Vol. 10(6), pp. 159-164, June 2018
DOI: 10.5897/JVMAH2018.0680
Article Number: 5837B7757243
ISSN: 2141-2529

http://www.academicjournals.org/JVMAH

ACADEMIC JOURNALS
expand your knowledge

Journal of Veterinary Medicine and Animal Health

Full Length Research Paper

Determination of pH and water holding capacity of beef from selected butcher shops of Mekelle, Ethiopia

Haileslassie W/mariam Gebrehiwot*, Endale Balcha, Yohanes Hagos and Kidane W/rkelul

Department of Veterinary Medicine, College of Veterinary Medicine, Mekelle University, Mekelle, Ethiopia.

Received 13 March, 2018: Accepted 13 April, 2018

A cross-sectional study was undertaken to determine the water holding capacity (WHC) of beef sold in selected butcher shops of Mekelle, Ethiopia and to establish the effects of pre-slaughter rests and age of the animals with pH and WHC of the meats. A total of 80 samples from 80 randomly selected butcher shops were sampled in 6 months study period of time, from May to October. Each sample was accompanied by questionnaires. The meats were taken to the laboratory to measure pH and water holding capacity using the filter paper press and drip loss methods. The means and standard deviations of filter paper press and drip loss were found as 49.4 ± 5.85 and 4.58 ± 0.96, respectively. The age of the slaughtered animals had significant association ($p<0.05$) with the pH measured at 24 h post-slaughter, drip loss and filter paper press measurements. The pre-slaughter rest period had strong effect on pH ($p<0.05$) at 3 h post-slaughter. The present study concluded that water holding capacity and pH as quality indicators of meat are influenced by age and pre-slaughter rest of the slaughtered animals.

Key words: Age, drip loss, filter paper press, pH, pre-slaughter stress.

INTRODUCTION

Muscle is a tissue that consists predominantly of contractile cells of animals. It has different spatial arrangements of myofibrils. The spatial arrangement of the fibrilar network of muscle has great role in the quality of the meats (Bowker et al., 2014). The pH of muscle is approximated from 6.9 to 7.0. The variation in pH may come from physical exercise, nutritional deficiencies, age, sex and/or other factors of the animals (Zhang et al., 2010; Simela, 2005; Simela, 2004). Muscle is converted into meat during the processes of rigor mortis. In the pre rigor stage, the muscle is converted into the stage of rigor and it becomes changed into meat. Fresh meat contains approximately 70 to 75% water, 15 to 20% protein, 5 to 10% lipids or fat and oils, 1 to 2% carbohydrates and 1% vitamins and minerals. At the rigor stage of meat, the amounts of these contents may be changed (Simela, 2005). Meat is said to be quality if it is suitable for use in specific products. The water holding capacity, the rate of decline in pH, flavor, juiciness, color, ethical quality and health quality are the quality indicators of meat. Good quality meat has a potential to have good water holding capacity, slow rate of declining pH, good appearance and

*Corresponding author. E-mail: whaile947@gmail.com.

fatty smell and does not have zoonotic diseases (Aaslyng, 2002). The quality of meat can be altered either by pre-slaughter conditions of the animals or by post mortem conditions of the meat (Miller, 2007).

Water holding capacity (WHC) of meat is defined as the ability of meat to retain the water when external force is exerted. Such forces can be exhaustive starvation and thirst, prolonged traveling on foot, extreme heat or windy air condition of the environment when the animals stay, dry or humid storage of meat, and the orientation of cutting, grinding, or processing of meat (Miller, 2007). The majority of water in meat is held within the structures of the muscle itself. It can be found within the myofibrils, between the myofibrils and the cell membrane (sarcolemma), between muscle cells and between muscles bundles (groups of muscle cells). Once muscle is harvested, the amount of water in meat can be changed depending on numerous factors related to the tissue itself and how the product is handled (Simela, 2005). Water held in the meat can have different names according to their location. Bound water is the water that is found within the protein of the meat. Entrapped water found within muscle structures. This water molecule may be held either by steric (space) effects and/or by attraction to the bound water but is not bound per se to protein. In early postmortem tissue, this water does not flow freely from the tissue, yet it can be removed by drying, and can be easily converted to ice during freezing. Entrapped or immobilized water is most affected by the rigor process and the conversion of muscle to meat. Upon alteration of muscle cell structure and lowering of the pH, this water can also eventually escape as wash out. This entrapped water is becoming free water when it is moved from the structure in pre rigor meat as a result of rigor mortis or post mortem effects. Free water is water whose flow from the tissue is unimpeded. Weak surface forces mainly hold this fraction of water in meat (Brondum et al., 2000). Maintaining as much of this water as possible in meat is the goal of meat handlers (Huff-Lonergan, 2005).

