J. Food and Dairy Sci., 3rd Mansoura International Food Congress (MIFC) October: 13 - 19, 2018

Tenderization of Camel Meat by Alkaline and Acidic Proteases from Mullet (*Mugil cephalus*) Viscera

Shalaby, M. T.[1]; A. S. Osheba[2]; M. M. Khalil[1]; A. D. El-Dhshan[1] and M. Fekry[2]
[1]Food Industries Department, Faculty of Agriculture, Mans. Univ., Mansoura, Egypt.
[2]Meat and Fish Technology Research Department, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt.

ABSTRACT

Recently, tenderness of meat become more interest due to its relation with meat quality. Camel meat chunks were tenderized by injected with 20 and 40U of alkaline and acidic proteases which extracted from mullet viscera for 2, 4 and 6 hrs at room temperature. Alkaline and acidic proteases increased moisture content, WHC values, solubility of collagen, sarcoplasmic, myofibrillar and total protein of treated camel meat chunks. On the other hand, decreased protein content, cooking loss and shear force values of treated camel meat chunks. Sensory evaluation appeared improvement in juiciness, tenderness and overall acceptability of all treated camel meat chunks compared to untreated camel meat (control sample) with no significant differences in appearance and flavor between all camel meat samples. The results indicated that, camel meat chunks were tenderized and improved their quality by treated with alkaline and acidic mullet proteases.

Keywords: Mullet alkaline proteases; Mullet acidic proteases; Camel meat; Tenderization.

INTRODUCTION

The fish industry generates a significant amount of wastes such as viscera, fins, scales, skin, and bones which represents a disposal and pollution problem (Archer *et al.*, 2001 and Osheba and El-Beltagy, 2007). The search for extraction of proteases from different sources such as fish viscera has increased in the last years with an estimation of nearly 50% of total industrial enzyme sales consisting of proteases. They have diverse applications in a wide variety of industries such as detergent, food, pharmaceutical, leather, and for the recovery of silver from used X-ray films (Gupta *et al.*, 2002 and Chellappan *et al.*, 2006).

The general estimate of the camel world population may probably be around 30 million head. In recent years, camel meat and milk have become increasingly available in many countries for the beneficial health benefits. The most important product from the camel is meat due to the high nutritive value "higher moisture, amino acid and inorganic mineral, with less fat content, lower cholesterol levels and relatively high in polyunsaturated fatty acid". In 2011 camel meat contributed approximately 338,289 tons which represented only 0.18% of total red meat production. Also, in 2011 Egypt is importing live slaughter camels with equivalent 19 million $ US and has the highest slaughtering rate of 121% which slaughtering the equivalent of more than its own camel population (Gheisari and Ranjbar, 2012; Faye, 2013 and Kadim *et al.*, 2014).

On the other hand, the main problems and constraints associated with camel meat are toughness and some undesirable flavors especially for an occasional consumer. Unacceptable tough of camel meat may be due to the age factor, since almost all old camels are slaughter (Kurtu, 2004). Meat toughness can be subdivided into actomyosin toughness, which is attributable to changes in myofibrillar proteins, and background toughness, which is attributable to connective tissues. Also the structure of collagen and elastin is a significant factor that affects the texture of meat (Takagi *et al.*, 1992). There are several means for tenderizing meat, chemically or physically, which mainly reduce the amounts of detectable connective tissues without causing extensive degradation of myofibrillar proteins. Treatment by proteolytic enzymes is one of the popular methods for meat tenderization. At present, several researches interest of tenderize camel meat by proteolytic enzymes such as those by Abdeldaiem and Ali (2014) who used plant proteolytic enzymes from fresh ginger rhizome (*Zingiber officinale*) for improving tenderness and overall qualities of tough aged camel meat. They marinated camel meat chunks with 15, 30 and 45% ginger extract for 48 hr at 4±1°C and the results showed an increase in solubility of sarcoplasmic , myfibrillar proteins and collagen of treated aged camel meat chunks. Also, they noticed a significant improvement in appearance, flavor, tenderness and juiciness of ginger extract treated samples compared to control samples, also they found that, 30% ginger extract treatment was the optimum level to achieve the best tenderization effect for aged camel meat. Moreover, Abdel-Naeem and Mohamed (2016) who added tenderizing agents as followed 7% ginger extract, 0.01% papain and mixture (5% ginger extract and 0.005% papain) in the formulation of camel meat burger patties to improve the physico-chemical and sensory characteristics of the product which increased the collagen solubility and sensory scores (juiciness, tenderness and overall acceptability) with reduction of the shear force values.

This study was carried out to tenderize camel meat by 20 and 40 U of alkaline and acidic proteases which extraction and purification from the viscera of mullet (*Mugil cephalus*) fish at room temperature (25±2°C) for 2, 4 and 6 hours.

MATERIALS AND METHODS

Materials

1. Camel meat:

Camel meat was purchased from the local market at Giza City, Egypt. Cut camel meat into chunks around 100 gm and divided randomly into five groups: untreated (control), treated chunks with 20U of mullet alkaline proteases; treated chunks with 40U of mullet alkaline proteases; treated chunks with 20U of mullet acidic proteases and treated chunks with 40U of mullet acidic proteases .

