

---

## UNIT 4 FACTORS AFFECTING QUALITY OF MEAT

---

### Structure

- 4.0 Objectives
- 4.1 Introduction
- 4.2 Meat Quality
  - 4.2.1 Functional Quality
  - 4.2.2 Eating Quality Parameters
  - 4.2.3 Wholesomeness
- 4.3 Pre-Slaughter Factors Affecting Meat Quality
  - 4.3.1 Animal Factors
  - 4.3.2 Managemental Factors
  - 4.3.3 Ante-mortem Factors
- 4.4 Post-Slaughter Factors Affecting Meat Quality
  - 4.4.1 Temperature
  - 4.4.2 Ingress of Contaminants
  - 4.4.3 Hot Processing/Accelerated Processing
  - 4.4.4 Others
- 4.5 Let Us Sum Up
- 4.6 Key Words
- 4.7 Some Useful Books
- 4.8 Answers to Check Your Progress

---

### 4.0 OBJECTIVES

---

After reading this unit, you will be able to:

- explain meat quality;
- conceptualize different quality parameters;
- identify factors those affect meat quality, and
- produce good quality meat.

---

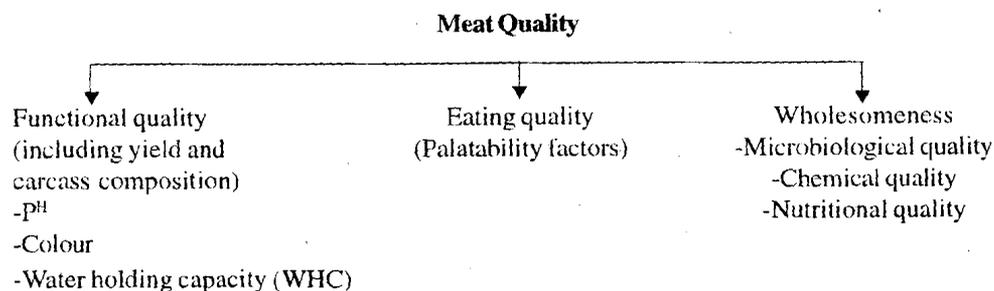
### 4.1 INTRODUCTION

---

The term 'Quality' has different meaning to different people depending upon their personal needs/fulfilment of expectations from the use of a particular item. For example, you think of an item of daily use namely, a shaving cream or a toilet soap. There are hundred of brands in the market, but you select one on the basis of your affordability and characteristics that suit to your requirements but many other people do not like the same brand as their requirements are different. Hence, quality is dynamic and is never absolute and because of this it means many things to many people. In the production and marketing of meat, major players are farmer, processor, wholesaler, retailer and consumer. Therefore, characteristics of meat those satisfy the needs of the above categories of users can be termed as 'meat quality'. Yield is an important parameter for the farmer and wholesaler, functional quality parameters are important to processor to produce a better product and palatability (eating quality) factors are important to the consumers who are the ultimate users of the meat.

## 4.2 MEAT QUALITY

In simple words 'Meat Quality' refers to some characteristics of meat (*viz.*, attractive colour, tenderness, flavour, water holding capacity) which should be present in a portion of meat (or in a meat sample) to call it a good quality meat. Based on these desirable characteristics, meat quality can be categorized as follows:



### 4.2.1 Functional Quality (Including Yield and Carcass Composition)

Yield is very important for the farmer and wholesaler as mentioned earlier because it reflects how much saleable meat/product you get from an animal and this is the determining factor for economics of meat production. Besides yield, amount of muscle, bone and fat obtained is also important. In general, a higher ratio of lean to fat is preferred now-a-days for health reason as most people are reluctant to purchase fatty meat. Functional properties such as  $p^H$ , WHC are of chief importance to the processors who produce processed meat products for the consumers. Composition of meat as well as functional properties will determine the quality of processed products in terms of juiciness, texture/tenderness, flavour and to some extent product appearance.

You have already learnt that post mortem  $p^H$  decline rate and ultimate  $p^H$  play very crucial roles in determining the final quality of meat and affects both colour and WHC. A fast  $p^H$  fall (5.2 or below within one to two hours of post mortem) while the carcass is still warm results in PSE (pale soft exudative) meat which has pale and watery appearance and very low water holding capacity due to denaturation of muscle proteins. On the contrary, DFD (dark firm dry) meat is obtained from an exhausted animal whose glycogen reserve has been severely depleted before slaughter, resulting in high ultimate  $p^H$  (>6.5). Meat with high ultimate  $p^H$  has very dark red appearance causing its low acceptability among consumers as fresh meat. Such meat, although, has high water holding capacity, has a very low shelf life because it is prone to microbial spoilage due to high  $p^H$ . Meat obtained from a healthy, well nourished, unstressed animal will have an ultimate  $p^H$  of 5.4 to 5.6, which is considered to be normal.

