Beef cattle breeding systems

Beef cattle breeding systems

Regardless of the breeding system chosen, the breeder must struggle for genetic improvement in the traits identified as economically important for both the current and future performance of the herd.

The basic objective of animal breeding is to enhance the efficiency of production and the quality of the product for the end-consumer through planned genetic change.

Beef cattle breeding systems

The choice of whether to straight breed or cross breed will be related to your ability to match your cattle, the environment and the market.

Straight breeding programs

Straight breeding produces not only progeny for further finishing, but also replacement females for the herd. For this reason, many traits have to be selected in balance, as they contribute to the overall package. it is important to identify and select those cattle that are superior for specific traits.

Straight breeding programs

Straight breeding programs appeal to many beef breeders because they produce replacement females from within the herd. They are reasonably easy to manage because only one cattle breed exists on the property.

Straight breeding programs

Important points

BREEDPLAN estimated Breeding Values (EBVs) and $indexes are available for selecting both bulls and cows.

Breeding management options are simple and don't require you to select sires from different breeds or to mate different sires in different paddocks.

Straight breeding programs

Herds are self-replacing: breeder replacements are produced within the herd.

Turnoff animals are similar, with little variation.

Lines that 'look' even (i.e. for colour) may attract a premium.

Straightbred females continue to be in demand for use in crossbreeding systems.

Crossbreeding programs

Crossbreeding systems can bring together a desired combination of genes more rapidly than can be achieved through within-breed selection. Advantage can be taken of complementarity among breeds, but knowledge of individual breed characteristics is important.

Crossbreeding programs

The decision to crossbreed is also often related to the potential gains of hybrid vigour, an additional boost to production. Hybrid vigour, or heterosis, is the difference between the performance of the progeny and the average performance of the parents.

Crossbreeding programs

In general, the more distantly the parental breeds are related, the greater the amount of heterosis that can be expected. the greatest level of heterosis results from the crossing of the least related purebred Bos indicus and Bos taurus breeds. Heterosis is greater for some traits than others (e.g. fitness traits: parasite resistance, survivability, environmental adaptation etc.).

Crossbreeding programs

For greatest benefit in all crossbreeding programs, it is essential that the programs be based on straightbred animals of high genetic merit for economically important traits. Tools such as Breed Plan EBVs and $indexes can be used to select these animals.

Crossbreeding programs

Continuing improvement from a crossbreeding program depends on the genetic merit of the foundation animals used in the cross (i.e. the selection intensity in the populations in which they were bred) and the selection intensity placed on the subsequent crossbred generations.

Crossbreeding programs

Crossbreeding provides flexibility because it allows you to quickly alter particular characteristics of a herd for a specific purpose, such as to cater to a particular market, increase production or remedy a problem. there can be disadvantages with cossbreeding, such as management difficulties.

Planned crossbreeding systems

Although the potential gains from crossbreeding are large, most of the success depends on good planning and the use of superior genetics to provide the priority traits identified for a specific breeding enterprise. The following briefly outlines the key 'planned' approaches to crossbreeding.

Rotational crosses

Hereford and Angus rotational cross.

Rotational crosses

- ***Rotational crossing simply means that two or more different sire breeds are used in sequence over the female groups, which are grouped according to their sire breed. Two, three or even four sire breeds may be used.***

Rotational crosses

- ***In a simple system that uses two breeds, cows of breed A are mated to sire breed B, with the resulting heifers being joined back to sire breed A.***

A(f) X B(m)

F(f) X A(m)

Rotational crosses

- ***Within a three-breed rotation, the progeny of sire breed A over cow breed B are mated to sire breed C. The female progeny of the latter cross are mated back to sire breed A for the rest of their breeding lives. the minimum number of joining groups is equal to the number of sire breeds.***

A(f) X B(m)

F(f) X C(m)

Rotational crosses

An increase of 10 to 20 per cent in the weights of calves weaned per cow joined can be achieved from a two-breed rotation (criss-cross).

A greater increase in the weight of calves weaned per cow joined can be achieved from a three-breed rotation.

Rotational crosses

In a rotational cross system, each breed contributes its strengths and weaknesses equally to the production system over a number of years. The level of heterosis achieved depends on the number of breeds involved (i.e. the more breeds, the more heterosis).

However, in a rotational cross system variability among the progeny may make it more difficult to consistently meet a market specification. Therefore, the use of breeds that are not radically different is probably preferred.

Rotational crosses

- ***All animals in the herd benefit from hybrid vigour for both growth and maternal traits. All females from a rotational cross system are potentially available for selection as replacements; this increases the selection intensity and subsequent opportunities for genetic improvement.***

Rotational crosses

- ***Rotational systems consider the market animal and the future replacement breeders. Rotational crossbreeding may present some management difficulties in that specific breeder groups need to be mated to specific sire breeds.***

Important points of rotational crosses:

**The system generates its own replacement females.*

**Hybrid vigour is retained, giving a 10 to 20 per cent increase in weaning weight.*

**Cows can be run as one mob for most of the year, as they need to be separated by sire group only for joining.*

**Depending on the breed chosen, some variability will occur within the progeny.*

**Breeds with good maternal traits should be used, as the female progeny of all sire breeds are kept.*

Two-way cross (F1)

Brahman Hereford two-way cross.

Two-way cross (F1)

This is a simple system whereby a bull of one breed is joined to straightbred cows of another breed. All the progeny are sold (to slaughter or, in the case of females, as F1 breeders).

A(m) X B(f) (straightbred)

F_1 (m) (sloughter), F_1 (f) (sloughter or breeders)

Two-way cross (F1)

- ***Hybrid vigour is generated in the progeny only. Because the cows are straightbred there is no hybrid vigour generated at this level.***

Two-way cross (F1)

This system does not produce its own replacements, so replacements need to be purchased or bred in a separate enterprise.

This system offers the opportunity to produce and market specialised F1 females that are often highly sought after.

Two-way cross (F1)

Male progeny can be sold as weaners or feeder cattle; this could be into a specialist trade

Important points of two-way crosses:

**There is a 5 to 10 per cent increase in weaning weight turned off per cow mated.*

**Straightbred female replacements can often be purchased.*

**Heifer progeny have increased value as F1 breeders.*

**F1 steers have increased value for feeding or slaughter.*

Terminal sire joined to first-cross (F1) females

Terminal sire joined to first-cross (F1) females

Terminal sire joined to first-cross (F1) females

In this system, a third breed of bull is joined to first-cross (F1) cows and all progeny are sold, meaning that the system terminates at that point.

A (m) X B (f) (straightbred)

↓

F_1 (f) X C (m)

↓

F_2 (m), F_2 (f) (sold)

Terminal sire joined to first-cross (F1) females

This is the most productive system, as F1 females of the right breed groups can maximise maternal heterosis for fertility, milking ability and longevity. They can also be selected for environmental adaptation and medium size, meaning that their feed requirements are not too high. Sires can then be selected for their growth and carcase traits.

Terminal sire joined to first-cross (F1) females

The main problem with this system is that it doesn't generate its own replacement females: they must be sourced from outside the system. they can be bred on another part of the property, but this necessitates running a herd of purebred cows, which are often of lower productivity. Buying F1 females can be difficult, but longevity can mean that fewer replacements are needed.

Terminal sire joined to first-cross (F1) females

The environment in which the herd is to run needs to be considered when you are selecting the breeds that make up the F1 females.
If feed resources are plentiful and of high quality, breeds with high milking ability may be used and may even include the dairy breeds. Some possible combinations are;

Friesian × Hereford or Simmental × Angus.

Terminal sire joined to first-cross (F1) females

In poor environments, breeds that have more moderate size and milk production may be more suitable (e.g. angus × Hereford).
In tropical and sub-tropical areas, Bos indicus or Sanga breeds may be combined with British breeds, e.g.

Brahman × Hereford, Santa Gertrudis × Angus)

Terminal sire joined to first-cross (F1) females

The environment and the target market need to be considered when selecting the terminal sire.

It may be possible to use a high growth, high carcase yield breed such as the Charolais or Limousin in environments with adequate high quality feed. However, in lesser situations a 50:50 European British cross sire may be better suited (e.g. Charolais × Angus).

Terminal sire joined to first-cross (F1) females

In some situations, the terminal sire breed chosen for the main breeding herd may not be suitable for use over heifers having their first calves. This may mean having separate sires available.

Terminal sire joined to first-cross (F1) females

Important points of joining terminal sire to first-cross (F1) females:

****Maximum hybrid vigour is utilised.***

****There is a 20 to 50 per cent increase in weaning weight turned off per cow mated.***

****The breed can be selected to maximise complementarity.***

Terminal sire joined to first-cross (F1) females

**Cows can be selected to best suit the environment and sires selected to specifications.*

**Offers an opportunity to select sires by using EBVs and indexes.*

**Replacement females are needed from outside the system.*

**Heifers may need to be mated to bulls with low calving risk.*

Composites

European British composite bull.

Composites

An alternative to crossbreeding in some situations is to use a composite breed.

Composites

The development of a composite breed results from the crossing of two or more existing breeds and then selecting from within that population. Examples include Santa Gertrudis, Droughtmaster and Brangus. The key advantage is that after the formation stage, when the initial crosses are made, the management requirements are the same as for straight breeding.

Composites

There is tremendous opportunity to change direction as the market or other circumstances dictate, by incorporating another new breed or crossbreed with desirable characteristics that change the animal's performance only as much as necessary.

Composite breeding allows for the blending of characteristics from a number of breeds into a composite that considers the turnoff animal as well as the replacement females.

Composites

The level of hybrid vigour retained depends on the number of breeds used to develop the composite (e.g. a four-breed composite will retain 25% more hybrid vigour than a two-breed one).

Important points of using composites:

*A high percentage of hybrid vigour can be retained.
*Replacement heifers are generated in the herd.
*Breeds can be selected to give the optimum mix of traits in one animal.
*Neither maternal nor paternal traits should be in extreme, because they are often antagonistic between male and female.
*In small herds the management is as simple as running a straightbred herd.
*Success in designing a composite requires a large herd and the avoidance of inbreeding.
*Variation in progeny will occur over the first three generations until the composite is stabilised.

Guidelines for humane handling, transport and slaughter of livestock

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RAP Publication 2001/4

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CONTENTS

PREFACE

Many developing countries have common problems concerning animal welfare, particularly in the livestock slaughter sector. These problems include handling of livestock, transport, pre-slaughter penning, stunning and bleeding.

The issues of humane treatment of slaughter animals in these countries are of growing importance because:

- In recent decades there has been an increased demand for livestock products, particularly meats;
- Meat output in developing countries now considerably exceeds that in developed countries, resulting in increasing numbers of animals slaughtered;
- Developing countries with a potential for exporting meat, where humane treatment of slaughter animals is not satisfactorily practised, will have to comply with sanitary and welfare requirements of importing countries;
- Humane treatment of slaughter animals not only reduces unnecessary suffering but also reduces loss of quality and value of meat and animal by-products, thus contributing to food security and income in most needy countries;
- Many developing countries have poorly developed and implemented welfare legislation, resulting in harsh conditions for livestock and excessive suffering.

FAO budgetary resources, mainly designated to maximise agricultural production in the food, crop and livestock sectors in developing countries, can provide only limited funds for livestock

welfare. Changes in developing countries towards more humane treatment of slaughter stock must come about by joint efforts of governments, producers, the meat industry and desirably also with the help of Non-Government Organizations (NGOs). However, FAO in cooperation with NGOs could be in a position to co-ordinate these efforts as well as provide technical advice and assistance.

This publication is provided as a joint effort between FAO and the NGO Humane Society International (HSI), to offer guidance to animal welfare personnel, transport operators, farmers and slaughterhouse management etc. in improving slaughter, livestock productivity and welfare.

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Illustrations were contributed by P.G. Chambers (Fig. 2, 3, 4, 5, 7, 8, 9, 10, 12, 14, 15, 17, 19, 20, 21, 23, 29, 31, 32, 34, 35, 36, 37, 38, 43, 45, 47, 49, 53, 55, 56, 58, 59, 60, 61, 73, 74), T. Grandin (Fig. 11, 13), G. Heinz (Fig. 1, 6, 16, 18, 22, 24, 25, 26, 27, 28, 30, 33, 39, 40, 41, 42, 44, 46, 48, 50, 52, 54, 57, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 75, 76, 77) and HSI (Fig. 51).

INTRODUCTION

Livestock referred to in this manual are animals from which meat is produced. Types of food animals vary in different parts of the world. This booklet will refer mainly to cattle, goats, sheep, pigs, poultry and ostriches. Other slaughter animals of relevance in particular in developing countries are buffaloes, camels and rabbits. The transformation of slaughter animals into meat is a chain of events including handling and loading on the farm, transport to the market, pens or slaughterhouse, off-loading and holding and finally slaughter. During these procedures poor operational techniques and facilities will lead to unnecessary suffering, injury and loss of production.

There are many advantages to improving conditions for livestock destined for slaughter. These will have the benefit of improvements in productivity, animal welfare and personnel safety.

Increased production through humane treatment of slaughter animals can be achieved, for example, through:

- reduced carcass damage and waste and higher value due to less bruising and injury;
- decreased mortality;
- improved quality of meat by reducing animal stress;
- increased quality and value of hides and skins.

Improving animal welfare is necessary to reduce suffering, in line with requirements of Governments, NGOs, and consumers, who are becoming more concerned with welfare of food animals. Better conditions of livestock operations will also improve safety of workers in the livestock and meat industry.

CHAPTER 1

ANIMAL STRESS AND PAIN

Scientific research has shown that warm-blooded animals (this includes livestock) feel pain and the emotion of fear. In particular mammals, including food animals of this group, have brain structures that enable them to feel fear and suffering from pain, and it is likely that they suffer pain in the same way as humans. Fear and pain are very strong causes of stress in livestock and stress affects the quality of meat obtained from this livestock. Pain is usually the effect of injury and suffering, which also affects the quality and value of meat from affected animals.

When animals are subjected to unusual conditions or circumstances due to the wilful actions of people, it is people's moral responsibility to ensure that the welfare of these animals is cared for and that they do not suffer unnecessary discomfort, stress or injury.

Efficient, experienced and quiet handling of livestock, using recommended techniques and facilities, as well as taking measures to eliminate pain and accidental injury, will reduce stress in the animals and prevent quality deficiencies in meat and by-products.

CHAPTER 2

EFFECTS OF STRESS AND INJURY ON MEAT AND BY-PRODUCT QUALITY

A. Meat quality

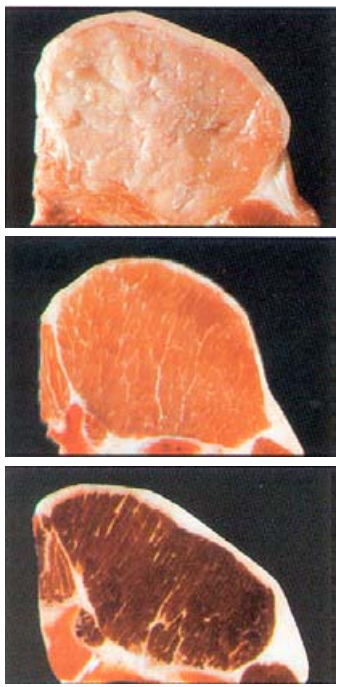
The energy required for muscle activity in the live animal is obtained from sugars (glycogen) in the muscle. In the healthy and well-rested animal, the glycogen content of the muscle is high. After the animal has been slaughtered, the glycogen in the muscle is converted into lactic acid, and the muscle and carcass becomes firm (rigor mortis). This lactic acid is necessary to produce meat, which is tasteful and tender, of good keeping quality and good colour. If the animal is stressed before and during slaughter, the glycogen is used up, and the lactic acid level that develops in the meat after slaughter is reduced. This will have serious adverse effects on meat quality.

Pale Soft Exudative (PSE) meat (Fig. 1)

PSE in pigs is caused by severe, short-term stress just prior to slaughter, for example during off-loading, handling, holding in pens and stunning. Here the animal is subjected to severe anxiety and fright caused by manhandling, fighting in the pens and bad stunning techniques. All this may result in biochemical processes in the muscle in particular in rapid breakdown of muscle glycogen and the meat becoming very pale with pronounced acidity (pH values of 5.4-5.6 immediately after slaughter) and poor flavour. This type of meat is difficult to use or cannot be used at all by butchers or meat processors and is wasted in extreme cases. Allowing pigs to rest for one hour prior to slaughter and quiet handling will considerably reduce the risk of PSE.

Dark Firm and Dry (DFD) meat (Fig. 1)

This condition can be found in carcasses of cattle or sheep and sometimes pigs and turkeys soon after slaughter. The carcass meat is darker and drier than normal and has a much firmer texture. The muscle glycogen has been used up during the period of handling, transport and pre-slaughter and as a result, after slaughter, there is little lactic acid production, which results in DFD meat. This meat is of inferior quality as the less pronounced taste and the dark colour is less acceptable to the consumer and has a shorter shelf life due to the abnormally high pH-value of the meat (6.4-6.8). DFD meat means that the carcass was from an animal that was stressed, injured or diseased before being slaughtered.



A.

B.

C.

Fig.1: A. Pale Soft and Exudative (PSE) meat
B. Normal meat
C. Dark Firm and Dry (DFD) meat

Spoilage of meat

It is necessary for animals to be stress and injury free during operations prior to slaughter, so as not to unnecessarily deplete muscle glycogen reserves. It is also important for animals to be well rested during the 24-hour period before slaughter. This is in order to allow for muscle glycogen to be replaced by the body as much as possible (the exception being pigs, which should travel and be slaughtered as stress free as possible but not rested for a prolonged period prior to slaughter). It is important that the glycogen levels in the muscles of the slaughtered carcass are as high as possible, to develop the maximum level of lactic acid in the meat. This acid gives meat an ideal pH level, measured after 24 hours after slaughter, of 6.2 or lower. The 24h (or ultimate) pH higher than 6.2 indicates that the animal was stressed, injured or diseased prior to slaughter.

Lactic acid in the muscle has the effect of retarding the growth of bacteria that have contaminated the carcass during slaughter and dressing. These bacteria cause spoilage of the meat during storage, particularly in warmer environments, and the meat develops off-smells, colour changes, rancidity and slime. This is spoilage, and these processes decrease the shelf life of meat, thus causing wastage of valuable food. If the contaminating bacteria are those of the food poisoning type, the consumers of the meat become sick, resulting in costly treatment and loss of manpower hours to the national economies. Thus, meat from animals, which have suffered from stress or injuries during handling, transport and slaughter, is likely to have a shorter shelf life due to spoilage. This is perhaps the biggest cause for meat wastage during the production processes.

Bruising and injury (Fig. 2 and Fig. 3)

Bruising is the escape of blood from damaged blood vessels into the surrounding muscle tissue. This is caused by a physical blow by a stick or stone, animal horn, metal projection or animal fall and can happen anytime during handling, transport, penning or stunning. Bruises can vary in size from mild (approx. 10-cm diameter) and superficial, to large and severe involving whole limbs, carcass portions or even whole carcasses. Meat that is bruised is wasted as it is not suitable for use as food because:

- It is not acceptable to the consumer;
- It cannot be used for processing or manufacture;
- It decomposes and spoils rapidly, as the bloody meat is an ideal medium for growth of contaminating bacteria;
- It must be, for the above reasons, condemned at meat inspection.

Fig. 2: Severe bruising
- Cattle carcass

Bruising is a common cause of meat wastage and can be significantly reduced by following the recommended correct techniques of handling, transport and slaughter.

Injuries (Fig. 4) such as torn and haemorrhagic muscles and broken bones, caused during handling, transport and penning, considerably reduce the carcass value because the injured parts or in extreme cases the whole carcass cannot be used for food and are condemned. If secondary bacterial infection occurs in those wounds, this causes abscess formation and septicaemia and the entire carcass may have to be condemned.

Fig. 3: Severe bruising
- Cattle head

Fig. 4:
Transport injury

B. Hides and skins quality

Hides and skins should have the highest value of any product of slaughter animals, other than the carcass. This is particularly so of cattle hides and small ruminants and ostrich skins. In the case of pigs and poultry, the skin forms part of the edible meat.

Useful leather can be made only from undamaged and properly treated skins. Proper handling of these items is important to produce a valuable commodity. Careless damage to hides and skins will cost the industry much loss.

Hides and skins of slaughter livestock (Fig. 5) can be damaged by thoughtless handling and treatment of these animals in the following ways:

Fig. 5:
Hide damage
- Brands and injury

1. Before slaughter:-
   - Indiscriminate branding;
   - Injuries from thorns, whips, sticks, barbed wire and horns;
   - Unsuitable handling facilities;

- Badly designed and constructed transport vehicles.

2. During slaughter:-
   - Causing the animals to become excited and injuring themselves;
   - Hitting or forcefully throwing the animal;
   - Dragging the carcass along the ground, alive or dead.

Consideration for animal welfare during transport and handling will improve the value of these by-products.

CHAPTER 3

MARKETING SYSTEMS AND LOSSES

Holding people accountable for losses

During the production chain from farm to market of meat and by-products, there may be considerable loss in the quality and quantity of meat and by-products. These losses may be in the form of:

- Carcass and meat condemnations due to bruising, injuries and deaths;
- Downgrading and unsuitability of hides and skins due to damage;
- Loss of meat quality due to DFD or PSE;
- Spoilage of meat due to stress and poor animal welfare of livestock.

In many developing countries, these losses are high because the marketing system does not always provide an economic incentive to reduce losses. One of the most efficient methods for improving welfare and reducing losses is to design marketing and payment system that hold people and organisations involved in the marketing chain of livestock accountable for these losses.

One of the worst marketing systems, from both welfare and an economic loss perspective, is to sell slaughter animals on a live mass or per head basis. This system does not provide an economic incentive to prevent bruising, injuries, stress or hide damage or other meat quality problems. When animals are sold to a slaughter plant on a live mass basis, the producer or transporter is not held accountable for losses due to bruises, injuries and other damages.

These losses are paid for by the slaughter plant. It is a common observation that cattle sold on a live mass basis have twice as many bruises as those sold on a carcass mass basis.

However, when cattle are sold based on the carcass mass and quality, both the producer and transporter have an economic incentive to reduce bruising and injuries, much greater care is taken of the handling and welfare conditions. Changing payment systems is one of the most effective ways to improve handling and transport practices.

The same applies to transport insurance. If animals on a transport vehicle are insured, the policy must be designed to encourage good handling practices and discourage poor practices. If a policy pays for all the bruised, crippled or dead animals, the transport operator has no incentive to handle animals carefully. Policies should have a deductible clause to pay only for a catastrophic loss, such as a truck accident, but will not pay for bruised animals or pigs dead from heat stroke. In another scheme, producers pay a bruising levy, which goes into a fund that pays for serious bruising, of say over 2 kg, or downgrading.

Only first-grade hides and skins can be used to make high quality leather. Hides and skins are graded according to the extent and distribution of damage. A bonus should be offered to owners and transporters for better grades, thus encouraging them to ensure that damage from various causes is kept to a minimum. In addition, slaughterhouse skinners should be charged a penalty for skins cut during flaying.

Segmented markets and piecework

Livestock marketing systems that have one or more agents between the producer and slaughter plant will usually result in more damage to livestock than market systems where animals are sold directly from the producer to slaughter plant or butcher. There are two reasons for this:

- First of all, the agents or middlemen have little incentive to ensure that damage to livestock is kept to a minimum;
- Secondly every time an animal is handled by a different middleman, it increases the likelihood of injury and stress. Animals taken to an auction before moving to the slaughterhouse will have to be loaded and unloaded an extra time.

Payment systems for people handling animals can greatly affect the way the animals are treated. Handling animals on a "piece work" basis provides the incentive for handling animals as fast as possible. This encourages abuse and reduces care. Producers have found that paying truck-loading workers on an incentive basis to reduce damages greatly reduced losses. In conclusion, it should be emphasised that appropriately changing payment and marketing systems is one of the best methods for reducing livestock damage and improving animal welfare during handling and transport. Anyone, who causes an animal to become injured, damaged, bruised or die must be held economically accountable for the losses.

CHAPTER 4

PRINCIPLES OF ANIMAL BEHAVIOR

Livestock behave in various ways, depending on circumstances and, to a large extent, species. A basic understanding of animal behaviour in typical circumstances from the farm to the market or slaughterhouse will assist handlers in the management of livestock and thereby prevent undue stress and injury.

For example, animals, which are unaccustomed to frequent contact with humans, such as ranched or extensively raised stock, will not allow people to approach or touch them easily. These animals will require more elaborate loading ramps, pens and handling races than tame ones. People loading extensively raised animals need to understand the psychology of the animal in order to prevent injury to either the animal or themselves. On the other hand, oxen, draught animals, those animals raised intensively or dipped regularly (for tick control) and animals living in close contact with humans, such as in rural areas, are generally more tame and easy to handle.

Relation of animal vision, hearing and smell to stress and injury

Ruminant animals can discriminate between different colours. The ruminant eye is most sensitive to yellow-green and blue light. Experience has shown that livestock, particularly cattle and pigs, as well as ostriches, are very sensitive to light contrast. This causes them to hesitate at and shy away from drains, gates, and changes from wet to dry or concrete to metal floors. Lighting should be even and diffuse and harsh contrasts of light and dark should be avoided. Ultraviolet or diffuse light has a calming effect on poultry and ostriches.

Some livestock species, e.g. cattle and ostriches have a wide angle of vision and to prevent them from becoming afraid of distractions outside confines, the holding pens, crowd races, stunning boxes and gates should have solid sides. Animals will also shy at moving things, as well as darkness and they may refuse to enter a dark place. Animals have a tendency to move from a darker to a lighter place. Extra, indirect lighting may help in moving animals in pens. Adding a light to illuminate a race entrance or removing a lamp to eliminate a sparkling reflection will often improve animal movement. All species of animals may hesitate and refuse to move when they see things in the race that scare them, such as sparkling reflections, dangling chains, moving people or equipment, shadows or water dripping. A calm animal will stop and look right at the distraction that scares it. If air is blowing towards the animal this should be changed. If animals hesitate, the distraction that causes this should be removed instead of increasing the force used to move them. Rapidly moving objects scare animals. Forcing them to quickly approach a vehicle, pen or building may cause them to panic.

Cattle, sheep and ostriches have very sensitive hearing, particularly to high frequency sound. Sounds that do not bother people, such as intermittent high-pitched noise, may hurt animals' ears. Reducing noise from equipment and people will improve animal movement, reduce stress and the risk of injury. People should not yell, whistle or make loud noises. Clanging and banging of equipment will unsettle animals and can be reduced by installing rubber stops. Hissing air is one of the worst noises but also easy to eliminate. It must be said, however, that in many rural circumstances where cattle live in close proximity to humans and where they are mustered, kraaled every night and regularly dipped, some of these noises can be useful aids to droving. For example in rural Africa, where cattle are accustomed to yelling and loud noise it encourages movement.

However, generally it is obvious that noise increases physiological stress levels. This refers also to preslaughter handling and handling at point of slaughter. Slaughter in a small, quiet abattoir produces less stress hormones in animals compared to a large, noisy commercial plant.

With regard to smell, emitted odours, particularly strange smells, may cause animals to become unsettled and excited. This is noticeable in animals, which are strangers to each other or to surrounding conditions. Pre-mixing of these animals, or smearing pigs with litter from a single source will reduce tension and fighting amongst strangers. Many people interested in the welfare of livestock are concerned about animals smelling blood. Cattle will hesitate and sometimes refuse to enter a stunning box or restrainer if the ventilation system blows blood smells into their faces. An exhaust fan to suck away smells will facilitate entry into a stunning box. If an animal becomes agitated and frenzied during slaughter handling, subsequent animals often become agitated as well and an entire slaughter day can turn into a continuous chain reaction of excited animals. The next day, after the surrounds and equipment have been washed, the animals will be calm. A stress pheromone in the blood of severely stressed animals can be smelt by others and cause excitement. Blood from relatively low–stressed animals may have little effect on others. Research with cattle and pigs indicates that stress hormones are secreted in the saliva and urine. Pigs and cattle tend to avoid objects or places, which are contaminated with urine from a stressed animal.

CHAPTER 5

HANDLING OF LIVESTOCK

General principles

The first principle of animal handling is to avoid getting the animal excited. It takes up to 30 minutes for an animal to calm down and its heart rate to return to be normal after rough handling. Calm animals move more easily and are less likely to bunch and be difficult to remove from a pen. Handlers should move with slow, deliberate movements and refrain from yelling.

Animals may become agitated when they are isolated from others. If an isolated animal becomes agitated, other animals should be put in with it. Electric prodders (prods) should be used as little as possible or only on stubborn animals. However it is more humane and causes less damage to give an animal a mild electric shock than to hit it with a stick or twist its tail. Battery-operated prods (Fig. 6) are preferred to mains-current operated ones (Fig. 7). The voltage used should not exceed 32 V and never be used on sensitive parts such as eyes, muzzle, anus and vulva.

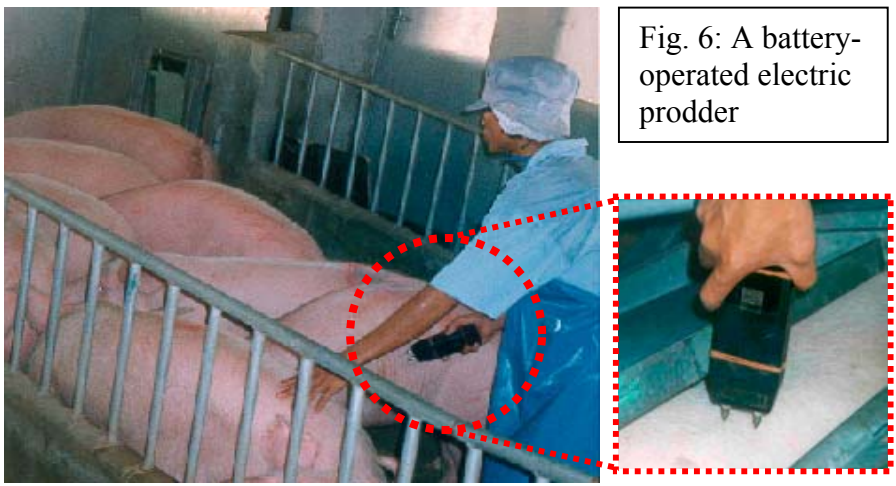


Fig. 6: A battery-operated electric prodder

Fig. 7: Mains-current operated electric prodder (not

Instead of prods, other droving aids should be used such as flat straps (Fig. 8), rolled-up plastic or newspaper, sticks with flags on or panels[1] for pigs. Hesitant animals can often be enticed into pens or vehicles by first leading in a tame animal and the others will follow.

Fig. 8: Flat strap for droving

[1] Panels for droving pigs are boards made of solid material, such as wood, plastic etc. of approx. 1-m square which are held by the drover to block the vision and movement of pigs and so guide its direction. Without such boards, it would be impossible to drove pigs in the convenient way using flags, rolled paper, branches and waving hands as for sheep and cattle.

Ostriches are particularly nervous and should be approached cautiously. They have a vicious forward kick. Tame birds can be led quietly by handlers (Fig. 9). A shepherds crook (Fig. 10) around the neck is a useful leading aid or placing a hood over the head will make the bird more docile.

Fig. 9: Leading tame ostriches to the stunning area

Fig. 10: Shepherds crook used to assist leading ostriches

Handling in crowd pens and races

Overloading the crowd pen is one of the most common animal handling mistakes. The crowd pen and the alley that leads to it from the yard should be only half filled. Handlers must also be careful not to force animals to move by using crowd gates. Animals should walk up the race without being forcibly pushed. If they are pushed up too tightly with a crowding gate, handling becomes more difficult. Tightly packed animals are unable to turn around to enter the race. If animals refuse to enter the single file race, they may be hesitating because of a distraction ahead, such as a moving person.

Flight zone and point of balance (Fig. 11)

An animal's flight zone is the animal's safety zone and handlers should work on the edge of the flight zone. If an animal turns and faces a person, the person is outside the flight zone. When a person enters the flight zone, an animal will turn away. If an animal in a pen or race becomes agitated when a person stands too close to them, this indicates that the person is in the flight zone and should move backwards away from them. The installation of solid sides on races (Fig. 12) and stunning boxes (Fig. 25) will help calm animals because they provide a barrier between the animals and people who approach too closely. The flight zone size depends on how wild or tame the animal is. Animals with a flighty temperament will have a larger flight zone. Animals that live in close contact with people have a smaller flight zone than animals that seldom see people. An excited animal will have a larger flight zone than a calm one. A completely tame animal has no flight zone and may be difficult to drive.