2. Mullet alkaline proteases

Alkaline proteases were extracted from viscera of mullet (*Mugil cephalus*) fish by used cold acetone and diethyl ether and dried over night at room temperature to obtained the acetone powder which mixed with distilled

water and the resulted supernatant was crude alkaline proteases then purified by ammonium sulfate precipitation (40-60%); dialysis against 0.05 M Tris-HCl buffer at pH 7.8 for 24hrs at 4°C and finally purified by gel filtration on Sephadex G-50 as shown in (Shalaby *et al.*, 2016).

Mullet acidic proteases

Acidic proteases were extracted from viscera of mullet (*Mugil cephalus*) fish by used cold acetone and diethyl ether and dried over night at room temperature to obtained the acetone powder which mixed with distilled water, adjusted the pH of resulted supernatant to 2.5 by 0.1 N HCl, then readjusted to pH 5.0 by 0.1 N NaOH. The resulted supernatant was crude acidic proteases which purified by ammonium sulfate precipitation (40-60%); dialysis against 0.05 M Sodium acetate buffer at pH 5.0 for 24hrs at 4°C and finally purified by gel filtration on Sephadex G-50

Methods

Tenderization of camel meat by mullet alkaline and acidic proteases

1. Tenderization of camel meat chunks by mullet alkaline proteases

Camel meat chunks were injected with 20 and 40U of mullet alkaline proteases and permitted to settle at room temperature (25±2°C) for 2, 4 and 6 hrs.

2. Tenderization of camel meat chunks by mullet acidic proteases

Camel meat chunks were injected with 20 and 40U of mullet acidic proteases and permitted to settle at room temperature (25±2°C) for 2, 4 and 6 hrs.

Chemical composition:

Moisture, protein (total nitrogen × 6.25), crude fat, ash contents were determined according to the methods described in the AOAC (1995).

Physical characteristics:

1. Determination of pH:

The pH was evaluated by homogenate camel meat sample (10 gm) with distilled water (100 ml) for 30 sec. Then, The pH was measured by a pH-meter (Jenway 3510, UK) at 25ºC as the method which described by Hood (1980) and AOAC (1995).

2. Determination of water holding capacity (WHC):

Water holding capacity (WHC) as an indication for tenderness was assessed using filter paper press as the method which described by Soloviev (1966): The minced sample (0.3 gm) was set on ashless filter paper (Watman, No. 41) and used a 1 Kg weight to press for 10 minutes. The planimeter (Placom KP-90N, Japan) be used for measurement the surface areas of two zones which formed on the ashless filter papers. Water holding capacity as cm^2/0.3gm was calculated by subtract the area of the internal zone from that of the outer one.

3. Determination of cooking loss (%):

Cooking loss was calculated as reported by Neel *et al.* (1987). Samples of camel meat were wiped by blotting paper then accurately weighed before cooking. After cooking, cooled and wiped the camel meat samples and immediately weighed. The decrease which occurs in camel meat samples weight after cooking divided on camel meat sample weight before cooking was commonly referred to as a percentage of cooking loss.

4. Shear force (N/cm^2) measurement:

Camel meat samples were cooked and then cooled to room temperature. Rectangular samples (cross section, 1×1cm), 5cm long with fibers parallel to the long axis were used for determination of the shear force. Each rectangular sample was sheared with a Warner-Bratzler shear force (WBSF) device attached to an universal testing machine (Cometech, B type, Taiwan) with a 55 Kg tension/ compression load cell and the crosshead speed was set at 200 mm/min (Shackelford *et al.*, 2004).

4. Collagen content and solubility:

Collagen content and solubility depend on hydroxyproline content and solubility of camel meat samples. Hydroxyproline content for samples of camel meat was evaluated using steps described by Abdeldaiem and Ali (2014) based on the procedure of Lin and Kuan (2010).

5. Sarcoplasmic, myofibrillar and total protein solubility:

Sarcoplasmic protein solubility and total protein solubility was determined by the method described by Joo *et al.* (1999). Myofibrillar protein concentrations were obtained by difference between total and sarcoplasmic protein solubility. Total protein solubility was expressed as mg of protein/gm of sample..

6. Sensory evaluation:

The sensory evaluation was carried out for untreated camel meat chunk and tenderized camel meat chunk samples with mullet alkaline and acidic proteases. To prepare cooked camel meat chunks were washed, drained and treated for 6 hrs with different concentrations (20U and 40U) of mullet alkaline and acidic proteases, then cooked for 30 min in boiling water. The cooked meat samples were evaluated for their appearance, flavor, juiciness, tenderness. The panel scores were obtained as described by Abdeldaiem and Ali, (2014).

