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MINISTRY OF AGRICULTURE

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Ministry of Agriculture
Export Abattoirs Inspection and Certification Directorate

Meat Quality Guidelines for Export Abattoirs

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Acronyms

Cm	Centimetre
DFA	desirable fatty acids
DFD	Dark Firm Dry
°C	Degree Celsius
°F	Degree Fahrenheit
ECTAD	Emergency Centre for Transboundary Animal Diseases
FAO	Food and Agriculture Organization of the United Nations
IMF	Intramuscular fat
M	Meter
Mb	Myoglobin
M/S	Meter per second
MAP	A meat packaging system where by meat products are enclosed in gas-barrier materials
MoARD	Ministry of Agriculture and Rural Development
Hrs	Hours
UV	Ultra violet
PA	Polyamide
PE	Polyethylene
PET/PETP	Polyester (polyterephthalic acid ester)
PVC	Polyvinylchloride
PVDC	Polyvinyliden chloride
PSE	Pale Soft Exudative
pH	Measure of acidity/alkalinity levels
PPM	Parts per million
TADs	Trans-Boundary Animal Diseases
WHC	Water holding capacity

Acknowledgements

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Foreword

This technical document entitled “Meat Quality Guidelines for Export Abattoirs” is one of the documents in a series of guidelines and Standard Operating Procedures that were developed from 2008 to 2010 by the then Ministry of Agriculture and Rural Development in collaboration with the Ethiopian Sanitary and Phytosanitary and Livestock and Meat Marketing Program under the title “Meat Darkening Prevention Guidelines”.

These Guidelines and Standard Operating Procedures are at present reviewed and updated by the Ministry of Agriculture in collaboration with the FAO-ECTAD Ethiopia, Improving Sanitary Capacity and Facilitating Export of Livestock and Livestock Products from Ethiopia Project. The main goal of project is to increase exports of meat and livestock to benefit Ethiopian livestock producers and exporters and to promote national economic development.

The guidelines are intended to provide guidance for export abattoir operators, feedlot managers, livestock handlers as well as meat inspectors on the importance of understanding the basic quality parameters under which the current fresh meat global market is operating and major factors determining the quality outcomes. It also outlines the general and specific operational procedures that should be applied across the chain of events starting from the purchase of slaughter livestock to the production, storage and delivery of fresh meat products that may comply with the quality requirements of foreign customers.

At this point, the Export Abattoirs Inspection and Certification Directorate of the Ministry of Agriculture would like to thank the FAO-ECTAD Ethiopia, Improving Sanitary Capacity and Facilitating Export of Livestock and Livestock Products from Ethiopia Project, for providing the necessary technical and financial support required for reviewing, updating and publishing this guidelines document.

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1. Introduction

Meat is considered to be a vital component of a healthy diet, an excellent source of protein, essential minerals, trace elements and vitamins. Global demand for meat and meat products increasing. Meat is one of the major agricultural commodities that Ethiopia has a potential to expand its export trade. The Middle East countries are the major destinations for the meat export trade. Apart from the impacts of Trans-Boundary Animal Diseases (TADs) in causing repeated trade bans imposed by the middle east countries on meat export, quality deterioration of fresh meat becomes one of the limiting problems contributing for the low performance of the Ethiopian meat export trade.

Meat quality has always been important to the consumer or importer, and it is an especially critical issue for the meat industry in the 21st century. As consumer demand for high quality meat is increasing in most countries, the meat industry should consistently produce and supply quality meat that is nice looking, tasty, safe for the consumer to ensure continued consumption of the meat products.

Rapid darkening, discolouration, spoilage, shortened shelf-life etc, are among the major complaints raised by the Middle East customers of the Ethiopia fresh meat trade. For this and related reasons, the Ethiopia's meat export performance has so far able to secure low relative share of the Middle East markets and the price paid to buy a unit of fresh meat from Ethiopia is said to be comparatively lower than other countries' products.

The presence of a number of countries who compete with Ethiopia in terms of maintaining a bigger share of the Middle East and other regional meat markets, successful meat export trade on our side will largely depend on our readiness and ability in supplying the meat and meat products that satisfy the quality and other requirements set by importing countries.

Supply of quality meat to the export markets require actions to be taken at different levels of the meat production and marketing chain of events starting from the feeding and handling of the live animals to the point of delivery of meat to the customers. Along these chain of events different actors such as livestock farmers, market and feedlot operators, livestock transporters, abattoir operators and regulatory inspectors will have their shares of responsibilities to play.

2. Objective

This guideline is prepared with the objective of indicating major fresh meat quality parameters of the Middle East and other regional markets and outline operational guidelines that the abattoir operators' and veterinary inspectors should follow for improving and maintaining the quality of fresh meat to be produced and supplied to export markets.

3. Scope

The scope of this guideline is limited to the quality parameters of fresh meat coming from cattle, sheep and goats presented as whole carcass or cuts of muscle rather than processed meat products. The guideline covers quality improvement and maintenance provisions of fresh meat at all levels starting from farm level practices, livestock purchase, conditioning, slaughter, dressing, packaging, storage to the pint of export dispatch.

4. Carcass and meat composition overview

Carcass is the body of a slaughtered animal after dressing. It 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. Markets may differ in their requirements on the 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. The characteristics of a superior carcass are: high proportion of muscle (lean), low proportion of bone and an optimal level of fat cover.

Meat is all parts of an animal that are intended for, or have been judged as safe and suitable for human consumption. Meat is an important commodity of human diet which needs careful handling throughout the whole production and processing chain. Meat is subdivided in to the following categories.

- *Red meat***:** The largest category in terms of volume of consumption and includes beef, mutton, goat meat, etc.
- *White meat/poultry meat:* Meat from domestic birds, e.g., chicken, turkeys, ducks, etc.
- *Seafood***:** This category includes fish, lobsters, oysters, etc.,
- *Game meat:* Meat from wild game or traditionally non-domesticated animals,

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.

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 demonstrates the potential of Ethiopian goats for the production of high-quality meat.

5. Meat quality

Meat quality can be defined as a set of properties that together identify what we appreciate about meat when we purchase it, eat it, or select it for use as a raw material for processing into meat products. The quality characteristics of fresh meat are influenced by various factors such as:

- muscle structure, chemical composition, chemical environment, interaction of chemical constituents,
- post-mortem changes in muscle tissues,
- stress and pre-slaughter effects,
- product handling, processing and storage,
- microbiological numbers and populations, etc.

Quality traits of fresh meat are categorized based on major factors such as:

- ❖ appearance quality
- ❖ eating quality and
- ❖ reliance quality

Consumers determine quality meat as one with desirable colour, firm texture, less drip, high marbling, and moderate visible fat and fresh meat odour, while discolouration, soft texture, large amount of drip, less marbling, excessive visible fat and abnormal meat odour are considered as poor-quality traits for fresh meat. Also, the consumer expects quality meat that is reliable in relation to safety, nutrition, sustainability and ethics.

