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INFLUENCE OF SLAUGHTERING PROCEDURE ON BLEEDING EFFICIENCY AND QUALITY TRAITS OF BREAST MUSCLE IN COMMERCIAL BROILER CHICKEN

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BY

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CERTIFICATION FORM

This project entitled **INFLUENCE OF SLAUGHTERING PROCEDURE ON BLEEDING EFFICIENCY AND QUALITY TRAITS OF BREAST MUSCLE IN COMMERCIAL BROILER CHICKEN** is prepared by **NORAFIQAH BINTI RASSID** and submitted to the Faculty of Agriculture in fulfilment of the requirement of SHW 4999 (Final Year Project) for the award of the degree of Bachelor of Agriculture (Animal Science).

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TABLE OF CONTENTS

List of Tables

List of Figures

List of Abbreviation

H	Halal
NH	Non Halal
DECAP	Decapitation
%	percentage
kg	kilogram
MFI	Myofibrillar Fragmentation Index
BE	Bleeding efficiency
g	gram
min	minute
°C	celsius
ml	mililiter
mm	milimeter
nm	nanometer
d	day

ABSTRACT

White meat from broiler chicken is the most preferable source of protein and have high demands in Malaysia due to its affordable price compared to the red meat. Slaughter is probably the most important operation in the transformation of an animal into pieces fit for human consumption. The main purpose of effective and humane slaughtering is to remove blood as quickly as possible while optimized bleeding enhance the quality of meat during storage. Bleeding efficiency has been implicated in shelf life, microbiological quality and other physic chemical traits of meat and meat products. The objective of this study was to determine the effect of slaughtering procedure on physico-chemical traits of *Pectoralis major* muscle in commercial broiler chicken. A total of thirty broiler chickens with a mean live weight of 2.00-2.50 kg were randomly assigned to either one of the three groups each consisting of 10 birds. The three treatment groups are: T1 - halal slaughter; T2 - non-halal slaughter and T3 - decapitation. Bleeding efficiency of each individual bird was determined during 90 sec of bleeding period through differences in body weight before and after slaughtering. Following to that, representative muscle samples were dissected at 4 specific periods, which are, 0 day (immediately after evisceration), 1 day, 3 days, and 5 days post mortem to represent the unconditioned (pre-rigor), 1 day-conditioned (chilled), 3 day-conditioned and 5 day-conditioned samples, respectively. Water holding capacity, pH, shear force values and myofibrillar fragmentation index were assessed objectively. The experiment was of a completely randomized design (CRD). Data of the bleeding efficiency and drip loss were subjected to one-way analysis of variance (ANOVA). Data for color, shear force, MFI and cooking loss were subjected to analysis of variance for a repeated measures

design. The results showed that bleeding efficiency of chickens slaughtered by halal method was significantly higher than those assigned to non-halal and decapitation. Additionally, the drip loss of *Pectoralis major* muscle obtained from the birds of T1 group was lower ($p<0.05$) than those of T2 and T3 at day 5 post mortem. The *Pectoralis major* muscle of T1 group showed lowest ($p<0.05$) ultimate pH than those of T2 and T3 after 5 days aging. Halal slaughter exhibited lower redness and yellowness than non-halal and decapitation. At day 5 of storage at 4ºC, the cooking loss of the *Pectoralis major* muscle of the birds of T1 group was lower ($p<0.05$) than those of T2. It can be concluded that halal slaughter method improve bleeding efficiency and some of the meat qualities such as water holding capacity, pH, and color.