Fig. 11: Flight zone and point of balance

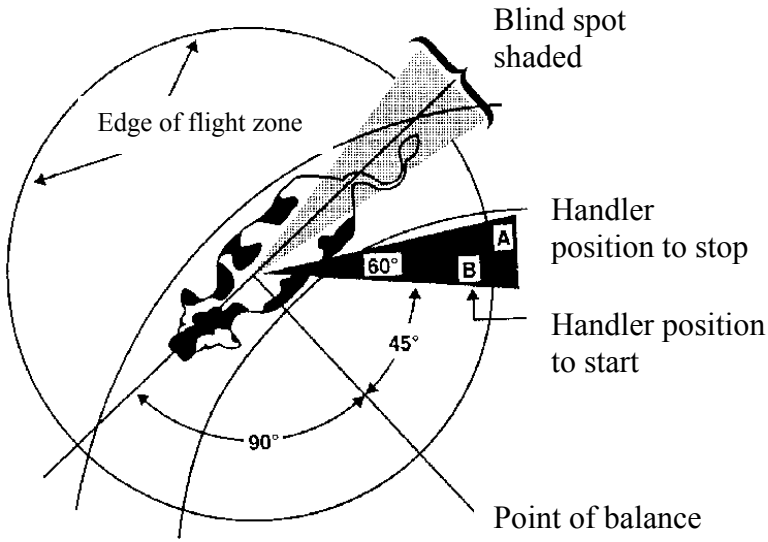
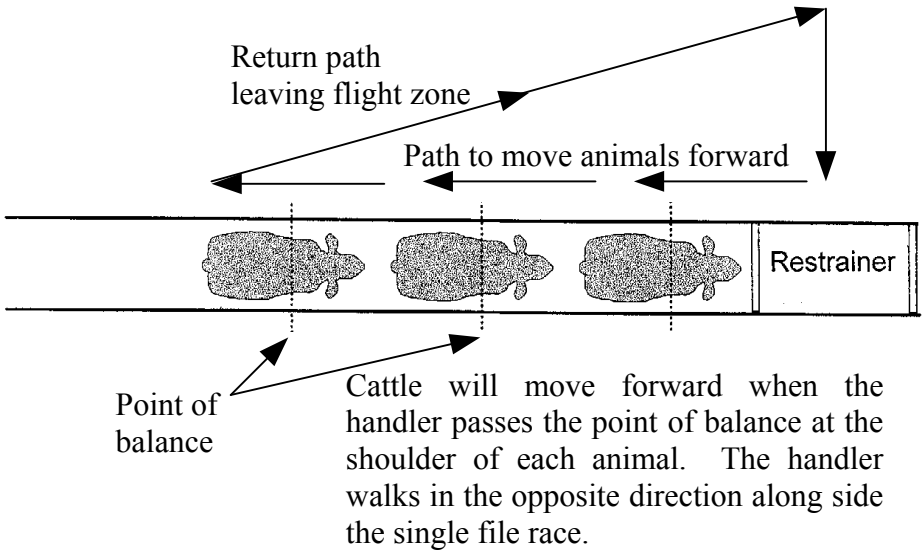


Fig. 12:
Curved cattle race with solid sides

To make an animal move forward, the handler must be behind the point of balance at the shoulder. To get the animal to move backwards, the handler must stand in front of the point of balance. Figure 13 illustrates handler movement patterns, which make it possible to reduce the use of electric prods or goads. Cattle, sheep or pigs will move forward in a race when a handler passes by the animal in the opposite direction of the desired animal movement. The handler must move quickly in order to pass the point of balance at the shoulder to make the animal move forward. The animal will not move forward until the handler passes the shoulder and reaches its hips.

Fig. 13: Handler movement pattern to keep cattle moving into a squeeze chute or restrainer



Designs of handling facilities

The risk of injury and stress during handling of livestock can be high, causing financial loss to producer, transporter and slaughterhouse. Examples are poorly designed pen fencing (Fig. 14), too low or unstable loading ramps, exposure of livestock to heat and intensive sunshine (Fig. 19). Properly designed and constructed facilities on farms, at auction yards and slaughter houses (Fig. 15, 16, 17, 18, 20, 21) etc. will contribute significantly towards the safe handling of livestock, thereby reducing the risk of injuries and stress to animals and workers alike.

Fig. 14: Poor designed fencing

Fig. 15: Well-constructed pens/platform for offloading and holding cattle

Fig. 16: Ramp for pigs and off-loading platform for vehicles leading to holding pens for pigs

Fig. 17: Holding pens for livestock awaiting slaughter

Pens—Livestock pens on farms, feedlots, auction yards and slaughterhouses should have sufficient space for the animals to be able to lie down (Table 1, Fig. 17, 18).

TABLE 1
Required floor space (m^2) per head of livestock for different species

Cattle	loose	2.0-2.8
	tied	3.0
Pigs	baconers/small porker	0.6
	sow	0.9
Calves /sheep	-	0.7

Ostriches	-	0.9

Bulls and boars should be individually penned, and if tied, they should be able to lie down. Water must be easily available. Troughs should be high enough or protected to prevent animals from falling in and drowning. In cold climates, pens should have walls and roofs to protect animals from weather stress. In the tropics, a roof is necessary for holding pens to protect stock, particularly pigs, from heat stroke and sunburn. Water sprays in the pig pens are useful to cool pigs down (Fig. 18). In open pens without roof and shade, even free-range cattle may suffer (Fig.19). Ostrich pens can be partially enclosed to make them darker as this keeps the animals more docile (Fig. 20).

Fig. 18: Nozzle for water spray to cool down pigs

Fig. 19: Open pens
- No shade

Fig. 20: Enclosed ostrich pens to create darker conditions

Fig. 21: Smooth tubular rails for pen partitions

Partitions–Rails made of tubular iron (Fig.20), wood or concrete (Fig. 21, 22) should be smooth and without projections such as hinges, broken ends or wire. Spaces should be adjusted to prevent animals from getting through or stuck and injuring themselves (Table 2).

TABLE 2
Rail distances and heights for different species

	Rail distances	Rail height
Cattle	20 cm apart	Top rail 1.5 m high
Sheep/goat	15 cm apart	Top rail 0.9 m high
Pigs	15 cm apart	Top rail 0.9 m high
Ostriches	20 cm apart	Top rail 1.5 m high

Floors (Fig. 22, 23)—Pen floors should be non-slip and have a gradient of not more than 1:10. If animals slip, this causes bruises, fractures, dislocations and/or skin damage. Concrete floors should have patterns engraved, or covered in mesh to provide traction, at the same time facilitating cleaning. Failing this flat stone will suffice.

Fig. 22: Tubular rails and concrete walls for pen partition, non-slip concrete floor

Fig. 23: Non slip concrete pen floor partition

Raceways—Lanes are necessary for animals to walk or be led on/off vehicles and platforms into holding pens or slaughter facilities etc. Races should be narrow enough so that animals cannot turn around or get wedged beside each other. This results in animals becoming injured, if they panic or are manhandled. Race width for cattle should be approximately 76 cm, depending on breed and size (Fig. 24, 25, 26, 27).

Where possible, raceways should be curved to facilitate animal movement (Fig. 12). Slaughterhouse and pre-stunning races should have solid sides to prevent animals balking.

Ramps and platforms—Both these structures are necessary for loading and unloading livestock from transport vehicles or walking them to slaughter facilities. Ramps should have cross slating or steps (10 cm high x 30 cm deep) to facilitate walking and prevent slipping. The ramp should be sloped at an angle of 20 degrees or less (Fig. 15, 16).

Fig. 24: Raceway for cattle from holding pens to stunning area

Fig. 25: One cattle waiting at the end of raceway in front of stunning box, another cattle staying in stunning box

Fig. 26: Pigs from holding pens entering the raceway to slaughterhouse

Fig. 27: Raceway for pigs to stunning area

CHAPTER 6

TRANSPORT OF LIVESTOCK

The need to transport food animals occurs essentially in commercial agriculture and to a lesser extent in the rural or subsistence sector. These animals need to be moved for a number of reasons including marketing, slaughter, re-stocking, from drought areas to better grazing and change of ownership. Typically, methods used to move animals are on hoof, by road motor vehicle, by rail, on ship and by air.

Generally the majority of livestock in developing countries are moved by trekking on the hoof, by road and rail. Historically, livestock has been moved on foot, but with increasing urbanisation of the population and commercialisation of animal production, livestock transport by road and rail vehicles has surpassed this.

Transport of livestock is undoubtedly the most stressful and injurious stage in the chain of operations between farm and slaughterhouse and contributes significantly to poor animal welfare and loss of production.

Effects of transport

Poor transportation can have serious deleterious effects on the welfare of livestock and can lead to significant loss of quality and production.

Effects of transport and movement include:

a. Stress –leading to DFD beef and PSE pork (Fig. 1);

b. Bruising –perhaps the most insidious and significant production waste in the meat industry (Fig. 2, 3);

c. Trampling –this occurs when animals go down due to slippery floors or overcrowding (Fig. 37-39);

d. Suffocation -this usually follows on trampling;

e. Heart failure -occurs mostly in pigs when overfed prior to loading and transportation;

f. Heat stroke -pigs are susceptible to high environment temperatures and humidity;

g. Sun burn -exposure to sun affects pigs seriously;

h. Bloat -restraining ruminants or tying their feet without turning them will cause this;

i. Poisoning -animals can die from plant poisoning during trekking on hoof;

j. Predation -unguarded animals moving on the hoof may be attacked;

k. Dehydration -animals subject to long distance travel without proper watering will suffer weight loss and may die;

l. Exhaustion -may occur for many reasons including heavily pregnant animals or weaklings;

m. Injuries -broken legs, horns (Fig. 4);

n. Fighting -this occurs mostly when a vehicle loaded with pig stops, or amongst horned and polled cattle.

Methods of transport

Cattle

The most appropriate methods of moving cattle are on hoof, by road motor vehicle or by rail wagon. Moving cattle on the hoof (trekking) (Fig. 28) is suitable only where road and rail infrastructure does not exist, or when distances from farm to destination are short. This method is slow and fraught with risks to the welfare and value of the animals. Rail transport is useful for short-haul journeys where loading ramps are available at railheads and communication is direct to destination. Road motor transport is by far the most versatile, the method of first choice and the most user friendly.

The most satisfactory method of transporting cattle is by road motor vehicle (Fig. 29, 30). Moving by rail truck (Fig. 31) requires more careful management and trekking is satisfactory for well-planned distances.

Fig. 28: Moving cattle on the hoof

Fig. 29: Road motor vehicle for transporting cattle (cross slating of cattle truck floor to prevent slipping)

Fig. 30: Large truck for cattle transport at unloading platform

Fig. 31: Rail truck for transporting cattle

Sheep/goats Of the food animals these are the easiest to transport and generally travel well on hoof, rail or road. Double-deck trucks are also suitable (Fig. 32).

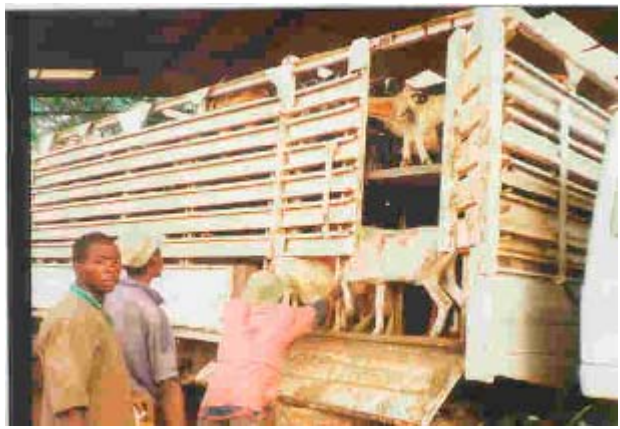


Fig.32: Double-deck truck for transporting sheep/goats

Pigs Pigs are difficult animals to transport, and the only satisfactory method is by road, although rail can be used under careful circumstances.

Poultry Broilers and other poultry such as turkeys or ducks are best transported by road. Flocks of birds should be subdivided in small numbers in crates (Fig. 33). Recommended are plastic crates, which can be stacked on top of each other on a vehicle and which can easily be washed after use. The lid of the crates is for loading and the opening at the side for removal of the birds.

Fig. 33: Crates for transport of chicken

Ostriches — The skin and meat of ostriches is particularly valuable, so careful transport by road vehicle is the only suitable method of transport.

Having selected the preferred method of transport of slaughter animals, it is necessary to take into account numerous factors in order to ensure the health and welfare of the animals.

Types of vehicles

Any vehicle used for the transport of slaughter livestock should have adequate ventilation, have a non-slip floor with proper drainage and provide protection from the sun and rain, particularly for pigs. The surfaces of the sides should be smooth and there should be no protrusions or sharp edges. No vehicle should be totally enclosed.

Ventilation—Transport vehicles should never be totally enclosed, as lack of ventilation will cause undue stress and even suffocation, particularly if the weather is hot. Poor ventilation may cause accumulation of exhaust fumes in road vehicles with subsequent poisoning. Pigs are particularly susceptible to excessive heat, poor air circulation, high humidity and respiratory stress. Well-ventilated vehicles are necessary (Fig. 29, 30, 34). The free flow of air at floor level is important to facilitate removal of ammonia from the urine.

Fig.34: Well-ventilated truck for transporting pigs. Heat combined with hot sun would require a cover (roof) for the vehicle.

Floors—Non-slip floors in all vehicles are necessary to reduce the risk of animals falling. A grid of cross slating made from wood or metal is (Fig. 29) suitable. The grid can be removable, so the vehicle can be used for other purposes. Other forms of non-slip surfaces such as grass or sawdust are not suitable. Additional balance for animals is provided by partitioning the interior of the vehicle with either wood or metal poles or solid boards. Broken floors will cause leg and other injuries (Fig. 35). Vehicle floors should be level with off-loading platforms (Fig. 16), otherwise animals will injure themselves climbing off or be manhandled in order to remove them (Fig. 36).

Floor space—Livestock require sufficient floor space so that they can stand comfortably without being overcrowded. Overloading results in injuries or even death of livestock (Table 3, Fig. 37, 38, 39).

Fig. 35: Cattle leg protruding through broken truck floor

Fig. 36: Poor offloading facilities resulting in injuries from mishandling of animals

Fig. 37: Overloading truck with goats

Fig. 38: Goats being trampled in the back of a truck

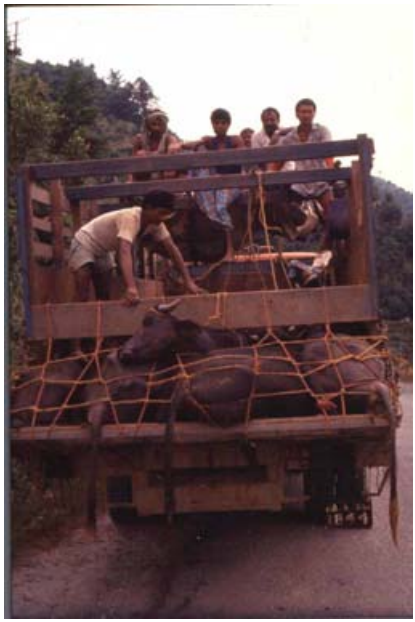


Fig. 39: Overloading truck with water buffaloes

TABLE 3
Approximate floor space for transporting different classes of animals

Classes of stock		Floor area /animal (m^2)
Mature cattle		1.0 – 1.4 *
Small calves		0.3
Pigs	porker	0.3
	baconer	0.4
	sow/boar	0.8
Sheep/goats		0.4
Ostriches		0.8

*50-60cm vehicle length/head loaded cross-wise

Allowances should be made for breed and body size. If the floor area is too large for the number of animals, partitions should be used to avoid animals being thrown about.

Sides—The sides of vehicles should be high enough to prevent animals, particularly pigs, from jumping out and injuring themselves. Insides could also be padded at hip level with, for example, old tyres to reduce bruising of cattle and ostriches. Also there should be no gaps through which a leg might protrude and be broken. Narrow entry doors can lead to considerable bruising of hips. Rail trucks should be fitted with spring coupling to cushion jerky movement.

Roof—A roof is not necessary on a transport vehicle for bovines and small ruminants provided the animals are not exposed for hours in the hot sun (Fig. 29, 30). Vehicles for pigs should have roofs unless the pigs are to be transported in the early morning or late evening. Poultry should be protected from sun and rain. Transporting in cages or crates (Fig. 33) will protect them from physical injury. They should be large enough to allow all the birds to sit down and move their heads freely. Ventilation should be adequate.

At the small-scale level in more primitive conditions animals are often transported under very unsuitable conditions, which may cause a great deal of pain or even death through suffocating, heat stress, dehydration etc. (Fig. 40, 41, 42, 71).

Fig. 40: Unsuitable transport of a

Fig. 41: Unsuitable transport of

Fig. 42: Unsuitable transport of

Pre-loading precautions

There are a number of simple procedures that can be implemented prior to the loading of livestock, which will considerably reduce the risk of injury and stress.

1. Pre-mixing of cattle or pigs leads to greater familiarity and these animals travel better than animals that are strangers. Cattle should be mixed in a pen 24 hours before loading. Victimised or wild animals can be weeded out during this period. Fighting amongst pigs that are strangers is common, resulting in skin damage, wounds and stress. Mix pigs from different pens together before loading, smearing pigs with litter or excreta from the same pen so that they smell similar.

2. Most animals can be fed and watered before transporting. This has a settling effect. However pigs should **not** be fed before transport as the feed ferments and the gas causes pressure on the heart in the thoracic cavity, leading to heart failure and death.

3. Do not mix horned and hornless animals in the vehicles as this causes bruising and injury. Different species should also not be mixed – sheep, goats and calves under 6 months can be mixed and individual animals can be transported in a loose sack tied at the animal's neck. Feet should not be tied, and animals should be turned every 30 minutes or so. Pigs should not travel with other species unless separated by a partition (Fig.43). Bulls should not be carried together with other stock unless separated by a strong partition.

Fig. 43: Malpractice of loading pigs, goats and sheep in the same truck

4. Animals that are diseased, injured, emaciated or heavily pregnant should not be transported, and unfit, heavy, penfed animals should not travel far as they cannot stand up to the rigours of transport.

5. Vehicles should be fitted with a portable ramp to facilitate emergency offloading in case of prolonged breakdowns.

Transport operations

A number of factors must be taken into account during the journey in order that the animals do not suffer, become injured or die.

1. Trekking—Only cattle, sheep and goats can be successfully moved on hoof, and here certain risks are involved. The journey should be planned, paying attention to the distance to be travelled, opportunities for grazing, watering and overnight rest. Animals should be walked during the cooler times of the day and, if moving some distance to a railhead, they should

arrive with sufficient time to be rested and watered before loading. The maximum distances that these animals should be trekked depend on various factors such as weather, body condition, age etc., but the distance given in Table 4 should not be exceeded when trekked.

TABLE 4
Maximum distances for trekking

Species	One day journey	More than one day	
		First day	Subsequent days
Cattle	30 km	24 km	22 km
Sheep/goats	24 km	24 km	16 km

2. Time of the day—High environment temperatures will increase the risk of heat stress and mortality during transportation. It is important to transport animals in vehicles during the cooler mornings and evenings or even at night. This is particularly important for pigs. A combination of high humidity and high environment temperatures is especially deadly to pigs. Heat can rapidly build up to lethal levels in a stationary vehicle. Wetting pigs with water will help keep them cool.

3. Duration of journey[2]—Where possible, journeys should be short and direct, without any stoppages. If the vehicle stops, pigs will tend to fight. Cattle and sheep/goats should not travel for more than 36 hours and should be offloaded after 24h for feed and water, if the journey is to take longer than that. Pigs should

[2] There are recent moves in developed regions, seeking to limit the duration of livestock transports to 8 hours or less.

have access to frequent drinks of water during long journeys, particularly in hot and humid conditions.

4. Driving—Vehicles should be driven smoothly, without jerks or sudden stops. Corners should be taken slowly and gently. The second person should be in attendance to spot downer animals so that the vehicle can be stopped and the animal lifted. Train drivers should avoid "fly shunting" of trucks with livestock.

5. Wind chill—Wind blowing on wet animals being transported in cold weather causes a wind chill factor, where the body temperature is considerably reduced, resulting in severe stress or deaths.

CHAPTER 7

SLAUGHTER OF LIVESTOCK

The obligation in the conversion of food animals into edible products and useful by-products is to slaughter the animal in a humane manner and to process the carcass in a hygienic and efficient way.

Preparing livestock for slaughter

At the time of slaughter, animals should be healthy and physiologically normal. Slaughter animals should be adequately rested. They should be rested, preferably overnight, particularly if they have travelled for some times over long distances. However, pigs and poultry are usually slaughtered on arrival as time and distances travelled are relatively short and holding in pens is stressful for them. Animals should be watered during holding and can be fed, if required. The holding period allows for injured and victimised animals to be identified and for sick animals to be quarantined.

When ready for slaughter, animals should be driven to the stunning area in a quiet and orderly manner without undue fuss and noise (Fig. 8, 9, 26). Droving can be facilitated using flat canvass straps (Fig. 8), rolled plastic or paper, and in the case of stubborn animals, prodders (Fig. 6) can be used occasionally. Animals should never be beaten nor have their tails twisted. Animals should be led in single file (Fig. 24, 25, 27) into the stunning area where they can be held in appropriate restraining device(s) before stunning.

Restraint devices

It is very important that slaughter animals should be properly restrained before stunning or bleeding. This is to ensure stability of

the animal so that the stunning operation can be carried out accurately and properly. Different types of restraints are appropriate for different species:

Cattle

A stunning box is the most common method of restraining cattle (Fig. 25, 44). The size of the box should be just wide enough to prevent the animal from turning around, and so be difficult to stun. The floor of the box should be non-slip. A simple neck crush used by farmers to restrain cattle for weighing is suitable for small-scale operations (Fig. 45). Restraining tame cattle outside the stunning box by securing the head in a halter and then pulling the rope through a metal ring in a concrete floor is effective. It is recommended that the operator should be positioned behind protective steel bars (Fig. 46).

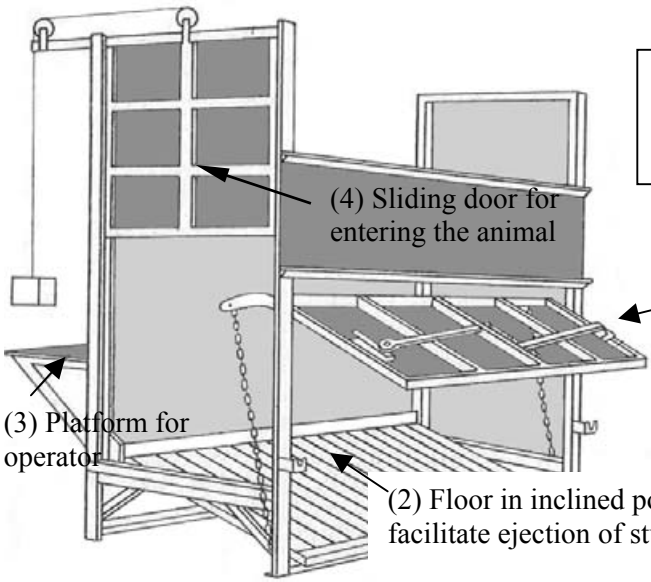


Fig. 44:

Stunning box for

Fig. 45: Simple, effective race and neck crush for cattle restraint

Fig. 46: Small-scale operation position of the pre-stunning operator behind protective steel bars

Sheep/goats A properly constructed metal stunning box is appropriate (Fig. 47). However, they can be restrained manually quite satisfactorily.

Fig. 47:
Sheep/goat
stunning box

Pigs — A stunning box is suitable for pigs (Fig. 48). Putting a few pigs in a small room is suitable but only for electrical stunning (Fig. 57, 58). On no account should pigs be restrained manually.

Poultry — Chickens are shackled by their legs onto a conveyor line (Fig. 49). This must be done gently to avoid injury and stress. In a small slaughterhouse, birds can be placed headfirst in cones (Fig. 50).

Ostriches — These are temperamental animals, and because they will kick, they must be securely restrained. This can be done by leading them into a padded V-shaped pen, with the head facing the apex of the pen. Also the feet can

be clamped immediately after electrical stunning has begun (Fig. 59).

Animals should never be left standing for a prolonged period in a restraint device and must be stunned immediately after being secured. The operator must be adequately trained and supervised. In some countries, people who handle and stun animals have to be trained and licensed.

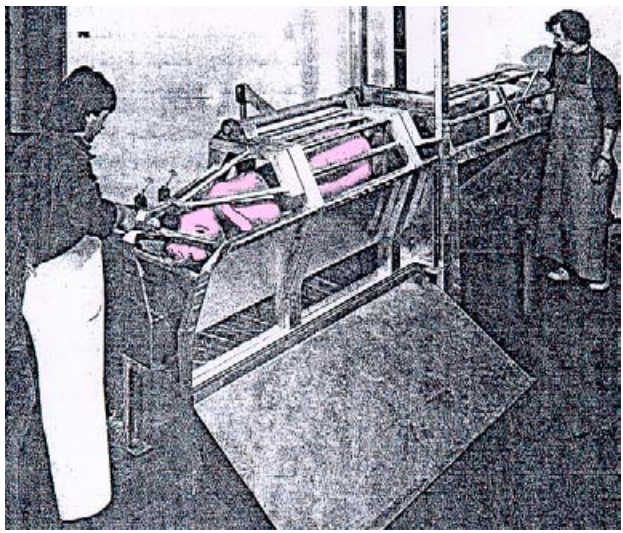


Fig. 48: Stunning box/restrainer for pigs

Fig. 49: Poultry shackled on conveyor by legs prior to electric stun

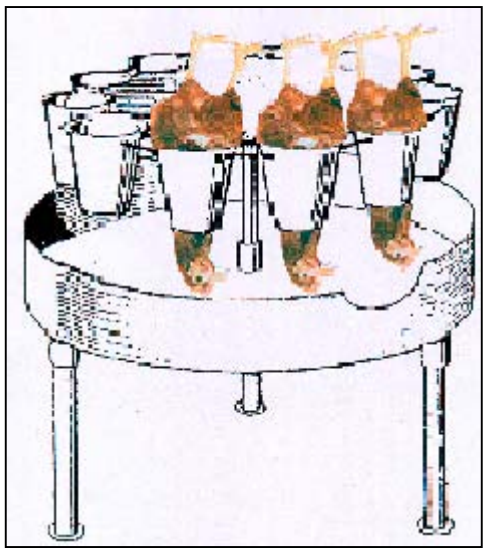


Fig. 50: Stun/bleed cones for small-scale poultry slaughter

Stunning methods

It is desirable to render an animal unconscious before it is slaughtered in order to eliminate pain, discomfort and stress from the procedure. Most developed and many developing countries have legislation that requires pre-slaughter stunning, with the exception of authorised ritual slaughter like Kosher or Halal. In some circumstances, traditional slaughter may be exempt from pre-slaughter stunning. Whatever the stunning method, the animal should be rendered unconscious for long enough so that bleeding results in enough loss of blood to cause death from lack of oxygen to the brain (cerebral anoxia). In other words, death should occur before the animal would have regained consciousness after stunning, had bleeding not taken place. There are three main technologies used to effect stunning—Percussion, Electrical and Gas. Only the first two are commonly used in developing countries.

Percussion stunning: - This method produces a physical shock to the brain (Fig. 51).

Captive bolt — This method works on the principle of a gun and fires a blank cartridge and it propels a short bolt (metal rod) from the barrel. The bolt penetrates the skull bone and produces concussion by damaging the brain or increasing intracranial pressure, causing bruising of the brain (Fig. 52). The captive bolt is perhaps the most versatile stunning instrument as it is suitable for use on cattle, pigs, sheep and goats as well as horses and camels, and can be used anywhere in the world. (Although electrical stunning is preferable to captive bolt pistols for stunning pigs and sheep.) There are several different manufacturers of captive bolt pistols, and after the initial expense, running costs are minimal. Users must ensure

sufficient supply of cartridges, which may be different in caliber for stunning guns from the different manufacturers. These features make the captive bolt the stunning instrument of choice, particularly in developing countries.

There are two variations of the gun. One has a handle and trigger. The other comprises hand-held barrel, which is tapped against the skull, which sets of the cartridge explosion (Fig. 52, 53).

Another type of bolt has a flat, mushroom end (Fig. 55). Unconsciousness is achieved through percussion by strong blow to the skull. The brain is not penetrated, and as the animal is not killed, it is a method that is acceptable in many countries for Halal slaughter. When in use, the captive bolt is positioned on the correct spot on the animal's head (Fig. 51, 53, 54). Poor maintenance is a major cause of poor stunning and the guns must be cleaned and serviced regularly, according to the manufacturer's instructions.

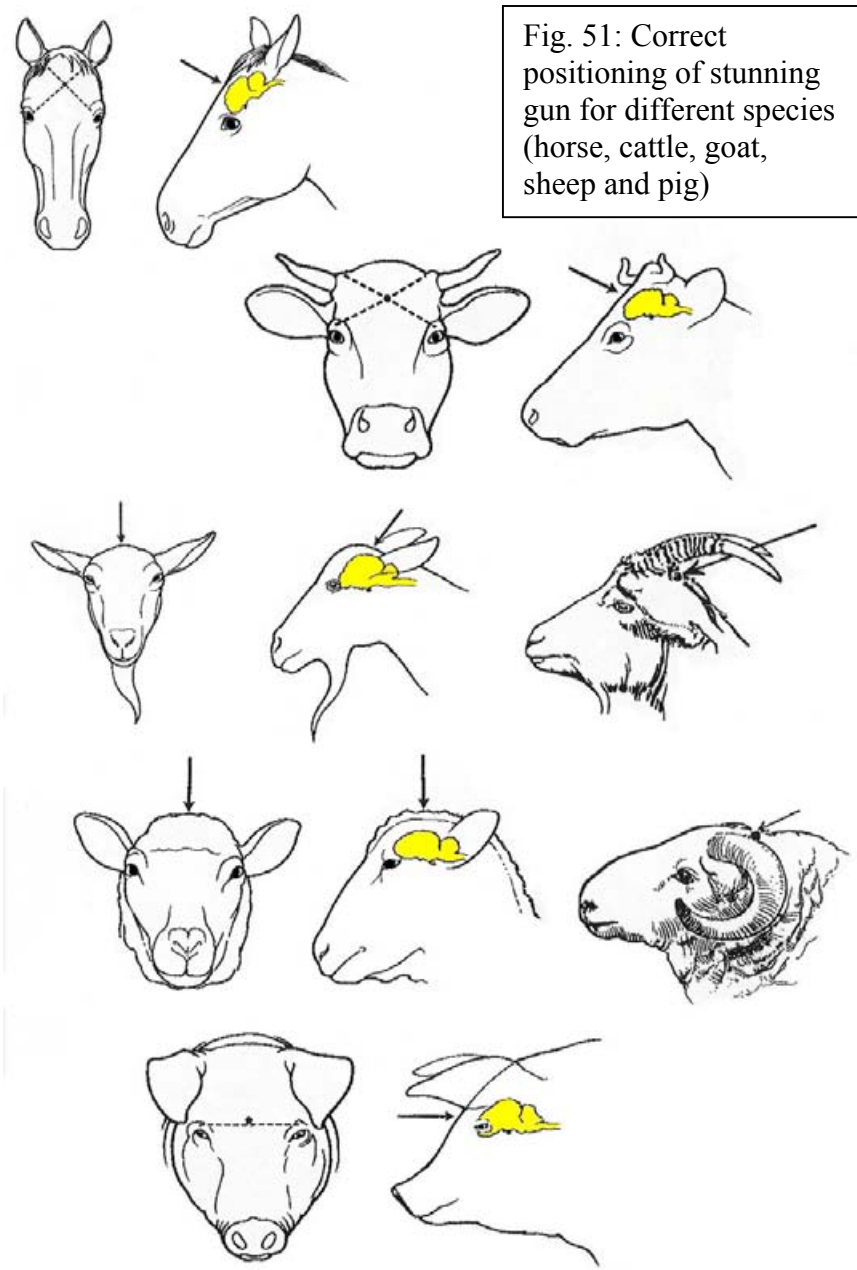


Fig. 51: Correct positioning of stunning gun for different species (horse, cattle, goat, sheep and pig)

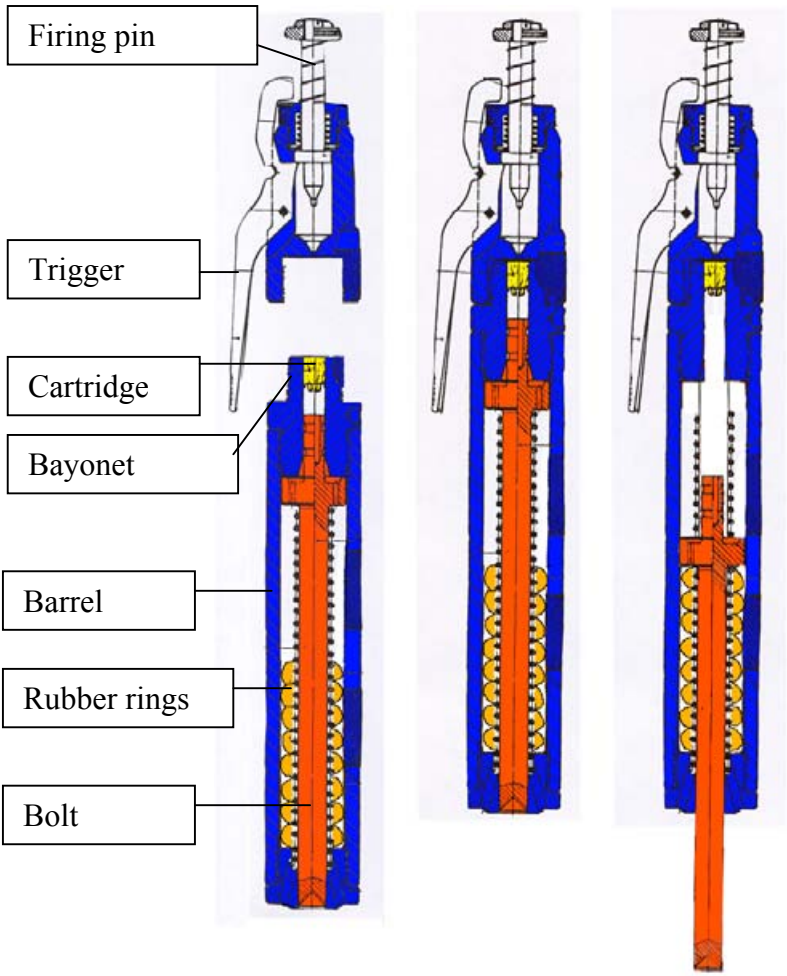


Fig. 52: Use of Captive Bolt Pistol (CBP)

A. Bottom part removed from main part of CBP for loading the cartridge
B. CBP in firing position (firing pin to be released through trigger)
C. CBP with expelled bolt after firing (rubber rings stop expulsion and partially withdraw bolt)

Fig. 53: Hand-held barrel captive bolt gun

Fig. 54: Wrong position of the captive bolt pistol

Fig. 55: Mushroom bolt stun gun

For effective stunning, it is important that the operator is well trained in its use of the stunning gun. If the operator becomes fatigued, accuracy of stunning is reduced, so in large plants, rotation of two stunners is recommended. Stunning of bigger pigs may require a stronger cartridge, as the sinus cavities of the skull are larger. Large bulls have a bony ridge in the forehead and penetration may be more difficult, requiring off-centre aim. A captive bolt gun is **not** suitable for stunning ostriches. Their brain is small and lobulated, and the bolt does not produce proper concussion.

