EFFECT OF HIGH AMBIENT TEMPERATURE CONDITIONING AND BONING TIME ON PROCESSED BEEF QUALITY

BY

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DEDICATION

TO MY FAMILY,
FRIENDS
AND ALL WHOM WERE SPECIAL FOR ME
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ABSTRACT

This study was conducted to investigate the effect of delayed hot boning time on processed meat conditioned at high ambient temperature. The rate of temperature and pH fall, chemical composition, bacterial load and muscles eating quality were investigated.

A total of 10 Baggara bulls were used. The hindquarters of those were divided in three groups. One group was immediately chilled at 2°C for 48 hrs (control) and each of the other two groups was subjected to either three or five hours delayed chilling time at ambient temperature. L.dorsi (LD), Semimembranosus (SM) and Semitendinosus (ST) were hot boned and subsequently chilled at 2°C for 48hrs, then each one was divided into two parts one part immediately used for chemical and physical analysis and the other aged for 7 days at 2°C till use for analysis.

Statistical analysis revealed no significant differences between the high ambient temperature hot deboning time and aging period in all the studied parameters except the objective of color assessment for all the muscles studied.

The chemical composition was significantly (P<0.05) different between the three muscles studied. The moisture percent was higher for SM and ST in comparison with LD. LD had a considerably less protein, higher fat and less ash than SM and ST muscles.

There was a more rapid and greater loss of heat from muscles from control than those delayed chilling for 3 and 5 hrs. Delayed boning time was accompanied by an increase in the rate of pH fall.

The extractability of myofibril proteins from hot boned muscles was reduced not significantly (P<0.05) with increasing the delayed chilling time to 5 hrs, while the extractability of sarcoplasmic and soluble non protein nitrogen increased not significant (P>0.05) for the three muscles studied.
Water holding capacity of SM, ST and LD was improved insignificantly (P>0.05) and there was a significant reduction in cooking loss.

Panel test scores indicate that meat from muscles that were early conditioned for 3 and 5 hrs and then hot boned were tender, juicier, flavorful and more acceptable to panelist. The 5 hrs treatment gave highest quality scores.

Increasing hot boning time resulted in not significant (P>0.05) increase in oxidative rancidity and reduction in total bacterial count in all muscles studied.

Increasing aging time to 7 days caused a significant (P<0.05) increase in the extractability of myofibril proteins and the non protein nitrogen, but the extractability of sarcoplasmic proteins decreased significantly (P<0.05) for all the muscles studied.

Water holding capacity increased while cooking loss decreased with increasing aging period to 7 days.

Color rating of aged LD, SM and ST revealed insignificant (P>0.05) decrease with increasing aging period. And a significant increase in tenderness, juiciness, flavor, acceptability, oxidative rancidity and total bacterial counts.

ground beef manufactured from delayed hot boned at high ambient temperature conditioned pre-rigor meat had higher improvement in water holding capacity and an increase in redness value and total bacterial counts.
ملخص الطروبة

أجريت هذه الدراسة لمعرفة تأثير زمن التشفيف في درجة حرارة الجو المحيط على عضلات الأرجل الخلفية (SM, ST, LD) لذبائح العجل عندما ترك بها لمدة 3 و 5 ساعات بعد الذبح مباشرة، ثم بعد ذلك في درجة حرارة 2°C بالمقارنة مع مثيلاتها اللاتي تم تبريدها بعد الذبح مباشرة، حوالي (ساعة) وكذلك تأثير طول زمن التخزين (الانضاج لمدة 7 أيام) وتأثيرهما على كل من:

- إنخفاض درجة حرارة العضلات، الأس الهيدروجيني (pH)، الترتيب الكيميائي، الحمل الميكروبي، عناصر جودة اللحم المطبوخ، اللحم المفرم الطازج وكذلك قياس التزرنخ.
- أخذت الاربع الخلفية لعشرة عجل من أبقار البقارة لمقياسها، إلى ثلاث مجموعات حسب المعالجات المذكورة أعلاه.
- أظهرت نتائج التحليل عدم وجود فرق معنوي بين درجة الحرارة العالمية و زمن التشفيف في الجو المحيط وطول مدة التخزين عدا في لون العضلات. وجد أن هناك فروق معنوية بين العضلات التي تمت دراستها في كل من نسبة الرطوبة والبروتين والدهن والرمل.
- كما وجد أن فقد الحرارة يتم بصورة أسرع في العضلات التي تم تبريدها بعد الذبح مباشرة مقارنة بالعضلات التي بقيت في درجة حرارة عالية في الجو المحيط لفتره 3 و 5 ساعات إذ أن العضلات التي أخر تبريدها أخذت 18 ساعة للوصول ل 5 درجة منوية بينما التي تم تبريدها بعد الذبح مباشرة أخذت 7 ساعات للوصول لهذه الدرجة.
- وجد أن قابلية ربط الماء تزداد بقلة فاقد الطهي معنوية وأن استخلاص البروتينات الليفيه يقل معنويًا بإزداد زمن تأخير التبريد بينما استخلاص البروتينات الساركوبلازمية النيتروجيني البروتيني لا تتأثر معنويًا.
- أثبتت الاختبارات الحسية أن العضلات التي بقيت في درجة حرارة الجو المحيط لفتره 3 و 5 ساعات أكثر طراوة وعصيرية وتحسن إنها تكونت ولونها مما زاد من قبولها لدى المتناولين.
- وقد حددت 5 ساعات أعلى درجات القبول مقارنة بالعضلات التي تم تبريدها مباشرة.
- العضلات التي بقيت في درجة حرارة الجو المحيط لفتره 3 و 5 ساعات تعرضت لتماس مباشر مع الأوكسجين مما أكسبها زيادة في اللون الأحمر نتيجة تأكد صبغة المايلوبين كما أنه
- أدي إلى جفاف السطح الخارجي للعضلات مما قلل من الزيادة المعنوية في أعداد البكتيريا.
- في فترة الانضاج (التخزين لمدة 7 أيام) تزداد قابلية ربط الماء وقلة فاقد الطهي، وأن استخلاص البروتينات الليفيه يزداد معنويًا بينما يقل معنويًا استخلاص البروتينات الساركوبلازمية ويزداد النيتروجيني البروتيني معنويًا.
أثبتت الاختبارات الحية أن زيادة إنضاج اللحم لمدة 7 أيام في درجة حرارة 2°C أدى إلى زيادة الطراوة معنوية والعصريه غير معنوية بينما تقل اللكهة واللون. ووجد أن هنالك زيادة في أعداد البكتريا الكلية.

وجد أن اللحم المقروم الذي صنع من العضلات التي أخر تبريدها أعطي نتائج تفوقت على اللحوم التي بردت بعد الذبح مباشرةً.
Chapter One
Introduction

The original bases of meat processing were preservation by inhibiting or deterring microbial decomposition. Early meat processing developments were based on this concept. In addition to preventing spoilage preservation also resulted in flavorful and nutritious products. With the advent and almost universal availability of refrigeration, meat processing has now taken an additional aspect of providing both convenience and variety to the meat portion of the diet. Today processed meat is regarded highly because of these two characteristics in meat processing has resulted in major changes in the demand for certain cuts of meat.

Widespread commercial application of hot processing under a variety of industry conditions have not been realized, even though economic benefits and high quality products can result from this technique. There are some areas of the world that practice hot processing from location to location arises in part because hot processing has been the traditional approach in some areas due to the lack of refrigeration (Kastner, 1982).

The removal of muscle and muscle systems before initial chilling of bovine carcass has been investigated in recent years to determine the feasibility of this processing method as a future alternative to conventional fabrication. (Will and Henrickson, 1976)

Hot boning the bovine carcasses has several potential advantages. Mainly reducing the amount of necessary cooling and benefiting from increased efficiency resulting from the utilization of on rail boning. This is enhanced by the fact that the muscle and fat are pliable and easily removed from the hot carcasses. The boneless product
would maximize refrigeration space and lend itself well to portion control (Brasington and Hammons, 1971). For extensive application of hot processing to be realized, it should satisfy the processing and quality requirements for all types of products. Hot boning increases production turn-over by removing the waste bone and fat before chilling. Thereby reducing inventory expenses, energy requirement, refrigeration space, transportation costs and chilling time (Henrickson, 1975).

High temperature conditioning implies holding the carcass or meat at elevated temperatures to accelerate the biochemical processes. Thus more rapid decline in muscle pH is induced, though, this effect is not as marked as with electrical stimulation (Reagan; 1983). It is generally accepted that cold shortening will cause muscle toughness when lamb and beef carcasses were fast chilled or frozen in the pre-rigor state. Cold shortening can be minimized by delaying the exposure of carcasses to cold temperatures until the muscle pH has reach a value below 6.0 as approximately 50% of the Adenosine Triphosphate (ATP) will be depleted (Bendall, 1975). High temperature conditioning processes based on rigid specifications for temperature, time, relative humidity and air flow have been in use in New Zealand for several years. (Locker et.al, 1975) The major drawback to commercial use of high temperature conditioning techniques was the increased space requirement needed for holding carcasses during the conditioning phase. In addition, the shrinkage of high temperature conditioning treated carcasses may be higher than conventionally chilled carcasses (Bowling et al, 1978; Stevenson et al, 1978).

The market for quality meat is always expanding domestically and overseas. Unfortunately Sudan is not main exporter of meat inspite of the increased number of the livestock, because of the high and expensive cost of production. Although slaughtering operations were done in healthy
environment, but the product need special processes to keep it in high
quality and prevent spoilage. The shortage of electricity power and hot
climate pressed the scientists and meat processors to find other
procedures to maintain quality in meat and meat products.

Objectives of the study:
The objective of this research is to study:
1 - Post mortem deboning time at high ambient temperature conditioning
as a technique to improve meat quality and reduce processing cost.
2 - The minimum conditioning time at ambient temperature before hot
boning could be initiated.
3 - The feasibility of hot boning beef carcasses at 3 and 5 hours
postmortem with respect to tenderness.
4 - Evaluate economic costs of meat preservation and transportation.
5 - To introduce new technological aspects in meat processing in Sudan
to enhance quality and shelf life of processed meat.

Following parameters will be determined.
Chapter Two

Literature Review

2:1 Introduction:

The lean of each meat animal consists of about 300 individual and different muscles of which only about 25 can be separated out and utilized as single muscle or muscle combination. (Gerrard, 1977). Lawrie, (1991) define meat as “The postmortem aspect of the three hundred or so anatomically distinct muscles of the body together with the connective tissue in which the muscle fibers are deposited and such intramuscular fat as cannot be trimmed off without breaking up the muscle as a whole. Intramuscular fat is anatomically included, being physically inseparable”.

Aging of carcasses after slaughter for varying periods up to 14 days at 0-4°C to improve their tenderness, has been practiced for many years. It still remains an important procedure for producing tender meat. The mechanism(s) of this tenderization process still remains and unresolved issue for meat scientist.

The basic concept of hot boning is that slaughtering boning and backing of the meat is all done within the span of single working day.

2:2 Meat Chemical compositions:

Meat contains 75% water, 19% protein, 2.5% lipid and 3.5% soluble non-protein substance in proximate composition (Lawrie, 1991). The muscle protein comprises several components. Sarcoplasmic proteins (5.5% of fresh muscle weight) are soluble at ionic strengths of 0.05 or less, comprising the proteins of the muscle cell cytoplasm. (Scopes, 1966) Many of them are enzymes of the glycolytic pathway. The myofibril proteins (11.5% of fresh muscle weight) are soluble at high ionic strength of 0.3 or greater. The stroma proteins (2% of fresh muscle
weight) are those proteins insoluble in neutral aqueous solvents regardless of ionic strength. Inorganic components such as phosphorus, potassium, sodium, magnesium and trace elements comprise 0.65% of fresh muscle weight. Vitamins are quantitatively minute (Goll et al., 1970).

2:2:1 Factors affecting meat chemical composition:

Meat chemical composition is affected by different factors such as species, breed, age, sex, and anatomical location of muscle, training and plane of nutrition. High significant breed difference (p<0.001) were reported by Elnazir (1994) on moisture and fat proportions in Baggara and Friesian crossbred bulls. The Baggara breed had higher protein (23.47 vs 22.41), higher fat (2.97 vs 2.02) and less moisture (73.55 vs 74.77) than Friesian crossbred. Higher percentage of myofibrillar (12.04 vs 11.55) and lower proportion of sarcoplasmic proteins (5.1 vs 5.05) and non-protein nitrogen were all not significantly different between the two breeds. Guma, (1996) reported a significant (p<0.01) breed difference between Baggara and Kenana on sarcoplasmic proteins (5.1 vs 5.05) and non-protein nitrogen, both values were higher in Baggara cattle. Moisture content was higher in the meat of Kenana cattle, while fat and proteins percentage were higher in Baggara cattle.

Elhashmi (1998) and Mohamed (1999) studied the effect of different feeding levels on Baggara bulls and reported that the protein percent of L. dorsi muscle varied between 21.44-22.32% and the moisture content from 74.01-75.46% and fat content from 1.8-2.17% according to the weight of the animal. The sarcoplasmic protein varied from 5.92-6.27%, myofibrillar proteins 11.57-11.93% while the non-protein nitrogen was 0.46%.

Bieber et al. (1961) found that L. dorsi and Semitendinosus muscle have 2.75% and 1.6% fat, 74.1% and 75.0% moisture respectively.
Brackebush et al. (1991) studied the relationship between L. dorsi muscle composition and the composition of the other major muscles of beef carcass with a low, medium or high marbling score. The fat content of all muscles was linearly related to that of L. dorsi. Semimembranosus muscle had the lowest (4.4%) and the Spinalis muscle had the highest (16.1%) fat content. The fat percentage of L. dorsi ranged from 3.59 to 15.42. Nour (2003) found that LD muscle had the highest fat, lowest protein and ash in comparison with SM and ST muscles.

2:3 Early postmortem changes in muscles:

As muscle is converted to meat a number of metabolic and structural changes occur. Protein changes occurring directly after slaughter are of special importance for meat quality and tenderness.

Glycogen is a basic carbohydrate in a muscle tissue. It disintegration, as a part of post-mortem changes, significantly affecting the properties of meat with respect to suitability for processing into individual meat products and its culinary treatment. The rate of glycolysis and the resulting change in PH value in muscle affects meat quality in two ways. In the case of rapid drop of PH value, meat will be pale, soft and exudative (PSE). While slow and incomplete drop of PH value at 24hr post mortem is characteristic of dark firm and dry meat.

