CHAPTER TWELVE

Sheep and Goat Meat Characteristics and Quality

Amha Sebsibe

Objectives

1. To describe meat quality related problems affecting the market.
2. To highlight strategies for improving small ruminant meat yield and quality.

Expected outputs

1. Knowledge of meat quality related problems shared to stakeholders (extension workers, producers, processors, etc.).
2. Increased awareness on methods of improving meat yield and quality.

12.1. Introduction

Ethiopia is home to 24 million sheep and 23 million goats, and meat production is the most important function of these animals in the country. There is high demand for live animals as well as meat from small ruminants by consumers in the Middle East and North and West African countries. There is also a high domestic demand for small ruminant meat, particularly during religious festivals. The country exported 12,000 tons of small ruminant meat in 2005/6. The goal for ruminant meat export in 2008 is 30,000 tons, of which 33% is expected to be from small ruminants.

The proximity of Ethiopia to consumers in Middle Eastern countries and their taste preference for our indigenous animals are advantageous for the Ethiopian meat export market. However, the international market for meat is becoming increasingly competitive and meat traders must adopt improved practices in production, processing and packaging of meat to maintain and grow market share. Strict quality control measures to meet specific export-market demands also need to be implemented. Hence, considerable training and extension will be essential in assisting various stakeholders to meet market requirements and maximize the foreign exchange generated from the growing meat industry.

12.2. Meat Production and Carcass Composition

12.2.1. Meat production

The annual national mutton and goat meat production is 77 and 62 thousand metric tons, respectively, largely because of the high average off-take rates estimated to be about 30% from sheep and 36% from goats. Sheep and goats, respectively, contribute some 21 and 16.8% of the total ruminant livestock meat output.

While contributing significantly to meat production in Ethiopia, present production levels of sheep and goats are far below their potential. Productivity per animal is reported to be very low. Annual meat production is estimated at 3–3.5 kg per animal per year in the population and 8–10 kg per animal slaughtered. These values are very low when compared with those in neighboring countries that have small ruminant populations 50–75% less than Ethiopia. A major cause contributing to such low meat yield is that animals are commonly slaughtered at immature body weights, 18–20 kg for sheep and 16–18 kg for goats.

Performance of some indigenous small ruminant breeds

Wide variability exists among Ethiopian small ruminant breeds with respect to potential growth rates and mature weight. Further, most Ethiopian breeds have undergone little selection for improved meat production and true breed potentials are not known. Horro rams have shown capability for post-weaning growth rates of approximately 150 g/day, which would enable them to reach a mature body weight of 45–50 kg at one year of age. Afar rams attain average mature bodyweights of approximately 40 kg, but post-weaning growth rates have been reported to be less than 100 g/day with supplementary feeding. The maximum post-weaning growth rate of Menz (small-sized breed) ram lambs under improved on-station management appears to be less than 100 g/day. The Awassi × Menz crossbred ram, however, was 40% heavier in yearling bodyweight under supplementary feeding than purebred Menz. Middle Rift Valley goats grazing natural pastures and supplemented with a concentrate had an average growth rate of 72 g/day. The growth rates indicated are unlikely to be achieved under natural grazing systems, and animals usually take extended periods of time to reach marketable weight. However, if properly fed, most Ethiopian small ruminant breeds could meet the current live weight requirement of some export markets in the Middle East.

Meat consumption

The domestic meat demand is believed to increase with increasing literacy and family income. Meat consumption is often an indicator of the economic status of a country or an individual. People with a higher social or economic status demand a greater amount of high-quality meat products. The per capita consumption of meat in developed/industrialized countries is much higher compared with developing

countries. Countries whose population consumes the least amount of meat are located in Africa and Asia. The ten lowest-ranking countries in meat consumption consume 3–5 kg per capita per year. In Ethiopia, the average annual meat consumption per capita is estimated to be 8 kg/year. Consumption of meat in the USA is 124 kg per capita per year (340 g/day). The global average meat consumption is 38 kg (104 g/day).

12.2.2. Carcass composition

A carcass is made up of various proportions of muscle, bone and fat. The ideal carcass can be described as one that has a minimum amount of bone, a maximum amount of muscle and an optimum amount of fat. Market requirements differ in size of carcass and level of fatness acceptable. A certain proportion of fat is desirable to reduce drying out of the carcass. On the other hand, too much fat is undesirable.

Muscle: Water makes up 74% of the total muscle weight. The remainder of the muscle is protein, lipid, minerals and some vitamins.

Bone: Bone provides the rigid support to which the muscles are attached. The hard, calcified cells give bone the strength needed to support the weight of the animal.