ABSTRAK

Daging putih dari ayam pedaging adalah sumber protein dan mempunyai permintaan yang tinggi di Malaysia kerana harganya yang sangat berpatutan berbanding dengan daging merah. Penyembelihan adalah proses yang paling penting dalam transformasi haiwan menjadi kepingan makanan yang sesuai untuk kegunaan manusia. Tujuan utama penyembelihan berkesan dan berperikemanusiaan adalah untuk membuang darah secepat mungkin semasa pendarahan bagi meningkatkan kualiti daging semasa penyimpanan. Kecekapan pendarahan telah dikaitkan dengan jangka hayat, kualiti mikrobiologi dan lain-lain ciri-ciri fiziko-kimia daging dan produk daging. Objektif kajian ini adalah untuk menentukan kesan prosedur penyembelihan pada sifat-sifat fiziko-kimia pectoralis otot utama dalam daging ayam komersial. Sebanyak tiga puluh ayam daging dengan berat hidup minimum 2.00-2.50 kg dipilih secara rawak dan dibahagikan kepada salah satu daripada tiga kumpulan, yang setiap kumpulan terdiri daripada 10 ekor setiap satu kumpulan. Tiga kumpulan rawatan adalah: T1 - penyembelihan halal; T2 - penyembelihan tidak halal dan T3 - pemenggalan leher. Kecekapan pendarahan bagi sembelihan untuk setiap ekor ayam ditentukan selama 90 saat melalui perbezaan timbangan berat badan sebelum dan selepas penyembelihan. Berikutan itu, sampel otot dada telah dibedah siasat pada 4 tempoh tertentu iaitu hari 0 (serta-merta selepas sembelihan), hari 1, hari 3, dan hari 5 untuk mewakili terlazim (pra-rigor), hari 1 dingin (sejuk), hari ke 3 dan hari ke 5 masing-masing diletakkan pada keadaan beku. Kapasiti penyimpanan air, pH, nilai daya ricih dan indeks pemecahan myofibrillar dinilai secara objektif. Reka bentuk eksperimen adalah sama sekali rawak (CRD). Data kecekapan pendarahan dan titisan kerugian tertakluk kepada analisis

varians sehala (ANOVA). Data untuk warna, daya ricih, MFI dan kehilangan berat ketika memasak tertakluk kepada analisis varians untuk reka bentuk langkah-langkah berulang. Hasil kajian menunjukkan bahawa kecekapan pendarahan ayam disembelih dengan kaedah halal adalah jauh lebih tinggi daripada tidak halal dan pemenggalan leher. Selain itu, kehilangan titisan air daripada pectoralis otot utama yang diperolehi daripada ayam di kumpulan T1 adalah lebih rendah ($p < 0.05$) berbanding dengan T2 dan T3 pada hari ke 5 bedah siasat. Otot pectoralis utama kumpulan T1 menunjukkan paling rendah ($p < 0.05$) pH utama daripada T2 dan T3 selepas 5 hari simpanan. Penyembelihan halal mempamerkan nilai warna kemerahan yang lebih rendah berbanding sembelihan bukan halal dan pemenggalan leher. Pada hari 5 penyimpanan pada 4ºC, kehilangan memasak daripada otot utama pectoralis ayam kumpulan T1 adalah lebih rendah ($p < 0.05$) berbanding dengan T2. Dapat disimpulkan bahawa kaedah penyembelihan halal dapat meningkatkan kecekapan pendarahan dan beberapa kualiti daging seperti keupayaan memegang air, pH, dan warna.

CHAPTER 1
INTRODUCTION

1.1 Background

White meat from broiler chicken is the most preferable source of protein and have high demands in Malaysia due to its affordable price compared to the red meat. In Malaysia, the slaughter age ranges from 21 to 35 days (typically around 5 to 7 weeks). According to Department of Veterinary Services Malaysia, (2014) the total production of broiler is 1495.53 tonne for one year of production. Meanwhile the per capita consumption as estimated by the Department of Veterinary Service Malaysia, (2014) is 47.12 kilogram. The statistics shown that Malaysian consumers prefer chicken as the main source of protein.

The Malaysian consumers particularly Muslims are really concern with issues pertinent to halal products. For example, as a turning point, the slaughtering procedures shall be conducted in accordance with the rules and guidelines set by the Fatwa Council and Syariah Law. Malaysian Protocol for the Halal Meat and Poultry Productions was developed by the Department of Islamic Development Malaysia (JAKIM) to give clear guidance in the production of halal meat and poultry. This protocol is intended to support the implementation of Malaysia's requirements for halal meat, poultry and their products.

