.07^{a}	0.7 ± 0.02^{a}	0.7 ± 0.02 ^{a}
Ginger (7%)	0.3 ± 0.05^{b}	0.3 ± 0.03^{b}	0.3 ± 0.02^{bc}	0.3 ± 0.02^{bc}
Papain (0.01%)	0.3 ± 0.02^{b}	0.3 ± 0.03^{b}	0.3 ± 0.01^{b}	0.4 ± 0.01^{b}
Ginger (5%) + papain (0.005%)	0.2 ± 0.02^{b}	0.2 ± 0.01^{b}	0.2 ± 0.02^{c}	0.3 ± 0.02^{c}

$^{a–c}$Means with different superscripts within the same column are significantly ($P < 0.05$) different.
* Values represent the mean of 3 independent replicates ± SE.

Table 4
Total volatile base nitrogen (mg/100 g) values of camel burger patties treated with ginger (7%), papain (0.01%) and mixture of ginger (5%) and papain (0.005%) during storage at −18 °C for 3 months.

Treatments	Storage period (months)			
	0-time	1st month	2nd month	3rd month
Control	4.3 ± 0.3^{a*}	4.5 ± 0.5^{a}	4.7 ± 0.5^{a}	4.9 ± 0.5^{a}
Ginger (7%)	4.6 ± 0.3^{a}	5.0 ± 0.4^{a}	5.1 ± 0.7^{a}	5.3 ± 0.6^{a}
Papain (0.01%)	4.5 ± 0.2^{a}	4.7 ± 0.2^{a}	4.9 ± 0.4^{a}	5.0 ± 0.5^{a}
Ginger (5%) + papain (0.005%)	4.6 ± 0.1^{a}	4.9 ± 0.1^{a}	5.0 ± 0.3^{a}	5.0 ± 0.3^{a}

^{a}Means with the same superscripts within the same column are not significantly ($P > 0.05$) different.
* Values represent the mean of 3 independent replicates ± SE.

for overall acceptability from 1 (dislike very much) to 9 (like very much).

2.6.5. Histological examination

Burger samples (1 × 1 cm) were fixed in 10% formalin for 24 h followed by overnight washing with running water. Fixed samples were dehydrated in a chain of upgrading concentration of ethyl alcohol, cleaned in xylene, and embedded in paraffin at 56 °C in hot air oven for 24 h. Paraffin blocks were sectioned at 4–6 μm thickness, and stained with Haematoxylin and Eosin using the technique recommended by Banchroft, Stevens, and Turner (1996). At least 20 micrographs from each treatment were viewed to be able to select an appropriate one and to discuss the changes that happened after treatment.

2.6.6. Statistical analysis

Statistical data analysis for the three independent replicates was carried out using SPSS statistics 17.0 for windows. The difference between means of values of proximate composition analysis, deterioration criteria, collagen solubility, shear force, color (L*, a* and b*), cooking loss, fat retention and moisture retention among different treatments was determined using one way analysis of variance (ANOVA) and multiple comparisons of means were done using Post Hoc (least square difference test, LSD) procedure. Scores of different sensory attributes were compared among different treatments using General linear Model (GLM) and multiple comparisons of means were done using Post Hoc (LSD) procedure to show differences among treatments. Fixed factor was the treatments. Differences were considered significant at the $P < 0.05$ level.

Table 6
Sensory quality of camel burger patties treated with ginger (7%), papain (0.01%) and mixture of ginger (5%) and papain (0.005%) during storage at −18 °C for 3 months (scores 1–9 with 1, extremely unacceptable and 9, extremely acceptable).