RESULTS AND DISCUSSION

1. Chemical composition of camel meat

Data presented in Table (1) showed the chemical composition of different camel meat chunks as affected by mullet alkaline and acidic proteases. The chemical composition of camel meat samples was 74.65, 75.54, 76.38, 75.73, 76.69% moisture; 21.14, 20.39, 19.70, 20.25, 19.44% protein; 2.71, 2.61, 2.52, 2.59, 2.49% fat; 1.42, 1.38, 1.32, 1.36, 1.30% ash and 0.08, 0.08, 0.08, 0.07, 0.08% carbohydrates for untreated camel meat sample (control), treated camel meat with 20 and 40U of mullet alkaline proteases and treated camel meat with 20 and 40U of mullet acidic proteases, respectively.

These values were line within ranges reported for camel meat by Osheba and Nagy (2006) who reported that, fresh camel meat contained 75.42% moisture; 21.25% protein; 2.31% fat and 1.02% ash. Kadim *et al.* (2013a) found that, chemical composition of camel meat from six muscles ranged from 63.0 to 77.7% moisture; 17.1 to 22.1% protein; 1.9 to 6.2% fat and 0.85 to 1.0% ash. Abdeldaiem and Ali (2014) who reported that, the camel meat contained 75.18% moisture; 21.35% protein; 2.25% fat; 1.07% ash and 0.15% carbohydrates.

Table 1. Chemical composition of camel meat as affected by the concentration of mullet alkaline and acidic proteases after 6 hrs of injection.

Treatments	Chemical composition (%)					MIR (%)
	Moisture	Protein	Fat	Ash	TC	
Control(untreated)	74.65	21.14	2.71	1.42	0.08	-
Meat injected with MKP (20 U/ 100g)	75.54	20.39	2.61	1.38	0.08	1.19
Meat injected with MKP (40 U/ 100g)	76.38	19.70	2.52	1.32	0.08	2.32
Meat injected with MCP (20 U/ 100g)	75.73	20.25	2.59	1.36	0.07	1.44
Meat injected with MCP (40 U/ 100g)	76.69	19.44	2.49	1.30	0.08	2.73

Whereas: TC= Total carbohydrates calculated by difference; MIR= Moisture increment ratio due to injection with different concentration of mullet alkaline and acidic proteases; MKP= Mullet alkaline proteases; MCP= Mullet acidic proteases.

Also, Table (1) showed that, the increment rate in moisture content of treated camel meat chunks was 1.19, 2.32, 1.44, 2.73% due to injection with 20 and 40U of mullet alkaline proteases and mullet acidic proteases, respectively. This increment of moisture indicates improvement in hydrophilic properties by the enzyme treatment (Naveena *et al.*, 2004 and Abdeldaiem and Ali, 2014).

2. pH values and physical properties of camel meat

pH values and some physical properties (WHC, cooking loss and shear force) of camel meat chunks as affected by mullet alkaline proteases and mullet acidic proteases for 2, 4 and 6 hrs are shown in Table (2). The pH values of untreated camel meat (control sample) were 5.82, 5.76 and 5.64 after 2, 4 and 6 hrs, respectively at room temperature (25±2°C). These values within the normal range for camel meat as reported by Kadim *et al.* (2013a) who found that, pH value of dromedary camel muscles ranged from 5.61 to 5.83. And, Al-Owaimer *et al.* (2014) who reported that, the pH value of Arabian camel meat ranged from 5.75 to 5.97. Also, it could be noticed that, relative increase in pH values of camel meat samples treated with mullet alkaline proteases especially when used 40U/100gm from 5.82 for control to 6.28 after 2 hrs of tenderization. This increase might be due to injection with mullet alkaline proteases which has pH value 7.8. On the other hand, pH values of camel meat samples treated with mullet acidic proteases were decreased especially with 40U from 5.82 for control to 5.31 after 2 hrs of tenderization, this decreased may be due to injection with acidic proteases which had pH value 5.0. Also, the pH values of treated camel meat samples were affected by time of tenderization.

The ability of meat to retain inherent water, defined as water holding capacity (WHC), is an essential quality parameter of meat. For the meat processing, the WHC of fresh meat is known to influence its technological quality (Maqsood *et al.*, 2015). Data in Table (2) cleared that, control sample had higher water holding capacity (i.e., lower values) when compared with treated camel meat samples by mullet alkaline and acidic proteases at any concentration or any time of tenderization. The values of WHC of control sample were 2.60, 2.64 and 2.72 cm^2/0.3gm after 2, 4 and 6 hrs, respectively. Generally, camel meat samples treated with 20 and 40U of mullet alkaline and acidic proteases had slightly higher WHC values compared to control sample. Water holding capacity of camel meat chunks treated with 40U of mullet alkaline proteases and mullet acidic proteases after 6 hrs were 3.39 and 3.42 cm^2/0.3gm, respectively. These results are in agreement with those obtained by Babiker and Yousif (1990) who reported that, water holding capacity of three muscles, i.e., L. dorsi muscles, Semitendinosus muscle and Triceps brachii muscle of the desert camel meat were 2.8, 2.1 and 2.32 cm^2/0.3gm, respectively. Whereas, Abdeldaiem and Ali (2014) found that, WHC values of untreated camel meat chunks was 1.90 cm^2/0.3gm and noticed increase in WHC values of camel meat samples treated with 15, 30 and 45% levels of ginger extract were 5.50, 6.10 and 5.70 cm^2/0.3gm, respectively. The decrease in WHC of treated samples might be due to degradation of proteins by mullet proteases which led to decrease protein capacity to bind water.