Fat: Fat is basically a food or energy reserve for the animal and is laid down in special cells in various sites of the body. The various fat depots found on a carcass are subcutaneous, intermuscular, intramuscular and miscellaneous. Subcutaneous fat is the fat immediately under the skin and lies on the outside surface of the carcass. Subcutaneous fat minimizes drying out of the underlying meat. Since fat has low water content, it is unsuitable as an environment for microorganisms to grow and effectively acts as a protective layer around the meat. Intermuscular fat lies in pockets between the muscle, frequently surrounding blood vessels and nerves, serving a protective, cushioning role. Intramuscular fat lies within the muscle between the bundles of muscle fibers and its content can vary from 1–15% of total muscle weight, depending upon the level of fatness. A high content of intramuscular fat is known as marbling, a common feature in feedlot and heavy-weight cattle, but seldom seen in sheep or goats. The miscellaneous fat depots include kidney, scrotal and gut fats.

Major factors affecting carcass composition

Weight: Carcass weight is a main factor affecting the composition of the carcass and is closely related to age at slaughter. As animals mature, they normally gain weight resulting in a heavier carcass. Much of the weight gain of a mature animal is fat rather than muscle. Thus, at heavier live weight, an animal's carcass will have lower proportions of muscle and bone and a higher proportion of fat.

Age: Increases in age, independent of changes in weight, tend to have little influence on the carcass composition of sheep. Normally, as animals age they gain weight that is largely made up of fat. It is this increase in weight that results in an increase in fatness.

Sex: At all weights, females tend to be fatter than ram lambs under similar management.

Breed: Some breeds mature earlier than others and the main breed differences in carcass composition are related to the rate of fat deposition during the later stages of growth. To achieve a similar level of fatness with breeds of different maturity types, it is necessary to market earlier maturing lambs at lighter weights than later maturing lambs.

Conformation: The conformation of a carcass refers to its shape. Carcasses that are short in the leg and plump or 'blocky' in appearance are said to have 'good' conformation. Carcasses with a longer 'leggy' appearance are said to be of 'poor' conformation. Carcasses having good conformation generally contain more fat and less protein than those of poor conformation.

Nutrition: The effect of nutrition on carcass composition is not a simple one as it involves the interactions among level of intake, the composition of the feed, and nutrient needs of the animal. As more food energy is

required to produce a kilogram of fat than a kilogram of muscle, one has to be conscious of the type of market targeted during the feeding operation.

Transferable Message

The characteristics of a superior carcass are: high proportion of muscle (lean), low proportion of bone and an optimal level of fat cover.

12.3. Meat and Indicators of Meat Quality

Meat is one of the most nutritious foods that humans can consume, particularly in terms of supplying high-quality protein (essential amino acids), minerals (especially iron) and essential vitamins. Meat is defined as all animal tissues suitable as food for human consumption. This includes all processed or manufactured products prepared from animal tissues. The majority of meat consumed comes from domestic and aquatic animals, but a number of lesser known species and products are continuously added to the list. Meat is subdivided in to the following categories.

Red meat: The largest category in terms of volume of consumption. Includes beef, mutton, goat meat, pork, etc.

Poultry meat/white meat: Meat from domestic birds, e.g., chicken, turkeys, ducks, etc.

Seafood: This category includes fish, lobsters, oysters, etc., from both fresh and saltwater habitats, wild or farm-raised.
Game meat: Meat from wild game or traditionally non-domesticated animals, e.g. rabbit, llama, camel, eland, impala, deer, game birds, etc.

Meat quality in this chapter focuses on eating quality. Eating quality comprises palatability, wholesomeness, and being free of pathogens and toxins. Factors influencing the palatability of meat include tenderness, flavor and juiciness. Each of these criteria is again dependent on many factors, including animal age and physiological state, gender, fat and connective tissue, the biochemistry of the post-mortem muscle and the effect of genetics on tissue character and metabolism. Consumers often tend to evaluate meat quality on the basis of tenderness, juiciness and flavor of cooked meat. Juiciness and tenderness are influenced by the cut of meat and how long the meat is cooked (grilled or fried). The longer meat is fried, the more liquid is lost and the tougher it becomes. The more tender the meat, the more rapidly juices are released by chewing and the less residue remains in the mouth after chewing. The following are some of the important parameters/indicators of meat quality.

12.3.1. Meat pH

A key determinant of meat quality is pH. The ultimate pH is determined 24 hours post-slaughter, using a pH meter. Good quality meat usually has a pH of 5.4–5.7. The muscle of a living animal has a pH of 7.1. The extent to which pH is lowered after slaughter depends on the amount of glycogen in the muscle prior to the animal's death.

The pH value determines environmental microbial balance. Low pH has a bacteriostatic effect on the meat. Accordingly, meats with pH values above 6 are generally considered unsuitable for storage because of the favorable development of proteolytic microorganisms.

