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Review on Meat Tenderization Challenging Factors

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Abstract: Ethiopia is the largest livestock producer in Africa and ranks eighth in livestock ownership in the world. Even though, Ethiopia has the largest number of livestock in Africa, we gain less income from the growing global market of livestock products. One of the livestock products is meat, which is the main source of protein and satisfaction of the consumers. However, toughness is the major cause for low quality meat due to rigor mortis and biochemical changes, which can be solved by tenderization. Tenderization involves the breaking down of muscle fibers in the meat to soften the texture and taste better by different method of tenderization. Proteases are a highly demanded group of enzymes as tenderizer in various industries with a market share of 60% of the total enzyme market and it is not sufficient enough. So, alternative tenderization methods are important to increase quality of meat. This includes; heat treatment, electrical stimulation, manual tenderization, ultrasonic tenderization and marinating. Tenderization is also applicable in high quality meat to enhance the quality. Tenderness is the most important meat quality trait but, variation in meat tenderness is the main factor for consumer dissatisfaction. Variation in meat tenderness is affected by breed, temperature, water holding capacity, pH, composition, age, time on feed, type of enzyme and stress. To combat undesirable effects some natural tenderizers could be used as it contain proteolytic enzymes responsible for tenderization of tough meat. New plant proteases actinidin, zingibain, papain, bromelain and microbial enzyme preparations are the recent interest due to controlled meat tenderization. However, some are not approved to use and using microbial enzyme has safety concerns. Any negative impact on the meat tenderization is controlled by protease inhibitor to control over tenderization of meat.

Key words: Inhibitor · Meat · Over-Tenderization · Protease · Sensory Evaluation · Tenderization

INTRODUCTION

According to the Central Statistical Authority [1] livestock population in Ethiopia is estimated about 59.5 million heads of cattle, 30.70 million heads of sheep, 30.50 million heads of goats, 56.53 million poultry population and 1.21 million camels. Livestock is central to the Ethiopian economy but, the income level from livestock population is below the estimated. As the country has the largest number of livestock, Ethiopia has much to gain from the growing global market for livestock products [2]. There is appreciable growth in terms of number of Ethiopian meat processing industries during the period 2005-2014. There are more than 22 meat industries (Abattoirs) that are either already established or under construction. Currently there are 15 industries that were engaged either in meat or offal processing but some of them stop their operation due to different reasons Ethiopian Meat and Dairy Industry Development Institute [3].

Meat is the most valuable livestock product and for many people serves as their first-choice source of animal protein. Meat is either consumed as a component of kitchen-style food preparations or as processed meat products. After slaughter of animals' natural process or rigor mortis shorten muscle protein fibers and results the meat to become tough. After 48 hours of rigor mortis biochemical changes takes place in the meat that result the meat to become tender or softer and satisfy the need of the consumers this process called tenderization or aging [4].

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In today's world food economy must be linked to food security concept that has acquired a new approach arising from globalization in the food trade, where Hazard Analysis Critical Control point (HACCP) systems have been introduced to produce safe food, according to the sanitary requirements of population [5]. Consumers understand the meat tenderness variability so; production of consistently tender meat is required to retain consumer confidence in quality meat which is competing with other types of meat that do not have toughness problem [6]. Consumer acceptance of meat is strongly influenced by the eating quality meat having fresh and processed meat such as color, water holding capacity, cooking losses and texture [7]. Meat quality can be achieved by application of different tenderizing method and enzyme.

Proteases are a highly demanded group of enzymes in various industries with a market share of 60% of the total enzyme market [8]. Two major plant proteases important in the food industry are papain and bromelain which cover only 8% of market demand [9]. Other methods have been tested to improve the tenderness of meat by the use of enzymes papain and microbial enzyme [10] electrical stimulation, heat and pressure [11] ginger extract [12] marination [13] ultrasound [14]. Proteolytic enzymes like; papain, ficin, bromelain, Aspergillusoryzae protease and Bacillus subtilisprotease recognized by United States federal agencies as generally recognized as Safe (GRAS) for meat tenderization. Apart from these GRAS enzymes, others have been evaluated including ginger rhizome [15].

