International Journal of Nutrition and Food Sciences
2021; 10(6): 153-158
http://www.sciencepublishinggroup.com/j/ijnfs
doi: 10.11648/j.ijnfs.20211006.15
ISSN: 2327-2694 (Print); ISSN: 2327-2716 (Online)

SciencePG
Science Publishing Group

Review on Different Post Mortem Contributing to Meat Quality Deterioration

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To cite this article:
Abdulmajid Haji, Endris Hussen. Review on Different Post Mortem Contributing to Meat Quality Deterioration. *International Journal of Nutrition and Food Sciences*. Vol. 10, No. 6, 2021, pp. 153-158. doi: 10.11648/j.ijnfs.20211006.15

Received: October 28, 2021; **Accepted**: November 23, 2021; **Published**: December 7, 2021

Abstract: Meat is one of widely consumed food item in many developing countries as a source of protein. The major composition of meat are 75% of water, 19% of protein, 3.5% of soluble non protein substances and 2.5% of fat and other minor components such as vitamins, enzymes, pigments and flavor compound. The quality of meat is described in term its tenderness, pH, colour, juiciness, flavour and nutritive value. Meat is highly perishable and has a short shelf-life unless preservation methods are used. Shelf life and maintenance of the meat quality are influenced by both pre slaughter and post slaughter factors. Even though Ethiopia produced great amount of meat, most of it lost due to inappropriate post-harvest handling, processing and preservation techniques. Post mortem factor that contribute to meat quality deterioration are techniques of stunning and slaughtering, use of electrical stimulation, deboning time, chilling method, environmental temperature and post-mortem ageing method. In addition to method of processing, post mortem change that occurs during conversation of muscle to meat also contribute for the post mortem quality deterioration of meat. The main objective of this is reviews focus on post-mortem factor contributing to meat quality deterioration.

Keywords: Post Mortem, Preslaughter, Post Slaughter, Deterioration

1. Introduction

Meat is defined as the edible part of the skeletal muscle of an animal that was healthy at the time of slaughter [13]. The most common sources of meat are sheep and poultry and to a lesser extent cattle, buffaloes and pigs. In some regions, other animal species such as camels, yaks, horses, ostriches and game animals are also eaten as meat. To a limited extent, meat is also derived from exotic animals such as crocodiles, snakes and lizards [19].

In many developing countries, meat is widely consumed as a source of protein; it is eaten as raw or processed into other forms to avoid associated spoilage [41]. Ethiopia has huge livestock population standing 1st in Africa and 10th in the world, indicating that the country has great prospective for meat and meat by-products [5]. The annual contribution of ruminants to meat production in Ethiopia is estimated at over 3.2 million tones, representing over 72% of the total meat production [5]. In developed countries the consumption is 77 kg of meat per capita annually as compared to developing countries which consumed only 25 kg of meat per capita annually [5].

Meat consumption in developing countries has been continuously increasing from a modest average annual per capita consumption of 10 kg in the 1960s to 26 kg in 2000 and will reach 37 kg around the year 2030 according to FAO projections. This forecast suggests that in a few decades, developing countries' consumption of meat will move towards that of developed countries where meat consumption remains stagnant at a high level [19].

In wide sense the composition of the meat can be approximated to 75% of water, 19% of protein, 3.5% of soluble non protein substances and 2.5% of fat and many other minor components such as vitamins, enzymes, pigments and flavor compound [42]. The relative extents of all these components give meat its particular structure, texture, flavour, colour and nutritive value. However, because of its unique biological and chemical nature, meat undergoes progressive deterioration from the time of slaughter until consumption [7].

Meat is a nutritious, protein-rich food which is highly perishable and has a short shelf-life unless preservation methods are used. Shelf life and maintenance of the meat quality are influenced by a number of interrelated factors including pre slaughter and post slaughter factors that result in detrimental changes in the quality attributes of meat and finally make it acceptable for consumer [41].

According to [19] defined meat quality on the basis of its conformational and functional qualities. Functional qualities as the desirable attributes of a product while the conformance qualities take into consideration producing products that exactly meets consumer's specifications. Meat quality is a function of tenderness, pH, colour, juiciness, flavour and nutritive value [14]. These quality attributes of meat are affecting by both pre slaughter and post slaughter factor. Both psychological stressors and physiological stressors that contributors to meat quality deterioration are considered as pre slaughter factors.

