PRINSIP PENGELUARAN TERNAKAN
SHW 3001

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Selangor Darul Ehsan
PENGENALAN KURSUS

a. Maklumat Kursus
Jabatan : Jabatan Sains Haiwan
Nama Kursus : Prinsip Pengeluaran Ternakan
Kod Kursus : SHW 3001
Jam Kredit : 3 (3+0)
Kursus ini merangkumi 3 jam kuliah seminggu.

b. Maklumat Penulis
Nama : Ismail bin Idris, Ph.D. (Prof. Madya)
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c. Objektif Kursus
1. menghubungkait prinsip pengeluaran ternakan dengan faktor yang mempengaruhi pelbagai sistem pengeluaran ternakan dan sumbangan industri ternakan (P2)
(1. link the principles of animal production with factors influencing various livestock production systems and contributions of the livestock industry (P2))
2. menghuraikan pelbagai industri ternakan (C3, LL)
(2. explain various livestock industries (C3, LL))
3. menerangkan kaitan antara sains haiwan, pemakanan dan penghasilan (A3, TS)
(3. explain the link between animal science, nutrition and production (A3, TS))
d. Sinopsis Kursus

Kursus ini merangkumi prinsip pengeluaran ternak, pengurusan pastura, bahan sampingan pertanian sebagai makanan ternak, faktor yang mempengaruhi pemakanan, reproduksi, pengurusan ternak ruminan dan bukan ruminan, serta hasil dan hasil sampingan ternak.

(This course encompasses the principles of livestock production, pasture management, agricultural by-products as feed, factors that influence feeding, reproduction, management of ruminant and non-ruminant livestock, and livestock product and by-products.)

e. Kandungan Kursus

1. Pengenalan kepada industri ternak dan sistem pengeluaran di Malaysia
   - interaksi antara ternak, tanaman dan manusia
   - hasil ternak
   *Introduction to livestock industry and production system in Malaysia*
   - interaction between livestock, crops and man
   - livestock products

2. Sistem pencernaan dan reproduksi ternakan
   - ruminan
   - monogastrik
   *Livestock digestive system and reproduction*
   - ruminant
   - monogastric

3. Pemakanan ternak dan bahan sampingan pertanian sebagai sumber makanan
   *Livestock nutrition and agriculture byproduct as a source of food*

4. Asas genetik haiwan
   - sistem pembiakbakaan
   - peningkatan prestasi ternak
   *Basic animal genetics*
   - breeding system
   - improvement of livestock performance

5. Pengurusan pastura
   - pembajakan
   - kadar penstokan
   - sistem foder
   *Pasture management*
   - fertilization
   - stocking rate
   - fodder system
6. Industri tenu
   - pengurusan dan perumahan
   - lembu dara pengganti
   - fisiologi laktasi
   Dairy industry
   - housing and management
   - heifer replacement
   - lactation physiology

7. Industri dan sistem produksi pedaging
   - pengurusan
   - perumahan
   Industry and beef production system
   - management
   - housing

8. Industri poltri
   - status dan ekonomi pengeluaran
   - pengurusan poltri pedaging, penelur, pembak
   Poultry industry
   - status and production economy
   - broiler, layer and breeder management

9. Industri ternak lain
   - kambing dan bebiri
   - kerbau dan rusa
   - babi
   Other livestock industry
   - goat and sheep
   - buffalo and deer
   - pig

10. Kebajikan haiwan, pengangkutan dan pengendalian ternakan, GAHP dan pengurusan sisa
    - cabaran industri ternakan dan isu semasa
    Animal welfare, transportation and livestock handling, GAHP and waste management
    - Challenges to livestock industry and current issues
## Jadual 1: Tajuk Unit dan Cadangan Jam Kuliah Diperuntukkan

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g. Penilaian Kursus
Penilaian kursus ini terbahagi kepada:

(i) Kerja kursus keseluruhan
   - Tugasan (individu) 20%

(ii) Peperiksaan pertengahan 40%

(i) + (ii) 60%

(iii) Peperiksaan akhir 40%

Jumlah keseluruhan 100%

**Penilaian kursus berubah daripada semasa ke semasa bergantung kepada pensyarah/pengajar kursus semasa.

Cadangan Jadual dan Aktiviti Pembelajaran

1. Perjumpaan Bersemuka 6 jam
2. Pembelajaran Kendiri 35 jam/seminggu
3. Sesi Tutorial (4-6 sesi) 15 jam
4. Pembelajaran Berkumpulan 14 jam
5. Online/Emel/Telefon/LMS/Kelas Maya dengan Pensyarah/Pengajar 30 jam
6. Tugasan/Amali dan Projek 20 jam

*Jumlah Jam Keseluruhan* 120 jam
h. Peperiksaan Pertengahan (jika berkenaan)

i. Peperiksaan Akhir (jika berkenaan)
Soalan peperiksaan ini akan merangkumi kesemua topik dalam modul, walau bagaimanapun penekanan ialah pada topik yang belum dinilai. Tutor di pusat pembelajaran akan dimaklumkan mengenai topik-topik ini atau pelajar boleh berhubung terus dengan pensyarah kursus untuk mendapatkan maklumat muktahir. Soalan peperiksaan akhir mesti berbentuk kombinasi objektif dan subjektif/esei.

(Perhatian!: bentuk soalan ini boleh berubah, maklumat terkini mengenai peperiksaan boleh berhubung terus dengan pensyarah/pengajar semasa perjumpaan bersemuka).

j. Rujukan Utama


k. Rujukan Tambahan


Penerangan mengenai ikon dalam modul

Untuk menolong pelajar memahami dengan lebih mudah kandungan modul ini beberapa ikon telah digunakan. Ikon-ikon ini bertujuan untuk memudahkan ingatan pelajar mengenai struktur modul. Di bawah disenaraikan ikon-ikon tersebut berserta dengan maksudnya.

a) Objektif ➔ Objektif modul, unit atau topik
b) Pengenalan ➔ Sama ada pengenalan unit, topik atau sub topik
c) Isi-isi penting ➔ Kumpulan isi-isi penting yang terdapat dalam unit, atau topik
d) Pemerhatian/ Pandangan ➔ Mengenai topik yang telah di kaji oleh beberapa sarjana atau maklumat daripada hasil kajian
e) Kesimpulan ➔ Kesimpulan yang boleh dibuat berdasarkan unit atau topik yang telah dipelajari
f) Soalan dalam teks ➔ Soalan-soalan yang disisipkan oleh penulis semasa membincangkan sesuatu topik
g) Soalan Penilaian kendiri ➔ Soalan yang disediakan oleh penulis untuk menolong pelajar mengetahui tahap kefahaman terhadap topik yang dibincangkan
h) Semak Jawapan Latihan ➔ Jawapan berdasarkan latihan-latihan yang telah disediakan di setiap unit
i) Rujukan ➔ Bahan rujukan yang boleh dijadikan panduan tambahan dalam kursus tersebut
j) Perhatian ➔ Simbol ini akan digunakan bagi perkara-perkara yang perlu diberikan perhatian oleh pelajar
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UNIT 1

LIVESTOCK INDUSTRY AND PRODUCTION SYSTEMS

Learning Outcomes

At the end of this unit, students able to:

1. Able to appreciate the diverse species of livestock raised in various production systems in Malaysia and the world.
2. Able to explain the varying function of livestock in the animal agriculture system.

OUTLINE

1. Introduction
2. History
3. Why do we keep livestock?
4. Animal products in human diets
5. Livestock industry in Malaysia
6. Climate and animal production
7. Production systems
Introduction
The agriculture sector is one of the oldest and largest primary industry that governs the economic life of all nations (Figure 1).
It provides employment to more than half of the world’s population, with more than two thirds of people in developing countries living on farms and ranches.

Figure 1. Comparative distribution of world’s population, agricultural production and income.

<table>
<thead>
<tr>
<th>Region</th>
<th>Asia</th>
<th>North America</th>
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<tr>
<td>World’s population</td>
<td>50%</td>
<td>6%</td>
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<tr>
<td>World’s agricultural production</td>
<td>28%</td>
<td>22%</td>
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<tr>
<td>World’s income</td>
<td>12%</td>
<td>40%</td>
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</table>

History
Cultivation of plants and domestication of animals began at the same place but at different times at the hill region of south-western Asia.
The shift from gathering food to growing crops began 10,000 to 16,000 years ago, with domestication of animals occurring in the Neolithic (New Stone Age) period, between 10,000 and 14,000 years ago.
Domestication was the first step towards civilisation (Figure 2), and is considered a prerequisite for a nomadic herding way of life (Hemmer, 1990).
**Why do we keep livestock?**

The main functions of livestock production for society are for food security, services and income generation.

The commodities that can be derived from livestock can be divided into:

- **Animal products**
  - Meat.
  - Eggs.
  - Milk and milk products.

- **Animal by-products.**
  - Bones: tools, buttons, glue, livestock feed (Ca²⁺).
  - Fats: soap, cream, dressing, food.
  - Collagen: glue, gelatine.
  - Intestinal tissue: surgical suture, musical instrument strings.
  - Hide: leather.
  - Hair: wool, mohair, cashmere.
  - Waste: fertilizer, livestock feed.

- **Miscellaneous.**
  - Labour: cultivate land, transport, control other animal species.
- Medical: assist physically and medically disabled individuals.
- Entertainment.

### Animal products in human diets
Meat, milk, eggs and fish supply approximately 16% of human food energy and 36% of human food protein.
There is a large variation among countries and regions.
The per capita consumption of foods from animals is leveling off in developed countries but increasing rapidly in developing countries (Figure 3).

#### Figure 3. Leading livestock producing countries. (Source: FAOSTAT, 2009)

<table>
<thead>
<tr>
<th>Beef &amp; Veal</th>
<th>Mutton &amp; Lamb</th>
<th>Pork</th>
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<tbody>
<tr>
<td>United States</td>
<td>China</td>
<td>China</td>
</tr>
<tr>
<td>Brazil</td>
<td>Australia</td>
<td>United States</td>
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<tr>
<td>China</td>
<td>New Zealand</td>
<td>Germany</td>
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<th>Horse</th>
<th>Chicken</th>
<th>Chevon</th>
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<tr>
<td>China</td>
<td>United States</td>
<td>China</td>
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<td>Kazakhstan</td>
<td>China</td>
<td>India</td>
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<td>Mexico</td>
<td>Brazil</td>
<td>Nigeria</td>
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### Livestock industry in Malaysia
Classified into:
- Ruminant: cattle, goat, sheep, buffalo, deer.
- Non-ruminant: pigs, chicken, ducks, game birds (i.e. quail, ostrich).
Despite emphasis and priority from govt, ruminant sub-sector still not well developed.
The pig and poultry industry are more than 100% self-sufficient.
Climate and animal production

Species characteristics influences:
- Adaptation to geographic areas and production systems.
- Feed type they can utilise.
- Individual size in relation to product volume.
- Susceptibility to stressors, e.g. extreme temperature, parasite and disease.

Production systems

Livestock can be reared in:
- Extensive production systems (Figures 5a and b)
  - Traditional method of farming.
  - Relatively inexpensive.
  - Animals are free to roam, forage for food and are able to perform its natural behaviour(s).
  - There is no routine management and/or husbandry practised.
  - The animals' health is not monitored.
Figure 5. Extensive livestock production: (a) Free-ranging domestic sow and her piglets; (b) Free-ranging hens.

- Intensive production system (Figure 6a and b)
  - Modern method of farming.
  - Costly.
  - Animals are confined and abnormal behaviours are frequently observed in these animals.
  - Feed and water are provided.
  - Routine management and husbandry is practised.
  - Health is regularly monitored.
Figure 6. Intensive livestock production: (a) Steers in feedlot system; (b) Deep-litter broiler production

- Semi-intensive production system (Figure 7a and b)
  - Animals are allowed to forage, and are given supplement feed.
  - The animals are usually housed in shelters during the night.
  - Occasionally the farming of livestock under this type of production system is integrated with plants and/or other livestock species.
  - Farmer obtains dual income from both activities
Figure 7. Semi-intensive production: (a) Goats reared in a rubber plantation; (b) Cattle reared in an oil palm plantation

References


UNIT 2a
Animal Digestive System

Introduction

Digestion is the mechanical and chemical breaking down of food into smaller components, to a form that can be absorbed and used by the animal. The process of digestion includes: The prehension of food or feed, the mechanical chewing and grinding and mixing with digestive acids and enzymes to chemically break down the foodstuffs. The process of absorption includes: Transport of the digested foods across the intestinal mucosa to the blood or lymph system.