Slaughtering of edible animals for food is a ritual of the Shari'ah that is observed by Muslims worldwide. It is a ritual that purifies an animal from blood

and filth thereby making it good and wholesome for consumption. This procedure of slaughtering animals includes using a well-sharpened knife to make a swift, deep incision that cuts the front of the oesophagus, trachea, the jugular veins and the carotid arteries. The rule includes lining up the head of the animal to be slaughtered in the direction of Al-Qiblah (facing towards Makkah). Furthermore, approved animals should be slaughtered upon pronouncement of the Islamic invocation 'Bismillah Allahu Akbar' (in the Name of Allah, Allah is the greatest). The Qur'an contains a number of verses referencing slaughter, and Allah reminds the believers to mention His name at the time of slaughtering, such as:

"*That they may witness benefits for themselves and mention the name of Allah on known days over what He has provided for them of [sacrificial] animals. So eat of them and feed the miserable and poor"* (Al-hajj 22:28).

"*You shall eat from that upon which Allah's name has been pronounced if you truly believe in His revelations*" (Al-An'am 6:118).

In a Hadith, Prophet Muhammad (PBUH) has warned in a clear expression that he will fight those (Muslims) who do not practice slaughter as he does:

"*I have been ordered to fight the people till they slaughter (animals) as we slaughter*,"(Sahih Bukhari).

Halal slaughtering of domestic animals is based on tenets of Islamic Law that recognize that blood is a source of contamination, impurity and uncleanliness, thus it is necessary to drain all the blood from the carcass of a slaughtered animal in preparation for it to be butchered and consumed. Removal of blood also positively affects the appearance (and thus appeal) and shelf life of meat (Gregory, 2008). The holy Qur'an makes reference to what is permitted and prohibited in terms of meat and food. Muslims deduce what is halal and haram from these verses such as:

"Prohibited to you are dead animals, blood, the flesh of swine, and that which has been dedicated to other than Allah, and [those animals] killed by strangling or by a violent blow or by a head-long fall or by the goring of horns, and those from which a wild animal has eaten, except what you [are able to] slaughter [before its death], and those which are sacrificed on stone altars…." (Al-Ma'idah 5:3).

"*Today, all good food is made halal (lawful) for you. The food of the people of the scripture is lawful for you, and your food is lawful for them*" (Al-Ma'idah 5:5).

"*Eat the lawful and virtuous things that Allah has provided for ye. Ye should fear Allah, in whom ye are believers*" (Al-Ma'idah 5:88).

Blood is considered to be an excellent medium for the growth of bacteria due to its high nutritive value, its temperature, pH and relative humidity. The amount

of blood bled by the animal depends on the slaughter method used. One of the most important factors that affects the level of contamination and enhance the extent of the deterioration is the amount of blood left within the carcass after bleeding. Previous study from (Sayda *et., al* 2011) about three different slaughtering method (traditional Islamic method, hanging Islamic method and also electrical stunning method) reported that the electrically stunned group recorded the lowest weight of blood, while that slaughtered by the Islamic hanging method recorded the highest weight of blood bled.

This study confirm the previous studies from McNeal *et al.,* 2003, that the traditional method can be used successfully as an alternative to conventional electrical stunning method based on ensuring an irreversible loss of consciousness while not negatively affecting carcass and meat quality. Study from Addeen *et al.,* 2014 reported that chicken meat from Islamic slaughtering methods showed the lower haem and non-haem iron contents with coincidental lowered lipid oxidation than meat obtained from other slaughtering methods. The oxidation of lipids induced by iron from haem, along with microbial growth, was plausibly the main cause of deterioration and losses in quality of chicken meat.