The pH level and the level of WHC of meat can be affected by the anti mortem events, such as lack of sufficient rest or extreme hot or extreme humid air condition of the lairage (pen), starvation and deprivation of water prior to slaughter of the animals for more than 12 h or the manner of handling like cutting of the meat during deboning and meat selling period of time, and while treating the meat to avoid meat spoilage can also affect the pH level and WHC of the meat (Lomiwes, 2008). This alteration of the pH level and WHC of the meat may come from the alteration of glycogen level of muscle of animals stressed during pre-slaughtered condition (Aaslyng, 2002; Miller, 2007). The stability of given meat can be ensured when the requirement of its water holding capacity is maintained and when there is a slow declining of its pH level. This means that the water holding capacity and the slowly declining of pH level of that meat have zoonotic, economic and nutritional importance (Simela, 2005). Meat inspectors and local abattoir administrators of Mekelle city mentioned that the butchers brought their animals to slaughter house directly from the local markets without getting pre-slaughter rest (Mekelle, 2016). Those animals might have travelled from a longer distance in starved condition and stressed by moving here and there in the market and sent directly to the slaughter house without giving sufficient rest prior to slaughter. Besides, most of those animals are poor in body condition, progressively exhausted in work and older age. The above-mentioned professionals and other meat consumers also mentioned that the meat found in the butcher houses in Mekelle city looks dry, dark in color and not attractive to consume it. However, the problem is not yet studied. Hence, the present work will deal with the following specific objectives.

(1) To determine the water holding capacity of beef sold in selected butcher shops of Mekelle
(2) To establish the associations between age and pre-slaughter rest with pH and water holding capacity.

MATERIALS AND METHODS

Study area

The study was conducted in Mekelle city, Tigray region, Northern Ethiopia. Mekelle is an urban centre and the capital of Tigray region. The city covers an area of about 53 km^2, with an estimated population of 215,546 people. It is located 783 km North of Addis Ababa (Figure 1). Currently so many regional, national and international people are visiting the city. From small to larger scales of restaurants are emerging in this city. It has 160 legal butcher houses that are distributed throughout the city and there are also some illegal butchers whose number is not determined yet (TRHDA, 2008).

Study design

A cross-sectional study was employed for the present study.

Sample size

The sample was collected from Mekelle Municipality abattoir where the legal butcher shops send their animals for slaughter. For maximum precision, samples from 50% of the butcher shops, that is 80 samples were collected.

Sampling design and sample collection

Simple random sampling technique was employed to select 80 butcher shops from the total of 160 (Mekelle, 2014) butcher houses. The longissimus dorsi (LD) muscle was taken because of its economic importance (cheapest in value in relative to the other parts of the muscle parts), long muscle and easy to sample (Preziuso and Russo, 2004). In order to know the age of the meat, all samples were taken from Mekelle Municipality abattoir. Collection of fresh meat sample was done immediately following