12.3.2. Meat color

Meat color is an important parameter in meat quality. It can be measured numerically using a colorimeter or subjectively. Several factors affect meat color such as species/breed, age, sex, cut of meat, surface drying of the meat and surface spoilage. Meat color is largely determined by the content of myoglobin and its derivatives. It is normal for meat to change color depending on the presence or absence of air. For instance, exposed meat changes color due to reactions occurring between myoglobin and oxygen. Meat color changes in response to both the quantity of myoglobin it contains, and chemical changes in the myoglobin itself. The more myoglobin in the meat, the darker the color exhibited. Older sheep contain more muscle myoglobin and hence have darker meat than lambs.

Color is also greatly affected by muscle pH. At a high pH, muscle has a closed structure and, hence, appears dark and the meat tends to be tough. Meat color is also affected by diet.

Meat can also become discolored before reaching a retail outlet if too much drying occurs. Hence, butchers prefer carcasses to have at least some fat cover (subcutaneous fat) evenly distributed over the carcass because it aids in maintaining quality and an attractive appearance by preventing the meat from drying.

12.3.3 Meat tenderness

Tenderness appears to be the most important sensory characteristic of meat and a predominant quality determinant. It can be evaluated by mechanical devices and/or a taste panel. Factors affecting meat tenderness include breed, nutrition, age, and muscle location.

Breed: Meats vary greatly in tenderness. There is variation among species and among animals within a species. Variation among animals reared in the same environment and slaughtered at the same age, weight, and degree of finish suggests a genetic cause for some tenderness variation. In beef, there is a heritability value of 60% for tenderness suggesting that heredity may be a major influence. This is expected to be similar in sheep and goats.

Nutrition: Nutrition influences tenderness principally through its effects on the amount and type of fat in the meat. Deposition of fat among the muscle fibers (marbling) as the animal grows and matures on a high-energy ration can improve tenderness.

Age: Meat generally becomes less tender as animals age. As an animal matures and the size of each muscle fiber increases, there would be an expected decrease in tenderness.

Muscle location: “Exercise muscles” are usually less tender than support muscles, i.e., the more a muscle is used, the stronger it becomes, and therefore the tougher the cut of meat will be.

12.3.3.1. Some methods of improving meat tenderness

Aging: Post-mortem aging of red meat is the time-honored practice of naturally improving palatability. Tenderness is improved when proteases or enzymes break apart the muscle fibers and reverse the effects of rigor mortis on the carcass. These effects occur largely during the first 3–7 days post-mortem. Aging also changes the flavor of the meat.

Freezing: Freezing increases tenderness apparently because muscle fibers are ruptured by ice formation and connective tissue components are stretched and ruptured. Lowering meat temperature to about -23°C (-10°F) apparently causes consistent increases in tenderness, but lower temperatures do not cause further tenderizing.

Electrical stimulation of the carcass: Electrical stimulation is a widely used method of improving the tenderness of mutton and beef. Electrical stimulation causes the carcass muscle to contract violently and hastens the conversion of muscle to meat. The pH level drops more rapidly and rigor mortis sets in more quickly than in non-stimulated carcasses. Electrical stimulation protects against cold shortening and may

improve meat tenderness, color, and appearance. Due to the enhanced quality of meat and reduced costs, electrical stimulation has become widely practiced in recent years in commercial slaughter houses as a method of tenderizing lamb and goat carcasses. On the other hand, electrical stimulation may result in increased protein denaturation resulting from an accelerated rate of glycolysis and high temperature.

The meat from spent animals is generally tough and poor in palatability due to high content of connective tissue. Electrical stimulation can be used to make the meat from these animals acceptably tender for use as table meat.

Transferable Message

Depending on the market, aim to produce carcasses with tender meat. Well-fed animals slaughtered while young will yield tender meat.

12.3.4. Chemical composition

The approximate composition of meat is about 75% water, 19% protein, 2.5% lipid, 0.65% minerals and some vitamins. Many goat breeds have lower carcass fat than sheep and deposit more fat in the abdominal cavity. However, the relatively higher mean carcass fat in some Ethiopian goat breeds (Table 12.1) would be useful in reducing chilling losses and improving quality. Figure 12.1 shows the fat cover of well-fed goats.

Table 12.1. Chemical characteristics of goat meat from different breeds.

Characteristics %	Australian Capretto goats	South African indigenous goat	Boer goat	Ethiopian goats
Moisture	75.2	69.8	69.4	67.0
Protein	18.9	24.8	22.8	20.1
Fat	3.25	7.9	10.5	12.6
Ash	1.10	0.97	0.95	1.19

Among the goat carcasses shown in Figure 12.1 (#1357 and #1355 — Long-eared Somali, #1258 and #1317 — Central Highland and #1283 and 1311 — Afar), the second (#1258) and fifth (#1317) have less fat cover than the others, particularly around the buttock area. This is mainly due to breed differences.