Treatments	Storage period (months)			
	0-time	1st month	2nd month	3rd month
Appearance				
Control	6.2 ± 0.1^{a*}	6.1 ± 0.1^{a}	6.1 ± 0.1^{a}	5.4 ± 0.1^{a}
Ginger (7%)	6.8 ± 0.1^{b}	6.2 ± 0.2^{a}	6.3 ± 0.2^{a}	5.6 ± 0.1^{a}
Papain (0.01%)	6.4 ± 0.2^{ab}	6.2 ± 0.1^{a}	6.2 ± 0.1^{a}	5.6 ± 0.2^{a}
Ginger (5%) + papain (0.005%)	6.2 ± 0.2^{a}	6.3 ± 0.2^{a}	6.0 ± 0.1^{a}	5.5 ± 0.1^{a}
Flavor				
Control	6.9 ± 0.2^{a}	6.2 ± 0.2^{a}	5.7 ± 0.2^{a}	5.9 ± 0.1^{a}
Ginger (7%)	7.8 ± 0.1^{b}	6.6 ± 0.2^{ab}	6.8 ± 0.2^{b}	6.5 ± 0.1^{b}
Papain (0.01%)	6.3 ± 0.2^{a}	6.6 ± 0.2^{ab}	6.8 ± 0.1^{b}	6.3 ± 0.1^{b}
Ginger (5%) + papain (0.005%)	6.7 ± 0.2^{a}	6.8 ± 0.1^{b}	6.7 ± 0.2^{b}	6.3 ± 0.1^{b}
Juiciness				
Control	5.9 ± 0.1^{a}	5.6 ± 0.2^{a}	5.4 ± 0.1^{a}	5.1 ± 0.1^{a}
Ginger (7%)	6.9 ± 0.1^{b}	6.7 ± 0.2^{b}	6.1 ± 0.1^{b}	6.2 ± 0.1^{b}
Papain (0.01%)	6.8 ± 0.1^{b}	6.6 ± 0.2^{b}	6.1 ± 0.1^{b}	6.0 ± 0.1^{b}
Ginger (5%) + papain (0.005%)	6.7 ± 0.1^{b}	6.7 ± 0.2^{b}	6.1 ± 0.1^{b}	6.1 ± 0.1^{b}
Tenderness				
Control	4.4 ± 0.1^{a}	4.4 ± 0.1^{a}	4.2 ± 0.1^{a}	4.2 ± 0.2^{a}
Ginger (7%)	6.9 ± 0.1^{b}	6.8 ± 0.1^{b}	6.6 ± 0.1^{b}	6.4 ± 0.2^{b}
Papain (0.01%)	6.6 ± 0.2^{b}	6.8 ± 0.1^{b}	6.8 ± 0.1^{b}	6.3 ± 0.2^{b}
Ginger (5%) + papain (0.005%)	6.7 ± 0.1^{b}	6.8 ± 0.1^{b}	6.6 ± 0.2^{b}	6.3 ± 0.2^{b}
Overall acceptability				
Control	4.3 ± 0.1^{a}	4.5 ± 0.1^{a}	4.4 ± 0.1^{a}	4.4 ± 0.2^{a}
Ginger (7%)	7.3 ± 0.1^{b}	7.1 ± 0.1^{b}	6.6 ± 0.2^{b}	6.6 ± 0.1^{b}
Papain (0.01%)	7.1 ± 0.1^{b}	6.9 ± 0.1^{bc}	6.7 ± 0.2^{b}	6.5 ± 0.1^{b}
Ginger (5%) + papain (0.005%)	6.3 ± 0.1^{c}	6.7^{c} ± 0.2^{c}	6.4 ± 0.1^{b}	6.4 ± 0.1^{b}

$^{a–c}$Means with different superscripts within the same column for each parameter are significantly ($P < 0.05$) different.
* Values represent the mean of 3 independent replicates ± SE.

Table 5
Physico-chemical characteristics camel burger patties treated with ginger (7%), papain (0.01%) and mixture of ginger (5%) and papain (0.005%).