Gunshot

In circumstances where animals are too fractious to be handled in the normal way, such as when they cannot be loaded on the farm or led into the stunning restraint, gunshot with a free, soft-nosed bullet is effective. A 22-calibre bullet is sufficient for most animals. Shooting with a free bullet can be dangerous to operators. If the animal is to be slaughtered on a farm, it should be accurately shot

while standing or lying on soft ground to prevent the bullet from ricocheting.

Electrical stunning

This method of stunning is well suited for pigs, sheep or goats, poultry and ostriches. (Use in cattle or other large species is in development, but if not properly applied it may result in excessive haemorrhage in the muscles or spinal fractures.) Electrical stunning induces electroplectic shock or epileptic state in the brain. This state should last for long enough for bleeding to be carried out so that the animal dies from cerebral anoxia. A low voltage alternating electric current is applied by means of two electrodes, which are placed on either side of the brain using tongs. Since the brain of animals is small, the electrodes should be accurately and firmly placed high up on the sides of the head in sheep, goats, pigs and ostriches (Figs. 56, 57, 58, 59).

Fig.56: Tongs for electrical stunning of sheep or goats

Another way is to place one electrode under the jaw and the other on the side of the neck behind the ears. This type of head-only stunning is reversible and the animal will regain consciousness. For this reason, stunned animals should be bled **immediately** after stunning (Fig. 77).

Irreversible stunning causes cardiac arrest. Here a third electrode is placed elsewhere on the body. Electrodes are applied in the form of tongs. They should never be placed on sensitive areas such as the eye, inside the ear nor rectum.

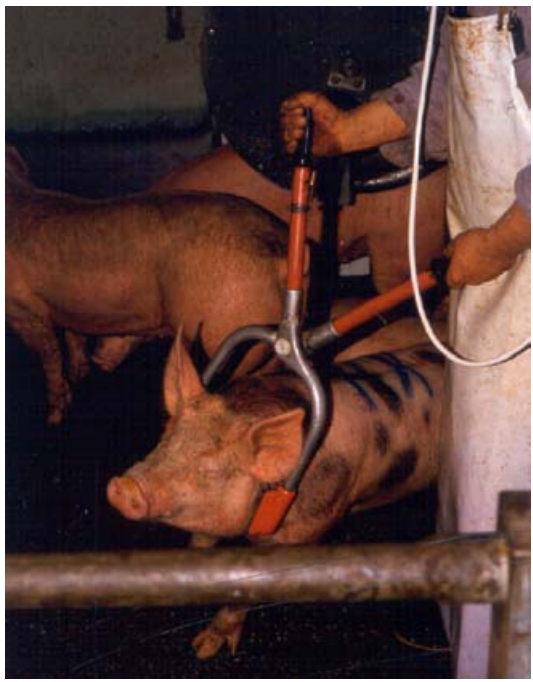


Fig. 57: Tongs for electrical stunning of pigs

Fig. 58: Tongs for electrical stunning of pigs

Fig. 59: Tongs for electrical stunning of ostriches

Ostriches should be stunned only electrically. The tongs are placed either at the sides of the head below and behind the eye or above and below the head (Fig. 59). Poultry can be stunned electrically using a manually operated device (Fig. 60) or using an automatic water bath (Fig. 61). Here birds are dragged through a trough of water that is charged with a low voltage current.

Fig. 60: Manually operated electrical stunning box for small-scale poultry slaughter

Fig. 61: Water bath for automatic electrical stunning of poultry

The strength of the current is a combination of amperage and voltage appropriate for the species. The equipment should be fitted with a meter to measure the correct current. Approximate current/time guides for different species are as follows:

TABLE 5
Recommended current and time characteristics for electrical stunning

Species		M/Amps	Amps	Volts	Time (sec.)
Pig (bacon/porker)		min. 125	min. 1.25	max. 125	max. 10 (until EPS*)
Sheep/goat		100-125	1.0-1.25	75-125	max. 10 (until EPS*)
Poultry[3]	1.5-2 kg broiler	200	2.0	50-70	5
	turkey	200	2.0	90	10
Ostrich		150-200	1.5-2.0	90	10-15

* EPS is electroplectic shock.

For sheep, goats, pigs and ostriches, during this period the limbs extend the back and head arch and the eyes close. After some 10 or more seconds, muscles gradually relax followed by paddling movements. The electrodes should be removed at this stage as stunning is complete (Fig. 58).

[3] An alternative way of electrical stunning of poultry is the utilization of high voltage (300-500 Volts), which causes immediate cardiac arrest. It is claimed that through this method possible insufficient stunning, which may occur in some cases when using the low-voltage stunning, is avoided.

The electrodes should be in good repair and not corroded. They should be cleaned daily. The operator should be competent to ensure correct positioning and good contact of the electrodes. Passage of electric current through the brain is facilitated by cutting the hair over the site or wetting the electrodes. If the whole face or body is wet, the current may short-circuit the brain.

Failure of the operator to apply the apparatus to the correct spot on the head may not produce unconsciousness, resulting in a condition known as missed shock or "the Nightmare State of Leduc". The animal becomes paralysed and unable to vocalise but remains fully conscious. The simplest commercially available electrical stunning units must have a transformer or other electric circuits that will deliver the recommended minimum amperage and voltage required inducing insensibility.

Unfortunately in many developing countries, homemade devices for electrical immobilisation are still being used. These may be simple wires attached to the animal or homemade tongs but without transformers to achieve the correct current parameters (Fig. 70). Home made stunners plugged directly into the mains are painful to the animals and very dangerous to the operator, as there may be exposed wires.

Generally, electrical stunning of cattle or other large species may result in excessive haemorrhages or spinal fractures due to large muscle spasms. This will be particularly so if unsophisticated technology is used. New Zealand and some other countries have developed modern methods for electrical stunning of cattle to overcome these problems, in particular for beef exports to some Muslim countries or for installation in slaughterhouses in Muslim countries where this method is acceptable (Fig. 62, 63). The New

Zealand technique is 'the Ranguiru System[4] or Wairoa Process[5]' and is a head-only stun.

Fig. 62

Fig. 63

Fig. 62 and 63: Electric stunning of cattle for large-scale slaughtering. Device is started through remote control once animal has entered stunning box.

[4] The Ranguiru system is a modified electrical stun, which is applied to Western-type cattle slaughter, where the animal is stunned through the brain and the heart stop beating. It is not accepted as Halal by Muslims.

[5] The Wairoa process is a slaughter technique developed in New Zealand, which involves an electrical head-only stunning. This renders the animal insensitive to pain but able to recover if the slaughter cut is not made. The heart remains beating. The system is humane, safe for workers and generally accepted as Halal by Muslims.

Carbon dioxide gas stunning (Fig. 64, 65)

The use of carbon dioxide (CO_2) gas is a relatively new method of stunning suitable for pigs and poultry. However, it is applicable only at large industrial plants, as the sophisticated technical equipment is relatively costly to install. Basically, animals are stunned using various concentrations of CO_2 in air. Concentrations of CO_2 for the stunning of pigs are at least 80% in air for 45 seconds and poultry of 65% for 15 seconds. The acceptability of this method on welfare grounds has been questioned however. For some genetic types of pigs, it may be satisfactory, and for others may be stressful.

Currently Argon gas is being tested for stunning purposes. It is assumed that Argon gas may have some advantages over CO_2, but the costs may be higher.

Malpractice in immobilization of livestock

The aim of rendering slaughter animals unconscious prior to bleeding is in good slaughterhouse practice achieved by using captive bolt pistols, electrical tongs or CO_2-gas. For the immobilization of bovines and pigs a blow to the skull with a large-sized hammer used to be a wide-spread method and is still being practised, in particular in developing countries. The method requires only manual force, no maintenance of equipment or spares as cartridges, and is therefore cheap (Fig. 66).

A blow with the hammer is certainly preferable to no pre-stunning, but it requires a skilled operator. Very often additional blows are needed, if the animal was not hit properly. The hammer method is prone to a high failure rate and should be replaced wherever possible by one of the above-mentioned stunning methods. Particular malpractice can be observed in pig slaughter, when a

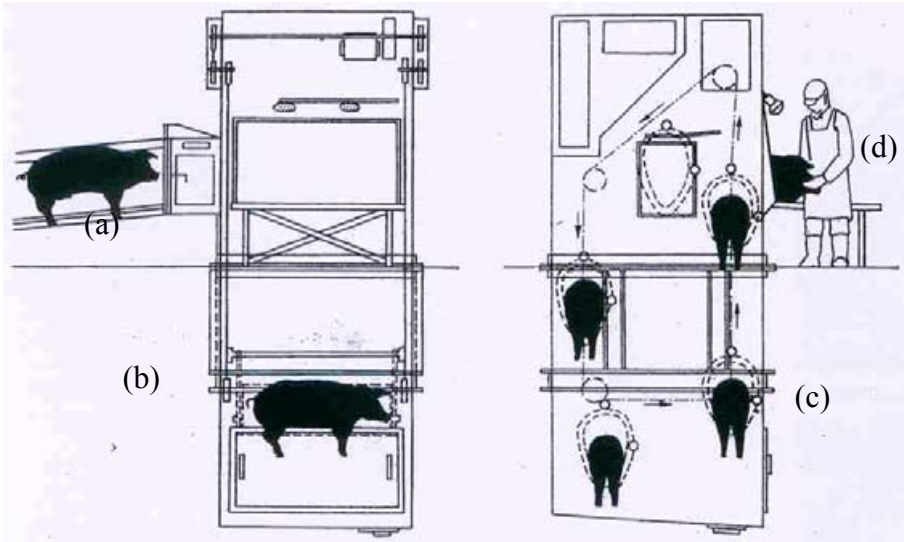


Fig. 64: Schematic view of CO_2 stunning of pigs.
In a discontinuous process the animals enter the CO_2 tunnel (a), are lowered into the pit with high CO_2 concentration where they fall unconscious (b), are lifted up again (c) and expelled from the tunnel (d).

Fig. 65: Runway and entrance to a CO_2-tunnel

Fig. 66: Pre-stunning of buffalo through blow with a hammer

number of pigs are driven into a stunning pen and indiscriminately treated with hammer blows. Because they move around, many animals are not hit efficiently; they need additional blows or arrive fully conscious at bleeding (Fig. 66, 67).

In many places in the developing world, immobilization of large ruminants (cattle, buffalo) is still carried out through the use of a sharp, pointed knife sometimes called a puntilla or Spanish pike (Fig. 68, 69). The knife is used to sever the spinal cord through the space (Foramen magnum) between the skull and neck position of the backbone. Upon inserting the knife and severing the spinal cord, the animal will collapse. It remains immobilized and the operators have easy access; however, the animals remain conscious until bleeding is complete. This practice should be discontinued, as it is not humane.

An equally inhumane method of immobilization of large animals involves severing the Achilles' tendons, which lead to the collapse of the animal. This practice can in particular be observed in camel slaughterhouses. In camel slaughtering it can also be observed that the animals are immobilized by bending the joints of the fore- and hind legs through tying thin wires around. This forces the animals into a painful sitting position. They may be kept like this for many hours before they are slaughtered.

Malpractice can also be observed in the use of electricity for stunning purposes. Electrical tongs can certainly be fabricated through local engineering work in developing countries, but it is essential that the electrical parameters required for efficient and humane stunning be achieved. Stunning tongs without transformers, using the voltage of the mains not only cause a great deal of suffering but also produce inferior meat quality (Fig. 70).

Absolutely unacceptable are practices using electrical wires attached to the limbs and necks of the animals and inflicting an electrical shock on the animal through connecting to the mains current. Similarly, devices resembling mains-current operated prodders (Fig. 7) but using high voltage, which are utilised for "stunning" of cattle, are inhumane. Moreover, they spoil the meat and damage the skins.

One tormenting method of immobilizing pigs is practised in some Asian countries. Pigs, when moving them from the farms to the slaughterhouses, are forced into crates made of steel bars. These crates can accommodate one pig but do practically not allow any movements upon arrival at the abattoir; the crates are piled one on top of each other. Pigs are kept waiting inside the crate for hours without water and ventilation. Finally the bleeding without stunning is carried out with the pig still in this position (Fig. 71).

Fig. 67:
Group of pigs knocked down by hammer blow and being hoisted for bleeding. Some

Fig. 68 and 69:
Puntilla for immobilization of large livestock

Fig. 70: Makeshift electric stunning tongs

Fig. 71: Bleeding of pigs in crates by using a

Religious or ritual slaughter (Halal and Kosher)

Most developed and many developing countries of the world require by law an animal to be rendered unconscious before it is slaughtered. This is in order to ensure that the animal does not suffer pain during slaughter. However, exceptions are made for the Jewish (Kosher) and Muslim (Halal) slaughter of livestock. Here stunning generally is not allowed and the animal is bled directly using a sharp knife to cut the throat and sever the main blood vessels. This results in sudden and massive loss of blood with loss of consciousness and death. However, many authorities consider that religious slaughter can be very unsatisfactory and that the animal may not be rendered unconscious and suffer considerable discomfort and pain in the slaughter process.

A number of factors must be given serious consideration before this type of slaughter is acceptable: -

1. Animals that are slaughtered according to Kosher or Halal requirements should be securely restrained, particularly the head and neck, before cutting the throat. Movement results in a poor cut, bad bleeding, slow loss of consciousness (if at all) and pain. This has serious implications for animal welfare. The knife that is used to cut the throat and the carotid and jugular blood vessels must be razor sharp and without blemishes and damage. This is to ensure a swift, smooth cut across the throat behind the jaw and to ensure immediate and maximum gush of blood. Poor bleeding causes slow loss of consciousness and reduces meat quality.

2. Animals should not be shackled and hoisted before bleeding. This causes them severe discomfort and stress. Hoisting should be done only after the animal has lost consciousness Restraining equipment should be comfortable for the animal.

3. Operator competence is of great importance in order to carry out satisfactory religious slaughter, and the authorities should license all slaughter personnel. A poor technique will result in great suffering and cruelty to the animal. Religious slaughter should be carried out paying attention to detail and ensuring the method, equipment and operators are correct. The slaughter process is slow.

The captive bolt gun is suitable for this stunning when using the mushroom shaped head of the bolt (Fig. 55). The mushroom gun is an improvement on the plain bolt, as this bolt does not penetrate the brain and cause death. This should be more acceptable to the religious authorities, and its use would encourage more humane slaughter amongst Muslims in developing countries, thereby improving animal welfare.

Fortunately, many Muslim authorities accept some forms of pre-slaughter stunning. Many Muslim authorities permit electric stunning of cattle, sheep and poultry, whose meat is destined for Muslim communities, because the animals subjected to this stunning method would recover if no bleeding was carried out. Electric stunning is also the method of choice in meat exporting countries where stunning of slaughter animals is required by law, for export to Muslim countries. Similarly, Muslim minorities in countries with stringent animal welfare regulations are allowed to use Halal slaughter methods, but in combination with electrical stunning.

Any kind of prestunning for livestock to be slaughtered according to the Jewish Kosher method has not yet been accepted.

Bleeding

Bleeding is the part of the slaughter process where the main blood vessels of the neck are severed in order to allow blood to drain from the carcass, resulting in the death of the animal from cerebral anoxia. The bleeding knife should continuously be sharpened. A blunt knife will prolong the incision and the cut ends of the blood vessels will be damaged. This may cause premature clotting and blockage of the vessels, delaying bleeding out and prolonging the onset of unconsciousness and insensitivity. Incisions should be swift and precise. In poultry, sheep, goats and ostriches, the throat is cut behind the jaw (Figs. 72, 73, 74).

Fig. 72: Incision for bleeding of poultry (ducks)

Animals are immobilized and unconscious as they passed through the water bath for automatic electrical stunning.

Fig. 73: Incision for bleeding sheep

Fig. 74: Incision for bleeding ostriches

The standard method for the bleeding of cattle is to open the skin at the neck between brisket and jaw through a 30-cm longitudinal cut. Then, for hygienic reasons, a clean knife should be used and inserted at a 45° angle (Fig. 75) in order to sever the jugular and carotid vessels.

In pigs, a longitudinal bleeding stick is made into the chest to sever the deep vessels (Fig. 76).

For all cuts, the jugular and carotid vessels should be completely severed. If all vessels are not cut, bleeding may be incomplete, causing excessive retention of blood in the tissue, which can result in early spoilage of meat.

A minimum of delay is required between stunning and bleeding for two reasons:

a. A prolonged delay in bleeding may result in a level of consciousness being regained particularly where animals have been stunned electrically. For example, poultry stunned electrically may regain consciousness within 1-3 minutes. Generally, bleeding of poultry should commence within 15 seconds of stunning. For other livestock, the interval between stunning and sticking/bleeding should also be kept very short. Periods of less than one minute are desirable (Fig. 77).

b. Delayed bleeding will result in an increase of blood pressure, and blood vessels will rupture, causing muscle haemorrhage. This extra blood in the tissue will cause the meat to decompose more quickly, resulting in waste of meat.

Fig. 75: Incision for bleeding cattle

Fig. 76: Incision for bleeding pigs

Fig. 77: Good arrangement for stunning and immediate bleeding of pigs at medium-sized

Determining insensibility at slaughter

It is important to be able to determine if an animal has become insensible after stunning, as the bleeding and dressing operations must not begin until complete stunning has been achieved.

When cattle, sheep, goats and pigs are stunned using a captive bolt, the animal should collapse immediately. Regular breathing should cease. There should be no corneal or blink reflex, if the eye is touched. These signs of insensibility should be looked for before bleeding commences, usually when the carcass is hanging on the bleeding rail.

In electrically stunned sheep, goats, pigs and ostriches, a "g*rand mal"*[6] seizure is induced which causes instant unconsciousness. This results in rigid spasms, which can last for up to 30 seconds. The animal should not be evaluated for insensibility until at least 30 seconds after electrical stunning. At no time after stunning should the animal vocalise (squeal, moo or bellow). Vocalising is a sign that the animal can still feel pain. It is normal to have leg-kicking reflexes in an animal that has been properly stunned with electricity, captive bolt or gunshot. If the animal has kicking reflexes, the head should flop like a rag doll. If it makes an attempt to raise its head, it may still be sensible. An animal showing a righting reflex must immediately be re-stunned.

The person assessing insensibility should concentrate on looking at the head and ignore kicking limbs. Gasping is

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[6] A "grand mal" seizure is a severe form of epilepsy characterized by paroxysmal transient disturbances of the electrical activity of the brain. This results in periodic recurrent convulsions of the body or "epileptic fit".

permissible: it is a sign of a dying brain. If the tongue is hanging straight down, limp and floppy, the animal is definitely stunned: if it is curled this is a sign of possible sensibility.

The heads of poultry that have been stunned with electricity should hang straight down after stunning. Birds that have not been properly stunned will show a strong righting reflex and raise their heads.

CHAPTER 8

MAINTENANCE OF GOOD ANIMAL WELFARE STANDARDS

People who handle or slaughter hundreds of animals become desensitised to suffering and have a tendency to become rough or careless unless their daily work is continuously monitored. Managers must maintain high standards of operational animal welfare.

Five major critical control points

It is strongly recommended that an HACCP-type system be used to measure and monitor the efficacy and performance of livestock and slaughter operators. HACCP—*Hazard Analysis and Critical Control Points*—is a system primarily used in meat plants to ensure food safety. By adapting the system to make regular measurements at Critical Control Points (CCPs) in the process, various critical operations, which are carried out by workers handling and slaughtering livestock, can be monitored to ensure that it is done correctly, leading to steady improvements in welfare and operational quality. An objective scoring system for certain operations is described. Evaluations of animal welfare against accepted standards and also between evaluators can be made. Five major critical control points of animal handling and slaughter are briefly outlined here.

Suggested control points for monitoring and evaluation are:

1. Stunning efficacy – the percentage of animals rendered insensible at the first attempt. (Insensibility is assessed according to criteria described on page 84/85.)

a. Captive bolt stunning - correct shooting
b. Electric tongs stunning – correct placement

2. Bleed rail insensibility – the percentage of animals that remain insensible before and after bleeding (using the same criteria as in 1).

3. Vocalisation – the percentage of cattle or pigs that vocalise (bellow, moo or squeal) during adverse events such as missed stuns, excessive electric prod use, excessive pressure from restraint device slipping or falling etc. Each animal is scored as a vocalizer or non-vocalizer during handling and stunning, not in the holding pens. Vocalising scoring is not used on sheep as they often do this anyway.

4. Slipping and falling--the percentage of animals that slip or fall during handling or stunning. Selected stations should be chosen for monitoring.

5. Electric prods – percentage of animals requiring prodding with an electric goad.

Monitoring and audit of these CCPs must be done on a regular basis.

Objective scoring of efficacy standards at critical control points

1.a. Captive bolt - Stunning efficacy

(Score, per day, a minimum of 20 animals or 20% in large plants)

* Excellent – 99-100 % instantly rendered insensible with one shot;

* Acceptable – 95-98 %;

* Not acceptable – 90-94 %;

* Serious problems – less than 90 %.

Action: if one-shot efficacy falls below 95% immediate action must be taken to improve the percentage.

1.b. Electrical stunning - Tongs placement efficacy

(Score all pigs, sheep or ostriches or a minimum of 100 in large plants)

* Excellent – 99.5-100% correct placement of stunning tongs;

* Acceptable – 99.4-99%;

* Not acceptable – 98-95 %;

* Serious problem – less than 95 %.

2. Insensibility after stunning

(Score a minimum of 20 animals or 20% in large plants)

-If the animal is hoisted immediately after stunning, evaluate after hoisting (unless it shows obvious sensibility);

-If the animal is left on the ground, wait 15-30 seconds before evaluating to allow spasms to stop (especially in electrically stunned);

-Any animal, which shows any signs of sensibility, must immediately be re-stunned.

* Excellent - Cattle – less than 1 per 1000 or 0.1%;

  - Pigs - less than 1 per 2000 or 0.05%;

* Acceptable - Cattle – less than 1 per 500 or 0.2%;

  - Pigs - less than 1 per 1000 or 0.1%.

3.a. Criteria for vocalization of cattle

- In crowd pen, lead-up race, stun box or restraint device.

(Score minimum of 20 animals or 20% in large plants)

Score each animal Yes for vocalizer and No for non-vocalizer

* Excellent - 0.05% or less of cattle Yes;

* Acceptable - 3% or less Yes;

* Not acceptable - 4-10% Yes;

* Serious problem – more than 10% Yes.

3.b Criteria for vocalization of pigs

- In restrainer, stunning pen or during stunning.

(Score minimum of 20 pigs or 10% in large plant)

Score each animal Yes for vocalizer and No for non-vocalizer

* Excellent - 0% of the pigs Yes;

* Acceptable - 1% or less pigs Yes for restrainer, 0% due to misplaced tongs;

* Not acceptable - 2% or more Yes in restrainer or pen;

* Serious problem - 5% or more Yes in restrainer or pen.

Reducing the level of pig squealing improves pork quality and decreases PSE.

Do not use vocalization scoring for sheep.

4. Slipping and failing in the stunning area

- Includes restrainer entrances, races, holding pens and unloads ramp.

(Score a minimum of 20 animals or 10% in large plants)

Score on Yes for slip and No for non-slip.

* Excellent - no slipping or falling;

* Acceptable - slipping of less than 3% of animals;

* Not acceptable - 1% falling down (body touches floor);

* Serious problem - 5% falling down or 15% slipping.

5. Electric prodding efficacy

If the prod causes the animal to vocalise, the current is too strong.

(Score a minimum of 20 animals or 10% in large plants)

Score Yes if the animals vocalise and No if don't.

a. Electric prods scoring criteria for cattle:

	Crowd pens to race	**Entrance to stun box**	**Total percentage of cattle prodded**
* Excellent	no Yesses	5% or less	5% or less
* Acceptable	no Yesses	10% or less	10% or less
* Not accept		20% or less	20% or less
* Serious problem			50% or more

b. Electric prods scoring criteria for pigs:

	Crowd pens to race	**Entrance to restrainer**	**Total percentage of pigs prodded**
* Excellent	no Yesses	10% or less	10% or less
* Acceptable	no Yesses	-	15% or less
* Not accept	no Yesses	-	25% or less
* Serious problem	-	-	50% or more

CONCLUSION

The international livestock industry must be encouraged to practice increasingly better handling and welfare of slaughter animals. This is particularly important for developing countries, as this will improve production. Here, the introduction of better stunning practices and improved pre-stunning methods for ritual slaughter are urgently required.

In developing countries good standards of animal welfare can be achieved during transport and slaughter without the use of expensive high-tech equipment. These countries should be assisted to produce simple locally or regionally made improvements such as metal grating on the slippery floor of a vehicle or stun box or materials to construct races and restraint devices, as well as stunning equipment like electrical tongs and cartridges for captive bolt pistols. Importing expensive equipment and the difficulties in securing regular supplies of cartridges causes many slaughterhouse managements to abandon recommended stunning methods and to resort to inhumane methods.

There is also a need around the world to change marketing systems, which will enable people to pass losses such as bruises along to the next segment in the marketing chain. People need to be held accountable for losses from bruises, hide damage, branding and dead animals. Changes in marketing systems and in the way people are paid is one of the best ways to improve welfare and reduce economic losses. People should not be paid on a piecework basis but should receive bonuses for reduced bruising and better stunning.

The formation of producer cooperatives would eliminate middlemen and those cooperatives could also initiate training programmes for staff who handle transport and slaughter livestock, thereby improving the standard of animal welfare and increasing economic return.

Carcass evaluation and meat grading

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Importance of grading

- Help the farmer (producers) to recognize their quality of animal and for better planning to improve program and produce high grade animals and carcasses.
- It helps to producer and processer to certify their animals and carcasses for class, quality and condition through authorized agencies.
- Helps the processor to select a required type according to the needs of market and consumers.

Conti……

- By producing the quality meat, gives satisfaction to consumers over the money he/she spent on purchase of meat and meat products .
- Also helps the consumers to utilize meat more efficiently by preparing it in the manner for which it is best suited .
- The systematic way to express value and quality of carcass by sorting in to groups according to selected characteristics.

conti

- **A systemic procedure by which carcass, meat and meat products are segregated on the basis of accepted palatability or yield attributes or other economically traits.**
- **Meat evaluation is an extension of grading that identifies carcasses composition and value differences with greater precision thane grades alone.**

System of carcass evaluation and grading

- In India, grading of meat carcasses and wholesale cuts is still confined at the export level, that too as per the agreement between the exporter and importer.
- USDA SYSTEM OF CARCASSE / MEAT EVALUATION
- A. Palatability or quality grades.
- B. Cutability or yield grades.

Factors used to establish palatability /quality grades

- Kind and class
- Maturity
- Marbling
- Firmness / texture
- Colour and structure of lean
- Confirmation , fleshing and finish

Maturity

- The physiological age of the animal or bird that produce t he carcass.
- Age has a significant effects on tenderness of meat
- Also related to texture of the meat (as an animal matures the texture of the lean changes from fine to coarse).

Determination of the maturity in carcass

- By observing carcass bone
- By structure of cartilage (tough white flexible tissue)
- By the size shape of ribs and ossification (vertebrae) of the bone
- Colour and texture of the lean meat
- (maturity is generally categorized as A B C D & E).

KIND AND CLASS

- Each species of animals is referred as a kind
- Class that are quite similar in physical characteristics.
- example:

  Classes for cattle : Heifer, Cow Steer, Bull and Bullock .

  Likewise in case of pig: Boar,Sow, Barrow and Gilt.