All these traits contribute to the consumer's expectation of high-quality meat. The balance among appearance, eating and reliance quality factors vary from country to country, depending on local customs and on the state of the local economy.

6. Quality parameters of fresh meat

6.1 Appearance quality

6.1.1 Colour

Consumers have certain expectations regarding the quality of meat they purchase. Meat colour is the most important appearance quality trait because it is the first factor seen by the consumer and is used as an indication of freshness and wholesomeness. A bright cherry-red colour is commonly utilized as an indicator of wholesomeness in fresh meat. Meat colour is dependent on the concentration and chemical state of the meat pigments, primarily myoglobin and haemoglobin, and on the physical characteristics of meat, such as its light scattering and absorbing properties.

Meat colour is also dependent on species, age and muscle type, and the colour differences are due to the different content of myoglobin (Mb) in muscle. The higher Mb content in a muscle fiber is due to Mb's function of storing and delivering oxygen in the muscle. The Mb content in muscle is affected by factors such as exercise and diet of the animal as well as genetic and environmental factors. In unpacked fresh meat, myoglobin can exist in one of three forms namely deoxymyoglobin, oxymyoglobin or metmyoglobin. Interconversion of the three pigment states is possible and the dominant pigment form depends on localised conditions.

Deoxymyoglobin, frequently referred to as myoglobin or reduced myoglobin is is purplish-red in colour and is responsible for the colour of meat immediately after cutting into a deep muscle, or of meat stored under a vacuum. Oxymyoglobin, a cherry-red form of the pigment, forms very quickly after exposure of deoxymyoglobin to oxygen. In red meats, oxymyoglobin imparts the colour that consumers associate with freshness .

The colour of red meats is relatively short-lived and both deoxymyoglobin and oxymyoglobin readily oxidise to metmyoglobin. Metmyoglobin is incapable of binding with oxygen and is thus physiologically inactive. Metmyoglobin gives meat a brown colour which consumers associate with a lack of freshness and unacceptability. Meat colour can be measured numerically using a colourimeter or subjectively.

Many factors contribute to the discolouration of meat during processing, storage and display. The predominant determinant of meat colour stability is the rate of Oxymyoglobin oxidation, and the

rate of discolouration in meat is muscle-specific. Surface-discoloured whole muscle cuts are ground to low-value products, such as ground beef, to salvage the cuts' interiors, which might still be red or are discarded often well before microbial safety is compromised; both practices lead to sales loss and wastage of valuable food.

6.1.2 Meat surface drip

Amount of drip on the surface of meat and purge in the tray are the two other important appearance quality parameters for fresh meat. Drip and purge loss depend on the water holding capacity (WHC) of fresh meat and WHC is closely related to the colour of meat due both to its role in the loss of Mb and reflectance at the surface of the meat. Additionally, WHC influences other physical properties including texture and firmness of raw meat, and eating properties of cooked meat. It is well known that excessive drip exudation and soft texture result from the combination of rapid pH decline, and high temperature in post mortem muscle.

6.1.3 Texture

Meat texture is directly related to the size of muscle fiber and the amount of connective tissue, and is partially affected by the quantity of intramuscular fat (IMF). Relatively large muscle bundles are responsible for the coarse, undesirable texture on the transversely cut surface of meat. Muscle fiber diameter varies with species, chronological age, state of nutrition of the animal, genetic background and composition of muscle fiber types. The coarseness of the meat surface is increased with thickened connective-tissue strands as well as increased size of muscle bundles.

6.1.4 Firmness

Meat firmness is also influenced by the status and quantity of the subcutaneous fat surrounding muscles and intramuscular fat (IMF). Meat firmness is influenced by the IMF firmness which is affected by composition of fatty acids and temperature. It is known that IMF produces effects on flavour, juiciness, tenderness and visual characteristics of meat with increased marbling in meat.

The quantity of IMF is affected by many factors including animal breed, slaughter weight, feeding strategy, and growth rate. In animals, adipogenesis occurs the earliest in the visceral fat deposit, closely followed by subcutaneous and intermuscular deposits, and adipogenesis in intramuscular fat occurs last. This adipogenesis can be affected by genetic, nutritional and environmental factors that are the key signalling pathways regulating adipogenesis in skeletal

muscle. Although there are variations among species, IMF tends to increase with advancing age when the major stages of muscle growth have been completed.

6.2 Eating quality

6.2.1 Tenderness

Tenderness is the most important eating quality trait that influences consumer's perceptions of acceptability.

Meat tenderness is mainly affected by:

- the amount and solubility of connective tissue,
- the composition and contractile state of muscle fibers,
- the extent of proteolysis in rigor muscle and also
- IMF content of meat

Tenderness is more important for red meat such as beef and lamb because of a high composition of red muscle fibers and connective tissue compared to chicken. Muscles with diverse muscle fiber characteristics have different patterns of post-mortem change during the conversion of muscle to meat. Meat tenderness varies with factors such as:

- the rate of post-mortem glycolysis,
- the rigor onset post-slaughter and
- the extent of glycolysis, which are all related to muscle temperature as well as muscle fiber characteristics.

6.2.2 Flavour

Flavour is also important for the eating quality of meat. Because meats consist mainly of the lean portion and the fat portion, the meat flavour is primarily dependent on the pool of flavour precursors in these two tissues. Meat flavour is affected by species, sex, age, *stress level*, amount of fat, and diet of animal. Beef, lamb, and poultry have distinctive flavour characteristics due to the variation of the flavour precursors generally in the fat between and within species.

The effect of animal gender on meat flavour is highly related to testosterone and skatole that are produced in intact males and females, respectively. Testosterone increases muscle growth and decreases intramuscular lipid deposition. In general, intact males deposit less fat throughout the body and within muscle, and are more susceptible to long-term pre-slaughter stress than females

or castrated males. Increasing serum-like bloody aromatics and metallic flavour are due to increased levels of Mb in the meat of older animals.

6.2.3 Juiciness

Juiciness is positively related with the WHC of meat and the IMF content in meat. The IMF content directly affects juiciness as well as flavour, and the human perception of juiciness is increased as the IMF content in meat increases. Moreover, the feel of juiciness in the oral cavity is generally sustained when meat has a large amount of IMF.

6.3 Reliance quality

The quality factors centred around the well-being of meat animals, the well-being of meat consumers, and the wellbeing of society as a whole are now principal attributes of meat production systems and the final product itself

6.3.1 Meat safety

Safety is always more important than appearance or eating quality traits of meat, and the microbial level in meat is the most important reliance quality trait of fresh meat. The categories of meat safety also include physical and chemical residues, food additives and animal identification of meat products. In general, consumers evaluate *meat safety* by visual and odour evaluations which are the most rapid indications of meat spoilage, although they are unreliable indicators of safety.