Unit Objectives

1. Describe and understand the basic functions of the primary components of the digestive system.
2. Compare the functions and locations of the digestive organs in man, poultry, horses, cows and swine.
3. Differentiate between and identify digestive systems of man, horses, swine, poultry and cows.
TOPIC:

1.1 Function of digestive tract

1.2 Type of digestive system
   a) Ruminant
   b) Non-Ruminant – simple stomach and simple stomach with enlarged caecum (hind gut fermentors)
   c) Poultry

1.3 Digestion Process

Important Points

1. Primary Function of digestive tract
   a) Transport food – peristaltic contractions
   b) Digestion - reduce feed particles to molecules that can be absorbed into the blood, mechanical breakdown by chewing and chemical breakdown by HCl and digestive enzymes
   c) Absorption - allows nutrients to pass through membranes of GIT to the blood stream, passive diffusion and active transport
   d) Synthesis - true protein, FA, starch, vitamins
   e) Excretion – elimination of waste products via bile (toxins, microbes etc), via rectum (Ca, Mg, P)

2. Type of livestock digestive system
   a. Ruminant : A stomach with more than one compartment (cows, sheep, deer)
   b. Non-ruminant :A stomach with one compartment (swine, horses)
   c. Poultry: No true stomach (chickens, geese)
Species-dependent Nutritional Adaptations

Includes involvement of:

i. Teeth

ii. Jaws and jaw musculature

iii. Alimentary canal

iv. Stomach - May be simple or become sacculated to compartmentalize functions for prolonged storage of feed and utilization of bacterial fermentation (langures and ruminants)
   1. May also become voluminous for storage of large amounts of feed (vampire bats)

v. Large intestine - varies substantially in length, compartmentalization, and complexity among species

Types of Stomachs

a. Simple Stomach - Man, Pig
   - Humans, swine, rabbits and horses
     Divided into three regions
     cardiac
     fundus
     pylorus
   - Digestion:
     - mechanical, muscle contractions
     - chemical, enzymes soften and break down macromolecules of food
   - enzymes are catalysts, they start the chemical reactions
     Enzymes that break down food
     o Gastric-break down proteins in stomach
     o Liver and pancreatic-break down fats in small intestine
     o Intestinal-break down carbohydrates and proteins in small intestine
b. Complex Stomach (ruminant) - Cattle, Sheep, Goats
   - The digestive system of ruminant animals includes the:
   - Mouth - grasps the food
   - Teeth - grind the food
   - Ruminants have only one set of teeth in the front of the mouth (incisors), and two sets in the back (molars).
   - Tongue - covered with finger-like projections (papillae) that contain taste buds.
   - Salivary glands - secrete saliva, that moistens food and is mixed with the food material to aid in swallowing

   c. Simple Stomach with enlarged caecum - Horses, Rabbits, Guinea Pigs
      - Divided into three regions
        o cardiac
        o fundus
        o pylorus
      - Digestion:
        o mechanical, muscle contractions
        o chemical, enzymes soften and break down macromolecules of food
      - enzymes are catalysts, they start the chemical reactions
      - Enzymes that break down food
        o Gastric-break down proteins in stomach
        o Liver and pancreatic-break down fats in small intestine
        o Intestinal-break down carbohydrates and proteins in small intestine

3. The General Mechanical Process in digestion are:
   1. Mastication - chewing
   2. Deglutition - swallowing
   3. Regurgitation - movement of digesta in reverse order from the stomach to mouth
   4. Defecation - voiding the fecal, or waste, materials from the body
Ruminant Digestive Systems

1. **Mouth**
   - no upper incisors, hard palate
   - molars for grinding coarse vegetation
   - saliva does not contain enzymes

2. **Esophagus**
   - muscular tube connecting the mouth to the stomach
   - Four Components of Ruminant Stomach

3. **Rumen:**
   - composes 80% of ruminant stomach in mature bovine animals and
   - 30% in young animals. Storage area and fermentation vat. Microbes
digest cellulose.

4. **Reticulum:**
   - composes about 5% of bovine stomach
   - prevents indigestible objects from entering the stomach. Nails and wire
   - may be found here – hardware stomach.

5. **Omasum:**
   - eliminates excess water from feed. Composes 7-8% of bovine
   - stomach. Absorb mostly water.

6. **Abomasum:**
   - true stomach, gastric juices and enzymes are secreted mature animals.
   - Composes 7-8% of stomach in mature and 70% in young animals
*Regurgitation:* first step in rumination
  - large quantities of roughage are consumed and are chewed just enough to swallow after swallowing, regurgitation ("cud chewing") takes place, food is re-chewed
  - After rumen is full, it lies down to ruminate (chew its cud)
  - Cattle spend from 5-7 hours ruminating, broken up into 6-8 periods
  - Regurgitation is the process of forcing the feed back into the mouth for chewing
  - Done through a series of muscular contractions and pressure in the rumen and reticulum

7. **Small Intestine:**
   - connects stomach to large intestine
   - food nutrients absorbed into blood
   - contains bile and pancreatic juices
   - pushes food through by muscle contractions

8. **Large Intestine:**
   - Contains Cecum, Colon and Rectum
   - Cecum: sac at junction of small intestine and large intestine
   - Colon and rectum: at end of system
   - not as long as small intestine, but larger in diameter
   - water and some nutrient absorption occurs here
   - where residue solidifies before excretion
   - absorbs mostly water
Non-ruminant (simple stomach) digestive system

Digestive Process - Monogastrics

- Animals having a simple stomach (such as pig), the mouth has teeth and lips for grasping and holding feed that is masticated (Chewed), and salivary glands that secrete saliva for moistening feed so it can be swallowed.
- Feed passes from the mouth to the stomach through the esophagus.
- There is a sphincter (valve) at the junction of the stomach and esophagus, which can prevent feed from coming up to the esophagus, when the stomach contraction occurs.
- The stomach empties its content into the small intestine known as duodenum.
- The pyloric sphincter, located at the junction of stomach and duodenum, can be closed to prevent feed from moving into or out of the stomach.
- Feed goes from the duodenum to portions of the small intestines known as jejunum and the ileum.
- From small intestines feed passes into large intestine, or colon.
- The ileocecal valve, located at the junction of the small intestine and the colon, prevents material in the large intestine from moving back into small intestine.
- The small intestine actually empties into the side of the colon, the anterior end of the colon.
- The blind anterior end of the colon is the cecum, or, in some animal, veriform appendix.
- The large intestine empties into the rectum

**Non-ruminant (Simple stomach with enlarged caecum/hind gut fermentor)**

**Digestive System**
Characterized by non-ruminant animals that consume and digest feeds high in fiber

---

### Digestive Process – Hind Gut Fermentors

1. **Mouth**
   - intact top and bottom incisors
   - molars adapted to chewing fibrous feeds
   - no digestive enzymes in saliva

2. **Esophagus**
   - not well adapted for regurgitation
   - connects mouth and stomach

3. **Stomach**
4. **Small Intestine**
   - similar to monogastric and ruminant systems
   - no gall bladder to store bile
   - enlarged cecum to aid in fiber breakdown

5. **Large Intestine**
   - similar to monogastric systems
   - cecum (at junction of small and large intestines) and colon take up most of the volume of the equine digestive system

**Poultry digestive system**

- Since chickens have no teeth, they swallow food whole and it’s stored in the crop.
- Feed in proventriculus are secreted by the glandular stomach and mixed with feed
- The feed moves to the ventriculus (gizzard) and is ground
- Epithelium breaks the feed into smaller particles, further mixing proventricular digestive juices with the feed in the gizzard
- The end of the digestive system is the vent

1. **Mouth**
   - no teeth which leads to the saying “scarce as a hen’s teeth!!!”
   - Salivation excretion moistens food
2. **Esophagus**
   - has a modification called the “crop” which stores and moistens food
   - connects mouth and stomach

3. **Stomach**
   - Contains two parts
   - Proventriculus: same as monogastric stomach and provides digestive excretions
   - Gizzard: located after proventriculus, very muscular, used to grind food

4. **Small Intestine**
   - similar functions as in ruminants and monogastric systems
   - long coiled tube connecting the ventriculus to large intestine
   - rest of the digestion and absorption takes place here
   - surface covered with villi (surface area)

5. **Large Intestine**
   - similar functions as in ruminants and monogastric systems
   - “cloaca”: chamber into which urinary and genital canals open
   - “ceca”: aids in fiber digestion and absorption.
   - caecum, colon, rectum
   - absorbs water (makes feces more solid)
   - some vitamins & minerals absorbed here
   - Cecal Fermenters (Horse): similar to rumen

**Conclusion**

Different species of animals have different digestive systems which are adapted to their unique requirements. The type of food, method of food gathering and energy needs are some factors that influence the type of digestive system an animal needs in order to survive.
Activity

1. What is the role of digestion?
2. How are animals classified?
3. What are the three classes of animals according to the types of feed they normally eat?
4. What are the basic parts of digestive tract?
5. The large intestine absorbs water and forms indigestible wastes into a solid called __________?
6. What are the three regions of the small intestine?
7. The stomach of ruminants such as cattle, sheep and goats has four compartments: True/False.
8. What is the functions of the rumen?
9. What structure of the colon, in some species like horses, performs the function of microbial fermentation of feed?
10. What feed component is most effectively digested by fermentation in the rumen and cecum?
11. What is the significance of fermentative digestion of cellulose by microorganisms in
12. Why are ruminants more efficient at utilizing roughages than are animals such as horses, that possess a large active cecum?
13. What are three regions of large intestine?
14. What is the glandular stomach in birds called?
15. What is the crop in birds?
16. Mechanical digestion in birds occur in the mouth, just as it does in mammals. True/False.
17. Ruminants regurgitate undigested roughage, which is referred to as _____, or chewing the _____.
18. What are four stomach compartments in ruminants?
19. _____ are organic catalysts that speed up a chemical reaction without being altered by the reaction and are important in digestion of specific nutrients.
20. What is the function of esophageal groove?
21. What are the products of fermentative digestion in the rumen that ruminant animals utilize as energy?
UNIT 2b
ANIMAL REPRODUCTION SYSTEM

Introduction

This module is designed to provide information of reproduction system in livestock. Reproductive efficiency in farm animals, as measured by the number of calves or lambs per 100 breeding females or number of pigs per litter, is a trait of great economic importance in farm animal production. Reproduction is important together with growth and carcass traits. It is important to understand the reproductive process in the creation of new animals in understanding animal productivity. Reproductivity include: production of sex cells, estrous cycles, mating, pregnancy, and birth.

Learning outcomes

At the end of this unit, students able to:

1. Gain a greater understanding of animal reproductive system
2. Describe the female and male reproductive organs and their functions
3. Understand the sexual maturity and estrus cycles in farm animals,
4. Understand the process of pregnancy, parturition
5. Gain knowledge in assisted reproductive technology such as artificial insemination and embryo transfer
Main points

1. Anatomy of female reproductive system
2. Function of female reproductive organs
3. Estrus cycle
4. Heat detection
5. Male reproductive system
6. Function of reproductive organs
7. Assisted reproductive technology

Female reproductive system

- The female reproductive organs of the female farm mammals (cow and sow) is similar, although there are a few obvious differences.
- The female reproductive organs include:
  a. A pair of ovaries, which are suspended by ligaments just back of kidneys,
  b. A pair of open-ended tubes, the oviducts (also called fallopian tubes),
  c. Uterus (womb), connected to the oviducts. The uterus has two horns or branches.
  d. The uterine body is protected by the cervix, which serves as a pathway to and from the uterus. Its surface is fairly smooth in mare and the sow, but is folded in the cow and ewe.
  e. The cervix opens into the vagina, a relatively large canal or passageway that leads posteriorly to the external parts – the vulva and clitoris.
  f. The urinary bladder empties into the vagina through the urethral opening
FEMALE REPRODUCTIVE ORGANS

Vulva
- exterior portion of reproductive tract
- provides visual signs of heat

Vagina
- between vulva & cervix
- Cows & Ewes: semen is deposited here
- Mares & Sows: semen is deposited in the cervix
- The vagina serves as the female organ of copulation at mating and as the birth canal at parturition.
- Its mucosal surface changes during the estrus cycle from very moist when the animal is ready for mating to almost dry, even sticky, between periods of heat.
- The track from urinary bladder joins the posterior ventral vagina; from this juncture to the exterior vulva, the vagina serves a dual role of a passageway for the reproductive and urinary systems.
FIGURE 10.1 Reproductive organs of the cow. Drawing by Dennis Giddings.