On other hand factors such as methods of stunning and slaughtering, application of electrical stimulation, deboning time, chilling method, environmental temperature and extent of post-mortem ageing as considered as post mortem factor that contribute to meat quality problems [8] and also reviewed that post-slaughter carcass handling cutting of meats into various parts, storage conditions, processing of meats into products and cooking conditions will definitely reflect affects meat quality. Most research has highlighted several pre-slaughter processes that affect meat eating quality at the farm [29].

However, some studies have focused on post-slaughter factors affect technological and microbiological quality of meat during processing and distributing [10]. Post-harvest losses can be as high as 50 percent of the meat produced, which may cause food insecurity and reduced profit margins to value chain actors [27]. Most of these losses are caused by inappropriate post-harvest handling, processing and preservation techniques. The main objective of this is reviews focus on post-mortem factor contributing to meat quality deterioration.

Objective

General objective

1) To review of different post mortem factor contributing to meat quality deterioration
2) Specific objective
3) To review post mortem change that contribute to meat quality deterioration
4) To review post mortem processing condition contribute to meat quality deterioration
5) To review unusual patterns of postmortem metabolism lead meat quality deterioration

2. Post Mortem Change That Contributes to Meat Quality Deterioration

2.1. Acidification of the Muscles After Animal Death

After the death of the animal, oxygen supply ceases therefore any further metabolisms undergoes through anaerobic pathway. The glycogen is broken down to lactic acid that is not removed by the blood system thus acidifies the muscle gradually [19]. The ultimate pH is inversely proportional to the concentration of lactate and the initial glycogen concentration becomes limiting below about 10 mg/g muscle. The pH of meat falls, muscle protein gets denatured thus the water bound to protein is reduced and leads to reduction in water holding capacity of muscles [11]. Reduction in water holding capacity further leads to increase in drip loss also increase in weight loss is observed. [16] also point out meat pH has an impact on its physical characteristics as well as appearance such as light scattering properties are altered with the change in protein structure.

2.2. Rigor Mortis

One of the most significant changes in muscle post-mortem is its transformation from being soft, flexible and stretchable, to a more rigid and inextensible state. This muscle state is known as rigor. It has been shown that the extensibility of muscles is directly related to the post-mortem loss of ATP [18]. Rigor mortis occurs when the ATP level falls below the very low level of 5mM required to maintain relaxation [34]. At this low ATP concentration, actin and myosin molecules combine to form an actomyosin complex, which is irreversible [39]. Rigor mortis can be classed into three stages - delay, rapid and post-rigor [12]. The delay stage is that period of time in which there is no change in muscle elasticity.

2.3. Rate of Post-mortem Glycolysis

Of the extrinsic factors, the effect of temperature on the rate of post-mortem glycolysis is the single most influential factor on meat quality [31]. The glycolytic rate is high at in vivo temperatures and falls as temperature declines to 5°C [45]. Within a carcass, various muscles will have different rates of post-mortem glycolysis depending on their myofibre type composition and their location within the carcass. White muscles are better adapted for efficient anaerobic metabolism and so their rate of post-mortem glycolysis can be significantly greater than that of red muscle [23]. The differences however may be partly obscured by the influence of the location of the muscle, with the deeper, and hence slow cooling muscles having higher rates than superficial ones.

2.4. Extent of Post-mortem Glycolysis

The degree of post-mortem glycolysis is reflected in the ultimate pH (pHu) attained by muscle. Ultimate pH is dependent on the amount of glycogen available to the muscle at slaughter and is attained when glycolysis ceases but not necessarily when glycogen is depleted [43].

Table 1. *Factor influence the rate and extent of post mortem glycolysis.*

Intrinsic factors	Extrinsic factors
Animal species	Stress
Genotype	Pre-slaughter drug administration
Age	Environmental temperature
Temperament	Post-mortem temperature
Type of muscle	Electrical stimulation
	Post-mortem commination
	Post-mortem oxygen tension

Adapted from Lawrie [1998]

3. Postmortem Processing Condition Contribute to Meat Quality Defects

3.1. Carcass Suspension

Traditionally, carcasses are suspended during postmortem chilling [35]. However, it has been clearly verified that this method of carcass hanging allows considerable rigor shortening and a resulting decrease in tenderness in some of the major muscles of the loin and hind limb in cattle [9]. When a load of ample degree is applied to a muscle during the postmortem period, despite undergoing the same rigor process, the muscle is unable to shorten [2]. During cutting carcass into different, pieces of meats may fall off and exposed to spoilage microorganisms [8]. Although varies method of carcass suspension such as horizontal, neck-tied, hip-tied, and hip-free by the obturator foramen in the pelvic or aitch bone, most reports [35] indicate that the latter method, also called Tender stretch, results in longer sarcomeres and improved tenderness in the longissimus and posterior muscles of the hind limb.

