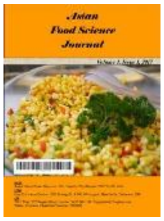

Asian Food Science Journal

6(3): 1-8, 2019; Article no.AFSJ.43880

Nutrititional Quality of *Suya* Prepared from Mutton Using Diffrent Types of Muscles

Sule Bamidele Akinleye[1*], Andrew Babatunde Omojola[1] and Kassim Olayemi Rashidat[1]

[1]Department of Animal Science, University of Ibadan, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2019/43880
Editor(s):
(1) Dr. Marie-Christine Raymond Shakib, Nutrition and Food Science, National Research Center, Egypt.
(2) Dr. Sherif Mohamed Lofti El-Kadi, Associate Professor, Department of Agricultural Microbiology, Damietta University, Damietta, Egypt.
Reviewers:
(1) Rayees Ahmed Bafanda, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu (SKUAST-J), India.
(2) Cristina El Mahdy, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, România.
(3) K. Immaculate Jeyasanta, Suganthi Devadason Marine Research Institute, India.
Complete Peer review History: http://prh.sdiarticle3.com/review-history/28030

Original Research Article

Received 06 July 2018
Accepted 30 September 2018
Published 31 December 2018

ABSTRACT

Mutton is expensive, especially during Muslim festivals. There is a need to increase the value of mutton into value-added products. This study aimed to evaluate the influence of different types of muscles on the physical, chemical, sensory and microbiological properties of suya.
Three different types of muscles (Semitendonisus (ST), Deltodius (DT) and Adductor (ADD)) were harvested from the carcasses of fattened Balami rams. The muscles were grouped into three treatments (ST, DT and ADD) to evaluate for physical properties of mutton and studying the changes in the chemical compositions of suya. The microbiological and sensory attributes of the mutton were measured.
The Water Holding Capacity was highest (P<0.05) in DT (78.17±9.83%) followed by ADD (77.21±9.63%) and least in ST (68.10%). The PY was highest in the DT with a value of 73.83±3.65%, and the lowest was 69.81±2.64% for ST. There were significant differences (P≤ 0.05) among the treatments in chemical analyses; indicated that suya samples from ST muscle had the highest percentage of moisture (23.01±0.51%) compared to the lowest percentages of DT (22.46±0.42%) and ADD treatments (22.43±0.37%) and high protein contents were in ADD (50.14±0.47%) treatment, while lowest contents were in DT (49.44±1.06%) treatments. Suya

**Corresponding author: E-mail: bamideleakinleye@yahoo.com;*

samples from ST treatments contained the lowest content of cholesterol (48.67±5.40 mg/100 g), while DT treatments contained the highest content of cholesterol (53.08±3.96 mg/100 g). However, there were significant differences when compared with suya samples from the DT muscles. This study revealed significant effects of muscles on physical, chemical indices and organoleptic properties of suya due to variation in the muscle fibre.

Keywords: Mutton; Suya; semitendinosus; deltodius and adductor; y; product yield.

1. INTRODUCTION

The nutritional quality is primarily determined by the chemical composition of muscle tissue and post-mortem biochemical changes that lead to its conversion into the meat. Muscle and connective tissues are the most abundant tissues in meat, their properties and relative proportion of each tissue are responsible for the leanness and quality of meat [1]. The structure and composition of muscle result in major differences in meat qualities. Therefore, the hierarchy between the most desired qualitative components varies. Meat quality has always been important to the consumer, and it is an especially critical issue for the meat industry. As consumer demand for high-quality meat is increasing, the meat industry should consistently produce and supply quality meat that is safe and healthy for the consumer to ensure continued consumption of meat products.

Mutton production remains one of the potentials of high-quality protein to meet the increasing demand for meat products. The amount of saturated fat is less than the total amount of unsaturated fat it contains with improves blood cholesterol levels (Suman and Joseph, 2014).

Processing helps in producing varieties and convenient meat products to meet various lifestyle requirements, while preservation aided by processing extends the shelf-life of meat and meat products [2]. *Suya* is primarily prepared from the boneless meat of animals [3]. Muscles meat of almost any kind can be used to increase its keeping quality.