2:4 Muscle Temperature and pH:

Temperature and pH decline during the first 24h postmortem are inversely related. Bendall (1978) Eilers et al (1996) reported that ultimate pH at 24h postmortem was related to tenderness and that higher LD muscle pH values at 24h produced less tender meat. Eilers et al (1996) reported that temperature was not closely related to steak tenderness but higher pH values at 24 h postmortem produced less tender beef. The calpain proteolytic system responsible for postmortem degradation of muscle proteins is affected by the rate of temperature and pH decline
Autoysis of µ calpain is increased as pH decreased from 7.0 to 5.8 and slowed as temperature decreased from 25°C to 5°C (Koohmaraie 1992a).

When pH decreases rapidly before the muscle has been chilled sarcoplastic and myofibrillar protein were partially denatured resulting in pale color (Ledward et al., 1992). Semitendinosus muscle from carcasses that had the lowest temperature decline and most rapid pH decline had the highest lightness (L) values. The rate of pH decline could at least in part explain the difference in (L) values (Kuber et al., 2004).

Rosenvold et al. (2001); and Van laack et al (2001) suggested that muscles with high frequency of anaerobic fibers and hence high glucose potential have higher probability of being poor eating quality due to more rapid accumulation of lactate, decline in pH and lower pHu. PHu is a major determinant of beef tenderness.

Postmortem PH fall in combination with muscle temperature will influence muscle shortening and proteolysis and thereby meat tenderness and water holding capacity (Offer, 1991). The combination of a very rapid fall in PH and slow cooling carcasses can lead to heat or rigor shortening. Where as a slow fall in PH and rapid cooling can lead to cold shortening.

Lesiak et al (1997) found that drip loss increased as the postmortem time before chilling was increased.

2:5 Postmortem glycolysis:

Ambient temperature had a pronounced effect on postmortem glycolysis and increased external ambient temperature of the muscle will increase its rate (Marsh, 1954). The rate of postmortem glycolysis is temperature dependent (Bendall, 1961, Khan, 1971, Busch 1972).

Immediately after a well-rested animal is slaughtered its muscle contains ATP, creatine phosphate, and has a pH of 6.7 to 7.2. Pre-rigor muscle is extensible and can be reversibly stretched to 130-140% of its
resting length. In living muscle the ATP is constantly turned over to maintain resting metabolism but when the oxygen carrying blood is cut off, the muscle becomes anaerobic and can no longer maintain the level of ATP by oxidative phosphorylation. At first, the level of ATP in the muscle is maintained by conversion of ADP to ATP at the expense of creatine phosphate but when the latter is exhausted the ATP level falls. The loss of ATP also triggers the anaerobic conversion of glycogen to lactate with the result that after 24h the pH fall from 7.2 to 5.5. When the ATP level falls below 0.1µm/g, the myosin filaments of the myofibril form bonds with the overlapping actin filaments and muscle loses its extensibility due to formation of actomyosin, and goes into rigor (Penny, 1980). This stiffening is referred to as rigor-mortis. The process of acidification normally takes 4-8h in pigs, 12-24h in sheep and 15-36h in cattle (Drasfield, 1994b).

Abnormal types of rigor mortis include thaw rigor and cold shortening. When rigor occurs at body temperature it is accompanied by some shortening, but this involves only a fraction of the muscle fiber (Bendall, 1973). Thaw rigor occurs when muscle that has been frozen whilst its ATP level is in pre-rigor value, is then thawed. This results in contraction of muscle to 80% of its initial length and exudes much drip (Judge et al., 1990).

Acceleration of postmortem glycolysis by elevated temperature was demonstrated in beef Sternomandipularis muscle. PH was found to require 72 h to reach its ultimate at 5°C; 30 h at 15°C; 24 h at 25°C and only 2 h at 37°C (Cassens and Newbold, 1967). Higher rates of pH fall were found at 39 and 32°C than at 16°C for beef sides held at those temperatures for 4, 6 and 8 h, respectively (Bowling et al., 1978).

Cooling the carcass to lower in vivo temperature (for microbial reason), slows the rate of pH fall in the range of 37-10°C. But the rate of
pH fall was found to increase again as the temperature at which it occurred was lowered to 1°C (Cassens and Newbold, 1967, Newbold and Scopes, 1967). The extent of pH fall depends mainly on the amount of glycogen at the time of slaughter as depletion of glycogen by adrenaline injections keep the ultimate pH high (Bendall and Lawrie, 1962). Fall in muscle pH is the measure of postmortem glycolysis and, by implication, of the onset of rigor mortis (Bendall, 1973). The mean initial pH of 25 muscles was 7.01 and the mean ultimate pH values of these muscles were: 5.79 at 1°C and 5°C, 5.7 at 15°C, 5.66 at 25°C and 5.67 at 37°C (Cassens and Newbold, 1967). In a muscle such as L. dorsi of the ox, from a well-fed and unstressed animal, the pH value will typically fall from about 7.2 to around 5.5. The ultimate varies between muscles (Dransfield, 1994b).

2:6 Postmortem proteolysis:

Hoagland et al. (1917) studied the chemical changes in postmortem muscle and observed that the changes that took place in 2-3 days were similar to, but less extensive than, those caused by enzymatic action when lean beef was autolyzed under aseptic condition for period of up to 100 days. Khan and Van Den Berg (1964) observed a decrease in non-protein fraction during the onset of rigor mortis. They suggested that during the post-rigor tenderization period amino acids and peptides increased in meat as the result of proteolysis. Aberle and Merkel (1966), Sharp (1963) and Lawrie and Voyle (1962) reported that soluble non-protein nitrogen increased significantly during postmortem aging. The extractability at high ionic strength of total myofibril proteins decreases by about 75% with the onset of rigor mortis, from the value immediately postmortem, but in subsequence storage at 2°C the extractability again rises up to and even beyond the initial level (Locker, 1960a). Goll et al. (1964) studied the L. dorsi and Semitendinosus muscles and found that
Sarcoplasmic protein was most extractable immediately after death and that its solubility decreased during postmortem aging. Myofibril proteins were least extractable at 24 h postmortem but their solubility was significantly higher 168-336 h than 24 h postmortem in both muscles studied. Davey and Gilbert (1966) and Parrish et al. (1969) failed to correlate the increase in non-protein nitrogen or free amino groups to postmortem tenderization. Although Valine and Pinkas (1971) reported an increase in protein solubility with aging. Goll et al. (1970) postulated that changes in sarcoplasmic protein during postmortem aging undergo large changes in composition during storage at temperature of 5°C or lower and that these proteins do not experience extensive postmortem proteolysis. Conversion of muscle to meat entrains changes in the properties (mechanical) of muscle fibers and connective tissue. Initially, toughness increases into rigor, then as proteolysis progresses and rigor is resolved tenderness increasing during ageing (Taylor et. al., 1995). Studies over the last 20 years have suggested that tenderization is primarily a result of calpian mediated degradation of myofibril and cytoskeletal proteins (Koohmaraie, 1992,1996; Taylor et al 1995; Wheeler et al 2000).

Recent data added additionally proposed that most proteolysis occurs between 3 and 14 days postmortem, when the activity of µ calpain is very low and the µ calpain may bound to myofibril and inactivated during postmortem storage indicating the µ calpain or other proteases are activate at this time(Delgado et. al., 2001).

It is suggested that water appearing as drip has been transported to the extracellular space via the conduit formed by the customers and that in pork proteolysis of these cytoskeletal proteins reduces this movement of eater to the extracellular space thereby, improving the water holding
capacity in storage and hence the quality of meat (Kristensen & Purslow 2001).

2:7 Conditioning, hot boning and aging of meat

2:7:1 High temperature Conditioning:

In practice the shortest possible conditioning time is desirable. In earlier work at high temperature the interest has been in rapid aging of beef. High temperature work has been concerned with aging for 1-2 day. Sometimes after prior conditioning in a chiller and using antibiotics or irradiation to control bacteria, cuts aged for 24 hrs at 44°C or for 48 hrs at 32°C were found to be as tender as cuts aged for 2 weeks at 2°C. It is worth noting that, after 24 hrs off-flavor was prominent at 49°C and noticeable at 44°C but bacterial growth was easier to control at 44°C than at 32°C. (Wilson et al., 1960) For beef the toughening occurring with prior excision can be eliminated by conditioning the side for 3 hr (Will and Henrickson, 1976) or 8 hr (Kastner et al., 1973) at 16°C before boning or by holding the excised, vacuum packaged cuts at 15°C for 24 or 48 hr before freezing (Schmidt and Gilbert, 1970). High temperature conditioning in addition to preventing excessive cold-shortening may also accelerate the aging process. Aging which starts at the onset of rigor-mortis (Locker et al., 1975) occurs during the holding of meat at cooler temperature. The resulting tenderization found during aging has been attributed to degradation of the Z-lines within the sarcomeres (Henderson et al., 1970) and myofibril fragmentation (Olson et al., 1976). Dutson et al, (1975) observed that muscles which were prevented from shortening by the tender stretch procedure and subjected to high temperature conditioning were tender than muscles that were subjected only to tender stretch.

2:7:2 Hot boning:
This procedure involves the removal of muscle or muscle groups from freshly slaughtered carcasses prior to chilling. Hot boning muscles followed by vacuum packing prior to chilling have several potential advantages (Follett et al., 1974). By early removal of fat and bone, refrigerated space for chilling is minimized, furthermore evaporative weight losses during chilling are substantially reduced, (Kastner, 1977).

Schmidt and Gilbert (1970) reported that hot processed Longissimus dorsi, Semimembranosus and Biceps femoris muscles within 2 hr postmortem and conditioned at 15°C for either 24 hr or 48 hr postmortem, were generally equal to or superior to the control chilled at 9°C until 24 hr postmortem in shear force and taste panel evaluation. Hot processed Semitendinosus muscle had significantly higher shear force values but equal taste panel tenderness rating.

Schmidt and Keman (1974) found that hot processed muscles (Longissimus dorsi, Psoas major, Gluteus medius, Semitendinosus, Semimembranosus, Biceps femoris and Quadriceps femoris) within 1 hr postmortem stored at 7°C for 4 hr then were placed in a 1°C chiller until 8 days, compared with the control conventionally chilled 1°C and aged at 8 days and not significantly in shear force and taste panel.

Taylor et al (1980) reported that cuts hot processed 1 to 3 hrs postmortem, conditioned at 10°C for 9 hr and then chilled at 1°C for an additional 18 hrs, were equivalent in yield, tenderness, flavor, juiciness and total bacterial count to the control sides conditioned at 15°C for 7 hrs and then chilled 0 – 1°C until 48 hrs postmortem. Hot processing results in more uniform chilling and color.

Schmidt and Gilbert (1970) thought to produce acceptable beef cut by prerigor excision. Setting in rigor for 24 hrs at 15°C was followed by aging for a further 24 hrs at 15°C, microbial growth was retarded by vacuum packing in cryovac bags. At 24 hrs post mortem, hot-
boned samples gave shear force values similar to those of controls, except for Semitendinosus (ST) muscle which had toughened. When the hot-boned samples were aged for a further 24 hrs, shear values fell to well below those for the unaged controls “with the exception of ST which had improved almost to the level of the control”. Taste panel assessment on juiciness texture, and general acceptability characteristic had been preserved.

Hot boning early postmortem improved the color and color stability of beef round muscles by accelerating postmortem chill rate (Sammel et. al.; 2002). Deboning of hot veal carcasses before the ultimate PH has been reached may result in muscle contraction, which may exert negative effects on tenderness and water holding capacity of veal. Effects of deboning time can at least partly be explained by differential effects on shortening of the muscle fibers (Klont et al; (2000).

2:7:3 Ageing:-

During meat storage, proteolytic enzymes degrade myofibril proteins and tenderness increases. Myofibril proteins are responsible for the decline in shear force during postmortem storage; optimum tenderness took 5 to 7 days (Tornberg et. al., 1994, Goll et. al., 1995; Koohmarais 1995, Van Laack et. al., 2001). Hot processed sample were more tender than control in term of shear force values measured at 3, 7 and 13 days postmortem (Sohmidt and Keman 1974). Mitchell et al, (1991) found no advantage due to aging SM steaks subjected to high – voltage electrical stimulation or tender stretch beyond 10 day ; but did find a slight non significant increase in tenderness through 21 days of postmortem aging. These researchers reported that the SM muscle should be aged 24 days to elicit a superior tenderness response. Superior
tenderness was used to describe steaks that had Warner-Bratzler shear force values of less than 7 pound \((Elires et al., 1996)\).

Optimal aging time for bottom round steaks was 12 days. While tenderness of top rounds could be improved if aged for up to 16 days \((Weatherly et al, 1998)\). The minimum recommended postmortem aging for steaks from the rib section was 11 to 15 days. The chuck roll and shoulder clod cuts from the chuck should be aged minimum of 12 and 11 days respectively. Strip loin and Top sirloin should be aged for at least 14 days and 21 days respectively. Top round and bottom round cuts should be aged for a minimum of 16 and 12 days respectively.

\(Xie \ et \ al, (1996)\) studied 27 wagyu-sired steers to evaluate the effect of postmortem aging on palatability of rib eye steaks. They found that shear force values and sensory tenderness ratings were significantly improved following 10 days of postmortem aging compared with 2 days. \(Daskiewiez \ et \ al \ (2003)\) found that after 14 days storage, a slight increase was observed in the percentage of dry matter, fat, crude protein, and ash as well as significant increase in the content of soluble proteins and non protein nitrogen.

2:8 Muscle shortening:

The rigor shortening is the cause of toughening and postmortem proteolysis was the reason for tenderization \((Wheeler and Koohmaraie, 1994)\). The time course of rigor development and extent of rigor shortening has also been reported to vary due to variation in temperature, PH at death and glycogen reserves \((Honikel et. a.l, (1983)\) \(Hertzman et. Al, (1993)\) reported that rigor shortening is temperature not PH dependent and that rigor shortening was very important to ultimate meat tenderness in muscle stored at \(37^\circ C\). \(Marsh and Leet (1966)\) demonstrated that up to 20% shortening had little effect on tenderness of beef sterno mandibularis 20 to 40% shortening resulted in dramatic
decreases in tenderness and 55-60% shortening resulted in tenderness similar to that with 20% shortening. There is considerable evidence to support the idea that proteolysis of key myofibril protein is responsible for the decline in shear force during post mortem storage (Goll et. al., 1983-1995; koohmaraie 1992 a, b 1994-1995).