3.2. Chilling Regime

Low temperatures are required during carcass storage to prevent microbial spoilage. However, cold shortening depends on the difference between hot carcass and environmental temperatures. Carcass size and degree of fatness are other factors that influence carcass temperature decline [47]. Regarding beef texture, several strategies have been proposed to increase tenderness by reducing the sarcomere shortening during rigor development. If carcasses are chilled too rapidly, the result is cold shortening and subsequent meat toughness [3].

On the other hand, several reports indicate that very fast chilling, namely the attainment of –1°C within approximately 5h postmortem, can result in improvements to tenderness in species other than beef, such as pork and lamb [25]. Low temperatures, obtained by very fast chilling, bring about a considerable release of calcium from the sarcoplasmic reticulum to the myofibrils [24]. Thus, some studies report an increase in toughness after very fast chilling, perhaps due to an insufficient decline in the internal temperature of the muscle [51].

3.3. Electrical Stimulation

Postmortem electrical stimulation (ES) of meat carcasses was first developed in the 1950s and became widely used by the red meat industry in the 1970s [15]. It originally developed to prevent cold shortening; electrical stimulation has been a commercially successful mechanism for improving beef tenderness. (Aalhus et al. 1994) [4] conclude that the largest improvements in tenderness are associated with high-voltage stimulation. However over stimulation however can lead to heat shortening and increased autolysis of calpains with the consequence of reduced aging potential. In addition increased drip loss could occur due to protein denaturation Electrical stimulation is used as a means of accelerating the post- slaughter fall of pH and the onset of rigor [35]. The reported differences are likely to result from the extent to which physical damage to the muscle fibers [17]. Electrical stimulation involves passing an electric current through the carcass after slaughtering. This stimulates the muscle to contract and utilize glycogen and ATP, thereby accelerating rigor mortis and causing a rapid decline in pH within the muscle occurs [23].

3.4. Ageing Method

Variation in meat tenderness is also created during post-mortem storage, under a process known as ageing. At slaughter, a muscle has an intermediate shear force, and during the first 12 to 24 hours after slaughter there is a large decrease in sarcomere length, i.e., rigor mortis development; which is associated with a large increase in toughness [22]. In reverse tenderization also begins either at slaughter or shortly after slaughter, resulting from the weakening of the myofibrils caused by the proteolysis of structural proteins, which are responsible for maintaining structural integrity of myofibrils [22]. For a given aging time, the intramuscular variations in texture can be explained by their different fat and moisture content, shape sarcomere length fiber type and connective tissue [32]. However, the evolution of different texture parameters during aging is more related to the rate of postmortem rigor shortening, myofibrillar proteolysis, moisture loss and collagen breakdown as well as to interactions among these factors [45].

3.5. Cooking Methods

Cooking is a process of heating beef at sufficiently high temperatures that denatures proteins and makes it less tough and easy to consume [21]. It can be achieved either by boiling or by roasting [48] and in all cases losses occur. Cooking loss is one of the meat quality parameters that not given too much consideration by meat processors and consumers due to inappropriate cooking time and temperature. It refers to the reduction in weight of meat due to evaporative (volatile) and drip loss during the cooking process [50]. Drip losses is the combination of juices and fat that drip from meat during cooking while Evaporative losses is the losses of weight from meat during cooking as a result of evaporation. During cooking process all water-soluble vitamins, minerals, some parts of soluble proteins has been susceptible to losses. The increased loss of such nutrients deteriorates the meat nutritional quality and has large substantial economic loss to beef industry [38].

4. Meat Quality Attributes

Meat quality has always been important to consumers and is a particularly important issue for the meat industry. The three key traits important to fresh meat quality are WHC, color, and texture [19].

4.1. Color

Color is considered the most important sensory attribute of fresh meat, and is what consumers primarily use as an indicator of quality and freshness of the products [19]. It relies on the distribution and amount of myoglobin species, deoxymyoglobin, oxmyoglobin and met myoglobin, together with internal reflectance influence the color of the pork [1]. Fresh meat color is also significantly influenced by post-mortem metabolism. Abnormally low pH causes denaturation of muscle proteins, including myoglobin, and reduces their ability to bind water. As a result, large amounts of water migrate from inside the muscle fibers to the extracellular space, which increases light reflectance and results in a paler meat color [52].