Table 1: Summary of the primary functions of the organs of the female reproductive tract

<table>
<thead>
<tr>
<th>Organ</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oviduct</td>
<td>Transport of Ova and Sperm</td>
</tr>
<tr>
<td></td>
<td>Site of fertilization and early cleavage</td>
</tr>
<tr>
<td>Ovary</td>
<td>Production of Oocytes</td>
</tr>
<tr>
<td></td>
<td>Production of estrogen (Graafian follicle)</td>
</tr>
<tr>
<td></td>
<td>Production of progesterone (corpus luteum)</td>
</tr>
<tr>
<td>Uterus</td>
<td>Assisting in sperm transport</td>
</tr>
<tr>
<td></td>
<td>Regulation of the corpus luteum</td>
</tr>
<tr>
<td></td>
<td>Site of implantation and pregnancy</td>
</tr>
<tr>
<td></td>
<td>Expulsion of fetus and fetal membranes</td>
</tr>
<tr>
<td>Cervix</td>
<td>Facilitating sperm transport (sow and mare)</td>
</tr>
<tr>
<td></td>
<td>Prevention of uterine contamination</td>
</tr>
<tr>
<td>Vagina</td>
<td>Copulatory organ</td>
</tr>
<tr>
<td></td>
<td>Birth canal</td>
</tr>
</tbody>
</table>
Cervix

- "Mouth of the womb"
- opening into uterus
- at birth cervix stretches to allow baby to pass (most painful part)
- during pregnancy cervix becomes blocked with a mucous plug to prevent infection
- Sperm are transported through the uterus into the oviduct after the female is inseminated.
- The oviducts are the sites where ova and sperm meet and fertilization takes place.
- After fertilization, 3-5 days are required in cows and ewes, for the ova to travel down the remaining two thirds of the oviduct.
- From the oviduct, the newly developing embryos pass to the uterus and soon attach to it.
Uterus

- The uterus varies in shape from the type that has long, slender left and right horns, as in sow, to the type that is primarily a fused body with short horns, as in mare.
- In the sow, the embryos develop in the uterine horn; in the mare, the embryo develops in the body of the uterus.
- Each surviving embryo develops into fetus and remains in the uterus until parturition (birth).
- The lower outlet of the uterus is the cervix, an organ composed primarily of connective tissue that constitute a formidable gateway between the uterus and the vagina.
- The cervix is lined with mucosal cells.
- The cervical passage changes from being tightly closed or sealed in pregnancy to a relatively open, very moist canal at the height of estrus.

Uterine Horns
- two branches of uterus

Fallopian Tube
- uterine horn becomes a small tube
- lined with cilia which aid in egg migration

**Oviducts**

- Immediately after ovulation, the ova are caught by the fingerlike projection of the infundibulum, which guide the ova into the tubular portion of the oviduct.

**Ovaries**

- Ovaries produce ova (female sex cells, also called eggs) and the female sex hormones estrogen and progesterone.
- The ova are the largest single cells in the body. Each ova develops inside a recently formed follicle within the ovary.
- The growing follicles produce estrogens.
- The mature follicles (Graafian follicle) ruptures and free the ovum – ovulation.
- Follicular development occurs as a multistage process eventually resulting in ovulation.
- Follicles can be classified as primordial (least mature), primary, secondary, tertiary and Graafian (most mature).
- Follicles changes in size and complexity, follicles vary in their hormonal responsiveness as they mature.
- After the ovum escapes from the mature follicle, the cells of the follicle change into a corpus luteum, or yellow body.
- The corpus luteum produces progesterone, which becomes a vitally important hormone for maintaining pregnancy.

- located at end of fallopian tubes
- possesses large number of eggs in all stages of development
- this is all the eggs she will ever have, unlike the male
- very few eggs reach maturity
- if not fertilized, the egg is reabsorbed by the body
Clitoris

- A highly sensitive organ, the clitoris is situated ventrally and at the lower tip of the vagina.
- The clitoris is homologue to the penis.

Reproduction in Females

- Farm animals reach sexual maturity at 4 months (sow) to 24 months (mare), then
  - Female comes in heat (estrus)
- Egg released by ovary
- Egg travels down tube until fertilized by sperm
- Estrogen - female hormone which regulates estrus

Sexual Maturity of Farm Animal*
  - The estrous Cycle
The estrous cycle is the sequence of hormonal changes that occurs through the ovarian cycle. These changes influence the behaviour and body changes of the female. The first hormone involved in the estrous cycle is follicle stimulating hormone (F.S.H.), secreted by the anterior pituitary gland. It stimulates the follicle to develop.

**Sexual Maturity of Farm Animal**

<table>
<thead>
<tr>
<th>Animal</th>
<th>Maturity Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>6 - 10 months</td>
</tr>
<tr>
<td>Sheep</td>
<td>7 - 8 months</td>
</tr>
<tr>
<td>Goat</td>
<td>7 - 9 months</td>
</tr>
<tr>
<td>Horse</td>
<td>1 - 2 years</td>
</tr>
<tr>
<td>Pig</td>
<td>4 - 5 months</td>
</tr>
<tr>
<td>Dog</td>
<td>6 - 9 months</td>
</tr>
<tr>
<td>Deer</td>
<td>14 - 18 months</td>
</tr>
<tr>
<td>Rabbit</td>
<td>5 months</td>
</tr>
<tr>
<td>Poultry</td>
<td>5 months</td>
</tr>
</tbody>
</table>

*Values for temperate animals

**What does “in heat” mean?**
- Heat is the time when a female is receptive to the male and will allow breeding to take place
- Heat is actually divided into 4 phases of the cycle.

**Estrous Cycle:**
- **Proestrus:** ovary is about to release an egg
- **Estrus:** female receptivity
- **Metestrus:** uterus prepares for pregnancy
- fertilized egg attaches to uterus
- **Diestrus:** longest period of cycle inactive
• Estrous Cycles stop after conception, and begin soon after Parturition (birth)

Heat Detection
• Producers miss 25-50% of heat periods
• Delays calving by 30-40 days
• Loss of income

Heat Detection Method
• Chin-Ball Marker: marker attached to bottom of a halter of a surgically altered teaser bull (Gomer)
• Heat-Mount Detector: fabric with ink-filled capsule, pressure breaks capsule
• Pen-O-Block: plastic tube placed within bull’s sheath, held by stainless steel pin
• Allows bull to mount cow, mechanically impossible to breed
• Vasectomized Bull: can transmit disease
• Gromer bull with Chin-Ball Marker-The penis has been altered
• Gromer bull attempting to mount female in estrus. He cannot successfully mate with the female.
• Heat-Mount Detector
• Sign of Standing Heat - Mounting other Animals or Stands to be Mounted
• Signs of “Standing Heat”
• Congregating - Cattle that are in standing estrus naturally seek out other animals in estrus and form a small group, referred to as the sexually active group.
• Mounting other animals
• Stands to be mounted - is actually in standing estrus. The cow that is doing the riding may or may not be in standing estrus.
• Clear mucus from vagina
• Nervousness or restlessness
• Roughed up tailhead
• Normal Range of Reproductive Behavior
Manipulating Estrous

1. Artificial Lighting:
   - ewes, mares, fowl
   - Lengthen days, then shorten to simulate natural breeding season

2. Hormones:
   - Progestagens: mimics pregnancy, feed, inject, implant, for 14-20 days, when removed, cows cycle 2-8 days later
   - Prostaglandins: single dose injection, 90 hours later = estrous

Estrus or Heat

- Is the period of time when the female will accept the male for breeding purposes.
- The female will exhibit some behavioral patterns that demonstrate she is on heat.
- Examples: a mare in estrus, when teased with a stallion will not avoid and kick him. The mare on heat will stand solidly, sometime squatting and urinating.
- Ovulation occurs in the cow after estrus.
- It occurs in the sow, ewe, goat, and mare toward the latter part of estrus.
- These species will ovulate spontaneously, ovulation takes place.
- Copulation is necessary to trigger ovulation (in rabbits, cats, ferret, mink) – referred to induced ovulation.
- Ovulation is controlled by hormones.
- The follicle of the ovary grows, matures, fills with fluid, and softens a few hours before rupturing.
- The follicle ruptures owing to a sudden release of LH (Luteinising hormones)

PREGNANCY

- When the sperm and the egg unite (fertilization), conception occurs, which is the beginning of the gestation period.
- The fertilized eggs begin as a series of cell division.
• About every 20 hours, embryonic cells duplicate their genes and divide, progressing through the 2-, 4-, 8- and 16 cell stages and so on.
• The embryo migrates through the oviduct to the uterus in 3-4 days, by which time it has developed to 16- or 32-cell stage.
• The embryo attaches to the uterus.
• The embryo obtains nutrients and discharges wastes through these membranes (chorionic and amniotic membrane).
• The embryonic stage is defined as that period when the body parts differentiate and essential organs are formed (45 days in cattle).
• When embryonic stage is complete, the young organism is called fetus, which lasts until birth.
• Length of pregnancy varies with breed and age of mother.

PARTURITION

• Parturition (birth) marks the termination of pregnancy.
• Fetus attaches to the uterus through the placenta, for the transfer of nutrients and wastes between the mother and fetus.
• Placenta produces hormones, especially estrogens and progesterone.
• Parturition process is initiated by release of hormone cortisol from the fetal adrenal cortex.
• Progesterone level decline, whereas estrogen, prostaglandinF2a, and oxytocin levels rise, resulting in uterine contractions.
• Parturition is a synchronized process. The cervix, until now tightly closed, relaxes.
• Relaxation of the cervix, along with pressure generated by uterine muscles on the contents of uterus, permits the passage of the fetus into the vagina and on to the exterior.
• Another hormone, relaxin aid in parturition.
• Relaxin originates in the corpus luteum or placenta. Helps to relax cartilage and ligaments in the pelvic region.
Gestation Length and Number of Offspring Born

<table>
<thead>
<tr>
<th>Animal</th>
<th>Number of Offspring Born</th>
<th>Gestation Length (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow (cattle)</td>
<td>1</td>
<td>285</td>
</tr>
<tr>
<td>Ewe (sheep)</td>
<td>1 – 3</td>
<td>147</td>
</tr>
<tr>
<td>Mare (horse)</td>
<td>1</td>
<td>336</td>
</tr>
<tr>
<td>Sow (swine)</td>
<td>6 – 14</td>
<td>114</td>
</tr>
<tr>
<td>Doe (goat)</td>
<td>2 – 3</td>
<td>150</td>
</tr>
<tr>
<td>Doe (rabbit)</td>
<td>4 – 8</td>
<td>31</td>
</tr>
<tr>
<td>Bitch (dog)</td>
<td>7</td>
<td>65</td>
</tr>
</tbody>
</table>

- At the beginning of parturition, the offspring assumes a position that will offer the least resistant as it passes into the pelvic area and through the birth canal.
- Fetuses of cow, mare, and ewe assume similar positions in which the front feet are extended with the head between them.
MALE REPRODUCTIVE ORGANS AND THEIR FUNCTIONS

- Figure 10.8 and 10.9 show the reproductive organs of the bull and boar.
- The organ of reproduction of a typical male farm mammal include:
  - Two testicles which are held in the scrotum.
  - Male sex cells (spermatozoa or sperm) are formed in the seminiferous tubule of the testicles.
  - The sperm from each testicle then passes through a ductal system into the epididymis, which is a highly coiled tube that is held in covering on the exterior of the testicle.
  - The epididymis functions to concentrate, store, transport and facilitate maturation of sperm cells.
  - The epididymis empties into a larger tube, the vas deferens (also called ductus deferens)
  - The two vasa deferentia converge at the upper end of the urethral canal, where the urinary bladder opens into the urethra
  - The wall of the upper end of vas deferens is thickened and forms a secretory gland called ampulla
  - The urethra is a large canal that leads through the penis to outside the body.
  - The penis has triple role:
    - Passage for semen
    - Passage for urine
    - Male organ of copulation.
- There are other accessory glands of the male namely:
  - Seminal vesicle – glandular tissue that secretes into urethra a substance that supplies nutrients for the sperm
  - The prostate gland - contains 12 or more tubes, each of which empties into the urethra
  - The bulbourethral (Cowper’s) gland, which empties its secretion into the urethral canal.
Testicles

- The testicles produce:
  - sperm cells that fertilize the female ova
  - a hormone, testosterone that condition the male so that his appearance and behavior are masculine.
- If both testicles are removed (as in castration), the individual loses his sperm production capability and is sterile, no testosterone – male appearance is not apparent.

Bull Reproductive Tract
The epididymis

- Is the storage site for sperm cells, which enter it from testicle to mature.
- Very long tube (95-115 ft in the bull, longer in boar and stallion)

The scrotum

- Is a two-lobed sac that contains and protects the two testicles.
- It also regulates the temperature of the testicles, maintaining them at a temperature lower than body temperature (3-7°F lower in bull, 9-13°F in ram and goat)
- When the environmental temperature is low, the tunica dartos muscle of the scrotum contract, pulling the testicles toward the body and its warmth;
- When the environmental temperature is high, this muscle relaxes, permitting the testicles to drop away from the body and its warmth.
- The cremaster muscle which is aligned with the spermatic cord functions in a similar manner to the tunica dartos as an aid to temperature control.
- Further more, the pampiniform plexus acts as a heat exchanger to cool blood as it enters the testes.
The vas deferens

- Vas deferens is essentially a transportation tube that carries the sperm-containing fluid from each epididymis to urethra.
- During mating, the secretion loaded with spermatozoa from each epididymis is propelled into each vas deferens and accumulates in the ampulla until ejaculation, into the urethra and then penis.

The Urethra

- Is a large muscular canal extending from urinary bladder through the full length of the penis.