If however, carcass temperature falls below 10 - 15°C in the early postmortem period when lactate accumulation has not led to a major reduction in pH (pH approximately 6.0 - 6.4) and there is sufficient residual ATP, the muscle will shorten and lead toughening (Bruce and Ball, 1990; Geesink 2000). It is suggested that a rigor temperature of 15°C has the greatest beneficial effects on tenderness (Devine et. al., 1999).

The importance of both temperature and sarcomere length is such that recommended limits for temperature with time, and best practice for carcass suspension to ensure stretching are included in recommendations set by the UK Meat and Livestock Commission (1991, 1993, 1995). Shear force value do not increase during rigor development when muscle is prevented from shortening, thus, the toughening that occurs during the first 24h of slaughter is most a likely due to sarcomere shortening (Koohmaraie et. al, 1996).

Since chilling and freezing are used extensively to preserve meat, cold and thaw shortening are likely processing hazards to be avoided not only to prevent toughening but also to achieve maximal tenderizing by aging. To avoid all possibility of cold shortening meat must be set in rigor mortis before its chilled much below 10°C (Locker and Hagyard, 1963; Davey and Gilbert, 1975).

Bendall (1972) pointed out that the critical temperature in muscle for onset of cold shortening is 4°C and that the muscle temperature of 3°C causes the most severe cold shortening effect. Toughness due to rapid postmortem chilling in red muscle is thought to be due to shortening of
macromere triggered by concentrations of Ca2+ (Davey and Gilbert, 1974), arising from the failure of sarcoplasmic reticulum disorganized by cold, to resorb Ca2+ released from mitochondria (Buege and Marsh, 1975, Bendall et al., 1976).

The changes that occur in muscle during early postmortem cooling period are especially sensitive to the modification by processing techniques. Carcass size, fat thickness and other protected shielding and the variability in bulk and shape of the carcass are likely to affect the cooling of muscle. Carcasses with more external fats would be further insulated against rapid chilling and might not undergo cold shortening (Marsh and Leet, 1966, Locker et al., 1975, Glover et al., 1977). This was shown to be a major factor in the variation of lamb and beef tenderness of rapidly chilled carcasses (Locker and Hagyard, 1963; Marsh and Leet, 1966).

Due to the relation between shortening and tenderness Locker (1960a) postulated that it should be possible to improve the quality of the L. dorsi muscle by hanging the carcass in such away that this muscle is prevented from shortening. Many carcass suspension methods were developed to ensure muscle restraint during carcass chilling (Herring et al., 1965a; 1956b; 1967b; Hostetler et al., 1970, 1972; Davey and Gilbert, 1973; Buege and Stouffer, 1974).

Smith et al. (1971) reported that these treatments had the disadvantage of resulting in irregular shaped carcasses, which presented problems in fabrication. Since cold shortening occurs only when lean carcasses are chilled very rapidly, it was obvious that it could be avoided by slow chilling or by a longer period of holding at 16°C before chilling to 0-2°C or freezing. Cold shortening can also be minimized by electrical stimulation of carcasses immediately after death, which accelerate postmortem glycolysis (Harsham and Deatherage, 1951) and quickly
lowers muscle pH to about 6.2, below which value muscles are no longer susceptible to cold shock and thus can be rapidly chilled without the risk of cold-shortening \((\text{Carse, 1973; Bendall and Rhodes, 1976})\). Many investigators compared carcass suspension methods and delayed chilling and concluded that delayed chilling appeared to be the most practical methods for industrial use \((\text{Smith et. al., 1971; McCrae et. al., 1971; Bouton et. al., 1973})\). However, delayed chilling by holding carcasses at 16-18°C for 10-16h postmortem is not without problems. \textit{Bouton et. al. (1973)} reported that it is necessary to keep carcasses conditioned at this temperature at low relative humidity. The combination of higher temperature and low humidity results in a large increase in evaporative weight loss.

Isolated fresh beef muscles have been found to shorten more at 2°C than at 37°C. Minimum shortening occurs in the temperature region of 14-19°C. At higher temperatures shortening coincides with the onset of rigor mortes but low temperature it begins rapidly and usually immediately \((\text{Locker and Hagyard 1963})\).

\textit{(Honikel et. al. (1981))} Reported that Beef muscle exposed to temperature above 25°C or below 4°C, greater muscle shortening occurred and was found to be directly related to greater amounts of muscle drip loss.

\textbf{2:9 Muscle Proteinases in Conditioning:}

The softening of the muscles post- rigor is caused by proteolytic enzymes disruption of the cross bridged myofibril structures, these effects can be readily observed when post rigor muscle is examined in the electron microscope. Here the disruption occurs initially at the junction of the 1 Band with the Z- disk \((\text{Penny, 1980})\). If the muscle is stretched then long transverse gaps appear as the thin filaments detached
from their points of anchorage in the Z-disk. As conditioning proceeds there is also degradation of the Z-disks and in fully conditioned meat both the Z-disk and m-line structures are substantially degraded. When the myofibril proteins were separated by sodium dodecyl sulphate-polyacrylamide-gel electrophoresis then the most noticeable change that occurs during-conditioning was found to be the progressive loss of troponin T (Penny, Voyle & Dransfield, 1974). Azanza et al (1979), Penny, (1980) found that there was a decrease in the content of desmin, C-protein, M-line protein and tropomyosin the major component of Z-disk, α actinin was not found apparently degraded and the disruption of the Z-disk, may therefore rise from the degradation of a minor protein that is involved in stabilizing the α actinin lattice.

The initial destruction at the Z-disk while the muscle pH is still high is most probably caused by the calcium-activated neutral proteinase (CANP) this enzyme activate at high pH values than the lysosomal cathepsins. CANP degraded desmin and the loss of this protein from the myofibrillars was allowed using an immuno-histological technique (Lazarides, 1980). CANP appears to be sarcoplasmic enzyme (Dyton et al 1975). But from immuno-histological evidence it is located close to the Z-disk (Ishura et al 1980).

There are claims to a measurable improvement in meat quality if carcasses are stimulated. The reasons for this are unclear. But recent data indicate that the lysosomal cathepsins may be participating to a greater degree in myofibril degradation. Sudden fall in pH during electrical stimulation while the carcass is still hot will prompt an earlier disruption of the muscle lysosomes. Electrical Stimulation releases the lysosomal activity with in the first hour following stimulation. These enzymes are not only earlier but they will exhibit greater proteolytic activity than non-stimulated carcasses as the pH is reduced while the
temperature of the muscles is still elevated (Dutson, Smith and Carpenter, 1980).

At the limit pH of 5.5 the muscle enzymes prompt a further improvement in the quality of meat while it was held in refrigeration, but not frozen storage. Since enzyme action is temperature dependent, proteolytic degradation can be accelerated if the carcasses are held for a while above or near ambient temperature; there is an early release of enzymes from the lysosomes under these conditions (Moller and others, 1976).

The effect of pH on myofibrillar proteolysis was studied in controlled autolysis of muscle homogenates above PH 6.0 CANP was the most effective enzyme but below 6.0 proteolysis was greatly enhanced in the presence of EDTA and thiol activators, which indicate that the cysteine cathepsins of the muscle lysisosme are the more effective enzymes during the main conditioning period (Penny- Ferguson- Pryce, 1979).

Like cathepsins B, cathepsins H, L and R are all cysteine proteinases. Cathpensin L MW 22.000 daltons purified from rat liver and other tissue Kirschke et al (1977a). This enzyme also an endopeptidase , exhibiting maximal activity in the region of pH 5.5- 6.0 for most substances. Experimentally it is readily identified from its ability to degrade a zocase at pH 6.0 in contrast to the others lysosomal cathepsins. Which do not clave the substrate at this PH. Rat cathpesin L was reported to degrade actin in vitro at PH 505- 6.0 (Bird et al 1980) this enzyme caused substantial breakdown of the Z- disk- α actinin in isolated myofibrils at PH 5.0 and also claved myosin, but only slowly above pH 5.0 Cathepsin H MW 26.000 dalton is both endo and exo peptidase and also purified from rat liver. It was reported that cathepsin H can degrade myosin in vitro at pH 5.5- 6.0 (Bird et al 1980).
Three lysosomal enzymes were known to possess collagenolytic activity, these are cathepsin B, L and N (Etherington, 1980) this enzyme property have been investigated mainly in vitro testing of the enzyme against defined collagenous substrates. Cathepsin B and L may be involved in the break down of myofibrillars structures, but cathepsin N appear to have very limited action on protein other than collagen. The enzyme has been purified from both bovine and human tissue 20.000, 35.000 daltons in its action against collagen cathepsin N was almost indistinguishable from cathepsin B. For these enzymes to have any action in muscle connective tissue post mortem they must be released first into the extra-cellular space and the time course for this may be significantly longer than the time required initially to exit from the lysosomes (Veiseth et al. (2001); Geesink et al.( 2001). Koohmaraie et al, (2002); Hopkins and Thomson (2001 a, b, c).

2:10: Protein fractionation

Myofibril fragmentation was faster in Longisimus dorsi and Semitendinosus muscles held at 25°C when compared to muscle held at 2°C (Olson et. al., (1976). Very often apart from regular test used to measure the amount of protein in meat an evaluation of their solubility is performed a more precise analysis may be performed using electrophoresis .The most common is electrophoresis in poly acryl amide gel with SDS (sodium dodecyle sulphate )which allows for protein separation based on molecular weight and for an evaluation of the proteolysis process(Bloughetal 1996). Currently its more and more often used together with isoelectrofocusing (Oh-Ishi 2000,Roncada et.al. 2002) It required the use of two dimensional separations which follow for an identification of proteins in relation to their iso-electric point and molecular weight.
2:11 Organolyptic attributes:

2:11:1 Color:-

Myoglobin accounts for only 10% of the total iron in the living animal. After bleeding, it might account for as much as 90.5% of the iron of the beef skeletal muscle. Differences between muscle types were generally significant for color value during and after oxygenation and total pigment concentration (Mitsumoto et. al., 1988). Oxygenation of the purple myoglobin to bright red oxymyoglobin, or “bloom”, occurs when fresh meat surfaces are exposed to air and is maximal after 24h exposure at 0°C. The formation of the undesired brown oxidized metmyoglobin on the surface results mostly from bacterial action but may be caused by long-term exposure to oxygen or by a coupled lipid oxidation mechanism (Benedict et. al., 1975). Meat color was influenced more by the final pH of muscle and the maturation period up to 9 days than by breed or diet.

Tarrant and Mothersill (1977) noted variations in muscle color at various depths within the thick muscles of the round. They attributed this to the variations in glycolytic and cooling rates. Often in carcasses which have little fat covering a dark ring of color (called "heat ring" in the U.S) appeared. The deep portions "8 cm" had higher driplosses than superficial areas as a result of the low pH. Fields et al. (1976) evaluated the effects of high temperature conditioning on color of Longisimus dorsi muscle steaks and found that steaks from steer carcasses conditioned for 12 hr at 16°C were brighter than those from conventionally chilled carcasses. Like wise, high temperature conditioning of cow carcasses for 16 hr at 16°C produced steaks with brighter color and higher consumer acceptability than did 2°C chilling. Conditioning of lamb carcasses at various temperatures had very little effect on lean color and over all appearance, unless the temperatures were very high (Bowling et. al., 1978).
Slightly dark beef with moderately high pH tends to be tougher than brighter colored meat with a normal ultimate pH \((Purchas, \ 1990); \ Jeremiah \ et. \ al., \ (1991); \ Watanabe \ et. \ al., \ (1996)\). Stronger relationship between pH and \(L\) values indicating that higher colored beef would have a lower pH \((Wulf \ and \ Wise \ (1990)). \)  \(Wulf \ et \ al \ (1997)\) found that yellowness \((b)\) values host stronger positive relationship to tenderness than lightness values. Thus of the color values, yellowness \((b)\) values may be the best indicator of beef tenderness. \(Page \ et \ al \ (2001)\) reported that color values for lightness \((L)\), redness \((a)\) and yellowness \((b)\) were negatively correlated with muscle pH and values for \((a)\) and \((b)\) were more highly correlated with muscle pH than values for \((L)\).

A darker color for hot boned meat was noted by \(Heinz \ et. \ al. \ (1975)\) only after the meat had been severely cold shortened, and by \(Kastner \ et. \ al., \ (1973)\) following a two hours conditioning period. \(Kastner \ and \ Russell \ (1975)\) found that hot boned meat conditioned for periods of 8-10h had a lower brightness than conventionally chilled meat. Hot boned meat reacts differently to storage than conventionally chilled meat. Hot boning results in a darker meat color throughout the storage time \((Strange \ and \ Benedict, \ 1978)\). Moreover hot boning of either the Semimembranosus or Quadriceps early postmortem improved the color and color stability of beef round muscles by accelerating postmortem chill rate \((Nichols \ and \ Cross \ 1980; \ Taylor \ et. \ al., \ 1984, \ Seyfert \ et. \ al., \ 2004)\).

2:11:2 Water holding capacity (WHC)

WHC has been defined as the ability of meat to retain its own or added water during the application of some external force or treatment \((Hammam, \ 1960)\). Water is present in meat as bound water (5% of total water) and “free water”. Hydrophilic groups attach bound water to protein, while “free water” is immobilized by the physical configuration
of meat proteins. Changes only take place in “free water” and are manifested as weep, drip or shrink. The water content of different muscles in beef and pork varies and this could be due to pH differences (Lawrie et al., 1963). Muscles having a high content of intramuscular fat tend to have a high water holding capacity (Saffle and Bratzler, 1959).

Denaturation of sarcoplasmic and myofibrillar proteins, whether by fast rate of pH fall or by high temperature lowers water holding capacity (Bendall and Wismer-Pederson, 1962; Scopes, 1964; Penny, 1969). Again fibre contraction in cold shortening was reported to significantly lower water holding capacity (Bouton et al., 1971).

Bowling et al. (1978) found a trend towards slightly higher values for expressible juice percentage following conditioning at higher temperatures suggesting a partial reduction in water holding capacity due to the high temperature and low pH conditions.