Also Table (2) presented that, cooking loss values of untreated camel meat sample were 33.67, 34.23 and 36.06% after 2, 4 and 6 hrs at room temperature. These results are close to the results obtained by Babiker and Yousif (1990) who recorded that, the cooking loss of three muscles from the desert camel meat ranged from 33.23 to 37.95%. Also, Kadim *et al.* (2013a) reported that cooking loss of *infraspinatus*, *longissimus thoracis* and *semimembranosus* muscles of the dromedary camel carcasses were 31.6, 33.5 and 30.6%, respectively. Meanwhile, Kadim *et al.* (2006) reported that, the maximum cooking loss of the Omani one-humped Arabian camel meat slaughtered at 3 - 5 years old was 29.88% and older camel meat had lower cooking loss. Moreover, the results obvious that, camel meat chunks treated with mullet alkaline and acidic proteases had lower cooking loss than control sample (36.06%) especially at 40U for 6hrs which recorded 29.42 and 35.22%, respectively. Also, it could be noticed that tenderization by mullet alkaline proteases led to reduction in cooking loss compared with tenderization by mullet acidic proteases.

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 (Abdel-Naeem and Mohamed, 2016). The effect of two concentrations (20 and 40U) of mullet alkaline and acidic proteases on shear force of cooked camel meat chunks are shown in Table (2). Shear force of control sample after 6 hrs from tenderization was 55.34 N/cm^2, whereas treated camel meat chunks with (20, 40U) mullet alkaline and acidic proteases for 6 hours recorded shear force values (40.65, 37.18 N/cm^2) and (39.78, 35.70 N/cm^2), respectively. The results showed that, the shear force values of treated camel meat chunks were lower (higher meat tenderness) compared to control sample, especially at 40U of mullet acidic proteases for 6 hrs. In this concern, Naveena *et al.* (2004) mentioned that, shear force values were significantly reduced in all cooked buffalo meat chunks treated with some plant proteases

from 40.52 N/cm^2 for control to 22.25 and 21.70 N/cm^2 for treated samples with extracts from cucumis and ginger, respectively. The higher shear force values of control samples might be attributed to the high amount of connective tissue in camel meat as reported by Abdel-Naeem and Mohamed, (2016). Meat connective tissue protein hydrolysis is considered to be a key factor in determining meat tenderness. Hydrolysis of these proteins had been shown to disrupt connective tissue structure, with an associated decrease in shear force and an improvement in meat tenderness (Ha *et al.*, 2012).

Table 2. pH values and physical properties of camel meat chunks as affected by 20 and 40U of mullet alkaline and acidic proteases for 2, 4 and 6 hrs.

Samples	Time of treatment (hours)	Raw meat		Cooked meat	
		pH values	WHC (cm^2/0.3gm)	Cooking loss (%)	Shear force (N/cm^2)
Control (untreated)	2 hrs.	5.82	2.60	33.67	55.70
	4 hrs.	5.76	2.64	34.23	55.45
	6 hrs.	5.64	2.72	36.06	55.34
Meat injected with MKP (20 U/ 100g)	2 hrs.	6.07	3.22	32.10	50.23
	4 hrs.	6.19	3.26	33.21	46.34
	6 hrs	6.27	3.33	34.91	40.65
Meat injected with MKP (40 U/ 100g)	2 hrs.	6.28	3.31	30.89	48.76
	4 hrs.	6.47	3.35	30.12	44.54
	6 hrs	6.64	3.39	29.42	37.18
Meat injected with MCP (20 U/ 100g)	2 hrs.	5.42	3.25	33.76	50.11
	4 hrs.	5.48	3.28	34.61	44.32
	6 hrs.	5.59	3.35	35.51	39.78
Meat injected with MCP (40 U/ 100g)	2 hrs.	5.31	3.34	33.62	45.87
	4 hrs.	5.37	3.38	34.46	39.98
	6 hrs.	5.46	3.42	35.22	35.70

Whereas: N= Newton, MKP= Mullet alkaline proteases, MCP= Mullet acidic proteases.

3. Collagen content and collagen solubility of camel meat

Connective tissue contains predominant proteins such as collagen which known as source of meat toughness. Muscle characteristics, collagen content, solubility and the activities of proteases are the most important physiological parameters that determine tenderness of meat (Kadim *et al.*, 2013b). As shown in Table (3) it could be noticed that, collagen content of control samples after 2, 4 and 6 hrs was 7.12, 7.23 and 7.20 mg/gm tissue, respectively. Treatment of camel meat chunks with (20, 40U) mullet alkaline and acidic proteases causes slight increase in collagen contents of these samples which recorded (7.32, 7.35 mg/gm tissue) and (7.32, 7.36 mg/gm tissue), respectively. These results are in accordance with Abdeldaiem and Ali (2014) who stated that, collagen content of camel meat chunks was 7.34 mg/g and this value slightly increased to 7.92, 8.15 and 8.27 mg/gm by treating camel meat with 15, 30 and 45% of ginger extracts, respectively.