Accessory Sex Glands

- The ampullae, seminal vesicles, prostate, and bulbourethral glands are known as accessory glands. Their primary functions are to add volume and nutrition to the sperm-rich fluids coming from the epididymis.
- Semen consists of two components: the sperm and the fluids secreted by the accessory sex glands.

The Penis

- The penis is the organ of copulation.
- It provides a passageway for semen and urine.
- It is spongy, erectile tissue that fills with blood under considerable pressure during periods of sexual arousal, making the penis rigid and erect.
- In bull, boar and ram, the penis is S-shaped when relaxed.
- This S curve, or sigmoid flexure, becomes straight when the penis is erect. The sigmoid flexure is restored after copulation, when relaxing penis is drawn back into its sheath by a pair of retractor penis muscles.
- The stallion penis has no sigmoid flexure; it is enlarged by engorgement of blood in the erectile tissues.
- All the accessory male sex organs depend on testosterone for their tone and normal function.
Reproductive Organs of the Bull

- Rectum
- Seminal Vesicles
- Ampulla
- Bladder
- Vas Deferens
- Prostate
- Cowpers Gland
- Sigmoid Flexure
- Retractor Penis Muscle
- Caput Epididymis
- Cauda Epididymis
- Scrotum
- Testis
- Gubernaculum
- Corpus Cavernosum
- Dorsal Artery
- Dorsal Vein
- Corpus Spongiosum
- Large Veins
- Retractor Penis Muscle
- Urethra

Cross Section of Bull Penis
Accessory Sex Glands

- prostate
- two seminal vesicles
- two cowpers glands
Functions of the Accessory Sex Glands

- provide medium for transporting sperm
- adds volume
- provides nutrients
- cleans & flushes urinary tract

Assisted Reproductive Technology

1. ARTIFICIAL INSEMINATION

- Artificial insemination (AI) is when semen is deposited in the female reproductive tract by artificial techniques rather than by natural mating.
- AI are available for use in horses, cattle, sheep, goats, swine, poultry, and laboratory animals.
- The primary advantage of AI:
  - It permits extensive use of outstanding sires to maximize genetic improvement.
  - (a bull may sire 30-50 calves naturally per year, but using AI a bull can produce 200-400 units of semen per ejaculate)
• AI also can be used to control reproductive diseases, and sires can be used that have been injured or are dangerous when used naturally.
• The success of an AI program is dependant on superior heat detection, high level of fertility, high quality of semen, and skilled semen handling and insemination technique.

Advantages of AI
• Increases use of outstanding sires (cost)
• Alleviates danger and bother of keeping a sire
• Can overcome physical handicaps of mating: large bulls on heifers
• Sire that is no longer alive
• Reduce sire costs
• Reduces possibility of sterile sires
• Helps control disease
• Possible to prove more sires (can determine genetic worth easier)
• Creates large families of superior animals
• Increase pride in ownership of superiors
• Increase profits

Limitations of AI
• Physiological Principles: timing of heat
• Requires skilled technicians
• Costly to start
• May restrict sire market (avg or poor bulls)
• Abuse: mislabeled semen

SEmen Collecting and Processing
• There are several different method of collecting semen.
• The most common method is the artificial vagina method
• The artificial vagina is commonly used to collect semen from bulls, stallions, rams, buck goats and rabbits.
• The semen is collected by having the male mount an estrous female or training him to mount another animal or object.
• When the male mounts, his penis is directed into the artificial vagina by the person collecting the semen, and the semen accumulates in the collection tube.
• Semen from the boar and dog is not typically collected with artificial vagina, but rather by applying pressure with gloved hand, after grasping the extended penis, as the animal mounts another animal or object.
• Semen can also be collected by using electroejaculator, in which a probe is inserted into the rectum and an electrical stimulation causes ejaculation.
• This is commonly used in bulls and rams that are not easily trained to use artificial vagina.
• After the semen is collected, it is evaluated for volume, sperm concentration, motility of sperm and sperm abnormalities.
• The semen is usually mix with an extender that dilutes the ejaculate to a greater volume.
• The extender is usually composed of nutrients such as milk and egg yolk, a citrate buffer, antibiotics, and glycerol.
• Each unit of semen for insemination in cattle should contain 10 million motile, normal spermatozoa.
• Most semen is stored frozen in liquid nitrogen (-96°C) and stored in plastic straws.

INSEMINATION OF THE FEMALE

• Prior to insemination, the frozen semen is thawed.
• Thawed semen cannot be refrozen and used again because refreezing will kill the sperm cells.
• High conception rates using AI depend on the female’s cycling and ovulating; detecting estrus; using semen that has been properly collected, extended, and frozen; thawing and handling the semen satisfactorily at the time of insemination.
DETECTING ESTRUS

- Estrus must be detected accurately because it signals time of ovulation and determines proper timing of insemination.
- The best indication of estrus is the condition called **standing heat**, in which the female stands still when mounted by a male or another female.
- Cows are usually checked for estrus twice daily, in the morning and evening.
- They are observed for 30 minutes to detect standing heat.

OBSERVABLE SIGNS OF ESTRUS

- Restlessness,
- Attempting to mount other cows,
- Clear mucous discharge from the vagina
- Vulva is usually red and swollen
- Elevation of tail
- Contractions of the vulva
- Spreading of legs
- Frequent urination

PROPER TIMING OF INSEMINATION

- The duration of estrus and ovulation time are quite different in farm animals.
- The sperm are short-lived when put into female reproductive tract
- Insemination time should be as close to ovulation time as possible; otherwise sperm will stay in the female reproductive tract too long and loose their fertilizing capacity.
- (cows found in estrus in the morning are usually inseminated in the evening.)
- Insemination time should be as close to ovulation time as possible
- Insemination toward the end of estrus or after estrus has been expressed in the cow.
- Insemination technique in cattle involves the inseminator having one arm in the cow’s rectum to manipulate the insemination tube through the cervix.
- The insemination tube is passed just through the cervix, and the semen is deposited into the body of the uterus.
REPRODUCTION IN POULTRY

- The testes of male poultry are contained in the body cavity.
- Each vas deferens opens into small papillae, which are located in the cloacal wall.
- The male fowl has no penis but does have rudimentary organ of copulation.
- Fertilization occurs in the infundibulum.
- Sperm stored in the oviduct are capable of fertilizing the eggs for 30 days in turkeys, and 10 days in chickens.

- The hen differs from farm mammals in that the young are not suckled, the eggs are laid outside the body, and there are no defined estrous cycle or pregnancy.
- The anatomy of the female reproductive tract is shown in Figure 2.
- At hatching time, the female chick has two ovaries and two oviducts.
• The right ovary and oviduct do not develop.
• Therefore, the sexually mature hen has a well-developed ovary and oviduct only on the left side.
• The ovary appears as a cluster of tiny gray eggs or yolks in front of the left kidney and attached to the back of the hen.
• The oviduct is a long, glandular tube leading from ovary to the cloaca.

The oviduct is divided into five parts:

1) infundibulum -(3-4 in long), which receives the yolk
2) magnum -(15 in long), which secretes the thick albumen, or white of the egg
3) isthmus -(4 in long), which add the shell membranes
4) uterus -(4 in long), or shell glands, which secrete the thin white albumin, the shell, and shell pigments
5) vagina -(2 in long)

• Ovulation is the release of a mature yolk (ovum) from the ovary.
• When ovulation occurs, the infundibulum engulfs the yolk and starts it on its way through the 25-27 in. oviduct.
• The yolk moves by peristaltic action through the infundibulum into the magnum area in about 15 minutes.

• During the 3-hour passage through the magnum, more than 50% of the albumen is added to the yolk.
• The developing passes through the isthmus in about 11/4 hours. Here water and mineral salts.

• The egg stays for 21 hours in the uterus, the remainder of the albumen is added, followed by the addition of shell and shell pigment.
• The egg finally move into the vagina and enters the cloaca and is laid.
• The entire time from ovulation to laying is usually slightly more than 24 hours.
• After 30 minute of laying, the hen releases another yolk into the infundibulum, and it will likewise travel the length of the oviduct.

• After the fertilized eggs is incubated for 21 days, the chick is hatched.
• The eggs are biologically structured to support the growth and life processes of the developing chick embryo during incubation and for 3-4 days after the chick is hatched.

• There are several egg abnormalities that occur because factors affecting ovulation and the development process
• Double yolked eggs result when two yolks are released about the same time or when one yolk is lost in the body cavity for a day and is picked up by the funnel when the next day’s yolk is released
• Soft-shelled eggs generally occur when egg is laid prematurely and insufficient time in the uterus prevents the deposit of the shell.
• Thin-shelled eggs may be caused by dietary deficiencies, heredity, or disease.
• Glassy or chalky-shelled eggs are caused by malfunctions of the uterus of the laying bird.
Conclusions

1. Reproductive efficiency, as measured by a number of offspring born in a herd or flock of breeding females, is a trait of high economic importance.
2. A knowledge of anatomy and physiology of the male and female reproductive organs is essential in understanding the production of ova and sperm, estrous cycles, mating, pregnancy and parturition.
3. Follicle stimulating hormone, luteinizing hormone, estrogen, progesterone, and testosterone are important hormones in reproductive process.
4. Reproduction in poultry is unique in that ova (eggs) are incubated outside the body, and is produced from only one ovary, and there are no well-defined estrus cycles or pregnancy.

Exercise 1 / Activity 1

1.
2.
3.

Discussion 1

1.
2.
3.
Answers to Exercise 1

1.
2.
3.
4.

Answers to Discussion 1

1.
2.
3.
UNIT 3
Animal Nutrition and agricultural by-products

Introduction
This module is designed to introduce students the basic principles of animal nutrition and the importance of balance ratio for optimum growth and development of livestock. Classes of nutrients and feed classification are also discussed in this module. In this unit, students will learn about the various types of agricultural by-products materials available locally and their use as livestock.

Unit Objectives

1. Recognize the nutritional needs of animals relative to their use in the agriculture industry
2. Student able to differentiate different categories of feed materials
3. Students are able to identify agricultural by-products that can be used as livestock feed

Main points

1. Background
2. Classification of nutrients: Water and dry matter
3. Feed classification: Concentrates, Roughages, Supplements
4. Agricultural by-products as livestock feed: Advantages and disadvantages of using agriculture byproducts as animal feed, example
of agriculture by-products, factors that may affect the use of agriculture by-products in livestock industry

Background

Food is any material which after ingestion by animals is capable of being digested, absorbed and utilized for physiological processes. Food can be described as an edible material that nourishes.

However, not all components of ingested materials are digested. For example, grasses and hay are described as food but they contain indigestible components. The components of food which are capable of being utilized by animals are described as Nutrients

Nutrients consist of water and dry matter. Although water is very important, the dry matter (DM) is crucial to the composition of a ration. More nutrients are needed when it contains more water. The needs will differ for each species and breeds within species, with season, age, work or performance level, lactation, pregnancy.

Classification of nutrients

The main components of a nutrient are:

- **Water**
- **Organic**
  - Carbohydrate
  - Protein
  - Lipids
  - Vitamins
- **Inorganic**
  - Major minerals
  - Minor (trace minerals)
1. WATER

Water is a major item in most animal’s diet. The water content of animal body varies with age. New born contains 750 – 800g/kg of water, but this reduces to about 500g/kg in mature fat animal. Water is vital to life and its contents should be maintained.

Function of water in livestock

1. Act as solvent in which nutrients are transported throughout the body
2. Solvent in which waste products are excreted
3. Helps in chemical reaction in the body such as enzymatic reaction which takes place in solution and involves hydrolysis
4. Water helps in regulation of body temperature due to high conductive property of water to distribute heat within the body and by vapourization of excess water released by metabolic reaction within the cells
5. Lubricates and cushions joints and organs

Livestock obtain water from three main source:

1. Drinking water
2. Water present in food
   - Highly variable in feedstuffs
   - Grains = 9-30% water
   - Forages
     - Hay <5%
     - Silage 65-75%
     - Lush young grass >90%
3. Metabolic water which is formed during metabolism by the oxidation of hydrogen containing organic nutrients
   - 1 g of carbohydrates = .6 g of water
   - 1 g of protein = .4 g of water
   - 1 g of fat = 1 g of water
   - May account for 5-10% of total water intake
Water requirement in livestock

Livestock are more sensitive to lack of water than food. The first noticeable effect of moderate restriction of water is a reduced intake in feed. Severe restriction of water intake will result in rapid weight loss and the body dehydrates. Water consumption is related to heat production.