An ongoing challenge for meat industry is inability to produce high quality meat having consistent flavor and texture [16]. Texture is the most important meat quality attribute it determine the consumer acceptance and marketability of final products [17]. Texture quality is evaluated by consumers based on the sensory consideration of appearance, tenderness and juiciness [18]. Tenderness is influenced by the length of the sarcomeres, structural integrity of the myofibrils that influence the actomyosin toughness [19]. Meat from older animals is generally tougher than meat from young animals since old animals have more collagen cross-linking [20]. Red meat industry needs to produce high quality meat with consistent tenderness to increase consumer confidence and encourage further purchase of meat products, but they cannot solve this problem effectively [21]. Also bacterial derived enzymes lead to safety concerns on the health of customers [19].

Therefore the Objectives of this Review Are to Highlight On: Alternative methods of reducing meat toughness to achieve tender meat.Safety concern and side effect of microbial and some natural protease.Practice and background of meat tenderization in Ethiopia.

Method of Meat Tenderization: After slaughter of the animals rigor mortis shorten muscle protein fibers causing the meat to become tough. After 48 hours of rigor mortis biochemical changes takes place in the meat that result the meat to become tender or softer and satisfy the need of the consumers and the process is called tenderization [4]. Muscle fibers are filled with intracellular sarcoplasm or cellular fluid which is made up of approximately 80% water as well as proteins, enzymes, lipids, carbohydrates and inorganic constituents [22]. Myofibrils are composed of thin filaments called actin and thick filaments called myosin [23]. There are different methods of tenderization these include;

Types of Natural Enzymatic which used in Meat Tenderization

Papain: Papaya contains the most significant amount of papain and chymopapainproteolytic enzymes which have diverse uses as meat tenderizers, digestive medicine, in brewing applications, manufacture of chewing gums and in pharmaceutical applications in the skin care and tanning industry [24]. It is also being used to tenderize meat and meat products in the manufacture of protein hydrolysis, chewing gum, in brewing industry to remove cloudiness in beer and in dairy industry for cheese production [25]. The stability of the enzyme both as a solid and in semi-solid formulations has been investigated at different temperatures and results was decrease in its activity when the temperature increases [26].

Papain has been reported to improve meltability and stretchability of Nabulsi meat with outstanding fibrous structure enhancing superiority in the application in kunafa, pizza and pastries [27]. Due to its proteolytic property it is extensively used in the food industry to tenderize meat and as an ingredient in flour and in beer manufacturing [28]. Papain has a tendency to over-tenderize the meat surface leading to undesirable mushy meat [10]leading to a limited use as a commercial meat tenderizer [29]. Reported that the activity of papain is strongly affected by type of substrate, the ratio of enzyme to substrate, pH, temperature and period of hydrolyzing process.

Bromelain: There are two different bromelains extracted from pineapple plant stem and fruit bromelain. Fruit bromelain is not commercially available. Bromelain is composed of cysteine proteases and non-protease components [30]. This proteolytic enzyme is mainly used for meat tenderization [31]. The effect of bromelain extract on beef and chicken meat were sprinkled with a powdered bromelain extract (0, 3%, 7%, 10% and 20% w/w). After mixing they were kept at room temperature for 1 hour prior to analyses [32]. Conducted a study characterizing the proteolytic activity of fruit bromelain using five different substrates: azocasein and azoalbumin (pH 3-10 at 20-70°C), casein and sodium caseinate (pH 2-10 at 20-70°C) and hemoglobin (pH 2-6.5 at 30-60°C) to tenderize meat of turkey [33].

Ficin: Ficin represents to the endoproteolytic enzymes from trees of the genus *Ficus*. The ficins that have been isolated from the latex of *Ficusglabrata*and*Ficuscarica* are the most widely studied ficins. However, recently a less known ficin from the latex of *Ficusracemosa* has been identified with a molecular weight of 44,500 ± 500 Dalton, optima pH between 4.5 and 6.5 and maximum activity at 60±0.5°C. These unique properties make it distinct from other known ficins and give it application in many sectors [34, 35]. Investigated the water holding capacity of ficin tenderized meat and evaluated the effect of ficin on meat protein by gel electrophoresis and concluded that solubility of meat protein increased when ficin was used as meat tenderizer.