MARBLING

Visible intramuscular fat, located in perimyseal connective between muscular fiber bundles

A positive effect on tenderness of meat possible by acting as a lubricant during chewing and swallowing

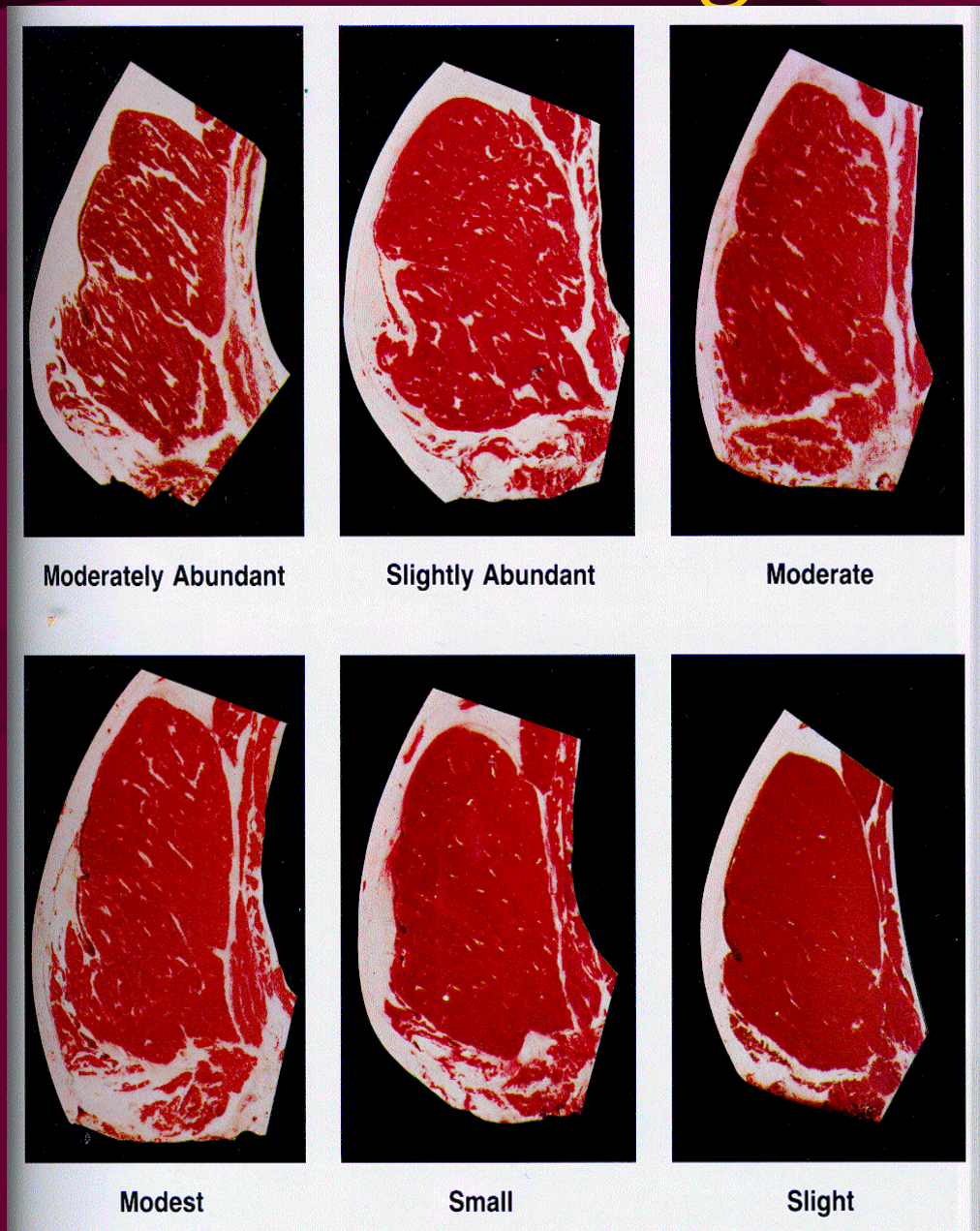
Highly desirable in any cut of meat is highly related to juiciness and flavour

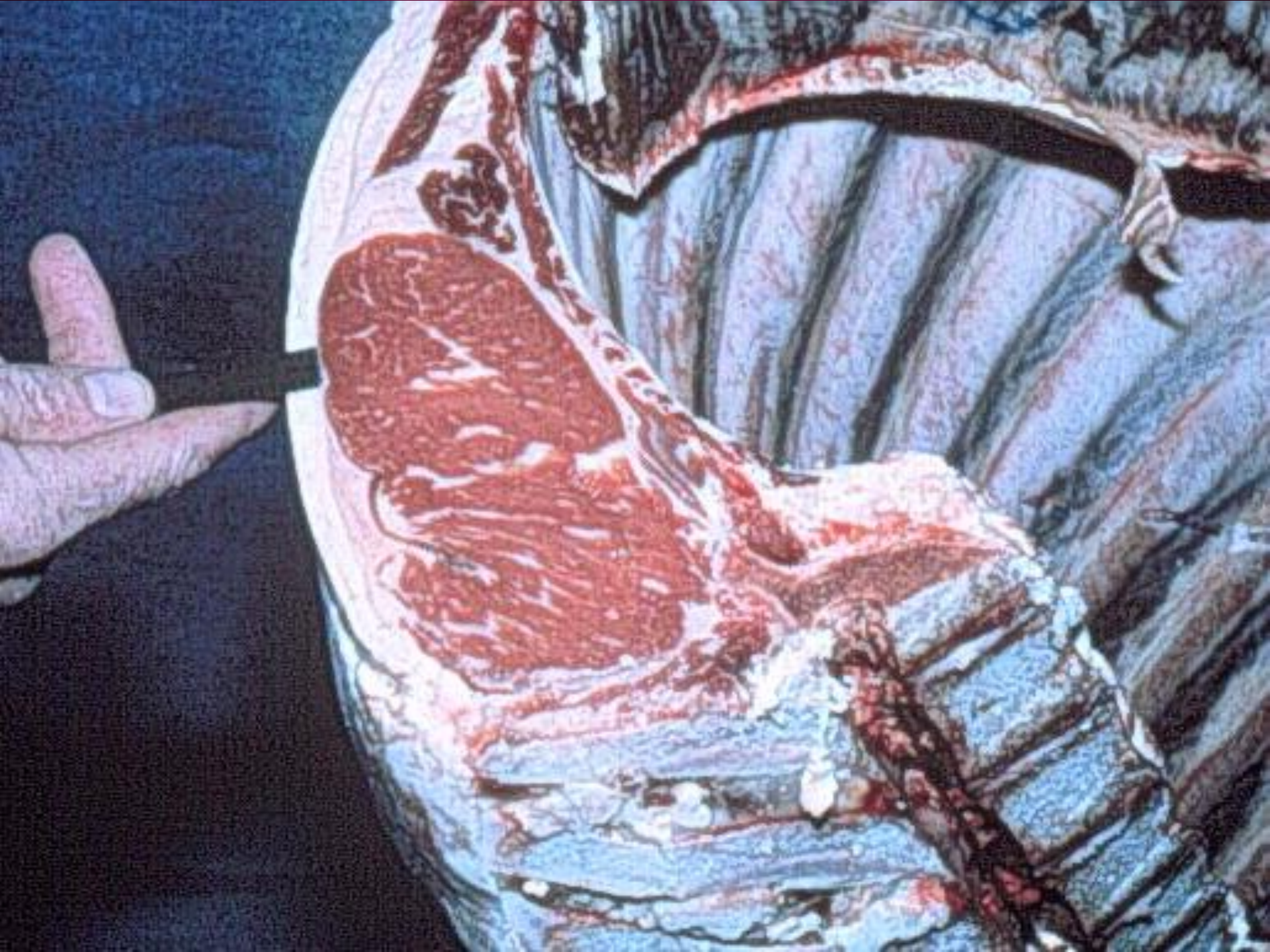
Conti……

- Marbling in lamb carcass is indicated by amounts of flank streaking
- Marbling in pork carcass is indicated by fine streaks of fat visible in the intercostal muscle between the rib called as feathering
- Determination of the marbling in carcass :
- On the basis of longismuss muscle cross section at 12^{th} rib in beef and lamb and 10^{th} ribin pork

Recognized levels of marbling

- Moderate abundant
- Slightly abundant
- Moderate
- Modest
- Small
- Slight
- Traces
- Practically devoid





Firmness

- Refers to firmness of the muscle
- Evaluated in the flank area of carcass or cut surface of the lean meat
- Greatly influenced by the amount of fat that is present in carcass
- No direct contribution to palatability

Texture

- Related to size of muscle fiber bundles and thickness of perimyseal connective tissue between fiber bundles
- 9 recognized levels firmness

1. FIRM	**4. Slightly soft**	**7. Soft and Slightly watery**
2. Moderately firm	5. . Moderately soft	8. Soft and watery
3. Slightly firm	6. Soft	9. Very soft and watery

Colour and structure of lean

- Practically the only criterion the consumer can use to judge the acceptability of most meat at purchase.
- Extreme colour and structure are undesirable
- 3 Attributes of color
- 1. Hue-Normally thought colour

2. Chrome- purity or saturation of colour

3. value-overall light reflectance of colour

Beef	Bright cherry red colour
Fish	Gray white to dark red colour
Lamb and Mutton	Light red to brick red colour
Pork	Greyish pink
Veal	Brownnish pink
Poultry	Grey white to dull red

Conformation, fleshing and finish

- Fleshing :

  also called as musculing.

  refers to the development of skeltal muscle

Finish :

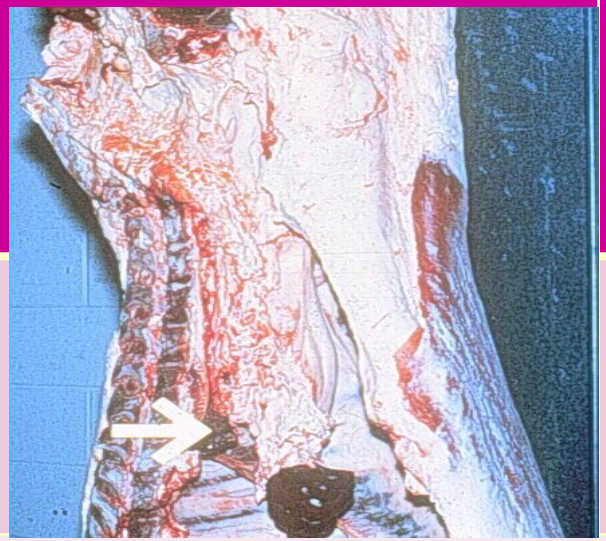
refers to the amount character and distribution of external, internal and intramuscular fat either in carcass or wholesale cuts

Conti……

- Refers to proportionate development of carcass part or wholesale cuts and to the ratio of muscle to bone
- Describe general built, form, shape, contour or outline of carcass, sides or cuts which yields greatest quality of edible meat

Factors used to establish yield grades of different species

For Beef	For lamb / Goat
a. Fat thickness	a. Fat thickness
b. Rib eye area (12th rib, longissmues dorsi muscle)	b. Percent kidney and pelvic fat
c. Percent kidney, heart and pelvic fat	c. Leg conformation (fullness of legs)



For pork

- 1. Class (barrow, gilt sows etc)
- 2. Back fat thickness
- 3. Muscling
- 4. Carcass weight
- 5. Belly thickness

Muscle development

- Rib eye area / lion eye area –cross sectional area of logissmus muscle
- Beef and lamb- between 12^{th}-13^{th} rib
- Pork – between 10^{th} -11^{th} rib
- Lion eye area is not used in grading of lamb and pork carcass because in industry practice pork and lamb carcass are not ribbed

Fat Depth / Thickness

- Located off the midline at a point 3/4th of the width of the longissmus muscle from the medial side and between 10th -11th rib (pig)

- For beef 3/4th longissmus width position between 12th -13th rib

- For lamb over the midpoint of logissmus muscle width between 12th – 13th rib

Live Weight

- Live weight (LW) is the actual weight of an animal at the time of evaluation or slaughter.
  - Beef average: 1200 lbs (Normal Range: 950 - 1500 lb)
- Shrink loss should be taken into account.
  - Beef 3 – 5%

Dressing %

- Beef average: 63% (choice steers, bullocks and heifers)
  - Normal Range: 55 - 67% for steers, bullocks, and heifers
  - Calculation: (CCW/LW)*100

What Affects Dressing %

- Amount of fill
- Degree of Muscling
- Degree of fatness
- Commercial Setting (Mud, Dags, etc.)

REA

- Live evaluation an estimation of the width and depth of the loin.
- Carcass evaluation actual dimensions in $in.^2$ using a grid.

Quality Grade

- Marbling: the intermingling of fat within the muscle
  - intra-muscular (IM) fat
- Evaluated at the ribbing site (12th rib)
  - Average: Slight to Modest
  - Normal Range: Traces – Abundant

Thank you

CANADA
4-H Manitoba

Judging Beef Cattle

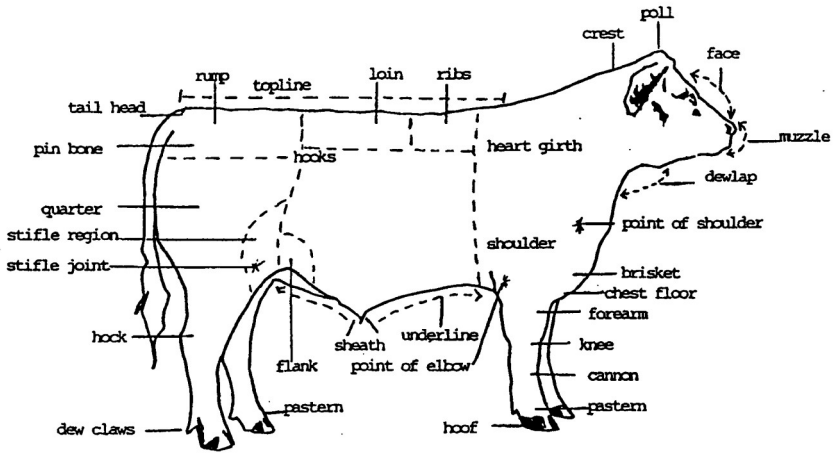
The aim of the beef industry is to efficiently produce carcasses of the type and quality demanded by the consumer. The ability to look at the live beef animal and evaluate its potential to produce these carcasses is a challenge to you and to others in the beef industry. We use live animal appraisal techniques in the show ring, the feedlot, the pasture and at the auction sale to assess the quality of our beef animals. This is what we refer to as judging beef – the art of visually comparing and ranking beef cattle.

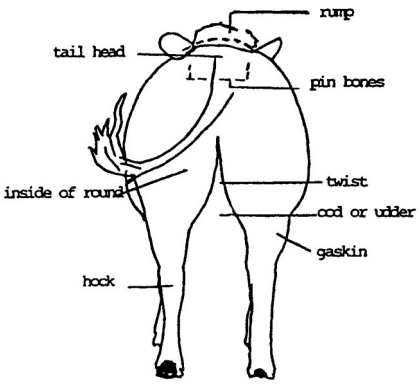
The objective of this unit is to:

- Give you background knowledge of the structure and function of the beef animal so you know the important points to look for when judging beef.
- Show you how to determine if a particular animal possesses these important traits.

First we must know what a beef animal looks like...

Parts of the Beef Animal





Beef Terminology

One of the most confusing things about judging is the terms we use to describe the animals. It may be hard to define some of these terms because they have different meanings to different people. Let's have a look at some of the more common terms and their definitions.

Market Steer Terminology

Muscle	-	red meat or lean
	-	that part of the carcass which is not bone or fat
Carcass	-	the part of the animal which remains after the removal of the head, feet, hide and internal organs
	-	the carcass is composed of bone, muscle, fat and connective tissue
Finish	-	the amount of fat covering on a market animal
	-	overfinished – the animal has too much fat cover
	-	underfinished – the animal doesn't have enough fat cover to fall into a desired grade
Cutability	-	the saleable meat in proportion to the total carcass
	-	a high cutability, or high proportion of red meat to bone and fat, is desirable
Frame	-	skeleton size
	-	this can be determined by looking at bone length and width and is easy to see in areas where there is nothing but bone, such as the cannon bone
Structure	-	must be sound or free from any defects, which inhibit performance
	-	must be correct and show the desired structural traits
Balance	-	the overall view of the animal, including how well the parts blend into one another and how freely and smoothly the animal moves
Trimness	-	freedom from excess fat or finish
	-	this can be determined by looking at places where fat tends to accumulate – the brisket, flank and twist
Grade	-	the description a carcass receives based on the maturity of the carcass, the quality (color, texture, and firmness of the muscle, marbling and fat) and the meat yield.
Style	-	way of going, alertness, gait, coloring
	-	this is often referred to as eye appeal
Meatiness	-	the degree of muscling
	-	a meaty animal will have superior muscling

Breeding Animal Terminology

The terms used for breeding stock are similar to those used for market animals. Soundness, correctness and breed character are most important in conformation of beef breeding stock. There are several terms, which relate to these qualities.

Conformation	-	the overall structure of the animal
	-	includes all the points mentioned
Masculinity	-	this term is used to describe bulls
	-	massiveness and strength of the animal
	-	secondary sex characteristics such as well-developed and defined muscles, thickness throughout the shoulder, neck and crest regions, overall well developed forequarters and a well-developed scrotum.
Femininity	-	this term is used to describe heifers and cows
	-	refinement of the head, neck and shoulders, the degree of muscling,
	-	evidence of udder and teat development
	-	females should have smoother muscling than bulls and should be more refined through the head, neck, and shoulder
Breed Character	-	the shape of head, length of body, height, color markings and other characteristics as defined by the Breed Associations as characteristic of that breed
Condition	-	this means the same thing as finish does for the market animal. It is the amount of fat and muscle that the animal is carrying
Broodiness	-	indicators that a female will be or is a good mother
	-	includes adequate size and frame to carry a calf, udder and teat development and disposition
Capacity	-	also means volume or depth
	-	the size and frame of an animal in relation to its ability to carry a calf, develop desirable muscling, and remain structurally sound over the years
Progeny	-	the offspring or calves of a female or bull

Carcass Terminology

In addition to the terms already defined, there are many other terms you will encounter when working with carcasses.

Because, in the beef industry, our product is meat, we need to understand the importance of these characteristics whether we are judging live animals or carcasses.

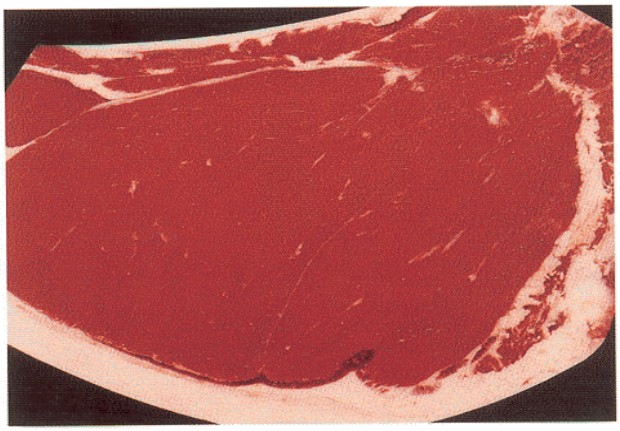
Connective tissue	-	includes tendons, ligaments and cartilage
	-	these all help to hold the body and organs together

Gristle	-	refers to the heavy deposits of connective tissue found in the muscle
	-	meat with lots of connective tissue will be tough to cut and chew
	-	connective tissue looks like white or colorless ribbons and threads through the meat
Cartilage	-	connective tissue which may be replaced by bone as the animal matures and develops
	-	in the mature animal, cartilage is only found in places where there needs to be elasticity and flex such as the ears and the joints
Maturity	-	the age of the animal or carcass
	-	affects the eating quality of the meat
	-	is determined by the degree of bone ossification or hardening of cartilage into bone
Marbling	-	amount, size and distribution of fat within the meat
	-	this does not include the outside covering found on many cuts nor any large fat deposits within the muscle
	-	looks like little white flecks in the meat
	-	marbling gives the meat flavor and tenderness
Fat level	-	means the fat measurement at the minimum point of thickness in the fourth quadrant of the longissimus muscle between the 12^{th} and 13^{th} ribs

Did you know that all meat would taste exactly the same if it were not for the fat? Lamb, pork and beef would all taste the same. But, because of the type and amount of fat, we have three very different tasting meats.

Marbling

Canada AA

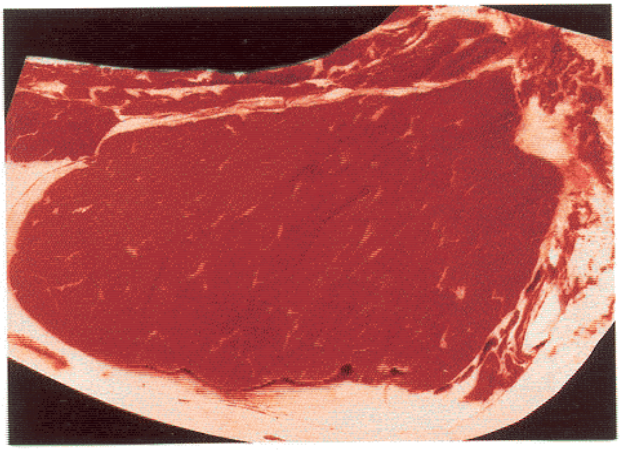


Slight*

*At the least, a **slight** amount, but less than a small amount*

YES: The carcass has qualified for Canada AA

Canada AAA

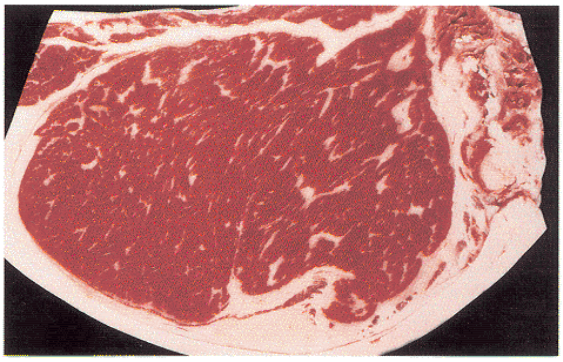


Small*

*A **small** amount or more*

YES: The carcass has qualified for Canada AAA

Canada Prime



Slightly Abundant*

***Slightly abundant** or more.*

Yes: The carcass has qualified for Canada Prime

Courtesy of National Cattlemen's Beef Association

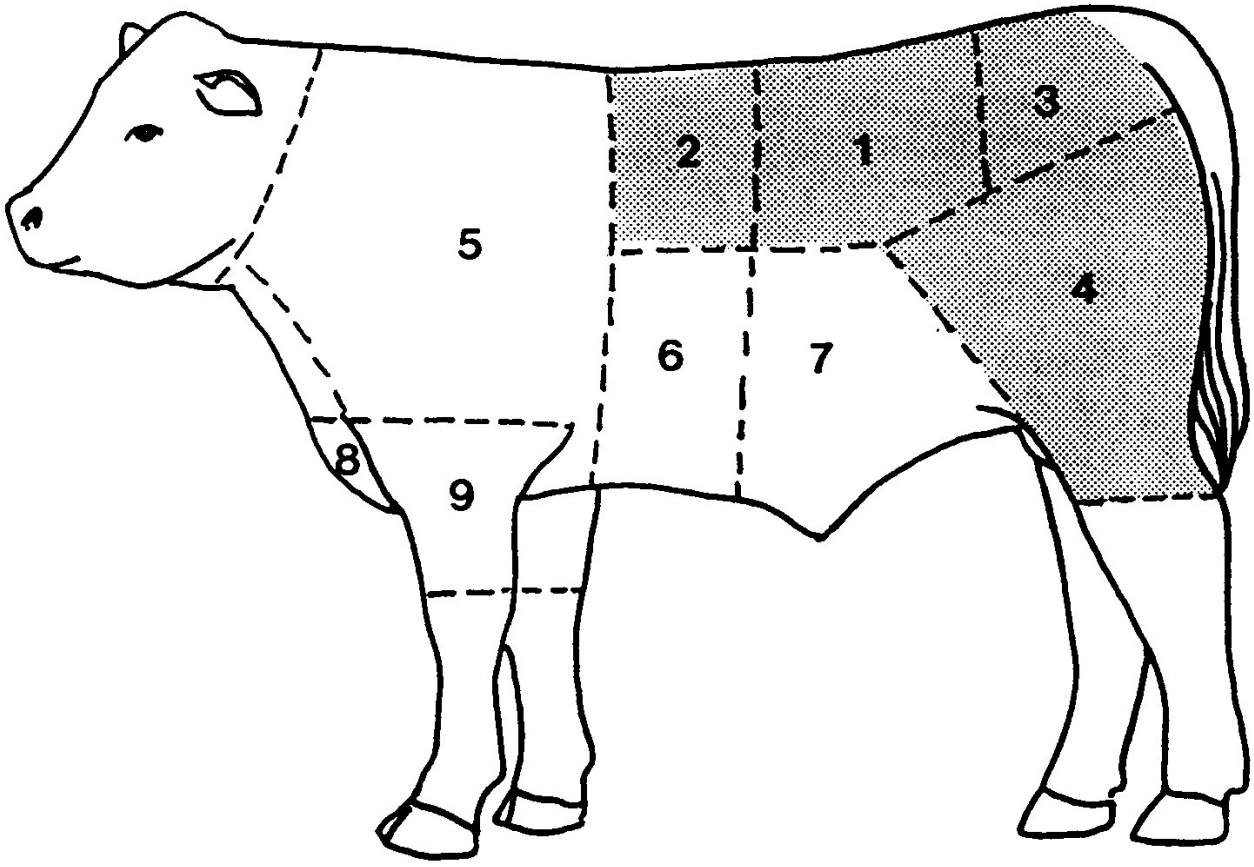
Before we learn about the live animal, let's discuss what to look for in a slaughtered animal, or in the meat. When the consumer buys meat, he or she looks mainly at price and grade. Grade gives the consumer an indication of color, tenderness, juiciness, flavor and the amount of fat or marbling.

Cuts of Beef

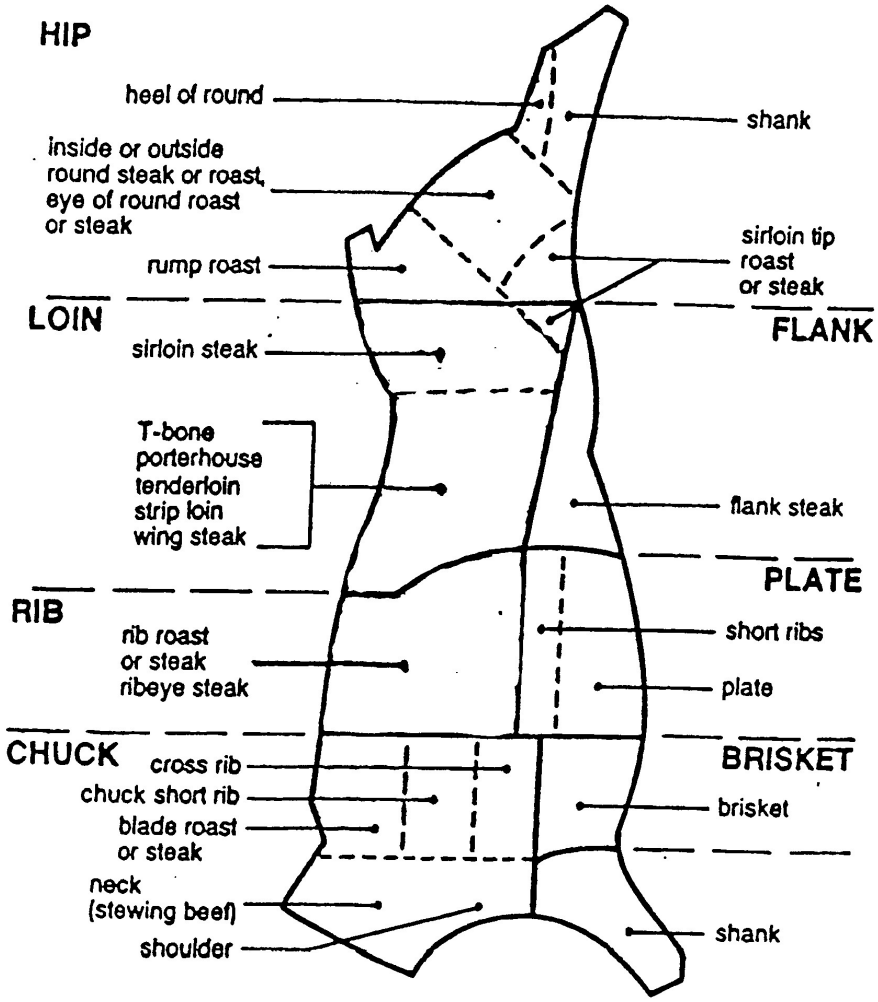
The wholesale cuts on the beef carcass are shown below. Note the locations of the higher priced cuts.

Wholesale Cuts of a Beef Carcass

	High Priced		Low Priced
1.	Loin	5.	Chuck
2.	Rib	6.	Plate
3.	Rump	7.	Flank
4.	Round	8.	Brisket
		9.	Shank



Beef Cuts Chart



Judging the Carcass Class

When you judge a carcass class, you do the same thing as the graders.

You look for the carcass or carcasses which will grade Canada Prime. You place the carcasses in order from highest to lowest quality.

The steps you should follow are:
1. Determine the maturity. You can determine this by looking at the amount of bone ossification or hardening.
2. Check the color of the muscle and fat. Look for bright red meat and a white fat cover.
3. Check the yield. Look between the 12th and 13th rib and see how much fat there is. A Canada Prime carcass must be greater than or equal to 2 mm.

Look for a carcass that has ample red meat. The muscles should be large bulging with the appropriate amount of fat cover. The muscles should be long and tapered where they attach to the bones and full and thick in the middle. Check to make sure the meat is firm and "bounces" back when you press into it. Remember that muscles is firm and fat is soft.

Place the class from most desirable to least desirable according to how you think the carcasses would be graded.

The Canadian beef grading system fulfils the primary purpose of dividing the population of cattle carcasses into uniform groups to facilitate marketing. The system provides an effective means of describing product that is easily understood by both buyers and sellers.

In Canada, beef grading is provided through the Canadian Beef Grading Agency in abattoirs, which receive either federal or provincial government meat inspection services. Grade standards and regulations are enforced by Government of Canada (Canadian Food Inspection Agency) employees.

There are thirteen (13) beef grades in the Canadian system. They are:

Canada A, Canada AA, Canada AAA, Canada Prime
Canada B1, Canada B2, Canada B3, Canada B4
Canada D1, Canada D2, Canada D3, Canada D4
Canada E1

The key grading criteria for the quality grades are:

- Carcass maturity
- Muscling
- Meat quality
- External fat covering
- Marbling

For full details on the "Specifications for Canada's Beef Carcass Grading Regulations", please refer to the "4-H Beef Program – Manitoba Livestock Education System" binder or visit www.cbef.com

More About Beef

Let's learn a few simple rules about beef cattle. You can apply these to judging both market animals and breeding stock. Circle "Truth" or "Not".

Tell Me – "Is this the Truth...or Not?"

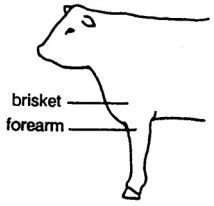
Rule #1	Cattle grow and develop in a genetically determined way. We cannot change the composition of cattle.	Truth	OR	Not
Rule #2	Muscle and fat are laid down evenly over the body of the beef animal.	Truth	OR	Not
Rule #3	Of the three components of cutability (bone, muscle, and fat), bone changes the least from one animal to the next.	Truth	OR	Not
Rule #4	Muscles are always located in the same place on each animal. These muscles always have a similar size and shape in proportion to the animal.	Truth	OR	Not
Rule #5	An animal lays down all its muscle before laying down fat.	Truth	OR	Not

Yes, all of the rules are **truths**. Let's take a closer look at each of these rules to help you understand how the beef machine works.

Rule #1

We cannot change the composition of cattle. Mother nature designed cattle to grow and develop in a genetically determined way. This is true for all cows, steers, heifers and breeds. Cattle deposit fat in the brisket area and not in the forearm area. There will never be any muscle development in the brisket and there will never be any fat on the forearm.

In any animal, there is a priority of nutrients. This means that as the animal takes in nutrients, or feed, these will first be used in the most important areas – that is maintenance. The most important is for the nerves; the least important is for fat. Once all of the important needs have been met, then the animal will lay down fat.



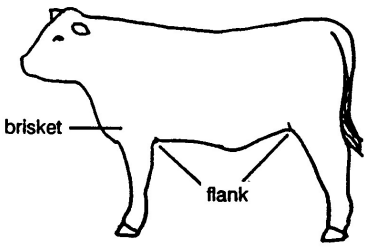
Rule #2

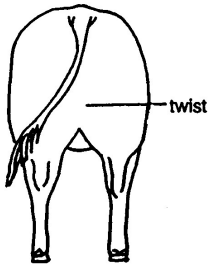
Muscle and fat are developed evenly in the beef animal. This means that muscle is laid down at the same rate all over the animal, regardless of where the muscle is located.

The proportions of one muscle type to the next are the same from one animal to the next. You know this because your beef animal should have symmetry and balance of all parts in order to function properly.

One steer could be bigger and show more muscle expression than another, but both would have exactly the same proportions of forearm muscle to round muscle. This is important for you to understand. When someone says "this steer showed more muscle expression in the areas of the high priced cuts", you know that if that steer is well muscled in the hindquarter, then he will be well muscled over his entire body.

This same principle applies to fat. Fat accumulates in certain places on the beef animal. It accumulates in these locations at the same rate. Look at the brisket, flank and twist. By determining the amount of fat your animal is carrying in any of these three places, you can predict the amount of total fat on your animal. A very fat cow will also have fat in the pin bone area. A very fat bull will also accumulate fat in the neck of the scrotum.





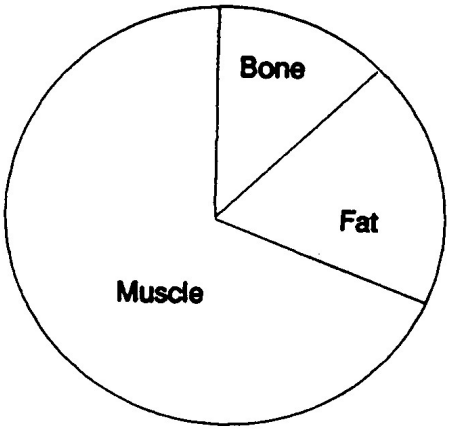
Rule #3

Of the three components of cutability (bone, muscle, and fat), bone changes the least from one animal to the next. The amount of bone or size of skeleton as a percentage of the total weight varies very little between cattle of similar height and weight.

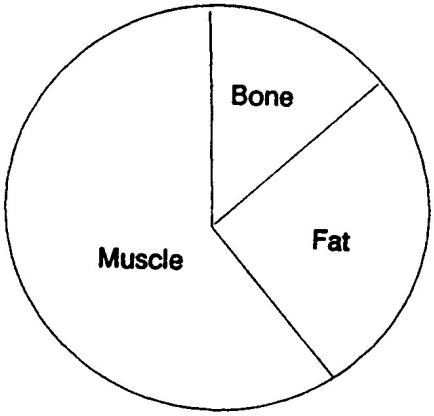
You can tell if animals have a similar skeletal structure by looking at the areas where there is only bone. Look at the cannon bone. If two animals have the same length of cannon bone, they have a similar size of skeleton because the length of the cannon bone is always a constant percentage of the whole skeletal size.

This will help you if you see two steers – one that looks taller and heavier and another that appears smaller and lighter. When you look at their cannon bones, you find that the cannon bones are the same length. This tells you that they have the same size skeleton. What could account for the difference you see in their size and weight? It must be either muscle or fat.

AN IDEAL STEER



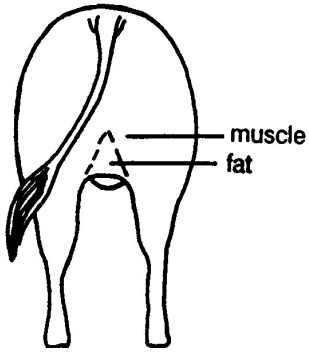
AN OVERFAT STEER



Rule #4

Muscles are always located in the same place on each animal. These muscles always have a similar size and shape in proportion to the animal. They do not increase in number or size or change location as the steer grows or gains weight. Double muscled steers are an exception to this.

This is an important point to remember because looking for the amount of red meat on an animal while the animal is still alive can be very difficult. If you know that the muscles covering the rump of the beef animal are long and tapered, you know that a square, flat hind end cannot be composed of entirely muscle because these muscles are rounded and tapered, not flat and square. The hind end must have an appreciable amount of fat on it to make it look square. Remember, muscle is round – fat is square.

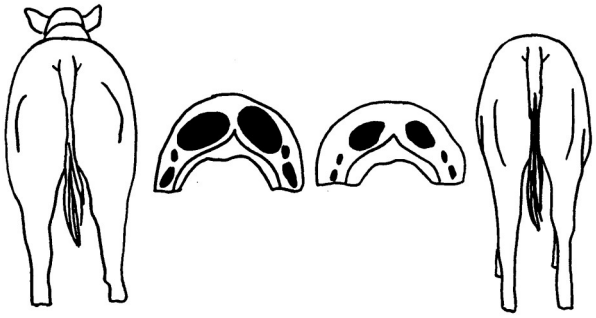


The same goes for the twist area. All beef are cut up in the twist. The muscle located in the twist is long and flat and cuts up high into the hip. If your live steer is full in the twist most of the way down to the hock, you know that this area must be filled with fat as muscles do not and never will develop in that fashion.

Rule #5

Animals grow and develop in a set way. They always lay down muscle before they lay down any significant amount fat. So you know that if you find much fat on a market ready steer, his muscles are not going to grow any more. He will just keep getting fatter.

Never think that a fat steer is going to develop more muscle – he has already developed all the muscle he is going to.



Both of these steers have finished developing muscle. If you continue to feed them they will lay down more fat, but no more muscle or meat.

