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Review on Beef Eating Quality Attributes (Tenderness, Juiciness and Flavor) and Quality Standards in Ethiopia

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Abstract
This review Assess the Eating Quality Attributes (Tenderness, Juiciness and Flavor) and Beef Quality Standards in Ethiopia. The largest livestock resources potential available in Ethiopia is not fully exploiting and the production and productivity of the animal is low and products being produced are of low quality. Quality remains a key demand driver within the beef category. Tenderness, flavor are juiciness are the important palatability characteristics to evaluating eating quality of beef while tenderness is most often cited as the fundamental determinant of a beef product's performance with respect to eating quality. In Ethiopia, research on meat and meat products are given lowest attention. As a result, lean meat yield, eating qualities and human nutritive value (proximate composition) are identified as the most important quality areas need attention for the future. In Ethiopia eating quality attributes standards concerning consumer safety and shelf life of meat have not been fully have developed. However, corned beef standard in line with the chemical and microbiological requirements were established.
Keywords: Tenderness, Juiciness, Flavor

1. INTRODUCTION

Livestock plays an important role in the agriculture of Ethiopia .Ethiopia ranks first in Africa and tenth in the world with respect to livestock population. The estimated livestock population of the country is 53.99 million heads of cattle, 25.49 million heads of sheep, 24.06 million heads of goats, 50.38 million heads of poultry and 5.21 million beehives. (Mesele *et al*., 2015). Thus, the country is not fully exploiting this large resource and several studies reveal that the production and productivity of the animal is low and products being produced are of low quality (Ayele *et al.,* 2003; Arse, 2013). Similarly Anon(2006) stated that dark cutting, improper handling of the product, poor sanitation, careless packing, poor management during transport, lack of continuous supply and unresponsive business communications were some of the problems of meat in Ethiopia. As a result, importing countries revealed that they are not satisfied with the quality of meat imported from Ethiopia (Farmer, 2010).

Beef is one of the widely consumed protein sources in the world. Furthermore, modern consumers are increasingly concerned about production of safe meat with no undesirable effects on their health (Andersen, 2005). Quality remains a key demand driver within the beef category (Steiner, 2014). Beef quality can be defined and interpreted many different ways. There are three main factors that make up beef quality: safety (wholesomeness), nutritional quality and palatability. Palatability of beef is determined by tenderness, juiciness, and flavor; with tenderness being the most important economic factor (Belew *et al*., 2003). Similarly, Jack (2013) stated that juiciness, flavor and tenderness are the three important characteristics while evaluating eating quality of beef.

Providing consumers with a desirable beef eating experience, on a consistent basis, requires the coordinated efforts of participants along the entire beef chain, beginning with the producer. Findings revealed that the eating qualities of beef are influenced by a variety of pre-harvest factors (both genetic and environmental) and that systematic control of cattle production and management practices can enhance palatability of the final product (Tatum, 2006).

In Ethiopia, research on meat and meat products are given lowest attention (Anon, 2010a; Arse, *et al.,* 2013). But, several scientists have indicated the importance of continuous assessment on meat eating qualities. Continuous study of meat quality is important to improve and sustain livestock production the reason being that meat should be more consistent in quality *i.e.* optimum level of eating qualities to ensure consumers have a consistently good eating experience (Kirton, 1989; CRC, 2004; von-Braun, 2010; Arse, *et al.* 2013). Particularly, Pethick *et al.* (2011) survey result noted that the three most important quality areas for future research are lean meat yield, eating qualities and human nutritive value (proximate composition). Mirzaei *et al.* (2011) also indicated that optimization of cattle production requires knowledge of the variation in meat quality and carcass traits and the association between them.

Therefore, the objective of this review is to assess the eating quality attributes (tenderness, juiciness and flavor) and beef quality standards in Ethiopia.