Water holding capacity is defined as the ability of meat to retain its own water during application of external forces such as cutting, grinding, pressing, cooking, etc. WHC is important for three main reasons. Firstly, meat with poor WHC produces more 'drip' or exudates (reddish watery liquid) in the packages on retail display. Secondly, more loss of drip as well as loss of moisture from the exposed surface results in more weight loss (shrink) of fresh meat during storage. Thirdly, meat with low WHC loses a lot of water during cooking and consequently causes lesser yield in processed products which may taste dry and lack succulence due to loss of more water. You will learn more about WHC in the next unit.

Colour or appearance of meat is important as it is the only criterion on the basis of which a consumer judges its acceptability during purchase of meat from the retailers.

Meat from different species differs in colour which will be discussed in details in the next unit.

### 4.2.2 Eating Quality Parameters (Palatability Factors)

Eating quality parameters are those factors or attributes of meat which determine the satisfaction of the consumers while eating meat or the pleasure s/he derives from eating meat. Important eating quality parameters of meat and meat products are colour, juiciness, texture and tenderness, and flavour/odour, although the liking for these parameters varies from culture to culture. For example, in many developed countries, people prefer their meat to be tender and the value of different cuts or joints reflects this. On the contrary, many Africans prefer their meat to be "chewy". Similarly, in India many people prefer 'bone-in' meat (especially mutton and chevon) compared to deboned meat for meat curry (major house-hold meat preparation).

### 4.2.3 Wholesomeness

Wholesomeness with regards to any food encompasses microbial safety, freedom from harmful chemical residues and availability of nutrients expected to be there in a particular type of food. Therefore, meat must be safe to eat, both in terms of freedom from parasites that may also infect humans, and microbial pathogens and hazardous chemicals. At the same time, it must be positively beneficial to the consumer's health in contributing minerals, vitamins and high value protein and possibly essential fatty acids to their diet.

---

## 4.3 PRE-SLAUGHTER FACTORS AFFECTING MEAT QUALITY

---

By this time, you know what does meat quality mean. You are also aware of different meat quality parameters. These quality parameters in different meats are affected by various factors.

Now, we will discuss about pre-slaughter factors.

Pre-slaughter factors are those which occur before the slaughter of the animal for meat purpose such as animal factor, managemental factors and ante-mortem factors. Animal and managemental factors are called as on-farm factors and traditionally, they are considered to be the most important, but under modern production systems, similar importance have also been given to ante-mortem handling of the animals and post-mortem handling of the carcasses.

### 4.3.1 Animal Factors

(a) **Species:** Meats obtained from different species of animals have species specific quality. For example, buffalo meat is lean, low in cholesterol and has excellent blending quality for production of corn beef, hot dogs and other types of sausages. When we compare goat meat (chevon) with sheep meat (mutton), we find that goats tend to deposit most of their fat in omentum, mesentery and around kidneys, whereas, sheep deposit more fat in the carcass. Goats lack the tendency to deposit sub-cutaneous fat particularly over the loin region as compared to sheep. Mean carcass fat in goat ranges below 4 per cent in young goats to about 18 to 20 per cent in mature goats.

In comparison, the dissectible fat in lamb carcasses commonly ranges from 20 to 35 per cent. The ether extract (marbling fat) is 3 to 4 per cent less in chevon. Therefore, of cost per unit of lean meat and in nutritional terms, chevon is better than goats have thicker muscle fibre bundles than sheep of similar

weight group. This makes chevon more 'chewable' (different from toughness) than mutton. This characteristic is liked by many individuals as mentioned earlier. Overall, meat from large animals (cattle and buffalo) are coarser in texture compared to small animals viz., pig, sheep, and goat.