12.3.5. Fatty acid composition

Studies have shown that fatty acid composition of muscle and adipose lipid tissue is influenced by breed, the quality and quantity of feed consumed, age/bodyweight, sex and level of fatness. Fatty acid composition in turn affects the nutritive value and the sensory characteristics of meat.

Animal fat has been the subject of much interest and debate because of health risks related to excess consumption of animal fat. Fat, however, is not only a concentrated source of energy for the body, but also improves meat palatability as it affects texture, juiciness and flavor as well as being important for meat preservation. When eaten, fat is also a carrier of the fat soluble vitamins A, D, E and K and the essential fatty acids. It is also important in growth and in the maintenance of many body functions. Fatty acids are the major components of lipids. Today, it is accepted that both the amount and the structure of the fatty acids consumed play a major role in maintaining human health.

Through research over the last decades, the scientific community has accepted that saturated fatty acids (SFA) tend to increase cholesterol levels in plasma while polyunsaturated fatty acids (PUFA) tend to

decrease it. The SFA, such as lauric (C12:0), myristic (C14:0) and palmitic acids (C16:0) are hypercholesterolemic, while the saturated stearic (C18:0), and unsaturated oleic (C18:1), linoleic and linolenic present a hypocholesterolemic action. The SFA C10:0 also does not raise blood cholesterol levels. Myristic has four times the hypercholesterolemic effect of the others. Compared to intensively fed Jebel (Oman) goats at similar slaughter body weight, Ethiopian goats had a 2.4-times lower concentration of myristic fatty acid.

All unsaturated fatty acids and stearic fatty acid are categorized as desirable fatty acids (DFA). The average percentage of DFA in goat meat was estimated between 61 and 80%; the mean DFA of some Ethiopian goats is 70%. These demonstrate the potential of Ethiopian goats for the production of high-quality meat.

Figure 12.1. The fat cover of well-fed goats.

12.3.6. Cooking loss

Breed significantly affects cooking loss and the values range 34.1–39% for Capretto and 32.5–51.5% for Chevon. Higher cooking loss (62.2%) is reported for Nanjiang yellow goats. The average cooking losses of some Ethiopian indigenous goats (29%) are lower than Australia Capretto goats (35%) at similar slaughter weight. In general, the lower the cooking loss, the better the juiciness of the meat. This is another valuable quality trait observed in some Ethiopian indigenous sheep and goats useful in market promotion efforts.

12.4. Factors Affecting Meat Quality On-farm

12.4.1. Genetic factors

Many physical properties of meat are greatly influenced by genetic factors. Tenderness is reasonably inheritable. Sheep and goat producers can make improvements to the end-quality of meat by careful selection of breeds, and strains within a particular breed.

12.4.2. Age and weight

Meat quality changes markedly with the animal's age or weight at slaughter. Hence, appropriate slaughter weights should be identified for various breeds to get better dressing percentage, meatiness and quality. Postponing the slaughter age permits a better exploitation of growth potential, but the parallel increase of the

carcass fat content and the subsequent worsening of the feed conversion index reduces potential economic returns.

12.4.3. Feed factors

The general feeding practice by traditional sheep and goat producers is to graze all livestock together on communal or privately owned grazing land. All animals are subjected to similar constraints imposed by grazing inadequate and overgrazed pastures. Culling unproductive animals is not practiced. The majority of indigenous sheep and goats from this system of management are marketed at average live weights of 20 kg, have low mean dressing percentages of less than 50% and poor carcass fat cover. Efforts are needed to help producers provide optimum nutrition to marketable animals to improve live weight at slaughter, the proportion of carcass contents and total edible meat produced.

A higher plane of nutrition promotes earlier fattening while a lower level results in a delayed or slower fattening process. Fatness varies a great deal with the husbandry method and genotype of the animal. Therefore, to attain the high or low fat levels a particular market may demand, farmers can accordingly vary feeding regimes and husbandry methods.

As indicated in 12.3.2 above, meat color is affected by diet. Research has shown that bulls fed forage-based, restricted diets had less glycogen, a higher muscle pH, and darker muscle color than bulls fed concentrates *ad libitum*. The same applies to sheep and goats.

12.4.4. Sex

Meat quality differences between sexes of animals is not fully understood, but is believed to be caused by differing levels of sex hormones circulating in the blood. Young rams have meat that tends to be relatively darker and tougher than that of female animals of similar age. Moreover, at similar age, ewe lambs are fatter than ram lambs.

12.5. Pre-Slaughter Management

There are a variety of environmental conditions which can cause stress in animals before slaughter. These include extremes in temperature, humidity, light, sound, and confinement. Other stressors are excitement, fatigue, pain, hunger, and thirst, all of which affect meat quality.