Other factors affecting water intake include:

- **Dietary Factor**: Dry matter intake is highly correlated with water intake at moderate temperature. High level of protein intake or fats may also increase water intake. Consumption of common salt or other salts increases consumption and excretion of water greatly.
- **Environmental Factor**: heat stress i.e the higher the heat the higher the water intake and vice versa

Example of average water requirement in livestock

<table>
<thead>
<tr>
<th>Animal</th>
<th>Water, liters</th>
<th>Animal</th>
<th>Water, liters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef cow, lactating</td>
<td>60</td>
<td>Swine, growing</td>
<td>6</td>
</tr>
<tr>
<td>Dairy cow, lactating</td>
<td>90</td>
<td>30 kg</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60-100 kg</td>
<td>8</td>
</tr>
<tr>
<td>Cow, Maintenance</td>
<td>60</td>
<td>Lactating sow</td>
<td>14</td>
</tr>
<tr>
<td>Poultry, hen</td>
<td>0.5</td>
<td>25 kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheep</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lactating ewe</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fattening lamb</td>
<td></td>
</tr>
</tbody>
</table>

Note: There is no evidence that, under normal conditions, an excess of drinking water is harmful. If water is offered ad lib, livestock normally drink what they require. It is important to note that a lack of water in the diet results in a reduced appetite: a cow will eat less thus might affect DM intake which can have many consequences.
Water losses

Water is lost by evaporation via the skin, periodic excretion in urine and faeces. Water excreted in urine act as a solvent for excretory product excreted via the kidneys. Urine concentration is related to the type of compound excreted (uric acid, urea and minerals,) for example, poultry excrete uric acid rather than urea as an end product of protein metabolism. Poultry excrete urine in semi-solid form with only small amount of water.

2. Energy

The most important item in livestock’s diet and overall feeding standards is based on energy needs. Meeting the energy requirements of a livestock can be a major cost in feeding. Livestock derive energy from partial or complete oxidation of carbohydrates, fats, and proteins ingested and absorbed from the diet or from breakdown of glycogen, fat, or protein absorbed in the body. Livestock require some energy even in a nonproductive state for sustaining the body and maintaining body temperature and muscular activity. Additional energy is required when performing work and for growth and fattening, pregnancy, and lactation.

Energy can be classified into four categories:

- Gross energy (GE)
- Digestible Energy (DE)
- Metabolizable Energy (ME)
- Net Energy, (NE)
**Gross energy** (GE) is the amount of heat resulting from the complete oxidation of a food. GE values from feedstuffs are used in the process of evaluating energy utilization. Energy values and nutrients (carbohydrates, proteins, and fats) values vary in feedstuffs.

```
Gross Energy (GE)
  \[\text{Digestible energy (DE)}\]
  \[\text{Fecal energy}\
    \text{a. Undigested feed residues}\
    \text{b. Metabolic products}\
    \text{• Mucosa}\
    \text{• Bacteria}\
    \text{• Enzymes}\]
```

**Digestible energy** (DE) of a feedstuff is the consumed portion minus the fecal energy. Analyzing the fecal and feed energy allows for the calculation of DE. The energy lost in feces accounts for the single greatest loss of nutrients. Depending on species of animal and diet, fecal losses can be from 10 percent in milk fed animals to 60 percent for animals on poor quality diets.

```
Digestible Energy (DE)
  \[\text{Metabolizable energy (ME)}\]
  \[\text{Urinary energy}\
    \text{a. N disposal}\
    \text{Gaseous energy}\
    \text{a. Gaseous products of fermentation (methane CH₄)}\
    \text{b. Lost via belching or bowels}\]
```
Metabolizable energy (ME) is the gross energy of feed minus the energy in urine, feces, and gaseous products of digestion. The values of ME account for additional losses in the digestion and metabolism of ingested feed. ME is used to establish feeding standards because feces and urine are excreted together. Methane generally accounts for the most combustible gas in ruminant animals. In the fermentation process as much as 8 to 10 percent of the energy consumed is converted to methane. Diets low in quality result in larger proportions of methane, and the amount of GE lost as methane decreases as feed intake increases.

Net energy (NE) is equal to metabolizable energy minus the heat increment and the heat of fermentation. NE of a feed is the portion that is available to the animal for maintenance or other productive services. It accounts for most of the losses in metabolism of a feed or by the livestock.

Energy contents of nutrients can be subdivided into:

1. Carbohydrate
2. Lipid
3. Protein

- Carbohydrates and lipids (fats and oils) are the major sources of energy in livestock rations.
- Carbohydrates are the most important because they are readily available, easily digested & lower in cost.
- Proteins are seldom fed for their energy content because of the higher cost of this source.

General Effect of energy deficiency

- Slow growth of young.
- A delay in the onset of puberty.
- A decrease in milk yield in lactating females.
- A shortened lactation period.
- A loss in body weight.
- Several kinds of reproductive problems including reduced fertility and delayed estrus.
  - In sheep, a reduction in wool quantity and quality.
  - A higher mortality rate.
  - A lowered resistance to disease.
  - Weakness, generally poor condition, and unthrifty appearance.
  - Hypoglycemia.
  - A loss of subcutaneous fat.
  - A reduction in levels of blood glucose, calcium, and sodium.

CARBOHYDRATE

Carbohydrates are energy-providing feed components composed of carbon, hydrogen, and oxygen. Carbohydrates should make up about 75% of an animal’s diet. The energy they provide powers muscular movements. Carbohydrates also produce the body heat that helps keep the animal warm. Carbohydrates are not stored in the body thus must be provided in the livestock’s diet every day. Unused carbohydrates are converted into fats to be stored. Carbohydrates may be either
simple or complex. Simple carbohydrates are easily digested. Sugars and starch are simple carbohydrates. Simple carbohydrates are found in concentrates, such as corn, wheat, oats, barley, and sorghum. Complex carbohydrates are more difficult to digest than simple carbohydrates. Cellulose and lignin are complex carbohydrates. These substances are found mainly in roughages, such as hay and pasture plants.

**Carbohydrate digestion**

- Dietary CHO must be converted to be absorbed
  - Simple sugars (monosaccharides)
- How?
  - Action of amylase enzyme
    - Salivary amylase (swine, poultry)
    - Intestinal amylase
  - Action of other diaccharidases
    - Produced by mucosal lining of duodenum
- Ruminants do not produce enzymes necessary to digest oligosaccharides and celluloses (fibrous feedstuffs)
  - Digestion occurs as result of bacterial fermentation
    - Where?
      - Rumen
      - Large Intestine (cecum and colon)
    - Once simple sugars are formed, they are absorbed rapidly by small intestine
    - Then monosaccharides diffuse into the portal vein which transports them to sites of metabolism
- Fermentation yields:
  - CO₂
  - H₂O
  - Heat (heat increment)
  - Volatile Fatty Acids (VFA) or also referred to as Short Chain Fatty Acids (SCFA), e.g.: acetic acid, propanoic acid, butyric acid
Volatile Fatty Acid (VFA)

- Serve as 70 - 80% of energy requirement in ruminants
  - VFA’s produced in rumen
    - Serve as ~16% of maintenance energy requirement in swine
  - VFA’s produced in large intestine
  - Absorbed through the rumen wall or large intestine mucosa
  - Provide energy source to the animal

LIPIDS

- A lipid is a food component that provides energy and is also the form in which livestock store energy.
- Fats are solid and oils are liquid at room temperature.
- Fats contain the highest amounts of energy.
- In fact, fats contain 2.25 times more energy than carbohydrates.
- Fats play an important role in supplying the energy needed by an animal for normal body maintenance.
- Good sources of fats in animal rations include meat and bone meal or fish meal.
- Insoluble in water but soluble in organic solvents
- Dense energy source:
  - 1 g fat = 9.45 kcal GE
  - 1 g protein = 4.5 kcal GE
  - 1 g CHO = 4.2 kcal GE
- Thus, fat produces 2.25 times the energy than CHO
- Rations for adult ruminant animals should contain no more than 3-5% fat and 15-20% fat for non-ruminants

Lipid digestion

- Occurs in the small intestine (duodenum)
- Bile produced by liver emulsifies fat
• Pancreatic lipase (enzyme) breaks apart fat for absorption
• Monoglycerides (MG)—absorbed into SI mucosal cells
• Free Fatty Acids (FFA)—absorbed into SI mucosal cells or enter blood circulation directly
• Very efficient
• Absorption rates range from 70-96%
• Generally, oils (unsaturated fats) are absorbed more completely that fats (saturated fats)

Sources of lipids
• Most feeds contain low levels
  – > 10%
  – Unprocessed oil seeds (soybean, sunflower seed) contain up to 20% fat
• Traditionally, if additional fat is needed it is added to the diet
  – Animal fats
  – Vegetable oils

PROTEIN

• Protein is the most expensive nutrient required in the development of muscles.
• Growing animals require greater levels of protein.
• Amino acids in proteins are the building blocks for muscle tissue, hair, etc.
• There are two types of amino acids: essential - must be provided in diet as the body cannot produce them; and nonessential – the body can produce.
• Dietary requirements highest in young, growing animals and declines at maturity

1. Essential Amino Acid

• Phenylalanine
• Valine
• Threonine
• Tryptophan
• Isoleucine
• Methionine
• Histidine
• Arginine
• Lysine
• Leucine

2. Non-Essential amino acid – livestock can produce enough of these amino acid to meet its requirement

• Alanine
• Arginine
• Asparagine
• Aspartic Acid
• Cystein
• Glutamic acid
• Glutamine
• Glycine
• Histidine
• Proline
• Serine
• Tyrosine

Biological function of proteins:
• Principal organic chemical constituents of body organs and soft tissues
• Enormous functional diversity
  – Cell membrane structure and function
  – Enzymes
  – Hormones and other chemical messengers
• Immune factors (antibodies)
• Fluid balance
• Acid-base balance
• Transport
• Source of energy and glucose

Structural and mechanical function
• Collagen
  – Bone and skin
• Keratin
  – Hair and nails
• Motor proteins
  – Make muscles work

In general, every livestock must have a constant supply of protein in order to remain healthy

Protein deficiencies
• Reduced growth & feed efficiency
• Infertility
• Reduced birth weights
• Reduced milk production

3. INORGANIC NUTRIENTS – MINERALS

• Needed in small amounts
• Contain NO Carbon (if the feed was burned the ash left would be minerals)
• Provide material for growth of bones, teeth, tissue, regulate chemical processes, aid in muscular activities, and release energy for body heat
• Proper balance of these nutrients is essential; overfeeding or underfeeding can cause disease or even death. Livestocks that don’t get their required minerals become unhealthy
• Two types – Major (Macro minerals) and Trace Minerals (minor mineral)
• Major (Macro Minerals): Minerals normally present at greater levels in animal body or needed in large amounts in the diet
  • Calcium (Ca)
  • Phosphorus (P)
  • Sodium (Na)
• Chloride (Cl)
• Magnesium (Mg)
• Potassium (K)
• Sulfur (S)
• Trace (Micro) Minerals: Minerals normally present at low levels in animal body
  or needed in small amounts in the diet.
  • Cobalt (Co)
  • Copper (Cu)
  • Fluoride (Fl)
  • Iodine (I)
  • Iron (Fe)
  • Manganese (Mn)
  • Molybdenum (Mo)
  • Selenium (Se)
  • Zinc (Zn)

Livestock mineral requirement vary by:
• Breed
• Age, sex and growth rate
• Nature and rate of reproduction
• Lactation
• Level and chemical form ingested
• Overall balance and adequacy of diet
• Hormonal and other physiological activities within the animal
• Climate

Sources of minerals
• Forages usually considered good sources of minerals
  – Largely dependant on soil conditions
• Grains are fair source of P, but low in other minerals
• Mineral premixes
• Mineral blocks

Mineral absorption
• Minerals are converted to their ionic form and absorbed in the small intestine

4. VITAMINS

• Organic substances required by the animal in very small amounts
• Necessary for metabolic activity but not part of body structure
• NOT normally synthesized by the body
• Content varies greatly in the feed
• Requirements depend on species
• Monogastrics = a lot b/c cannot synthesize
• Ruminants = few vitamins due to microbial synthesis
• Two types
  – Fat-soluble vitamins
    • Vit A (carotene): vision, green, leafy forages, corn, fish oil
    • Vit D: Ca, P absorption, fish oils, sun-cured hay
    • Vit E (tocopherol): antioxidant, seed germ oils, green forage or hay
    • Vit K (menadione): blood clotting, green forage, fish meal
    • Short shelf life (3-4 months)
    • Need lipids for absorption
    • Destroyed by heat, minerals
  – Water soluble – B, C
    • Vitamin C is found in green pastures and also farm animals can produce enough vitamin C in their body
    • Vitamin B complex sources- green pastures, cereal grains, milk, fish solubles, and animal proteins

Vitamin absorption
• Most vitamins are absorbed in the upper portion of the small intestine
• Water soluble vitamins are rapidly absorbed
• Fat soluble vitamin absorption relies on fat absorption mechanisms

Vitamin deficiencies
- Vitamin A
  - Night blindness
  - Poor growth, reproductive failure
- Vitamin D
  - Rickets
  - Osteomalacia
- Vitamin K
  - Poor blood clotting/hemorrhaging
- Vitamin C - Scurvy: slow wound healing, spongy gums, swollen joints, anemia
- B Complex Vitamins
  - Reduced growth/poor appetite
  - Dermatitis
  - Muscular incoordination

FEED CLASSIFICATION

Livestock Feed is classified into:
- Roughages
- Concentrates
- Supplements

Roughages
- High in fiber, relatively low in digestible nutrients.
- Forages
  - Pasture /fodder
  - Eg Guinea, Napier, Setaria, African Star, Digitaria, Para, and Signal
- Legumes: eg., Centrocema pubescens, Stylosanthes guianensis, petal
  belalang (Leucaena leucocephala), Desmodium spp. and Calapogonium

Sources of raoughages
- Grasses (pasture)
- Legumes
- Fodder crops
• Agricultural by-products
• Conserved fodders
• Industrial roughage
• Miscellaneous feedstuffs

**Concentrates**

• Feeds that are low in fiber and relatively high in digestible nutrients
• Includes grains, industry by-products, animal by-products, food additives
• Eg: Corn, Cottonseed, Barley, Oats, Sorghum

**Supplements**

Along with the two major divisions of feedstuffs, other ingredients are also used when formulating a feed ration

Typically, there are two other types of ingredients:

• Nutrition Supplement - a mixture of vitamins and minerals designed to ensure proper nutrition and balance that meets/exceeds minimum requirements
• Medical supplement - provides some sort of treatment and/or prevention through the animal eating/consuming the feed ration provided

**5. AGRICULTURE BY-PRODUCTS AS LIVESTOCK FEED**

Agriculture is an important sector of Malaysia's economy, contributing 12 percent to the national GDP and providing employment for 16 percent of the population. The 3 main crops, rubber, palm oil, and cocoa—have dominated agricultural exports.