It is believed that there is a relationship between the properties of muscles and physicochemical traits of meat. In light of this, the current study aimed at comparing the effects of muscle types on physicochemical properties, sensory evaluation and microbiological qualities of *suya* produced from *Semitendinosus* (ST), *Deltodius* (DM) and Adductor (ADD) muscles harvested from carcasses of fattened Balami rams.

2. MATERIALS AND METHODS

2.1 Meat Preparation

Mutton used for this study were the *Semitendinosus* (ST), *Deltodius* (DM) and Adductor (ADD) muscles harvested from the carcasses of fattened Balami rams (average age of 14 to 16 months) slaughtered by the Halal method at the slaughter-house of the Department of Animal Science, University of Ibadan. The slaughtered animals were conventionally skinned and eviscerated. Meat samples were packed in polyethene bags and kept in ice bag, transported to the meat laboratory for analysis. On arrival at the laboratory, the external fat, bone and connective tissues were removed from the meat, and then samples from each muscle were collected for physical attribute determinations. All analyses were performed in triplicate.

2.2 Physical Evaluation

2.2.1 Water-holding capacity (WHC)

WHC of meat samples from the ST, DT and ADD muscles were determined with press method as slightly modified by Suzuki et al. [4]. An approximately 1g of meat sample was placed between two 9cm Whatman No.1 filter papers (Model C, Caver Inc, Wabash, USA). The meat sample was then pressed between two 10.2 X 10.2 cm^2 plexi glasses at about 35.2 kg/cm^3 absolute pressure for 1 minute using a vice. The meat samples were removed and oven dried at 105^oC for 24 hours to determine the moisture content. The amount of water released from the meat samples was measured indirectly by measuring the area of filter paper wetted relative to the area of pressed meat samples. Thus, water holding capacity was calculated as follows:

$$WHC = \frac{100 - (Aw - Am) \times 9.47}{Wm \times Mc} \times 100$$

Where:

Aw = Area of water released from meat samples (cm^2)
Am = Area of meat samples (cm2)
Wm = Weight of meat samples (g)
Mc = Moisture content of meat samples (%)
9.47 = a constant factor

2.2.2 Cooking loss (CL %)

Meat sample (150 g) was placed in a tightly sealed polyethene oven bag and heated in a water bath at 75°C until an internal temperature of 71°C (as indicated by a thermocouple) was achieved. The Cook-out was drained and the cooked mass was cooled, dried with filter paper and reweighed. The CL was expressed as the percentage loss related to the initial weight [5].

2.2.3 Shear force (kg/cm^2)

Measurement for shear force value as an indication of meat tenderness was carried out using Warner-Bratzler Shear force (WBSF) apparatus. Samples were cooked into polyethene bags in a water bath using the same cooking method as for cooking loss determination. After cooling, 3–5 muscle cores (1 cm x 1 cm x 3 cm) were cut parallel to the long axis of the muscle fibres, and WBSF values were taken on the cores.

2.3 Preparation of Ingredient for *Suya (tsire)*

Spices and other additives used for the preparation of ingredient for *suya (tsire)* were purchased individually from Bodija Market, Ibadan, Nigeria. All the spices were sundried, milled and mixed thoroughly with powdered groundnut cake and seasoning as shown in Table 1.

2.3.1 Preparation of *Suya*

The ingredient was spread on a clean, dry tray and each stick of meat was properly dusted with the ingredient [6]. An individual *suya* stick, which was about 30 cm long, was weighed and the thin sheets of meat inserted into the *suya* stick. A total of 60 sticks of *suya* were prepared from each muscle type. The weight of ingredient ranged from 16.00-20.00 g, while the weight of *suya* before roasting for 20-25 minutes ranged from 109 g-126 g and the weight of *suya (tsire)* after roasting ranged from 83.95 g-95.95 g. Sticks of *suya* made from each muscle type were labelled for easy identification. After proper coating with the ingredient, the stick of meat was re-weighed and spread back on the tray. About 5-10 ml of groundnut oil was sprinkled on each meat before roasting.

2.3.2 Roasting of *Suya*

Labelled and weighed staked meats were arranged around a glowing, smokeless fire was made from charcoal. The distance of the staked meats to the point of heat was between 24 and 25 cm. The stick meat was allowed to stay on the fire for an average of 20 minutes with the intermittent turning of the samples. Additional groundnut oil was sprinkled on the meat while roasting continued.