Ginger rhizome: Since its discovery as a new protease source [36]ginger or *ZingiberofficinaleRoscoe* has been drawing a huge interest among researchers to extract, purify, characterize and study its application in various food products. Ginger powder has been used to improve meat tenderness and flavor in chicken kabab, an Indian traditional food [37]while ginger rhizome extract (GRE) was reported to improve the properties of patties made from goat meat or chevon [13].

The collagenase activity of ginger proteases (GP) is better than other plant cysteine proteases such as papain and bromelain based on its ability to hydrolyze native collagen [38] Cheaper and easilyavailable ginger rhizome could effectively beused for tenderization of tough meat. Whichobtained from ginger rhizome a natural spicehas an advantage over other tenderizing agentthat it has a greater proteolytic activity in heatedcondition which is desirable [39].

Ginger rhizome is a source of plant proteolytic enzyme. The ginger protease shows optimum activity at 60°C and rapid denaturation at 70°C. Its proteolytic activity on collagen was greater than it was on actomyosin [39]. It has been reported that ginger extract has antioxidant and antimicrobial characteristics as well as its tenderizing properties [40].

According toNaveena and Mendiratta[12] whocompared two plant proteolytic enzymes from Cucumbers and Zingier officinal roscoe with papain in point of tenderizing effect. They reported that all enzyme treated samples made an improvement in flavor, juiciness, tenderness and overall acceptability scores. However, the samples treated with GE received better scores while the samples treated with papain and cucumbers received almost the same scores with a high optimum temperature (60ºC), GP may have a viable potential application in the food industry especially in the dairy or meat processing industry where high processing temperatures are often necessary [41]. GE had a great effect on degradation of several major cytoskeletal/myofibrillar proteins [42].

Actinidin: Actinidin also spelled as Actinidain is obtained from the kiwi fruit. The enzyme is available from other cultivars but the level of actinidin varies greatly among them. The actinidin levels in 28 cultivars range from non-detectable to 10.7 mg/ml juice [43].Commercially, the enzyme is obtained from ripe fruit that has been frozen and thawed to disintegrate the cell walls and maximize the yield. Actinidin hydrolyze both myofibrillar proteins [21]. But it appears to have higher proteolytic activity toward collagen [11].

Microbial Enzymes

Bacterial enzyme or Bacillus subtilisprotease: The proteolytic activity of many bacterial strains has been known for many years. For example; Bacillus plays a very important role in protein degradation in fermented meat and fish products [44]. Bacterial proteases have lower hydrolytic activity toward myofibrillar proteins compared to plant proteases, but their ability to hydrolyze collagen was intermediate to that found bromelain and papain [45].

Qihe *et al*. [46] conducted a research for the tenderization feasibility of a microbial enzyme, elastase from Bacillus species comparing with papain. In their research, meat tenderization was done by dipping the beef meat cut in different enzyme solutions (0.1% papain, 1% papain and 1% of a new elastase from Bacillus species) after freeze-dehydration. After 4 hours treatment the samples were stored at 4°C for 24, 48and 72 hours before analyses. As a result the elastase from Bacillus species had the same tenderization effect on beef meat as papain. However, it was reported that there were some problems when the elastase was used such as elastase safety and elastic stabilization in the meat tendering process.

Cold-adapted Collagen Lytic Protease MCP-01: Cold-adapted collageno-lytic protease MCP-01 was isolated from the deep-sea psychrophilic bacterium Pseudoalteromonas species [47]. This enzyme nearly has high activity at 0-25°C and is unstable at temperature higher than 40°C. Since meat tenderization is usually achieved at room temperature before cooking with ideal meat tenderizer should have high activity at room temperature and be comfortably inactivated during cooking. Due to their high activity at 0-30°C and losing their activity at temperatures higher than 50°C, cold-adapted proteases may be functional as meat tenderizers [48]. Also, they explained that the water loss of the meat treated by papain and bromelain was 3-4 folds higher than the water loss of the meat treated by MCP-01. This showed better freshness, color features and better tenderization effect than papain and bromelain.

Fungal Enzyme Oraspergillusorayzae Protease: The action of fungal proteases plays a very important role as a source of microorganisms for the production of proteases or tenderizing preparations [15, 49] Studied the tenderization effect of five GRAS enzymes (Papain, ficin, bromelain, Bacillus subtilis protease two variations of Aspergillusoryzae proteases which are Aspergillusoryzae concentrate and Aspergillusoryzae 400) and homogenized fresh ginger on beef muscles.