Physico-chemical characteristics	Treatments			
	Control	Ginger (7%)	Papain (0.01%)	Ginger (5%) + papain (0.005%)
Collagen solubility %	3.9 ± 0.8^{a*}	22.7^{b} ± 1.3^{b}	14.3^{c} ± 1.8^{c}	26.8^{d} ± 1.8^{d}
Shear force (Kg_f)	1.1 ± 0.1^{a}	0.9^{ab} ± 0.1^{ab}	0.8^{b} ± 0.1^{b}	0.4^{c} ± 0.1^{c}
Color values				
L*	42.1 ± 0.3^{a}	43.7 ± 0.6^{b}	41.2 ± 0.6^{a}	41.9 ± 0.^{4a}
a*	19.6 ± 0.4^{a}	19.9 ± 0.2^{a}	20.6 ± 0.4^{a}	20.1 ± 0.1^{a}
b*	14.7 ± 0.3^{a}	14.9 ± 0.1^{a}	15.4 ± 0.5^{ab}	15.9 ± 0.1^{b}
Cooking loss%	23.9 ± 0.2^{a}	27.8 ± 0.1^{b}	37.9 ± 0.03^{c}	32.7 ± 0.3^{d}
Fat retention (%)	90.2 ± 3.5^{a}	80.1 ± 0.9^{b}	39.6 ± 4.1^{c}	64.8 ± 2.3^{d}
Moisture retention (%)	43.9 ± 0.9^{a}	45.1 ± 0.5^{a}	40.3 ± 0.2^{b}	43.8 ± 0.7^{a}

$^{a–d}$Means with different superscripts within the same raw are significantly ($P < 0.05$) different.
* Values represent the mean of 3 independent replicates ± SE.

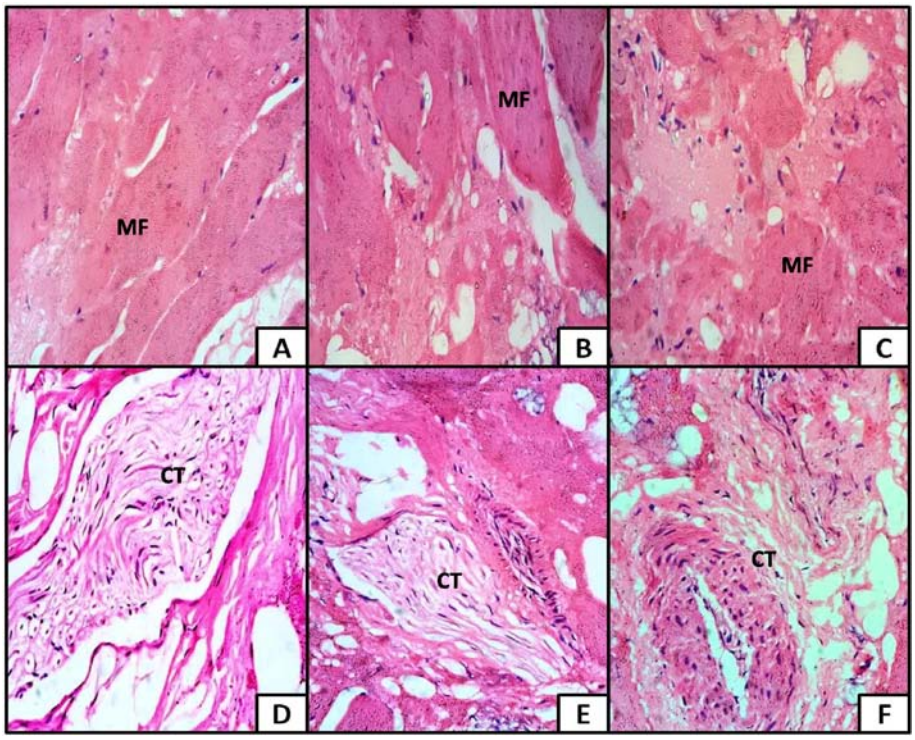

Fig. 1. Light micrographs of control untreated camel burger patties stained with H & E showing intact muscle fibers (MF, A, B and C) and intact connective tissue (CT, D, E and F) ×200.