2.3.3 Selection of *Suya (tsire)* samples

Total of 120 sticks of *suya (tsire)* was selected out of 180 sticks prepared and used for this study. Twenty (20) sticks of *suya* from each treatment were used for evaluating fresh *suya,* while ten (10) sticks of *suya* from each treatment were preserved and evaluated.

Table 1. Percentage composition of *Suya* ingredient

Name of spices and Additives	Scientific names	%
Groundnut cake powder	(*Arachis hypogaea*)	52.00
Ginger	(*Zingiber officinale*)	5.00
Garlic	(*Allium sativum*)	5.00
Red Dried pepper	*(Capsicum annuum)*	10.00
White pepper	(*Piper nigrum*)	5.00
Curry	(*Murraya koenigii*)	5.00
Salt	(*sodium chloride*)	8.50
Seasoning	(*monosodium glutamate*)	7.50
Groundnut oil		2.00
Total		100.00

Source: Omojola et al. [6]
** 5-10 ml of groundnut oil was added to each stick of meat during roasting*

2.3.4 Percentage of product yield of fresh *Suya (tsire)*

The product yield of *suya* was calculated using the method described by Kembi and Okunbajo [7]. It was expressed as the ratio of the final weight of the product to the initial weight of raw samples of *suya*.

$$\text{Product Yield (\%)} = \frac{\text{Weight of cooked } suya}{\text{Weight of uncooked } suya} \times \frac{100}{1}$$

2.4 Chemical Indices

Proximate composition of moisture content, crude protein, ether extract and ash contents) was determined for *suya* samples using standard analytical methods [8], while the amount of nitrogen-free extract was calculated by differences. Five-gram samples were weighed in duplicate and analysis of lipid oxidation was conducted according to the method of Leick et al. [9] after 24 hours of production. A direct-probe type electrode pH metre was used to determine the pH of meat samples used in *suya* production.

2.5 Mineral Composition

A dry ashing procedure was used for mineral analysis. Calcium (Ca), Iron (Fe), Magnesium (Mg), Sulphur (S), Manganese (Mn) and Zinc (Zn) were measured using Atomic Absorption Spectrophotometer according to the methods of AOAC [10]. Phosphorus (P) was determined with colourimetric method (AOAC, 1994).

2.6 Microbiological Quality

The microbiological quality and safety of *suya* were assessed on the basis of Total Aerobic Count (TAC) and Total Coliform Count (TCC) using Nutrient agar and MacConkey agar, respectively. Diluted meat samples in normal saline were spread onto these plates and incubated at 37°C for 24 hours, following the procedures described by ICMSF [11], APHA, [12] and AOAC, [13]. Microbial counts were expressed as mean colony forming unit per gram (CFU/g).

2.7 Sensory Evaluation

Suya samples were cut into uniform size, coded and served warm for organoleptic properties. A 9-point hedonic scale was used to assess the following categories of *suya* samples: appearance, flavour, tenderness, juiciness, hotness and overall acceptability. Scores were assigned with 9 being ‘’like extremely" and 1 ‘’dislike extreme". Semi-trained panellist received two pieces of *suya* samples with a different code number to be appraised. Water and cream cracker biscuits were provided for each panellist to freshen their mouth between each sample assessment.

2.8 Experimental Design and Statistical Analysis

The design for fresh *suya (tsire)* in this study was completely randomised design (CRD). Data generated were subjected to statistical analysis using [14], while means were separated with Least Significant Difference (LSD) of the same software.

3. RESULTS AND DISCUSSION

3.1 Processing Characteristics of *Suya*

The results of the effects of muscle on the physical properties of mutton are expressed in Table 2. The water holding capacity varied between 68.10±10.12 and 78.17±9.83%, 68.10±10.12 in ST muscle; while 77.21±9.63 in ADD and 78.17±9.83% in DT muscles. The results of the analysis indicated the differences in water holding capacity between the three muscles were significant ($P<0.05$). The greater variation in the WHC of ADD and DT compared to ST was a reflection of the amount of fat and different accumulation of IMF in different muscle types, with more IMF in the ADD and DT. The improved WHC for DT and ADD muscles could be due to proteolytic degradation which has subsequently caused swelling of the myofibrils and allowed the meat to retain water [15]. It was observed that the cooking loss in ST was higher (30.67±2.78%) compared to DT (26.70±3.85%) and (26.70±3.00%). The DT and ADD were significantly different ($P<0.05$) from the ST muscle. The highest cooking loss might be due to change in sarcomere length which resulted in longitudinal shrinkage and more cross-links that compelled more water out of the cooked muscles. There were differences ($P<0.05$) in SF values across the three different muscles investigated in this study. The highest SF values ($P< 0.05$) were obtained for DT (4.79±0.31) and ST (4.39±0.21) while the lowest SF values