Observations made in some export abattoirs demonstrated that there is a lack of strong abattoir policy with respect to rest and related management of slaughter animals. In some cases, the conditions of transportation of animals to the abattoir by the middlemen and other suppliers have also been observed to be unsatisfactory.

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/glucose results in a build up of lactic acid, which then causes a drop in pH of the meat.

If at slaughter the animal has adequate glycogen reserves, and the slaughter and the storage processes are appropriate, glycolysis and the concomitant increase in lactic acid results in a pH fall from about 7.2 to about 5.5. An ultimate pH of 5.5 is desirable and is associated with light-colored, palatable meat. However, if pre-mortem glycogen reserves are low due to some stress, the glycogen will be depleted before a pH level of 5.5 is attained.

The final quality of meat is greatly affected by the rate of pH decline in the meat after slaughter. If the animal's glycogen is depleted before slaughter, the pH may not drop quickly enough after slaughter because of insufficient lactic acid production. In this case the meat will be very dry and dark in color. This condition

is known as Dark, Firm, Dry (DFD) meat. An additional problem with this type of meat is that it is more susceptible to spoiling since it lacks the lactic acid which normally helps retard growth of microorganisms.

At the other extreme, if there was a great lactic acid build-up before slaughter, the pH of the meat declines too quickly after slaughter and a Pale, Soft, Exudative (PSE) condition may develop. As suggested by the name, the affected meat is pale, soft, and fluid may drip from the surface.

The following are some of the major pre-slaughter factors resulting in stress and subsequent poor meat quality.

Distance and conditions of travel to the abattoir: Traveling long distances exerts substantial stress on animals which could lead to greatly reduced glycogen levels.

Nutrition and fasting: The rate of glycogen repletion is particularly slow in animals that have been on poor quality diets and/or that have been fasted long periods prior to slaughter.

Mixing strange animals prior to transportation or slaughter: This can lead to fighting while establishing a new social order.

Physical activity: Too much physical exertion prior to transport or slaughter can increase stress.

Transportation-related problems and precautions: These include the following:

- Loading and unloading are often the most stressful parts of the transport process and it is imperative that proper thought and planning be given to the procedure to avoid using excessive force. For instance, one of the most common mishandling practices involves deep and extensive bruising along the back of the animals caused by lifting the live animal by the hair or wool. If the sheep must be lifted during the loading and unloading operations, the workman should embrace the lamb by extending both arms through the flank region under the body. When caught from the rear they should always be grasped by the hind leg and never by the wool.
- Animals should not be overcrowded. This helps prevent injury and unnecessary suffering.
- The journey should be made in a careful manner avoiding sudden stops and starts, fast-turning and unnecessary delays.
- Lambs and kids may travel for 9 hours before a minimum rest period of 1 hour followed by a further maximum of 9 hours. Adult sheep and goats may travel for 14 hours before a minimum rest period of 1 hour, followed by a further maximum of 14-hours travel.
- Feed and water should be available during the rest periods.
- Animals normally lose weight during transport. It is possible in many cases to restore some, if not all, of this loss with adequate rest. In South Africa, the resting of adult Merino sheep for 24 hours with feed and water after rail transport for more than 3 days had beneficial effects on carcass yield.

12.5.1. Animal husbandry in the lairage

Minimizing stress in the period immediately before slaughter is important for economic reasons related to meat quality as well as for animal welfare. Animals must be handled carefully at all times with minimal use of force.

- Most lairages in the abattoir should have solid non-slip floors suitably sloped for adequate drainage. They must be well-lit and ventilated. During the pre-slaughter period in the lairage, animals must be kept under conditions which prevent any further contamination of feet, hides, fleeces or skins.
- The attitude of the attendant in the abattoir can be all-important to the calm and efficient operation of the facility. Persons experienced in animal husbandry know instinctively where to stand when moving stock and can carry out their task using only encouraging noises and the occasional tap or wave of a stick.

Inexperienced operatives, however, frequently excite, confuse and antagonise the animals making handling difficult.

- Animals should receive ample drinking water during their stay in the lairage as this serves to lower the bacterial load in the intestine and facilitates the removal of skin during the dressing of the carcass.
- Stock should not be held for more than a day in the lairage and must not be slaughtered in sight of other stock.

12.5.2. Fasting during the holding period

Small ruminants should be held without feed but with access to water for 12–24 hours prior to slaughter. Withholding feed results in greater ease of evisceration and minimizes the migration of ingested bacteria from the gastrointestinal tract into the blood stream. This helps in lengthening the period of time carcasses can be held without spoilage after slaughter.

Transferable Messages

Proper handling of animals before slaughter can greatly reduce their discomfort and stress, thereby improving meat quality. This includes:

1. Proper feeding.
2. Rest.
3. Proper techniques for moving and transporting animals.

12.6. Post-Slaughter Factors

To produce quality meat, appropriate temperature, airflow and relative humidity must also be employed in the chillers.