Water holding capacity increases during aging, which may be due to changes in the ion protein relationships through absorption of K+ and release of Ca+ ions with consequent increase in net charge (Arnold, 1956). Processing techniques that reduce the effect of high temperature in the deep musculature of beef hind limbs e.g. hot deboning improve the WHC (Follet et al., 1974). Electrical stimulation initially improves WHC of muscles possibly through its enhancement of conditioning changes and, thereby, of osmotic pressure. Conditioning of meat increases its WHC at various environmental pH values. Meat from hot boned sides exhibited a higher WHC than cold boning sides, increased moisture retention result in higher ash retention in the hot boned meat (Hamm, 1960).

2:11:3 Cooking Loss

Differences between the hot processing and conventionally chilled control treatment were small regard less of the chilling treatment for hot
processed muscles (Sohmidt and Keman, 1974) Since the high temperature involved in cooking will causes protein denaturation and considerable lowering in WHC. The induction of high ultimate pH in muscle will diminish cooking loss, which is due to exudation of moisture. A faster rate of pH fall will increase moisture loss in cooking (Lawrie, 1991). The effect of conditioning meat in enhancing WHC is to some extent reflected in diminished cooking losses.

Meat cooked quickly to a given internal temperature has a lowered cooking loss and is juicier than that cooked slowly to the same temperature. Carcass weight loss increases and cooking weight loss decrease with increasing storage time (Hipe et al., 1991).

Lyon et al (1982) removed from steer Psoas major and Triceps branchi steers muscles 2 hours postmortem and chilled them at 2 – 4 °C until 48 hr P M. After excision and packaging they were aged at 1 – 5 °C until 6 days P M hot processed steaks were equal or superior to control in shear force and cooking loss

2:11:4 Tenderness:

Parrish et al (1969) reported that conditioning of heavy weight, choice grade beef carcasses at 7 °C or 15 °C for 24 hrs/ or 48 hrs or at 21 °C for 24 h had no significant effect on palatability attributes of LD or SM muscles. Simth et al (1971) compared the effect of conditioning at 16°C for 8, 16 or 20hrs conditioning resulted in significant improvement in LD tenderness. Likewise, Parrish et al (1973) reported that LD samples from choice carcasses conditioned for 24 hr at 16°C before subsequent chilling were as tender as sample from control carcasses chilled aged 7 d at 2°C changes that take place in muscle during the first 24 h post-mortem are very important in determining the ultimate tenderness (Bendall, 1973; Locker, 1985; Marsh 1985). It is well
established that longissimus muscles from different carcasses tenderize differently during post-mortem storage and this explains carcass variation in longissimus tenderness (Koohmaraie 1992a).

The principle source of error is attempting to measure tenderness in pre-rigor meat is excision and heat induced shortening Locker (1985). The rigor shortening is the cause of toughening and post-mortem proteolysis was the reason for tenderization (Wheeler and Koohmaraie, 1994). There is considerable evidence to support the idea that proteolysis of key myofibril protein is responsible for the decline in shear force during post-mortem storage (Goll et al., 1983-1995; Koohmaraie 1992a, b 1994-1995). Numerous Studies have demonstrated that muscles that shorten less during rigor or were stretched (i.e., long sarcomeres) were more tender (Locker, 1985; March, 1985). Difference in rate and extent of post-mortem tenderization are the principle source of variation in meat tenderness and are probably the source of inconsistency in meat tenderness at consumer level (Koohmaraie, 1995). Changes that take place in muscle during first 24 h post-mortem are very important in determining the ultimate tenderness (Bendall, 1973; Locker, 1985; Marsh 1985).

The chilling or conditioning of hot boned muscle for a period of time at temperature ranging from 5-15°C has resulted in products equal or superior in their muscle properties to conventionally processed beef (Kastner, 1983). In addition, reductions in tenderness due to hot boning have been eliminated by delayed processing until 8h postmortem (Kastner et al., 1973, 1976; Kastner and Russell, 1975). Even a delay of 3h before processing has resulted in a product which had only slight reduction in tenderness, which were considered to be of no practical significance (Falk et al., 1975). Neither delayed chilling (2h at 12°C) nor electrical stimulation produced consistent meaningful alteration in any of
the physical, cooking or palatability attributes of Semimembranosus, L. dorsi and Triceps branchii bovine muscles

The precise relationship between tenderness and pH is complex and not fully understood (Van laack et al 2001). Meat with PH (often>6.5) described as dark cutting or dark firm and dry occurs when animals have lower than normal muscle glycogen levels at slaughter. As a result lactate production is low (40 µ M-lactate/g) compared with (100 µ M-lactate/g) in normal meat. The tenderness of meat with high pH is a matter for considerable debate. Some studies showed that it might be more tender than normal (Dransfield, 1981) because the reduction in glycolytic substrate availability causes more rapid ATP depletion and early rigor, (the latter reducing susceptibility to cold shortening, and allows prolonged activity of proteases (Watanabe et al., 1996). On the other hand other studies reported that dark firm and dry beef had higher shear force values and less palatable than normal beef (Wulf et al., 2002). In contrast meat with a low pHu is likely to be of poor eating quality; the enzymes involved in postmortem tenderization are inhibited by acidification and low pHu is also associated with increased drip loss high (Maltin et al., 2003). Storage had appositive time effect on the organoleptic properties of beef but their satisfactory levels was observed as late as 10 days after storage (Daskiewiez et al., (2003).

Morrison et al, (1998); Vestergaard et al( 2000); Maltin et al(2001b) showed very clearly that the variation in overall acceptability between muscles cannot be attributed simply to fiber type and tenderness is clearly complex and it is likely that other variables interact With fiber type characteristics to determine eating quality.

Recent studies in cattle using growth rates at or above those used commercially showed that neither pre-weaning (Allingham et al., 2001) nor pre slaughter growth rates (Moloney et al., 2001; Sinclair et al 2001)
affect tenderness. Moreover, even when compensatory changes were evident in terms of elevated rates of both protein synthesis and protein degradation (Labley et al., 2000) no improvements in eating quality were observed and the major effects appeared to relate to genotype (Lobley et al 2000; Sinclair et al 2001).

### 2:11:5 Flavor

It originates from water or fat soluble precursors and from the release of volatile substances pre-existent in meat. The flavor of meat tends to improve with conditioning and can be related to progressive breakdown of nucleotides whereby ADP and AMP respectively are de-phosphorylated and de-aminated to inosine or further split to ribose and hypoxanthine. Changes in the free fatty acids as the increase in the level of oleic acid in the intramuscular fat of L. dorsi during aging of beef at 2°C, probably also contribute to flavor changes (Howard et al., 1960 and Lawrie, 1991).

Components of meat responsible for flavor and aroma have not been completely identified. It is likely that many constituents of muscle connective and adipose tissues become flavor compounds upon being heated. Prolonged storage under unfavorable conditions may cause the development of proteolytic or putrid odors from protein decomposition, sour or tainted odors from microbial growth and rancid odors from fat oxidation (Judge et al., 1990).

Flavor development is an important result of the cooking process. The nature and intensity of meat flavor depend in part on the type, length of time, and temperature of cooking (Price et al., 1970). Microorganisms growing in meat tend to produce sour or putrid odor respectively (Ingram and Dainty, 1971).
2:11:6 Juiciness

Juiciness of cooked meat can be classified into two effects: one is the impression of wetness during the first chews produced by the rapid release from meat fluid the other is due to the stimulating effect of fat on salivation (Weir, 1960). Good quality meat is juicier than the poor quality meat, the difference being at least partly attributed to higher content of intramuscular fat in the former.

The degree of shrinkage on cooking is directly correlated with loss of juiciness. The principal source of juiciness in meat, as detected by consumer, is the intramuscular lipids and the water content (Judge et al., 1990). Steaks with slight or greater marbling levels were significantly juicier than those with traces of marbling.

There are some suggestions that juiciness reaches a minimum when pH level of the meat is about 6.0 (Howard et al., 1960). The ranking order shows that juiciness was greatest in the fresh (frozen) meat of high ultimate pH (Lawrie, 1979). Tenderness and juiciness are closely related, the more tender meat the more juicy. Juiciness varies inversely with cooking losses (Judge et al., 1990).

2:12: Meat Microbiology

The deep tissue from animals slaughtered under reasonably hygienic conditions are generally sterile (Gill, 1979). Surface bacteria do not penetrate into muscle tissue until high bacteria numbers have been attained and overt spoilage has developed. Penetration is delayed because bacterial proteolytic activity is required and proteolytic enzymes are produced only in the late logarithmic phase of growth (Gill and Penny, 1977). Spoilage of meat is therefore a surface phenomenon.

Total bacterial count of aerobic bacteria in fresh refrigerated beef was found to increase with progress in refrigeration time (Abdel Karim, 1992 and Hussein, 1987). Total aerobic count on vacuum packed
beef (loin steak) were 7.0 log10 cfu/cm² after been stored for 4 weeks at 4°C. For steaks being packed in oxygen permeable film, the total count increased rapidly to 7.0 log10 cfu/cm² after 4-6 days at 4°C and 2.5-4 days at 8°C. So the temperatures during the storage of steaks greatly affect their shelf-life (Borch, 1989). Meat microbial count (log10/cm²) of the surface was reduced by lowering the storage chilling temperature and decreasing the storage time, 2.9 and 2.61 log10/cm² for carcasses chilled at 3°C and –2°C respectively at 7 days post mortem. At both chilling temperatures, surface count was far below the recommended bacteriological limit of fresh meat (Glover et al., 1977).

Extensive microbial assays were carried out in meat. Initial counts on meat cuts were a round 10²-10³/cm² and these rose only slightly during 24 hrs at 15°C. In the next 24 hrs counts rose by less than the order of magnitude, and only in one case exceeded 10⁴/ cm². It appears that the utilization of oxygen and the generation of CO₂ with in the impermeable bag had effectively controlled growth (Schmidt and Gilbert; (1970). Analysis of 39 samples of chilled minced beef, packed in plastic containers and stored at a temperature of refrigerates in supermarkets revealed that 15.4% of the samples did not conform to current meat hygiene regulations. Mesophilic bacteria were found in 10.2 % and 2.5 % of samples had coliform bacteria.

Spoilage can be extremely rapid when the initial level of contamination is high and/or when the conditions are favorable for microbial growth. The most common indications of spoilage are off-odor and slime usually due to the growth of aerobic bacteria on the cut surfaces of meat and fungal growth, which is favored at water activities too low for bacterial growth. Bone-taint or deep spoilage due to anaerobic or facultative microorganisms and discoloration are primarily due to alteration on myoglobin, the muscle pigment (Banwart, 1981).
The most common methods for prolonging the shelf life of meat are the use of chilling. When the temperature of meat and meat products is lowered to just above its freezing point (-2 to 5°C), in which the low temperature retard microbial growth, enzymatic and chemical reactions that cause deterioration and spoilage (Judge et al, 1990). Chilling meat postmortem from 40°C down to 0°C and keeping it cold will give a shelf-life up to 3 weeks, provided high standards of hygiene were observed during slaughter and dressing (FAO, 1991).

Water is required by microorganisms, so reducing the water available below the optimum level will prolong shelf life of meat. If meat is stored at a relative humidity below 95% moisture will be lost from the surface. Since most spoilage bacteria, being aerobic can grow only on the surface so surface drying will extend the shelf life of meat. Moulds (fungi) are able to grow in drier conditions than bacteria so that desiccation has a selective effect on microbial growth. It is possible at higher temperature to alter the rate of spoilage development by modifying the storage conditions and thus the environment to which the bacteria are exposed (Gill, 1976).

With uncontrolled ambient conditions, the surface desiccation associated with cooling will usually ensure a lag of about 24 hours before any growth commences. Desiccation will even delay for several hours microbial growth on carcasses held at body temperature (Wilhelm et al., 1982, Nour 2003). This delay is particularly valuable as meat can not be chilled soon after slaughter without toughening (Locker et al., 1975). Slow cooling, which will allow rapid bacterial growth in the absence of drying, is therefore essential unless carcasses are subjected to electrical stimulation which accelerate the rigor process and so allows early chilling without irreversible toughening (Chrystall and Devine, 1983).
Immediate reduction of bacterial population on beef surface using rapid desiccation with dry heat is more effective than water washing. Modification of desiccation process could minimize discoloration and decreased moisture loss (Cutter et al., 1997). Concentration of salts in the desiccated tissues causes oxidation of myoglobin and darkening of color due to optical changes in the tissue (Locker and Hagyard, 1963).

2:13: Ground Pre-rigor Beef:

Hot boning of beef carcasses and processing of pre-rigor meat is reported to have marked economic advantages (Cuthbertson, 1980, Kastner, 1982). Furthermore, processing of pre-rigor beef may provide products of excellent water-holding and fat emulsifying capacity (Hamm 1977; Honikel and Ham, 1978).

Several reports (Abubakar et al., 1988. Berry and Leddy, 1988) upon the use of pre-rigor muscle for (non salted) ground beef showed lower cooking losses in hot than in cold processed products. Additionally products manufactured from pre-rigor meat were more tender and more juicier than in cold processed controls.

Ground beef processed from pre-rigor hot boned beef has been showed to be superior to cold-boned beef in palatability (Cross and Tennent, 1981); Wells et al, 1980). Pre-rigor hot boned muscle may react differently than chilled beef to various processing methods.

Mechanical desinewing has effectively improved tenderness and remove connective tissue with chilled beef (Cross et al., 1978a; Wells et al., 1980) but not with hot boned beef (Wells et al, 1980).

Cross et al., (1979) successively demonstrated that ground beef prepared from un chilled beef muscle is equal or superior to ground beef from chilled muscle in palatability and cooking properties. However, if processing of ground beef from hot boned beef is to be practical, the hot
processing of selected cuts for steaks and roasts from the same carcass must be also feasible.

Jones et al (1986) showed hot boning sides have a higher binding ability of the meat proteins, signifying an increased protein extraction in hot boning meat.

The shelf life of electrically stimulated ground beef at 5°C was extended by 3 days as compared with that of the non stimulated control (Raccah and Henrickson 1978). Aerobic plate counts of ground beef and steaks from stimulated sides were often numerically lower than those of corresponding samples from non stimulated sides (Mrigadat et al 1980), however differences in aerobic plate counts between electrically stimulated and control samples usually were not significant (p>0.05).

**Oxidative rancidity:**

There is a high positive correlation between TBA value and panel scores for cooked ground beef. TBA value increase and thus rancidity with increasing storage time (Younthan et. Al, (1980)). Disruption of muscle structures could promote lipid oxidation and increase the off-flavor problem in meat (Dutson et al 1980). Lipid oxidation increases the rate of met-myoglobin formation and conversely met-myoglobin acts as catalyst of lipid peroxidation so that in beef muscle displayed under oxygen permeable film, lipid oxidation and met-myoglobin levels were closely correlated (Anton et al 1996).