3. Results and discussion

3.1. Proximate chemical composition

Results of proximate chemical composition of raw and cooked burger patties after treatment with ginger extract (7%), papain (0.01%) of mixture of ginger (5%) and papain (0.005%) are presented in Table 1. Raw burger patties treated with ginger (7%) showed significant ($P < 0.05$) increase of moisture and significant ($P < 0.05$) reduction of fat contents with non-significant ($P > 0.05$) reduction of protein content. Treatment of burger patties with papain (0.01%) resulted in significant ($P < 0.05$) reduction of the protein contents and significant ($P < 0.05$) increase of fat content with non-significant ($P > 0.05$) decrease of moisture contents. Burger patties treated with mixture of ginger (5%) plus papain (0.005%) showed significant ($P < 0.05$) increase of moisture content, significant ($P < 0.05$) reduction of fat contents and non-significant ($P > 0.05$) increase of protein contents. However, the ash contents of all formulas showed non-significant ($P > 0.05$) change. The composition analysis of cooked formulas revealed significant ($P < 0.05$) increase of moisture contents and significant ($P > 0.05$) reduction of protein, fat and ash contents of all treated samples when compared with control.

The resulted higher moisture contents in ginger treated formulas indicate improvement of the hydrophilic characteristics. Meanwhile, the reduction of protein contents may be due to degradation of protein by

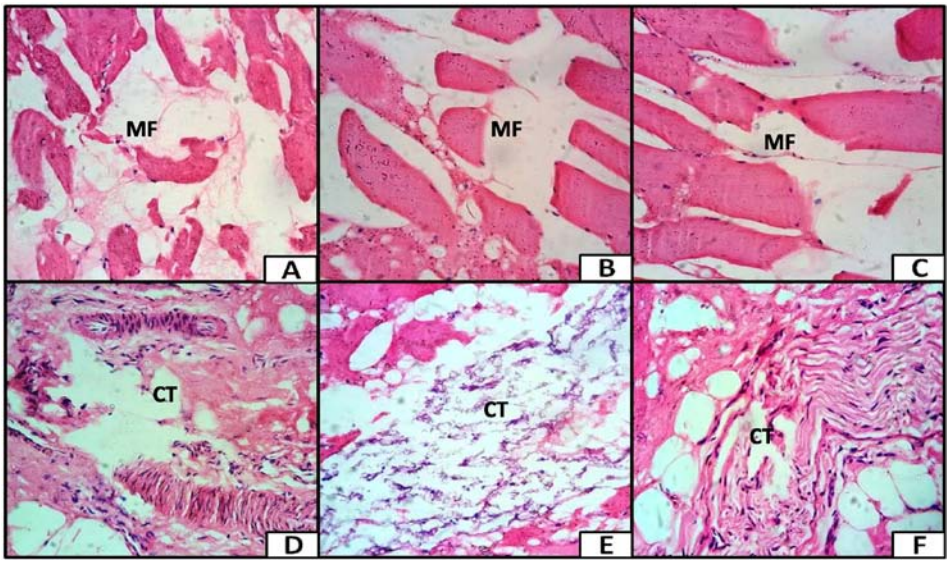

Fig. 2. Light micrographs of camel burger patties treated with ginger extract 7% stained with H & E showing broken muscle fibers (MF, A, B and C) and destructed connective tissue (CT, D, E and F) ×200.