Class Live Scoring

Live scoring consists of a live evaluation of Lean Yield, Usefulness of Animal and Gain and Quality Grade Score. Use the 4-H Market Livestock Education System – Beef Score Card to place the live animals.

Manitoba Livestock Education System

Number	Weight	A.D.G.	Scan Data

LEAN YIELD

Yield Grade		Range	Score	
High	1	>61.0%	20	
Medium	1	60.0-60.9	18	
Low	1	59.0-59.9	16	
High	2	58.0-58.9	14	
Medium	2	56.0-57.9	11	
Low	2	54.0-55.9	8	
	3	<53.9%	5	
Maximum Score Available 20			Score	

USEFULNESS EVALUATION
Score Range 1 – 9

Trait	Low	Fair	Avg.	Good	Excellent	
Total Muscling	1	3	5	7	9	
Total Trimness	1	3	5	7	9	
Growth/Frame	1	3	5	7	9	
Structure/Balance	1	3	5	7	9	
Maximum Score Available 36					Score	

GAIN & QUALITY GRADE

A.D.G.	B	A	AA or Better	
2.4 or <	14	30	42	
2.6	17	33	45	
2.8	19	35	47	
3.0	21	37	49	
3.2	23	39	51	
3.4	25	41	53	
Maximum Point Spread/Grade 11			Score	

Comments:	Beef Live Weight Bonuses		
	<1050	0	
	1051-1150	+3	
	1151-1350	+5	
	1351-1450	+3	
	>1451	0	TOTAL (Max. 114)

Printed Sept. 2001

Lean Yield: When a carcass qualifies for Canada Prime or any of the Canada A Grades a prediction of yield is also made. It is an estimation of the percentage of the carcass that is red meat. Meat yield is influenced by the degree of muscling and thickness of fat. The larger the rib eye the greater amount of fat the animal can carry to achieve a higher yield grade. Scan data of back and rib eye area can assist in determining a lean yield.

Usefulness: Total muscling, total trimness, growth/frame and structure/balance of the animal is evaluated on a scale of low to excellent. Traditional judging equates this with "seeing the animal".

Gain & Quality: Looking at the live animal the judge estimates if it is a B, A, AA or Better. Referring to the rate of gain information the grid will score the animal. Usually the greater the fat thickness the greater the marbling that has occurred (breed differences influence the degree of marbling).

Live Weight Bonuses: Bonuses for animals that are ideal for market conditions.

Judging the Market Animal

The aim of the beef industry is to efficiently produce carcasses of the type and quality demanded by the consumer. The ability to look at a live beef animal and evaluate its potential to produce these carcasses is a challenge to you and others in the beef industry. Live animal appraisal techniques are used in the showing, the feedlot, on pasture and at the auction sale to assess the quality of beef animals. This is what is referred to as "judging beef" – the art of visually comparing and ranking beef cattle.

The ideal market steer weighs 1100 – 1250 pounds and possesses enough size and scale to carry this weight with a minimum of finish. The steer should demonstrate enough finish to indicate a high quality carcass (Canada AAA or USDA choice grade), but yet a minimum of finish to increase carcass cutability. Heavy muscling is desired in the high priced cuts.

Selecting Slaughter Animals – Some Main Points to Remember

The meat type animal of today has a high percentage of muscle and low percentage of fat. The best indicators of muscling are:

- Thickness through the rear quarter
- Natural thickness and turn over the edge of the top
- Muscling in the forearm
- Natural width of leg placement

When you judge market steers, you are trying to visually assess the cutability in an animal that is still breathing, walking and dragging its owner all over the ring.

CUTABILITY = MUSCLE AS A % OF TOTAL BODY WEIGHT

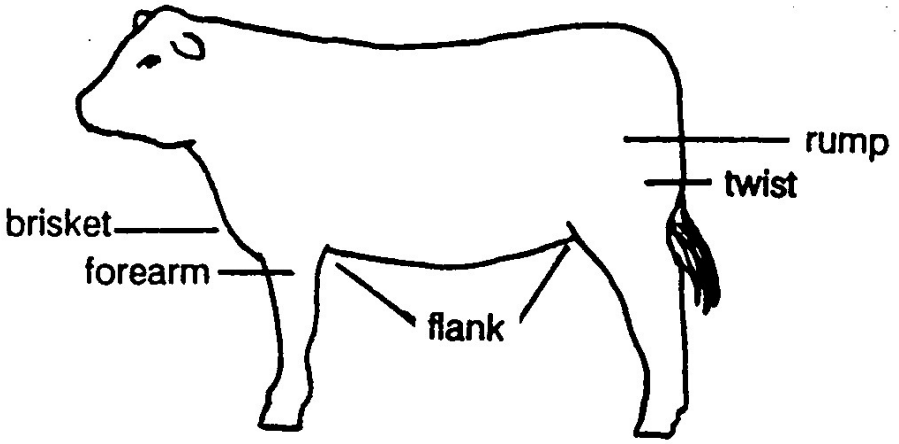
There are three components influencing cutability. These are bone, muscle, and fat. Your first place animal should be the one with the highest cutability. This will be the one with the highest percentage of lean meat compared to bone and fat. How can you find this animal?

There are some fairly accurate steps you can take to estimate the cutability if you first understand how a beef animal grows and develops. The idea is to "undress" the steer with your eye to see the meat parts. Your difficulty is trying to "see through" the fat and hide in order to evaluate the meat that is underneath.

The 5 rules gave you a quick lesson in cattle biology. Let's now relate this to judging a class of steers.

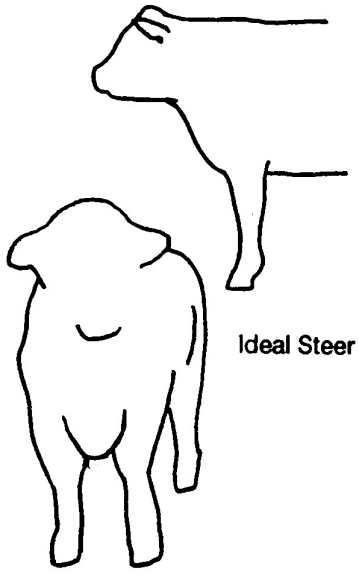
The most important thing to find in market animals is a desirable degree of finish, or amount of fat covering. Graders look for the fat between the 12^{th} and 13^{th} rib. Obviously, we cannot check that area in a live animal but we can look at other areas that indicate fat amount. The challenge for you is to identify which is fat and which is muscle.

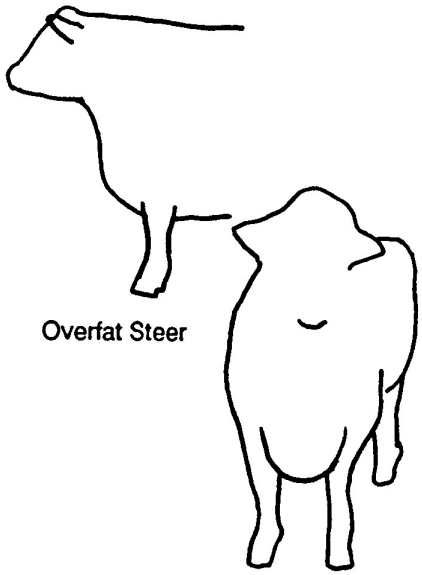
There are 5 key areas where you should check for the amounts of fat and muscle. These are the brisket, flank, twist, rump, and forearm. Let's take a close look at each of these key areas.



The Brisket (view from the front and the side)

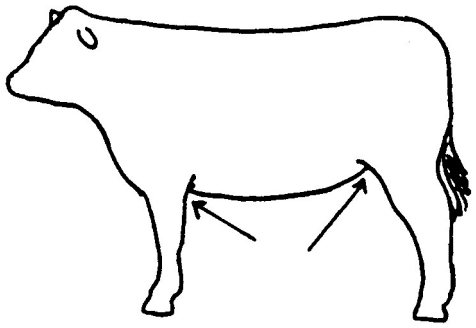
The brisket is located underneath the breastbone. The breastbone has very little muscle over it – just the tips of two long and narrow muscles. Therefore, if the brisket is deep and full it must be full of waste fat not muscle. If there are fat deposits here, there will be deposits of waste fat in other areas of the carcass.



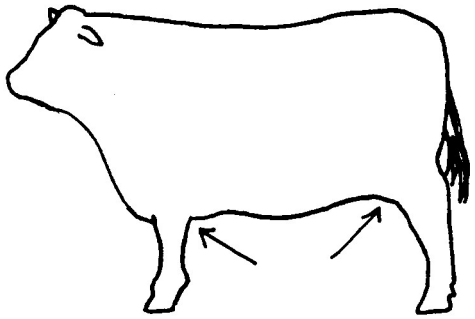


The Flank (view from the side)

If we look at the muscular structure of the beef animal in the flank area, we can see that there is no muscle or meat there at all. There is also no bone or skeletal structure. It is an area of skin and tough connective tissue. If the flank is deep and full, what could account for this? Nothing but fat. If there is fat here, then there will be other deposits of waste fat in the carcass, because the flank is the final place the animal deposits fat.



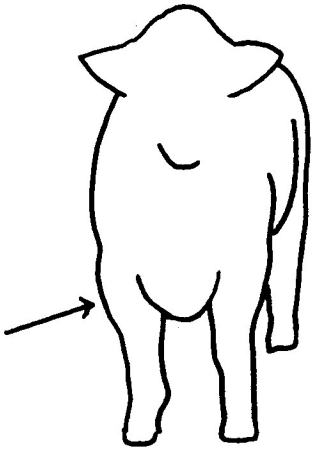
Ideal Steer



Overfat Steer

The Forearm (view from the front)

Examination of the forearm will give you an indication of how well muscled the animal is all over. Look at the forearm because no fat ever accumulates here. It is composed entirely of muscle and bone. If the forearm is bulging and muscular, the animal will have well developed muscles all over its body because, as we already know, muscle develops evenly.

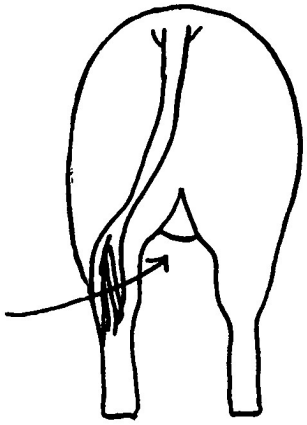


Ideal Steer

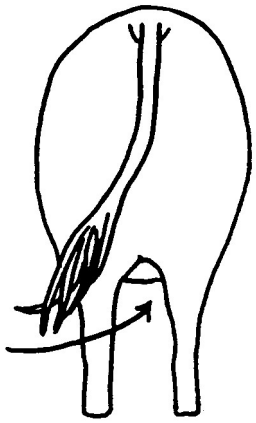
Overfat Steer

The Twist (view from directly behind)

A deep, full twist indicates fat, not muscle. If your steer is full all the way down to the hock, this must be fat because the muscles do not extend all the way down to the hock.



Ideal Steer



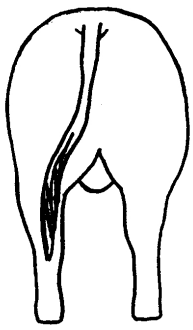
Overfat Steer

The Rump (view directly from behind)

A desirable steer has a thick hind end. This indicates good muscling. The muscles covering the rear should be curved and rounded. If the steer has a flat, square rump, it cannot be full of muscle because muscles are not square and rectangle. It must be fat.

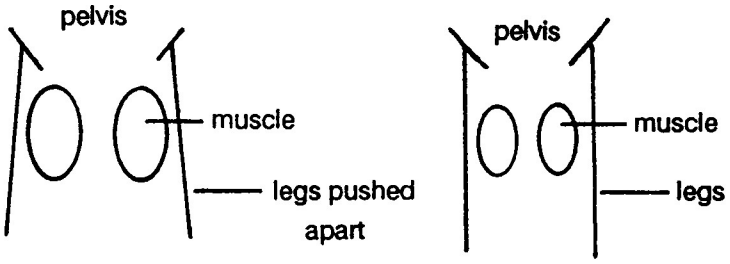
Thickness is desirable low in the stifle area. The steer should be thicker through the stifle area than anywhere else. Very little fat is ever laid down on the outside of the stifle region. If the steer is thick here we know it must be full of meat.

We can observe most about the amount of muscling on the steer by looking directly from behind. Look at the placement of the hind legs. Does the steer stand wide on his hind legs? The hind legs are attached way up in the hip area. If there is lots of meat through this area, the legs will be pushed apart and the steer will stand wide. The hind end contains the high priced cuts. An animal with a wide leg stance, indicating superior muscling in this area, will yield lots of red meat from the hind end.



Ideal Steer

Narrow Steer



Once you have viewed the animal at a distance and evaluated 5 areas, move in for a closer look. There are points on the steer that contain no muscle or meat, just bone and hide, and…if the animal is finished, a certain amount of fat.

Evaluating Finish

A steer should be muscular with indications of a high meat yield. He should show muscling when viewed from any angle plus have the necessary fat cover. This muscling is indicated by bulges and creases rather than smoothness, as seen in over-finished or less muscular steers.

A muscular, correctly finished steer is:

- Thick or widest through middle of the rounds.
- Wide at pins. Stands and walks wide on hind legs. Wide, thick back, loin and rump with correct onset shape or turn over top. Carries muscling well down on legs. Tailhead may be prominent – no excessive fat deposits.
- Muscle creases evident.
- Large rib-eye with minimum covering of finish.

An average muscled, over-finished steer is:

- Wide at the top but tapers in width from top to bottom of round.
- Full deep twist denoting excess fat.
- Lacks muscle in the middle round.
- Flatness over the rump and loin indicating muscle and excessive finish. Rib-eye muscle is smaller with excessive finish.

The easiest place to determine the finish of the steer is over the ribs. Feel the ribs about half way down. There should be about 1 cm of fat between the hide and the bone.

Feel the shoulder blade, for there is no muscle here either. There should be only a thin covering of fat over the bone. Handle the steer with the flat surfaces of your fingers or your whole hand, not just your fingertips. The tips of your fingers tickle the animal and make it prone to kick or fidget.

In the showring, market animals are also evaluated on the way they walk, style and eye appeal, shape of the head, etc. Remember that these things do not affect the quality of meat so don't place more importance on these points than you do on muscling and fat. When placing your class of steers, consider the most important things first – muscle, fat and finish. Then consider the less important characteristics.

The Ideal Steer:

From the front: Stands wide and shows trimness in the brisket and neck.

From the rear: The top is rounded with the widest point through the stifle. The legs stand wide apart and the twist shows evidence of muscle development.

From the side: The brisket and neck are trim, the topline is long and straight, legs are long, and the flanks and middle are trim. Assess the size and scale of the animal. Remember to look at the cannon bone for an indication of size of bone and skeleton.

A steer should be sound, alert, healthy, and move without any hindrances. Remember, he has to be able to make it from his bed to his trough and then to the slaughterhouse!

The Ideal Steer

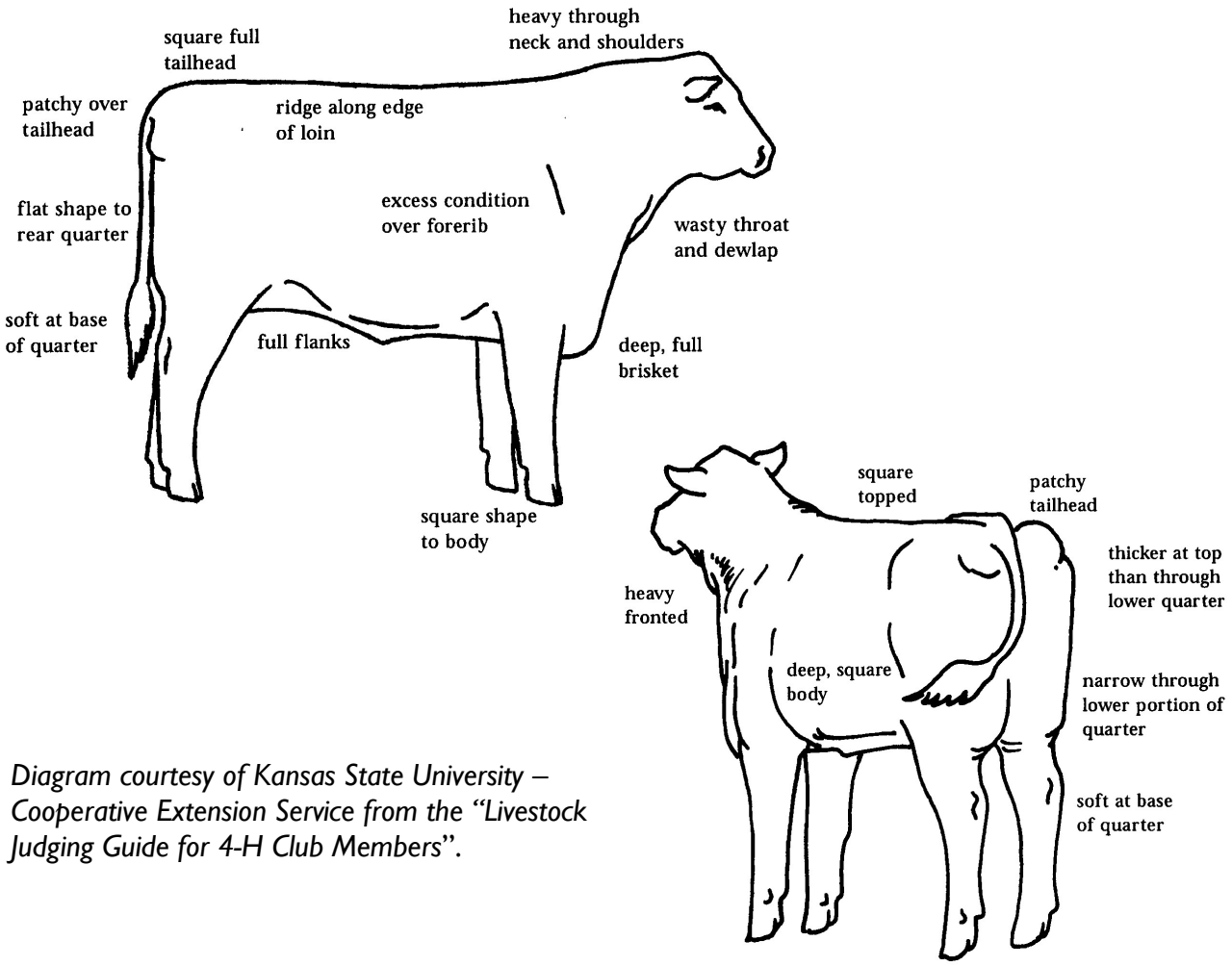
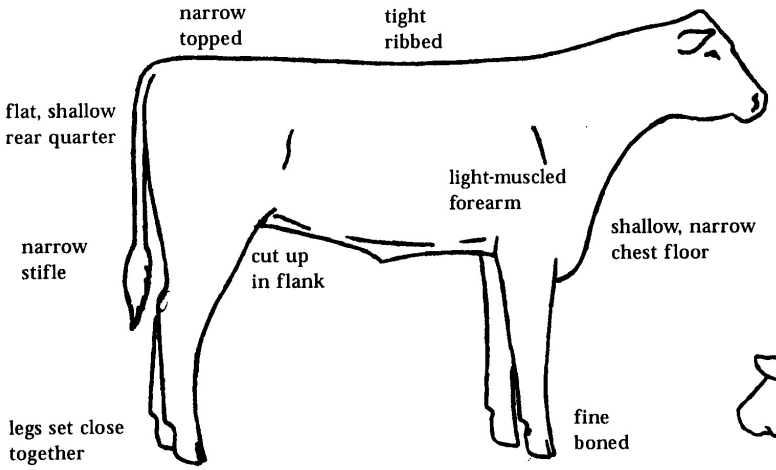


Diagram courtesy of Kansas State University – Cooperative Extension Service from the "Livestock Judging Guide for 4-H Club Members".

Narrow, Shallow, Light-muscled Steer



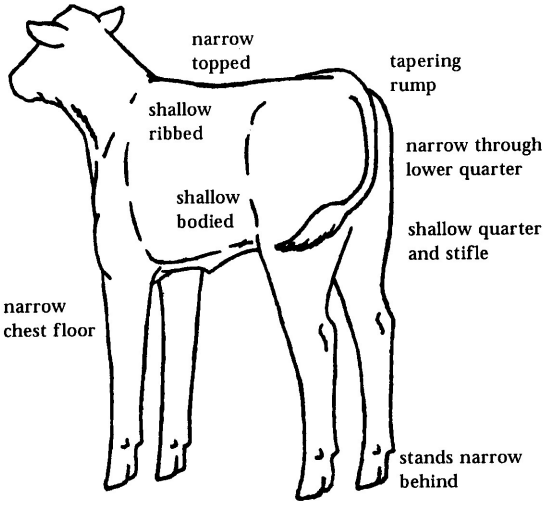
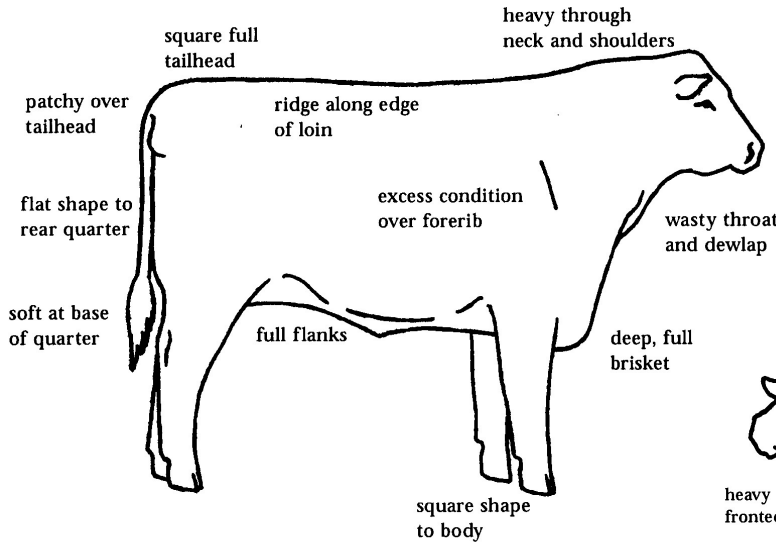


Diagram courtesy of Kansas State University – Cooperative Extension Service from the "Livestock Judging Guide for 4-H Club Members".

Over-conditioned, Light-muscled Steer



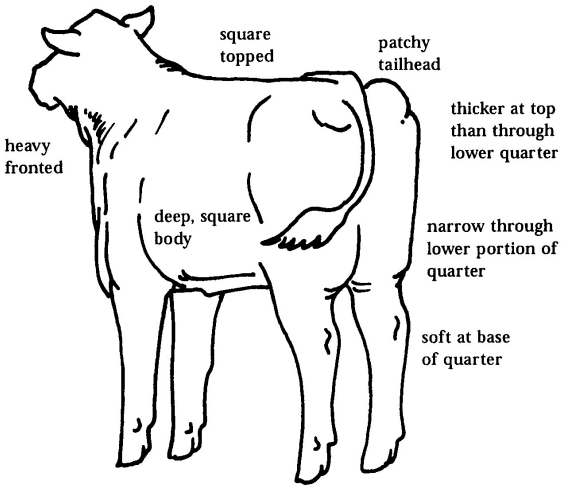


Diagram courtesy of Kansas State University – Cooperative Extension Service from the "Livestock Judging Guide for 4-H Club Members".

Judging Breeding Animals

There is more to judging the breeding animal than just evaluating muscle and fat. The breeding animal must be able to last substantially longer than the market steer. Structure and conformation are important. The better the conformation of a cow or bull, the greater the chance that their offspring will also have good conformation.

We want our males and females to consistently produce calves that will:

- Produce more quality calves or
- Go to the slaughterhouse and return maximum profit

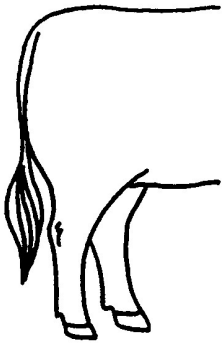
The market animal must make it from the calving pen to the feedlot in about a year. A breeding animal must last for many years, withstanding harsh winters, flies, calving, breeding and foraging. Therefore, structure and soundness are very important considerations when selecting breeding stock.

If you are in the purebred industry, you want animals that meet the breed specifications. Breed character and type are also extremely important.

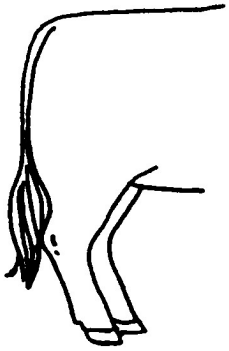
How do you look for these things? It is harder than predicting how a steer will grade but we'll give you a few hints. Remember – all those things that you looked for in a steer are still important because breeding stock must produce those steers. Your breeding stock should have exceptional muscling characteristics just like in a steer. So, all that time and energy spent learning about the market animals has not gone to waste! First, let's look at the ideal breeding animal.

Feet and Legs

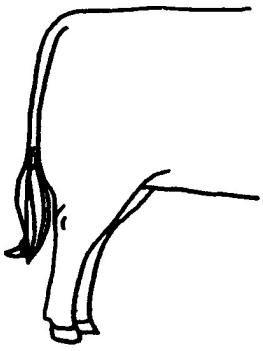
The legs should be set squarely underneath the animal. They should be widely placed and straight, not bow legged, cow hocked, or weak in the pastern. The hooves should be solid and healthy with no cracks or lesions, and should not be long in the toe. The dewclaws should also be short and without any curl.



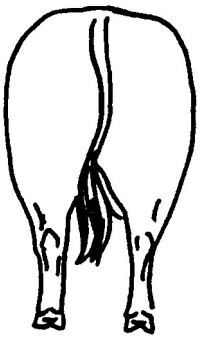
Correct



Sickle-Hocked



Post-Legged



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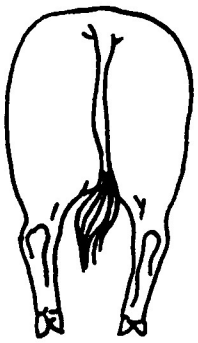
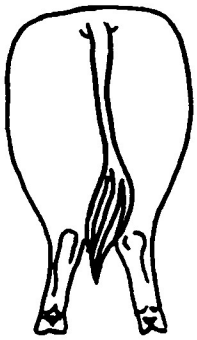


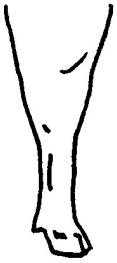
Bow-Legged



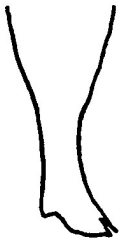
Cow Hocked

Rear Leg: Correct Pastern Set

Rear leg: Weak Pastern



Correct Pastern Set
And Straight Front Leg



Straight Front Leg
And Weak Pastern

Back at the Knee

Buck-Kneed

General Appearance

The animal should be healthy and alert, moving freely and easily. The desirable head has good distance between the eyes and a wide muzzle. The shoulder should be smooth and the body parts blended well.

The bull should have more muscle definition than the cow or heifer and his muscles should bunch or ripple when he walks. Remember that the animal, when viewed from the rear, should be widest in the stifle area as this indicates superior muscling. A bull should be more massive than a cow of the same breed. In the bull, the development of the crest, scrotum and other secondary sex characteristics give you evidence of maturity.

The heifer and cow should appear feminine. The head and neck should be refined. She should show appropriate udder and teat development. She should have a wide muzzle so she can forage effectively.

Capacity

All beef animals should have capacity or adequate internal size. This is shown by a good spring of rib and depth through the chest and heart. Width through the chest and width through the hind end are also desirable.

Breed Character

The animal should exhibit breed characteristics according to the breed association standards. This will include size, frame, shape and conformation.

It is difficult to compare animals of different breeds in the same class. You can make this easier by becoming familiar with characteristics of the different breeds.

Fertility and Reproductive Capacity

This is where judging can be inaccurate. We do not know for a fact that any heifer will be a good mother, an easy calver, or a producer of progeny with a good rate-of-gain. We do not know by looking at a bull that he will be a successful breeder. However, we do have indicators that assist us in predicting fertility. These are all you have to go on in the showring. Here are some clues that the industry uses:

The Bull	-	rugged and massive about the head, neck, and shoulders
	-	head should be carried with poll slightly above the topline of the animal, indicating alertness
	-	a crest over the neck region with size dependent on age
	-	scrotum should be large and hang straight, not twisted
	-	sheath should be compact and close to body
The Heifer	-	refined about the head, neck and shoulder
	-	pins slightly below the hooks with good distance between the pins
	-	signs of udder development with four evenly spaced teats
	-	vulva should be tight and firm to guard against infection
The Cow	-	the producing cow should show the same refined features as the heifer
	-	udder balanced with four functioning teats
	-	vulva healthy and flush with the body

In a cow-calf class, look at the calf. Is it healthy and thriving? Does it have energy, size, and frame? Is its conformation better than that of the cow? An exceptional cow which produces an inferior calf will not be profitable to you. We want cows which pass on their superior qualities to their calves.

Condition

Condition means the same thing in breeding animals as "finish" does in the market animal. The breeding animal should have less fat than the steer. The breeding animal should not have excess finish or be ready for market.

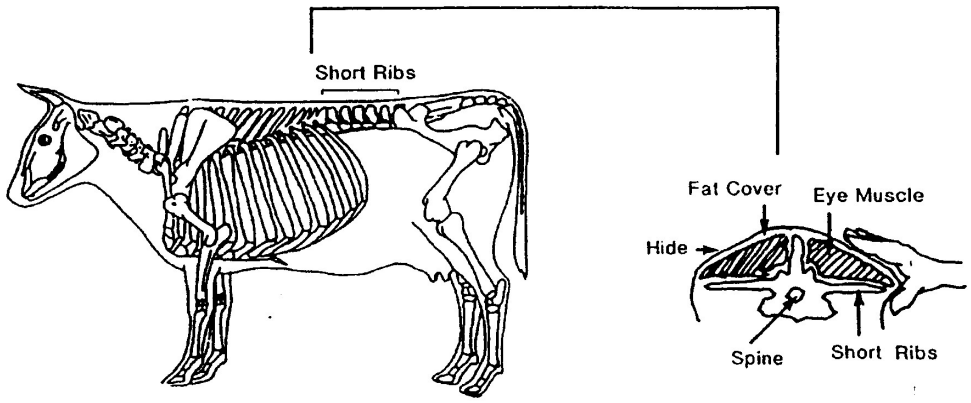
Assess the amount of fat and muscle present to determine growth characteristics. If a heifer carries a lot of fat at one year of age, she will be a less efficient cow than a heifer on the same diet carrying minimal fat or condition. You are not looking for skinny animals – you are looking for muscular, healthy cattle which are not fat.

There must be a desirable amount of muscle expression in both the sire and dam for the offspring to have the chance of developing desirable muscle. A bull will look meatier and have more overall muscle than a heifer or a cow. A bull should also have less fat than a heifer or cow. Females should show good muscling even though the muscles will not be as pronounced as in bulls.

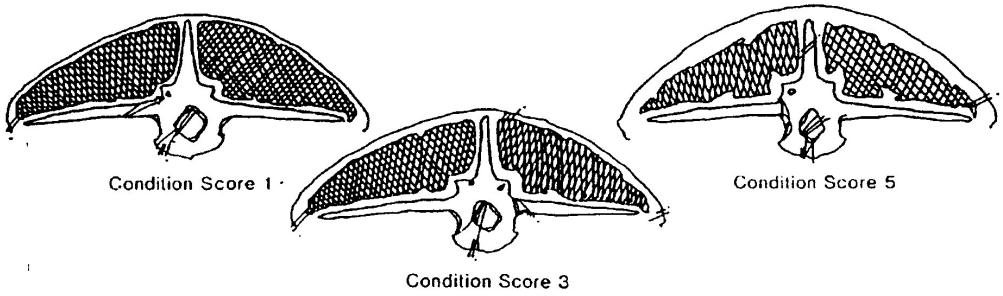
Body Condition Scoring

Something to consider if you are selecting replacement beef cows or heifers for your herd is Body Condition Scoring (BCS). BSC is a system of classifying breeding females by degrees of relative body fatness. In Canada, a five point scoring system is used. The fat cover over the loin area and tailhead is evaluated and scored.

A condition score of 1 means the animal is extremely thin. On the other end of the scale, a BSC of 5 would mean the animal is obese.



Location to Condition Score



Typical Fat Cover Over The Short Ribs in Cows in Various Body Condition Scores

Breeding females should be in moderate to good body condition (scoring 2.5 to 3) at calving time in order to:

- produce a strong, healthy calf;
- realize potential milk production; and
- regain ability to cycle again for rebreeding within 60 days of calving.

This condition scoring system enables producers to closely monitor and meet the nutritional needs of the cow herd.

Scoring should be done:

- Prior to weaning. If the animals are thin, decide whether to wean the calves and / or supplement herd.
- Prior to calving. Thin cows result in a decreased live calf crop while fat cows experience more calving difficulties.
- Prior to breeding. Animals should score no less than 2.5 at breeding. Feed animals to achieve desired body condition score for maximum reproduction performance.

Environmental and nutritional stresses can cause cows and heifers to lose condition rapidly. Adjustments must be made to the feeding program to meet the target score if cows are too thin or too fat.

Structure

Structure is the skeleton and frame or size of an animal. While there are differences in structure between the breeds, certain things remain true for all cattle. Good feet and legs are essential for good structure. The animal must travel for many years on these feet and legs, so they must be sound and correct. All beef animals must show good size and frame as determined by their breed. They should be long over the top, have ample length of leg, and show capacity and depth.