4.2. Water-holding Capacity

The ability of pork to retain its inherent moisture has a dramatic impact on consumer acceptance of fresh pork. WHC is an important quality attribute as it influences the yield and the quality of fresh and processed meat products [30]. Many factors, such as pH and post-mortem proteolysis, influence WHC by altering the amount and location of moisture in muscle [30]. Rapid pH decline coupled with high muscle temperature in early post-mortem causes the denaturation of approximately 20% of muscle proteins, leading to their loss of functionality and their ability to hold water. WHC is closely related to the color of meat and influences other physical properties including texture and firmness of raw meat and eating properties of cooked meat [49].

4.3. Texture

Texture is a complex concept that involves several attributes comprising, tenderness, juiciness, firmness, and cohesiveness [46]. Post-mortem factors that contribute to the texture of the meat are decline in post-mortem pH, carcass temperature, contractile state, proteolysis, and their interactions [46].

4.4. Unusual Patterns of Postmortem Metabolism Lead Meat Quality Deterioration

4.4.1. Thaw Rigor

The term thaw rigor is somewhat of a misnomer. The name refers to the shortening that occurs when muscle is rapidly frozen prerigor and then subsequently thawed. Muscle that has been treated in this way shortens markedly (as much as 70–80%) and loses large amounts of liquid (more than 25% of the initial weight) as drip [36]. The mechanism of this phenomenon is believed to be the disruption of the sarcoplasmic reticulum due to ice crystal formation followed by the release of calcium upon thawing [28]

4.4.2. Cold Shortening

The usual dependence of postmortem metabolism rate on temperature does not hold in certain cases. The muscles that depend on primarily on oxidative metabolism may undergo a slow but significant shortening if excised and held at temperatures below 10°C [33]. The muscle length can decline as much as 50% in unrestrained muscle [40]. Cold shortening is a slow process; the time course may be minutes to an hour and depends on the cooling rate. The shortening occurs before there is any reduction in muscle ATP levels [40]. It occur due to slow rise in the cytosolic calcium level by release from either mitochondria or the sarcoplasmic reticulum (the calcium pump operates more slowly at low temperature [10]. The slightly elevated calcium causes a weak contractile response and the muscle shortens. The rapid cooling that occurs with high efficiency chillers exacerbates the problem. Cold shortening leads to an increase in meat toughness and also affect meat quality [37].

4.4.3. Pale Soft Exudative Condition

An unusual postmortem phenomenon is one in which the muscle becomes pale in color, develops a soft texture, and exudes large amounts of liquid [22]. The postmortem metabolic rate is vastly increased, with ATP depletion, completion of rigor mortis, and pH values as low as occurring within 10–15 min after death [12]. The low pH that develops while the muscle temperature is still high leads to a denaturation of some of the muscle proteins, notably myosin. This reduces the water-holding activity of the muscle and results in excess drip loss. This phenomenon occurred usually in pork processing industries [51].

4.4.4. Dark, Firm, Dry Condition

The dark, firm, dry (DFD) condition in pigs results from the same ryanodine receptor mutation that causes PSE. In this case, the glycogen has been largely depleted before death and lactic acid therefore does not accumulate in the muscle. The time to rigor mortis completion is very short and the resulting ultimate pH is high (it may be > 6.5) [51]. The meat is dark in color and has a firm texture. The surface is dry and sticky to the touch. Such meat has excellent properties for use in processed meat products because of its high water-binding activity [51].

5. Conclusion

Transformation of muscle to meat involves several physiological and biochemical processes change. The magnitude, extent, and timing of these responses before, during or post-slaughter can dramatically affect meat quality development. The rate and extent of post-mortem glycolysis has a profound effect on meat quality. Post-slaughter practices contribute significantly to the quality of meat produced. This will in affect profits, processing/functional properties, eating qualities and the acceptance of the meat

6. Recommendation

The quality of meat can be affect by post mortem metabolism and post slaughter processing methods. Post-slaughter practices contribute significantly to the quality of meat produced. This will in turn affect profits, processing/functional properties, eating qualities and the acceptance of the meat in question by consumers. All post-slaughter practices have been geared towards producing meat of better qualities, although some of these practices come with it negative effect on meat quality and human health. Therefore to reduce the adverse effects the research should be done to optimize the processing conditions that affect meat quality.

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