The traditional quality factor, normally expressed as freshness or wholesomeness, relates to the perception that the meat is safe to eat, in terms of lack of pathogens, parasites, infections agents, or toxins. Although freedom from infections agents is an unseen quality, we associate it with “freshness”; meat that looks old to us is untrusted. The importance of meat as a carrier of bacterial pathogens is considerable in terms of public health.

Another major concern of modern consumers of meat is the possibility that residues of antibiotics, growth promoters, hormones, and other drugs given to animals in the production process may end up in the meat they consume. Therefore, strict and stringent safety requirements in the processing of meat have been developed and implemented in many countries.

6.3.2 Wholesomeness

Consumers are also concerned on quality issues related to the wholesomeness of the meat produces they buy. The issue of wholesomeness includes assurances in knowing that a certain meat product is coming from a slaughtering plant practicing ritual slaughtering techniques such as Halal slaughter in the case of Muslims, the correct identification of the species of animals from which the meat is coming and the standard of sanitary and hygienic practices applied in the abattoir.

6.3.3 Fat content

There is no doubt that quality meat is one with high nutritional value, and meat is one of the most nutritional foods. In the past, quality meat was more closely related to the sensory perceptions, freshness, and safety aspects of meat products, whereas more recently it is associated with nutrition, well-being and functionality in relation to human health. Consequently, consumers may consider the high content of fat and cholesterol in meat as undesirable and unhealthy, although meat is nutritious because it is a rich source of protein, essential amino acids, minerals and vitamins.

6.3.4 Welfare

In recent years there has been a considerable increase in consumer concern with regard to how meat is produced. Concern about animal *welfare* has greatly increased around the world, and there has been an enormous development of the 'organic' rearing of animals. Consumers demand that animals are reared, transported and slaughtered under humane conditions.

Consumers also want to be confident that the meat they purchase is derived from *ethically robust production systems*. Consequently, farmers, veterinarians, packers and scientists need to become more knowledgeable on how to assess and audit animal welfare at the farm, market, transport and slaughter plant.

6.3.5 Traceability

It should be emphasized that the importance of *traceability* has increased in relation to reliance quality parameter. Regulatory agencies in many countries have insisted on the implementation and application of product identification and traceability systems be put in place.

6.3.6 Odour

Post slaughter biochemical changes which accompany the conversion of muscle to meat give rise to conditions where the process of lipid oxidation is no longer tightly controlled, and the balance between pro-oxidative and antioxidative capacity favours oxidation. The rate and extent of subsequent lipid oxidation in muscle foods is influenced by *both pre-slaughter factors, such as stress and diet, and post-slaughter factors, such as post-mortem pH decline and carcass temperature*.

Lipid oxidation is the process by which molecular oxygen reacts with unsaturated lipids to form lipid peroxides to produce a variety of products including *alcohols, aldehydes and ketones*. Although phospholipids make up only 0.43–1.0% of muscle weight their susceptibility to oxidation makes them important contributors to deterioration in flavour, colour, odours, flavours and lowering of meat quality.

On the other hand, decreased levels of muscle glycogen lead to overall limited amounts of glycogen in the meat that can be converted to lactic acid. Lactic acid bacteria normally grow on meat and "compete" with spoilage causing bacteria. The reduction in glycogen, utilized by lactic acid bacteria, leads to a substantial decrease in lactic acid bacteria. Therefore, bacteria that produce hydrogen sulphide, which causes an off odour and green discolouration, proliferate and become numerous.

6.3.7 Shelf-life

Meat and meat products present an ideal substrate for supporting growth of several spoilage and pathogenic bacteria which, unless correctly stored, processed, packaged and distributed, spoil quickly and become hazardous owing to microbial growth. The potential for microbial contamination is influenced by factors such as animal condition before slaughter, slaughter-plant practices, extent of handling and subsequent storage conditions. A combination of factors such as pH, temperature, relative humidity, packaging characteristics and interactions determine the microbiology of meat. The pH of meat is very important for keeping quality (shelf life) and is related to its cooking properties, colour and consumer acceptance. Reduced shelf life is largely due to a higher than normal pH and an increased water-holding ability, which are both conducive to microbial growth. Meat spoilage is not always evident and consumers indicate that

gross discolouration, strong off-odours and slime development constitute the main qualitative criteria for the rejection of meat.

7. Impact of stress on meat quality

It is known that with higher levels of stress of slaughter animals, poorer meat quality is eminent, quite apart from being inhumane. Pale Soft Exudative (PSE) and Dark Firm Dry (DFD) meats are two of the major quality defects facing the meat industry. These defects reduce consumer acceptability, shelf life and yield of meat thus affecting profits tremendously.

Meat colour stability is important for the international chilled meat market due to the time spent in transit before reaching supermarket shelves. Colour is important when meat is purchased, stored, and cooked. Often an attractive, bright colour is a consideration for the purchase. Myoglobin is a water-soluble protein that stores oxygen for aerobic metabolism in the muscle. It is the principal protein responsible for meat colour, although other heme proteins such as hemoglobin and cytochrome C may also play a role in meat colour. Myoglobin doesn't circulate in the blood but is fixed in the tissue cells and is purplish in colour.

Oxymyoglobin, commonly known as the ***fresh meat colour***, is the most desirable colour for fresh meats. Maintaining this colour requires that the meat surface be free from any contamination which would cause a chemical reaction resulting in the formation of the ***brown pigment metmyoglobin***. Also, oxygen should be available at a sufficient concentration in order to combine with the myoglobin to form oxymyoglobin. The change from myoglobin to oxymyoglobin and vice versa usually occurs quite readily. Similarly, the reaction that produces the brown meat metmyoglobin occurs quite easily, but the reverse of this is more difficult.

A number of factors contribute to discolouration in meat during storage and the rate of metmyoglobin accumulation is related to factors such as muscle pH, diet of animals, as well as factors such as pre-slaughter treatment of animals and chilling of carcasses. Meat pH is a measure of acidity/alkalinity levels of the meat. It is very important for keeping quality (shelf life) and is related to its cooking properties, colour and consumer acceptance. After slaughter, the reserves of glycogen (energy) in the animals' muscles are converted to lactic acid, causing the pH to fall. The normal pH decline in muscles is from approximately 7.0-7.2 down to near pH

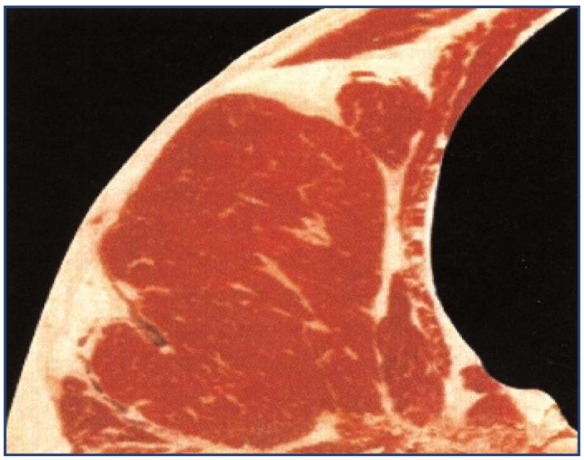
5.5-5.7 over about 24 hrs. With this pH decline, whole tissue will have the characteristic colour of the species

. Meat with a pH greater than 5.8 influences meat quality in a number of ways:

- Decreases shelf-life of meat by permitting growth of spoilage bacteria;
- Increases meat toughness, and
- High pH meat is “mushy”, darker and is often referred to as “dark-cutting meat”

The carbohydrate (sugar) glycogen is used as an energy source for muscle contraction and relaxation. Lactic acid is a by-product of glycogen utilization by the muscle when energy is produced in a stress event. After death, lactic acid accumulation in the meat is responsible for the pH decline from 7.0 to about 5.7 during normal rigor mortis development period.