In addition to these products, Malaysian farmers produce a number of fruits and vegetables for the domestic market, including bananas, coconuts, durian, pineapples, rice.

Malaysia is the largest producer of Palm Oil. The total area under oil palm covers more than 2 million hectares and 18.91 million tonnes of CPO was produced in 2011.
18-22% Palm Oil, 23% is solid waste: Empty Fruit Bunches

Agriculture by-products

- Crop residue
  - Agricultural wastes - after harvesting rice straw, cane trash, peanut shell, corn leaves and cobs, cassava stem, oil palm frond, coconut shell and leaves
  - Agro-industrial residues, i.e. residues that are resulted from following processing on rice husks, biogases, cassava peels, peanut shells, coffee husks, empty oil palm fruit bunch

Advantages and disadvantages of agricultural by-products as animal feed

- Advantages
  - Contain useful nutrients
  - Frequently very inexpensive
- Disadvantages
  - Variable nutrient content from batch to batch
  - Availability on an inconsistent basis

Sources of by-products includes the following:

- Grain by-products
- Oat bran
- Maize/rice bran
- Rice, broken
- Rice polishing
- Wheat bran
- Wheat germ

- Oil by-products
  - Oil palm frond - pellet
  - Palm Kernel Cake (PKC)
  - By-product from the process of palm kernel extraction – high in fibre, low in digestible protein
  - Palm Press Fibre (PPF) – high in fibre
  - Palm Oil Mill Effluent (POME) – liquid waste

- Waste materials and Industrial raw by-products

**Corn Industry:**
- The main waste from maize production that is available for roughage source, is the corn stover (the stalk and leaves after harvesting), the corn husk, the leaves and the cobs.
- Corn Stover is the residue left in the field after the corn has been harvested. The stover is 50% stalks, 22% leaves, 15% cob, and 13% husk.
- In maize producing areas (sweet and baby corn producing areas) the stover is usually harvested and chopped for use as roughage for dairy cattle.
- For dairy production, corn stover could be used as a roughage source both in its fresh and in ensiled form.
- Stover from baby corn production has a higher nutritive value than corn stover from sweet maize production.

**Sugar industry:**
- sugarcane tops, sugarcane leaves, bagasse and molasses
- Sugarcane tops and leaves are by-products that can be used as roughage for cattle, and their nutritive values are rather higher than rice straw
- Molasses is a viscous by-product of the processing sugarcane into sugar
  
  Advantages- Improves palatability, liquid carrier in feedstuffs
  Disadvantages- can be laxative at high levels, expensive energy source

- Bagasse is the fibrous matter that remains after sugarcane stalks are crushed to extract their juice

**Rice by-products:**
- Rice straw is particular high in lignin and silica, but it has poor digestibility and is low in protein, mineral and vitamin content.
- Generally, rice straw is fed to dairy cattle and ruminant species in nearly all dairy farms, especially in the dry season when no green forage is available.
- During dry season farmers have to supplement more concentrate feed to lactating animals to get enough milk, which consequently results in higher costs of feed.
- To improve the palatability and nutritive value of rice straw, several treatments have been widely used such as chopping and/or soaking it in water or a salt solution, which slightly increase feed intake and its digestibility.

**Pineapple Industry**
- Pineapple waste is a by-product from pineapple production and cannery plants
- Consist of the crown, core, peel, leaves and waste from flesh trimming

**Banana Industry**
- Banana stems are high in moisture content but are widely used as feed in dairy farms, especially in the dry season.
- The stems are sliced and chopped before being ensiled with rice bran.
- Normally they are used for cattle feed in the fresh form or ensiled form for feed supplements

**Vegetable by-products**
- Vegetable waste from the cannery industry is composed of undergraded vegetables from export products
- Soybean, French beans, sliced baby corn and carrots.
- This waste is high in both digestibility and moisture content. It can be used as a replacement in concentrate feed for dairy cows without any affect on their growth and milk production.

**Important factors which may affect the use of agricultural by-products**

- **Production Region**
  Processing or crop residues are most convenient to use when the distance from the field or factory to the farm is short. If suitable by-products are produced far from livestock farms, high transportation costs will reduce any economic benefits.

- **Pesticide Residues**
  There are many insect pests in Malaysia which affect the production of crops. Farmers often use large amounts of pesticide to kill these insects. Pesticide residues are a big problem when agricultural by-products are used as feed.

- **Price**
  The price of agricultural by-products depends on what profit the manufacturer expects, the broker's charges, and the transportation fees. Generally, the cost of transportation is at least 50% of the total cost. The greater the distance of delivery, the higher the cost.

- **Nutritional Balance**
  The nutrient content of each agricultural by-product is completely different from that of the others. Before by-products can be used as feed, their chemical composition has to be determined. Farmers also need to be educated through short extension courses about the differences between agricultural by-products. Using agricultural by-products as only one part in the total mixed rations is the best method of balancing all the nutrients.

- **Health of Animals**
Some agricultural by-products contain toxins which affect the health of animals. When cattle eat too much sweet potato vines or peanut vines, for example, they develop diarrhea. The proteinase in pineapple, and the cyanic ions in cassava, also affect the health of livestock.

- **Preservation**
  Only a few farmers in Malaysia have enough space to build a silo in which to preserve agricultural by-products. Most agricultural by-products are stored in piles, without any covers, near livestock pens. The surface layer soon becomes spoiled, and so loses its nutrient value.

- **Milk Quality**
  Some agricultural by-products have strange flavors which can be transmitted to milk, while their nutrient content may not compete with that of forage. If dairy cattle consume a large quantity of these, the flavor of milk may change, and its quality may decline.

**Conclusion**

A nutrient is a substance contained in feed that is necessary for an livestock to live and grow. Nutrients required for proper growth in all livestock are called essential nutrients. There are six classes of essential nutrients—water, carbohydrates, fats, proteins, minerals, and vitamins. Water is essential for an animal’s survival. Water’s two main functions in the body are to regulate the livestock’s body temperature and to assist in transporting nutrients. Carbohydrates provide energy and should make up about 75 percent of an livestock’s diet. Carbohydrates may be simple (sugars and starch) or complex (fiber). Fats, or lipids, are food components that provide energy and are also the form in which livestock store energy. Fats contain 2.25 times more energy than carbohydrates. Proteins are seldom fed for their energy content because of the higher cost of this source. Feeding of agricultural by-products and crop
residues to livestock in the tropics is a common practice especially during the dry season when the available pasture is of low quality. These by-products have been evaluated mainly for their potential as sources of energy and protein. Agriculture by-products can be used to replace concentrate feeds and reduce the cost of production; it may also solve the problem of environmental pollution which results from the accumulation of agricultural by-products in the field

References


Exercise/Activity

1. What nutrient is most important to the survival of animals?
2. Why do animals need carbohydrates and fats?
3. What is the difference in a concentrate and roughage?

Group Discussion

1. Describe the six food classes that livestock feed are based upon
2. Explain the role of water in livestock nutrition
3. Discuss Advantages and disadvantages of using agriculture byproducts as animal feed, example of agriculture by-products locally available and factors that may affect the use of agriculture by-products in livestock industry
Answer for exercise/activity 1

1. Water
2. Source of energy
3. Concentrates are high in energy, roughages are high in fiber

Answer for group discussion

1. Question 1
   Water
   Carbohydrates
   Protein
   Fats
   Vitamins
   Minerals

2. Question 2
   Provides the basis for all the fluid in the animal’s body.
   Bloodstream-circulation
   Digestion to breakdown nutrients
   Movement of feed through the digestive tract
   Produces milk
   Provides cells with pressure to maintain their shape
   Helps the body maintain a constant temperature
   Flushes the animal’s body wastes and toxic material

3. Question 3
   Advantages
   Contain useful nutrients
   Frequently very inexpensive
   Disadvantages
   Variable nutrient content from batch to batch
   Availability on an inconsistent basis
UNIT 4
GENETICS AND BREEDING

Introduction

Genetics is the science of heredity and variation. It is the scientific discipline that deals with the differences and similarities among related individuals. All animals have a predetermined genotype that they inherit from their parents. However, an animal’s genotype can be manipulated by breeding and more advanced scientific techniques (genetic engineering and cloning). Two organisms may appear to be similar, but they can have different genotypes. Similarly, if two individuals with identical genotypes are exposed to the same environmental conditions, such as nutrition, climate, and stress levels, their phenotypes (measurable and observable characteristics) should be the same.

Learning outcomes

At the end of this module, students will be able to;

1. understand the basic knowledge of genetics principles that lies behind the livestock breeding program
2. Compare the different design of mating program, genotypic and phenotypic effects of the mating program
Important points

1. Basic genetic concept: Gene and chromosomes, allele, homozygous and heterozygous, genotype and phenotype
2. Breeding methods – pure breeding, in-breeding, cross-breeding, genetic effects and benefit
3. Breeds and breed formation, including common breeds as well as rare breeds and genetic resources

1. Basic genetics concept

Breeding
Deals with application of genetics principles for the improvement of economically important characteristics or traits

Heredity
Passing of traits from parent to offspring

Progeny
Created by the union of gametes (sperm from the male and egg from the female). Each gamete produced by an individual is unique. Patterns of inheritance depend on:
- The gametes produced by the parents.
• The possible combination of gametes.
• The action of different alleles

Chromosomes
Storage units of genes

Gene
Segment of a chromosome that contains the heredity traits of an animal. Genes determine the inherited characters.

DNA
A nucleic acid that contains the genetic instructions specifying the biological development of all cellular forms of life

Principal of dominance
In animals, chromosomes are paired and, therefore, genes are paired. These paired genes code for the same trait, but they are not identical. They can have different forms, known as alleles

Dominant
Traits that are expressed ie dominant alleles mask the expression of recessive alleles. A dominant allele is expressed even if it is paired with a recessive allele

Recessive
Traits that are covered up ie recessive traits appears in an organism only when a dominant gene for that trait is not present. A recessive allele is only visible when paired with another recessive allele

Genotype
The genetic constitution (makeup) of an animal

Phenotype:
The physical appearance of an animal because of its genetic makeup (genotype). It is the observable or measurable characteristics (called traits) of the animals

Heritability
Degree of relationship between genotype and phenotype. It is the capacity of a trait to be passed down from a parent to offspring and generally reported as a percentage. Production traits vary in heritability.
Most reproductive traits (conception rate, etc.) are low (< 20%), production traits (weight, etc.) are medium (20% to 40%), and product traits (lean tenderness, etc.) are high (> 40%).

Example of heritability traits livestock

<table>
<thead>
<tr>
<th>Trait</th>
<th>Sheep</th>
<th>Swine</th>
<th>Cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weaning weight</td>
<td>15-25%</td>
<td>15-20%</td>
<td>15-27%</td>
</tr>
<tr>
<td>Post-weaning gain efficiency</td>
<td>20-30%</td>
<td>20-30%</td>
<td>40-50%</td>
</tr>
<tr>
<td>Post-weaning rate of gain</td>
<td>50-60%</td>
<td>25-30%</td>
<td>50-55%</td>
</tr>
<tr>
<td>Feed efficiency</td>
<td>50%</td>
<td>12%</td>
<td>44%</td>
</tr>
<tr>
<td>Loin eye area</td>
<td>53%</td>
<td>53%</td>
<td>56%</td>
</tr>
</tbody>
</table>

Note: The actual configuration of genes in an animal is called the genotype. For any given trait there are three possible genotypes AA, Aa, or aa. Genotype is looking at the specific make up of that organism. In contrast phenotype depicts the physical appearance of the animal. Phenotype is looking at the broader picture. Phenotype doesn't tell what traits are masked, the recessive traits; it only depicts the dominant traits that mask the recessive ones.