**(b) Breed:** Within the same species, different breeds of animals differ in meat quality. The best quality beef is often obtained from traditional beef breeds of cattle like the Hereford and Aberdeen Angus. Hereford and Aberdeen Angus are early maturing breeds and deposit subcutaneous and intra-muscular (marbling fat) fats in the carcasses at earlier age compared to dairy breeds of cattle viz., Friesian, Holstein and Jersey. Beef breeds produce higher meat-bone ratio and such meat is more tender, juicy and flavourful due to higher degree of marbling. Different breeds of animal have different inherent amounts of intra-muscular fat. Other important exotic beef breeds are Belgian Blue, Limousin, Charolais etc. The beef from humped indigenous cattle (*Bos indicus*) tends to be tougher than that from above mentioned European breeds (*Bos taurus*).

Indian goat breeds have been classified into milch type, meat type and fibre type depending upon their production potential. Important meat type breeds of goats are: Bengal, Barbari, Gohilwadi, Kutchi, Malabari (Tellicherry), Marwari, Mehasana, Osmanabadi, Sangamneri and Zalawadi. Similarly, important sheep breeds for mutton production are Bikaneri, Magra, Malpura, Mandya, Muzaffarnagari, Madras red, Nellore etc.

**(c) Age:** As used in meat grading standards, maturity is defined as the physiological age of the animals or birds from which carcasses are produced. Maturity or age at slaughter is very closely related to meat tenderness. In general, tenderness decreases with increasing age. Therefore, meat from a young animal is more tender than from a mature animal of the same species and breed. This is mainly because of changes in inter-molecular cross-linkages in collagen fibres. In young animals, these cross-linkages are less in number and are more easily broken. As the animal grows older, the number of cross-linkages increases and the linkages are converted to stable linkages. Consequently, during cooking collagen is more soluble in meat from young animals and becomes less soluble as the animal ages. Age has profound effect on the colour and flavour of meat. With the advancement of animal's age, the muscle colour becomes darker due to increasing myoglobin (Mb) concentration. Such muscles, when used in processed meats contribute positively to the development of desirable product colour. Leg muscles are deep red than loin and myoglobin concentration increases with age. Veal and lamb are paler than beef. Mb concentration is low in rapidly respiring animal like rabbit (0.02 per cent). Mb forms 0.7 per cent or more of the muscle weight in horses and at levels of 5 to 8 per cent in seals and whales. Meat flavour intensity increases with animal age. The main reason of this flavour change is increased concentration of nucleotides in muscle which degrade to inosinic acid and hypoxanthine post mortem.

**(d) Location of muscles:** Location of muscles in the carcass is also important as there are distinct differences in tenderness between muscles. Muscles of the limbs, neck, etc. (where the workload) are more become tougher due to high degree of movement with the advancement of age compared to muscles of loin which require little or no mobilization (movement) during day-to-day activities.

**(e) Sex:** Sex of the animal determines the rate and extent of fat deposition, growth rate as well as development of some odourous compounds in the body related to sexual maturity which affect the quality of meat. In general, males have less intramuscular fat than females, whereas castrated animals of any sex have more intra-muscular fat than the corresponding sexually entire animals. Intact males produce

superior carcass leanness and hence preferred by fresh meat merchandisers and the consumers who prefer lean meat. The muscles of male animals tend to be larger than corresponding muscles in females and castration in male reduces the efficiency of weight gain in comparison to entire animals. But sometimes, 'boar-taint', an objectionable onion like or perspiratory odour is noted by some consumers in the pork from entire male (boar) and this is mainly due to the presence of a metabolite of testosterone,  $5\alpha$  androst-16 en- 3 one in the edible tissues.

### 4.3.2 Managemental Factors

**(a) System of rearing:** Among the managemental factors, the most important is the system of animal rearing. These are intensive system, mostly followed in developed countries, extensive system as followed in our country and other Asian and African countries and the semi-intensive system which is in-between intensive and extensive system of animal rearing, where animals are grazed and also supplemented with concentrate feeds.

Free range animals have the potential to have access to variety of feed stuffs prior to slaughter that may affect the flavour of the meat. Meat from grass finished cattle is of lower quality and less tender from grain fed cattle. In intensive system, if the animals are over crowded, there may be limited access to feed and water and animals exhibit undesirable social behaviours such as fighting, chewing and inability to rest properly. In these situations, animals' growth rate will be affected and meat obtained from them will be lower in overall fatness and may have a higher incidence of quality problems related to stress during slaughter. On the other hand, new animals reared in more ideal conditions will have better growth rate, uniform fat deposition and will produce better quality meat. Free range animals have more muscle pigments than their stall-fed counterparts. A high plane of nutrition and a diet low in iron lead to low myoglobin concentration.