Hot boning the knuckle muscle had no effect on oxidative rancidity and sensory properties (Seyfert et. al, 2005).

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**CHAPTER THREE**

**MATERIALS AND METHODS**

3.1 Experimental animals
Ten animals, baggara bulls (Nyalawi type) 3 years old were used in this study. They ranged in live weight from 325-360 kg. Animals were obtained from the Fattening Research Unit of the Department of Meat Production, Faculty of Animal Production at Shambat (Khartoum North), University of Khartoum. Animals destined to slaughter were allowed to drink, but not fed, for 12 hours before slaughter. They were slaughtered according to the local Muslim practice.

Two experiments were designed to investigate beef processing under tropical temperature, these involved:

**Experiment one**

Concerned with evaluation of the effect of hot boning (conditioning or delayed chilling time,) and postmortem aging times of SM, ST and LD beef muscles held at ambient temperature (28-29°C) on their chemical composition, protein fractionation and quality attributes.

**Experiment two**

Processing of minced meat from pre-rigor meat conditioned at high ambient temperature.

The term conditioning has been used, throughout this study to describe the temperature time treatment the muscle received before being hot boned and moved to the chiller.

Aging describes the treatment post rigor hot boned muscle received after completion of the early conditioning.

### 3.3 Experiment one

#### 3.3.1 High temperature conditioning of beef:

In this experiment 15 hindquarters. The quarters were obtained immediately after dressing, splitting and washing. They were moved into the meat-cutting laboratory. Warm quarter’s weights were obtained.
Quarters were divided into three groups of five each. Each group was assigned at random to the different conditioning treatments.

One group comprised the control where carcass quarters were kept at 2°C for 48h. The other two groups were hanged from the achilies tendon at room temperature which ranged from 28-29°C for either 3 or 5 hours before hot boning and chilling at 2°C up to 48h.

3.3.2 Temperature recording (Rate of chilling):

Temperature was continuously monitored every hour for the first 5 hrs postmortem. Temperature was read in the geometric centre of the LD, SM and ST muscles by inserting a thermocouple (DL2Data Logger-AT-Data –T-Devices) in the center of the muscles at a depth of 5 cm.

3.3.3 PH determination:

Psoas major muscle was used for ph determination immediately after postmortem dressing (one hour) and up to 5hours and then at 24h and 48h. The procedure at each measurement involved excising of a fresh cut surface and sampling it with sterile plate. The area was covered by polythene cover to avoid desiccation. Sample weighing approximately 1 gm was homogenized in 10 ml 5 mM Iodoacetic acid; 150mM KCl (Bendall 1973) neutralized to pH 7.0 by dilute NaOH and HCL. The pH was then read on laboratory pH meter, (adjusted with buffer, pH 7.0) at room temperature.

3.3.4 Hot deboning and Preparation of Samples for chemical composition and quality characteristics:

After 3 and 5h (postmortem) conditioning at ambient temperature LD, SM and ST muscles were dissected from the hindquarters. Each muscle was divided into 2 portions. Each portion was weighed and placed in a polyethylene bag. The samples were then assigned at random to 48hours and 7 days aging periods at 2°C. While the control ones were
dissected after 48 hours chilling at 2°C. Then the muscles were sub sampled for quality and chemical analysis.

3.3.5 Chemical Composition:

3.3.5.1 Protein fractionation

Samples for protein fractionation were trimmed of excessive subcutaneous fat and connective tissues before mincing. A 5gm sample was weighed and fractionated into sarcoplasmic and myofibrillar proteins according to the procedure described by Babiker and Lawrie (1983). All fractionation procedures were carried at 4°C.

3.3.5.2 Non-protein Nitrogen (NPN)

Thirty ml sample from the combined filtrate (containing both sarcoplasmic proteins and non-protein nitrogen fractions) was obtained from the protein fractionation and mixed with 10ml of trichloroacetic acid 20% (w/v), for 15 minute and filtered through filter paper (Whatman No. 1), to obtain non-protein nitrogen content of this fraction. It was then expressed as a percentage of fresh sample weight.

3.3.6 Water parameters:

3.3.6.1 Water holding capacity (WHC)

Duplicate samples (about 1 gm) from the minced muscles (LD, SM, and ST) were used. Each sample was placed on humidified filter paper (Whatman No.4 in a desiccator over saturated KCl solution) and pressed between two plexiglass plates for 1 minute at 25 kg/cm² load. The meat filter area was traced with a ball pen and the filter paper was allowed to dry. Meat and moisture areas were measured with a compensating planometer. The resulting area covered by the meat was divided into the moisture area to give a ratio expressed as water holding capacity of meat. A large ratio indicates an increase in the watery condition of the muscle or a decrease in the water holding capacity (Grauard and Hamm, 1953).
Water holding capacity (WHC) = \( \frac{\text{Loose water area} - \text{Meat film area}}{\text{Meat film area}} \)

3.3.6.2 Cooking loss:

Samples were trimmed of all external fat and connective tissues. They were cut into portions 5x5x7 cm with the fibre direction parallel to the long axis. Each sample was placed in a polythene bag and totally immersed in a water bath at 80°C for 90 minutes (internal temperature at the centre of sample was 80°C). After cooking each sample was cooled in running tap water for 20 minutes in its exuded fluids and then removed and dried with paper towel (Bouton et al., 1978). Cooking loss was determined as the difference in weight of sample before and after cooking, and was expressed as a percentage of the weight before cooking.

\[
\text{Cooking loss} = \frac{\text{Wt. Before cooking} - \text{Wt. After cooking}}{\text{Wt. Before cooking}}
\]

3.3.7 Meat Quality attributes

3.3.7.1 Objective measurements:
**Color measurements:**

Samples were taken from the experimental muscles (LD, SM, and ST) and Hunter colour components lightness (L), redness (a) and yellowness (b) were recorded using Hunter Lab Tristimulus colorimeter model D25 m-2. Subsequently these samples were frozen and stored for cooking loss determination.

**3.3.7.2 Subjective measurements:**

Sensory panel evaluation was conducted with a 10-member panel as described by Parrish et al. (1973). LD, SM and ST samples were overnight thawed at 4°C and roasted, wrapped in aluminum foil, in an electric oven at 175°C to an internal temperature of 75°C. To ensure that the centre of each sample had reached 75°C, thermocouples were inserted into the centre of two randomly selected samples and the temperature was recorded every 15 minutes throughout the cooking time (Griffin et al., 1985). Semi-trained panelists evaluated warm meat samples in individual booths. Panelists evaluated each meat sample for tenderness, flavour, juiciness and acceptability on the basis of a hedonic scale of 5-1, with 5 being extremely tender, desirable flavour, extremely juicy acceptable and 1 being extremely tough, undesirable flavour, dry or unacceptable. The average of the 10 panelist values was used as the tenderness, flavour, juiciness and acceptability score for each sample.

**3.3.8. Oxidative rancidity**

The oxidative rancidity of the muscles samples was determined using 2-thiobarbituric acid (TBA) method as described by Hoyland and Taylor (1989) the method employed was as follows:
A) Preparation of samples:
1- A 3g of meat sample was weighed.
2- 50 ml of distilled water was added.
3- The mixture was homogenized in a micro-blender jar for 5 minutes.
4- The homogenized sample was transferred to Kjeldhal flask.
5- The blender jar was washed with 47.5 ml distilled water to remove all the remaining of the homogenized meat.
6- 2.5 ml of 4N HCl was added.
7- The kjeldhal flask was put on distillation apparatus and heated at high temperature after the addition of anti-foaming granules.
8- A 50 ml was collected by distillation.

B) TBA Preparation:
1- 0.2884 of TBA was weighed.
2- 100 ml of glacial acetic acid was added.
3- Then dissolved with heating.
4- 5 ml was taken from the sample after shaking and added to 5ml of TBA.

c) Blank Preparation:
The blank solution was prepared from 5 ml of distilled water +5 ml TBA solution.

D) Final preparation of the sample solution:
1- The flask containing sample solution (5 ml of the sample +5 ml of TBA) was covered with aluminum foil.
2- The flask was heated with the vapor of water bath for 35 minute.
3- Then cooled for 10 minutes.
4- The reading of oxidative rancidity was taken using a spectrophotometer at the wave length of 538 nm.

Calculation:
Oxidative rancidity (mg /ml) = Spectrophotometric Reading x 7.8
Sample Wt

3.3.9 Microbiological evaluation

Thirty grams were obtained from each LD and SM that were excised from the conditioned quarters immediately after 3 and 5h hours postmortem and 48h chilling. The samples were then blended with 270ml sterile distilled water by using electric blender (Homogenizer MSE) for 3 minutes as described by Harrigan MeCanee (1976). Duplicate samples were taken. Serial dilutions were made for each sample and each dilution was plated in standard plate-count Agar. Duplicates of each sample were incubated at 37°C for 48 hours. Bacterial colony count was expressed as log10/10gm colony count.

3.4 Experiment two

Based on the results of experiment (1), this experiment was conducted with the objective of evaluating the effect of using 3 and 5hr postmortem delayed chilled meat on fresh minced meat quality attributes.

3.4.1. ground beef Processing

The flank cuts from each treatment and control were separated after the completion of the chilling period. Trimmed off fats, 1kg muscle samples were taken and minced for preparation of samples to determine colour, WHC and total microbial load.

3.4.2 Color measurement

The colors of the minced meat samples mix was measured immediately with a Hunter Lab Difference Meter Model D25. L, a and b measurements were determined; where (L) lightness (a) redness and (b) yellowness.
3.4.3 Water Holding Capacity

WHC was determined as already described on this study.

3.4.4 Microbiological evaluation

Total bacterial colony count was determined as already described on this study.

3.5 Statistical analysis:

Data for experiment 2 was analyzed as a completely randomized design with a 3x3 factorial arrangement of treatments using analysis of variance treatment means were compared by Duncan's multiple range tests by using SPSS version 10.05-computer program.

CHAPTER FOUR

RESULTS

4:1 Chemical composition of beef round muscles (SM, ST) and (LD) chilled at 2° for 48 hr postmortem:

Table (1) gives the chemical composition of Semimembranosus (SM), Semitendinosus (ST) and L.dorsi (LD) determined on fresh muscle weight base. The percentage of moisture content was significantly
(p>0.01) lower for LD compared with the SM and ST respectively. The difference in moisture percentage was not significant (p>0.05) between the SM and ST muscles. The protein and ash showed the same trend as moisture percentage although the differences were significant (p<0.05) for the protein between the three muscles, but not significant (p>0.05) for the ash content. The LD muscle having the lowest protein and ash compared with the SM and ST muscles respectively. LD fat percent was significantly (p<0.01) higher compared with the SM and ST muscles although the difference between the two latter muscles was not significant (p>0.05).

4.2: Effect of hot boning time (delayed chilling) of beef muscles (SM, ST and LD) conditioned at ambient temperature (28-29°C) for 3 and 5hrs postmortem on:

4.2.1 Temperature Fall (Rate of chilling):

Figure 1, revealed that the most rapid temperature decline in the LD followed by the ST, and lastly the SM. The LD and ST muscles had attained their maximum rates of temperature decline from 1-3 hr postmortem, where as, the SM muscle showed almost slight temperature

<table>
<thead>
<tr>
<th>Parameters</th>
<th>SM</th>
<th>ST</th>
<th>LD</th>
<th>SE</th>
<th>LS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table (1): Chemical Composition of Musculature of Beef Hindquarters (SM, ST and LD) at 48 hr Postmortem</td>
<td></td>
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<tr>
<td></td>
<td>SM</td>
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<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>------</td>
<td>-----</td>
</tr>
<tr>
<td>Moisture</td>
<td>76.19</td>
<td>75.79</td>
<td>75.22</td>
<td>0.315</td>
<td>NS</td>
</tr>
<tr>
<td>Protein</td>
<td>21.11</td>
<td>22.01</td>
<td>20.62</td>
<td>0.310</td>
<td>*</td>
</tr>
<tr>
<td>fat</td>
<td>1.38</td>
<td>1.31</td>
<td>1.54</td>
<td>0.042</td>
<td>**</td>
</tr>
<tr>
<td>Ash</td>
<td>1.01</td>
<td>1.02</td>
<td>0.99</td>
<td>0.029</td>
<td>NS</td>
</tr>
</tbody>
</table>

In this and subsequent tables:

SM: Semimembranosus Muscle
ST: Semitendinosus Muscle
LD: Longissimus dorsi Muscle

*: P<0.05.
**: P<0.01.
***: P<0.001.
NS : Non-Significant.
SE: standard error of the mean.

decrease during this interval. Subsequently the rate of temperature decline slowed for the LD and ST muscles for the SM muscle.

4.2.2: PH determination:

As noted in figure 2, the PH curves of hot and cold – boned beef hind quarters indicated that the rate of PH decline was greater for the muscles conditioned at ambient temperature than those conditioned at 2c.
4. 2.3: Protein fractionation:-

Table (2) gives values for the different protein fractions of hot boned beef muscles, (SM, ST and LD). The extractable myofibrillar protein decreased with increasing delayed chilling hot boning time of all experimental muscle (SM, ST and LD) treatments. But this difference was not significant (p>0.05). Increasing the time of hot boning to 5 hr after slaughtering resulted in the least extractable myofibrillar protein percentage (10.88), (10.87) and (10.80) for the SM, ST and LD muscle respectively. While the control (conventionally chilled at 2°C for 48 hr) gave the highest extractable myofibrillar proteins percentage (11.04), (11.01) and (11.10) for SM, ST and LD muscles respectively. The amount of extractable sarcoplasmic proteins increased not significant (p>0.05) in all experimental treatments. The ST muscle (5.80) had the highest increase in the amount of extractable sarcoplasmic proteins in comparison with SM (5.69) and LD (5.67) respectively.

Non-protein nitrogen increased slightly but not significantly (p>0.05) with increasing time of hot boning in all muscles studies.
Figure 1  Temperature decline of LD,ST and SM beef muscles conditioned at ambient temperature for up to 5 hours.

Figure 2  PH decline in hot vs cold psoas major beef muscle
conditioned at ambient temperature for 3 and 5hrs post mortem

Table (2): Percentage of muscle protein as Affected by Hot Boning Time.