Also, from data in Table (3) it could be observed that, camel meat samples treated with mullet proteases had higher collagen solubility than untreated camel meat (control sample) during time of tenderization. Collagen solubility of untreated camel meat was 7.01, 7.20 and 7.46% after 2, 4 and 6 hrs of treatment time at room temperature. Moreover, collagen solubility of camel meat samples treated with mullet alkaline proteases was higher than that treated with mullet acidic proteases specially with high concentration of proteases (40U) at 6 hrs. Collagen solubility of camel meat samples treated with 40U of mullet alkaline and acidic proteases after 2, 4 and 6 hrs at room temperature was (11.24, 17.23, 21.76%) and (8.16, 10.45, 12.98%), respectively.

Table 3. Collagen content and collagen solubility of camel meat chunks as affected by 20 and 40U of mullet alkaline and acidic proteases.

Samples	Time of treatment (hours)	Collagen content (mg/gm tissue)	Collagen solubility (%)
Control (untreated)	2 hrs.	7.12	7.01
	4 hrs.	7.23	7.20
	6 hrs.	7.20	7.46
Meat injected with MKP (20 U/ 100g)	2 hrs.	7.28	9.23
	4 hrs.	7.30	12.70
	6 hrs	7.32	17.82
Meat injected with MKP (40 U/ 100g)	2 hrs.	7.30	11.24
	4 hrs.	7.32	17.23
	6 hrs	7.35	21.76
Meat injected with MCP (20 U/ 100g)	2 hrs.	7.27	7.67
	4 hrs.	7.30	9.81
	6 hrs.	7.32	10.73
Meat injected with MCP (40 U/ 100g)	2 hrs.	7.34	8.16
	4 hrs.	7.35	10.45
	6 hrs.	7.36	12.98

Whereas: MKP= Mullet alkaline proteases, MCP= Mullet acidic proteases.

These results are in agreement with other studies which treated camel meat and their products with proteolytic enzyme extracts such as Abdeldaiem and Ali (2014) who observed that high significant in collagen solubility values of all treated samples with ginger extracts especially at high concentration which recorded 14.05, 17.69 and 20.81% when treated camel meat with 15, 30 and 45% of ginger extract, respectively compared with collagen solubility of control 7.34%. Moreover, Abdel-Naeem and Mohamed (2016) who reported that collagen solubility values of all treated formulas of camel burger were significantly higher than control sample (3.9%), whereas the highest collagen solubility value was obtained when treated with combinations of ginger and papain

(26.8%) followed by samples treated with ginger only (22.7%) and then samples treated with papain only (14.3%).

4. Sarcoplasmic, myofibrillar and total protein solubility of camel meat.

The protein solubility changes were due to myofibrillar protein degradation. Protein solubility is used as an indicator of protein denaturation, and low protein solubility indicated a high extent of protein denaturation (Joo *et al.*, 1999 and Maqsood *et al.*, 2015).

The solubility of sarcoplasmic, myofibrillar and total protein of camel meat chunks as affected by mullet proteases and their concentrations are shown in Table (4). Results illustrated marginally increase in the sarcoplasmic protein solubility values of treated camel meat chunks with (20, 40U) mullet alkaline and acidic proteases after tenderization for 6 hrs which recorded (23.87, 24.57 mg/gm) and (20.59, 22.88 mg/gm), respectively in comparison to control (18.75 mg/gm). On the other hand, high increment in both of myofibrillar and total protein solubility values were observed especially samples treated with 40U of mullet alkaline and acidic proteases for 6 hrs which recorded (88.28, 112.85 mg/gm) and (74.70, 97.58 mg/gm), respectively compared to 64.92 and 83.67 mg/gm for control sample, respectively. Also it could noticed that myofibrillar and total protein solubility values of camel meat treated with mullet alkaline proteases were higher than those treated with mullet acidic proteases. The previous results are in accordance with Abdeldaiem and Ali (2014) reported marginally increase in the sarcoplasmic protein solubility of camel meat chunks treated with 15, 30 and 45% ginger extract which recorded 21.87, 22.07 and 22.53 mg/gm, respectively compared with control sample (20.34 mg/gm). Also, they reported that, high significant increase in both myofibrillar and total protein solubility values of all treated camel meat chunks by different concentrations of ginger extracts which recorded 74.46 and 96.33 mg/gm for 15%; 75.95 and 98.02 mg/g for 30% and then 77.21 and 99.74 mg/gm for 45% in comparison to 61.83 and 82.17 mg/gm for untreated camel meat chunks, respectively. Naveena *et al.* (2004) they observed only marginally increased in sarcoplasmic protein solubility values of buffalo meat chunks treated with papain and enzyme extracts of cucumis and ginger compared with control sample. In addition, significantly higher myofibrillar and total protein solubility values were observed in all treated buffalo meat chunks compared to control.