**(b) Feeding:** Feeding of high energy carbohydrate diets leads to faster growth and fat deposition in all livestock. Feeding of meat animals with fish meal, certain plants such as sting weed, certain strains of clove and other legumes may produce meat with abnormal flavour (taint). Use of high concentration of animal manure as a source of organic nitrogen may also lead to tainting of meat.

**(c) Treatment:** Some volatile chemicals such as turpentine, linseed oil, ammonia (gas) used in veterinary practices may lead to tainting of meat. Of course, this can be managed by chilling of affected dressed carcasses for 24 hours. Care must be taken to provide adequate gap between medication and slaughter, so that veterinary drug residues are not present in the meat.

### 4.3.3 Ante-mortem Factors

Important ante-mortem factors affecting meat quality are transportation of live animals, lairage management, pre-slaughter handling and stunning.

**(a) Pre-slaughter handling:** Pre-slaughter handling of meat animals include the process of loading at farm, the journey to the abattoir lairage and subsequent handling upto the point of slaughter. During completion of these processes animals are subjected to wide variety of 'stressors', which adversely affect the meat quality. Animals exposed to long term pre-slaughter stress have reduced glycogen content in the muscles at slaughter. As a result, upon onset of rigor mortis,  $p^H$  decline does not proceed at a normal rate and the ultimate  $p^H$  is higher than normal ( $\geq 6.5$ ) resulting in Dark, Firm and Dry (DFD) meat. DFD meat is perfectly fit for food but has a less desirable colour and flavour and lower keeping quality. This meat is also resisted by the meat

trade for use as normal meat cuts. Moreover, DFD meat gets spoiled rapidly due to high  $p^H$ . Short term stress results in Pale, Soft and Exudative (PSE) meat which has a lower  $p^H$  than normal. The meat is pale in colour with very poor water holding capacity. During cooking, PSE meat loses a high amount of moisture resulting in drier, tougher and less flavourful meat. Improper rough handling, mixing of animals of different social orders during transportation and in the lairage, poorly designed holding and handling facilities in the lairage and other conditions that induce stress just prior to slaughter result in PSE meat.

**(b) Transportation:** The transportation phase of livestock marketing can be one of the most important event affecting meat quality. In India, the animals are transported mostly on hoof to the markets and from there by trucks to urban abattoirs. Most death losses and tissue bruising occur during transit. Improperly ventilated trucks, warm climatic conditions, overloading etc. can result in extreme stress to the animals resulting in poor quality of carcass and loss of weight which is referred to as 'shrinkage'. However, under normal marketing conditions the muscle weight is not affected, even though animals may lose 2 to 5 per cent of their live weight mainly due to loss of contents of gastro-intestinal tract.

**(c) Stunning/ Immobilization method:** The type of stunning method used can affect meat quality, either by short-term pre-slaughter stress or by affecting bleeding (exsanguination). Therefore, stunning process is not completely free from stress, but definitely reduces stress responses compared to exsanguination without stunning. The severity of stress of stunning process is usually expressed in muscles by the degree of glycogen depletion. These differences in glycogen content in muscles will determine the ultimate  $p^H$  and the physical properties of meat as discussed earlier. If there is delay between stunning and sticking operations, both captive bolt pistol and electrical stunning may produce 'blood splash' in muscles (small blood spots due to rupture of capillaries) due to marked rise in arterial blood pressure. Pigs anaesthetized by carbon dioxide produce the lowest incidence of PSE and blood splash and the quality of meat produced is superior.

---

## 4.4 POST-SLAUGHTER FACTORS AFFECTING MEAT QUALITY

---

You have already studied the different pre-slaughter factors that affect meat quality. Now, we will discuss about some post-slaughter factors which affect different aspects of meat quality *viz.*, functional quality, eating quality and wholesomeness of meat.

### 4.4.1 Temperature

Temperature is a major factor determining the rate of post-mortem chemical reactions in muscles. Therefore, temperatures at which freshly dressed carcasses/meats are stored have a profound effect on the functional and eating qualities of meat. It is always desirable to reduce muscle temperature after slaughter as quickly as possible to minimize protein denaturation and to check microbial growth in meat. But two undesirable conditions known as 'cold shortening' and 'thaw rigor' may develop in muscles due to low temperature in muscles before the onset of rigor mortis. You will study about 'cold shortening' and 'thaw-rigor' in details afterwards.