(P< 0.05) were observed for ADD (3.97± 0.30). These differences could be attributed to the differences in intramuscular fat content and muscle fibres due to their high binding ability and water holding capacity.

The highest product yield was obtained for *suya* produced from DT muscle. However, the cooking yield was significantly (P<0.05) higher and better in DT (73.83±3.65) and ADD (72.95±3.02) than ST (69.81±2.64). It might be attributed to fibre type composition of muscles and its relation to meat quality, the structural differences associated with different fibre type and the variation in fibre type within muscles. It was observed that pH value slightly varied in different muscles. pH value of 5.85±0.05 was obtained for ST, while DT and ADD have 5.71±0.06 and 5.68±0.05 pH values respectively. The variation in pH is a possible source of tenderness variation. From the processing point of view, meat with pH 5.6-6.0 is better for products where water binding is required, as meat with higher pH has a higher water binding capacity.

3.2 Chemical Composition of *Suya* from Different Muscle Types

The proximate composition of *suya* from different types of muscles is as shown in Table 3. The effects of muscles on the chemical composition of *suya* in this study were not significantly different for crude protein, ether extract, TBARS and nitrogen-free extract. The *suya* produced using ST muscle had the highest moisture content (23.03±0.51%), followed by that *suya* produced using DT (22.46±0.42%) and *suya* produced from ADD (22.43±0.37%). Average values for protein content were 49.50±0.95% in ST, 49.44±1.06% in DT and 50.14±0.47% in ADD, Protein is the most important muscle constituents and is made up of the myofibrilla, sarcoplasmic and connective tissues. Fat is usually deposited in connective tissues, and muscles. Higher fat contents were recorded for all the samples in this study might be due to the higher marbling rate in the muscle. However, fat serves as a transport compound that is very essential for the development of eating flavour in foods. Ash content measures the mineral contents of the *suya* samples. The ash contents of *suya* produced from ST (7.98±0.41%) and ADD (7.98±0.51%) were statistically similar, while the ash content of *suya* produced from DT (8.53±0.47%) was significantly different. Ash content was high in all the samples; as the ash content is an indication of the content of minerals. TBARS is an indication for secondary lipid peroxidation [16]. The main thiobarbituric acid reactive substance that is measured is the malonaldehyde, which is a secondary product formed as a result of lipid peroxidation [17]. TBARS values were not significant across the *suya* samples and fall within the minimum threshold value (1-2 mg malonaldehyde/kg) recommended by the Central Agency for Standardization and Quality Control [18]. The low TBARS values in the treatment products might be due to antioxidative properties in some of the ingredients which are of plant origin (Garlic and Ginger) and the presence of reduced unsaturated fatty acids [19]. Similar findings have been reported by Esenbuğa et al. [20]. The mean TBARS value of the meat products in this study was found to be lower than 1.0 mg malonaldehyde/kg, accepted as the critical value of lipid oxidation for meat and meat products. The highest (P<0.05) value of cholesterol was established in *suya* produced from DT (53.08±3.96 mg/100 g), and it is higher than the values obtained for suya from ST (51.33±4.60 mg/100 g) and ADD (48.67±5.40 mg/100 g) muscles. The three conventional types of muscle showed definite differences in their cholesterol content. The results of this study indicated a predicted relationship between muscle types and cholesterol [21]. It might be hypothesised that the differences between DT and the other two muscles cause a significant influence on cell structure, which could result in higher cholesterols. The different oxidative fibre proportion in muscle and intramuscular fat content can explain these differences. This result is in agreement with Chung et al. [22] who found a strong relationship between cholesterol concentrations and marbling scores.