Blood contains a high amount of haemoglobin, a major haem protein found in blood. Haemoglobin is made up of four polypeptide chains with each chain containing one haem group; each haem consists of an iron atom coordinated inside the porphyrin ring (Alvarado *et al.,* 2007). Decreases in haem iron content with increasing storage time were probably due to haem breakdown, resulting in the release of non-haem iron (Benjakul and Bauer, 2001). The released iron can stimulate lipid oxidation of muscle during the extended storage (Tappel,

1995). Thus from his finding he conclude that Islamic slaughtering method yielded chicken meat with the better quality and oxidative stability during post-harvest storage.

Slaughter is the most significant method in the transformation of an animal into something appropriate for human consumption that is, into food. There are a lots of procedures to slaughter chicken. The slaughtering procedure may be influenced by religion, culture, and common practice by industry. Bleeding efficiency has been implicated in shelf life, microbiological quality and other physic-chemical traits of meat and meat products. Recently, a little information about the effect of halal, non-halal and decapitation slaughtering methods regarding bleeding efficiency and meat quality has been reported. It was hypothesized that halal slaughter may enhance bleeding efficiency and the quality of chicken meat. Therefore, this experiment was conducted to examine the influence of different slaughtering methods on bleeding efficiency and meat quality in commercial broiler chicken.

1.2 Significance of the study

Better result in obtaining a specific method of slaughtering will ensure good quality of product after slaughtering.

1.3 Objectives

The study aims to determine the influence of slaughtering procedure on physico-chemical traits of breast muscle in commercial broiler chicken.

The specific objectives of this study were:

- To evaluate the effects of different way of slaughtering on bleeding efficiency in commercial broiler chickens.
- To examine the effects of different way of slaughtering on major physico-chemical characteristics of broiler chicken meat.

CHAPTER 6

REFERENCES

Aaslyng, M. D., Bejerholm, C., Ertbjerg, P., Bertram, H. C. & Andersen, H. J. (2003). Cooking loss and juiciness of pork in relation to raw meat quality and cooking procedure. Food Quality and Preference, 14(4), 277-288.

Addeen A, Benjakul S, Wattanchant S, and Maqsood S. (2014). Effect of Islamic slaughtering on chemical composition and post quality changes of broiler chicken meat. International Food Research Journal 21(3): 897-907.

Adeyemi Kazeem Dauda and Awis Qurni Sazili. Efficacy of carcass electrical stimulation in meat quality enhancement: A review. (2014). Asian-Australasian. Journal of Animal Sciences 27, (3): 447 456.

Agbeniga B., Webb E.C & O'Neill H.A. (2013). Influence of Kosher (Shechita) and conventional slaughter techniques on shear force, drip and cooking loss of beef. South African Journal of Animal Science 2013, 43:1.

Allen C. D., Fletcher D. L. Northcutt J. K, And. Russell. S. M (1998). The relationship of broiler breast color to meat quality and shelf-life Poultry Science, 77:361–366.

Ali A. M., Lawson M. A., Tauson A., Jensen J. F., & Chwalibog A. (2007). Influence of electrical stunning voltages on bleed out and carcass quality in slaughtered broiler chickens. Archive fuer Gefluegelkunde, 71(1):35–40.

Al-Quran Kareem. Surah Al-Mukminun 23:21, Surah Al-An'am 6:118, Surah Al-Hajj 22:28, Surah Al- Hajj 22:34 Surah Al-Ma'idah 5:3, Surah Al-Ma'idah 5:5, Surah Al-Ma'idah 5:88, Surah An-Nahl 16:5, Surah An-Nur 24:45, Surah Ghafir 40:79, Surah Yasin 36:71.

Alvarado, C. Z., Richards M. P., and Wang H. (2007). The Effect of blood removal on oxidation and shelf life of broiler breast meat. Poultry Science, 86:156-161.

American Veterinary Medical Association, AVM Guidelines for the Euthanasia of Animals: (2013) Edition Version 2013.0.1.

AMSA. Handbook of American Meat Science Association Committee on guidelines for meat color evaluation. (1991).