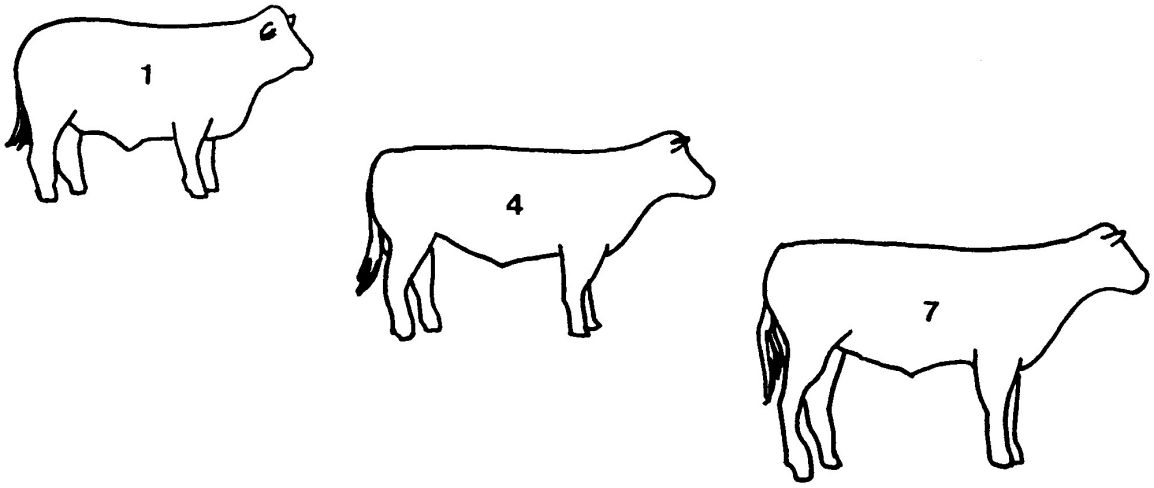
Capacity in the female means the ability to carry a calf, metabolize food, and produce large quantities of lean meat. The pins should be slightly below the hooks and the hind end should be large and wide.

The animal should move straight and true. The front hooves should point straight ahead. The back hooves may turn in a little bit at the toe. The back hooves should be set down almost straight behind the front hooves when the animal walks. To see the hoof placement, look at the prints the animal makes in the dirt when it walks.

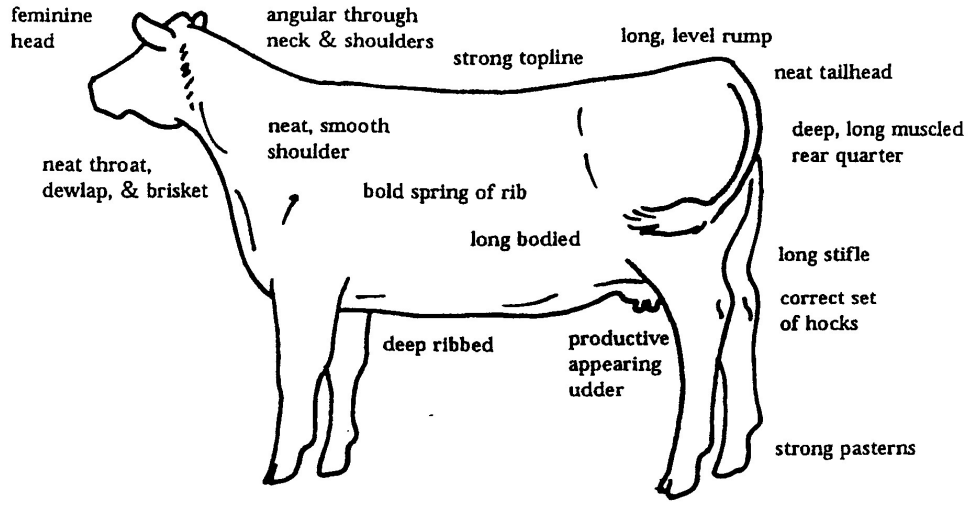
Body type or frame and muscling are economically important traits. They are related to the ability of the animal to gain weight, develop optimal muscling and cutability characteristics.

A process called frame scoring evaluates body type and muscle on a consistent basis from animal to animal. The body type and muscling at 6 to 8 months is often a very good indicator of the body type the animal will have as a yearling or adult.

A frame score is made on a scale of 1 through 7. The smallest type of cattle will get a low frame score and the largest type will receive a high score. A score of 6 or 7 does not necessarily mean that the animal is the best but indicates that it is the largest type of cattle.



Ideal Heifer



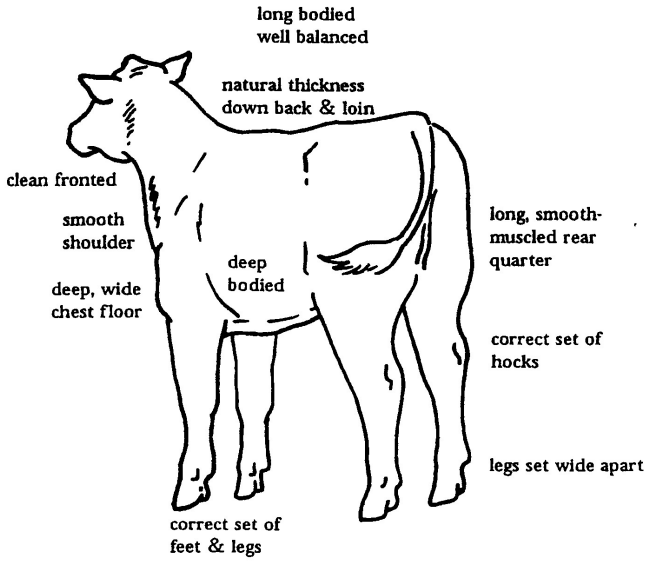
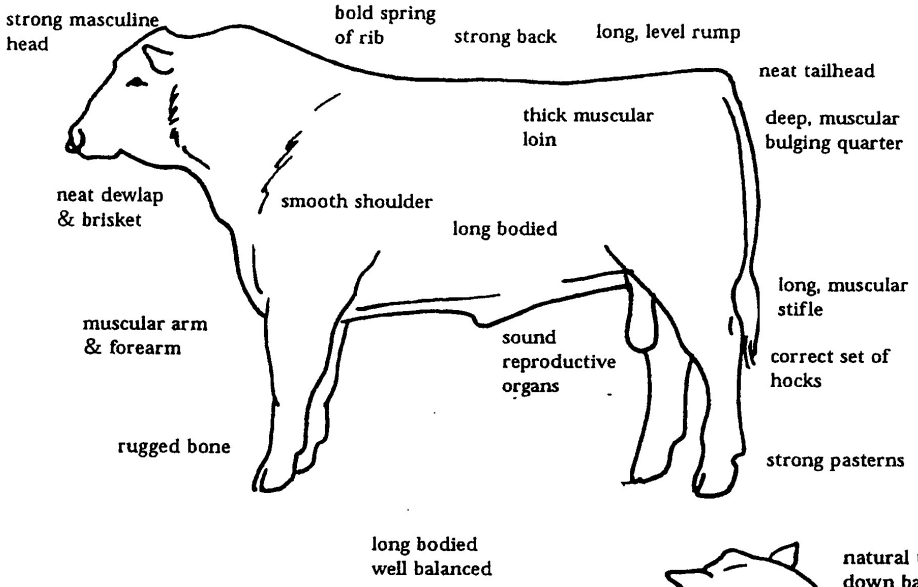


Diagram courtesy of Kansas State University – Cooperative Extension Service from the "Livestock Judging Guide for 4-H Club Members".

Ideal Bull



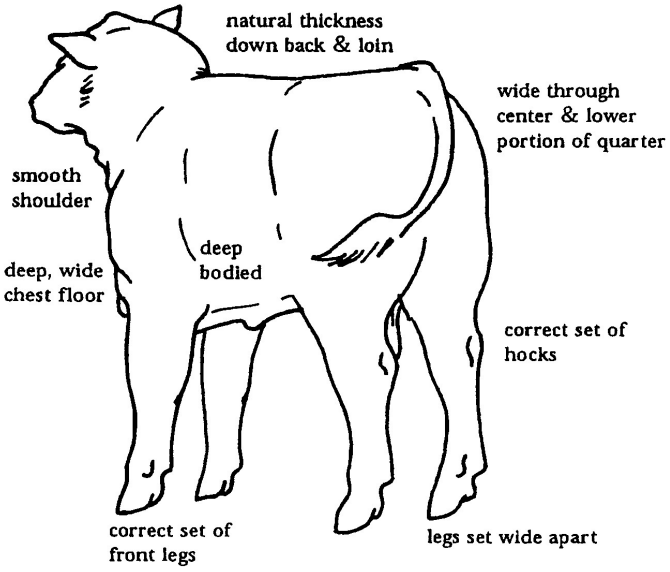


Diagram courtesy of Kansas State University – Cooperative Extension Service from the "Livestock Judging Guide for 4-H Club Members".

The Breeding Animal Checklist

Feet and Legs	-	legs straight, square and placed wide apart
	-	no swellings, cracks or lesions in the legs or hooves
General Appearance	-	appears healthy and alert
	-	blended, smooth body
	-	widest in the stifle
	-	bull thick and massive
	-	female refined with udder development
	-	evidence of lots of muscle; little waste in the neck and brisket
Breed Character	-	exhibits characteristics according to breed standards

Fertility / Reproductive Capacity	-	bull – rugged, massive with a high headset, crest development, superior muscling, large straight scrotum, compact sheath
	-	female – refined and smooth, pins slightly below hooks, width between pins, shows capacity and depth, udder development
Condition	-	less finish than a steer
	-	evidence of superior muscling
Structure	-	long over the top, long straight legs
	-	lots of capacity and depth, large, wide hind
	-	moves straight and with ease

About Beef Breeds…

In the beef cattle industry, there are many different breeds. There are important differences between these breeds, which you must take into account when judging cattle.

Some breeds have been bred with the emphasis on carcass and growth characteristics while some have been bred for their hardiness and maternal qualities. They all look different in size, shape and color. It is important to learn about the popular breeds and be able to take their individual features into consideration when judging. You can learn more about the breeds by looking at cattle magazines, breed books, promotional material printed by the Breed Associations and by attending cattle events.

Familiarity with the breeds is the key to solving the dilemma of comparing different breeds to each other. Know the characteristics of the different breeds.

A Few Final Hints:

Now you know what to look for in the market steer and the breeding animal. The problem is actually picking out these things in the showring, the field or the judging class. As a 4-H member, you are taught how to groom and fit your animals to show them to their best advantage. You are trying to highlight the superior characteristics of your animal, and downplay the other characteristics.

Now the tables are turned and you must look beyond the wrapping and see the real animal underneath. It takes a lot of practice to do this successfully, but it sure can be fun to try!

Good luck judging beef cattle. What you learned for the showring will help you when you go to the auction mart to buy a heifer, the neighbor's pasture to pick next years' calf, or the feedlot to pick the steers which are ready for market.

Judging will never be an exact science, but with a lot of patience and a little luck, you can become much more successful at selecting the most desirable animals!

The Judging Class

When evaluating the beef judging class, develop your own system and follow it each time you judge. Your first impression is the most important. Stand 8 to 10 meters from the class and view from a distance. Compare the animals.

When you view from the rear, compare:

- thickness over the back, loin and rump
- spring of fore and rear ribs
- trimness of middle
- muscling along the top and in the rear quarter
- freedom from excess finish in the twist, round and pins
- thickness through the stifle
- the set of rear feet and legs

When you view from the front, compare:

- breed type and sex character about the head and neck
- substance of bone
- set of front feet and legs
- muscling through the forearm
- depth and width of chest
- trimness in the throat and brisket
- smoothness through the shoulders

When you view from the side, compare:

- size, balance
- length of body
- strength of top
- length of rump – from hooks to pins
- levelness of rump
- trimness of brisket and middle
- muscle development in forearm, round, over back and loin
- substance of bone
- depth of rib
- set to feet and legs
- length of neck
- finish over ribs and forequarters

When the animals walk, watch for:

- style, freedom of movement
- correct set to feet and legs
- strength of topline
- tightness of frame
- those areas where you look for muscle development
- firmness and amount of finish

When you have an opportunity to handle the animals, check for:

- firmness
- uniformity, smoothness and amount of finish
- length of rump
- muscling in the shoulder, forearm, rear quarters
- thickness and quality of hide

Terminology for Reasons

The following terms are acceptable in your reasons. There are many more terms, but these will give you an idea of some of the terms you should be using in your reasons.

Remember to put emphasis on the different areas depending on whether you are judging market or breeding animals.

General Terms:
- a taller, more lengthy heifer
- carrying more uniform thickness from front to rear
- more desirable meaty type
- female showing more balance and symmetry
- larger, longer, trimmer, more correctly finished steer

Head, Style and Breed Character Terms:
- more feminine through the head, neck and shoulders
- shows more desirable breed character through head, ears and neck
- cleaner bone and more refined in the legs
- shows more desirable balance and eye appeal
- more stylish and alert

Fore Quarter Terms:
- fuller in the heart with a more desirable spring of rib
- more smoothly blended through the neck and shoulder
- shows more muscle expression in the forearm

Ribs, Back and Loin Terms:
- straighter and stronger over the topline
- thicker, meatier, more heavily muscled loin
- more correctly finished over the top and loin

Hind Quarter Terms:
- more bulging rear quarters
- wider, meatier steer
- extremely thick and muscular through the center part of the round
- freer from excess flesh in the twist
- cleaner and trimmer in the flank
- longer, deeper, more dimensional quarter
- showing greater evidence of muscling through the stifle region

Legs and Bone Terms:
- straighter, stronger legged, standing on more substance of bone
- moves straighter and truer on the walk
- stands more squarely on all four legs
- longer bodied, longer hipped
- larger framed steer

Finish and Carcass Terms:
- more uniform in his condition
- more uniform fat cover
- cleaner over the loin edge
- showing a more desirable degree of finish
- harder, firmer, and more correct in the finish over the ribs

Sample Oral Reasons - Hereford Market Steers

I placed this class of Hereford Market Steers 1-2-3-4 for the following reasons.

I started this class with 1, placing him over 2 because 1 is larger, stretchier, more heavily muscled and stands more squarely on more substance of bone than 2. 1 shows more muscle development in the forearm region, and is longer ribbed, longer rumped and thicker through the stifle. 1 has a more desirable amount of finish than 2. I grant that 2 is cleaner through the throat, neck and brisket than 1.

In my middle pair, I placed 2 over 3 in a very close placing because 2 shows more size, scale and length through the body than 3. 2 is trimmer and cleaner along the underline, and is cleaner in the throat than 3. 2 shows more muscle expression through the forearm than 3, and is cleaner and firmer through the flank. I admit that 3 shows more thickness through the top of the rear quarter than 2.

In my bottom pair, I placed 3 over 4 because 3 is thicker, meatier, and more heavily muscled than 4. 3 is more correctly finished and trimmer and cleaner through the brisket than 4. 3 shows a deeper, thicker, more heavily muscled rear quarter than 4. I grant that 4 is taller and more lengthy than 3, but felt that 4 was too wasty in the brisket and twist regions to place any higher in the class.

These are my reasons for placing this class of Hereford Market Steers 1-2-3-4 as I see them here today.

The above reasons have these desirable qualities:

- analysis is completed in pairs
- both descriptive and comparative in terminology
- terms are first general then more specific within each pair
- the reasons are positive and avoid criticizing the animals
- minimum of 3 points are detailed about each pair
- emphasis is first on the most important qualities to look for in market steers and then in the less important qualities
- introductory and concluding statements completely identify the class

If your reasons have these desirable qualities, are representative of the class you judged, and are well presented, then you will be successful with your reasons.

Good luck!

Sections of the Judging Fact Sheets were adapted from the Alberta Judging Beef Material with the permission of Alberta Agriculture, from the Kansas State University - Cooperative Extension service with permission, and from the Manitoba 4-H LES Manual.

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Principles of Meat Production

Animal cleanliness is an important factor in hygienic meat processing

A hygienic treatment of meat is highly important for the final quality of the meat. The used animals need to be kept clean before they reach the processing stage. The cleanliness of the animals is a major source of contamination. Failures in slaughter hygiene, meat handling or transportation, meat cutting, the hygiene of by-products in the process and additives in the meat can contribute to quality losses, and moreover the final processed meat products will deteriorate. Hygiene is a very important factor in minimizing hazards and risks as much as possible since contaminated raw meat is unfit for further processing.

A lower level of hygiene in the meat production will have an impact on the final products since end products which are made from unhygienic raw meat are tasteless, unattractive in color, untypical in taste and will have a shorter shelf life. Furthermore, unhygienic meat production will always increase the risk of food poisoning microorganisms – these small microorganisms can pose a significant public health hazard. In regard to living animals, the muscle meat is as good as sterile, but other parts of the animals contain a massive number of bacteria, such as their hooves and intestines. These bacteria are transferred to the carcass and contaminate the meat during the slaughter process, if the slaughter does not maintain good hygiene. But the bacterial contamination of meat does not stop after slaughtering – it is ongoing both during meat cutting and meat processing. To keep the meat unspoiled from bacteria, keep the meat cooled down (-1°C – +4°C) or frozen (below 1°C). Most bacteria will be able to grow in the range between 30°C and 37°C.

How can certain types of hygienic controls reduce the risk of contamination?

There are different control and monitoring systems in food plants with the goal of minimizing or eliminating health hazards to consumers as well as avoiding spoilage meat. There are different work procedures surrounding the slaughtering of the creature that they should be aware of and follow. The following section will address how these procedures can actively support the reduction of contamination risks.

The slaughterhouses must follow some general hygienic rules and apply recognized hygienic principles, as well as regulations and laws issued by the authorities. Some of the general hygienic rules include that all staff receive regular training on hygiene requirements, and that all raw materials must meet hygiene quality standards etc. Moreover, the slaughterhouses must prevent health hazards before or during the production of meat to counteract suspected or emerging health risks.

he right production equipment is designed to maximize a hygienic meat production

A careful instruction and implementation of the best meat practices are important when designing a hygienic meat production. Further, the hygiene needs to be built into the design of the production or equipment facility. Even the tiniest details or components of the facilities must be hygienic, for instance the stainless steel castors, the conveyor belts or the side guides for conveyor belts in the processing equipment. If the components are hygienic and implemented correctly in the production plant, the entire meat production will be of a great quality.

Meat Spoilage Mechanisms and Preservation Techniques

CAUSES OF MEAT SPOILAGE Preslaughter handling of livestock and postslaughter handling of meat play an important part in deterioration of meat quality. The glycogen content of animal muscles is reduced when the animal is exposed to pre-slaughter stress which changes the pH of the meat, to higher or lower levels, depending on the production level of lactic acid (Miller, 2002; Chambers and Grandin, 2001; Rahman, 1999a). Lactic acid is produced due to the breakdown of glycogen content of animal muscles via an anaerobic glycolytic pathway as shown in Fig. 1 (Rahman, 1999a). Higher levels of pH (6.4-6.8) result in Dark, Firm and Dry (DFD) meat. Long term stress causes DFD meat which has a shorter shelf life (Miller, 2002; Chambers and Grandin, 2001). Sever short term stress results in a Pale, Soft and Exudative (PSE) meat. PSE meat has a pH lower than normal ultimate value of 6.2 which is responsible for the breakdown of proteins, providing a favorable medium for the growth of bacteria (Miller, 2002; Chambers and Grandin, 2001; Rahman, 1999a). Figure 2 shows the texture and color of the DFD, PSE and normal meat. The factors affecting the shelf life of meat and meat products are summarized in Table 2. There are three main mechanisms for meat and meat products spoilage after slaughtering and during processing and storage: (a) microbial spoilage, (b) lipid oxidation and (c) autolytic enzymatic spoilage.

: Factors affecting shelf life of meat (Rahman, 1999a) Type Factors Intrinsic Type of animal (bovine, porcine) Breed and fed regime Age of animal at time of slaughter Initial microflora Chemical properties (peroxide value, pH, acidity, redox potential) Availability of oxygen Processing conditions and control Hygiene (standard of personnel and equipment cleaning) Extrinsic Quality- management system Temperature control Packing system (materials, equipment, gases) Storage types

Microbial spoilage: Meat and meat products provide excellent growth media for a variety of microflora (bacteria, yeasts and molds) some of which are pathogens (Jay et al., 2005). The intestinal tract and the skin of the animal are the main sources of these microorganisms. The composition of microflora in meat depends on various factors: (a) preslaughter husbandry practices (free range Vs intensive rearing), (b) age of the animal at the time of slaughtering, (c) handling during slaughtering, evisceration and processing, (d) temperature controls during slaughtering, processing and distribution (e) preservation methods, (f) type of packaging and (g) handling and storage by consumer

Hayes et al. (2003) found Enterococcus spp. to be the most dominant bacteria on 971 of the 981 samples (99%) of all meat (chicken, turkey, pork and beef) in the state of Iowa. About 97% of pork samples contained Enterococci with 54% of isolates identified as Enterococcus faecalis and 38% as Enterococcus faecium, 3.4% as Enterococcus hirae, 2.4% as Enterococcus durans, 0.8% as Enterococcus casseliflavus, 0.4% Enterococcus gallinarum and 1% as unindentified. All of beef samples contained enterococci with 65% of isolates identified as Enterococcus faecium, 17% as Enterococcus faecalis, 14% as Enterococcus hirae, 2% as Enterococcus durans 0.7%, as Enterococcus casseliflavus, 0.4% Enterococcus gallinarum and 0.9% as unindentified. Cerveny et al. (2009) stated that storage conditions affect the type of microbes found in meat and meat products. They reported that Pseudomonas spp., Moraxella spp., Psychrobacter spp., Acinetobacter spp. and Gram-negative psychrotrophic members of the family. Enterobacteriaceae are frequently present on refrigerated meat product. They also indicated that psychrotrophic lactic acid bacteria, Enterococci, Micrococci and yeasts are predominately found in raw, salted-cured products such as corned beef, uncooked hams and bacon due to their resistance to curing salts.

Lipid oxidation: Autoxidation of lipids and the production of free radicals are natural processes which affect fatty acids and lead to oxidative deterioration of meat and off-flavours development (Gray, 1978; Pearson et al., 1983; Simitzis and Deligeorgis, 2010). After slaughtering of animals, the fatty acids in tissues undergo oxidation when the blood circulation stops and metabolic processes are blocked (Gray and Pearson, 1994; Linares et al., 2007). Lipid oxidation is the reaction of oxygen with double bonds of fatty acids (Hultin, 1994). It involves three stage free radical mechanisms: initiation, propagation and termination

Autolytic enzymatic spoilage: Enzymatic actions are natural process in the muscle cells of the animals after they have been slaughtered and are the leading cause of meat deterioration. The enzymes have the ability to combine chemically with other organic compounds and work as catalysts for chemical reactions that finally end up in meat self deterioration (Tauro et al., 1986). In the autolysis process, the complex compounds (carbohydrates, fats and protein) of the tissues are broken down into simpler ones resulting in softening and greenish discoloration of the meat. These autolysis changes include proteolysis and fat hydrolysis which are prerequisite for microbial decomposition. Excessive autolysis is termed “souring” (Tauro et al., 1986). Postmortem breakdown of polypeptides are the result of tissue proteases and is responsible for flavour and is textural changes in meat (Toldra and Flores, 2000). Post mortem aging of red meat results in the tenderization process (Huss, 1995). Post-mortem autolysis takes place in all animal tissues but at different rates in different organs, quicker in glandular tissue such as the liver and slower in striated muscle (Fearon and Foster, 1922). The enzymes calpains, cathepsins and aminopeptidases are found to be responsible for the post mortem autolysis of meat through digestion of the z- line proteins of the myofibril (O’Halloran et al., 1997; Huss, 1995). Among these enzymes, calpains has been described as a preliminary contributor to the proteolytic tenderization process of meat. Cathepsins were, also, found to contribute to tenderization at low pH. The mechanism of calpain catalyzed meat proteolysis is shown in Fig. 3 (O’Halloran et al., 1997). Proteolytic enzymes are active at low temperatures (5°C) which lead to deterioration of meat quality due to growth of microbes and biogenic amines production (Kuwahara and Osako, 2003). PRESERVATION OF MEAT Meat preservation became necessary for transporting meat for long distances without spoiling of texture, colour and nutritional value after the development and rapid growth of super markets (Nychas et al., 2008). The aims of preservation methods are: (a) to inhibit the microbial spoilage and (b) to minimize the oxidation and enzymatic spoilage. Traditional methods of meat preservation such as drying, smoking, brining, fermentation, refrigeration and canning have been replaced by new preservation techniques such as chemical, biopreservative and nonthermal techniques (Zhou et al., 2010). Current meat preservation

methods are broadly categorized into three methods (a) controlling temperature (b) controlling water activity (c) use of chemical or biopreservatives (Zhou et al., 2010). A combination of these preservation techniques can be used to diminish the process of spoilage (Bagamboula et al., 2004). Low temperature methods: The basic aim of cooling techniques is to slow or limit the spoilage rate as temperature below the optimal range can inhibit the microbial growth (Cassens, 1994). Low temperature methods of storage are used in three levels: (a) chilling (b) freezing and (c) superchilling. All these levels help t(b) freezing and (c) superchilling. All these levels help to inhibit or completely stop bacterial growth (Zhou et al., 2010). However, the growth of psychrophilic group of bacteria, yeasts and molds is not prevented by all levels of refrigeration (Neumeyer et al., 1997) and both enzymatic and non enzymatic changes will continue at a much slower rate (Berkel et al. 2004). Chilling: Chilling is employed at slaughtering plants immediately after slaughtering and during transport and storage. It is necessary to reduce the temperature of carcass immediately after evisceration to 4°C within 4 h of slaughtering (USDC, 1995). Chilling is critical for meat hygiene, safety, shelf life, appearance and nutritional quality

It is employed by two methods: (a) immersion chilling, in which the product is immersed in chilled (0-4°C) water and (b) air chilling, in which the carcasses are misted with water in a room with circulating chilled air (Carroll and Alvarado, 2008). Carcass surface temperature is reduced at faster rate by air chilling which improves carcass drying and minimizes microbial spoilage (Ockerman and Basu, 2004). The microbial quality of the air-chilled product is better than that of a water-chilled product (Barbut, 2002; Sanchez et al., 2002). Young and Smith (2004) reported that air-chilled carcasses lost 0.68% of their postslaughter weight in storage prior to cutting but lost no more during cutting or postcutting storage. On other hand water chilled carcasses absorbed 11.7% moisture in the chillers, of which 4.72% was lost within 24 h of intact carcass storage, 0.98% was lost during cutting and 2.10% was lost during storage resulting in 3.9% net water retention. Tuncer and Sireli (2008) studied microbial growth on broiler carcasses stored at 0, 4 and 7°C for 14 days after air- and water-chilling. Samples were taken on days 0, 4, 8, 10 and 14 of storage and analyzed for total bacterial count and Pseudomonas spp., Enterobacteriaceae, yeasts and molds. The results indicated that the air-chilling procedure was safer than the water-chilling procedure with respect to microbiological count. With regard to shelf-life, storage at 0°C was better than storage at 4 and 7°C in preventing spoilage. Zhou et al. (2010) stated that rapid chilling also helps to prevent denaturing of proteins which may lead to bacterial attack as they are more susceptible to denaturated protein than native protein. On the other hand, cold-shortening and toughening may result from ultra-rapid chilling of pre-rigour meat (Ockerman and Basu, 2004). Saide-Albornoz et al. (1995) found several foodborne pathogens in pork during processing at 3 slaughtering plants. They reported that Salmonella spp., Yersinia enterocolitica decreased, Staphylococcus and S. aureus increased while Listeria monocytogenes remained same during 24 h of chilled storage. Epling et al. (1993) examined pork carcasses immediately after slaughtering and then after 20 h of chilling at 4°C and found that Campylobacter coli caused contamination and 29% of Salmonella was not affected by chilling. Freezing: Freezing is an excellent method of keeping the original characteristics of fresh meat. Meat contains about 50-75% by weight water, depending on the species, and the process of freezing converts most of water into ice (Heinz and Hautzinger, 2007). Meat freezing phenomenon is fast and almost 75% of tissue fluid freezes at -5°C. The freezing rate is increased with decreases in temperature, almost 98% of water freezes at -20°C and complete crystal formation occurs at - 65°C (Rosmini et al., 2004). However, more than 10% of muscle bound water (chemically bound to specific sites such as carbonyl and amino group of proteins and hydrogen bonding) will not freeze (Rosmini et al., 2004; Garthwaite, 1997). Freezing rate (slow and fast) affects the quality of frozen meat significantly. Fast freezing produce better quality meat than slow freezing. During slow freezing formation of large ice crystals damages the cell and results in protein denaturation. Concentration of enzymes and presence of other compounds govern the process of protein denaturation (Rahman, 1999b; Rahelic et al., 1985). The

preservation capacity of frozen meat is limited because the physical, chemical or biochemical reactions that take place in animal tissues after slaughtering do not stop absolutely after cold treatment (Rosmini et al., 2004). Microbial growth stops at -12°C and total inhibition of the cellular metabolism in animal tissues occurs below -18°C (Perez-Chabela and MateoOyague, 2004). Complete quality changes of meat can be prevented at a temperature of-55°C (Hansen et al., 2004). However, enzymatic reactions, oxidative rancidity and ice crystallisation will still play an important part in spoilage (Zhao et al., 2010). During freezing, about 60% of the viable microbial population dies but the remaining population gradually increases during frozen storage

Super chilling: Super chilling is a different concept than refrigeration and freezing and it has the potential to reduce storage and transport costs (Reynolds, 2007). Super-chilling refers to the temperature zone below its initial freezing point (1-2°C) but where ice crystals are not generated. In this process, instead of adding external ice to the food product, part of the internal water is frozen and works as a refrigeration reservoir, ensuring its refrigeration during distribution and transportation (Bahuaud et al., 2008) Respiratory metabolism and aging process are repressed but cell activity is maintained during the storage period of superchilling (Ando et al., 2005). This method is mainly used for preservation of fish (Bahuaud et al., 2008; Ando et al., 2005; Hansen et al., 2004; Chang et al., 1998) and poultry (Frperc, 2004). The main advantage of this method of preservation over traditional methods is that it increases the shelf life of meat for upto 4 times (Magnussen et al., 2008). Although most microbial activities are stopped or inhibited, chemical and physical changes may progress and in some cases are even accelerate (Magnussen et al., 2008). James et al., (2006) reported that to eliminate the surface freezing of the chicken carcass during chilling, they were water chilled after eviscerated then kept at -15°C in an air freezer for approximately 30 min and stored and distributed at 1-2 °C.

Sodium chloride: NaCl in growth media or foods can be a source of osmotic stress by decreasing water activity (Doyle, 1999). Borch et al. (1996) stated that salt-sensitive microorganisms, such as Pseudomonas spp. and Eriterobacferiuceae, did not grew in meat when the water activity (aW) was reduced from 0.99 to 0.97 with the addition of 4% sodium chloride. However, salt tolerant microorganisms such as lactic acid bacteria and yeasts could grow at that level of water activity. Chawla et al. (2006) reported a reduction in water activity of fresh lamb intestine from 0.95 to 0.80 with the addition of 10% (w/w) of sodium chloride. Bennani et al. (2000) reported that Enterobactereaceae species were eliminated in kaddid (dry-salted meat product) as a result of reduced water activity (aw) below 0.9 after 3 days due to the subsequent actions of salting, spicing and drying. Domowe (2010) reported that adding 3% salt reduced initial water activity level to 0.97 in sausages which was further reduced to 0.95 through the 6 day drying process and as a result pathogenic bacteria (Salmonella, Bacillus) stopped multiplying. Wijnker et al. (2006) studied antimicrobial properties of salt (NaCl) for the preservation of natural sheep casings at different water activity (aw) levels and found the activities of most spoilage and pathogenic bacteria (Escherichia coli, Salmonella typhimurium, Listeria monocytogenes, Staphylococcus aureus and E. coli O157:H7) stopped when an aw of 0.89 was reached

Use of Novel Feed Additives in Beef Cattle Production

Evaluating feed additives Factors that should be considered when evaluating the potential addition of a feed additives to the ration are anticipated response, economic return, available research, and field responses (Hutjens, 1991). Feed additives act in many different ways – some affect the ruminal environment, others impact post-ruminal digestion and metabolism; and still others act to depress subclinical problems (acidosis, liver abcesses, heat stress) in which there are no visible disease

symptoms or to improve immune response. Examples of ruminal effects include stabilization of the rumen environment and pH, stimulation of rumen microbial growth, improved nutrient digestibility (fiber, starch, etc…), mitigation of methane production, or increased rate of passage or flow of nutrients out of the rumen. Post-ruminally, nutrient digestion may be increased in the small intestine, intestinal absorption and liver metabolism may be increased, and insulin sensitivity may be improved. Benefits to health, safety, and quality of meat products may also result from use of feed additives. Ultimately, the decision whether or not to use a feed additive largely comes down to profitability. Do improvements in ruminal and post-ruminal metabolism have a measurable impact on the primary influencing factors of profitability – average daily gain, feed intake, and feed efficiency?