Table 4. Sarcoplasmic, myofibrillar and total protein solubility of camel meat as affected by 20 and 40U of mullet alkaline and acidic proteases.

Samples	Time of Treatment (hours)	Sarcoplasmic protein solubility (mg/gm)	Myofibrillar protein solubility (mg/gm)	Total protein solubility (mg/gm)
Control (untreated)	2 hrs.	18.27	64.37	82.64
	4 hrs.	18.36	64.62	82.98
	6 hrs.	18.75	64.92	83.67
Meat injected with MKP (20 U/100g)	2 hrs.	19.62	67.03	86.65
	4 hrs.	21.31	73.97	95.28
	6 hrs	23.87	80.18	104.05
Meat injected with MKP (40 U/100g)	2 hrs.	19.89	70.32	90.21
	4 hrs.	22.43	77.81	100.24
	6 hrs	24.57	88.28	112.85
Meat injected with MCP (20 U/100g)	2 hrs.	18.51	65.36	83.87
	4 hrs.	19.78	66.56	86.34
	6 hrs	20.59	70.13	90.72
Meat injected with MCP (40 U/100g)	2 hrs.	18.98	66.11	85.09
	4 hrs.	20.67	68.79	89.46
	6 hrs	22.88	74.70	97.58

Whereas: MKP= Mullet alkaline proteases, MCP: Mullet acidic proteases.

5. Organoleptic evaluation of cooked camel meat.

Sensory properties of cooked camel meat chunks as affected by mullet alkaline and acidic proteases and their concentrations were presented in Table (5). From statistical analysis of these data, it could be noticed that, no significant differences ($p>0.05$) in appearance scores between the control sample (7.50) and all treated camel meat chunks which ranged from 7.45 to 7.55.

Also, no significant differences ($p>0.05$) in flavor scores between all camel meat samples. Flavor scores of treated camel meat samples were insignificantly increased by increasing proteases extract concentration from 20 to 40U. The highest score (7.30) of flavor was recorded for camel meat sample treated with 40U of mullet alkaline proteases. Meanwhile, the lowest score of flavor (7.05) was recorded for the control sample. Finally, it could be concluded that, mullet alkaline and acidic proteases led to improving the flavor of camel meat chunks. In this concern, Naveena *et al.* (2004) reported the meat chunks treated with cucumis and ginger extracts, and papain received high score for flavor.

Also, from statistical analysis of these data, it could be observed that, there were significant differences ($p<0.05$) in juiciness, tenderness and overall acceptability scores between treated camel meat samples with mullet proteases and control sample. All camel meat samples which treated with alkaline and acidic mullet proteases had significantly higher juiciness and tenderness scores than untreated camel meat (control sample). The highest scores of juiciness (7.70) and tenderness (7.55) were recorded for camel meat treated with 40U of mullet alkaline proteases whereas, sample treated with 40U mullet acidic proteases obtained 7.20 and 6.85 for juiciness and tenderness, respectively. While, the lowest scores for juiciness (6.15) and tenderness (5.80) were recorded for the control sample.

Overall acceptability of all camel meat samples ranged from 6.62 to 7.51. The highest overall acceptability score (7.51) was recorded by panelists for camel meat sample treated with 40U of mullet alkaline proteases followed by 20U mullet alkaline proteases (7.30); 40U mullet acidic proteases (7.17) and finally 20U bolti acidic proteases (7.11) with no significant differences between them.

Table 5. Sensory properties of cooked camel meat as affected by 20 and 40U of mullet alkaline and acidic proteases.

Treatments	Sensory properties				
	Appearance	Flavor	Juiciness	Tenderness	Overall acceptability
Control (untreated)	7.50^{a}	7.05^{b}	6.15^{e}	5.80^{e}	6.62^{c}
Meat injected with MKP (20 U/100g)	7.55^{a}	7.15^{ab}	7.35^{bc}	7.15^{bc}	7.30^{ab}
Meat injected with MKP (40 U/100g)	7.50^{a}	7.30^{ab}	7.70^{a}	7.55^{a}	7.51^{a}
Meat injected with MCP (20 U/100g)	7.50^{a}	7.10^{ab}	6.90^{d}	6.60^{d}	7.02^{bc}
Meat injected with MCP (40 U/100g)	7.45^{a}	7.20^{ab}	7.20^{bcd}	6.85^{bc}	7.17^{ab}
LSD at 0.05 level	0.32^{ns}	0.33^{ns}	0.31^{*}	0.36^{*}	0.41^{*}

Whereas: Mean values in the same column with the same letter are not significant different at 0.05 level.
*= Significant, ^{ns} = non-significant, LSD= least significant differences.
MKP= Mullet alkaline proteases, MCP= Mullet acidic proteases.