Bacillus subtilis protease and both Aspergillusoryzae proteases indicated more degradation effect on myofibrillar than collagen proteins. While ficin show the most balanced degradation effect on both myofibrillar and collagen proteins. There are also some specific enzymes that degrade the texture of meat including newer fungal extracellular protease with respect to texture changes in whole pieces of pork loin [50]. The protease isolated from Penicilliumchrysogenum on dry curd ham and injected to rib or loin muscle of pork [51].

Meat Tenderization by Other Methods

Using HPP in Meat Tenderization: Heating is commonly used method for processing meat products which increases the palatability of meat; change meat flavors and kills microorganisms [52]. The final tenderness of the meat largely depends on the heating conditions. During the heating process the changes of myofibrillar proteins have substantial impact on tenderness of meat [53] however there were few attempts on the interaction and structural changes of actin and myosin during the application of heat treatment [54].

Tenderizing with Electrical Stimulation: Proper application of high voltage electrical stimulation will prevent the cold shortening in leaner carcasses and consequently improve meat tenderness. Electrical stimulation speeds up the post-mortem conversion of muscle to meat and thus reduces the ageing time [55]. Where animals are rendered unconscious by electrical stunning immediately prior to slaughter the muscles are positively affected by tenderness mainly through mechanically fracturing of the giant, intermediate and shorter muscle fibers of meat. Cold shortening occurs in pre-rigor meats if a rapid cooling of the muscle compromises the ability of sarcoplasmic reticulum and mitochondria to retain calcium. This increase calcium concentration in the sarcoplasm and muscle fiber contraction is promoting the toughness [56].

Ultrasonic Meat Tenderization: The shockwave propagates through liquid medium at the velocity extending the speed of sound. The shockwave travels rapidly through the fluid and any objects which are acoustical match with water. Since meat is a composed of 75% water, the wave passes through the meat sample and tears muscle protein. This produce rupture effect as consequence the meat tenderization is favored [57].

Meat Tenderization by Other Methods

Using HPP in Meat Tenderization: High hydrostatic pressure processing (HPP) has also been investigated as method for tenderness improvement. The effect of HPP is due to the disruptive nature induced by pressure that causes dissociation of myofibrillar proteins [58]. The application of HPP to pre-rigor meat stops the metabolism and the conversion from muscle to meat resulting in higher pH and higher tenderness score. While tenderizing effect of post rigor HPP treatments are only measurable if pressure and heat treatment are combined [59]. In addition HPP causes color changes due to muscle protein denaturation at the pressure required for meat tenderization what makes the HPP-treated meat non acceptable anymore as fresh meat from consumer perspectives. The HPP also requires high initial investment this excludes the HPP from industrial application [57].

Marinating: Marinating is the process of soaking or injecting meat with a solution containing ingredients such as vinegar, lemon juice, wine, soy sauce, brine, essential oils, salts, tenderizers, herbs, spices and organic acids to flavor and tenderize meat products [60]. Vinegar, buttermilk and all these ingredients such as fruit pulp (Kiwifruit or lemon) will help to break down the muscle fiber in the meat [61].

Factors Affecting Meat Tenderization

Protein Composition

Myofibrillar Protein: Myofibrillar proteins contribute for meat tenderness to determine the capacity of water retention and hydration of meat, fat emulsifying and gelling capacity. Myofibrillar proteins by high intake of essential amino acids, contribute about 70% to the nutritional value of meat [62]. Tenderness is influenced by the length of the sarcomeres, structural integrity of the myofibrils that influence the actomyosin toughness and the integrity of the connective tissue that affects the background toughness [19].

Sarcoplasmic Proteins: Muscle contains metabolic enzymes like; mitochondrial, lysosome, microbial, hemoglobin, myoglobin and cytochromes [63]. Some ofthese enzymes have important activity during postmortem and further processing. The main sarcoplasmic protein is myoglobin which is responsible for the red meat color. The amount of myoglobin depends on the fiber type, age of animal and animal species. For example, beef and lamb meat include more myoglobin than pork and poultry. In general, the amount of myoglobin increases with the age of the animal [4].