3.3 Mineral Composition of *Suya* from Different Types of Muscles

Mineral composition of *suya* samples produced from different types of muscles is presented in Table 4. The results indicated that meat products are a rich source of various minerals [23]. Results obtained showed significant (P<0.05) concentrations of Magnesium (15.59±0.75 mg/100 g), and Sulphur (25.42±2.02 mg/100 g) for ST and ADD, respectively. No significant difference (P>0.05) was obtained in Calcium and Iron concentrations which ranged between 167.08±2.52 and 179.58±22.80 mg/100 g and 8.36±0.59 and 8.90±0.41 mg/100 g, respectively in all the treatments. According to Greenfield and Southgate [24], meat exhibits natural variations in the amounts of nutrients contained, and limits of the natural nutrient variation are not defined. Based on the results, it is evident that several mineral contents in the ADD muscle are much higher than those in ST and DT.

3.4 Sensory Attributes of *Suya* Produced from Different Types of Muscles

Taste panel evaluations for the *suya* produced from different types of muscles are presented in Table 5. *Suya* produced with ADD muscle exhibited the highest (P<0.05) colour value (5.44±0.32), followed by *suya* those produced with ST muscles (4.95±0.49) and DT muscles (4.37±1.06). Types of muscles did not have any effect on the colour of the product. The juiciness scores of the ST (6.31±0.41) and ADD (6.32±0.39) were similar but significantly (P<0.05) higher than the juiciness of *suya* produced from DT (5.48±0.35) muscles. It might be due to the peculiar mouthfeel provided by the intramuscular fat present in each of the muscle types which was attributable to better juiciness. Muscle type significantly (P<0.05) affected the sensory tenderness score *suya* assessed by panellists. The *suya* from ST (6.30±0.60) better than DT (5.65±0.31), however, ST (6.30±0.60) and ADD (6.36±0.30) are within the same range for tenderness. Significant (P<0.05) differences were also observed in the ratings for hotness and overall acceptability of the product.

3.5 Microbial Loads of *Suya* Produced from Different Types of Muscles

The microbiological evaluation of the three *suya* samples is as shown in Table 6. No significant difference (P<0.05) was found in TAC and TCC. The reason for this might be due to the addition of some preservatives which have an important role in reducing the growth of anaerobic bacteria and coliforms [25]. Suya produced from ADD and DT (CFU/g of *suya*) showed means as high as 5.84±2.08 for TAC and TCC, respectively. The microbiological quality remained acceptable in all the cooked products, irrespective of muscle types. According to ICMSF [26], spoilage in meat products become evident when the bacterial counts exceed international guidelines of good manufacturing practice (10^7 CFU g^{-1}). For this study, meat products prepared from the three muscle types (ST, DT and ADD) did not exceed threshold levels that could cause microbiological spoilage of the meat products. The reason for the organisms isolated from *suya* within twenty-four hours of production could be due to contaminated ingredients, environment, handling contamination issues and holding time. The most probable reasons of high microbial counts in meat preparations and meat products might be poor hygienic quality the ingredients, as well as contamination from inadequate temperature-time parameters of thermal processing, or due to contaminated packaging material can enhance the microbial load of the end- products [27] and [28].

Table 2. Physical properties of mutton used in *suya* production

Parameters	ST	DT	ADD
Water Holding Capacity (%)	68.10±10.12^b	78.17±9.83^a	77.21±9.63^a
Cooking Loss (%)	30.67±2.78^a	26.70±3.85^b	26.70±3.00^b
Shear Force (kg/cm^2)	4.39±0.21^b	4.79±0.31^a	3.97±0.30^b
Product Yield (%)	69.81±2.64^b	73.83±3.65^a	72.95±3.02^a
pH	5.85±0.05^a	5.71±0.06^b	5.68±0.05^c

^{a,b} : Means with different superscripts in the same row differ signifcantly (P<0.05)

Table 3. Chemical composition of *suya* produced from three different types of muscles

Parameters	ST	DT	ADD
Moisture Content (%)	23.03±0.51^a	22.46±0.42^b	22.43±0.37^b
Crude Protein (%)	49.50±0.95	49.44±1.06	50.14±0.47
Ether Extract (%)	18.04±0.46	18.05±0.67	17.99±0.49
Ash (%)	7.98±0.41^b	8.53±0.47^a	7.98±0.51^b
Nitrogen Free Extract (%)	0.82±0.16	0.86±0.14	0.86±0.14
Cholesterol (mg/100 g)	48.67±5.40^b	53.08±3.96^a	51.33±4.60^{ab}
TBARS	0.21±0.02	0.22±0.04	0.21±0.02