2. LITERATURE REVIEW

2.1. Tenderness of Beef

Tenderness is one of the most important meat palatability attributes, and consumers are willing to pay more for beef which is tender (Lusk *et al*., 2001; Farzad, 2014).The extensive body of research on beef tenderness has shown that many different factors influence beef quality (Koohmaraie, 1996; Brewer and Novakofski, 2008; Lepetit, 2008; Farzad, 2014). In particular, tenderness has been linked to the animal's age, marbling, muscle location and aging (Farzad, 2014).The older the animal, the tougher the meat in general (Berit, 2012). The greatest tenderness and quality of beef is achieved with cattle less than 36 months of age; thereafter the meat becomes tougher. Approximate chronological ages corresponding to the physiological maturity groups are: A- 9 to 30 months, B- 30 to 42 months, C- 42-72 months, D- 72 to 96 months, and E- over 96 months (USDA, 1997; Semler, 2015)

Marbling (intramuscular fat) is a major trait in characterizing beef quality and an important factor for determining the price of beef. It is also a complex trait, which is obtained from many genes like tenderness. Therefore, a complex trait like marbling demands such an approach, because no single factor determines a large proportion of the trait variations in the population (Hwang, *et al*,.2008; Dajeong Lim *et al*, 2014). Marbling arises from white flecks of fat within the meat muscle (intramuscular fat). Beef cuts with high levels of marbling are more likely to be tender, juicy and flavorful than cuts with low levels of marbling (Blumer, 1963; Wheeler *et al*., 1994; Farzad, 2014). There is a direct correlation between the amounts of marbling in younger beef with the beef's quality grade. Younger beef has a lighter texture and red color which is associated with greater tenderness, juiciness and flavor.

2.2. Juiciness of Beef

Juiciness refers to the quantity of apparent juice that comes from meat during chewing (Miller, 2003; Satyavisal, 2012). Juiciness and tenderness are closely related and it is often noted that the more tender the meat, the more readily juices are emitted, and the "juicier" the meat is perceived. Juiciness of meat varies with every cut and can play a vital role in the palatability of beef to consumers. Juices contain many important flavor components and assist in fragmenting and softening meat during chewing (Aberle et al., 2001; Cattlemen's Beef Association, 2012). Without juiciness, the acceptability of beef is extremely limited and the palatability profile is destroyed. Juiciness in meat is attributed to water and melted lipids that are released upon chewing (Cattlemen's Beef Association, 2012). According to Aberle *et al*. (2001) the water and melted lipids as a broth which may stimulate flow of saliva and thus improve apparent juiciness. It also has been documented that differences in pH, water-holding capacity, fatness, and firmness were directly related to the juiciness of cooked meat products (Lawrie, 1966; Cattlemen's Beef Association, 2012)

2.3. Flavor of Beef

Flavor represents the interaction between aromatic compounds within the nasal cavity and chemical compounds that contact the tongue during eating (Miller, 2003; Satyavisal, 2012). Flavor is also an important component of beef palatability. The National Beef Customer Satisfaction Survey II NCBA (1998) concluded that flavor is the most important palatability characteristic to consumers. Beef flavor can vary greatly due to a number of factors ranging from breed type, to cattle diets or even meat processing / aging techniques. Raw beef is a reservoir for numerous flavor precursor compounds. Proteins, lipids, and carbohydrates all play a role in beef flavor development (Spanier and Miller, 1993; Mottram, 1998; O'Quinn, 2012). During heating Maillard reaction and the oxidation of lipids play a key role in the development of flavor (Rhee, 1989; Farmer, 1994; Mottram, 1998; Calkins and Hodgen, 2007; O'Quinn, 2012).

2.4. Measuring Variability in Palatability

Tenderness, juiciness and flavor can vary greatly among and within beef because of the several biochemical properties that affect these traits. Tenderness is the most easily measured factor of beef palatability. There are two primary methods utilized to assess tenderness: Warner-Bratzler shears force (WBSF) and sensory analysis. Warner-Bratzler shear force is an objective measure of the peak force (measured in pounds or kilograms) needed to cut through the muscle fibers. Sensory analysis is often used as a measure of tenderness, and may be conducted using either a trained panel or a consumer panel. A third method, "Slice Shear Force," has been developed and has been cited as being more rapid and technically less-difficult to conduct than WBSF (Shackelford et al. 1999).