The normal pH decline of meat during rigor mortis is altered due to a lower level of glycogen at death if animals are stressed prior to slaughter. This results in meat retaining a high pH. If the pH does not drop much post-mortem, the meat will be dark, firm and dry (DFD). As the ultimate pH increases, the meat gradually becomes darker. This darkening of colour becomes noticeable when the muscle pH exceeds 5.7.



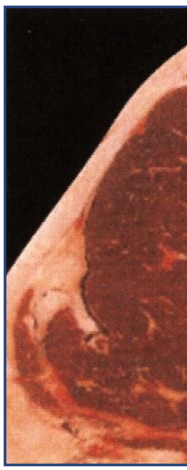


Fig. 1. Normal beef lean colour Dark, firm and dry beef lean colour

Dark cutting meat is most often known as dark, firm, and dry (DFD also be called “high pH” meat is a result of an animal’s depleted muscle glycogen reserves prior to slaughter. DFD meat exhibits a dark, purplish red to almost black lean colour and a dry, often-sticky lean surface.

Due to high pH, lean surfaces act similarly to a dry sponge resulting in increased water binding capacity within the muscle. The muscle appears dark because of higher intracellular water, which reflects less light.

The higher pH results in less denaturation of myoglobin and would facilitate a higher level of aerobic metabolism at the surface. In addition, the high pH actively holds the reduced (ferrous) state. Metmyoglobin is incapable of binding oxygen and is thus physiologically inactive. Metmyoglobin gives meat a brown colour which consumers associate with a lack of freshness and unacceptability. The muscle is firm due to the high-water holding capacity, and the surface feels dry as the water is tightly held within the muscle. The rate and extent that muscle pH declines post-mortem have a great impact on the colour of meat and meat products. If the pH declines to the pH of 5.5-5.7 within 45 min or less, the muscle will appear very pale soft and exudative (PSE). A very low ultimate pH (<5.4) will also result in a paler colour.

Both PSE and DFD conditions occur in all species of slaughter animals depending on how animals are handled pre-slaughter. PSE and DFD meats look unattractive and discriminated against by consumers. PSE and DFD meats have, poor processing characteristics, reduced yield and high potential of spoilage compared to normal meat. There can also be the danger that consumers will begin to associate poor quality meat to food safety issues.

7.1 Events leading to dark, firm and dry beef

In cattle that are rested and not exposed to stress, muscle glycogen levels will be 0.8% to 1.0% prior to death. However, an animal exposed to various forms of long-term pre-slaughter stress significantly depletes its glycogen reserves. A depleted state of glycogen less than approximately 0.6% will hinder normal post-mortem pH decline. Muscle with a post-rigor pH of greater than 5.9 generally develops some form of dark cutting characteristic. The pH range of normal meat of an unstressed animal is 5.4-5.7. DFD meat will have a much higher pH of 5.9-6.5, with some meat being as high as a pH of 6.8.

The depletion of muscle glycogen may be caused by a variety of severe pre-slaughter stresses including transport exhaustion, fear, climatic stress, aggressive behaviour with young bulls, hunger, prolonged withholding of feed and water prior to slaughter, mixing of unfamiliar animals and resulting extreme adrenaline excitement. When stressed livestock are slaughtered before they have sufficient time to replenish their muscle glycogen stores, their carcasses will exhibit the

DFD condition. Replacement of muscle glycogen stores may take a few days or as long as two weeks post stress.

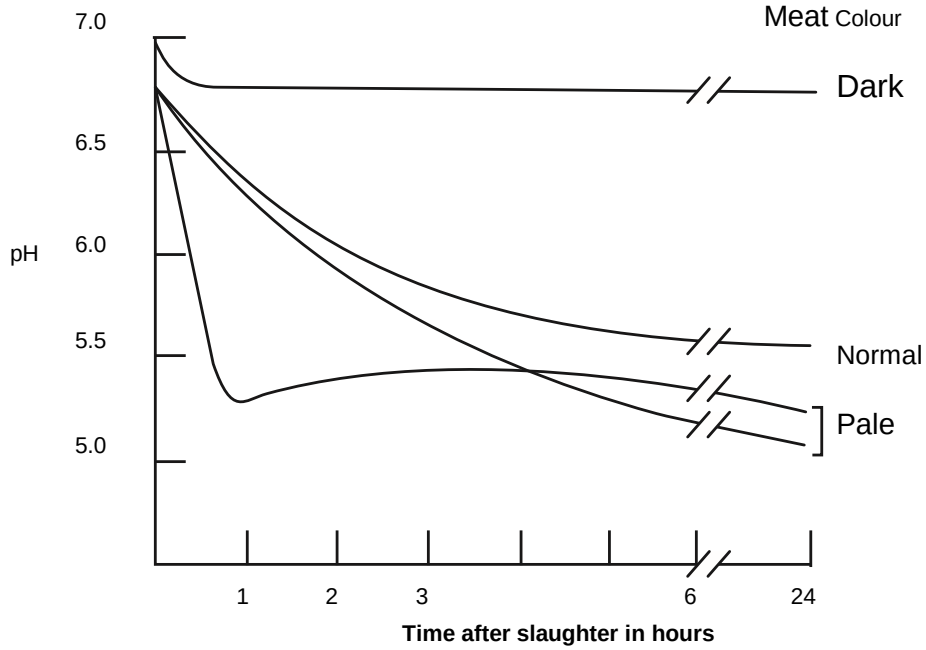


Figure 2: Post-mortem pH decline and the resulting meat colour

7.2 Problems on DFD meat

Normal muscle blooms to a bright red colour when exposed to air. Muscle with the dark cutting condition will not bloom to a bright red colour and remains a dark purple red to black in colour. Consumers relate the dark coloured lean to meat from an old animal, spoilage, undesirable flavor, toughness and poor shelf life. The dark red state of DFD meat in a retail display case has proven to be one of the leading causes of consumer rejection of dark cutting beef.