^{a,b,} : Means with different superscripts in the same row differ signifcantly (P<0.05)

Table 4. Mineral composition of *suya* produced from three different types of muscles

Parameters (mg/100 g)	ST	DT	ADD
Calcium	174.67±15.05	179.58±22.80	167.08±12.52
Magnesium	15.59±0.75^{a}	14.59±1.31^{b}	15.68±0.84^{a}
Iron	8.36±0.59^{b}	8.63±0.66^{ab}	8.90±0.41^{a}
Phosphorus	235.00±24.77^{b}	223±20.26^{ab}	246.67±18.13^{a}
Sulphur	24.42±2.61^{b}	21.25±4.20^{a}	25.42±2.02^{a}

^{a,b,}: Means with different superscripts in the same row differ signifcantly (P<0.05)

Table 5. Sensory Evaluation of *suya* produced from three different types of muscles

Parameters	ST	DT	ADD
Colour	4.95±0.49^{ab}	4.37±1.06^{b}	5.44±0.32^{a}
Flavour	5.23±0.44^{b}	6.18±0.44^{a}	4.88±0.37^{b}
Juiciness	6.31±0.41^{a}	5.48±0.35^{b}	6.32±0.39^{a}
Tenderness	6.30±0.60^{a}	5.65±0.31^{b}	6.36±0.30^{a}
Hottiness	5.09±0.20^{b}	5.49±0.25^{a}	4.89±0.16^{b}
Overall Acceptability	5.80±0.38^{b}	6.78±0.41^{a}	6.04±0.41^{b}

^{a,b} : Means with different superscripts in the same row differ signifcantly (P<0.05)

Table 6. Microbiological properties of *suya* produced from three different types of muscles

Parameters (CFU/g)	ST	DT	ADD
TAC	4.95±2.13	3.99±3.02	5.84±2.08
TCC	3.21±2.15	4.13±2.04	3.89±1.94

^{a,b,} : Means with different superscripts in the same row differ significantly (P<0.05)

4. CONCLUSION

As indicated by physical properties, chemical composition, organoleptic profiles, mineral composition, as well as microbiological qualities, it is concluded that *Deltodius* and *Adductor* muscles are excellent sources of meat alternative to *Semitendinosus* muscle in *suya* production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Astruc T. Carcass, composition, muscle structure, and con- traction," in Encyclopedia of Meat Sciences, C. D. M. Dikeman, Ed. Elsevier, Oxford, UK, 2nd Edition. 2014;148–166.
2. Vasilev D, Djordjević V, Karabasil N, Dimitrijević M, Petrović Z, Velebit B, Teodorović V. Inulin as a prebiotic and fat replacer in meat products. Theory and Practice of Meat Processing. 2017;2(2): 4-13.
3. Abdullahi IO, Umoh VJ, Ameh JB, Galadima M. Hazards associated with kilishi preparation in Zaria, Nigeria. Nig. J. Microbiol. 2004;18(1-2):339–345.
4. Suzuki A, Kaima N, Ikeuchi Y. Carcasses Composition and Meat quality of Chinese pure bred and European x Chinese cross bred pigs. Meat Sci. 1991;29:31–41.
5. Peña F, Bonvillani A, Freire B, Juárez M, Perea J, Gómez G. Effect of breed and slaughter weight on the meat quality of CriolloCordobes and Anglonubuian kid produced under extensive feeding condition. Meat Sci. 2009;83:417-422.
6. Omojola AB, Adesehinwa AOK, Madu H, Attah S. Effect of sex and slaughter weight on broiler chicken carcass. J. Food Agri. Environ. 2004;2(3-4):61-63.
7. Kembi SO, Okubanjo AO. Physicochemical and sensory properties of dehydrated beef patties containing soybean products. Trop. Anim. Prod. Invest. 2002;5:137-148.
8. AOAC. Official Methods of analysis (12th ed). Association of Official Analytical Chemists, Washington, D.C; 1990.
9. Leick CM, Puls CL, Ellis M, Killefer J, Carr TR, Scramlin SM, England MB, Gaines AM, Wolter BF, Carr SN, McKeith FK. Effect of distillers' dried grains with

solubles and ractopamine (Paylean) on quality and shelf-life of fresh pork and bacon. Journal of Animal Science. 2010; 88:2751-2766.