Besides above changes, holding of meat at low temperature results in improvement in tenderness, juiciness and flavour of meat. This phenomenon is called 'ageing' or 'conditioning'. This is an important event which determines the palatability of meat particularly beef. The major factor responsible for meat 'ageing' is degradation or

proteolysis of muscle proteins. Proteolysis in post-mortem muscles is contributed mainly by calcium activated sarcoplasmic factors (CASF) i.e., calpains and the level of their inhibitor, calpastatin in the muscles.

#### 4.4.2 Ingress of Contaminants

Contamination during slaughter and subsequent handling of meat determines the wholesomeness of meat to a greater extent. Stunning instruments, knives, scalding tank (in case of pig and poultry) are major sources of contamination of dressed carcasses, if proper cares are not taken during their use. The significance of contamination of carcasses during the slaughter is that more the number of microorganism, less is the storage life of meat and vice-versa. Moreover, lesser the degree of contamination, lesser is the chance of presence of pathogens in the carcasses thereby improving the wholesomeness of the meat. Meat receives extensive handling during cutting and deboning which makes it more susceptible to contamination. The level of contamination depends on local conditions, the throughput of the deboning room, the temperature, the period of time meat is present in the room and the cleanliness of the cutting tables, conveyor belts, knives and other equipments. To check the microbial growth and aerial contamination, temperature of meat cutting room must be maintained at 12°C or below.

#### 4.4.3 Hot Processing/Accelerated Processing

Conventional system of beef processing follows the chilling of the carcasses to 7°C or below before subsequent cutting into smaller cuts and further processing. In this process, muscles including bones and fats are also cooled which is waste because while preparing the carcasses for retailing much of the bones and fats are removed. By this way, lot of energy required for cooling the carcass goes waste. Moreover, because of its large size and irregular shape, whole carcass gets unevenly cooled. To solve this problem, a processing method referred to as hot boning, hot deboning or hot cutting has been developed. In this method, deboning (removal of muscle from the bones) is done when the carcass is still hot (before any cooling). Hot processing affects the meat quality both positively and negatively. Hot boning improves functional properties of meat, particularly the WHC but encourages rapid microbial growth unless chilled rapidly.

Such hot processed meat has a better yield (about 2% more), better WHC resulting in less drip on storage and uniform colour. It also reduces refrigeration space, energy, labour cost and also reduces the time needed to produce marketable meat. Some disadvantages include non-maintenance of characteristic shapes of joints and slightly tougher meat. Toughness in hot processed meats results from both 'heat shortening' due to prolonged holding of meat at high temperature and also from 'cold shortening' due to very fast cooling compared to whole carcasses. Precautions must be taken regarding hygiene while going for hot deboning because conditions will be highly conducive for microbial contamination and growth due to prolonged handling of carcasses at relatively high temperature.

#### 4.4.4 Others

Other post-slaughter operations to improve meat quality include electrical stimulation of carcasses, hanging beef sides from aitch bone, infusion of calcium chloride in muscle etc. These will be discussed in details in the latter chapter under appropriate headings.

### Check Your Progress

1) What is meat quality?

.....  
.....  
.....  
.....

2) What are different types of meat quality? Name some meat quality parameters.

.....  
.....  
.....  
.....

3) Enlist the pre-slaughter factors which affect the quality of meat.

.....  
.....  
.....  
.....

4) What do you mean by hot processing?

.....  
.....  
.....  
.....

5) Define water holding capacity.

.....  
.....  
.....  
.....

---

### 4.5 LET US SUM UP

---

Some parameters are taken into consideration while determining the quality of a product. Meat quality parameters are colour,  $p^H$ , water holding capacity, texture and tenderness, flavour, juiciness and also include microbiological, chemical and nutritional quality of meat. Factors affecting these parameters can be broadly classified into pre-slaughter factors and post-slaughter factors. Pre-slaughter factors can further be grouped into on-farm factors and ante-mortem factors. On-farm factors can be further sub-grouped into animal factors and managerial factors. Among animal factors important are the species, breed and age of the animal, while important managerial factors are feeding, nutrition and rearing system (extensive, intensive or semi-intensive). Meat obtained from different species of animals have species specific quality. Thus meats obtained from bovine, caprine, ovine species vary from each other in various parameters mentioned above. Similarly, breed, age, plane of nutrition, management systems employed to rear meat animals have profound effect on different meat quality parameters. Among the ante-mortem factors, transportation

of animals, lairage management, stunning processes determine the ultimate  $p^H$ , water holding capacity, colour and shelf-life of meat. Post-mortem factors such as slaughtering, meat cutting, conditioning, hot processing etc. affect both eating quality and microbial quality of meat. Therefore, to produce wholesome, quality meat all the factors are to be taken into considerations and due care/precautions should be taken at every step of meat production and processing.