Temperature: Heating at 70°C did not affect the activity of bromelain, ficin and papain, but the collagenase activity was abolished. Because of the high inactivation temperature for papain (90°C) and bromelain and ficin (˜75°C) there is potential for high residual activity after cooking especially with medium or rare degrees of doneness which can lead to over-tenderization [64]. Zingibain has an optimum activity at about 60°C and 75% of the activity is lost at 70°C [36]this explains its mild tenderizing effect.

Temperature control does not apply to live animal production but, begins at the slaughter process. Temperature control is one of the most effective tools in producing safe product. Controlling the temperature of carcasses during the slaughter process has been proven to not only help control microbial growth, but also to assist in creating a quality meat product [65]. To understand the effects of stress on final meat quality it is important to understand the relationship of glycogen and lactic acid to pH decline in meat after slaughter. An animal which has not been stressed will have normal levels of glycogen in its body. When the animal is slaughtered the metabolic process continues but, oxygen no longer circulates. In the absence of oxygen, the breakdown of glycogen or glucose results in a buildup of lactic acid, which then causes a drop in pH of the meat [66].

Heat Ring: Heat ring is a problem associated with beef carcasses and results from differential chilling rates of the muscles after slaughter. A heat ring is a dark, coarsely textured band around the exterior portion of the muscle. In muscles that have a thin layer of external fat, the outer portion of the muscle may chill too fast after death, resulting in a slower pH decline in the outer layer and a dark-colored ring. This condition is also alleviated by electrical stimulation of beef carcasses after slaughter, causing a more even pH decline throughout the muscle [67].

Water Holding Capacity (WHC) and pH: Ketnawa and Rawdkuen[33] Reported that WHC decreased as the bromelain concentration increased in beef, chicken and squish. They stated that the lower WHC in the bromelain treated samples was probably due to denaturation of myofibrillar proteins. However, Chan et al. [22] studied low and normal pH of turkey breast meat and correlated with protein denaturation. They showed that low pH of meat had lower WHC than normal pH meat. On the other hand, Huff-Lonergan and Lonergan [68] reported that myofibrillar proteins lost the ability to bind water as they closed to their isoelectric point. So, there are different reasons for the lower water retention ability of low pH meat instead of protein denaturation [69].

According to Abdullah and Matarneh[70] ,WHC, color and composition of broiler breast were not affected by carcass weight, broiler sex and post chill carcass aging duration. They reported that lower WHC in poultry meat could depend on phospholipase A2 (PLA2) enzyme activity in muscle [22]. pH value of meat products is highly important because it has a major influence on water holding capacity (WHC), tenderness and juiciness [64]. Lowering the pH of beef also reduced moisture losses during cooking contributing to an overall improvement in the juiciness of the cooked product [71].

Slaughter Timing: The way that animals are handled pre-slaughter and animal temperament may have a marked effect on meat quality, during the conversion of muscle to meat an acidification of the tissue occurs, resulting in a pH fall from about 7.0 to 5.5 in normal meat. Pre-slaughtering handling can cause an unusually high rate of pH fall or a limited pH fall, resulting in pale, soft and exudative (PSE) and dark, firm and dry (PFD) meat respectively. The PSE condition is usually attributed to acute stress in the immediately pre-slaughter period, while DFD is usually associated with chronic stress or prolonged feed withdrawal [72].

The rate of pH reduction and the ultimate pH have effects on meat quality and color development. Dark, firm and dry (DFD) meat a quality defect is often the result of animals exposed to long term stress prior to slaughter [73]. Stress and exercise deplete the animals glycogen reserves and the pH drop will be minimal then the ultimate pH will remain high [74]. DFD meat has a higher water holding, dark color and dry appearance [75].

The meat toughness is determined by postmortem changes in the contractile apparatus of muscle sarcomere which undergoes a shortening phase during the development of rigor mortis. The toughness caused by muscle shortening is primarily influenced by processing conditions by manipulating these processing conditions for the significant improvement in meat tenderness to be achieved. Shortening induced toughness is resolved to a variable degree by the actions of endogenous proteases during postmortem storage of meat or ageing. This is mainly attributed to the actions of μ-calpain [76].