B. Panea, C. Sanudo, J. L. Olleta and Civit, D. (2008) Effect of ageing method, ageing period, cooking method and sample thickness on beef textural characteristics. Spanish Journal of Agricultural Research. 6(1):25-32

Barbut, S., (1993). Colour measurements for evaluating the pale soft exudative (PSE) occurrence in turkey meat. Food Res. Intl. 26:39-43.

Bendall, J. R. (1975). Cold-contracture and atp-turnover in the red and white musculature of the pig, post mortem. Journal of the Science of Food and Agriculture, 26(1):55-71.

Bendall, J. R. & Swatland, H. J. (1988). A review of the relationships of pH with physical aspects of pork quality. Meat Science, 24(2):85-126.

Benjakul, S. and Bauer, F. (2001). Biochemical and physicochemical changes in catfish (Silurus granis Linne) muscle as influenced by different freeze-thaw cycles. Food Chemistry 72: 207-217.

Culler, R. D., Parrish, F. C., Smith, G. C., & Cross, H. R. (1978). Relationship of myofibril fragmentation index to certain chemical, physical and sensory characteristics of bovine *longissimus muscle*. Journal of Food Science, 43:1177–1180.

Den Hertog-Meischke, M. J. A., Van Laack, R. J. L. M. & Smulders, F. J. M. (1997). The water holding capacity of fresh meat. The Veterinary Quarterly, 19:175−181.

Department for Environment, Food and Rural Affairs, United Kingdom. (2007).The welfare of poultry at slaughter or killing, PB13539

Department of Veterinary Service Malaysia, (2014). Malaysia output of livestock product 2005-2014.

Department of Islamic Malaysian Development. (2011). Protocol for the halal meat and poultry productions, 1:4-15.

Dhanda, J. S., Taylor, D. G. & Murray, P. J. (2003). Part 1. Growth, carcass and meat quality parameters of male goats: effects of genotype and live weight at slaughter. Small Ruminant Research, 50(1):57-66.

Drummond, L. S. & Sun, D. W., (2005). Feasibility of water immersion cooking of beef joints: Effect on product quality and yield. Journal Food Eng, 77:289-294.

Farm Animal Welfare Compendium Compassion in World Farming (2013) - Registered Charity No. 1095050 Updated 01.05.2013.

Faustman, C., Sun, Q., Mancini, R. & Suman, S. P. (2010). Myoglobin and lipid oxidation interactions: Mechanistic bases and control. Meat Science, 86(1):86-94.

Fernandez, X. & Tornberg, E. V. A. (1991). A review of the causes of variation in muscle glycogen content and ultimate ph in pigs. Journal of Muscle Foods, 2(3):209-235.

Fernandes M, Mukesh, S, Rahul K, Rajiv S. K. and Deepak Sharma (2007). Conservation of red junglefowl Gallus gallus in India. Paper presented at the 4th International Galliformes Symposium, 2007, Chengdu, China.

Froning. G. W., 1966. Effect of various additives on the binding properties of chicken meat. Poultry Science. 45:185–188.

Froning, G. W., Babji A. S., and Mather F. B., (1978). The effect of pre slaughter temperature, stress, struggle and anesthetization on color and textural characteristic of turkey muscle. Poultry Science. 57:630–633.

Gann G.L., Merkel R.A. (1978). Ultra structural changes in bovine *longissimus* muscle during postmortem ageing. Meat Science Volume 2(2):129-144.

Grandin, T. and Regenstain, J. M. (1994). Religious slaughter and animal welfare: a discussion for meat scientists. Meat focus International. International Food Research Journal, 21(3):897-907.

Gregory, N. G. (2008). Animal welfare at markets during transport and slaughter. Journal of Meat Science, 80(1):2–11.

Hamm, R. (1972). Colloid chemistry of meat. Paris, Berlin and Hamburg. Meat Science 5 81:99-107.

Heymann, H., Hedrick, H. B., Karrasch, M. A., Eggeman, M. K. & Ellersieck, M. R. (1990). Sensory and chemical characteristics of fresh pork roasts cooked to different endpoint temperatures. Journal of Food Science, 55(3):613-617.