12.7. Meat Safety — Producer Responsibilities

The production of meat for direct consumption or export consists of two main phases. The on-farm production is referred to as *pre-harvest* while *post-harvest* refers to practices of livestock slaughter and subsequent meat processing. The farmer or pastoralist has no control over post-harvest procedures. Conversely, the abattoir and meat processors have no control, except that exerted through market channels, on the product they receive for processing. The responsibility of delivering an animal that can yield high quality, and high value, edible product belongs to the producer.

There are three main hazards that occur in food, i.e., biological (microbial contamination), chemical (toxins or drug residues), and physical (foreign material in food, e.g., glass or plastic). Livestock producers must eliminate as many of these hazards as possible.

- *Biological hazards* are minimized by maintaining the health of the animal, including providing vaccinations and proper health care. Animal pens and corrals should be well maintained to prevent injury to animals that could allow entry of disease organisms.
- *Chemical hazards* of most concern in meat are drug residues. Only drugs approved for use in small ruminants should be used and then only under supervision of an animal health official. Withdrawal times (the time needed for a drug to clear an animal's system) for both meat and milk products have been set for most drugs. These should be followed and no animal should be slaughtered or milk consumed during the withdrawal period. These rules must be followed for animals sold for export as well as those slaughtered for village or home consumption. Chemical contamination can also come from animals eating feed with

fertilizer, pesticide, or herbicide residue. Be careful when using chemicals and do not feed grain, hay, or grass that may have been contaminated.

- *Physical hazards* are not common in meat animals coming off farm. However, broken needles are one example of a physical hazard that can be prevented on-farm. Care should be taken when injecting animals. ***All injections (subcutaneous, intramuscular, and intravenous) should be given in the neck area in front of the shoulder. Never inject an animal in the rear leg.*** Injection site lesions (areas of toughened scar tissue resulting from an injection) can form in muscle. After slaughter, this portion of the meat must be cut out and discarded. This affects animal price and negatively affects the small ruminant meat industry, particularly the export market.

Transferable Messages

Livestock raisers have a responsibility to provide animals to market that produce safe, wholesome meat. They should strive to:

1. provide proper care to animals;
2. use all drugs correctly and follow withdrawal times;
3. be careful when using fertilizers and other chemicals to not contaminate animal feed; and
4. never inject in the rear muscle.

12.8. Carcass classifications and grading

In many countries, animal carcasses are classified and graded based on quality. Animals yielding carcasses of higher quality receive a premium in the marketplace while animals with inferior carcasses are discounted. Producers, then, have an incentive to raise and produce animals that yield superior meat. Through meat labeling, consumers know the quality of the meat they purchase and pay higher prices for premium quality cuts.

Classifying refers to dividing animals according to kind, sex, age and weight while grading is the process of sorting the classified animals into sub-groups based on the relative merit of the meat produced. In other words, classification is the grouping together of carcasses having similar features while grading separates meat into groups based upon quality characteristics.

Classification and grading of carcasses are important marketing tools and also the means of clearly communicating carcass and meat quality characteristics back to the producer and to the consumer. Objective classification and grading is the responsibility of a central authority. The objective, in general, is to easily predict, with acceptable accuracy, carcass and meat features from easily accessible and related characteristics and to communicate these to the marketer, processor and consumer. Meat yield, muscle content and fatness are the most important characteristics sought in carcasses.

12.8.1. Advantages of classifying and grading

- Producers can receive a premium for animals producing high-quality meat.
- Establishes consistent quality and uniformity within a group.
- Reduces purchasing risks; consumers benefit by paying a fixed price for a specified grade.
- No time is wasted by bargaining, thus consumers tend to buy graded animals for a fixed price.
- Provides a quick, cheap and easy method of comparing individual animals under differing management system, seasons or environments.

12.8.2. Meat grading in different countries

The grading method and system practiced in different countries varies depending on the objectives of the system and on the degree of uniformity that exists among types and species of animals. In many countries, quality is measured by third-party evaluation. As an example, the US and Australia use a grading system based on marbling, age and sex of slaughter animals. In South Africa, the 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.

In Ethiopia, there is no grading system for live animals or meat. Therefore, proper market research and adequate consultation involving the various stakeholders should be conducted to determine the important factors to be considered. In the domestic market, there is a similar unit price for all meat, i.e., both tender and less tender cuts are sold at similar prices. Regarding the export market, whole carcasses are sold at a similar price per kilogram. In neither case do producers have any incentive to raise animals producing high-quality carcasses.