Age and Related Factors

Breed or Genetic differences: The effect of genetics on meat tenderness is clearly observed when meat of Bostaurus is compared with meat of Bosindicus. The latter type presents tougher meat due to lower proteolysis of myofibrillar proteins, as a result of the higher activity of calcium-dependent protease inhibitor [77].

Chronological Age: As animal's increasein chronological age tenderness decreases [78] and sensorypanel scores for tenderness decrease. Stromal proteins predominantly contain collagen providing strength and support to the muscle structure then skeletal muscle becomes tougher with age because, the number of crosslinks increase in the collagen fibers. This is the reason why meat tenderness decreases in older animals [4]. Due to low rate of nutritionally essential amino acid, stromal protein cause to lower nutritive value of meat [79]. The meat with a high content of collagen is generally tough and requires a prolonged heat treatment [80].

Accessibility of Feed: Longer time on feed have effect on tenderness, marbling and sensory characteristics of meat. However, animals that are finished on concentrate feed tend to reach a given slaughter weight sooner than animals that are finished on the pasture. Thus, concentrate fed animals usually are slightly tenderer because they are slaughtered at younger age. The influence of growth rate on meat tenderness seems to depend mainly on changes of muscle protein turnover [81].

Meat from older animals is generally tougher than meat from young animals since old animals have more collagen cross-linking, conventional aging with endogenous enzymes like calpains and cathepsins is time consuming and may still result in toughness [20]. Meat toughness is mostly influenced by factors such as breed, sex, age and physical activity. Processing and postmortem handling practices will have little effect on meat toughness and contribution of connectivetissue to meat toughness depends on the structure or the amount of different collagens and elastin in the meat [82].

Methods to Control Over-tenderization of Meat: Plasma proteins from bovine, pork and chicken as protease inhibitors in the fish industry has the negative side and gave undesirable reddish color, which is not a problem if used in red meat. Several plants especially legumes have protease which could be potentially useful. Clearly any successful use of these compounds as future inhibitors will be dictated by the safety of the effective level of use consumer acceptability. For example; fraction from serum of taboo animals in certain societies affects the meat sensory quality specifically flavors and cost associated with the use of compounds [83].

Potato powder (1%); whey protein concentrate (3%) and natural cysteine proteases can inhibit papain activity. New emerging technologies such as pulsed electric field may play an important role in limiting the over tenderizing effect of proteases [84].

Sensory Evaluation of Tenderized Meat: Various technological alternatives have been explored to enable minimally processed meat preservation, including novel thermal and non-thermal processing tools that have been successfully applied throughout the food supply chain without affecting the functional or sensory properties of fresh meat and meat product [85]. Sensory attributes are important quality factors in the meat industry and are responsible for consumer's meat choices. For this reason, methods are needed to ensure the safety, nutritional and sensory qualities of meat [86].

Texture is a particular sensory property of tenderness and also is essential parameter in the meat quality [61]. Texture is the most important meat quality attribute to determine the consumer acceptance and marketability of final products [17]. Texture quality is evaluated by consumers based on the sensory consideration of appearance, tenderness and juiciness [18]. He also added that consumers are willing to pay more for high quality meat products. High concentration of some microbial proteases can have a negative impact on the sensory properties of meat texture [46].

Consumers understand the inherent tenderness variability in different meat cuts and associate the differences in tenderness with price and cooking methods for different meat cuts. However, inconsistent tenderness within cuts is a problem for the meat industry and consumers that carries financial consequences. So that; the production of consistently tender meat is required to retain consumer confidence in red meat which is competing with other types of meat that intrinsically do not have toughness problems [6]. Carcass fat proportion, especially intramuscular fat marbling plays an important role in the meat sensory characteristics. Since it contribute directly to its sensory properties [87].

Table 1: Descriptors that characterize a beef meat sample.