2.5. Factors Affecting Beef Eating Quality

2.5.1. Breed/Genetic effects

As the fraction of *Bos indicus* inheritance increases, tenderness decreases (Seideman *et al.,* 1987; Barkhouse *et al.,* 1996). The reduced proteolytic potential in *Bos indicus*, caused by a greater *Beef* calpastatin activity, is well

documented and explains the lower tenderness values reported for meat from this subspecies (Wheeler *et al.,* 1990b; Shackelford *et al.,* 1991). Within breed, different lines of cattle exhibit differences in calpastatin activity. In particular selection for high growth rate or net feed efficiency can increase calpastatin activity and therefore reduce proteolysis post slaughter (Oddy *et al.*, 2001). Tatum (2006) stated that tenderness is moderately heritable in *Bos taurus* cattle (0.24-0.53). The author referred to the potential of gene markers while, again, emphasizing the need for validation in the population of interest. He also commented that flight-time has a strong genetic correlation with shear force (longer flight time, lower shear force) but a poor phenotypic correlation. On the other hand, differences in overall carcass leanness between *Bos taurus* and *Bos indicus* cattle contribute to a limited extent to overall variation in tenderness (Wheeler *et al.*, 1994).

2.5.2. Sex

Sex has been recognized as one of the ante mortem factors contributing to variation in beef muscle characteristics because it affects muscle and fat depositions in the carcass (Choat *et al*., 2006; Guillemin *et al*., 2009; Panjono *et al*., 2009; *Ying et al.,* 2010).Small differences in palatability have been observed between the sexes. However, Beef from bulls can be more variable and this is often associated with the higher variability in ultimate pH (AMPC and MLA, 2006).Beef flavour intensity may be reduced and abnormal flavour intensity increased in bulls compared with steers and heifers(Wood and Richardson,2004). Heifers have greater tenderness (Bass *et al*., 2010) and better sensory traits and marbling scores than steers (Frickh *et al*., 2003; McIntyre *et al*., 2009).

2.5.3. Age

More tender beef is found in young animals because of their greater enzymatic activity compared to older animals (Bouton et al., 1978; Shorthose and Harris, 1990; Farzad, 2014). Normally, the amount of connective tissue (collagen) increases with the age of the animals, thus lessening meat tenderness and requiring greater cooking time using techniques such as braising and casseroling to reduce the meat's resistance (Warren and Kastner, 1992; Farzad, 2014). Similarly, Gerrard et al.(1987) observed that collagen in bulls matures more rapidly than in steers.

2.5.4. Diet

Diet was the major factor influencing flavour in meat animals including beef cattle (Melton, 1990). Various constituents in tissues are influenced by diet to affect flavour but the most important are the fatty acids (Melton, 1990; Larick and Turner, 1990). Feed can alter fatty acid composition, flavour and oxidative stability of meat (Wood *et al.,* 1999; Mandell *et al*., 1998). Grass feeding produces less desirable-flavoured beef (Harrison *et al*., 1978; Schroeder *et al*., 1980; Mederios *et al.,* 1987; Berry *et al*., 1988; Larick and Turner, 1990).

There are numerous studies featuring diet and especially ration ingredients and meat quality. Eiras *et al*., (2013a and b; Ana,2013) and Françozo *et al*., (2013; Ana,2013) replaced corn by glycerin diet and found that replacement failed to affect beef color, texture, cooking loss, chemical composition and percentage of fatty acids. Moreover, sensory characteristics were not affect by glycerin (EIRAS *et al*., 2013b; Ana, 2013). Colour and fat stability of beef can be enhanced by the use of another vitamin supplement - vitamin E. A large number of papers support the use of vitamin E in this respect for beef. In a review of the literature, there is increasing evidence that the flavour characteristics of beef are influenced by dietary composition. Similarly, Morgan (2007) indicated that the supplementing vitamin D in cattle rations affects beef palatability. The active form of vitamin D (1, 25-dihydroxyvitamin D3) increases serum calcium concentrations in the body. Calcium is necessary to activate the natural tenderization processes that occur in beef postmortem.