If average daily gain is the measurable response, a breakeven can be calculated based on expected response and anticipated live cattle prices (Table 1). For example an additive that costs 10 cents per day must increase average daily gain in every steer by 0.10 lb/d to recover the added expense. As live cattle price increases, the gain required to recover costs decreases. A similar breakeven can be calculated for dry matter intake. Another consideration when evaluating feed additives is duration of effectiveness. If the additive is not strategically used only in populations of cattle that will respond favorably, for example receiving cattle, responding animals must cover the cost for non-responding cattle (Hutjens, 1991)

accumulation of hydrogen and other compounds that are not energy substrates for ruminants and often results in decreased fermentation, fiber degradability, feed intake, and animal productivity

Probiotics/direct fed microbials The term ‘probiotic’ has been used to describe viable microbial cultures, culture extracts, enzyme preparations, or various combinations of the above (Yoon and Stern, 1995). Therefore, the U.S. FDA has required feed manufacturers to use the term “direct-fed microbial“ (DFM) instead of probiotic (Miles and Bootwalla, 1989) and has narrowed the definition to “a source of live, naturally occurring microorganisms” (Yoon and Stern, 1995). Microorganisms used as DFM for ruminants include viable cultures of bacteria and/or yeast. The bacterial DFM strains may be classified as lactic acid producing bacteria, lactic acid utilizing bacteria, or other microorganisms including Lactobacillus, Propionibacterium, Bifidobacterium, Enterococcus, Streptococcus, and Bacillus, and strains of Megasphaera elsdenii and Prevotella bryantii. The most commonly used yeast preparations are from Aspergillus oryzae or Saccharomyces cerevisiae. Direct fed microbials are generally supplied as dried preparations of live cells with their spent growth medium. Bacterial DFM are fed to establish a population in the rumen to improve function, however, bacterial DFM frequently fail to persist in the rumen (Krause et al. 2000) and thus have to be fed daily for them to be effective. Yeasts are aerobic and cannot survive for long in an anaerobic environment such as the rumen and also must be supplied continuously in feeds to reach a minimum effective concentration. Both types of DFM are most effective when fed to beef cattle during stress situations when the microbial balance could be disturbed (in calves, at weaning, during feedlot receiving, or during diet transition). During stress, DFM work to prevent the colonization of the GI tract by enteropathogens (E. Coli, Salmonella), which often results in diarrhea.

Amylolytic enzymes Amylases have been used in some studies with mixed results on animal performance. Feeding exogenous amylase increased intake and consequently average daily gain in the early stages of the finishing period in feedlot steers fed cottonseed hulls as the roughage source (Tricarico et al., 2007). However, another experiment by the same authors found no differences in growth performance over the entire feeding period when steers received cracked corn or high moisture

corn (Tricarico et al., 2007). Burroughs et al. (1960) demonstrated improvements in gain and efficiency when amylase was added to high forage feedlot diets, whereas DiLorenzo et al. (2011) reported that exogenous amylase improved organic matter digestibility but had no effect on performance of cattle fed 5% alfalfa hay and 5% cottonseed hull diets. Fibrolytic enzymes Commercial fibrolytic enzyme products used in the livestock industry are of fungal (Aspergillus oryzae and Trichoderma reesei) or bacterial (Bacillus subtilis, Lactobacillus acidophilus, Lactobacillus plantarum, and Enterococcus faecium spp.) origin (McAllister et al., 2001). Although commercial enzyme preparations are commonly referred to as cellulases or xylanases, secondary enzyme activities such as amylases, proteases, esterases, or pectinases are invariably present as these preparations seldom consist of a single pure enzyme (McAllister et al., 2001). This diversity is advantageous, as it facilitates targeting of a range of substrates using a single product, yet it complicates the identification of the specific enzymes responsible for any positive responses observed in feed digestion.

Buffers/alkalizers True degradation of lignin is an oxidative process that is primarily performed by aerobic fungi. As the rumen is anaerobic, lignin is not truly degraded, but rather its solubilization is a key step in increasing the amount of cellulose and hemicellulose available for microbial fermentation. Various strategies have been attempted to hydrolyze the ferulic acid ester bonds and improve forage quality by ruminant livestock, including treatment with physical agents such as heat, steam, and pressure, with chemicals such as acids, alkalis, ammonia (NH3), and ozone, with biological agents such as white rot fungi, or via natural selection, breeding, or molecular engineering (Berger et al., 1994, Buanafina et al., 2008). However, none of these methods is widely used for improving forage quality and ruminant animal performance. This is due to the capital and energy intensive nature of physical methods such as steam or pressure treatment, the potential of pelleting, chopping, or grinding to limit salivary buffering of ruminal acids, the cost and corrosive and/or hazardous nature of chemicals such as NH3 and NaOH, the potential for excessive DM losses following hydrolysis by white rot fungi, and the protracted nature of breeding approaches

Principles and Practices of Modern Meat Technology

IMPROVED PROCESSING EFFICIENCY Cutting and processing of carcasses soon after slaughter and before conventional chilling holds considerable potential in improving processing efficiencies. Hot processing involves removal of excess fat and bone before chilling and can result in significant savings, particularly in energy, labor and product weight loss (12,13,14). However, because one is working with a product that is near body temperature, special care must be taken to prevent excessive microbial growth. Researchers have defined chilling and handling conditions required to produce a microbially acceptable hot-processed product (10,17). Some aspects of hot processing are being applied in the U.S. industry; however, other countries are using this technique more extensively.

TENDERIZATION TECHNOLOGY Because tenderness is an extremely important quality of meat, the industry is currently using a variety of techniques to insure tenderness and reduce its variability. Historically cooler aging has been used to increase tenderness and this technique is still employed even though for most meat today the time period between slaughter and marketing has been reduced as compared to previous years. Most of the tenderizing benefits of aging are realized within the current slaughter-to-marketing time frame, and the risks (i.e. excessive microbial growth) associated with prolonged aging are minimized. The aging process, caused principally by muscle enzymes, begins soon after death and continues until cooking unless the product is frozen. Aging primals or subprimals in

vacuumized packages is a grnwing trend as it allows the aging process to continue yet retards microbial growth, and reduces trim and moisture losses (14,21). Nonetheless, microbial spoilage will result if the product is aged too long, whether or not it is packaged. An aged, partially degraded product is an excellent source of nutrients for microorganisms.

Principally enzyme preparations from plant sources have and are being used to tenderize meat. These may be applied by spraying or dipping cuts into the enzyme solution. Antemortem or postmortem distribution via the vascular system and random muscle pumping are also used. The antemortem injection is the patented Swift Proten process. The proteolytic plant enzymes (ficin, papain and bromelin) have received the most emphasis and act primarily during the cooking process. Even though product uniformity is difficult to control, this practice continues to grow. All solutions and application equipment should have low microbial counts to avoid unnecessary product contamination (14,2/). Mechanical blade tenderization is accomplished by passing meat under a bank of long slender needles or blades which disrupt the integrity of the muscle, thus tenderizing it. This is a very effective, commercially applicable method of tenderization. However, unless strict sanitation of equipment and product is maintained, large quantities of meat can be unnecessarily inoculated with microorganisms (14,21). These microorganisms may not pose a health hazard, but can increase the rate of color deterioration which shortens the display life and reduces the value of the product. Conditioning carcasses or cuts at elevated temperatures of approximately l5°C (60°F) for up to 24 h after slaughter speeds the aging process and avoids the toughening effects that may accompany rapid chilling soon postmortem. Carcass insulation has also been used to accomplish this same end. When the concept of elevated temperature conditioning of carcasses was patented (Tenderay process) several years ago, it was recognized that microbial growth could be a problem upon prolonged conditioning; therefore, ultraviolet lights were used to limit the growth. More recently shorter elevated temperature conditioning times have been used to help insure muscle tenderness, and microbial problems have been avoided (14,21). Suspension of the carcass by the pelvic girdle stretches and improves tenderness in some muscles in the carcass that would normally contract and become less tender during the process of rigor mortis. Even though this process, developed by Texas A&M University, is effective, it has not been used commercially because of the unconventional shape of the chilled carcass. Other methods of stretching the muscles during the onset of rigor mortis have also proved effective in increasing tenderness, but are seldom used commercially (14,21). Electrical stimulation of the carcass, usually within 1 h postmortem, improves the tenderness of some muscles either by accelerating the aging process, disrupting muscle integrity, increasing connective tissue solubility, avoiding cold-induced toughening, or a combination of these mechanisms. It has been proposed that electrical stimulation might also be effective in controlling microbial growth, but this proposition has not been consistently demonstrated (14,16,17.,21). The meat industry in the U.S. and other countries is using this technique. Pre-rigor muscle subjected to rapid cooking or a pressure heat treatment is significantly improved in tenderness because of super-contraction which disrupts the muscle integrity. Even though it is an effective method of tenderization, it is not being used commercially (14). Cooking the product, before marketing to the ultimate consumer, will significantly lower microbial counts found on the raw product; however, recontamination of the product must be controlled as potential pathogens may flourish in the absence of the normal microbial flora (23). PRODUCT SANITATION The most desirable approach to

achieving a high quality product from a microbial standpoint is to minimize product contamination during slaughter and subsequent processing. However, some technologies are designed to retard or prevent microbial growth as invariably microorganisms will be found on the product. Refrigeration, freezing, canning, curing, smoking and dehydration are examples of technologies used in achieving this end. Aqueous chlorine solutions have also been applied to carcasses of a variety of species (15). The patented Swift Clor-Chil process of intermittent spraying of a dilute chlorine solution on carcasses during the first few hours of chilling has been effective in reducing microbial populations and growth (14). Other compounds not necessarily approved or controlled in their usage on the whole spectrum of meat products also possess antimicrobial potential. These include acetic acid, sorbic acid, ethylene diamine-tetraacetic acid (EDTA), polyphosphates, phenolic compounds such as butylated hydroxyanisole (BHA), and naturally occurring compounds such as those produced by lactic acid producing bacteria (1). Unless the surface has been violated, the interior of the muscle from healthy animals is virtually free of microorganisms, thus surface sanitizing treatments are quite effective. Precooking of meat to provide convenience products or as a part of the normal processing sequence, such as in cured cooked products, also lowers microbial counts found in raw product. Short-term treatment with microwaves may also be used to reduce microbial counts in an effort to increase the shelf-life of meat products (3,4,5,9). As with the cooking of pre-rigor meat, recontamination of the product must be avoided as potential pathogens may flourish in the absence of the normal flora on fresh meat (23). The preservative properties of heat treatments have been demonstrated to increase shelf-life from a microbial standpoint, but because a product is heat treated, consumers and possibly processors may have a tendency to disregard proper post-heat treatment preservation and handling practices. The microbiological characteristics of these products must be understood and proper handling procedures conveyed to processors and ultimate consumers. Irradiation of meat products is an effective means of controlling microorganisms but not enzymes. Therefore, combinations of irradiation and heat treatment are being studied to improve shelf-life. Sub-sterilization irradiation doses in combination with heat treatments and other forms of preservation increase shelf-life yet minimize the off-flavors caused by irradiation (2). Many of the shelflife benefits to be realized by old, new and potentially beneficial technologies may be lost by handling products as if they would no longer have shelf-life or wholesomeness difficulties. CONTROLLED ATMOSPHERE STORAGE OF MEAT During the past several years there has been an increased interest in using modified atmospheres to increase the shelf-life of meat. This practice has fostered continued interest in centralizing processing practices such as the boxed beef concept. Vacuum packaging and packages containing elevated levels of carbon dioxide and nitrogen are examples of modified atmospheres used to effectively extend shelf-life. Storage in modified atmospheres has been demonstrated to improve shelf-life and limit growth of some potential pathogens, but may also encourage proliferation of other potential pathogens, if the product is temperature abused (23). Additional research is needed to realize the full potential and further define the limitations of this technology. COMMUNUTED AND RESTRUCTURED MEAT PRODUCTS Comminuted meats continue to be an extremely important part of the industry. Fresh ground meat, such as ground beef, holds a prominent and growing position in the market. Comminuted meats used in sausages are also of vital importance. However, with the trend to decrease residual nitrite levels, one must consider the microbial implications of this practice on shelf-life and wholesomeness. The nutritional concerns over sodium intake will likely result in decreased levels of sodium chloride in cured meats. Such a practice holds potential for not only

influencing functional and sensory properties of cured meats, but also the microbial characteristics of these products Recovering meat and marrow from bones by mechanical deboning is a relatively inexpensive way to recover over 2 million metric tons of red meat each year (6). In this process, meat and bone are forced against a screened or slotted face plate with meat and some marrow passing through the openings, thus being separated from broken or coarsely ground bone. Poultry and fish are treated in a similar way, to economically retrieve additional high quality protein (8,19). Mechanical deboning produces a highly nutritious product that can be easily used in other comminuted products (7). With any comminuted food, the product surface area is increased and exposed to microorganisms and the temperature of the product is increased during processing, both of which encourage microbial growth. To continue to realize and maximize the full economical and nutritional potential of comminuted products, in part, hinges on our understanding and control of those factors which influence their shelf-life and wholesomeness.

Beef cattle breeding systems

Beef cattle breeding systems Regardless of the breeding system chosen, the breeder must struggle for genetic improvement in the traits identified as economically important for both the current and future performance of the herd. The basic objective of animal breeding is to enhance the efficiency of production and the quality of the product for the end-consumer through planned genetic change.

Beef cattle breeding systems The choice of whether to straight breed or cross breed will be related to your ability to match your cattle, the environment and the market.

Straight breeding programs Straight breeding produces not only progeny for further finishing, but also replacement females for the herd. For this reason, many traits have to be selected in balance, as they contribute to the overall package. it is important to identify and select those cattle that are superior for specific traits.

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Straight breeding programs Straight breeding programs appeal to many beef breeders because they produce replacement females from within the herd. They are reasonably easy to manage because only one cattle breed exists on the property.

Straight breeding programs Important points BREEDPLAN estimated Breeding Values (EBVs) and $indexes are available for selecting both bulls and cows. Breeding management options are simple and don’t require you to select sires from different breeds or to mate different sires in different paddocks.

Straight breeding programs Herds are self-replacing: breeder replacements are produced within the herd. Turnoff animals are similar, with little variation. Lines that ‘look’ even (i.e. for colour) may attract a premium. Straightbred females continue to be in demand for use in crossbreeding systems.

Crossbreeding programs Crossbreeding systems can bring together a desired combination of genes more rapidly than can be achieved through within-breed selection. Advantage can be taken of complementarity among breeds, but knowledge of individual breed characteristics is important.

Crossbreeding programs The decision to crossbreed is also often related to the potential gains of hybrid vigour, an additional boost to production. Hybrid vigour, or heterosis, is the difference between the performance of the progeny and the average performance of the parents.

Crossbreeding programs In general, the more distantly the parental breeds are related, the greater the amount of heterosis that can be expected. the greatest level of heterosis results from the crossing of the least related purebred Bos indicus and Bos taurus breeds. Heterosis is greater for some traits than others (e.g. fitness traits: parasite resistance, survivability, environmental adaptation etc.).

Crossbreeding programs For greatest benefit in all crossbreeding programs, it is essential that the programs be based on straightbred animals of high genetic merit for economically important traits. Tools such as Breed Plan EBVs and $indexes can be used to select these animals.

Crossbreeding programs Continuing improvement from a crossbreeding program depends on the genetic merit of the foundation animals used in the cross (i.e. the selection intensity in the populations in which they were bred) and the selection intensity placed on the subsequent crossbred generations.

Crossbreeding provides flexibility because it allows you to quickly alter particular characteristics of a herd for a specific purpose, such as to cater to a particular market, increase production or remedy a problem. there can be disadvantages with cossbreeding, such as management difficulties.

Planned crossbreeding systems Although the potential gains from crossbreeding are large, most of the success depends on good planning and the use of superior genetics to provide the priority traits identified for a specific breeding enterprise. The following briefly outlines the key ‘planned’ approaches to crossbreeding.

Rotational crosses Hereford and Angus rotational cross. Rotational crossing simply means that two or more different sire breeds are used in sequence over the female groups, which are grouped according to their sire breed. Two, three or even four sire breeds may be used. In a simple system that uses two breeds, cows of breed A are mated to sire breed B, with the resulting heifers being joined back to sire breed A. A(f) X B(m) to F(f) X A(m)

Within a three-breed rotation, the progeny of sire breed A over cow breed B are mated to sire breed C. The female progeny of the latter cross are mated back to sire breed A for the rest of their breeding lives. the minimum number of joining groups is equal to the number of sire breeds. A(f) X B(m)to F(f) X C(m)

An increase of 10 to 20 per cent in the weights of calves weaned per cow joined can be achieved from a two-breed rotation (crisscross). A greater increase in the weight of calves weaned per cow joined can be achieved from a three-breed rotation. In a rotational cross system, each breed contributes its strengths and weaknesses equally to the production system over a number of years. The level of heterosis achieved depends on the number of breeds involved (i.e. the more breeds, the more heterosis).

However, in a rotational cross system variability among the progeny may make it more difficult to consistently meet a market specification. Therefore, the use of breeds that are not radically different is probably preferred. All animals in the herd benefit from hybrid vigour for both growth and maternal traits. All females from a rotational cross system are potentially available for selection as replacements; this increases the selection intensity and subsequent opportunities for genetic improvement.

Important points of rotational crosses: *The system generates its own replacement females. *Hybrid vigour is retained, giving a 10 to 20 per cent increase in weaning weight. *Cows can be run as one mob for most of the year, as they need to be separated by sire group only for joining. *Depending on the breed chosen, some variability will occur within the progeny. *Breeds with good maternal traits should be used, as the female progeny of all sire breeds are kep

Beef Carcass Grading and Evaluation

Evaluation of beef quality and composition is important to cattle producers, meat packers and retailers, and consumers. Consumers desire cuts of beef that are lean, nutritious, and possess desirable eating characteristics. Meat researchers have developed reliable methods for measuring the factors that influence eating characteristics and factors affecting yield of lean cuts. Using these evaluation techniques, producers and packers can produce and sell carcasses that meet consumer demand.

This guide provides information about standard U.S. Department of Agriculture beef carcass yield and quality grading systems. Other useful and accurate evaluation procedures will also be introduced.

Beef carcass grading is divided into quality grading and yield grading.

Quality grading

Quality grades indicate the factors related to the sensory characteristics of tenderness, flavor, color, texture and juiciness. The quality grade is intended to reflect the cooked product's overall acceptability.

The USDA quality grades for steer and heifer carcasses are prime, choice, good, standard, and utility. These grades are determined by balancing maturity and degree of marbling.

Maturity refers to the physiological age of the live animal. Maturity in the carcass is determined by the degree of ossification (bone development) of the split chine bones (back bones) and the color and texture of the cut lean surface.

Cartilage changes into bone as the animal matures. This process of ossification proceeds from the back toward the front portion of the vertebral column. The degree of ossification in the vertebral buttons near the thorax, which is the cavity containing heart, lungs, etc., is the most useful in evaluating maturity. Rib bones also become flatter and whiter as the animal matures.

Meat from young animals is lighter colored and finer textured compared to older beef. Generally, a fine-textured lean will be more tender than a coarse textured lean. Carcass maturity is closely related to beef tenderness. As the animal matures, changes in the connective tissue cause the meat to be less tender.

The degrees of maturity are A, B, C, D and E. Age ranges for these maturity groups are approximately

Maturity group	Age
A	9 to 30 months
B	30 to 42 months
C	42 to 72 months
D	72 to 96 months
E	more than 96 months

Dark-cutting beef is not necessarily from older animals but can also result from cattle that were physiologically stressed before slaughter. Dark-cutting beef is highly discriminated against by consumers and retailers. Dark-cutting beef may be reduced up to one full quality grade.

Marbling is fat within the muscle and is evaluated in the rib eye between the 12th and 13th ribs. The 10 USDA degrees of marbling are abundant, moderately abundant, slightly abundant, moderate, modest, small, slight, traces, practically devoid, and devoid. Marbling has a strong correlation with the juiciness and flavor of beef.

Final quality grades are arrived at by a composite evaluation of maturity and marbling.

Yield grades estimate the quantity or the amount of closely trimmed boneless retail cuts from the loin, round, chuck and rib. There are five USDA yield grades, 1 through 5. Yield grade 1 carcasses have the highest yield of retail cuts and yield grade 5, the lowest.

The expected boneless retail yield from the round, loin, rib and chuck is as follows:

Yield grade	Percent of carcass weight in boneless, uniformly trimmed retail cuts
1	more than 52.3
2	52.3 to 50.1
3	50.0 to 47.8
4	47.7 to 45.5
5	less than 45.5

These yield figures are sometimes used in carcass show results as a measure of cutability.

Yield grade also can be used to predict the total retail cuts from a carcass or quarter.

Total percent retail cuts (closely trimmed, semi-boneless)

Yield grade	Carcass	Forequarter	Hindquarter
1	82 0	84.0	79 9
2	77 4	79.0	74.9
3	72 8	75.6	69.9
4	68.2	71.4	64.9
5	63.6	67.2	59 9

The USDA yield grade is based on four factors:

- Hot carcass weight (pounds)
- Rib eye area at the 12th rib (square inches)
- Adjusted fat thickness over the rib eye at the 12th rib (inches)
- Percent kidney, pelvic, and heart (percent of carcass weight).

These measurements are used in the official USDA formula as follows:

Yield grade = 2.5 + [(2.50 x adjusted fat thickness, inches) + 0.2 percent of kidney, pelvic, and heart + (0.0038 x hot carcass weight, pounds) - (0.32 x area rib eye, square inches)]

When computing yield grades, any decimal is dropped; yield grades are presented as whole numbers. Care and accuracy of these measurements are essential to derive reliable estimates of the cutability. The USDA grader, in practice, estimates the factors and uses a short-cut formula.

Fat thickness
The amount of fat on a beef carcass has the greatest effect on the percent retail yield. As the percent fat increases, the percent muscle decreases. Fat thickness is measured at a point three-fourths of the length of the rib eye (longissmus) muscle from the chine bone, perpendicular to the surface fat, at the 12th rib. This measurement may be adjusted according to the total amount of fat on the carcass.

Rib eye area
Total square inches of rib eye is used to estimate muscular development of a beef carcass. This measurement can be taken objectively between the 12th and 13th rib. A calibrated transparent plastic grid placed over the rib eye is commonly used to determine the area.

An alternative method is to trace the perimeter of the rib eye on acetate paper and calculate the area with a compensating planimeter, which is an instrument that measures area of irregularly shaped objects.

Hot carcass weight
Hot carcass weight, or 102 percent x chilled carcass weight, is the weight of the carcass after slaughter. The carcass weight has an inverse effect on the percent retail yield.

Kidney, pelvic, and heart fat
The amount of kidney, pelvic and heart fat is fat accumulated in the body cavity of the carcass. The weight is reported as a percent of the carcass

weight. The range of kidney, pelvic and heart fat is 1 to 8 percent (with a typical average of 3.5 percent).

Yield grades estimate the proportions of lean and fat. Meat graders determine yield grades with fast, simple visual appraisals of fat and muscle of the carcass. Fat thickness, hot carcass weight and rib eye area are objective measures with kidney, pelvic and heart fat being a subjective measure.

USDA grading is done on a voluntary basis by the packer. The packer absorbs the cost. When a carcass is submitted for grading, it must be both quality and yield graded.

USDA grades should not be confused with the USDA inspection for wholesomeness.

Beef carcass evaluation

The purpose of beef carcass evaluation is to assist beef producers in:

- Producing high-quality beef carcasses
- Producing high-yielding beef carcasses
- Identifying superior lines of breeding stock
- Promoting a desirable, marketable product.

Improving the efficiency of beef cattle production is important to feeders, cow/calf ranchers and seed stock producers. Feeders can evaluate their feeding and management practices with cutability scores or the percentage or number of their cattle grading choice. cow/calf ranchers may use grades to rank or performance-test their stock. Seed stock producers can ultimately use quality and yield grades in sire evaluation.

Some other guidelines or indexes that may be useful in beef carcass evaluation are a growth factor or loin eye index.

Growth factors can be used to express the composition of growth. Expressing the pounds of retail cuts per day of age is one method.

This figure is determined by this formula: pounds of trimmed retail cuts per day of age = (carcass weight x cutability) divided by age in days.

Example A 600-pound carcass, 400 days old with a yield grade 3 (50 percent retail yield) produces 0.75 pounds of retail cuts per day of age:

(600 x 0.5) ÷ 400 = 0.75 pounds of retail cuts per day of age.

Loin eye area has been highly correlated to the percent muscle in a carcass. A goal of progressive beef producers is to produce cattle yielding at least 2 square inches loin eye area per 100 pounds of carcass.

Example
A 550-pound carcass with a 12.5 square inch loin eye would yield 2.27 square inches loin eye area per 100 pounds of carcass (12.5 ÷ 5.5 = 2.27 square inches loin eye area per 100-pound carcass).

Use of the USDA's Beef Carcass Data Service is a service designed to provide carcass data to breeders or others who don't own the animals at the time of slaughter. Cattle are ear tagged with USDA ear tags and upon slaughter the proper quality and yield grade data are forwarded to the purchaser of the ear tags. This is especially helpful to seed stock producers.

For information on source of ear tags and cost of the service, contact Livestock Division, Agricultural Marketing Service, U.S. Department of Agriculture, Washington, D.C. 20250.

Carcass Evaluation and Grading: Step Forward to Ensure Meat Quality

Introduction

The part of the food animal body that remains after commercial dressing procedures is popularly called carcass. Evaluation and constant maintenance of carcass quality is the measure of output which paves the way for upbringing trade in meat sector which in turn pays the efforts of farmers and uplifts their living standards. According to Polkinghorne et al. (2010) carcass classification affects the price determination and is responsible for meeting the consumer expectations, which is a concept called “consumer grading system”. It helps the farmer to recognize quality of animal which they are producing and hence can have improved and better planning to have high grade animals and carcasses. In addition, it can certify their animals and carcasses for class, quality and condition through authorized agencies. It also helps the meat processing sector to select the different meat grades on the basis of market and consumer demands. The classification depends upon the description of carcasses using specifically defined anatomic features which are simultaneously important to the sellers as well as buyers (Sather et al., 1991). Thorough knowledge, how this grading system can help in upbringing the output of meat sector in upgrading quality as well as for meeting consumer demands is very much necessary.

Evaluation of carcass

Evaluation of carcass simply means to evaluate all those factors which determine the average value per unit weight of carcass (Purchas, 2012). Evaluation of carcass primarily depends on the carcass weight, dressing out percentage and the composition of carcass. According to Jones (1989), evaluation of carcass has at two significant functions; that are evaluation of carcass composition as a part of scientific experiments and a system for evaluation of commercial carcasses based on lean meat content.

Why carcass evaluation is necessary

The evaluation of potential carcass qualities in live animal is an important requirement in case of breeding males since they can have a greater population characteristic influence in comparison to females. Carcass evaluation is an important aspect of grading and classification of carcass. With grade or class there can be some similar characters in common and with that classification becomes a comparatively easier process, but with different grades one may be superior or inferior to another while classes are just different (Kempster et al.,1982). In some instances, the carcass evaluation can be done mainly for research purpose (Purchas, 2012).

Factor Influencing Carcass Value

The carcass weight and dressing out percentage along with carcass composition chiefly determines the value of carcass.Carcass weight or hot carcass weight can be defined as the hot or un-chilled weight of carcass after removing head, hides, internal viscera and gastrointestinal tract. Carcass confirmation and length of the carcass are significant in increasing the weight of it. Carcass with a good confirmation tends to have a thicker appearance and well-defined muscles. If the level of fatness remains the same, well confirmed animal tends to have more lean meat (Warris, 2001). Carcass length is a straight line from the forward edge of the first rib to the forward edge of the aitch bone. If all other factors influencing the composition remain the same, carcass with more weight tends to have an increased carcass value.

The dressing percentage can be simply defined as the carcass weight as a percentage of live weight immediately prior to slaughter or in other words, the live weight multiplied by the dressing percentage gives the carcass weight (Coyne et al., 2019). Dressing percentage is directly depended on the live weight. According to Coyne et al. (2019), dressing percentage is influenced by both genetic and non-genetic factors. The animal factors influencing dressing percentage include sex, age, fatness, muscularity and pregnancy status. Factors affecting live weight such as gut fill and carcass weight such as bruising or decoction for shrink influence dressing percentage. The dressing percentage increases as the live weight of the carcass decreases (McKiernan et al., 2007).
Purchas (2012) illustrated that carcass composition is determined primarily by the lean meat yield percentage which in turn is determined by the carcass fat percentage and the muscle to bone ratio. The lean meat quality depends on external factors which involve mainly the processing of meat and intrinsic factors which include palatability factors (viz., odour, juiciness, flavour etc.); appearance (viz., colour, texture etc.); nutritive value, safety, wholesome characters and the processing properties. Carcass composition is also influenced by the distribution of lean and fat and the carcass shape. Yet another study states that the carcass composition is highly determined by genetic factors, age of the animal status of nutrition, hormonalbalance, environmental condition and the changes can even occur during pre-slaughter handling. Dry firm and dry condition in beef and Pale soft exudative condition in pigs are the commonly encountered carcass conditions (Irshad et al., 2013).

Grading Of Carcass

Polkinghorne et al. (2010) defined carcass classification as a set of terms describing characteristics of the carcassthat are helpful to thosewho are involved in trading of carcasses. Grading is the placing of different values on the carcasses for the pricing purposes, depending upon the requirements of traders and market.It is a systematic way to express value and quality of carcass by sorting in to groups according to selected characteristics. Grading plays a very significant role in marketing and merchandising of carcass. The animals which score high, fetches higher grades in carcass too. Different countries have their specific grading patters to suit their consumers and market patterns. The most popular among them is the system developed by United States department of Agriculture, popularly called the USDA system or Federal system of carcass grading. Grading is done so that it helps the farmer to recognize their quality of animal and for better planning to improve program and produce high grade animals and carcasses.It helps the producer to certify

their animals and carcasses for class, quality and condition through authorized agencies and it helps meat processing sector to select a required type according to the needs of market and consumers.

Indian standards

According to Bureau of Indian standards (BIS) –IS:2537, which came into existence in 1995,there are six standards in India based on conformation, finish and quality. They are Prime, Choice, Good, Commercial, Utility, Cutter and Canner. Likewise, lamb and poultry are also classified.

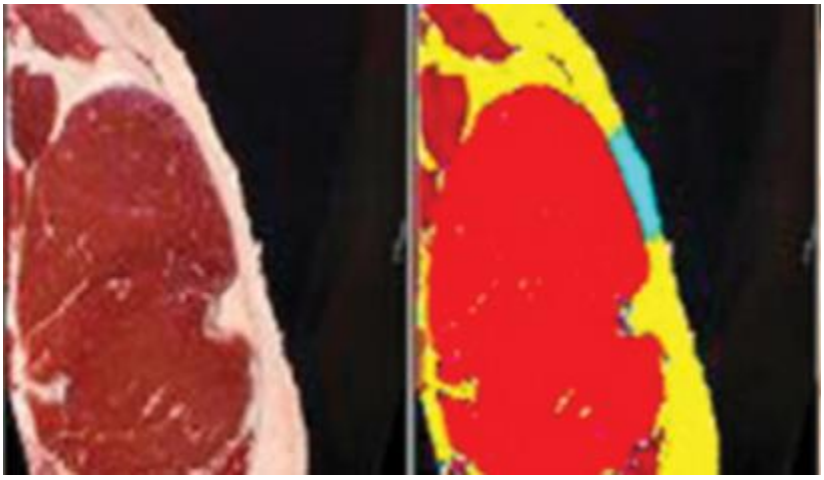
Fabrication of carcass

Cutting procedure or fabrication of carcasses of food animals refers to the method of separating a chilled carcass into different commercial parts. The fabricated cut up parts fetch an improved price range in the market compared to a whole carcass. Fabrication also helps in proper cooking of different cut up parts each fetching a different value. Fabrication is more or less same for all slaughter animals except pigs.

Novel upcoming grading strategies

At present, majority of the on-line evaluation of carcass uses back fat thickness and depth of the muscle to determine the overall yield and this technique seems to reach its maximum potentiality and accuracy.

The novel strategies for improvement need to be sorted out since dissection of carcass is time consuming, expensive and subjected to biases, newer methodologies using magnetic resonance imaging (MRI), X-Ray technologies are on research. Certainly, future evaluation and grading system will be based on weight of commercial cuts, its economic market value and the ration of lean and fat it contains. Colour, marbling which deals the aesthetic quality will also be given much importance (Kerry, 2009). Video Image Analysis (VIA) systems using electronic camera technology, and with computer-based digital image analysis techniques, to derive the significant features from multiple images of carcasses and which estimates of various carcass attributes including carcass composition and yield will be soon coming into existence. VIA can be effectively utilized to get direct measures of fat cover, eye muscle size, and dimension to infer composition and yield (Fig 2) (Craigie et al., 2012).



Conditioning Scoring Of BEAF cATTLE

he objective of condition scoring is to obtain a simple and reliable estimate of the body fat reserves of live cattle. The condition score provides an estimate of fat reserves that is independent of size, and is a more reliable description of condition than liveweight alone.