<table>
<thead>
<tr>
<th>Hot boning time (hours)</th>
<th>Parameters</th>
<th>0</th>
<th>3</th>
<th>5</th>
<th>S.E</th>
<th>LS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Myofibril proteins</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>11.04</td>
<td>10.98</td>
<td>10.88</td>
<td>0.05</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>ST</td>
<td>11.01</td>
<td>10.85</td>
<td>10.87</td>
<td>0.05</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>LD</td>
<td>11.10</td>
<td>10.89</td>
<td>10.80</td>
<td>0.05</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Sarcoplasmic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SM</td>
<td>ST</td>
<td>LD</td>
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<td>-------</td>
<td>-------</td>
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<td></td>
</tr>
<tr>
<td>proteins (%)</td>
<td>5.57</td>
<td>5.64</td>
<td>5.69</td>
<td>0.84</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.69</td>
<td>5.73</td>
<td>5.80</td>
<td>0.84</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.66</td>
<td>5.68</td>
<td>5.67</td>
<td>0.84</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Non-protein nitrogen %</td>
<td>0.44</td>
<td>0.45</td>
<td>0.45</td>
<td>0.002</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.44</td>
<td>0.44</td>
<td>0.45</td>
<td>0.002</td>
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</tr>
<tr>
<td></td>
<td>0.44</td>
<td>0.45</td>
<td>0.45</td>
<td>0.002</td>
<td>NS</td>
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</tr>
</tbody>
</table>
4.2.4 Water holding parameters:

Table (3) shows the water holding capacity and cooking loss as percentage of fresh muscle weight. Water holding capacity improved non significantly (p>0.05) with increasing hot boning time for all the treatments studied. The control (immediately chilled) gave the least WHC (2.84), (2.88) (2.80) for the SM, ST and LD muscles respectively compared with the 3 hr hot boned treatment muscles groups SM (2.71), ST (2.79) and LD (2.71), while the 5hr hot boned muscles values were (2.64), (2.72) and (2.59) for SM, ST and LD muscles respectively. Comparing the muscles studied, the SM muscle had the lowest WHC followed by LD muscle and ST muscles respectively.

Non significant decrease in percentage of cooking loss was found with increasing time of hot boning for 3hr and 5hrs postmortem in all treatments over control.

4.2.5 Oxidative Rancidity:-

Table (4) shows the effect of hot boning time of beef muscle on oxidative rancidity (TBA) value. As seen from the table oxidative rancidity value (TBA value) were increased slightly and not significant (p>0.05) with increasing time of hot deboning for 3hr and 5hrs after slaughtering. LD muscle gave the highest TBA value (0.12) compared with the SM (0.09) and ST (0.09) muscles.

4.2.6 Meat Quality attributes

4.2.6.1 Color measurements:-

Table (5) shows the effect of hot boning time (delayed chilling at ambient temperature) on color co-ordinate Lightness (L), redness (a) and yellowness (b) of SM, ST and LD muscles. Lightness (L) increase
Table (3): The Effect of Hot Boning Time (Delayed Chilling) on Water Holding Parameters of Beef Muscles SM, ST and LD

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Hot boning time (hours)</th>
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<th>S.E</th>
<th>LS</th>
</tr>
</thead>
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<tr>
<td></td>
<td>0</td>
<td>3</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WHC (ratio)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>2.84</td>
<td>2.71</td>
<td>2.64</td>
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<td>NS</td>
</tr>
<tr>
<td>ST</td>
<td>2.88</td>
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<tr>
<td>LD</td>
<td>2.80</td>
<td>2.71</td>
<td>2.59</td>
<td>0.04</td>
<td>NS</td>
</tr>
<tr>
<td>Cooking loss %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>43.58</td>
<td>43.23</td>
<td>42.81</td>
<td>0.30</td>
<td>NS</td>
</tr>
<tr>
<td>ST</td>
<td>42.84</td>
<td>43.15</td>
<td>42.94</td>
<td>0.30</td>
<td>NS</td>
</tr>
<tr>
<td>LD</td>
<td>43.61</td>
<td>43.16</td>
<td>43.48</td>
<td>0.30</td>
<td>NS</td>
</tr>
</tbody>
</table>
Not significant (p>0.05) with increasing time of hot boning up to 5 hrs delayed chilling at ambient temperature 28.7 c for all experimental muscles. Redness values (a) for SM, ST and LD muscle increased significantly (p<0.05) with increasing post mortem time at ambient temperature before hot boning. Increasing the time of hot boning to 5hr after slaughtering had the highest redness value (20.28),(17.98) and (21.24) for SM, ST and LD muscles respectively compared with (20.19), (15.04) and (20.27) for control muscles respectively. This might be due to meat surface desiccation and absorption of more oxygen. Yellowness (b) values shown in table (5) revealed a significant (p<0.01) increase with increasing high ambient early conditioning time of hot boned muscles. ST muscle showed the highest increase in (b) value (9.50) followed by SM muscle (8.52) and LD muscle (8.49) respectively at 5 hr deboning time. This could be due to increased protein denaturation at low muscle PH and high ambient temperature.

4.2.6.2: Subjective Attributes:

Panel rating of color, flavor, tenderness, juiciness and acceptability of Seminembranosus , Semtendirnosus and L.dorsi muscles are given in Table (6). Delayed high temperature hot boning times did not induce significant difference (P>0.05) in color for all the muscles tested compared with the conventionally chilled muscles, although color scores were higher with increasing postmortem hot boning.
Table (4): The Effect of Hot Boning Time of Beef Muscles on Oxidative Rancidity (TBA value).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hot boning time</th>
<th>0</th>
<th>3</th>
<th>5</th>
<th>S.E</th>
<th>LS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td></td>
<td>0.09</td>
<td>0.11</td>
<td>0.11</td>
<td>0.01</td>
<td>NS</td>
</tr>
<tr>
<td>ST</td>
<td></td>
<td>0.09</td>
<td>0.10</td>
<td>0.11</td>
<td>0.01</td>
<td>NS</td>
</tr>
<tr>
<td>LD</td>
<td></td>
<td>0.11</td>
<td>0.11</td>
<td>0.12</td>
<td>0.01</td>
<td>NS</td>
</tr>
</tbody>
</table>

Table (5): The Effect of Time of Hot Boning at Ambient Temperature 29 ºC on Color of Beef Muscles (SM, ST and LD):

<table>
<thead>
<tr>
<th>Parameter</th>
<th>0</th>
<th>3</th>
<th>5</th>
<th>S.E</th>
<th>LS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>0.09</td>
<td>0.11</td>
<td>0.11</td>
<td>0.01</td>
<td>NS</td>
</tr>
<tr>
<td>ST</td>
<td>0.09</td>
<td>0.10</td>
<td>0.11</td>
<td>0.01</td>
<td>NS</td>
</tr>
<tr>
<td>LD</td>
<td>0.11</td>
<td>0.11</td>
<td>0.12</td>
<td>0.01</td>
<td>NS</td>
</tr>
<tr>
<td>Parameters</td>
<td>Hot boning time</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>SE</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>SM</td>
<td></td>
<td>30.61</td>
<td>30.88</td>
<td>31.27</td>
<td>0.37</td>
</tr>
<tr>
<td>L ST</td>
<td></td>
<td>36.59</td>
<td>36.59</td>
<td>36.98</td>
<td>0.37</td>
</tr>
<tr>
<td>L LD</td>
<td></td>
<td>33.33</td>
<td>33.09</td>
<td>32.93</td>
<td>0.37</td>
</tr>
<tr>
<td>a SM</td>
<td></td>
<td>20.19</td>
<td>20.25</td>
<td>20.28</td>
<td>0.36</td>
</tr>
<tr>
<td>a ST</td>
<td></td>
<td>15.04</td>
<td>17.01</td>
<td>17.98</td>
<td>0.36</td>
</tr>
<tr>
<td>a LD</td>
<td></td>
<td>21.04</td>
<td>20.24</td>
<td>21.27</td>
<td>0.36</td>
</tr>
<tr>
<td>b SM</td>
<td></td>
<td>8.27</td>
<td>8.50</td>
<td>8.52</td>
<td>0.16</td>
</tr>
<tr>
<td>b ST</td>
<td></td>
<td>8.26</td>
<td>8.87</td>
<td>9.50</td>
<td>0.16</td>
</tr>
<tr>
<td>b LD</td>
<td></td>
<td>8.53</td>
<td>8.56</td>
<td>8.49</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Color co-ordinates:
L = lightness

a = Redness

b = Yellowness
time than in the conventional chilled muscles. Flavor improved non significantly (P>0.05) with increasing high ambient temperature postmortem hot boning time for all the three muscles studied. Although tenderness scores values were higher with increasing postmortem hot boning time in all muscles studied than in the conventional chilled muscles but were not significantly different (P<0.05).

Juiciness scores showed no significantly different (P<0.05) between the treatments and the control muscles.

The experimental muscles were found to be tender, more acceptable and had better flavor and Juiciness. Generally high temperature postmortem hot boning time improved the quality attributes of beef muscles studied.

4.2.8: **Microbiological evaluation:-**

Table (7) show bacterial colony counts of delaying hot boning time to 3 hr gives the highest total bacterial colony counts for the two tested muscles SM (4.22) and LD (4.23) compared with the 5hr treatments (4.19) for SM and (3.84) for LD muscles, while the control shows the least counts (3.19) for SM and (3.08) for LD muscles.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hot boning post mortem</th>
<th>SE</th>
<th>LS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>2.96</td>
<td>3.21</td>
<td>3.36</td>
</tr>
<tr>
<td>ST</td>
<td>3.07</td>
<td>3.11</td>
<td>3.21</td>
</tr>
<tr>
<td>LD</td>
<td>3.33</td>
<td>3.27</td>
<td>3.29</td>
</tr>
<tr>
<td>Flavor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>3.24</td>
<td>3.32</td>
<td>3.36</td>
</tr>
<tr>
<td>ST</td>
<td>3.18</td>
<td>3.11</td>
<td>3.36</td>
</tr>
<tr>
<td>LD</td>
<td>3.44</td>
<td>3.12</td>
<td>3.14</td>
</tr>
<tr>
<td>Tenderness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>3.32</td>
<td>3.39</td>
<td>3.90</td>
</tr>
<tr>
<td>ST</td>
<td>3.00</td>
<td>3.05</td>
<td>3.98</td>
</tr>
<tr>
<td>LD</td>
<td>3.39</td>
<td>3.56</td>
<td>3.59</td>
</tr>
<tr>
<td>Juiciness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>3.00</td>
<td>3.04</td>
<td>3.21</td>
</tr>
<tr>
<td>ST</td>
<td>3.96</td>
<td>3.00</td>
<td>3.33</td>
</tr>
<tr>
<td>LD</td>
<td>3.11</td>
<td>3.20</td>
<td>3.20</td>
</tr>
<tr>
<td>Acceptability</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>SM</td>
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<td>3.14</td>
<td>3.22</td>
</tr>
<tr>
<td>ST</td>
<td>3.11</td>
<td>3.20</td>
<td>3.28</td>
</tr>
<tr>
<td>LD</td>
<td>3.28</td>
<td>3.28</td>
<td>3.34</td>
</tr>
</tbody>
</table>
Table (7): The Effect of Time of Hot Boning on Total Bacterial Colony Counts (log10/10gm).

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Hot boning time</th>
<th>SE</th>
<th>LS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>SM</td>
<td>3.10</td>
<td>4.22</td>
<td>4.19</td>
</tr>
<tr>
<td>LD</td>
<td>3.08</td>
<td>4.23</td>
<td>3.84</td>
</tr>
</tbody>
</table>

4.3: Post mortem aging effects on hot boned bovine muscles (LD, SM and ST) aged at 2°C for 7days.

4.3.1: Protein fractionation:-
Table (8) gives means and standard errors of the means for percentage of myofibril and sarcoplasmic proteins and non-protein nitrogen extracted from hot boned SM, ST, and LD bovine muscle aged for 7 days at 2c. The amount of extractable myofibril proteins increased non-significant from day 1 (immediately after hot boning) to day 7 for all the three muscles studied. LD muscle had the least extractable myofibril protein (11.01) compared with SM and ST muscle (11.09 and 11.04 respectively). The amount of extractable sarcoplasmic protein decreased non significantly with increasing aging period to 7 days for all the three muscles studied. LD muscle had the lowest decrease and high extractable amount of sarcoplasmic proteins (5.69) while SM muscle had highest decrease and low extractable amount of sarcoplasmic proteins (5.59) compared with the ST muscle (5.6) which was intermediate between the other two muscles. Day one gave high extractable amount of sarcoplasmic protein for all three muscles investigated. Soluble non protein nitrogen (NPN) increased slightly and non significant during post mortem aging time from day one to 7 days in all the muscle studied amounting (0.44) at day 7 and (0.44) at day one.

4.3.2: Water holding parameters:

Table (9) demonstrates water holding capacity ratio and percentage cooking loss for hot boned muscles SM, ST and LD ages at 2C for 7 days postmortem. Increasing aging time from day one to 7 days was associated with significant improvement in water holding capacity in all the three muscles studied.

Table (8) Percentage of muscle protein fractions as Affected by Aging Time.
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Aging time (days)</th>
<th>2</th>
<th>7</th>
<th>S.E</th>
<th>LS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myofibril proteins %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>10.84</td>
<td>11.09</td>
<td>0.04</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>ST</td>
<td>10.78</td>
<td>11.04</td>
<td>0.04</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>LD</td>
<td>10.86</td>
<td>11.01</td>
<td>0.04</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Sarcoplasmic proteins (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>5.75</td>
<td>5.59</td>
<td>0.07</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>ST</td>
<td>5.77</td>
<td>5.60</td>
<td>0.07</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>LD</td>
<td>5.71</td>
<td>5.69</td>
<td>0.07</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Non-protein nitrogen %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>0.44</td>
<td>0.45</td>
<td>0.002</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>ST</td>
<td>0.44</td>
<td>0.45</td>
<td>0.002</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>LD</td>
<td>0.44</td>
<td>0.45</td>
<td>0.002</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
Table (9) The Effect of Aging Time on Water Holding Parameters of Beef Muscle (SM, ST and LD):

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Aging time (days)</th>
<th>SE</th>
<th>LS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>W.H.C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>3.09</td>
<td>2.63</td>
<td>0.03*</td>
</tr>
<tr>
<td>ST</td>
<td>3.02</td>
<td>2.74</td>
<td>0.03*</td>
</tr>
<tr>
<td>LD</td>
<td>2.96</td>
<td>2.76</td>
<td>0.03*</td>
</tr>
<tr>
<td>Cooking loss %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>43.86</td>
<td>42.61</td>
<td>0.24*</td>
</tr>
<tr>
<td>ST</td>
<td>43.61</td>
<td>42.34</td>
<td>0.24*</td>
</tr>
<tr>
<td>LD</td>
<td>43.80</td>
<td>42.62</td>
<td>0.24*</td>
</tr>
</tbody>
</table>
Cooking loss decreased significantly (p>0.05) with increasing aging time to 7 days in all muscle evaluated. Between the treatments muscles SM muscle had the highest cooking loss (43.86) while ST muscle had the least cooking loss (43.61) and LD muscle (43.80) was intermediate between the two other muscles.