2. Livestock Breeding

Selection of animal for breeding

- Process that determines which individuals become parents, how many offspring they produce, and how long they remain in the population.
- Purpose - to identify and select superior animals which possess a large proportion of superior genes for a desirable trait, or traits, for breeding
When discussing different generations in genetics, the first generation is referred to as the parent or P generation. Their offspring are referred to as the first filial or F₁ generation.

When individuals from the F₁ generation are mated with each other, their offspring are referred to as the F₂ generation.

**Method of Selection**

- Selection on appearance is strictly subjective.
- Selection on pedigree is done strictly on the basis of an individual’s ancestors.
- Selection on individual performance relies on measuring production traits, and selecting on that basis.
- Selection on progeny performance can be more accurate but also is the slowest.
- Combining pedigree, individual performance, and progeny performance is most effective.
- Select only for traits that have some bearing on herd or flock profit or objectives.
• Use the most objective measures when available.
  
  If there are no objective measures, be sure any visual methods are meaningful and affect profit

**Most important traits in livestock**

• Reproductive performance - highest economic value

• Maternal ability - including milk production

• Growth and efficiency - weaning weight, postweaning gain, yearling weight, feed conversion

• Market price - with traditional live methods by weight, or carcass grids, or by the head as replacements

• Temperament (cattle) Flocking instinct (sheep goats) - ease of handling

• Longevity - length of productive life

**Cause of phenotypic variation**

Heredity: Animals genetic background for phenotype

Environment: Conditions under which the animals are born and raised; climate, nutrition, disease, general management, etc.

The relationship between phenotype and genotype is expressed as the following equation:  

\[ P = G + E \]

\( P = \) phenotype,  
\( G = \) genotype, and  
\( E = \) environment

The environment within which the animals are developed certainly has a greater influence on the ability of the genes to express themselves. Genes may have the capability or potential, but if they do not have the opportunity, that is, if the environment is not right, then all is for naught.

It may be difficult to distinguish between the better performers and the poorer if not supply the right conditions. Thus, the environment has a great deal to do with the
expression of the genes as seen in performance traits and physical characteristics, conformation

Matching Genetic Programs to Existing Conditions
Matching livestock genetics to the production environment can be accomplished by using breeding programs. Breeding programs can be made once a phenotype(s) is identified that increases profitability of the farm through cost effective modification of the production environment. The existing production environment may include:

- Climate
- Topography
- Pests
- Forage - Forage availability is the main determinant of optimum mature body size. Larger animals need more forage
- Labor
- Management skill
- Markets - Breeds should be chosen primarily on the basis of climatic adaptability and compatibility with other production conditions, but performance and marketability should also be considered.

Mating Plans and Breeding Systems
Mating plans are important in livestock breeding program for:

Genetic Superiority – Have animals that are genetically superior to other animals in the same breed or class. Animals are superior based on traits selected by the breeder.

Hybrid vigor (heterosis) – Performance of offspring that is greater than the average of the parents

Mating Plans

- Random – no effort to control relationship of parents.
- Pure breeding
  Pure bred animals with superior qualities
Used in the genetic improvement of commercial livestock
Eg: KedahKelantan (KK) x KedahKelantan (KK)
Eg. Simental x Simental

- **Inbreeding** - mating animals more closely related than the average of the population. Main use is **linebreeding**, to increase genetic influence of superior sires or dams

Inbreeding between Brother (C) x sister (D)
This can be considered to be intense inbreeding. Individual A is repeatedly mated to his daughters. In this example, individual A is the father, grandfather, great-grandfather of individual E.

**Genotypic effect of inbreeding**

↑ homozygosity, ↓ heterozygosity (just the opposite of crossbreeding).

Inbreeding example:
- Father x daughter
- Mother x son
- Brother x sister

**Phenotypic effect of inbreeding**

↑ frequency of abnormalities.
↓ vigor (more susceptible to stress).
↓ reproductive efficiency.
  (↓ ovulation; ↑ embryo death).
↓ survivability.
↓ production

**Advantages and disadvantages of inbreeding**

**Advantages:**
- Form families
- Produce breeding stock
- Develop lines for crossbreeding
- Determine genetic value

**Disadvantages:**
- Decrease in reproductive efficiency
- Decrease in vigor
- Decrease in survival rates
- **Outbreeding**
  Matings between animals that are:
  - distantly related
  - of different breeds (crossbreeding)
  - of different species (hybridization)
Opposite of inbreeding

**Types of outbreeding**

- Crossbreeding (Mating of animals of different established breeds)
  eg. KK x Simental = KKS
- Backcrossing: eg. KKS x Simental = KKSS
- Hybridization (Crossing of animals of different species): eg. KK x gaur
- Outcrossing: Mating of unrelated animals within the same breed.
- Grading up: Mating of purebred sires to commercial grade females and their female offspring for several generations

![Breed A](image1.png) ![Breed B](image2.png) ![Breed C](image3.png)

Crossbreeding cattle of different breed
Benefit of crossbreeding

- Heterosis (hybrid vigor) or outbreeding enhancement, is the improved or increased function of any biological quality in a hybrid offspring. It is the occurrence of a genetically superior offspring from mixing the genes of its parents. Advantage of crossbreds compared to their purebred counterparts. Especially for fertility and survivability.
- Genetic (breed) complementarity
  Combining breeds or lines in an optimum manner.
- Quick genetic change
  Change is more dramatic and quicker than selection within a breed or line

Genetic effect of crossbreeding

- Increases heterozygosity
- Decreases homozygosity
- Results in heterosis
- Opposite effects of inbreeding
  \[
  \text{Breed 1 X Breed 2} \Rightarrow F_1 \text{ cross} \\
  \text{all AA} \quad \text{all aa} \quad \text{all Aa}
  \]

Choosing applicable genetic type and breeds

Cattle:
- Bos taurus - non-humped types, originating in Continental Europe and the British Isles, most cold tolerant
- Bos indicus - humped types, also called Zebu; originating in south central Asia, most heat tolerant

Sheep: Genetic Classes
- Hair Sheep
- Wool Sheep
• Types and breeds of a livestock can be placed into functional-type breed groups based on genetic classification, body size, milking potential, and body composition (lean-to-fat ratio).

Example of functional breeds
• Cattle: *Bos taurus*, moderate size, low to moderate milk, low to medium lean-to-fat. (Examples: Angus, Hereford, shorthorn)
• Dairy - *Bos taurus*, small to large size, high to very high milking, very low to low lean-to-fat. (Examples: Holstein, Jersey)
• Beef - *Bos indicus*, moderate to large size, low to medium milking, low to medium lean-to-fat. (Example: Brahman)
• *Bos taurus X Bos indicus*, moderate to large size, medium to high milking, low to medium lean-to-fat. (Examples: Beefmaster, Brangus, Santa Gertrudis.)
• Sheep & Goats: Dairy – Examples: Alpine, Nubian, Saanen, Damasus, Toggenburg
• Meat Goats, examples: Boer
• Dual purpose goats: meat and milk, probably most of the species in the world are dual purpose

Genetic improvement through advanced method

Genetic improvement is accomplished by selecting males and female with superior transmitting ability as parents of new generations

Artificial Insemination

Artificial insemination is used instead of natural mating for reproduction purposes and its purpose is that the desirable characteristics of a bull or other male livestock animal can be passed on more quickly and to more progeny than if that animal is mated with females in a natural breeding.

Other reproductive processes that have been or may be used to improve genetics of livestock are:
1. Frozen Semen
2. Separation of Male/Female producing sperm  
3. Synchronization of estrus  
4. Superovulation  
5. Embryo Transfer  
6. Storing embryos  
7. In vitro fertilization  
8. Environmental influence on puberty  
9. Splitting and cloning embryos  
10. Transferring genetic material  

**Conclusion**  
- Genetics is a science of heredity concerned with behaviour of genes passed from parents to offspring in the reproductive process. It involves the study of heredity and variation in cells, individuals, their offspring and population. If two individuals with identical genotypes are exposed to the same environmental conditions, such as nutrition, climate, and stress levels, their phenotypes should be the same. For breeding purpose, breeds should be chosen primarily on the basis of climatic adaptability and compatibility with other production conditions, but performance and marketability should also be considered.  

**Activity 1**  
1. What is the difference between genotype and phenotype  
2. What is heritability?
Group Discussion 1

1. Discuss the importance of breeding system
2. Explain the different type of mating/breeding system

Answer Activity 1

1. The actual configuration of genes in an animal is called the genotype. For any given trait there are three possible genotypes AA, Aa, or aa. Genotype is looking at the specific make up of that organism. In contrast phenotype depicts the physical appearance of the animal.

2. Degree of relationship between genotype and phenotype, ie the capacity of a trait to be passed down from a parent to offspring

Answer for group discussion

1. Question 1
   Genetic Superiority – Have animals that are genetically superior to other animals in the same breed or class. Animals are superior based on traits selected by the breeder.
   Hybrid vigor (heterosis) – Performance of offspring that is greater than the average of the parents

2. Question 2
   Inbreeding – The mating of animals more closely related than the average of the breed or population
   Outbreeding:
   - Crossbreeding: Mating of animals of different established breeds
   - Hybridization: Crossing of animals of different species
   - Outcrossing: Mating of unrelated animals within the same breed.
   - Grading up: Mating of purebred sires to commercial grade females and their female offspring for several
UNIT 5
PASTURE AND FODDER

Introduction
The main factor to consider before undertaking livestock rearing is feed, where the main components are pasture grass and fodders. Animals need sufficient quality and balanced diet to ensure maximum health, reproduction and production of milk and meat. Due to this, the type or species of pasture and fodder of high quality and of high yield need to be produced as feed for the animals. Critical planning regarding animal feed to increase efficiency for easy management of livestock and to upkeep the quality of production to an economical level should be undertaken. This unit introduces students to the basic principles of pasture management and forages production practices, including grazing management, types of pastures, grasses and legumes.

Learning Outcomes
At the end of this unit, students will be able to:

1. Gain a greater understanding of basic principles of pasture management and forages production practices
2. Identify types of grasses and legumes found in pastures and their values
3. Describe the characteristics of good quality pasture and main pasture problems
4. Understand the establishment of pasture from selection of pasture to harvesting process
5. Understand the need for fodder conservation and fodder conservation methods

Important Points

1. Pasture and fodder definition, and characteristics of good quality pasture
2. Management of pasture and challenges
3. Fodder conservation, the needs and method

Definition

**Forage** - plant material (mainly plant leaves and stems) eaten by grazing livestock, grassland and fodder plant. belongs to the family of gramineae and leguminosae and provide more than 90% of energy and protein requirement of ruminants world-wide

**Fodder** - food given to the domesticated livestock such as cattle, goats, sheep, chickens including plants cut and carried to them, rather than that which they *forage* for themselves, it includes hay, straw, silage, compressed and pelleted feeds, oils and mixed rations, and also sprouted grains and legumes

**Pasture** – Pasture are forage species that are cultivated foe livestock feed. The species usually belongs to either the grass or legume family. Residues from grain crops such as maize are also useful as a form of forage for livestock

**Feed** - Is a more general term that includes also non-vegetative plant parts e.g grains, seed etc. fed to animals
Advantages & limitations of forages

- Grass is the cheapest feedstuff
- Potential of producing the highest dry matter
- Unstable quality - Management
- Low in digestibility and protein content.
- Average Daily Gain of cattle feed with tropical forage is around 300 - 600g and milk production (8-9 kg) per head.

Pasture management

The objectives in pasture management are to secure maximum quantity of nutritious animal feed, which is distributed as widely as possible throughout the year, and to maintain this high level of production as long as possible. Good pasture management would ensure the efficient utilization of the feed production and thus obtain maximum profit from animals industry.

Generally there are 5 essential steps to be followed for establishing improved tropical pastures; Selection of pasture, preparation of land and planting materials, either using seed or vegetative materials, sowing and fertilization and harvesting.

Main pasture problems commonly faced by farmers are:

- Low dry matter yield
- Low quality pasture
- Seasonal distribution of forage production
- Forage utilization
- Stability or resistance of pasture
- Economics of production
1. Selection pasture species

The pasture species should be carefully chosen, with the following points to be considered:

- Type of soil
- Potential uses
- Type of livestock
- topographical condition
- perennial or annual species
- cost involved
- equipment available

Herbaceous plants as forage

- Grasses: These make up the bulk of plants found in many mixtures of the natural vegetation that supply animal feed. Grasses also have certain characteristics that make them very suitable as herbage plants.

- Legumes: these have a relatively high value for animal production, mainly on account of the high nitrogen content in the vegetative matter that represent the animal feed. They also play significant roles components in sustainable agricultural systems

What are the characteristics that made grasses suitable as animal fodder plants?

Why grasses are ideal for fodder?