Example — the USA sheep meat grading program

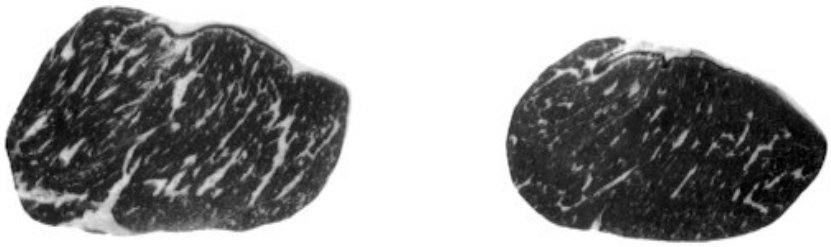
In the USA, consumers can be assured of receiving a wholesome product and good quality meat by looking for the United States Department of Agriculture (USDA) grade shield on raw meat packages. The shield is a guide to the quality of meat and also an assurance that the meat is wholesome because only meat that has first passed inspection may be graded. The USDA's quality grading program is voluntary and paid for by user fees.

Sheep meat in the USA is classified as either lamb or mutton. Lamb is produced from animals less than a year old. Meat from older sheep is called yearling mutton or mutton. Lamb meat grades are Prime, Choice, Good, and Utility. Lamb meat graded as Prime or Choice is usually labeled in stores. Lower grades of lamb and mutton (Good, Utility, and Cull) are seldom marked with the grade if sold at retail. Grades for yearling mutton are the same as for lamb, except that mutton does not qualify for the Prime grade and the Cull grade applies only to mutton.

USDA Prime: Prime grade lamb is very high in tenderness, juiciness, and flavor. It has moderate marbling, which enhances both flavor and juiciness.

USDA Choice: Choice grade lamb has slightly less marbling than Prime, but still is of very high quality. Choice chops and roasts also are very tender and juicy, and have choice flavor.

The following pictures are graded beef. They are displayed to help you observe the differences in marbling used while grading.



USDA Prime USDA Choice

Figure 12.2. USDA's quality grades.

12.9. The Meat Industry and Export Market Specifications

Strengthening the meat export market would provide a means of reducing poverty levels, particularly in rural Ethiopia. Animal production would be stimulated and producers would have a larger number of outlets for their animals. Initially, production would be stimulated in the traditional sector, which is the major source of animal production. When meat quality begins to be taken into account in live animal pricing, livestock producers will have an economic incentive to produce high-quality animals. This will result in improved livestock nutrition and management.

The export abattoirs currently operating, those expected to come into operation in the near future and their locations are shown in Table 12.2.

Table 12.2 Export abattoirs currently operational or expected to come into operation in the near future.

Abattoirs' name	Location	Abattoirs' number	Status
ELFORA, HELIMEX	Debre Zeit	2	Functional
Modjo Modern, Mojo Luna	Mojo	2	Functional
Organic	Mojo	1	Future
Mewashe	Metehara	1	Functional
Bahirdar, Kombolcha, Mekele	Bahirdar, Kombolcha, Mekele	3	Future

The annual slaughter capacity of the existing abattoirs is 2.5 million small ruminants with a possibility of expansion to attain a maximum capacity of 4.5 million. However, only a small amount of their existing capacity is currently used.

Some of the major importing countries of small ruminant meat and/or live small ruminants are the United Arab Emirates, Saudi Arabia and Yemen. Saudi Arabia also imports meat by-products such as liver, kidney, heart, tongue, small intestine and brain.

12.9.1. Potential and actual volume of export

The estimated annual potential for export is 72,000 metric tons of meat. Recently, the volume of small ruminant meat exported was 12,000 tons and a comparable amount or more is the export goal for 2008.

12.9.2. Major preference of breeds in the export market

According to the abattoirs, among sheep breeds, the Black Head Somali and Afar are preferred. The Borana, Somali and Afar are the preferred goat breeds. However, during periods of high demand from different importers, mainly during holiday and festival periods, other breeds of small ruminants are also slaughtered and exported. There are some complaints concerning highland sheep and goats due to the alleged darkening of meat during storage. This problem is being investigated so that both the highland and the lowland small ruminant breeds could be made to contribute to alleviating the constraints related to the consistent and uniform supply for the export market.

12.9.3. Export market specifications

The specifications indicated in Table 12.3 show the product type and weight category required by some countries. However, the other important consideration such as the sanitary and phytosanitary requirements of the World Organization for Animal Health (OIE) and the importing countries must also be considered.

Table 12.3. Meat preference of different importing countries.

Consumers	Product specification
Middle East (Saudi Arabia and Dubai)	Skin-off carcass mutton: 8–12 kg; goat: 5–7.5 kg
Malaysia	Skin-off, lean carcass, <10 kg
Malaysia	Skin-off, lean carcass, 20 kg
Malaysia	Boneless lean meat
Taiwan	Skin-on, lean, 14–16 kg goat carcass
Europe	Kid, skin-off, lean, 5–12 kg carcass

12.10. Opportunities and Constraints of Meat Marketing

The following are some of the important opportunities and challenges/constraints influencing the meat industry in Ethiopia, particularly the export sector.