---

## 4.6 KEY WORDS

---

- Conditioning/Ageing** : Holding of meat at low temperature (above its freezing point) results in improvement of tenderness, flavour and juiciness of meat. This is called conditioning or ageing and this is an important event that determines palatability of meat, particularly beef.
- DFD (Dark Firm Dry) meat** : Meat with high ultimate  $p^H$  (>6.5) has very dark red appearance causing its low acceptability among consumers. This is due to preslaughter exhaustion of glycogen store in muscle resulting in high ultimate  $p^H$ .
- Eating quality of meat** : Those factors or attributes of meat which determine the satisfaction of the consumers while eating meat or the pleasure s/he derives from eating meat.
- Meat quality** : Characteristics of meat those satisfy the need of farmers, processors, wholesalers, retailer and finally consumers can be termed as meat quality.
- PSE (Pale Soft Exudative) meat** : Meat which is pale and watery appearance with very low water holding capacity due to very fast rate of  $p^H$  decline causing denaturation of muscle proteins.
- Wholesomeness** : It includes microbiological, chemical and nutritional quality of a food product.
- WHC** : Water holding capacity is defined as the ability of meat to retain its own water during application of external forces such as cutting, grinding, processing, cooking, etc.

---

## 4.7 SOME USEFUL BOOKS

---

- Forrest, C.F., Aberle, E.D., Hedrick, H.B., Judge, H.D. and Merkel, R.A., (1975). *Principles of Meat Science*. W.H. Freeman and Company, San Francisco.
- Lawrie, R.A. (1998). *Lawrie's Meat Science*. 6<sup>th</sup> ed. Woodhead Publishing Limited, England.
- Sharma, B.D. (1999). *Meat and Meat Products Technology*. 1<sup>st</sup> ed. JAYPEE Brothers, New Delhi.
- Warriss, P.D. (2000). *Meat Science — An Introductory Text*. CABI Publishing, U.K.

## 4.8 ANSWERS TO CHECK YOUR PROGRESS

- 1) The term quality has different meaning to different people depending upon their personal needs and fulfilment of expectations from the use of a particular item. Hence, concept of quality is dynamic and is never absolute. In the production, processing and marketing of meat major players are farmers, processors, wholesalers, retailers and consumers. Therefore, characteristics of meat those satisfy the needs of the above categories of users can be termed as meat quality.
- 2) Meat quality can be categorised into three main categories. They are functional quality including yield and carcass composition, eating quality (palatability factors) and wholesomeness.

Yield is very important for the farmers and wholesalers because it reflects the amount of saleable meat that can be obtained from an animal which is the determining factor for economics of meat production. The amount of meat, fat and bone (carcass composition) obtained from a carcass is also important to meat products processors as well as to consumers. Now-a-days consumers prefer meat with less fat for health reasons. Other functional quality parameters namely, colour,  $p^H$ , water holding capacity are of highly valued to the processors.

Eating quality parameters include colour (appearance), texture and tenderness, juiciness and flavour/odour of meat. Of course liking for these parameters vary among the consumers belonging to different cultures. Some people prefer tender meat whereas others prefer 'chewy' meat. Chevon is the most preferred meat in India whereas people in many countries can not withstand the flavour/odour of chevon.

Wholesomeness of meat includes microbiological quality, chemical quality and nutritional quality. Consumers value the product which offer them microbial safety, freedom from undesirable chemical residues and sufficient nutrition for which they are paying.

- 3) Pre-slaughter factors which affect the quality of meat are as follows:
  - a) Animal factors like-species, breed, age, sex and location of muscle.
  - b) Managemental factors like-system of rearing, feeding and treatment.
  - c) Ante-mortem factors like pre-slaughter handling, transportation and stunning.
- 4) Hot processing is a method where the deboning i.e., removal of muscles from bone is done when the carcass is still hot i.e., before any cooling. This method is also known as hot deboning or hot cutting. It results in better yield, better WHC, lesser drip loss, better colour, lesser requirement for refrigeration space, energy and labour cost.
- 5) Water holding capacity is defined as the ability of meat to retain its own water during application of external forces such as cutting, grinding, processing, cooking etc.