Honikel, K. O. (1997). Reference methods supported by OECD and their use in Mediterranean meat products. Food Chemistry, 59(4):573-582.

Honikel, K. O. (1998). Reference methods for the assessment of physical characteristics of meat. Meat Science, 49(4):447-457.

Hopkins, D. L., Littlefield, P. J., & Thompson, J.M. (2000). A research note on factors affecting the determination of myofibrillar fragmentation. Meat Science, 56(1):19–22.

Huff-L. E., Steven M. L. (2005). Mechanisms of water-holding capacity of meat: The role of postmortem biochemical and structural changes. Meat Science 71:194–204.

Humane Slaughter Association England, Practical Slaughter of Poultry, (2013), Charity No. 209563.

Hunt, M. C. (1980). Meat color measurements. Meat Conference of the American Meat Science Association Purdue University, Lafayette, Ind. 41-46.

Joanna, D., Katarynza, P. (2009). Effect of transport to the slaughterhouse on stress indicators and meat quality of broiler chickens. Ann. Animal Science, 9(3):307 – 317.

Koohmaraie, M. & Geesink, G. H. (2006). Contribution of postmortem muscle biochemistry to the delivery of consistent meat quality with particular focus on the calpain system. Meat Science, 74(1):34-43.

Kopp, J., & Bonnet, M. (1982). The muscle tissue. Bulletin Technique du INRA, 48:34–37.

Kristensen, L. & Purslow, P. P. (2001). The effect of ageing on the water-holding capacity of pork: role of cytoskeletal proteins. Meat Science, 58(1):17-23.

Lawrie, R. A. (1985). Meat Science, .4th edition of Pergamon Press, Oxford, UK.

Lerner PT (2009). Evaluation of haemoglobin and myoglobin in Poultry slaughtered by stunning and Kosher slaughter. Folia Veterinary. 53:25–27.

Lindahl, G., Lundstrom, K. & Tornberg, E. (2001). Contribution of pigment content, myoglobin forms and internal reflectance to the colour of pork loin and ham from pure breed pigs. Meat Science, 59(2):141-151.

Locker, R. H. & Wild, D. J. C. (1982), Journal of Texture Studies, 13:71-82.

Lomiwes, D., Reis, M. M., Wiklund, E., Young, O. A. & North, M. (2010). Near infrared spectroscopy as an on-line method to quantitatively determine glycogen and predict ultimate pH in pre rigor bovine M. *longissimus dorsi*. Meat Science, 86(4):999-1004.

Maki, A. A., and Froning, G. W. (1987). Effect on the quality characteristics of turkey breast muscle of tumbling whole carcasses in the presence of salt and phosphate. Poultry Science 66:1180–1183.

Mancini, R. A. & Hunt, M. C. (2005). Current research in meat colour. Meat Science, 71(1):100-121.

Marsh, B. B. & Leet, N. G. (1966). Studies in Meat Tenderness. Journal of Food Science. 31:450.

Mashhad al-allaf (2003). Islamic divine law (shari'ah). Structuring the life of man by divine law. The five ruling values (the five ahkam).

McCormick. R. J. (1994). The flexibility of the collagen compartment of muscle. Meat Science 36 (1-2):79-91.

McKenna, D. R., Mies, P. D., Baird, B. E., Pfeiffer, K. D., Ellebracht, J. W. & Savell, J. W. (2005). Biochemical and physical factors affecting discoloration characteristics of 19 bovine muscles. Meat Science, 70(4):665-682.

McNeal, W. D., Fletcher, D. L. and Buhr. R. J. (2003). Effects of stunning and decapitation on broiler activity during bleeding, blood loss, carcass and breast meat quality. Poultry Science 82:163-168

Moiler, A. J., Vestergaard, T. & Wismer-Pedersen (1973). Myofibril fragmentation in bovine *longissimus dorsi* as an index of tenderness. Journal of Food Science, 38: 824-5.