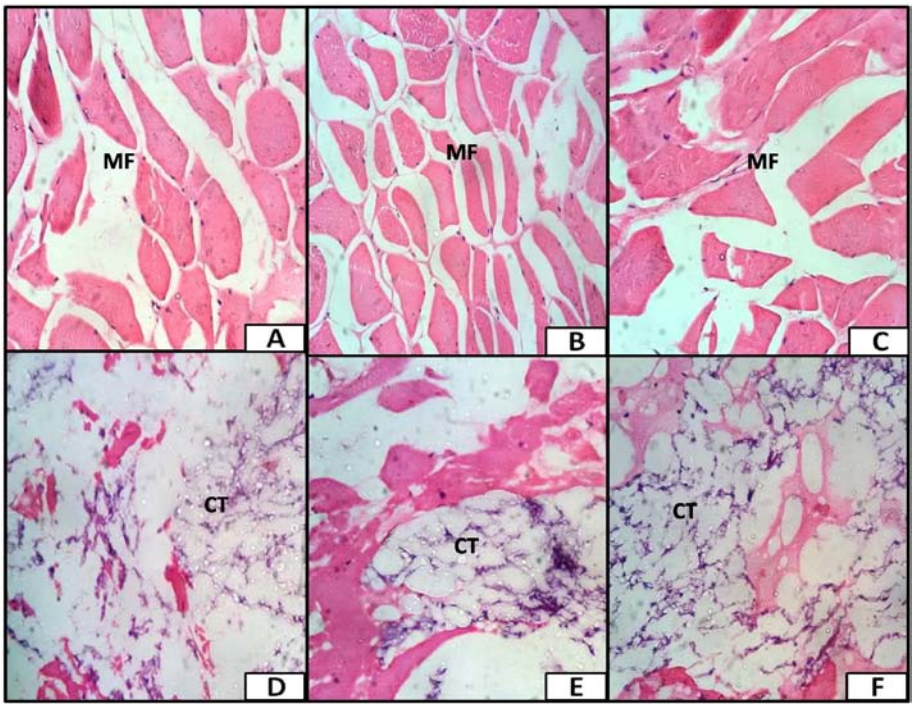

Fig. 3. Light micrographs of camel burger patties treated with papain 0.01% stained with H & E showing broken muscle fibers (MF, A, B and C) and destructed connective tissue (CT, D, E and F) ×200.

proteolytic enzymes leading to the release of free amino acids and peptides. Different observations have been recorded previously by different authors. Naveena, Mendiratta and Anjaneyulu (2004) recorded no change in moisture and protein contents of buffalo meat after treatment with ginger extract and papain. Reduction of moisture and protein contents of goat meat after treatment with ginger extract during storage was observed by Pawar, Mule, and Machewad (2007). However, an increase of the moisture contents of cooked camel meat was reported after treatment with ginger extract (Abdeldaiem & Ali, 2014).

3.2. pH value

The pH values of formulas treated with 7% revealed slight non-significant ($P > 0.05$) increase in comparison with that of control