Dark, firm and dry beef is of significantly lower quality as it has a reduced shelf life and a greater ability to support microbial growth. Increased microbial growth leads to increased spoilage and an undesirable flavour. Reduced shelf life is largely due to a higher than normal pH and an increased water-holding ability, which are both conducive to microbial growth.

Decreased levels of muscle glycogen lead to overall limited amounts of glycogen in the meat that can be converted to lactic acid. Lactic acid bacteria normally grow on meat and “compete” with spoilage causing bacteria. The reduction in glycogen, utilized by lactic acid bacteria, leads to a substantial decrease in lactic acid bacteria. Therefore, bacteria that produce hydrogen sulfide, which causes an off odour and green discolouration, proliferate and become numerous.

7.3 Major stress causing factors

There are a variety of factors that result in animals' stress. When stress factors are coupled with extreme or changing weather conditions, the animal's stress levels are severely increased and its chances of producing DFD beef also increase. Animal stress factors include, but not limited to; biological type, geographical origin, aggressive behaviour, mounting behaviour, environmental conditions, temperature, relative humidity, wind, mixing of unfamiliar animals and carrying overnight at the slaughter plant. Adverse or fluctuating weather conditions, such as extreme temperatures, increase the stress level of an animal. It has been found that an average temperature above 35°C (95°F) over a period of 24-48 hours can drastically increase animal heat stress.

8. Use of meat quality improvement technologies

Meat discolouration is inevitable during storage and retail, and therefore strategies to prolong the colour stability contribute significantly to profitability. Common strategies used for this purpose of fresh meat quality improvement technologies can be divided in to packaging, use of antioxidants and use of nonmeat ingredients as indicated below.

8.1 Packaging

Packaging can influence meat quality in a number of ways. It can prevent contamination and spoilage that could otherwise compromise meat shelf-life, prevent dehydration and drying and can help maintain normal meat colour. Today the most widely used method employed to extend the storage life of fresh meat is vacuum packaging. Vacuum packaging is intended to preserve products from microbial contamination, from dehydration, helps retain its red colour on re-exposure to air and from environmental factors that affect quality and nutrition. Vacuum packaged meat of normal pH (<5.8) can be stored for 12 to 14 weeks at 0^{o}C.

Modified atmosphere packaging **(**MAP) is a meat packaging system where by meat products are enclosed in gas-barrier materials in which the gaseous environment has been changed. The common MAP systems used for fresh meats are high oxygen (80% oxygen and 20% carbon dioxide) and low carbon monoxide (0.4%), with the balance nitrogen and carbon dioxide). The

oxygen and carbon monoxide, in the gas mixture bind with Mb to provide the desirable cherry-red colour. When used at 55% to 80% in high-oxygen MAP, oxygen helps maintain the consumer-desirable colour of meat for a longer time than in aerobic packaging. Fresh red meats retailed in high-oxygen MAP retain acceptable red colour for up to 14 days of display, compared with less than seven days for aerobically packaged counterparts.

8.2 Use of antioxidants

In meat production and supply chain, antioxidants can be applied either pre-harvest or post-harvest to minimize lipid oxidation–induced colour deterioration.

- Vitamin E can be used in the finishing diet of cattle to increase colour stability of beef.
- Feeding food animals with plant extracts rich in antioxidant compounds such as tea catechin and rosemary extract also can increase meat colour stability.
- Supplementing plant extracts that contain polyphenols in the diets of culled cows improved steak colour stability.
- Natural antioxidants can be employed in meat systems to improve colour in postharvest applications in fresh meat. A variety of natural antioxidants, including grape-seed extract, rosemary and olive-leaf extract improve meat colour stability.

8.3 Use of nonmeat ingredients

The addition of non-meat ingredients into whole meat cuts is a well-established technology. The addition of non-meat ingredients serves to modify or enhance meat characteristics and shelf life whereby parameters such as texture and tenderness, water holding capacity, cook yield, meat particle binding and sensory properties are enhanced.

- ❖ Injection enhancement of whole-muscle beef cuts with solutions that contain nonmeat ingredients is widely employed to improve colour quality.
- ❖ The incorporation of functional non-meat ingredients into whole meat cuts, often referred to as enhancement, represents a strategy to improve the quality of meat cuts with low commercial value. A variety of ingredients, either alone or in combination, are used in brine (enhancement) solutions including salt, phosphates, lactates.
- ❖ Non-meat ingredients are also known to exert antimicrobial (e.g. salt, lactates), lipid antioxidant (e.g. phosphates) and colour-stabilizing (e.g. lactates) activity in meats.

Ingredients may be incorporated via marination (immersion), multi-needle injection and/or tumbling/vacuum tumbling technologies.

- Injection enhancement of beef with brine solutions or marinades is widely practiced in the value-added meat industry .
- Carcasses (mostly beef), which are not to be cut, or de-boned can be wrapped with sterile linen sheets or a large piece of cloth soaked in 10% salt solution (sodium chloride solution which helps to minimize colour shrink and improve the external appearance of the carcass) around the outside of the carcass halves and attached with metal shroud pins and then conveyed to the cold room.
- In meat products, alkaline polyphosphates aid salt-induced solubilization of myosin, function as a processing aid, increase water-binding strength through an increase in pH and exhibit antioxidant activity. In addition to increased antioxidant activity, phosphate addition to meats results in improved meat product characteristics such as increased water holding capacity and cook yield, enhanced juiciness and flavor.
- Sodium, potassium and calcium lactates are salts derived from lactic acid that are generally used in meat and meat products as antimicrobial agents. In addition to antimicrobial activity, lactates have also been shown to enhance beef quality attributes, such as flavor, juiciness, tenderness and cook yield. Lactates have also been shown to improve beef colour stability.

9. Guidelines for improving meat quality

As indicated above, in todays globalized world, satisfying consumers' demand on quality parameters related to fresh meat are major determining factors for successful export trade performance. Satisfying those quality demands in our context may require addressing basic meat quality limiting factors starting from farm, point of purchase, fattening or conditioning, transporting, lairage and slaughter handling, to overall sanitary, product handling and dispatch operations in the abattoir.

9.1 Farm management practices

Tropical breeds in are known for their resistance to stress but the meat quality parameters including such as meat composition; weight gain rates etc may differ

significantly. For this the following guidelines need to be followed in managing meat animals at farm level:

- Raise meat animals selected from available breeds known for their promising performances in terms of growth rate, daily weight gains and compositional quality of meat.
- Improve the overall farm level health care and husbandry practices that may include provision of supplemental feeding before marketing them.
- Avoid indiscriminate use of veterinary drugs and chemicals on meat animals without considering their deleterious effects on the health of the consumers.
- Actively participate in any livestock identification programme that may be put in place in the area.