Novel Feed Additives for Beef Cattle

Function and effectiveness of feed additives targeting the rumen Four main targets have been identified for feed additives to optimize rumen function and achieve more efficient nutrient utilization: 1) shift methane (CH4) production to propionate to improve the energy balance of animals; 2) decrease feed protein degradation to increase bioavailability of amino acids in the small intestine; 3) decrease the rate of degradation of rapidly fermentable carbohydrates to control lactic acid concentration; and 4) improved fiber digestion (Jouany and Morgavi, 2007). Because of the benefits for the host ruminant in terms of health and energy utilization, improvements of these ruminal functions have been a goal for beef nutrtionists and microbiologists for decades. Ionophores achieve most of the 4 listed objectives in the rumen. Lawrence and Ibarburu (2007) analyzed the use of pharmaceutical technologies in modern beef production and reported a value of $20 per animal when using ionophores. Ionophores are considered the "gold standard" to which alternative technologies are often compared, both in terms of function and cost/benefit ratio. The vast array of recent research into modifying ruminal fermentation to mitigate methane production or to find an effective "natural" alternative to antibiotics has resulted in many potential feed additives that can enhance productivity.

Methane inhibitors

Methane inhibitors are chemical compounds that are toxic to methanogens. These compounds act by inhibiting some aspect of methanogen metabolism and include halogenated methane analogues, alcohol–halogen derivatives, diaryliodonium derivatives, coenzyme-M analogues, hydroxymethylglutaryl-S-CoA reductase inhibitors and uncouplers of the proton motive force. Among the most successful compounds tested in vivo in various ruminant species are bromochloromethane, 2-bromoethane sulfonate, chloroform, and cyclodextrin (Hristov et al., 2013). Inhibition of methanogenesis by these compounds in vivo can be up to 60% with the effect of bromochloromethane shown to last long-term (Hristov et al., 2013). However, some studies have suggested adaptation of the rumen microbiota to this class of compounds (Hristov et al., 2013), thus reducing their long-term efficacy. Furthermore, concerns for animal health, food safety, or environmental impact have limited their potential. Recently a synthetic methane inhibitor, 3-Nitrooxypropanol (3NOP), that overcomes these obstacles has been developed (Duval and Kindermann, 2012). 3-Nitrooxypropanol resembles coenzyme-M (CoM), which is used by methanogens in the last step of methanogenesis – the reduction of methyl CoM and coenzyme B (CoB) by methyl coenzyme M reductase into a CoM-CoB complex + methane (Ermler et al., 1997). Because Methanobrevibacter ruminantium, the predominant methanogen in the rumen, is unable to produce its own CoM it must rely on environmental CoM (Leahy et al., 2010), thus the ability of 3NOP to interfere. In short-term metabolism studies, 3NOP decreased CH4 production per unit of DMI by 24% in sheep (Martinez-Fernandez et al., 2013) by 60% in dairy cows (Haisan et al., 2013), and by 33% in beef heifers (Romero-Perez et al., 2014). In a 146 d metabolism study, 3NOP decreased CH4 production per unit of DMI by 59%, increased ruminal propionate and butyrate concentrations, and decreased ruminal acetate in beef heifers (Romero-Perez et al., 2015). The effect of 3NOP on performance of beef cattle has not been determined, however, in a 12 week study Hristov et al. (2015) demonstrated a 30% decrease in CH4 per unit of DMI and an 80% increase in body weight gain in lactating Holstein cows, with no effect on DMI or milk production.

Essential oils Plants synthesize a broad range of compounds that originate from secondary metabolism that are not directly involved in their growth or development (Balandrin et al., 1985; Jouany and Morgavi, 2007). These compounds are responsible for the odor and color of plants and spices, have important ecological functions as chemical messengers between the plant and its environment, protect them from predators and competition, and they often exhibit antimicrobial activity against a wide range

of bacteria, yeasts, and molds (Calsamiglia et al., 2007). The term 'essential oils' (EO) includes a large number of compounds extracted from the plants volatile fraction by the general process of compression, steam distillation, solvent extraction, or CO2 extraction (Benchaar et al., 2011). Essential oils are not essential for nutrition or metabolism of animals nor are they composed of glycerol, rather, they contain specific essences that provide the plant with their characteristic odor and flavor. Essential oils are hydrophobic, and thus interact with the cell membrane of gram+ bacteria altering ion transport, analogous to ionophores

Probiotics/direct fed microbials The term 'probiotic' has been used to describe viable microbial cultures, culture extracts, enzyme preparations, or various combinations of the above (Yoon and Stern, 1995). Therefore, the U.S. FDA has required feed manufacturers to use the term "direct-fed microbial" (DFM) instead of probiotic (Miles and Bootwalla, 1989) and has narrowed the definition to "a source of live, naturally occurring microorganisms" (Yoon and Stern, 1995). Microorganisms used as DFM for ruminants include viable cultures of bacteria and/or yeast. The bacterial DFM strains may be classified as lactic acid producing bacteria, lactic acid utilizing bacteria, or other microorganisms including Lactobacillus, Propionibacterium, Bifidobacterium, Enterococcus, Streptococcus, and Bacillus, and strains of Megasphaera elsdenii and Prevotella bryantii. The most commonly used yeast preparations are from Aspergillus oryzae or Saccharomyces cerevisiae. Direct fed microbials are generally supplied as dried preparations of live cells with their spent growth medium. Bacterial DFM are fed to establish a population in the rumen to improve function, however, bacterial DFM frequently fail to persist in the rumen (Krause et al. 2000) and thus have to be fed daily for them to be effective. Yeasts are aerobic and cannot survive for long in an anaerobic environment such as the rumen and also must be supplied continuously in feeds to reach a minimum effective concentration. Both types of DFM are most effective when fed to beef cattle during stress situations when the microbial balance could be disturbed (in calves, at weaning, during feedlot receiving, or during diet transition). During stress, DFM work to prevent the colonization of the GI tract by enteropathogens (E. Coli, Salmonella), which often results in diarrhea

Amylolytic enzymes Amylases have been used in some studies with mixed results on animal performance. Feeding exogenous amylase increased intake and consequently average daily gain in the early stages of the finishing period in feedlot steers fed cottonseed hulls as the roughage source (Tricarico et al., 2007). However, another experiment by the same authors found no differences in growth performance over the entire feeding period when steers received cracked corn or high moisture corn (Tricarico et al., 2007). Burroughs et al. (1960) demonstrated improvements in gain and efficiency when amylase was added to high forage feedlot diets, whereas DiLorenzo et al. (2011) reported that exogenous amylase improved organic matter digestibility but had no effect on performance of cattle fed 5% alfalfa hay and 5% cottonseed hull diets.

Fibrolytic enzymes Commercial fibrolytic enzyme products used in the livestock industry are of fungal (Aspergillus oryzae and Trichoderma reesei) or bacterial (Bacillus subtilis, Lactobacillus acidophilus, Lactobacillus plantarum, and Enterococcus faecium spp.) origin (McAllister et al., 2001). Although commercial enzyme preparations are commonly referred to as cellulases or xylanases, secondary enzyme activities such as amylases, proteases, esterases, or pectinases are invariably present as these preparations seldom consist of a single pure enzyme (McAllister et al., 2001). This diversity is advantageous, as it facilitates targeting of a range of substrates using a single product, yet it complicates the identification of the specific enzymes responsible for any positive responses observed in feed digestion.

Buffers/alkalizers True degradation of lignin is an oxidative process that is primarily performed by aerobic fungi. As the rumen is anaerobic, lignin is not truly degraded, but rather its solubilization is a key step in increasing the amount of cellulose and hemicellulose available for microbial fermentation. Various strategies have been attempted to hydrolyze the ferulic acid ester bonds and improve forage quality by ruminant livestock, including treatment with physical agents such as heat, steam, and pressure, with chemicals such as acids, alkalis, ammonia (NH3), and ozone, with biological agents such as white rot fungi, or via natural selection, breeding, or molecular engineering (Berger et al., 1994, Buanafina et al., 2008). However, none of these methods is widely used for improving forage quality and ruminant animal performance. This is due to the capital and energy intensive nature of physical methods such as steam or pressure treatment, the potential of pelleting, chopping, or grinding to limit salivary buffering of ruminal acids, the cost and corrosive and/or hazardous nature of chemicals such as NH3 and NaOH, the potential for excessive DM losses following hydrolysis by white rot fungi, and the protracted nature of breeding approaches

Meat Spoilage Mechanisms and Preservation Techniques

Different technical operations are involved in slaughtering: (a) stunning, (b) bleeding, (c) skinning, (d) evisceration and (e) carcass splitting. Inadequacy at one stage will result in a rigorous negative impact on the product and/or process in the following stage (FAO, 1991). In addition to the hygiene and storage temperature, the acidity of the meat and the structure of the muscular tissue also affect the rate of meat spoilage. For example, liver will spoil faster than the firm muscular tissue of beef (Berkel et al., 2004). After few hours of slaughtering of animals, muscles becomes firm and rigid, a condition known as rigor mortis. The process of rigor mortis depends on the stress induced on the animals during the slaughtering process (Miller et al., 2002). Raw meat quality is reported to be severely affected by the stress conditions during slaughtering process and the slaughtering methods (Miller et al., 2002; Chambers and Grandin, 2001). Fat, protein, minerals, carbohydrate and water are the constituents of meat (Heinz and Hautzinger, 2007). The quality of meat and meat products degrade as a result of digestive enzymes, microbial spoilage and fat oxidation (Berkel et al., 2004). Lipid oxidation, protein degradation and the loss of other valuable molecules are the consequence of meat spoilage process. Table 1 shows the chemical composition of fresh raw and processed meat. Proteins and lipids can break down resulting in the production of new compounds causing changes in meat flavor, tenderness, juiciness, odour and texture. It is therefore, important to understand the causes of spoilage of meat and meat product in order to develop optimum preservation techniques to maintain the freshness of these food products.

CAUSES OF MEAT SPOILAGE

Preslaughter handling of livestock and postslaughter handling of meat play an important part in deterioration of meat quality. The glycogen content of animal muscles is reduced when the animal is exposed to pre-slaughter stress which changes the pH of the meat, to higher or lower levels, depending on the production level of lactic acid (Miller, 2002; Chambers and Grandin, 2001; Rahman, 1999a). Lactic acid is produced due to the breakdown of glycogen content of animal muscles via an anaerobic glycolytic pathway as shown in Fig. 1 (Rahman, 1999a). Higher levels of pH (6.4-6.8) result in Dark, Firm and Dry (DFD) meat. Long term stress causes DFD meat which has a shorter shelf life (Miller, 2002; Chambers and Grandin, 2001). Sever short term stress results in a Pale, Soft and Exudative (PSE) meat. PSE meat has a pH lower than normal ultimate value of 6.2 which is responsible for the breakdown of proteins, providing a favorable medium for the growth of bacteria (Miller, 2002; Chambers and Grandin, 2001; Rahman, 1999a). Figure 2 shows the texture and color of the DFD, PSE and normal meat. The factors affecting the shelf life of meat and meat products are summarized in Table 2. There are three

main mechanisms for meat and meat products spoilage after slaughtering and during processing and storage: (a) microbial spoilage, (b) lipid oxidation and (c) autolytic enzymatic spoilage.

Microbial spoilage:

Meat and meat products provide excellent growth media for a variety of microflora (bacteria, yeasts and molds) some of which are pathogens (Jay et al., 2005). The intestinal tract and the skin of the animal are the main sources of these microorganisms. The composition of microflora in meat depends on various factors: (a) preslaughter husbandry practices (free range Vs intensive rearing), (b) age of the animal at the time of slaughtering, (c) handling during slaughtering, evisceration and processing, (d) temperature controls during slaughtering, processing and distribution (e) preservation methods, (f) type of packaging and (g) handling and storage by consumer

Lipid oxidation: Autoxidation of lipids and the production of free radicals are natural processes which affect fatty acids and lead to oxidative deterioration of meat and off-flavours development (Gray, 1978; Pearson et al., 1983; Simitzis and Deligeorgis, 2010). After slaughtering of animals, the fatty acids in tissues undergo oxidation when the blood circulation stops and metabolic processes are blocked (Gray and Pearson, 1994; Linares et al., 2007). Lipid oxidation is the reaction of oxygen with double bonds of fatty acids (Hultin, 1994). It involves three stage free radical mechanisms: initiation, propagation and termination

Autolytic enzymatic spoilage: Enzymatic actions are natural process in the muscle cells of the animals after they have been slaughtered and are the leading cause of meat deterioration. The enzymes have the ability to combine chemically with other organic compounds and work as catalysts for chemical reactions that finally end up in meat self deterioration (Tauro et al., 1986). In the autolysis process, the complex compounds (carbohydrates, fats and protein) of the tissues are broken down into simpler ones resulting in softening and greenish discoloration of the meat. These autolysis changes include proteolysis and fat hydrolysis which are prerequisite for microbial decomposition. Excessive autolysis is termed “souring” (Tauro et al., 1986). Postmortem breakdown of polypeptides are the result of tissue proteases and is responsible for flavour and is textural changes in meat (Toldra and Flores, 2000). Post mortem aging of red meat results in the tenderization process (Huss, 1995). Post-mortem autolysis takes place in all animal tissues but at different rates in different organs, quicker in glandular tissue such as the liver and slower in striated muscle

PRESERVATION OF MEAT Meat preservation became necessary for transporting meat for long distances without spoiling of texture, colour and nutritional value after the development and rapid growth of super markets (Nychas et al., 2008). The aims of preservation methods are: (a) to inhibit the microbial spoilage and (b) to minimize the oxidation and enzymatic spoilage. Traditional methods of meat preservation such as drying, smoking, brining, fermentation, refrigeration and canning have been replaced by new preservation techniques such as chemical, biopreservative and nonthermal techniques (Zhou et al., 2010). Current meat preservation methods are broadly categorized into three methods (a) controlling temperature (b) controlling water activity (c) use of chemical or biopreservatives (Zhou et al., 2010). A combination of these preservation techniques can be used to diminish the process of spoilage (Bagamboula et al., 2004).

Low temperature methods: The basic aim of cooling techniques is to slow or limit the spoilage rate as temperature below the optimal range can inhibit the microbial growth (Cassens, 1994). Low temperature methods of storage are used in three levels: (a) chilling (b) freezing and (c) superchilling. All these levels help to inhibit or completely stop bacterial growth (Zhou et al., 2010). However, the growth of psychrophilic group of bacteria, yeasts and molds is not prevented by all levels of refrigeration

(Neumeyer et al., 1997) and both enzymatic and non enzymatic changes will continue at a much slower rate (Berkel et al. 2004).

Chilling: Chilling is employed at slaughtering plants immediately after slaughtering and during transport and storage. It is necessary to reduce the temperature of carcass immediately after evisceration to 4°C within 4 h of slaughtering (USDC, 1995). Chilling is critical for meat hygiene, safety, shelf life, appearance and nutritional quality

It is employed by two methods: (a) immersion chilling, in which the product is immersed in chilled (0-4°C) water and (b) air chilling, in which the carcasses are misted with water in a room with circulating chilled air (Carroll and Alvarado, 2008). Carcass surface temperature is reduced at faster rate by air chilling which improves carcass drying and minimizes microbial spoilage (Ockerman and Basu, 2004). The microbial quality of the air-chilled product is better than that of a water-chilled product

Sodium chloride: NaCl in growth media or foods can be a source of osmotic stress by decreasing water activity (Doyle, 1999). Borch et al. (1996) stated that salt-sensitive microorganisms, such as Pseudomonas spp. and Eriterobacferiuceae, did not grew in meat when the water activity (aW) was reduced from 0.99 to 0.97 with the addition of 4% sodium chloride. However, salt tolerant microorganisms such as lactic acid bacteria and yeasts could grow at that level of water activity. Chawla et al. (2006) reported a reduction in water activity of fresh lamb intestine from 0.95 to 0.80 with the addition of 10% (w/w) of sodium chloride. Bennani et al. (2000) reported that Enterobactereaceae species were eliminated in kaddid (dry-salted meat product) as a result of reduced water activity (aw) below 0.9 after 3 days due to the subsequent actions of salting, spicing and drying. Domowe (2010) reported that adding 3% salt reduced initial water activity level to 0.97 in sausages which was further reduced to 0.95 through the 6 day drying process and as a result pathogenic bacteria (Salmonella, Bacillus) stopped multiplying. Wijnker et al. (2006) studied antimicrobial properties of salt (NaCl) for the preservation of natural sheep casings at different water activity (aw) levels and found the activities of most spoilage and pathogenic bacteria (Escherichia coli, Salmonella typhimurium, Listeria monocytogenes, Staphylococcus aureus and E. coli O157:H7) stopped when an aw of 0.89 was reached.

Principles and Practices of Modern Meat Technology

IMPROVED PROCESSING EFFICIENCY Cutting and processing of carcasses soon after slaughter and before conventional chilling holds considerable potential in improving processing efficiencies. Hot processing involves removal of excess fat and bone before chilling and can result in significant savings, particularly in energy, labor and product weight loss (12,13,14). However, because one is working with a product that is near body temperature, special care must be taken to prevent excessive microbial growth. Researchers have defined chilling and handling conditions required to produce a microbially acceptable hot-processed product (10,17). Some aspects of hot processing are being applied in the U.S. industry; however, other countries are using this technique more extensively.

TENDERIZATION TECHNOLOGY Because tenderness is an extremely important quality of meat, the industry is currently using a variety of techniques to insure tenderness and reduce its variability. Historically cooler aging has been used to increase tenderness and this technique is still employed even though for most meat today the time period between slaughter and marketing has been reduced as compared to previous years. Most of the tenderizing benefits of aging are realized within the current slaughter-to-marketing time frame, and the risks (i.e. excessive microbial growth) associated with prolonged aging are minimized. The aging process, caused principally by muscle enzymes, begins soon after death and continues until cooking unless the product is frozen. Aging primals or subprimals in vacuumized packages is a grnwing trend as it allows the aging process to continue yet retards microbial

growth, and reduces trim and moisture losses (14,21). Nonetheless, microbial spoilage will result if the product is aged too long, whether or not it is packaged. An aged, partially degraded product is an excellent source of nutrients for microorganisms.

PRODUCT SANITATION The most desirable approach to achieving a high quality product from a microbial standpoint is to minimize product contamination during slaughter and subsequent processing. However, some technologies are designed to retard or prevent microbial growth as invariably microorganisms will be found on the product. Refrigeration, freezing, canning, curing, smoking and dehydration are examples of technologies used in achieving this end. Aqueous chlorine solutions have also been applied to carcasses of a variety of species

CONTROLLED ATMOSPHERE STORAGE OF MEAT During the past several years there has been an increased interest in using modified atmospheres to increase the shelf-life of meat. This practice has fostered continued interest in centralizing processing practices such as the boxed beef concept. Vacuum packaging and packages containing elevated levels of carbon dioxide and nitrogen are examples of modified atmospheres used to effectively extend shelf-life. Storage in modified atmospheres has been demonstrated to improve shelf-life and limit growth of some potential pathogens.

HE TEHSIL/TOWN MUNICIPAL ADMINISTRATION [NAME OF THE TMA] (SLAUGHTER OF ANIMALS AND MAINTENANCE OF SLAUGHTERHOUSES) BYE-LAWS

Definitions.–In these bye-laws unless there is anything repugnant in the subject or context, the following expressions shall have the meaning hereby respectively assigned to them:- (a) “Animal” means a buffalo, buffalo-bull, camel, cow, cow-bull, goat sheep and ostrich and any other Halal animal of any age; (b) “Carcass” means slaughtered eviscerated body of an animal; (c) “Cull” means to pick an animal which is suitable neither for breeding purposes nor for draught purposes; (d) “Government” means Government of the Punjab; (e) “Flesh” means the meat of animals as distinguished from the edible tissue of fish or fowl; (f) “In-charge of Slaughterhouse” means an officer in-charge/Veterinary officer of slaughterhouse maintained by TMA; (g) “Slaughterhouse” means any building or premises used for slaughtering animals and approved by the TMA and includes modern „abattoir‟ fully equipped with modern techniques &machinery; (h) “Larraige” means any enclosure, approved by the TMA, where animals are assembled for examination by the Veterinary Officer to determine whether they are suitable for slaughter or not, or where animals approved for slaughtering are housed until they are removed to the slaughter house; (i) “TMA” means the Tehsil / Town Municipal Administration _____; (j) “TO(R)” means Tehsil / Town Officer (Regulation); (k) “Useful Animals” include; (i) a female sheep and goat below the age of one year and six months; (ii) a female sheep or goat of the age exceeding one year and six months but not exceeding four years except, which is pregnant or fit for breeding purposes; (iii) a female animal, other than sheep or goat, below three years of age; (iv) a female animal, other than sheep or goat, which is pregnant or in milk or fit for breeding purpose; (v) a female cattle, between three to ten years of age, which is fit for draught purposes, but does not include any such animal which on account of culling, injury, illness or other cause, is certified in writing by the Veterinary Officer as not likely to live or as no longer a useful animal. 3. Provision of Slaughter House.– (1) The TMA shall provide and maintain at such site or sites, one or more Slaughterhouses for the slaughter of animals within its local area

(2) The slaughterhouse should be situated away from residential areas and access for animals - either by road, rail and/or stock route shall be assured. (3) Fence shall be erected around the slaughterhouse to prevent access of unauthorized persons, the public, dogs and other animals. (4) Essential equipment shall be provided by the TMA. 4. Operation of Slaughter of Animals.–(1) Slaughterhouses will be provided for the slaughtering operation of animals during such hours as the TMA may, from time to time, determine. (2) The in-charge of slaughterhouse shall fix at a conspicuous place in a slaughterhouse

a notice board showing: - (a)The hours of the working of slaughterhouse. (b) The fee payable. (c) Any other directions that the in-charge of slaughterhouse deemed appropriate to issue. (3) No animal shall be slaughtered in a Slaughterhouse at any time other than that fixed for the purpose. 5. Prohibition.–(1) No animal shall be slaughtered for the purpose of sale of meat at any place other than a slaughterhouse except: (a) When on account of accident, injury or other cause not related to any disease likely to die before it is presented to the In-charge of slaughterhouse; (b) On the days of Eid-ul-Azha or any other religious purpose. Provided that a fully aware of the mode of Halal slaughtering as mention in bye-law No.10 shall be observed and the contents of stomach &bowels shall not be washed into the drain but shall be emptied into the buckets or other receptacles so that the same are disposed of at proper place, to keep the environment clean and hygiene. (2) No person shall slaughter an animal on Tuesday and Wednesday or on such other days as Government may, by notification in official gazette, specify in this behalf. 6. Pre-Slaughter Conditions.–(1) No person shall slaughter a useful animal. (2) No person shall bring into or any part of slaughterhouse; (i) a diseased, emaciated, widely bruised, or otherwise unhealthy animal; (ii) a male animal which is less than three months of age in case of sheep/goat and six months in other case; (iii) an animal which is pregnant, or with weaning young; (iv) a buffalo or cow during the period of lactation; (v) a carcass; (vi) a carnivorous e.g. dog, cat etc. ; (vii) an animal not meant for slaughter or for the slaughter of which slaughterhouse is not provided; (viii) an animal for which restrictions have been imposed by the Government on its slaughter; and (ix) a starved or under-fed animal

7. Pre-Slaughter (Ante-Mortem) Inspection of Animals.–(1) Every animal for slaughter shall, on being brought to slaughterhouse, be presented for inspection to the incharge of slaughterhouse who shall satisfy himself/herself that: (i) The female animal is not fit for producing milk; (ii) Flesh of the animal will be fit for use as human food. (iii) The animal is not diseased or in dying condition, provided that any animal, which has met with an accident and is otherwise healthy. (iv) The animal fulfills the conditions of these bye-laws and all the instructions issued by the Government from time to time in this regard. (2) The animal shall be brought in slaughterhouse only through the gate fixed for this purpose. (3) An animal brought in contravention of these bye-laws shall immediately be removed from the slaughterhouse premises under the directions of the in-charge of slaughterhouse. 8. Functions of In-charge Slaughterhouse.– (1)The in-charge of slaughterhouse shall maintain a register in which he/she shall enter a brief description of each animal passed for slaughter and the fees recovered thereof. (2) An animal approved for slaughter by the in-charge of slaughterhouse shall be branded with a distinctive mark on ears, hoofs or horns if necessary, and admitted into the larraige of a slaughterhouse having the facility of water supply. (3) All animals when approved shall be kept in the larraige. (4) The in-charge of slaughterhouse shall be responsible for their security when these are in the larraige. He shall also be responsible for the security of the dressed carcasses, while they are in the slaughter hall. (5) No animal shall be admitted into the waiting yard, unless the prescribed fee has been paid. 9. Disposal of Animals Unfit for Slaughter.– (1) Animals rejected as unfit for slaughter shall be removed from the premises of slaughterhouse. (2) Animals found to be affected by any infectious or contagious disease or which may reasonable be suspected of being so affected shall, if in-charge of slaughterhouse so directs, be forthwith apprehended and removed to the Veterinary Hospital or such other place as the TMA may provide for the purpose. The animals so seized shall be disposed of in the manner as given in TMA Regulation for Disposal of Animals Carcasses Bye-laws. (3) Animal suffering from zoonotic diseases, the flesh of which is unfit for human consumption shall be destroyed under order of the in-charge slaughterhouse. 10. Mode of Slaughtering.– (1) Each animal shall be slaughtered by a person having the licence from the Punjab Halal Development Agency, Lahore to slaughter an animal. (2) Slaughter shall be performed by a Muslim, who shall precede the slaughter by invoking the name of Allah, most commonly by saying "Bismillah" and then "Allahuakbar". (3) The animal shall be slaughtered with a sharp knife by

cutting the throat, windpipe and the blood vessels in the neck (while the animal is conscious), causing the animal‟s death without cutting the spinal cord. Lastly, the blood from the veins must be drained; see Schedule-I

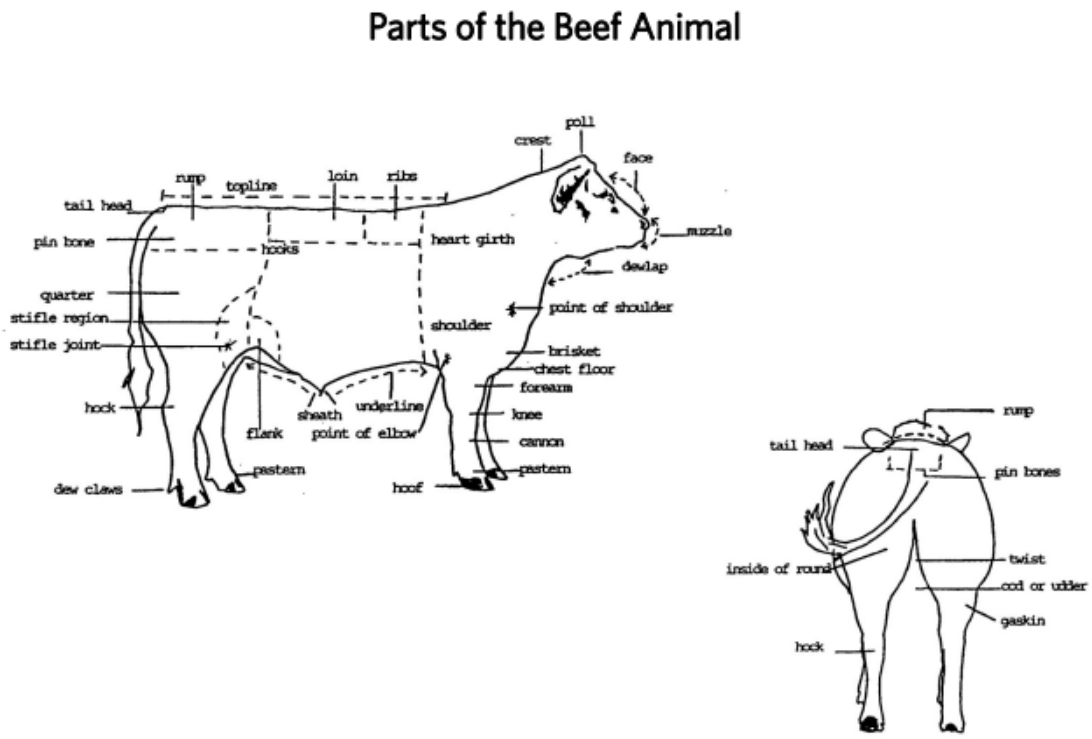
(4) For short necked animal i.e. cow, sheep, goat, etc, slaughter shall be performed in accordance with the process of “Zibah” and for long necked animal i.e. camel, ostrich, etc, process of “Nahar” shall be followed. Explanation: (i) Zibah – To cut the vessels of the animal between the “lahyain, jawbone and the “labbah”. (ii) Nahar – To cut the vessels of the animal in the lower part of the neck near the chest. (4)The licencee shall drain the blood into bleeding chamber and no blood shall be allowed to flow on the floor. (5)No animal shall be kept waiting at the slaughter floor. (6) Animals intended for slaughter shall be secured in humane way to avoid cruelty and a very sharp knife shall be used for slaughter. (7)Slaughtered animals shall be flayed and evince after all reflexes are over. (8) The contents of the stomach and bowels shall not be washed into the drain or allowed to drop on the floor, but shall be emptied into buckets or receptacles provided at the slaughterhouse or in a separate room. (9)No person shall process any inedible byproducts within any portion of slaughterhouse or in the immediate neighbourhood of the slaughterhouse premises. 11. Dressed Animals.– (1) All dressed carcasses shall, after de-skinning and cleaning, be presented to the in-charge of slaughterhouse for inspection. (2) Carcasses, which have been passed by the in-charge of slaughterhouse as fit for human consumption, shall be branded or stamped so as to define their quality. (3) No person shall remove any dressed carcass from the slaughterhouse premises until it has been duly passed by the in-charge of slaughterhouse. (4) The in-charge of slaughterhouse shall cause any dressed carcass or its part, which is, in his opinion, unfit for human consumption to be buried or destroyed. 12. Post Slaughter conditions. - (1) No person shall remove entrails and offal from the slaughterhouse until they are properly washed and cleaned. (2) No person shall blow or infuse water in meat or lungs within or outside the slaughterhouse premises and the in-charge slaughterhouse shall bury or destroy any meat found blown or stuffed. (3) No whole dressed carcass or meat in parts or skins shall be sold at the premises of the slaughterhouse. (4) No person shall sell any meat within the jurisdiction of TMA, which is not slaughtered and dressed at the TMA slaughterhouse or any other slaughterhouse approved by the TMA, if found unfit for human consumption, and such person shall be liable to fine and imprisonment as per provisions of the Punjab Local Government Ordinance, 2001. If found fit, the same will be stamped as such and auctioned. The sale proceeds shall be deposited into TMA‟s account. (5) No person shall remove or cause to be removed from the premises of the slaughterhouse any dressed carcass or meat except in a clean receptacle and covered in such a manner as to be screened from public view and adequately protected against flies and dust

(6) The in-charge slaughterhouse shall, by general or special order, direct the disposal of all skins or hides, heads, horns and foot of slaughtered animals and all dressed carcasses or meat found or left in the slaughter house after the hours fixed for closing the slaughter house. 13. Prohibition of Using Un-Lincenced Slaughterhouse.– (1)On coming into the notice, it shall be the responsibility of the TO(R) and in-charge slaughterhouse to inspect the unauthorized slaughterhouse/place and shall seize and forfeit the animals and the meat at such place. (2) The animals or meat so seized shall be disposed of in the manner as given in TMA Regulation for Disposal of Carcasses of Animals Bye-laws. (3) Any carcass or meat ordered to be destroyed shall be destroyed/buried immediately. 14. Restriction on entry of Un-authorised Person.–(1) No person affected with leprosy, sores or any other skin disease shall enter the slaughterhouse premises. (2) No person other than the TMA staff on duty and licensed butchers, licensed flayers or their bonafide licensed servants, shall enter the slaughterhouse premises during the process of slaughtering, flaying or dressing the carcass, without permission of the incharge slaughterhouse. 15. Butchers and Flayers.–(1) No butcher or flayer shall be allowed to slaughter and dress more than 5 cattle or buffaloes or 25 sheep and goats per day in a slaughterhouse. (2) No person

other than the butcher or the flayer or their staff licensed by the Punjab Halal Development Agency, Lahore shall be allowed to slaughter and dress any animal at the slaughterhouse. (3) The licensed butchers and flayers shall use the special flaying knives as approved by the in-charge of slaughterhouse. (4) No person shall create any disturbance or nuisance in the slaughterhouse premises. (5) A person transgressing the provisions of the bye-laws shall be removed from the slaughterhouse premises under the directions of the in-charge of slaughterhouse, immediately. 16. Responsibilities of TMA.–(1)The blood, unwanted offal, refuse or other offensive material left at the slaughterhouse shall be removed under the supervision and control of the in-charge of slaughterhouse to a place fixed for that purpose by the TMA and the sanitation of the premises properly maintained after the slaughtering operations are over. (2)The TMA may, from time to time, issue necessary instructions in respect of sanitation and other matters connected with the affairs of the slaughterhouse. (3) All slaughterhouses shall be properly paved and have a constant supply of water, proper drainage and well ventilated. (4) Slaughterhouse shall be regularly whitewashed at least twice in each year. (5) Slaughterhouse shall be kept thoroughly clean and in good order and all dung and filth removed therefrom at least once every twenty four hours. (6) Pests (insect, rodents and birds) shall be controlled to prevent their access to slaughterhouse

washed out in a proper manner and blood and offal removed shall be by the person or persons who have slaughtered the animal. (8) All skins, hides, leather and all blood saved in the slaughterhouses shall be removed therefrom within twenty four hours and shall not be again brought back. (9) No deceased, unfit or useful animal shall be slaughtered in the slaughterhouse nor brought the same therein. (10) A person who shall by himself, or anyone in his employment, shall not cruelly beat, ill-treat, abuse or torture any animal in a slaughterhouse or cause such to be done.

Judging Beef Cattle



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