12.10.1. Opportunities

- Proximity to Middle East countries and their preference to the taste of Ethiopian animals.
- High and increasing demand. The annual total meat demand of the Middle East countries is about 207 thousand tons of meat and 12 million head of sheep, goats, cattle and camels. Considering population sizes, purchasing power and level of meat imports, there is also a potential market in the following African countries: Algeria, Angola, Benin, Cote d'Ivoire, the Democratic Republic of Congo (DRC), the Gabon, Egypt, Mauritius and South Africa. These countries annually import 82% of the total meat imported to the continent. There is also a possibility of expansion to Asian markets such as Malaysia, which require halal-slaughtered, frozen, skin-off carcasses with less stringent hygienic regulations. The carcass weight categories are less than 12 kg, 12–18 kg, and greater than 18 kg. Currently in Ethiopia, at least the former weight category can be targeted.
- High livestock population and diverse genotypes.
- Diverse agro-ecologies.
- Increasing number of export abattoirs.
- The expansion of agro-industries and the increase of by-product feeds.

12.10.2. Constraints/challenges

- Inadequate research and extension programs in the production, processing and marketing of meat.
- Inadequate knowledge and technologies to make optimal use of local animal feed resources in diets.
- Livestock diseases and inadequate veterinary support services. There are frequent import bans mainly due to the stringent health requirements of some importers.
- Inadequate application of HACCP (Hazard Analysis and Critical Control Point) procedures.
- Lack of constant and uniform animal supply.
- Inadequate infrastructures on transportation routes and markets.
- Lack of marketing information and cooperative systems for the marketing of animals.
- Lack of a grading system to provide incentives to producers and to assist in the development of meat exports. In most markets, there are no weighing facilities, and animals are subjectively sold according to appearance and size.
- Inadequate knowledge at different levels of stakeholders (producers, dealers, meat handlers, consumers, etc). A consumers' forum should be established. The importance of packaging should be taught to the meat sellers.
- Contraband trade around the lowland borders of the country. East African livestock trade is characterized by illicit trade between neighboring countries and the inflow stocks are used either for domestic consumption (Kenya), or for re–export and domestic consumption (Somalia) or re-export alone (Djibouti).

Illicit trade seriously affects Ethiopia. Data from the Livestock Marketing Authority (LMA, 2001) revealed that an estimated 1,150,000 sheep and goats and 300,000 skins outflow every year from Ethiopia through illicit cross–border trade.

- Lack of an integral connection between the stakeholders involved in the production chain.
- Inadequate market promotion and study tours to potential importing countries.
- Lack of efficient air transport for export of fresh and chilled meat.
- Some markets are also dominated by influential personalities.

Transferable Messages

1. Appropriate breeds and technologies and targeting of markets have to be used to increase animal off-take as well as productivity per animal with acceptable quality and safety, and to ensure a constant and uniform supply of meat.
2. Attention should be given to the establishment of disease-free zones for livestock export.

Glossary

Aging: refers to holding of carcasses at certain temperature to allow naturally present enzymes to tenderize the meat.

Ante-mortem: Before death.

Antioxidant: A compound that prevents oxidation. Used in mixed feeds to prevent rancidity or loss of vitamin potency.

Capretto: A suckling goat only a few weeks old.

Carcass: The major portion of a meat animal remaining after slaughter. It varies among animals, but usually the head, the skin, internal organs and the shanks have been removed.

Chevon: The meat of an older, weaned meat goat.

Chilled meat: Meat kept between 0 and 4^{o}C in a chiller or refrigerator usually 24 hours post-slaughter.

Conformation: The structure or shape of an animal or its carcass, or a cut from the carcass.

Dressing percent: Carcass weight divided by live weight and multiplied by 100. Usually the cold carcass weight is used.

Fatty acids: A basic unit of fats. They are lipids that can be directly utilized as a source of energy by most body cells.

Hypercholesterolemic: Fatty acids that may increase cholesterol level.

Hypocholesterolemic: Fatty acids that may reduce cholesterol level.

Lactic acid: A byproduct which results when glucose is broken down without a sufficient supply of oxygen. Post-mortem lactic acid build-up is an important factor in the pH decline in meat and has an impact on final meat quality.

Lairage: A place for keeping livestock temporarily in the abattoir.

Lipids: Lipids are organic molecules which are not soluble in water, including fats and cholesterol. Lipids are important constituents of cell walls and the starting materials for the synthesis of steroids.

Marbling: Small visible streaks of fat within a meat cut.

Myoglobin: A red iron-containing protein pigment in muscles that is similar to hemoglobin.

Post-mortem: After death.

Rigor mortis: Stiffening of muscles after slaughter.

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