10. AOAC. Official methods of analysis of the association of the official analysis chemists 16th (ed.) Arlington, Virginia; 1995.
11. ICMSF. Micro organisms in food 2. Sampling for Microbiological Analysis. Principles and Specific Applications (2nd ed). Canada: University of Toronto Press; 1986.
Available:http://www.cifst.org
12. APHA. Compendium of method for the microbiological examination of foods, 3rd edn Ame. Public Health Ass. In C. Vanderzant, & D. F. Splitsloesser (Eds.). Michigan, USA; 1992.
Available:http://www.apha.org
13. AOAC. Official Methods of Analysis. 17th Edn., Association of Official Analytical Chemists, Washington, DC; 2000.
14. Statistical Analysis System Institute (SAS); 1999. User's guide. SAS Institute Inc. Cary, N.C. Suman S. P and Joseph. Myoglobin chemistry and meat color. Annual Review of Food Science and Technology. 2013;4(1):79–99.
15. Huff-Lonnergan E, Lonnergan SM. Mechanisms of water holding capacity of meat: The role of post-mortem biochemical and structural changes. Meat Science. 2005;71:194-204.
16. Lukaszewicz M, Szopa J, Krasowska A. Susceptibility of lipids from different flax cultivars to peroxidation and its lowering by added antioxidants. Food Chem. 2004;88: 225–231.
17. D'agata M, Nuvoloni R, Pedonese F, Russo C, D'ascenzi C, Preziuso G. Effect of packaging and storage time on beef qualitative and microbial traits. Journal of Food Quality. 2010;33:352–366.
18. Central Agency for Standardization and Quality Control. Standard Specification for Beef, Buffalo, Fresh and Cooled and Frozen No. 1185/2. Republic of Iraq; 1987.
19. Devatkal SK, Nassaih K, Borah A. Anti-oxidant effect of extracts of known of kinnow,rind,pomegranete rind and seed powders in cooked goat meat patties. Meat Science. 2010;85:155-159.
20. Esenbuğa N, Macit M, Karaoğlu M, Aksakal V, Aksu MI, Yörük MA, Gül M. Effect of breed on fattening performance, slaughter and meat quality characteristics of Awassi and Morkaraman lambs, Livestock Science. 2009;123:255–260.
21. Baggio SR, Bragagnolo N. The effect of heat treatment on the cholesterol oxides, cholesterol, total lipid and fatty acid contents of processed meat products. Food Chem. 2006;95:611–9.
22. Chung KY, Lunt DK, Choi CB, Chae SH, Rhoades RD, Adams TH. Lipid characteristics of subcutaneous adipose tissues and M. Longissimus thoracis of Angus and Wagyu steers fed to United States of American and Japanese end points. Meat Science. 2006;73:432-441.
23. Mioc B, Pavic V, Ivanovic A, Havranek D. Concentration of macro and microminerals in muscle of kids. Czech J. Anim. Sci. 2000;45:533-538.
24. Greenfield H, Southgate DAT. Food Composition data: Production, management and use (2nd ed.). Rome: FAO; 2003.
25. Al-Obaidi DAA. Study Some Quality and Bacteriological Characters of Frozen and Canned Beef Imported to Iraq through 2003-2004. MSc Thesis, University of Baghdad; 2005.
26. ICMSF. Microorganisms in foods 8. Use of data for Assessing Process Control and Product Acceptance. New York: Springer. 2011;400 S.
27. Nura NA, Yousef ME. Microbiological quality of meat and meat products. International Scientific Research and Review. 2014;1(2):020-024.
28. Ain AMZ, Erkihun A, Mohd AK, Ruhil HH, Al-Sultan II, Soon JM. Microbiological quality of cooked meat products sold in Kelantan, Malaysia during Ramadhan month. International Food Research Journal. 2017;24(1):414-421.

Peer-review history:
The peer review history for this paper can be accessed here:
http://prh.sdiarticle3.com/review-history/28030