Muchenje, V., Dzama, K., Chimonyo, M., Raats, J. G. & Strydom, P. E. (2008a). Meat quality of Nguni, Bonsmara, and Aberdeen Angus steers raised on natural pasture in the Eastern Cape, South Africa. Meat Science. 79: 20-28.

Muchenje, V., Dzama, K., Chimonyo, M., Raats, J. G. & Strydom, P. E. (2008b). Tick susceptibility and its effects on growth performance and carcass characteristics of Nguni, Bonsmara and Angus steers raised on natural pasture. Animal. 2:298 – 304.

Murphy, R. Y., Johnson, E. R., Duncan, L. K., Clausen, E. C., Davis, M. D., & March, J. A. (2001). Heat transfer properties, moisture loss, product yield and soluble proteins in chicken breast patties during air convection cooking. Poultry Science, 80:508–514.

Murphy, R. Y., & Marks, B. P. (2000). Effect of meat temperature on proteins, texture and cook loss for ground chicken breast patties. Poultry Science, 79:99–104.

Nakyinsige, K., Fatimah, A., Aghwan, Z. A., Zulkifli, I., Goh, Y. M., & Sazili, A. Q. (2014). Bleeding efficiency and meat oxidative stability and microbiological quality of New Zealand white rabbits subjected to halal slaughter without stunning and gas stun-killing. Asian-Australasian Journal of Animal Sciences, 27(3):406–413.

Nakyisinge, K., Che-Man, Y. B. & Sazili A.Q. (2012). Halal authenticity in meat products. Meat Science, 91:207-214.

Nishimura, T. (2010). The role of intramuscular connective tissue in meat texture. Animal Science Journal, 81(1):21-27.

Offer, G., & Trinick, J. (1983). On the mechanism of water holding in meat: the swelling and shrinking of myofibrils. Meat Science, 8:245–281.

Offer, G. & Knight, P. (1988). The structural basis of water-holding capacity in meat. Part 2: drip losses. In Developments meat science, ed. R. Lawrie, Elsevier Science Publications. London. 4:173- 243.

Olson. D. G. and F. C. Parrish. (1977). Relationship of myofibril fragmentation index to measures beef steak tenderness. Journal of food science 42:506-509.

Ouali, A., Sentandreu, M. A., Aubry, L., Boudjellal, A., Tassy, C., Geesink, G. H. & Farias-Maffet, G. (2005). Meat toughness as affected by muscle type. In Indicators of milk and beef quality. EAAP Publication eds. J. F. Hocquette & S. Gigli, Wageningen Academic Publishers. Wageningen, the Netherlands. 12:391–396.

Panea B., Sańudo C., Olleta J.L., Civit D. (2008) Effect of ageing method, ageing period, cooking method and sample thickness on beef textural characteristics. Spanish Journal of Agricultural Research 6(1):25-32.

Palka, K., & Daun, H. (1999). Changes in texture, cooking losses, and myofibrillar structure of bovine M. Semitendinosus during heating. Meat Science, 51:237–243.

Pearce, K. L., Rosenvold, K., Andersen, H. J. & Hopkins, D. L. (2011). Water distribution and mobility in meat during the conversion of muscle to meat and ageing and the impacts on fresh meat quality attributes. A review. Meat Science, 89(2):111-124.

Sayda A.M. Ali, H. O. Abdalla, and Ibrahim M. M. (2011). Effect of slaughtering method on the keeping quality of broiler chickens' meat. Egypt. Poultry Science 31: 727-736.

Sayre, R. N. (1970). Chicken myofibril fragmentation in relation to factors influencing tenderness. J. Food Science,. 35:7-10.

Savell, J. W., Cross, H. R., Francis, J. J., Wise, J. W., Hale, D. S., Wilkes, D. L., & Smith, G. C. (1989). National consumer retail beef study: interaction of trimlevel, price and grade on consumers acceptance of beef steaks and roasts. Food Quality, 12: 251–274.