4.3.3: Oxidative Rancidity:

Table (10) gives the means and standard errors of the means of oxidative rancidity (TBA) values determined in fresh muscle hot boned and aged at 2°C for 7 days postmortem. Non significant (p>0.05) increase in (TBA) value was observed with progressing aging time to 7 days. ST muscle had the least TBA value (0.14) compared with the SM and LD muscles which almost had the same level of TBA value (0.15).

4.3.4 :Color measurement:-

Table (11) reveals the color co-ordinate of boned muscles SM, ST and LD aged at 2°C for 7 days postmortem . Lightness (L) increased not-significantly (p>0.05) with increasing aging time to 7 days for all three hot boned muscles studied. ST muscle had the highest (L) value (37.08) followed by LD muscle (33.32) and SM muscle (31.58) respectively. Redness (a) value decreased significantly (p<0.01) with increasing storage time to 7 day. Yellowness (b) value increased significantly(p<0.01) with increasing aging time to 7 days (LD) muscle had the highest (b) value (9.0) while SM muscle had (8.64) and ST muscle had the least (b) value (8.53) .
Table (10): Effect of Aging Time of Beef Muscles on Oxidative Rancidity (TBA value)

<table>
<thead>
<tr>
<th>Storage (days)</th>
<th>muscle</th>
<th>0</th>
<th>S.E</th>
<th>LS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rancidity</td>
<td>SM</td>
<td>0.06</td>
<td>0.15</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>ST</td>
<td>0.07</td>
<td>0.14</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>LD</td>
<td>0.07</td>
<td>0.15</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Storage = storage time
Table (11): The Effect of Aging Time on Color of SM, ST and LD Muscles of Beef.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Aging time (days)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>7</td>
<td>SE</td>
<td>LS</td>
</tr>
<tr>
<td>l SM</td>
<td>30.26</td>
<td>31.58</td>
<td>0.303</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>36.35</td>
<td>37.08</td>
<td>0.303</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>32.90</td>
<td>33.32</td>
<td>0.303</td>
<td>NS</td>
</tr>
<tr>
<td>a SM</td>
<td>20.78</td>
<td>19.70</td>
<td>0.29</td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>17.18</td>
<td>16.17</td>
<td>0.29</td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>21.01</td>
<td>19.78</td>
<td>0.29</td>
<td>**</td>
</tr>
<tr>
<td>b SM</td>
<td>8.21</td>
<td>8.64</td>
<td>0.13</td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>9.22</td>
<td>8.53</td>
<td>0.13</td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>8.05</td>
<td>9.00</td>
<td>0.13</td>
<td>**</td>
</tr>
</tbody>
</table>

Color co-ordinates:
l = lightness
a = Redness
b = yellowness

Table (12): Mean Values for Quality Attributes of Hot Boned Bovine Muscles Aged for 7 days at 2°C

| Parameter | Aging time (days) | SE | LS |
|-----------|------------------|---|---|---|
|           | 2 | 7 | SE | LS |
|           | 8.21 | 8.64 | 0.13 | ** |
|            | 9.22 | 8.53 | 0.13 | ** |
|            | 8.05 | 9.00 | 0.13 | ** |
4.3.5: Subjective assessment:

Table ( ) shows means and standard errors for bovine *L. dorsi* *Semimembranosus* and *Semitendinosus* muscle eating quality attributes. The results showed that postmortem aging at 2°C for either 2, or 7 days had no significant (P>0.05) effect on cooked LD, SM and ST quality attributes. Although the sensory panel rating of color, flavor, tenderness,
juiciness and acceptability increased with increasing aging time for the three muscles evaluated, the differences were not significant (P>0.05).

4.3.6 Microbial evaluation:

Bacterial colony count:-

Table (13) shows the means and standard errors of the means of the logarithms of bacterial count at 37°C for both control and treatments aged at 2°C for 7 days postmortem. Bacterial total count was observed to increased significantly (p>0.05) with increasing aging period to 7 days.(3.8), (3.84) comparing with (3.74) and (3.60) at day one for SM and LD muscles respectively.

4.4 Ground pre-rigor beef:

4.4:1 Effect of hot deboning time on WHC, Color and Bacterial Colony Count of ground beef manufactured from pre rigor meat:

Table (14) showed that water holding capacity value of hot boned ground beef was not significantly (p>0.05) superior than those of the conventionally chilled at 2 c for 48 hr.

Hunter Lab color values indicated that lightness(L),redness (a) and yellowness(b) increased significantly (p>0.05) with increasing time of deboning up to 5 hr after slaughtering table (15). However the control conventionally chilled to 48 hr at 2 c showed the least values.
Aging time

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>7</th>
<th>S.E</th>
<th>LS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>3.739</td>
<td>3.804</td>
<td>0.058</td>
<td>*</td>
</tr>
<tr>
<td>LD</td>
<td>3.837</td>
<td>3.598</td>
<td>0.058</td>
<td>*</td>
</tr>
</tbody>
</table>

Table (16) gives Bacterial Counts as (log_{10}/10GM) of ground beef. The difference in total bacterial plate count between hot boned and control samples were significant (p<0.001). Increase in count was larger for the 3 hr hot boned samples (4.20) than for 5hr ones (3.94) while the control (conventionally chilled at 2 c for 48 hr ) had the least total count. The decrease in total count of the 5 hr hot boned samples could be due to surface drying of the meat.

4.4.2: Effects of aging on WHC, color and bacterial colony counts of ground beef manufactured from pre rigor meat:
Table (17) gives water holding capacity ratio of the ground beef stored at 2°C for 7 days. Increasing aging time from 1 to 7 days postmortem was associated with significant (p>0.01) improvement in water holding capacity of ground beef stored at 2°C for 7 days. Showed that water holding capacity of hot boned ground beef was non significantly (p<0.05) higher than those of the conventionally chilled at 2°C for 48 hr postmortem.

Table (18) gives color measurement for ground beef during refrigerated storage at 2°C for 7 days. Lightness (L) and yellowness (b) value increased with increasing storage period to 7 days. While the redness decreased with increasing storage period to 7 days. This might be due to the oxidation of myoglobin to metmyoglobin.

Table (19) gives bacterial colony count as (log_{10}/10cm) of ground beef stored at 2°C for 7 days. Total bacterial counts at 37°C was significantly (p<0.05) decreased with increasing aging period to 7 days (3.68) comparing with the control (conventionally chilled 48 hr at 2°C) 3.78. This indicated that most of the bacteria were mesophilic organisms.

Table (14): The Effect of hot boning Time on Pre Rigor ground beef quality.

<table>
<thead>
<tr>
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<td>LS</td>
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<td>WHC</td>
<td>2.38</td>
<td>2.35</td>
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<tr>
<td>Lightness (L)</td>
<td>29.8</td>
<td>30.7</td>
<td>31.3</td>
<td>0.38</td>
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<tr>
<td>Redness (a)</td>
<td>17.64</td>
<td>19.7</td>
<td>21.36</td>
<td>0.22</td>
<td>**</td>
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<tr>
<td></td>
<td>7.86</td>
<td>8.6</td>
<td>9.0</td>
<td>0.11</td>
<td>**</td>
</tr>
<tr>
<td>------------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>-----</td>
</tr>
<tr>
<td>Yellowness (b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Count(log10)</td>
<td>3.06</td>
<td>4.20</td>
<td>3.94</td>
<td>0.037</td>
<td>***</td>
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</tbody>
</table>

Color co-ordinates:

l=lightness
a=Redness
b=yellowness
Table (17) The Effect of aging Time on Pre Rigor ground beef quality.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Time of aging</th>
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<tbody>
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<td>7</td>
<td></td>
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</tbody>
</table>
| WHC               | 2.30          | 1.81| 0.02| *
| lightness (L)     | 29.5          | 32.63| 0.31| ***
| Redness (a)       | 19.95         | 18.77| 0.18| ***
| Yellowness (b)    | 7.57          | 9.41| 0.09| ***
| Total Count (log10/10gm) | 3.78          | 3.68| 0.03| *

Color co-ordinates:
l=lightness.
a=Redness.
b=yellowness.
DISCUSSION

5.1: Proximate chemical composition of SM, ST and LD Muscles:-

Generally the proximate chemical composition of the three muscles, Semimembranosus Semitendinosus and Longisimus dorsi were found within the range determined by Bieber (1961), Lawrie(1991) and Nour (2003).

The present findings showed that the overall means of the moisture percent was higher for Semimembranosus and Semitendinosus in comparison with L.dorsi. L.dorsi muscle had a considerably lesser protein percent and higher fat percent and lesser ash than correspondence Semimembranosus and Semitendinosus muscles. These finding agree with Tanaka (1985) in that there was a negative correlation between intramuscular fat and moisture content in muscles with average fat free moisture content of 76.2% for L.dorsi. These finding were also comparable to the finding of Brack bush et at (1991)who reported that the fat content of all muscles was linearly related to that of L. dorsi ,with Semimembranosus muscle had to the lowest 4.4% and Spinalis muscle had the highest (16.1%) fat percent. The fat percentage of L.dorsi ranged from 3.59 to 15.42. The difference in values between their findings and ours was due to breed differences. Mohamed (1999), Elhashmi (1998), Guma(1996) and Hedrick et al (1981) compared different weight finished carcasses and concluded that the percentage of moisture and protein declined as percentage of fat increased.

5.2: Effect of hot deboning time (delayed chilling) on some beef hindquarters (SM, ST and LD) on:

5.2.1 Rate of temperature and pH fall

The results showed that the most rapid temperature decline in the
LD followed by the ST, and lastly the SM. The LD and ST muscles had attained their maximum rates of temperature decline at 1-3 hr postmortem, whereas, the SM muscle showed almost slight temperature decrease during this interval. Then the rate of temperature decline after the first 3 hr slowed for the LD and ST muscles although it increased for the SM muscle (Fig. 1). These findings were similar to many reported findings (Marsh and Leet, 1966; Locker et al., 1975, Falk et al., 1975; Glover et al., 1977; Locker et al., 1980, Nour 2003). Considering the mass and location rapid cooling of L. dorsi and Semitendinosus muscle and slow cooling of Semimembranosus might be responsible. They reported that changes occurring in muscle during early postmortem cooling period were especially sensitive to the modification by processing techniques, carcass size, fat thickness and muscle location. The PH of the high temperature conditioned (3-5 hr) Psoas major muscle was always lower from the conventionally chilled ones. The pH of the muscles from quarters delayed chilled for 3, 5 hrs fell to about 6. The somewhat more rapid rate of PH decline allowing the muscles to maintain their temperature for a longer period of time 3-5 hours postmortem. Changes in pH and temperature during the early postmortem period were important determinant of ultimate beef tenderness, in this regard; Marsh et al. (1981) concluded that, provided exceptionally rapid chilling did not induce cold shortening, a slow postmortem glycolysis was associated with a higher degree of tenderness.

These data provide evidence that the hot boned muscles had begun to proceed into the onset phase of rigor mortis before excision was initiated. Such findings were in agreement with Schmidt and Gilbert (1970) who reported that hot processed Longissimus dorsi, Semimembranosus and Biceps femoris muscles within 2 hr postmortem and conditioned at 15°C until either 24 hr or 48 hr postmortem, were generally equal to or
superior to the control chilled at 9°C until 24 hr postmortem in shear force and taste panel evaluation. *Bouton et al.* (1972); *Kanster et al.* (1973); *Falk et al.* (1975) who reported that the problem incurred by fabricating hot carcasses at 2hrs postmortem while still in the delay phase of rigor mortis may be overcome by restraining the muscle on the carcass for an additional hour before fabrication. For beef the toughening occurring with prior excision can be eliminated by conditioning the side at high temperature for 3 hr (*Will and Henrickson. 1976*; *Nour* (2003) or 8 hr (*Kastner et al., 1973*) before boning or by holding the excised. The optimal temperature for activity of lysosomal enzymes and the CAF enzymes systems is at or near 37°C (*Dayton et al., 1975, Bird and Carter, 1980; Dutson, 1983*), indicating that more disruption of myofibril proteins by these enzymes should occur at higher temperatures. Changes in pH and temperature during the early postmortem period were important determinant of ultimate beef tenderness, in this regard; *Marsh et al. (1981)* concluded that, provided exceptionally rapid chilling did not induce cold shortening, a slow postmortem glycolysis was associated with a higher degree of tenderness. *Jones et al (1986)* showed that hot boning sides have a higher binding ability of the meat proteins, signifying on increased protein extraction in hot boning meat.

### 5.2.2: Protein Fractionation:

In the present data the extractability of myofibril proteins from the high ambient temperature delayed chilled hot boned pre-rigor muscles was reduced with increasing the hot boning time. Increasing the time of hot boning to 5 hr after slaughtering resulted in the least non significant (p>0.05) myofibril protein percentage for the SM, ST and LD muscle respectively while the control (conventionally chilled at 2c for 48 hr) had
the highest extractable percentage. These findings agreed with that reported by Wierbicki et al. (1956), Locker (1960a) and Nour (2003) who reported that the extractability at high ionic strength of total myofibril proteins decreases with the onset of rigor mortis from the value immediately postmortem. Myofibril fragmentation was faster in Longisimus dorsi and Semitendinosus muscles held at 25°C when compared to muscle held at 2°C (Olson et al., 1976); But on subsequent storage at 2°C the extractability again rose up to and even beyond the initial level. This was partly due to the precipitation of sarcoplasmic proteins onto those of the myofibril (Bendall and Wiesmer Pederson, 1962).