9.2 Type and age of slaughter animals

Major quality parameters of fresh meat such as meat colour, texture and tenderness are known to be affected by breed, age, slaughter weight, growth rate and sex of animals to be slaughtered. For this the following guidelines need to be followed during purchasing of live animals:

- Ensure the slaughter animals to be purchased are from the required species, breeds or types of animals specified by importers (if there is any).
- Ensure the age, sex and weight categories of slaughter animals purchased are within the range of the specifications set by the importers.
- Ensure those animals to be purchased are in well body conditions that can be conditioned to the desired level or slaughtered immediately.

9.3 Feeding practices in feedlots and holding stations

The Mb content of meat, that affects colour differences in different muscles, is affected by factors such as *diet of the animal as well as environmental factors*. It is also known that IMF that produces effects on flavour, juiciness, tenderness and visual characteristics with increased marbling in meat is affected by many factors including slaughter weight, feeding strategy and growth rate of animals.

In the meat production and supply chain, antioxidants can be applied pre-harvest to minimize lipid oxidation–induced colour deterioration. In this regard, vitamin E can be used in the finishing diet of cattle to increase colour stability of beef and lamb. In addition, feeding meat animals with plant extracts rich in antioxidant compounds also can increase meat colour stability. In this regard, the following guidelines should be followed:

- Ensure the supply of nutritious feeds to slaughter animals kept under feedlot management system so that they will attain the required level of slaughter weight, intramuscular fat content and glycogen levels that will improve the appearance and eating qualities of meat after slaughter.
- Feed supplementations with vitamin E and other plant extracts that will improve meat colour stability can be used in consultation with the regulatory authority and in accordance with the relevant legal provisions of the country.
- Ensure use of drugs, vaccines, and chemicals such as acaricides that are approved to be used in feedlot systems by the regulatory authority and based on the recommendations and supervision of the veterinary inspectors.
- Avoid any possible use of growth promotors to feedlot animals.
- Ensure all animals ready for slaughter have completed the drug withdrawal times as specified by the manufacturer of the drug if they were treated before.

9.4 Stress factors impact minimization

Pre-slaughter stress factors are major contributors of fresh meat quality losses encountered in many countries. Stress factors contribute to meat discolouration, darkening, off odour, spoilage, reduced shelf-life, loss of flavour, tenderness and texture of meat leading to consumer rejection or downgrading and low pricing of the meat product. Meat from stressed animals has greater ability to support microbial growth that leads to increased spoilage and an undesirable flavour. Reduced shelf life is largely due to a higher than normal pH and an increased water-holding ability, which are both conducive to microbial growth.

Therefore, livestock welfare guidelines outlined in the Livestock Handling and Transport Guideline, Ante-mortem Inspection Guideline and Meat Inspectors and Inspector Veterinarians Guide for Regulating Export Abattoir Operations should be followed. Major stress minimization guidelines to be followed for meat quality improvement include the following:

9.4.1 Livestock handling during transport

- Make the necessary planning and preparation for the intended journey to ensure prompt delivery of livestock and timing of arrival before transporting livestock
- Ensure arrangement of well-designed transport vehicles for the journey
- Ensure livestock are managed and handled by competent livestock handlers
- Livestock should be loaded and unloaded from the transport vehicle in a calm and quiet manner.
- Painful procedures including whipping, use of sticks, stones, pipes, metal roads or tail twisting, etc should not be used to move animals. Instead, other droving aids such as flat straps and rattles should be used
- Animals should be loaded without unnecessary noise, harassment or force, and that untrained assistants or spectators are not impeding the process.
- As much as possible, loading should be carried out in day light
- Loading of animals should be conducted by trained animal handler(s).
- Livestock should not be loaded either too loosely or too tightly because this may increase the risk of injury
- Give consideration to availability of feed and water requirements, provision of adequate shelter and protection from inclement weather.
- Limit the journey duration, feed and water-deprivation time as specified by relevant guidelines on species basis
- Provide the required water, feed and rest before transport and at unloading as specified by relevant guidelines
- Avoid mixing of different species and class of livestock that would fight or disturb each other during travel
- Ensure livestock should be loaded and unloaded from the transport vehicle in a calm and quiet manner.

- ❖ Painful procedures including whipping, use of sticks, stones, pipes, metal roads or tail twisting, etc should not be used to move animals. Instead, other droving aids such as flat straps and rattles should be used
- ❖ Drivers should use smooth driving techniques, without sudden turns or stops, to minimize excessive movements of livestock and to prevent injuries, bruising, slipping and falling of livestock
- ❖ Airflow should be appropriate at all times, including when the vehicle is stopped
- ❖ In hot weather, the journey should be conducted during the cooler parts of the day and providing shade and other cooling strategies
- ❖ No other commodities or goods should be loaded and transported along with animals
- ❖ Livestock should not travel for more than 36 hours and should be offloaded after 24 hours for feed and water, if the journey is to take longer than that.

9.4.2 Livestock handling within abattoir facilities

The following guidelines should apply for unloading animals, moving them into holding pens, out of lairage to the slaughter point.

- The conditions of the animals should be assessed upon arrival for any animal welfare and health problems.
- Animals should not be forced to move at a speed greater than their normal walking pace, in order to minimise injury through falling or slipping.
- Animals for slaughter should not be forced to walk over the top of other animals.
- Animals should be handled in such a way as to avoid harm, distress or injury.
- Under no circumstances should animal handlers resort to violent acts to move animals, such as crushing or breaking tails of animals, grasping their eyes or pulling them by the ears.
- Animal handlers should never apply an injurious object or irritant substance to animals and especially not to sensitive areas such as eyes, mouth, ears, anogenital region or belly.
- Pen separately animals which might injure each other (i.e. fractious animals, bulls and horned cattle) or which are vulnerable to injury from others (younger animals, sick or disabled animals).
- Pre-slaughter resting of animals in holding pens should be adequate to allow them recover from exhaustion

- Potable drinking water and feed should always be provided to all animals in kept in holding pens including those kept in the isolation or suspect pen.
- Once animals are transferred to lairage, feed and water supply should continue for those animals which are to be slaughtered using halal methods but those animals to be slaughtered using non-halal methods, only water can be provided.
- When ready for slaughter, animals should be driven to the stunning box in a quiet and orderly manner without undue stress and noise.
- Only those animals certified as fit for slaughter should be moved to the slaughter hall
- Animals should be stunned and bled in humane manner
- Depending the requirements of importers, religious practices in stunning and bleeding should be practiced accordingly.

9.5 Product handling in slaughter and dressing operations

Meat quality losses encountered as a result of poor hygienic dressing, storage and transport practices are largely manifested in product discolorations, off-odour, off flavour and short shelf-life of meat as a result of microbial growth and contamination. Besides the detailed provisions outlined in the *Ante-mortem Inspection Guidelines and Meat Inspectors and Inspector Veterinarians Guide for Regulating Export Abattoir Operations,* the following guidelines should be followed and applied to improve meat quality.