Sazili A.Q., Abdul Rahim A.H. & M Hilmi (2014). A study on the effects of conditioning on shear force values and water holding capacity of different skeletal muscles in Malaysian indigenous (MALIN) sheep. Halal Products Research Institute, Putra Infoport, Universiti Putra Malaysia.

Sazili, A. Q., Parr, J., Sensky, D. L., Jones, S. W., Bardsley, R. G., & Buttery, P. J. (2005). The relationship between slow and fast myosin heavy chain content, calpastatin and meat tenderness in different ovine skeletal muscles. Meat Science, 69(1): 17–25.

Sazili, A. Q., Norbaiyah, B., Zulkifli, I., Goh, Y. M., Lotfi, M., & Small, A. H. (2013). Quality assessment of longissimus and semitendinosus mscles from beef cattle subjected to non-penetrative and penetrative percussive stunning methods. Asian-Australasian Journal of Animal Sciences, 26(5): 723-731.

Setser, C. S. (1984). Color: reflections and transmissions. Journal of food quality, 6(3):183-197.

Skrlep, M. & Candek, P. M. (2007). Pork color measurement as affected by bloom time and measurement location. Journal of Muscle Foods, 18(1): 78-87.

Swatland, H. J. (1982). The challenges of improving meat quality. Canadian Journal of Animal Science, 62(1):15-24.

Tappel, A. L. (1955). Unsaturated lipid oxidation catalyzed by hematin compounds. Journal of Biological Chemistry 217: 721-733.

Taylor, R. G., Geesink, G. H., Thompson, V. F., Koohmaraie,M., & Goll, D. E. (1995). Is Z-disk degradation responsible for postmortem tenderisation? Journal of Animal Science, 73:1351–1367.

Trout, G. R. (1988). Techniques for measuring water-binding capacity in muscle foods- A review of methodology. Meat Science, 23(4):235-252.

Warkup, C. C. (1993). In J. D. Wood, T.L.J. Lawrence (Eds.), Safety and quality of food from animals. Occl. Publication Britain. Society Animal Production. n. 17:63-69.

Warris P.D., Kestin S.C., Brown S.N., Knowles T.G., Wilkins L.J., Edwards J.E., Austin S.D. and Nicol C.J. (1993). The depletion of glycogen stores and indices of dehydration in transported broilers. Br. Vet. J., 149 (4): 391–398.

Watanabe, A., Daly, C. C. & Devine, C. E. (1996). The effects of the ultimate pH of meat on tenderness changes during ageing. Meat Science, 42(1): 67-78.

Whipple, G., Koohmaraie, M., Dikeman, M. E. & Crouse, J. D. (1990). Predicting beef-longissimus tenderness from various biochemical and histological muscle traits. Journal of Animal Science, 68(12): 4193-4199.

Wood, D. F., and J. F. Richards, (1975). Effect of some antemortem stressors on postmortem aspects of chicken broiler Pectoralis muscle. Poultry Science 54:528–531.

Wood, J. D., Nute, G. R., Fursey, G. A. I., & Cuthbertson, A. (1995). The effect of cooking conditions on the eating quality of pork. Meat Science, 40: 127–135.

Yang, C. C., and T. C. Chen, (1993). Effects of refrigerated storage, pH adjustment, and marinade on color of raw and microwave cooked chicken meat. Poultry Science 72:355–362.

Yoon, K. S. (2002). Texture and microstructure properties of frozen chicken breasts pre-treated with salt and phosphate solutions. Poultry Science, 81:1910–1915.

Young, O. A., West, J., Hart, A. L. & Van Otterdijk, F. F. H. (2004). A method for early determination of meat ultimate pH. Meat Science, 66(2):493-498.

Yu, L. H., Lee, E. S., Jeong, J. Y., Paik, H. D., Choi, J. H. & Kim, C. J. (2005). Effects of thawing temperature on the physicochemical properties of pre-rigor frozen chicken breast and leg muscles. Meat Sci. 71:375- 382.