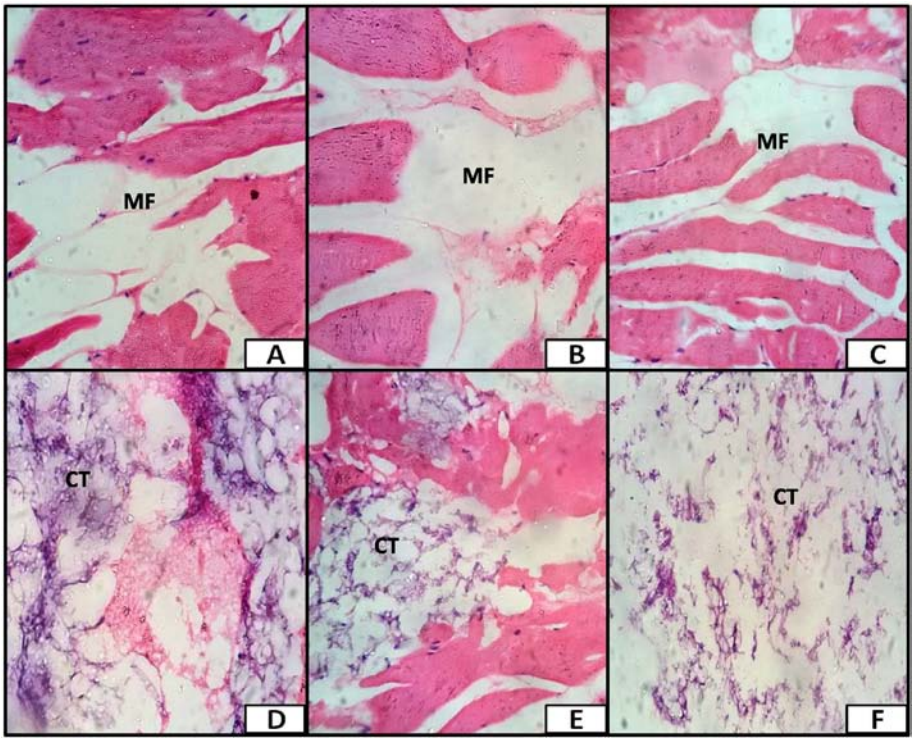

Fig. 4. Light micrographs of camel burger patties treated with mixture of ginger extract (5%) and papain (0.005%) stained with H & E showing broken muscle fibers (MF, A, B and C) and destructed connective tissue (CT, D, E and F) ×200.

formula. However, treatment of burger patties with papain (0.01%) or combinations of ginger (5%) plus papain (0.005%) resulted in non-significant ($P > 0.05$) reduction in the pH values when compared with control after processing and during frozen storage for 3 months (Table 2). The slight change in pH values of treated burger patties may be attributed to the effect of these enzymes on the ionic strength of the meat. Slight increase in pH values after treatment of goat meat with ginger was observed by Pawar et al. (2007), however, treated samples showed lower pH values as compared with control during storage. Higher pH values of ginger extract treated buffalo meat were observed by Naveena and Mendiratta (2004). Slightly higher pH values were observed after treatment of buffalo meat by ginger and papain (Naveena et al., 2004). However, non-significant reduction in pH of camel meat was recorded after treatment with ginger extract (Abdeldaiem & Ali, 2014).

3.3. Thiobarbituric acid reactive substances (TBARS) values

The thiobarbituric acid reactive substances (TBARS) values of different treated formulas were significantly ($P < 0.05$) lower than those of control after processing and during the frozen storage for 3 months (Table 3). There was no significant ($P > 0.05$) difference among values of different enzyme treatments. The reduction of TBARS was reported in ginger extract treated sheep meat (Mendiratta et al., 2000), ginger extract treated smoked spent hen (Naveena, Mendiratta, & Anjaneyulu, 2001) and in ginger extract treated goat meat (Pawar et al., 2007). From these observations, it can be concluded that the tenderizing proteolytic enzymes possess antioxidant activities. It has been reported that ginger extract as an antioxidant was effective against TBARS formation when incorporated into meat during frozen storage (Formanek et al., 2009). The reduction in TBARS by ginger has been attributed to peroxide-scavenging enzyme activity, which could reduce unsaturated fatty acid and total unsaturated fatty acid oxidation. Moreover, some active components in the ginger may involve desaturase and elongase activities (Mariutti, Orlien, Bragagnolo, & Skibsted, 2008; Frank, Xu, Jiang, & Xia, 2014).

3.4. Total volatile base nitrogen (TVBN) values

Treatment of camel burgers with ginger extract (7%), papain (0.01%) or combinations of ginger (5%) plus papain (0.005%) resulted in slight non-significant ($P > 0.05$) increase of the total volatile base nitrogen (TVBN) values after treatment and during frozen storage for 3 months (Table 4). This slight increase in TVBN values may be explained by the proteolytic activity of these enzymes which result in degradation of proteins and production of volatile compounds.