2.5.5. Pre-slaughter transport and handling

It is clearly best practice to minimize pre-slaughter stress. Thus cattle should be loaded on the farm, transported, unloaded at the abattoir and delivered to the point of stun with the minimum of stress and risk of physical damage to the animals. In the last few years there have been papers showing that there is an effect of animal temperament on eating quality (King *et al.*, 2006) and animals showing nervous behaviour have higher shear force than calm or simply restless animals (Gruber *et al.*, 2010) and more 'flighty' animals (measured by a flight speed and a 'crush score') give rise to tougher meat. This effect is more evident in *Bos indicus* breeds but can also be observed in *Bos taurus* types. Mixing can also be associated with tougher meat (Bass *et al.*, 2010).

Purchas (1991) and Richardson (2004) indicated that, if cattle are put under stress in the period between the farm and abattoir, they may produce dark, firm, dry (DFD) beef. This is because muscle glycogen stores are mobilised by stress hormones, leaving a low concentration of glycogen in muscle at slaughter and a correspondingly low fall in muscle pH post mortem. Muscle pH in *m.longissimus* 48hr after slaughter (ultimate pH) is typically 5.5 in normal cattle and above 6.0 in DFD muscles. The problem of dark, firm, and dry beef is much more common in bulls than in steers or heifers. As ultimate pH increases, the desirable flavours associated with cooked beef tend to decline (Dransfield, 1981; Richardson, 2004).

2.5.6. Carcass fatness and conformation

There is evidence that the leanest of animals tend to produce poorer eating quality although this effect is not large. A widely used cut off is that of fat class with leaner animals excluded from quality specifications. In terms

of fatness, published evidence (mainly North American and Danish) indicates that at low levels of intramuscular (or marbling) fat, the tenderness and juiciness of beef is less satisfactory (Buchter, 1986; Dikeman, 1987). There is also some evidence that beef flavour requires a minimum level of intramuscular fat. Denoyelle(1995) found that 4% was needed as a minimum in the longissimus lumborum but found no effect in two other muscles.

2.5.7. Electrical stimulation (ES)

Electrical stimulation is known to accelerate *post mortem* glycolysis and the onset phase of rigor, so that rapid cooling/freezing may be done soon after slaughter, without the risk of cold shortening of the muscles (Carse, 1973; Davey *et al*., 1976; Agbeniga;Webb, 2014). Electrical stimulation has also been adopted as a means of meat tenderisation in beef, lamb and goat carcasses (Chrystall and Hagyard, 1976; Savell *et al.,* 1977; Geesink *et al.,* 1994; B. Agbeniga; E.C. Webb, 2014.). Tenderization of muscle is achieved by enhancing the rate of proteolysis, which is stimulated by the release of Ca^{2}+ at higher temperatures (Savell *et al.,* 1981; B. Agbeniga; E.C. Webb, 2014.). Electrical stimulation then also reduces variation in tenderness, compared to what is achieved in unstipulated meat (Rosenvolt *et al.,* 2008; Devin *et al.,* 2009; Agbeniga and Webb, 2013).

2.6. Beef Eating Quality Standard in Ethiopia

Meat quality refers to the compositional quality and the palatability of meat. The major parameters considered in the assessment of meat quality are appearance, juiciness, tenderness, and flavour (Lawrie & Ledward, 2006). Quality is measured in many countries by third party evaluation. For instance, the US and Australia use a grading system based on marbling plus age and sex of slaughter animal, whereas, the South Africa grading system is based on external fat covering and age of the animal. Countries have established the system that best allows consistency of product for their consumers. Presently there is not a grading system in Ethiopia (David, 2008).