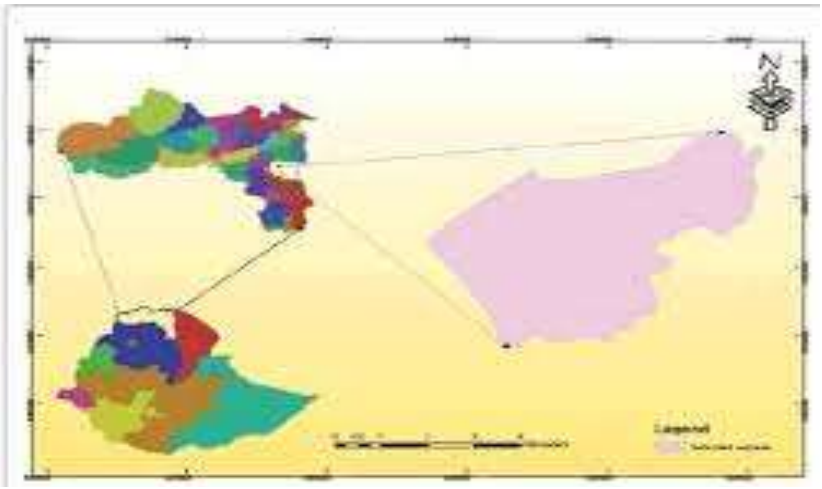

Figure 1. Location map of the study area.
Source: Awetehegn (2016).

each slaughter by labeling each sample orderly in accordance to the code of the questionnaire. To prevent moisture loss during sample collection and preparation a tightly sealed plastic tube was used.

Questionnaire survey

Each sample was accompanied by questionnaire for characteristics of the owners' address, sex; characteristics of the slaughtered animal, the service provided, and observational characteristics of the meats.

Laboratory works

The work was conducted in the microbiology lab, college of Veterinary Medicine, Kalamino campus. The pH of the collected meat was measured using digital pH meter by probing it in to the meat for 30 to 60 s (Abraham and Kumar, 2000) and reading was recorded each sample along with its own code. Before taking the measurement it was calibrated using standard buffer solution (neutral) and it was rinsed with distilled water after taking each measurement. Firstly it was measured at 3 h period of time, and secondly, the same test was carried out at 24 h (Santos-Silva, 2001). The water holding capacity of meat was determined by two fundamentally different principles: Filter paper press method and the water drip loss method.

Filter paper press method

The external force used to drive out the water was the filter paper press method. Chromatography paper Whatman No. 40 was kept for 24 h in a dissociated 38% sulfuric acid in advance that it complies with 60% humidity and it helped to diffuse out the water freely through the paper (Kashif et al., 2014). Five grams of 24 h aged meat was homogenized on a metal plate. Out of this, 300 mg meat which was measured right after preparation was put on the Whatman paper No. 40 and then was placed between two slides on which a 100 g weight was placed on the top slide for 5 min so as to exert downward force and to release water from the meat as per the method described by Abraham and Kumar (2000).

The water released from the meat was wetting the paper and the boundary of that wetted area was demarcated using sharp pencil and was measured and reported in percentage of the ratio of the diameter of the meat to the diameter of the water wetted paper as per Mendiratta et al. (2008).

Water drip loss (Honikel bag method)

A 2.5 cm thickness slice, 2 × 5 cm width and length 24 h aged raw meat was cut parallel to the muscle fiber and hanged for 2 days in plastic sealed tube at 4°C as described by Brondum et al., (2000). The water drip out of the meat was measured and was reported in percentage of the ratio of weight of water loss to weight of meat prior to drip out the water (Diaz et al., 2010; Brondum et al., 2000; Honikel, 1998).

Data analysis

The qualitative and quantitative data were analyzed using simple descriptive and computer based statistical software (STATA 11) was used to analyze the data in order to compare means of age and pre-slaughter stress of the slaughtered animals on pH and water holding capacity of the meat. For the purpose of this study, $p<0.05$ was considered to be significant.

RESULTS

Questionnaire survey

The characteristics of the slaughtered animals had shown that the majority (65%) of the slaughtered animals were old. Only 35% of the slaughtered animals were at the stage of bull. More than half (66%) of the respondents did not have lairage for giving rest for the purchased animals before they were slaughtered. 96.3% of the slaughtered animals were Zebu breed, only 3.7% of them were crossbreed. More than 78% of the carcasses were dark in color and stored in the butcher shops for more than

Table 1. Owners' response for the characteristics of the animals slaughtered and their carcasses.