The amount of extractable sarcoplasmic proteins increased not significantly (p>0.05) in all experimental treatments. The ST muscle (5.80) gave the highest increase in the amount of extractable sarcoplasmic proteins in comparison with SM (5.69) and LD (5.67) respectively. In respect of sarcoplasmic proteins high ambient temperature delayed chilling resulted in a non-significant increase in their extractability for the three muscles studied. This agreed with Scopes (1964) who found that at temperature above 25°C soluble sarcoplasmic proteins began to precipitate at all pH values. These results were in line with Yates et al. (1983) who reported that the effects of lowered postmortem pH on muscle protein disruption were increased by elevating temperature.

Soluble non-protein nitrogen increased non-significantly with increasing time of hot boning in all muscles studies at high ambient temperature in comparison with the control. This agreed with Nour (2003), Babiker and Lawrie (1983); Lawrie and Voyle (1962) and Sharp (1963) who reported that this might reflect the greater hydrolytic and proteolytic action of enzymes at high temperature/low pH combinations. Khan and Van Den Berg (1964) observed a decrease in non-protein
nitrogen fraction during the onset or rigor.

5.2.3: Water holding Parameters

Increase of high ambient temperatures delayed chilling hot boning time caused a non-significant improvement in water holding capacity of the *L. dorsi*, *Semimembranosus* and *Semitendinosus* muscles as compared with the corresponding conventionally chilled controls. The control gave the least WHC for the SM, ST and LD muscles compared with the 3 and 5hr hot boned treatment muscles groups. This could be due to an early conditioning changes and thereby, an improvement in osmotic pressure of the muscles (*Lawrie, 1980*) induced by a combination of low pH and high temperature in comparison with their conventionally chilled controls. It could also be due to prevention of cold shortening whereas fiber contraction in cold shortening was reported to significantly lower WHC (*Bouton et al., 1971, Duston et al., 1975*). This agreed with Hamm, (1960) who found that meat from hot boned sides exhibited a higher WHC than cold boning sides; increased moisture retention resulted in higher ash retention in the hot boned meat. *L. dorsi* had a high water holding capacity followed by *Semimembranosus* and *Semitendinosus* muscles respectively. This could be due to the fact that *L. dorsi* muscle had a slightly higher pH level than *Semimembranosus* and *Semitendinosus* muscles. This result agreed with *Saffle and Bratzler (1957)* who reported that muscle having a high content of intramuscular fat tended to have a higher WHC. Similarly *Lawrie et al. (1963)* reported that water content of different muscles in beef and pork varied and this could be due to pH differences.

Postmortem PH fall in combination with muscle temperature will influence muscle shortening and proteolysis and thereby meat tenderness and water holding capacity (*Offer, 1991; Nour 2003*). This improvement in WHC was manifested in a non significant decrease in percentage of
cooking loss. These agreed with *Schmidt and Keman (1974)* who reported that Differences between the hot processing and conventionally chilled control treatment were small regardless of the chilling treatment for hot processed muscles.

5.3.3: Muscle Eating Quality

Delayed high temperature hot boning times did not induce significant difference in color for all the muscles tested compared with the conventionally chilled muscles, although color scores were higher with increasing postmortem hot boning time. Hot boning early postmortem improved the color and color stability of beef round muscles by accelerating postmortem chilling rate. Hot processing resulted in more uniform chilling and color (*Sammel et. al.; 2002*). Semitendinosus muscle from carcasses that had the lower temperature decline and rapid pH decline had the higher lightness (L) values. The rate of pH decline could at least in part explain the difference in (L) values (*Kuber et. al., 2004*).

Flavor improved not significantly with increasing high ambient temperature postmortem hot boning time for all the three studied muscles. Juiciness scores showed no significant difference between the treatments and the control muscles. The experimental muscles were found to be tender, more acceptable and had better flavor and Juiciness. Generally high temperature postmortem hot boning time improved the quality attributes of beef. This agreed with *Schmidt and Gilbert (1970)* who reported that hot processed Longissimus dorsi, Semimembranosus and Biceps femoris muscles within 2 hr postmortem and conditioned at 15°C until either 24 hr or 48 hr postmortem, were generally equal to or superior to control in shear force and taste panel evaluation. *Taylor et al (1980)* reported that cuts hot processed 1 to 3 hrs postmortem, conditioned at 10°C for 9 hr and then chilled at 1°C for an additional 18 hrs, were equivalent in yield, tenderness, flavor, and juiciness. Hot
processing resulted in more uniform chilling and color. The increased tenderness might also be due to the fact that high temperature conditioning produced its desirable effect on tenderness through enhancement of proteolytic enzymes activities of lysosomal enzymes (Dustson, 1977, Moller et al. 1976, 1977).

5.3.4 Oxidative rancidity:
As seen from the result oxidative rancidity value (TBA value) were slightly increased but not significantly (p>0.05) with increasing time of hot deboning for 3hr and 5hrs after slaughtering. LD muscle had the highest TBA value (0.12) compared with the SM (0.09) and ST (0.09) muscles. This could be due to the high fat % (percentage) of the LD muscle. While the SM and ST almost had the same values.

5.3.5: microbial evaluation:
Delaying hot boning time to 3 hr gave the highest total bacterial colony counts for the two tested muscles SM (4.22) and LD (4.23) compared with the 5hr treatments (4.19) for SM and (3.84) for LD muscles, while the control showed the least counts (3.19) for SM and (3.08) for LD muscles. This could be due to the drying and cooling of the control surface and muscles. Refrigeration retards bacterial growth and extends the shelf life. In uncontrolled ambient conditions, the surface desiccation associated with cooling will usually ensure a lag of about 24 h before any growth commences (Hicks et al. 1955, Nottingham and Wyborn 1975). Desiccation will even delay for several hours’ microbial growth on carcasses held at body temperature (Wilhelm et al. 1982). The results obtained in this study were in agreement with those reported by West et al. (1972) and Newton et al. (1978). Who found that the large majority of initial floras on carcass surfaces were gram positive mesophiles derived from soil and faecal organisms.
5.4 Effect of Post Mortem Aging time of Hot Boned Beef hind quarter muscles (SM, ST & LD) ON :-

5.4.1: Protein fractionation:-

The amount of extractable myofibril proteins increased non-significant from day 1 (immediately after hot boning) to day 7 for all the three muscles studied. LD muscle had the least extractable myofibril protein (11.01) while SM and ST muscle had (11.09) and (11.04) respectively. This agreed with Aberle and Merkel (1966) who reported that solubility of extractable myofibril proteins was significantly higher at 7 days and 14 days than at 24hr postmortem in semitendinosus and L. dorsi muscles.

Aging induced chemical changes in protein components of muscles. Lawrie and Voyle (1962) and Sharp (1963) indicated that the main autolytic affect of the muscle cathepsins when muscle was aged for 30 days at 37°C or 5°C was upon sarcoplasmic proteins. Nour (2003) found that the extractability of myofibril proteins increased significantly with increasing aging time to 15 days, myofibril proteins extractability was least at day one (24 h post slaughter) and most at 15 days of aging for all the three muscles studied. L. dorsi exhibited the greater increase and Semimembranosus was the least of the three muscles.

Sacroplasmic proteins decreased significantly with increasing aging period as a result of proteolysis. This agreed with Aberle and Merkel (1966) and Goll et al., (1964) and Nour (2003) who reported that, L.dorsi and Semitendinosus muscles, the sacroplasmic proteins were most extractable immediately after death and their solubility decreased with increasing aging time.

Non protein-nitrogen increased significantly with increasing aging time, this could be due to autolytic enzymes, cathepsins (Lawrie and Voyle, 1962; Sharp 1963). This agreed with Aberle and Markel (1966)
who reported that soluble non protein nitrogen increased significantly during postmortem aging in both L.dorsi and semitendinosus muscles exhibiting the greater increase. Daskiewiez et al (2003) found that after 14 days storage, a slight increase was observed in the percentage of dry matter, fat, crude protein, and ash as well as a significant increase in the content of soluble proteins and non-protein nitrogen.

5.4.2: Meat Quality attributes:

Water holding capacity increased with increasing aging period up to 15 days in all the three muscles studied. This might be due to aging effect which induced protein denaturation and proteolysis as well as changes in the ionic charges of muscle proteins (Lawrie, 1991). Where K$^+$ ion were absorbed and Ca$^{2+}$ ions released with the consequent increase in net charge (Arnold, 1956). Also hot boning improves water holding capacity by reducing high temperature from muscle according to Follet., et al (1974). These results agreed with Saffle and Bratzler (1959) whom postulated that muscles having high content of intramuscular fat tend to have a high water holding capacity.

The results showed that postmortem aging at 2ºC for either 2, or 7 days had no significant (P>0.05) effect on cooked LD, SM and ST quality attributes. Although the sensory panel rating of color, flavor, tenderness, juiciness and acceptability increased with increasing aging time for the three muscles evaluated. This agreed with the finding of Tornberg et. al. (1994), Goll et al (1995) Koohmamiae (1995) and Van laack et al (2001) in that during meat storage for up to 7days proteolytic enzymes degrade myofibril proteins and hence increased tenderness .Hot processed samples were more tender than control for values measured at 3, 7, and 13 days postmortem Schimidt and Keman, (1974) . These findings were supported by the fact that proteolysis of key myofibril protein was responsible for tenderness during postmortem storage (Goll et al 1983 ,
Prolonging the aging time, decreased the redness value, storage time at low oxygen pressures favor the formation of met myoglobin (Kramlish, 1973). Hot boning result in darker meat color throughout the storage time (Strange and Benedict, 1978). Other workers reported that the formation of undesired brown oxidized met myoglobin on the surface resulted mostly from bacterial action but it might be caused by long term of exposure to oxygen (Penny et al., 1963, Benedict et al., 1975; and Lawrie 1991). Moreover hot boning either SM or Qudriceps muscles early postmortem improved the color and the color stability of beef round muscles by accelerating postmortem chilling rate (Nichols and cross 1980; Tylor et al.1984 and Seyfert et al., 2004).

5.4.3: Oxidative rancidity:

As seen for oxidative rancidity TBA value were slightly increased but not significantly (p>0.05) with progressing aging time. This agreed with Younthan et. Al, (1980). Who postulated that TBA value increase and thus rancidity with increasing storage time. And also agreed with Dutson et al (1980). Who reported that Disruption of muscle structures could promote lipid oxidation and increase the off-flavor problem in meat.

5.4.4: Microbial Evaluation:

Bacterial colony counts:-

Increasing aging time caused increase in total Bacterial count at 37°C incubation temperature. The temperature of storage greatly affected the shelf life of meat. Borch, (1989) reported that aerobic counts on vacuum packed beef loin steak was 7.0 log$_{10}$cfu/cm$^2$ after 4 weeks at 4°C. Meat microbial counts (log$_{10}$cfu/cm$^2$)of the surface was reduced by lowering the storage chilling temperature and decreasing the storage time. The increase in total bacterial count during meat storage could be due to
the fact that most of contaminating bacteria were mesophililies which grow better at high temperature (Warris 2000, West et al., 1972; Newton et al., 1978). These findings agreed with Abdelkarim (1992) who found that total bacterial count increased with progress in refrigeration time, but staphylococci count decreased and agree with Hussein (1987) who found that total bacterial count increased with progress of storage time.

5.5: Ground Pre Rigor Beef

The color values for lightness (L), Redness (a) and yellowness (b) for minced meat made from pre-rigor meat conditioned at high ambient temperature early conditioning time was highly significantly difference from the control. They increased with increasing early conditioning time. The increase of redness might be due to surface exposure to oxygen and oxygenation of myoglobin to bright red oxy-myoglobin the attractive color to consumer (Lawrie 1991) and might be due to the grinding effect by increasing the surface area of meat exposed to the fat.

The results showed that minced meat manufactured from pre-rigor meat conditioned at high ambient temperature had significantly superior water holding capacity which could be due o early conditioning. This result agreed with Lawrie (1991) who reported that conditioning of meat before freezing decreased drip by increasing intracellular osmotic pressure. Judge et a (1990) showed that the increased changing in cell membrane permeability due to the proteolytic enzyme on protein structures that resulted in exchange of ions in muscle proteins during aging consequently improved water holding capacity.

The result showed that minced meat manufactured from pre-rigor meat conditioned at high ambient temperature had significant great total count of mesophilic at 37°C and 3hr delayed chilling then the count decreased significantly at 5hr delayed chilling. This might be due to surface desiccation associated with high ambient temperature delayed
chilling which reduced the water activity on the surface (Nottingham and Wyborn, 1975; Wilhelm et al., 1982 and Nour (2003))

Conclusion

This study was conducted to investigate the effect of delayed hot boning time on processed meat conditioned at high ambient temperature. The rate of temperature and pH fall, chemical composition, bacterial load and muscles eating quality were investigated.

From this study it can be concluded that:

PH and temperature fall of post mortem muscle enhanced meat tenderness possibly through disruption of myofibril proteins. High ambient temperature (29c) conditioning time up to 5 hours before fabrication can positively affect the meat tenderness.

Hot deboning technique (delay chilling) accelerated post mortem glycolysis without impairment of meat eating quality provided by consistently lowered PH while the muscle temperature was still high.

Chemical composition of the studied muscles was significantly (p<0.05) different between the three muscles studied. LD muscle had less moisture percent because its superficial location lead to rapid loss of
moisture and heat than the deepest muscle (SM and ST) and affected their tenderness.

The increased of extractability of sarcoplasmic proteins besides the exposure of muscle to the oxygen give a meat the favorable high red color while the color of meat decreased with increasing aging time.

Water holding capacity improves and cooking loss decrease with progressing aging time to 7 days.

Oxidative rancidity increased insignificantly with increasing hot boning time and also increased significantly with progressing aging time due to the different in muscle fat content.

The color of muscles subjected to high ambient temperature was brighter than those of conventionally chilled at 2c.

Panel test scores showed that meat from muscles that were early condition for 3 and 5 hrs and then hot boned were tender, juicer, flavorful and more acceptable to panelist. The 5 hrs treatment gave highest scores.

Ground beef manufactured from delayed hot boned at high ambient temperature conditioned pre-rigor meat had superior water holding capacity, redness value but high total bacterial counts.
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various properties of low-fat ground beef. *J. Food Qual.* 11: 159-171.


Dubuque, Iowa. U. S. A.


springs. Co. prepared by Amer meat. Sci Asso. e. Chicago IL.


Veiseth, E., S. D. Shackelford, T. L. Wheeler, and M. Koohmaraie (2001). Effect of post-mortem storage on μ-calpain and m-


Appendix (1): Rate of temperature fall for LD, ST and SM

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Appendix (2): Rate of pH fall for Psoas major muscle

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