3.5. Physico-chemical characteristics

The results of the collagen solubility (%), shear force (Kg_f), color values (L*, b* and a*), cooking loss (%), fat retention (%) and moisture retention (%) are illustrated in Table 5. The collagen solubility values of all treated formulas were significantly ($P < 0.05$) higher than those of control samples. The highest value for collagen solubility was recorded for burger patties treated with combinations of ginger and papain followed by samples treated with ginger only then samples treated with papain only. The increased collagen solubility of ginger treated formulas in our study was in agreement with the observations of Mendiratta et al. (2000) in sheep meat, Naveena et al. (2004) in buffalo meat, Pawar et al. (2007) in goat meat and Abdeldaiem and Ali (2014) in camel meat after treatment with ginger extract. Significant higher collagen solubilities have been observed after treatment of beef and buffalo meat with papain (Takagi, Arafuka, Inouye, & Yamasaki, 1992; Naveena et al., 2004.)

Tenderness has been recognized as the most important palatability attribute that has direct effect on eating quality of meat products and the perception of taste (Wheeler, Saveli, Cross, Lunt, & Smith, 1990). The tenderness can be quantified by an objective tool by measuring the force required to shear a standardized piece of meat (shear force) with lower shear values denote higher tenderness. Shear force values of all treated samples were significantly ($P < 0.05$) lower than those of control samples. The lowest shear force values were recorded in samples treated with combinations of ginger (5%) and papain (0.005%) followed by samples treated with papain alone then samples treated with ginger alone. The higher shear force values of control samples may be attributed to the high amount of connective tissue in camel meat. Significant reduction in shear force values with ginger extract treatment was also recorded in sheep meat (Mendiratta et al., 2000), buffalo meat (Syed Ziauddin, Rao, & Amla, 1995; Naveena et al., 2004), spent hen meat (Naveena et al., 2001), goat meat and patties (Pawar et al., 2007) and camel meat (Abdeldaiem & Ali, 2014). Moreover, significant reduction in shear force values of buffalo meat treated with papain powder was reported by Naveena et al. (2004). The significant decrease in shear force values of the samples treated with ginger has been explained previously (Pawar et al., 2007) by the tenderizing effect of proteolytic enzymes in combination with moisture retention and increased WHC property of ginger. Moreover, the solubilized collagen derived from the connective tissues after treatment with ginger and papain has excellent water binding capacity and is able to improve the tenderness of the cooked meats (Badr, 2008).

The color of the surface of meat and meat products has been interpreted into values that can explain the difference between different treatments using standard illuminant light source. These values include; L* (lightness), a* (redness), and b* (yellowness). The L* value of ginger treated samples was significantly ($P < 0.05$) higher than that of control, however, a* and b* values were not significantly ($P > 0.05$) different. The L* a* and b* values of papain treated samples were not significantly ($P > 0.05$) different from those of control samples. Meanwhile, the color values of samples treated with mixture of ginger and papain revealed non-significant ($P > 0.05$) difference in L* and a* values and significant ($P < 0.05$) difference in b* values. The increased L* values when burger formulas treated with ginger (7%) alone may attribute to the effect of ginger extract compounds on the pigment of camel burger samples. A non-significant ($P > 0.05$) difference in L*, a* and b* values between ginger treated chicken meat emulsion and control was observed by Singh, Sahoo, Chatli, and Biswas (2014).

The cooking loss, moisture retention and fat retention represent important parameters that reflect the quality of processed meat. The cooking loss reflects the amount of losses (moisture and fat) after cooking; moisture or fat retentions reflect the amount of moisture or fat retained in meat after cooking and are important for the juiciness and mouse feel of cooked meat. The cooking loss percentages of all treated samples were significantly ($P < 0.05$) increased when compared with those of control samples accompanied with significantly ($P < 0.05$) lower values for fat retention for treated formulas. Moreover, the samples treated with papain (0.01%) revealed significantly ($P < 0.05$) higher values for cooking loss and significantly ($P < 0.05$) lower values for fat retention in comparison to samples treated with ginger extract (7%) or mixture of ginger extract (5%) and papain (0.005%). Treatment of camel burger patties with ginger extract (7%) resulted in non-significant ($P > 0.05$) increased of moisture retention values, however, treatment with papain (0.01%) resulted in significant ($P < 0.05$) increase of water retention values. On the other hand, the treatment of camel burger patties with mixture of ginger (5%) and papain (0.005%) resulted in a non-significant ($P > 0.05$) change in the water retention values in comparison with control samples. The higher cooking loss in camel burger patties treated with ginger and papain may be attributed to the lower fat retention. Non-significant increases of cooking yield in buffalo meat have been observed after treatment with ginger and papain (Naveena et al., 2004). Abdeldaiem and Ali (2014) reported increase of the cooking yield after treatment of camel meat with ginger at different concentrations.