9.5.1 Abattoir personnel sanitary practices

- All meat handlers and abattoir employees should be made aware of the importance of hygienic and sanitary practices in compromising the quality and safety of the meat product they handle.
- They should be provided with standard operational procedures that specify the required sanitary measure to implement while working in the abattoir.
- Employees should be neatly and cleanly dressed, wear head coverings that properly cover their hair, avoid any unwarranted contact with the product such as contact with the forearms
- Hand wash facilities should be used by everyone upon entering the meat production area.

- Every person, while on duty on the slaughtering or meat handling area, should be obliged to wash his/her hands thoroughly as soon as his hands come in contact with blood or any other dirt with a suitable hand cleaning preparation such as liquid soap under running warm water.
- Hands should always be washed and disinfected immediately, with 100-ppm chlorine or 15-ppm iodine solution or liquid soap under running warm water, before commencing work after using the toilet or handling any material, which might be capable of transmitting disease.
- Persons handling materials or products capable of contaminating the end product should not come in contact with any end product unless and until they discard all protective clothing worn by them and have changed in to clean protective clothing.

9.5.2 Overall abattoir sanitary practices

As part of the export abattoir specific sanitary measures required to be applied in every chain of event from slaughter to product dispatch for sale, the following are outlined as general practices.

- There should be a written and acceptable cleaning and sanitation program for the entire premises of the abattoir.
- Ensure abattoir sanitation operations are carried out by trained persons and effective training records are available.
- The abattoir managers should conduct daily monitoring and supervision on implementation of sanitary operations and take corrective actions as found necessary.
- Ensure facilities used for sanitizing equipment are adequate and all equipment are maintained in a sanitary manner at all steps in the dressing procedure.
- Ensure the temperature of hot water sanitizing is always kept at a minimum of 82^0C.
- Ensure abattoir sanitation operations conform to the conditions indicated in “the Guideline for the construction of export abattoir, Meat Inspectors and Inspector Veterinarians Guide for Regulating Export Abattoir Operations and Ante-mortem inspection guideline.

9.5.3 General carcass dressing procedures

- Carcasses should be dressed after being suspended by the hind legs.
- Procedures, including sticking and bleeding, should be conducted in a hygienic manner with measures to avoid contamination
- ensure that instruments/equipment are clean, and sanitized as necessary
- ensure skin and hide is cut from inside-out

- Ensure the carcass does not contact other carcasses before inspector veterinarian's approval
- Avoid having the carcass contacted with splashing from the floor or unhygienic structures
- Avoid letting the carcass contact the floor or unhygienic structures
- Avoid the transfer of heads over unprotected edible meat products unless effective controls (e.g. trays, pans) are in place to protect from cross-contamination
- ensure defects that may contaminate a piece of equipment will be removed prior to the next procedure
- Ensure any fecal, ingesta or milk contamination that occurs during dressing be removed, by trimming prior to the final carcass wash.
- Ensure equipment should be cleaned and sanitized if it comes into contact with contamination (or parts that by nature can be considered contaminated/inedible), pathological defects or any biological hazards.
- Once the carcass has been approved, any residual bone dust and blood should be removed prior to refrigeration by a final carcass wash.

9.6 Temperature control

Temperature affects fresh meat quality in number of ways. If not properly regulated, temperature may affect the rate of glycolysis in which the carcass may not attain the required level of acidity (pH level) within the expected time period or resulting in pale or dark discolouration of meat. It may cause cold-shortening of meat which can result in unacceptably tough meat. It may also favour microbial growth that will result in development of meat discolouration, rancid odour, off flavour or even food poisoning.

Apart from the good sanitary measures that should be applied in the abattoir to limit carcass microbial contamination, use of regulated temperature application at different stages of abattoir operations will help in maintaining the quality of meat and avoiding product spoilage.

The operational procedures specified in Meat Inspectors Guidelines for Regulating Export Abattoir Operations and Meat Cold Chain Guidelines for Export Abattoirs should be strictly followed. The major guidelines to be applied include, but not restricted to, the following.

9.6.1 Initial cooling

- ❖ Rapid growth of bacteria occurs between 10 and 50^0C. Therefore, it is imperative that meat should not be allowed to remain at this temperature for very long time.

- As soon as the dressing operations are completed, carcasses, sides or quarters, should be moved to a room with a temperature of 10 ^{0}c (3^{0}c for offals) and the mean air speed at a level 0.75m/s or above to be kept for the first 12 hours to allow carcass maturation.
- The surface temperature of carcasses should be 7°C or less within 24 hours of the end of carcass dressing.

9.6.2 Chilling

- After 12 hours of initial cooling, the product's surface temperature should continue to go down in a continuous manner to 4°C or less. This should take place as quickly as possible and the cooling media (chilling room) shall be maintained within 0 to 2^{o}c and the mean air speed over the product above 0.75 m/s with relative humidity below 95% or if the product is to be stored for more than 72 hours, below 90%.
- For the storage of offal, the temperature should be maintained below -2 ^{o}c or, if to be stored for more than 72 hours and below -10 ^{o}c.
- Measures should be put in place to control the holding temperature of the carcass or offal chilling rooms. Refrigeration parameters should be defined, established and recorded.
- Carcass temperature should be taken and recorded daily from 5 randomly spaced locations.
- Chilling room condensation should be prevented or minimized.

9.6.3 Freezing

- The carcasses can be frozen whole or cut transversely along the last rib into two and packed in a way to allow free air movement around them.
- As soon as the dressing operations are completed, carcasses, sides or quarters, should be moved to a room with a temperature of 10^{o}c and the mean air speed at a level 0.75m/s or above to be kept for the first 12 hours.
- Freezing is performed in tunnels or in chambers with intense air circulation called blast chambers while air should circulate at high speed, from 2 to 4 m/sec up to 6 m/sec. Air temperatures should be in the range of -30°C to -35°C.

- Meats properly frozen should be transferred from the freezer to storage chambers of -18°C to -25°C where temperature, relative humidity and air circulation should be adequate and can be tightly controlled. In particular fluctuations in temperature should be kept to a very narrow time interval.
- The freezing temperature should be in the range of -18°C to -25°C for periods of preservation of one year or more.
- For the storage of offal for more than 72 hours the temperature should be maintained below -10 ^{o}c.