Characteristics		Number of respondent	Percentage
Age	Young/Bull	28	35
	Old/Steer	52	65
Rest	24 h rest	27	34
	Immediate slaughter	53	66
Breed	Zebu	77	96.3
	Cross	3	3.7
Age of carcass	12 h	17	21.3
	24 h	63	78.7
Color of meat	Dark red	63	78.7
	Light red	17	21.3

24h period of time before completely sold. Only 21.3% of them were light in color and sold before 24 h of storage time.

Water holding capacity

The mean value of the drip loss of the total meat samples was shown as 4.58 with a low standard deviation (0.95). (Table 2). On the other hand, the filter paper press result was shown with the mean value of 49.4 with a relatively wider standard deviation (5.85) (Table 2).

pH at 3 and 24 h post-slaughter

The mean pH value of the total sampled meat measured at 3 h post-slaughter was 6.2 with low standard deviation (0.26), and reduced to the mean value of 5.9 and standard deviation of 0.11 pH level measured at 24 h post-slaughter (Table3).

Effects of age on pH, drip loss, and filter paper press measurements

The age had statistically significant association with the pH measured at 24 h post-slaughter, drip loss and filter paper press ($p<0.05$) (Table 4).

Association between pre-slaughter rest and pH at 3 h post-slaughter

There was statistically significant association between the pre-slaughter rest and the pH of the meats measured at 3 h post-slaughter ($p<0.05$) (Table 5).

DISCUSSION

In the present study, it was found that 65% of the animals slaughtered were old whereas 35% were young (Table1). This agrees with the report of Dawit et al. (2013) that64.4% of the animals slaughtered at Mekelle abattoir were old in age. According to 78% of respondents, they spent more than 24 h to sell for a total carcass (Table 1). This prolonged storage of the meat might expose the meat to excessive drip loss. This is well supported by the reports of Walukonis et al. (2002). It was claimed that meat with low glycogen level will have dark color and high water holding capacity (Miller, 2007). According to the present study, the meat from 78.3% of butcher shops in Mekelle was dark red (Table 1). This disagreed with a similar study in Texas by Miller (2007) who found 2.3% of the sampled meats were dark red. The results of mean drip loss of meat of the present study on 97.3% Zebu and 3.7% crossbreds (Table 1) was relatively higher (4.58%) (Table 2) than the findings of Waritthitham et al. (2010) reported as 3.09% on Brahman breed which were fed with unknown type feeds; similarly, Yuksel et al. (2011) reported 1.8% drip loss on Holstein Friesian breeds fed on specific feeds. on the other hand, the result of filter paper press of this study was with the mean value of 49.4% (Table 2) of dark colored meat that was agreed with the reports of Gunenc's (2007) that had shown with mean value of 48.75 of PSE meat ($p<0.05$), and Miller (2007) also reported similar findings of dark colored meat with higher dark firm dried meat (DFD). These indicated that the low water holding capacity of the meat could cost butchers house significantly which was also supported by Huff-Lonergan (2005).

The pH at 3 h post-slaughter recorded was 6.1 to 6.6 (Table 3). This is comparable with the work of Troy (1999) who recorded 6.1 to 6.37. The higher pH might be

Table 2. Measurements of drip loss under gravity and filter paper press.

Parameter	Observation (n)	Mean ± SD
Drip loss	80	4.58 ± 0.95
Filter paper press	80	49.4 ± 5.85

Table 3. Measurements pH of the sampled meat at 3 and 24 h post slaughter.

Parameter	Observation (n)	Mean ± SD
pH at 3 h	80	6.2 ± 0.26
pH at 2 4 h	80	5.9 ± 0.11

Table 4. Effects of age on pH at 24 h and drip loss and filter paper press measurements.

Observation	pH at 24 h			Drip loss			Filter paper press		
	Mean	SD	P	Mean	SD	P	Mean	SD	P
Old/steer (52)	5.96	0.14		4.4	0.89		48.4	5.2	
Young/bull (28)	5.87	0.12	0.004	4.85	0.99	0.046	51.1	6.5	0.048

Table 5. Association between pre-slaughter rest of animals and pH at 3 h post-slaughter.