Improvement of flavor, juiciness and tenderness for treated samples are consistent with other reports by Ziauddin *et al.* (1995) they noticed that, improvement of appearance, flavor and juiciness of buffalo meat samples treated with ginger extract and organic acids. Naveena *et al.* (2004) reported that, meat chunks treated with cucumis and ginger extracts, and papain received high scores for flavor, juiciness, tenderness and overall acceptability compared with that of control. Improvement eating satisfaction of cooked treated camel meat chunks especially samples treated with mullet alkaline proteases extract agreement with observed increases in solubility of both collagen and protein. Hydrolyze collagen derived from the connective tissues has excellent water binding capacity and is able to improve the tenderness of the cooked meats (Badr, 2008). Moreover, Abdeldaiem and Ali (2014) they observed that treatment with ginger extract improved flavor, juiciness and tenderness scores of treated camel meat chunks compared to the control.

CONCLUSION

Alkaline and acidic proteases which extracted from mullet viscera are effective means for tenderization tough meat such as camel meat through its action on collagen, myofibrillar and proteins. In addition to improvement the camel meat quality.

REFERENCES

Abdeldaiem, M. H. H. and Ali, G. M. (2014). Tenderization of camel meat by using fresh ginger (*Zingiber officinale*) extract. Food Science and Quality Management, 23, 25–38.

Abdel-Naeem, H. H. S. and Mohamed, H. M. H. (2016). Improving the physico-chemical and sensory characteristics of camel meat burger patties using ginger extract and papain. Meat Science, 118, 52–60.

Al-Owaimer, A. N.; Suliman, G. M.; Sami, A. S.; Picard, B. and Hocquette, J. F. (2014). Chemical composition and structural characteristics of Arabian camel (*Camelus dromedarius*) *m. longissimus thoracis*. Meat science, 96, 1233–1241.

AOAC (1995). Official Methods of Analysis, 16th Ed. Association of Official Analytical Chemists. Arlington Virginia, 22201, USA.

Archer, M.; Watson, R. and Denton, J. W. (2001). Fish Waste Production in the United Kingdom-The Quantities Produced and Opportunities for Better Utilization. SEAFISH report number: SR537.

Babiker, S. A. and Yousif, O. Kh. (1990). Chemical composition and quality of camel meat. Meat Science, 27, 283–287.

Badr, H. M. (2008). Tenderness properties and microbial safety of spent hen meat treated by papain and gamma irradiation. Journal of Radiation Research and Applied Sciences, 1, 443–462.

Chellappan, S.; Jasmin, C.; Basheer, S. M.; Elyas, K. K.; Bhat, S. G. and Chandrasekaran, M. (2006). Production, purification and partial characterization of a novel protease from marine *Engyodontium album* BTMFS10 under solid state fermentation. Journal of Process Biochemistry, 41, 956–961.

Faye, B. (2013). Camel Meat in the World, *In*: Camel Meat and Meat Products. Kadim, I. T.; Mahgoub, O.; Faye, B. and Farouk, M. M. (Eds.), CABI International, Wallingford, England, p. 1–16.

Gheisari, H. R. and Ranjbar, V. R. (2012). Antioxidative and antimicrobial effects of garlic in ground camel meat. Turkish Journal of Veterinary and Animal Sciences, 36, 13–20.

Gupta, R.; Beg, Q. and Lorenz, P. (2002). Bacterial alkaline proteases: molecular approaches and industrial applications. Journal of Applied Microbiology Biotechnology, 59, 15–32.

Ha, M.; Bekhit, A. E.; Carne, A. and Hopkins, D. L. (2012). Characterisation of commercial papain, bromelain, actinidin and zingibain protease preparations and their activities toward meat proteins. Food Chemistry, 134, 95–105.

Hood, D. E. (1980). Factors affecting the rate of metmyoglobin accumulation in prepackage beef. Meat Science, 4, 47–50.

Joo, S. T.; Kauffman, R. G.; Kim, B. C. and Park, G. B. (1999). The relationship of sarcoplasmic and myofibrillar protein solubility to colour and water-holding capacity in porcine *longissimus* muscle. Meat Science, 52, 291–297.

Kadim, I. T.; Al-Karousi, A.; Mahgoub, O.; Al-Marzooqi, W.; Khalaf, S. K.; Al-Maqbali, R. S.; Al-Sinani, S. S. and Raiymbek, G. (2013a). Chemical composition, quality and histochemical characteristics of individual dromedary camel (*Camelus dromedarius*) muscles. Meat Science, 93, 564–571.

Kadim, I. T.; Mahgoub, O.; Al-Marzooqi, W.; Al-Zadjali, S.; Annamalai, K. and Mansour, M. H. (2006). Effects of age on composition and quality of muscle *Longissimus thoracis* of the Omani Arabian camel (*Camelus dromedaries*). Meat Science, 73, 619–625.

Kadim, I. T.; Mahgoub, O.; Faye, B. and Farouk, M. M. (2013b). Camel meat and meat products. CABI International, Wallingford, England.

Kadim, I. T.; Mahgoub, O. and Mbagat, M. (2014). Potential of camel meat as a non-traditional high quality source of protein for human consumption. Animal Frontiers, 4, 13–17.