Meat processing units are also generally not equipped with quality control system in the country. Further, to measure the quality of meat available in the market, it is essential to have a comprehensive code or document listing national meat standards. Establishment of quality standards concerning consumer safety and shelf life of meat helps in production of quality meat and meat products and their evaluation. Such standards have not been developed fully in Ethiopia. The first and foremost step in this direction is to have data on various parameters of quality of meat, which is lacking in Ethiopia (Ashwani *et al*, 2009). Similarly, Mohammad and Samuel (2009) revealed that, there are no official grades and standards for beef in the domestic market in Ethiopia .The authors also indicated that in Addis Ababa consumers differentiated quality and safety of beef on the basis of fat content, freshness, hygiene of sales outlet and staff, abattoir stamp and price, and they had specific preferences for beef based on these attributes.

But, the country have developed corned beef standard which was sated in 2005 by own Standard in line with the Chemical and Microbiological requirements showed under table1 and 2, respectively.

Table1. Chemical requirements for corned beef

No.	Characteristics	Requirements	Test methods
1	Plate count / gram	2 x 10^{-5}	ES ISO 4833
2	Coliform / gram	Nil	ES ISO 4831, 4832
3	Clostridium perfringens / gram	Nil	ES ISO 7937
4	Staphylococcus / gram	Nil	ES ISO 6888-1, 6888-2
5	Salmonellae / gram	Nil	ES ISO 6579

Source: Ethiopian Standard (ES) 1112:2005

Table2. Microbiological requirements for corned beef

No.	Characteristics	Requirements	Test methods
1	Total protein, % by mass min	21	ES ISO 937
2	Ash, % by mass max.	3	ES ISO 936
3	Sodium nitrite, mg/kg	50	ES ISO 2918
4	Lead ,as (Pb) mg/kg	1	ES 989
5	Arsenic ,(As) mg/kg	1	ES 988
6	Tin ,as (Sn) mg/kg	200	ES 1117

Source: Ethiopian Standard (ES) 1112:2005

3. SUMMERY AND CONCLUSION

3.1. Summary

The largest livestock resources potential available in Ethiopia is not fully exploiting and the production and productivity of the animal is low and products being produced are of low quality. Quality remains a key demand driver within the beef category. Tenderness, flavor are juiciness are the important palatability characteristics to evaluating eating quality of beef while tenderness is most often cited as the fundamental determinant of a beef

product's performance with respect to eating quality. In Ethiopia, research on meat and meat products are given lowest attention. As a result, lean meat yield, eating qualities and human nutritive value (proximate composition) are identified as the most important quality areas need attention for the future.

Tenderness is one of the most important meat palatability attributes. Juiciness refers to the quantity of apparent juice that comes from meat during chewing. Flavor represents the interaction between aromatic compounds within the nasal cavity and chemical compounds that contact the tongue during eating. Variability of palatability of tenderness can be measured by Warner-Bratzler shear force (WBSF), sensory analysis and Slice Shear Force.

Beef eating quality traits can be influenced by production methods on farm and a wide range of factors beyond the farm gate. In Ethiopia eating quality attributes standards concerning consumer safety and shelf life of meat have not been fully have developed. However, corned beef standard in line with the chemical and microbiological requirements were established.

3.2. Conclusion and Recommendation

In this review, even though, the country has numerous cattle resources potential, their productivity and quality earned of these resource is low. For the three beef eating quality attributes standard was not sated in the country.

However, attention is required to overcome the constraints that affecting beef eating quality attributes, like Pre and post- handling of animals and beef, respectively. This was related to variation in palatability that leads to disparity in beef quality. In view of the review, the following recommendations are suggested:

- Livestock resource potential of the country/Ethiopia should be fully utilized, by using modern livestock production technologies and through awareness creation for livestock men
- To advance lean meat yield, eating qualities and human nutritive value (proximate composition) to the standard;
    - Universities and research institutes capacitate beef cattle produces with knowledge and skills through training and they consider as priority research thematic area.
    - Integrated research activities between Agriculture, Nutrition and Health should be done
- Beef eating quality attributer standards should be developed by concerned bodies in the country

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