Rest category	Observation (n)	pH at 3 h post-slaughter		
		Mean	SD	P
24 h rest	27	6.37	0.27	0.0009
Immediately slaughtered	53	6.1	0.33	

due to pre-slaughter stress. Gunenc (2007) stated that pre-slaughter stress has effect on PM pH 3. The pre-slaughter rest of the animals had strong statistically significant ($p<0.05$) (Table 5), association with PM pH 3 of the meat which agrees with the statement of Lyczynski et al. (2006) that "pre-slaughter stress of animals had statistically significant effect on the early PM pH of meat ($p<0.05$). This is possibly due to the accumulation of lactic acid in muscle of slaughtered animals which was formed as a result of glycolysis process formed by pre-slaughtering stress of slaughtered animals and it is agreed with the reports of Zhang et al. (2010).

Water holding capacity and drip loss of the meat had statistically significant association with the age of the animals ($p<0.05$). This statement is supported by the findings of Kashif et al. (2014) who stated that water holding capacity and drip loss varied ($p<0.05$)(Table 4). between three groups of 1.5 and 2.5 years, and greater than 2.5 years olds animals. These findings also revealed that water holding capacity of meat was found lower in old age of the slaughtered animals. This might be because of higher accumulation of fat and lower moisture content in old age animals comparing to young age animals which is in agreement with the suggestions of Zhang et al. (2010).

CONCLUSION AND RECOMMENDATIONS

Determination of the water holding capacity (WHC) of meat is most important that it is one of the quality indicators of meat. The WHC of the meat was found as 49.4% by filter paper press results and water drip loss was 4.58%. These results were found as having statistically significant associations with age and pre-slaughter rest of the animals. Old age and lack of pre-slaughter rest of the animals resulted in increased ultimate pH level. The prolonged storage of that meat for more than 24 h lead to the spoilage of that meat due to high amount of water in the meat which is conducive for bacterial growth and that could be source of food born diseases and/or cause for the vigorous loss of the profit of the sellers.

The following possible recommendations were forwarded:

(1) Owners of butcher shops should get training on pre-

slaughter handling of animals.
(2) Stressed animals should not be approved for slaughter.
(3) The study should be expanded to other breeds and species of animals.

ACKNOWLEDGEMENTS

The authors are kindly indebted to thankful the College of Veterinary Medicine, Mekelle University that provided the laboratory and other materials to conduct the research work. They are additionally grateful for “Mekelle Zone Municipality abattoir service rendering unit” that cooperated to conduct the study.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Aaslyng M (2002). Quality indicators for raw meat. Danish Meat Research Institute, Roskilde. CRC Press LLC and Woodhead Publishing Ltd: pp. 1-13.

Abraham RJ, Kumar KS. Practicalmaual For Meat Techology And Duality Control. Available at: http://krishikosh.egranth.ac.in/bitstream/1/2040511/1/TNV-363.pdf

Awetehegn NB (2016). Precipitation and temperature trend analysis in Mekelle city, Northern Ethiopia, the Case of Illala Meteorological Station. Available at: https://www.omicsonline.org/peer-reviewed/pprecipitation-and-temperature-trend-analysis-in-mekelle-city-northern-ethiopia-the-case-of-illala-meteorological-stationp-68927.html

Bowker B, Hawkins S, Zhuang H (2014). Measurement of water-holding capacity in raw and freeze-dried broiler breast meat with visible and near-infrared spectroscopy. Poult. Sci. 93(7):1834-1841.

Brondum J, Munck L, Henckel P, Karlsson A, Tornberg E, Engelsen SB (2000). Prediction of water-holding capacity and composition of porcine meat by comparative spectroscopy. Meat Sci. 55(2):177-185.

Dawit G, Adem A, Simenew K, Tilahun Z (2013). Prevalence, cyst characterization and economic importance of bovine hydatidosis in Mekelle municipality abattoir, Northern Ethiopia. J. Vet. Med. Anim. Health 5(3):87-93.