Kurtu, M. Y. (2004). An assessment of the productivity for meat and carcass yield of camel (*Camelus dromedarius*) and of the consumption of camel meat in the eastern region of Ethiopia. Tropical Animal Health and Production, 36, 65–76.

Lin, Y. K. and Kuan, C. Y. (2010). Development of 4-hydroxyproline analysis kit and its application to collagen quantification. Food Chemistry, 119, 1271–1277.

Maqsood, S.; Abushelaibi, A.; Manheem, K. and Kadim, I. T. (2015). Characterisation of the lipid and protein fraction of fresh camel meat and the associated changes during refrigerated storage. Journal of Food Composition and Analysis, 41, 212 –220.

Naveena, B. M.; Mendiratta, S. K. and Anjaneyulu, A. S. R. (2004). Tenderization of buffalo meat using plant proteases from *Cucumis trigonus Roxb* (Kachri) and *Zingiber officinale roscoe* (Ginger rhizome). Meat Science, 68, 363–369.

Neel, S. W.; Reagan, J. O. and Mabry, J. W. (1987). Effects of rapid chilling and accelerated processing on the physical and sensory characteristics of fresh pork loins. Journal of Animal Science, 64, 765–773.

Osheba, A. S. and El-Beltagy, A. E. (2007). Purification and characterization of alkaline proteases from the viscera of mackerel (*Scumber scumbrus*) and macaroni fish (*Saurus tumbil*). Egyptian Journal of Food Science, 35, 71–82.

Osheba, A. S. and Nagy, K. S. (2006). Production and evaluation of extruded foods fortified with animal proteins. Annals Agriculture Science., Ain Shams Univ., Cairo, 51, 135-154.

Shackelford, S. D.; Wheeler, T. L. and Koohmaraie, M. (2004). Evaluation of sampling, cookery, and shear force protocols for objective evaluation of lamb Longissimus tenderness. Journal of Animal Science, 82, 802–807.

Shalaby, M. T.; Osheba, A. S.; Khalil, M. M.; El-Dhshan, A. D. and Fekry, M. (2016). Extraction and purification of alkaline protease from mullet fish (*Mugil cephalus*) viscera and its biochemical characteristics. Egyptian Journal of Food Science, 44, 29–46.

Soloviev, V. E. (1966). Meat aging. Food industry. Pub., Moscow, pp. 53–81.

Takagi, H.; Kondou, M.; Tomoaki, H.; Nakamori, S.; Tsai, Y. C. and Yamasaki, M. (1992). Effects of an alkaline elastase from an alkalophilic Bacillus strain on the tenderization of beef meat. Journal of Agricultural and Food Chemistry, 40,2364–2368.

Ziauddin, S. K.; Rao, D. N. and Amla, B. L. (1995). Effect of lactic acid, ginger extract and sodium chloride on electrophoretic pattern of buffalo muscle proteins. Journal of Food Science and Technology, 32, 224–226.

تطرية اللحم الجملى بالبروتييزات القاعدية و الحامضية من أحشاء سمك البورى

محمد طه شلبى[١] عاطف سعد عشيبة[٢]، منى محمود خليل[١]، أماليكا درويش الدهشان[١] و محمد فكرى[٢]

[١] قسم الصناعات الغذائية, كلية الزراعة ، جامعة المنصورة ، المنصورة ، مصر.

[٢] قسم بحوث تكنولوجيا اللحوم و الأسماك ، معهد بحوث تكنولوجيا الأغذية ، مركز البحوث الزراعية ، الجيزة ، مصر.

تمت معاملة (تطرية) قطع اللحم الجملى عن طريق حقنها بـ ٢٠, ٤٠ وحدة من البروتييزات القاعدية و الحامضية التى تم استخلاصها من أحشاء أسماك البورى ثم تنقيتها (بالترسيب بكبريتات الأمونيا, الديلزة, الترشيح بالجل) و التطرية تمت لمدة ٢, ٤, ٦ ساعات على درجة حرارة الغرفة.عملت كلا من البروتييزات القاعدية و الحامضية على زيادة كلا من محتوى الرطوبة, قيم القدرة على مسك الماء بالاضافة الى زيادة قابلية بروتينات الكولاجين, الساركوبلازميك, الميوفيبريلار على الذوبان فى اللحم الجملى المعامل.فى حين انخفض كلا من المحتوى البروتينى, الفقد أثناء الطبخ, قيم القوة اللازمة للقطع فى اللحم الجملى المعامل بالبروتييزات القاعدية و الحامضية من سمك البورى.كما أظهرت نتائج التقييم الحسى وجود تحسن فى كلا من عصيرية, طراوة, التقبل العام للحم الجملى المعامل بالبروتييزات القاعدية و الحامضية من سمك البورى مقارنة بعينات اللحم الجملى الغير معاملة (الكنترول), مع ملاحظة عدم وجود فروق معنوية من حيث المظهر و النكهة لجميع عينات اللحم الجملى سواء المعاملة و الغير معاملة (الكنترول).