3.6. Sensory evaluation

The sensory scores of treated burger patties and controls are presented in Table 6. The camel burger patties treated with ginger extract (7%) received significantly ($P < 0.05$) higher scores for appearance and flavor as compared with control and other formulas after treatment. During storage, the appearance scores of all treatments were non-significantly higher than those of controls, however, the favor scores received significantly ($P < 0.05$) higher score than those of controls. Moreover, the burger patties of all treated formulas received significantly ($P < 0.05$) higher scores for juiciness, tenderness and overall acceptability as compared with those of control after processing and during the whole period of storage. The sensory evaluation scores for tenderness in all treated samples are in good agreement with the resulted shear force values. The improvement in juiciness in the treated samples has explained by Pawar et al. (2007) by the increasing the WHC and moisture retention property after treatment with ginger extract. Improvement of the appearance, flavor, juiciness, tenderness and overall acceptability of beef, buffalo meat, goat meat, sheep meat and camel meat after treatment with ginger extract and/or papain has been recorded previously by different authors (Syed Ziauddin et al., 1995; Mendiratta et al., 2000; Naveena et al., 2001; Naveena et al., 2004; Pawar et al., 2007; Mendiratta, Sharma, Narayan, & Mane, 2010; Sullivan & Calkins, 2010; Abdeldaiem & Ali, 2014).

3.7. Microscopic changes

Light micrographs of control camel burgers stained with H & E revealed nearly intact myofibers which were closely bound to each other and presence of large amounts of intact fibrous connective tissue (Fig. 1). The light micrographs of camel burger treated with ginger extract (7%) revealed multiple longitudinal and cross breaks across the muscle fibers with increased interfibrillar space and appearance of spaces between muscle fibers in addition to slight destructive effect on connective tissue (Fig. 2). These microscopic observations are in consistent with the scanning electron micrographs of buffalo meat treated with ginger extract examined by Naveena and Mendiratta (2004) who recorded disintegration of myofibrillar structure with high amount of exudate and appearance of voids between muscle fibers. They explained these observations by degradation of endomysial collagen and sarcolemma surrounding muscle fiber. Moreover, the transmission electron microscopy micrographs of ginger treated meat examined by Lee et al. (1986) revealed extensive fragmentation of myofibrils associated with widespread degradation of thin filaments in the I-bands. The micrographs of burger patties treated with papain (0.01%) revealed fragmentation of muscle fibers with noticeable effect on connective tissue (Fig. 3). However, the micrographs of samples treated with combinations of ginger (7%) and papain (0.005%) revealed extensive muscle degradation with sever destructive effect on connective tissue (Fig. 4).

4. Conclusion

Addition of ginger, papain and their mixture to camel meat burger patties during formulation resulted in significant increase of the collagen solubility and sensory scores of juiciness, tenderness and overall acceptability and significant reduction of the shear force values. Moreover, ginger extract and papain resulted in improvement of the lipid stability of treated burger patties. Therefore, from this study, it can be concluded that addition of ginger extract and papain powder to the meat during formulation of camel burger patties can improve their physicochemical characteristics as well as sensory properties during storage. Moreover, they can be applied in the industrial scale and household level as an easy method to improve camel burger patties quality and prevent lipid oxidation during storage.

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