Diaz O, Rodríguez L, Torres A, Cobos A (2010). Chemical composition and physico-chemical properties of meat from capons as affected by breed and age. Spanish J. Agric. Res. 8(1):91-99.

Gunenc A (2007). Evaluation of pork meat quality by using water holding capacity and vis-spectroscopy (Doctoral dissertation, McGill University).

Honikel KO (1998). Reference methods for the assessment of physical characteristics of meat. Meat Sci. 49(4):447-457.

Huff-Lonergan E, Lonergan SM (2005). Mechanisms of water-holding capacity of meat: The role of postmortem biochemical and structural changes. Meat Sci. 71(1):194-204.

Kashif A, Shahzad A, Muhamed MK, Mohamed TK (2014). Effect of age on physico-chemical quality of buffalo meat. Glob. Vet. 13(1):28-32.

Lomiwes D (2008). Rapid on-line glycogen measurement and prediction of ultimate pH in slaughter beef (Doctoral dissertation, Auckland University of Technology).

Mozdziak P, Pietrzak I, Formanowicz D, Grzymisławski M, Wojciechowski J, Karamucki T (2006). Effect of environmental conditions on pork meat quality–a review. Pol. J. Food Nutr. Sci. 15(56):2.

Mekelle (2016). Municipality abattoir service rendering unit, Mekelle Zone, Regional State of Tigrai, Ethiopia.

Mendiratta SK, Kondaiah N, Anjaneyulu AS, Sharma BD (2008). Comparisons of handling practices of culled sheep meat for production of mutton curry. Asian Australasian J. Anim. Sci. 21(5):738.

Miller M (2007). Dark, firm and dry beef. Beef Facts-Product Enhancements. Available at: https://fyi.uwex.edu/wbic/files/2011/04/Dark-Firm-and-Dry-Beef.pdf

Santos-Silva J (2001). The effect of weight on carcass and meat quality of Serra da Estrela and Merino Branco lambs fattened with dehydrated lucerne. Anim. Res. 50(4):289-298.

Simela L (2005). Determination of meat quality, University of Pretoria, etd. Literature review: 4-44. Available at: https://repository.up.ac.za/bitstream/handle/2263/29932/02chapter2.pdf?sequence=3

Simela L, Webb EC, Frylinck L (2004). Effect of sex, age, and pre-slaughter conditioning on pH, temperature, tenderness and colour of indigenous South African goats. South Afr. J. Anim. Sci. 34(5).

Preziuso G, Russo C (2004). Meat quality traits of longissimus thoracis, semitendinosus and triceps brachii muscles from Chianina beef cattle slaughtered at two different ages. Italian J. Anim. Sci. 3(3):267-273.

Tigray Region Housing development agency (TRHDA) (2008). Tigray Region Housing development agency, Housing report of 2007/2008.

Troy J (1999). Biochmical and physiological indicators of beef, Dunsinea, Castleknock, dublin 15, Res. Rep. 13:4-34.

Walukonis J, Morgan T, Gerrard E, Forrest C (2002). A technique for predicting water-holding capacity in early postmortem muscle. Purdue swine Res. Rep. 110-117.

Waritthitham A, Lambertz C, Langholz HJ, Wicke M, Gauly M (2010). Muscle fiber characteristics and their relationship to water holding capacity of Longissimus dorsi muscle in Brahman and Charolais crossbred bulls. Available at: https://bia.unibz.it/handle/10863/1018

Yuksel S, Turgut L, Yanar M, Aksu M, Kaban G, Unlu N (2011). Fatty acid composition, lean color and drip loss of the different muscles from young Holstein Friesian bulls finished on diets containing varied proportions of wet sugar beet pulp and wheat straw. Bulgarian J. Agric. Sci. 17(5):696-703.

Zhang YY, Zan LS, Wang HB, Xin YP, Adoligbe CM, Ujan JA (2010). Effect of sex on meat quality characteristics of Qinchuan cattle. Afr. J. Biotechnol. 9(28):4504-4509.