Attribute	Descriptor	Definition
Appearance	Whitish	Perception of greater amount of white light on the surface of the meat.
	Pink	Pale shade of red.
	Grayish Meat	Meat with less intense hue and brown tone.
	Light-brown	Brown hue reflecting more light.
	Pale	Meat color is observed to be less saturated.
Color	Raw meat	Raw meat Amount of beef odor in the sample
	Grilled meat	Full aromatic generally associated with beef suet that has been grilled.
	Fresh cook meat	Odor or note of aromatic fresh-cooked beef.
	Boiled meat	Aromatic notes associated with boiled meat or soup stock.
	Metallic	Aromatics associated with impression of slightly oxidized metal.
Flavor	Metallic	Taste associated with undercooked meat (bloody taste).
	Fresh bovine cooked meat	Taste characteristic of all meat, the aromatics associated commonly in Partially cooked meat.
	Greasy	Flavor associated with fat heated to a high T^0.
	Dry meat	Flavor associated with meat that is overcooked and charred on the outside.
	Bovine meat	The aromatics commonly associated with matured cooked beef muscle products (boiled beef broth).
Texture	Soft	Describes beef meat that is easy to bite between the teeth (low hardness).
	Juicy	Perception of the amount of water released by the product during the first bites.
	Fibrous	Indicate that the orientation of particles in meat beef is similar to that perceived in celery.
	Tough	The number of chews required to masticate beef meat into a state ready for swallowing is similar to that necessary for old cow meat.
	Elastic	Describes the rapidity of recovery from a deforming force.

Sources: Nolletand Toldra[88].

Practice of Meat Tenderization in Ethiopia

Livestock Production in Ethiopia: According to the Central Statistical Authority [1] livestock population in Ethiopia are estimated about 59.5 million heads of cattle, 30.70 million heads of sheep, 30.50 million heads of goats, 56.53 million poultry population and 1.21 million camels. Livestock is central to the Ethiopian economy but, the income level from livestock population is below the estimated. As the country has largest number of livestock, Ethiopia has much to gain from the growing global market for livestock products [2].

Meat Production Capacity of Ethiopia: There is appreciable growth in terms of number of Ethiopian meat processing industries during 2005-2014. There are more than 22 meat industries that are either already established or under construction. Currently there are 15 industries that were engaged either in meat or offal processing but some of them stop their operation due to different reasons Ethiopian Meat and Dairy Industry Development Institute [3].

Method of Meat Tenderization in Ethiopia: Consumer acceptance of meat is strongly influenced by eating quality meat. Meat quality can be defined as a combination of diverse properties of fresh and processed meat. These properties contain both sensory characteristics and technological aspects such as color, water holding capacity, cooking losses and texture [7]. Red meat industry needs to produce high quality meat of consistent tenderness to increase consumer confidence and encourage further purchase of meat products [21]. But there is no any record data of meat tenderization method and practice in Ethiopia.

CONCLUSION AND RECOMMENDATIONS

Even though, Ethiopia have large number of livestock the income level from meat is below the estimated which may be associated with lack of tenderness. Tenderization involves the breaking down of the muscle fibers in the meat to soften the texture and taste better by different method of tenderization with appropriate instruction. However, there is no appropriate documented data and instruction for all methods which is the principal factor for consumer dissatisfaction. Tenderizing tougher meat using improper dose and microbial protease has safety concern for consumers. Some manual and ultrasonic methods have side effects and need better experience. The concentration of enzyme is different depend on the nature of tenderizer and duration of time. The use of plasma proteins from bovine, pork and chicken as protease inhibitors in the meat industry has the ability to improve over-tenderization of meat but, using animal protease have religious taboo.

Based on the above conclusion the following recommendations are forwarded:

- ✓ Using animal proteases as inhibitor and improper application of microbial and some natural protease have side effect to the health of consumers. So, the enzymatic level and dose need further research and should be documented.
- ✓ As Ethiopia has largest livestock population with infrastructure like, abattoirs it is possible to export tenderized meat for developed country. The government policy should also give special attention on livestock management, further construction of abattoirs and distribution of tenderized meat to customers.

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List of Abbreviations:

CSA	Central Statistical Authority
DFD	Dark Firm and Dry
GE	Ginger Enzyme
GP	Ginger Protease
GRAS	Generally Recognized As Safe
GRE	Ginger Rhizome Extract
HACCP	Hazard Analysis Critical Control point
HPP	Hydrostatic Pressure Processing
MCP	Cold-adapted Collagenolytic Protease
pH	Potential of Hydrogen
PLA2	Phospholipase A2
PSE	Pale Soft and Exudative
W/W	Weight by Weight
WHC	Water Holding Capacity

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