In all the chilling and/or freezing rooms the following activities should be performed:

- Each room should be loaded as quickly as possible.
- Meat should be hanging or placed in a suitable corrosion resistant trays by allowing adequate circulation of air around meat (with on rail carcass space of 0.5m for cattle and 0.3 m for sheep and goat. See also “Export Abattoirs Construction Guidelines” and “Meat Cold Chain Guidelines”).
- Meat that is not in cartons should be placed in corrosion resistant trays and allowed to get sufficient circulation of air.
- Doors should not be left open for extended periods, and should be closed immediately after use.
- Chilling room or freezing rooms or freezer store should not be loaded beyond their designed capacity.
- Temperature should be checked and recorded regularly

9.7 Packaging

Packaging can influence meat quality in a number of ways. It can prevent contamination and spoilage that could otherwise compromise meat shelf-life, prevent dehydration and drying and can help maintain normal meat colour. The guidelines include, but not limited to, the following:

- Packing materials should be specifically recommended for packing food items.
- Packaging materials should not impart any undesirable substance to the meat product, either chemically, physically or microbiologically and should protect them sufficiently to avoid contamination. Liners should be used when packaging exposed meat products into unwaxed cardboard containers. Every effort should be made to prevent the meat products from coming into contact with the exposed surfaces of any shipping containers during filling.
- Packaging practices should be conducted in a clean and sanitary manner
- The wrapping should be sufficient for the purpose of protecting the meat from contamination.

9.7.1 Vacuum packing

The following guidelines, but not limited to, should be considered:

- Meat should be packed in gas-permeable plastic laminated bags at 2-4°C and a pH of 5.5-5.8 and stored at between -18°C and 1°C. At this time, residual oxygen is used up and carbon dioxide accumulates. Without air and water, bacterial growth is significantly reduced. The meat regains its red colour on re-exposure to air. Under a good vacuum, the package headspace consists of <1% oxygen and 10–20% carbon dioxide.
- The materials used, besides being specifically for food, should be chemically inert and prevent the transfer of foreign odours or flavours. They should be stable at low and high temperatures, elastic, tear-resistant, and proof against water vapour, oxygen and volatile substances. They should offer protection against light, particularly UV light.
- The following plastics should be used which are compatible with the meat industry for cold storage. Polyamide (PA), polyethylene (PE), polyester (polyterephthalic acid ester) (PET/PETP), polyvinylchloride (PVC), polyvinyliden chloride (PVDC).
- Vacuum-packed product should not be loaded out until the meat temperature is at or below 0°C. The optimum storage and transport temperature for chilled meat is the lowest possible temperature at which no freezing occurs. Non-vacuum-packed meat commences to freeze at about –1.5°C, and vacuum-packed meat starts to freeze at about –2°C (depending on meat type and pH). Therefore, the aim should be to reduce the meat temperature to -1°C to 0°C as soon as possible after packaging.

- ❖ When meat cuts are prepacked without vacuum, air pockets should be avoided. A 2 cm space should be left in the upper part of the box to allow for expansion.

9.8 Meat transportation

Meat should be loaded into refrigerated containers and transported to the port or airport under strict temperature-controlled conditions. To maintain the optimal shelf life and quality of beef, sheep and goat meat during transport, the temperature should be maintained at 0 to 2^{o}c for chilled and below -18°C for frozen products.

9. 8.1 Land transport

- ❖ Meat and carcasses should be transported from the abattoir to the port of exit in sealed and specially designed vehicles.
- ❖ Vehicles should be fitted with refrigeration system and minimum and maximum thermometer or another temperature sensing or recording device to monitor cold chain inside the meat container.
- ❖ Vehicles should be properly cleaned, disinfected out and air-dried before they are allowed to transport meat and carcasses.
- ❖ Vehicle doors and seals should be securely closed and that there will be no air leaks.
- ❖ Vehicles should be pre-cooled for at least 1 hour before loading to remove residual heat from the insulation, inner lining and the air of the trailer and it should be capable of maintaining the required temperature of the meat during the journey.
- ❖ Meat handlers and drivers should apply personal hygiene before handling meat.
- ❖ Meat and carcasses should be loaded, transported, unloaded or stored hygienically. In case of flight schedule break downs, it should be unloaded, stored and loaded by maintaining the required cold chain.

9.8.2 Air transport

During flight, the temperature is normally maintained between 15 and 20°C. Perishable cargo is usually carried in standard containers, sometimes with an insulating lining and/or dry ice but is often unprotected on aircraft pallets. The following measures should be put in place:

- Insulated containers should always be used to reduce heat gain.
- Meat should always be pre-cooled and held at the required temperature until loading.
- Containers should be filled to capacity.

- A thermograph should accompany each consignment.

9.9 Ensuring product wholesomeness, traceability, consistency and continuity

Meat quality issues related to wholesomeness, traceability, consistency and continuity of supply are some of the major factors affecting meat trade. To properly address those issues, the following measures should be implemented.

- Ensure strict compliance on application of ritual stunning and slaughter methods, such as Halal slaughter, if it is specified in the importing countries requirements
- Ensure meat products produced under certain ritual slaughter methods be clearly identified as such before shipped to the destination markets.
- Avoid any possible suspicion to be created by importers or consumers that the meat may be adulterated or comes from species of animals different from the ones agreed to be supplied or presence of any type of negligence or deliberate violations of enforcing the required regulatory measures.
- Collect, record and maintain as much as possible any relevant information that will help to trace back the identity and origin of the slaughter animals when required.
- Always maintain the consistency and conformity of the products supplied with the agreed specifications.
- Maintain continual supply of the required meat products in the specified amount and timing interval.

9.10 Addressing meat safety issues

Though the meat product may look attractive in terms of appearance and other sensory perceptions, consumers still require the product the purchase is safe to consume. Product safety matters most to modern day consumers. Consumers are concerned on the possibility that residues of antibiotics, growth promoters, hormones, and other drugs given to animals in the production process may end up in the meat they consume. Besides provisions outlined in the Meat Inspection Guidelines, Meat Inspectors and Inspector Veterinarians Guidelines and Meat Cold Chain Guidelines, measures including the following should be applied:

- ❖ All animals presented for slaughter should be subjected to ante-mortem inspection on an individual or lot basis and all records are properly recorded and kept.

- ❖ No animal should be slaughtered unless inspected by inspector veterinarian and certified as fit for human consumption.
- ❖ All sanitary measures should be applied to prevent any microbial or chemical contamination of meat during dressing, storage and transport operations until it reaches the destination markets
- ❖ Cold chains should be kept at all times and levels of operation
- ❖ Packaging practices should not compromise the hygienic and quality status of meat.
- ❖ Any meat product coming out of export abattoirs should bear official inspection mark as fit for human consumption.

9.11 Use of meat quality improvement technologies

Different technologies that may help to preserve, extend or enhance different aspects of meat quality parameters are being investigated and in use in many countries today. The guidelines for using these technologies particularly use of non-meat ingredients should include the following:

- Use of any chemical substance or non-meat ingredients on meat should be made incompliance with the national legal provisions, importing countries requirements and with the full awareness and approval of the veterinary inspectors.
- Ensure the non-meat substances to be used on fresh meat are free from any possible chemical or microbial contamination
- Ensure the non-meat substances are sourced from reliable supplier, stored and handled in a sanitary manner.

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