- Able to re-grow after grazing/cutting
- High proportion of edible herbaceous part
- Nutrient composition match to animal requiremen
- Adapted to varied ecological region
Characteristics of good pasture/fodder

- It should have good yield potential
- High nutrient value especially crude protein content
- High digestibility
- High resilience, can withstand bad conditions like drought, overgrazing but easy to maintain
- It should be short duration variety (Fast growth rate)
- High leaf to stem ratio
- Can be easily mixed with other species esp. legumes
- Economical
- Palatable
- Suitable for preservation

Pasture plant species

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Star grass</td>
<td>Cynodon plectostachyus</td>
</tr>
<tr>
<td>Signal grass</td>
<td>Brachiaria decumbens</td>
</tr>
<tr>
<td></td>
<td>Brachiaria humidectola</td>
</tr>
<tr>
<td>Para grass</td>
<td>Brachiaria mutica</td>
</tr>
<tr>
<td>Guinea grass /rumput kuda</td>
<td>Panicum maximum</td>
</tr>
<tr>
<td>Napier grass /rumput gajah</td>
<td>Pennisetum purpureum</td>
</tr>
<tr>
<td>Kazungula grass</td>
<td>Setaria sphacelata cv. kazungula</td>
</tr>
<tr>
<td>Splendida grass</td>
<td>Setaria sphacelata var. splendida</td>
</tr>
<tr>
<td>Nandi setaria</td>
<td>Setaria sphacelata cv Nandi</td>
</tr>
<tr>
<td>MARDI Digit/Pangola grass</td>
<td>Digitaria setivalva</td>
</tr>
<tr>
<td>Guatemala grass</td>
<td>Tripsacum andersonii</td>
</tr>
<tr>
<td>Kikuyu grass</td>
<td>Pennisetum clandestinum</td>
</tr>
</tbody>
</table>
### Legumes

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centro</td>
<td>Centrosema pubescens</td>
</tr>
<tr>
<td>Stylo</td>
<td>Stylosanthes guyanensis</td>
</tr>
<tr>
<td>Pueru / Kudzu Tropika</td>
<td>Pueraria phaseoloides</td>
</tr>
<tr>
<td>Calapo</td>
<td>Calapogonium mucunoides</td>
</tr>
<tr>
<td>Ipil-ipil/Petai belalang</td>
<td>Leucaena leucocephala</td>
</tr>
</tbody>
</table>

**Source:** DVS

2. Land preparation

Land preparation is extremely important to ensure successful establishment of the pasture and high yield. Before land could be prepared for growing of grass, the land should be cleared. All plants, timber, tree stumps, roots etc. need to be burnt to ashes. If the area is waterlogged, trenches should be dug to drain the water and if the area consists of small mounds and hills, it should be leveled first. Land preparation can be done mechanically for large areas but for small areas, manual labor will suffice. Land preparation is best done on the onset of the dry season.

**Stages of land preparation**

1. **Ploughing** – Aim to break down the soil, turning over the sod completely to expose the land containing roots of plants and weeds to the sun. This can be done using a disc plough or chisel plough. At least 2 stages of ploughing:
   - 1st ploughing to break the soil
   - 2nd ploughing to aerate the soil
   - 3rd ploughing is to kill emerging weeds (when needed)
The time period required between the first two stages is approximately 2-4 weeks. This is to ensure complete exposure of soil containing pest and roots to the sun and provide ample time to soften and loosen soil.

II. Liming

Land with acidic pH not suitable for growing legumes, thus liming should be done. Liming depends on the pH of the soil. The use of other fertilizer is not encouraged until the acidity is corrected. Liming is done immediately after land is ready. Liming can be done using spinner broadcaster or hand.

3. Planting/Sowing

Depending on pasture species, planting will be done with seed or vegetative planting materials. Growing of grass best be done during rainy season. The use of sprinkler will help in maintaining correct moisture,

4. Fertilization

• Necessary for pasture and fodder establishment.
• Types of fertilization
  – Initial fertilization
  – Maintenance fertilization
• Initial fertilization is first done before or during planting.
• It is aimed at improving/encouraging root establishment and a healthy and strong initial growth for continuous growth and development
• In Malaysia, it is recommended to apply 60 kg N, 30 kg P and 30 kg K for successful establishment of grasses which normally takes about three months.

• For the legumes and grass-legume mixtures, 30 kg P, 30 kg K and 2000 kg of lime are necessary for the initial growth period before first cutting or grazing commences. Phosphorus and lime, if necessary, are incorporated into the soil before or at planting time

5. Harvesting
• First Cut
  – Generally a few days before flowering
  – At this stage the percentage of dry matter content is at its highest and the percentage crude protein content is high.
• The flowering stage is a good sign to determine the time for cutting
• Resting period or the intervals between each cutting or grazing of several kinds of pasture or fodder

Intensive fodder production
• Hydroponic
  – Hydroponic fodder has excellent nutritive value as it is fed to animals in its entirety - roots, seed, and green foliage.
  – The hydroponic fodder can be grown from grains such as oats, barley, rye, wheat, sorghum or corn.
  – Each kg of hydroponic cereal grass fodder is equivalent nutritionally to 3 kg of fresh alfalfa
  – Environmentally controlled cabin for hydroponically germinating and growing barley grass for feeding
  – Insect/pest proof
  – Landless
  – Excellent nutritive values – fed to animals entire plants: roots, seed and green foliage
- Hybrid variety
  - Legumes
  - Grasses
  - Grains (legumes and cereals)

**FODDER CONSERVATION**

- Feed shortage are common in Malaysia – rainy and dry season
- Their occurrence is one of the most important problems animal industries face as they affect productive and reproductive processes that determine the quantity and quality of their products.
- Ideally, sufficient fodder should be produced, conserved and stored over time to meet such seasonal periods of feed deficiency
- Sources of fodder for conservation include whole plants, stubbles or other by-products of crops, pastures and grain

**Need for fodder conservation**

- Feeding during drought or floods
- Utilizing surplus forage
- Maintain the quality of feed
- Ease transportation

**Method of conservation**
a) Hay

- Hay is grass, legumes or other herbaceous plants that have been cut, dried, and stored for use as animal fodder. Contain not more than 12 - 14% moisture for safe storage.
- Grasses are cut at optimum growth stage
- Left in the field to dry
- Machine used to turn over grass to aid drying (tedder)
- Dried grass swept in rows (windrow)
- Hay baler used to compress dried grass – cubes or big round bales
- Can also be used to conserve rice straw

b) Silage

- Chopped, fresh plant material that has been preserved by a process of fermentation (ensiling) in which organic acids are formed, particularly lactic acid
- The resulting acidity prevents unfavorable microbes from developing on the material and causing it to spoil
- The main purpose is to store the fodder or feed without reducing the nutritional quality, especially in drought or flood
- Silage is based on the conversion of sugars into lactic acid by lactic acid bacteria.
- Causing increased acidity (pH reduction).
- Which inhibits enzymatic degradation by plant enzymes, undesirable microorganisms and ultimately the lactic acid bacteria themselves.
- Which allows the retention of energy (organic acids, remaining sugars and digestible fiber), proteins and other nutrients in a form that can be efficiently utilized by cow

**Advantages for Silage**

- More palatable than hay
- Not dependent on weather
- Can be kept longer without deterioration
- Not easily inflammable
- Requires less storage area

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Potential disadvantages
- Not easily transportable like hay bales
- May need to invest in special storage structures such as upright silos
- If improperly stored, losses will be high

Materials that can be ensiled
- Grasses
- Legumes
- Maize
- Oil palm fronds
- Crop byproducts (pineapple skin, cocoa pods)

Ensiling guidelines
- Harvest at a stage of maturity that optimizes forage quality/quantity
- Ensile at the proper DM content
- Chop the forage into small particles
- Avoid silage contamination with dirt
- Fill silo rapidly
- Pack the silo so as to best expel oxygen
- Seal with plastic for at least 14 days
- Remove 15-20 cm of silage a day once the silo is open
- Use additives only if required

Silo structure
- Silage may be prepared and stored in the following:
  - Mechanised silawrapping bales
  - Bunker silo
  - Trench Silo
  - Tower silo
  - Plastic drum

c) Haylage
- a grass crop which is cut, harvested, and stored for feeding farm animals.
It is made from the same crops as normal hay, but with a higher moisture content.
With the proper equipment and storage techniques, this method significantly increases the food value and decreases losses for the crop.

Conclusion

Feed is the main factor to be considered before undertaking livestock rearing and the main components are pasture grass and fodders. Animals require sufficient quality and balanced diet to ensure maximum health, reproduction and production of milk and meat. The type or species of high quality and of high yield pasture and fodder are to be considered to maximize the production.

References


Activity 1

1. List the essential steps in establishing pasture
2. What are the main method of conserving fodder
3. Why fodder is conserved?
Group discussion

1. Explain why grasses are ideal as fodder
2. Discuss the characteristics of high quality fodder

Answer for exercise

1. Selection of pasture, preparation of land and planting materials either using seed or vegetative materials, sowing and fertilization and harvesting
2. Hay and silage
3. Fodder is conserved:
   - To preserve feed at optimum nutritional value
   - To shift available feed from the present to the future
   - To move feed from one location to another location
   - To assist pasture management
Answer for group discussion

1. Question 1
   - Able to regrow after grazing/cutting
   - High proportion of edible herbaceous part
   - Nutrient composition match to animal requirement
   - Adapted to varied ecological region

2. Question 2
   - High yield all the time (i.e. dry matter content)
   - High nutrient value especially crude protein content
   - High digestibility
   - High resilience, can withstand bad conditions like drought, overgrazing but easy to maintain
   - Fast growth rate;
   - High leaf to stem ratio
   - Can be easily mixed with other species esp. legumes
   - Economical; Palatable
UNIT 6
DAIRY INDUSTRY

Learning Outcomes
At the end of this unit, students able to:

1. Able to comprehend the production flow of the dairy cattle industry in relation to the various production systems practiced.

OUTLINE

1. Introduction to the dairy industry
   1.1. Global and local dairy industry
   1.2. What is milk?
   1.3. Carbohydrates in milk
   1.4. Proteins in milk
   1.5. Fats in milk
   1.6. Minerals in milk
   1.7. Vitamins in milk
   1.8. Colostrum
   1.9. Mammary gland of cattle
   1.10. Ideal udder characteristics
   1.11. Dairy cattle breeds
   1.12. Popular breeds of dairy cattle

2. Dairy cattle management
   2.1. Dairy herd goals
   2.2. Calf management
2.3. Dairy calf management
2.4. Breeding dairy heifers
2.5. Pregnant heifer feeding
2.6. Lactation curve
2.7. Lactating cow management
2.8. Dry period

3. Dairy cattle housing
   3.1. Types of housing

INTRODUCTION TO THE DAIRY INDUSTRY

Global and local dairy industry
There is a great deal of variation in the pattern of dairy production worldwide (Figure 1). Many countries which are large producers consume most of this internally, while others (in particular New Zealand), export a large percentage of their production. Internal consumption is often in the form of liquid milk, while the bulk of international trade is in processed dairy products such as milk powder.

Figure 1. World milk production for the year 2009 (Source: FAO)
Locally, milking stock animals were traditionally not specialised dairy animals as fresh milk was not major milk product. Milk was converted to more stable products, such as fermented milk and ghee, which retains their feed value for a longer period without cooling. The milk output from the dairy industry in Malaysia has increased over the years (Figure 2), with consumption also showing a steady increase over the years (Figure 3).

**Figure 2. Milk output from the Malaysian dairy industry**

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Region</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>Peninsular</td>
<td>34.06</td>
<td>38.35</td>
<td>39.31</td>
<td>50.05</td>
<td>55.20</td>
<td>59.35</td>
<td>62.78</td>
</tr>
<tr>
<td></td>
<td>Malaysia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sabah</td>
<td></td>
<td>6.98</td>
<td>7.05</td>
<td>11.70</td>
<td>6.37</td>
<td>7.04</td>
<td>7.58</td>
<td>8.02</td>
</tr>
<tr>
<td>Sarawak</td>
<td></td>
<td>0.06</td>
<td>0.05</td>
<td>0.06</td>
<td>0.07</td>
<td>0.06</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>41.10</td>
<td>45.45</td>
<td>51.07</td>
<td>56.49</td>
<td>62.30</td>
<td>67.00</td>
<td>70.87</td>
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</table>

**Figure 3. Malaysia: Milk consumption**

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Region</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>Peninsular</td>
<td>884.45</td>
<td>957.84</td>
<td>1,047.87</td>
<td>1,137.90</td>
<td>1,264.17</td>
<td>1,360.54</td>
<td>1,403.01</td>
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<tr>
<td></td>
<td>Malaysia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sabah</td>
<td></td>
<td>7.99</td>
<td>15.22</td>
<td>16.37</td>
<td>14.37</td>
<td>7.92</td>
<td>8.51</td>
<td>8.78</td>
</tr>
<tr>
<td>Sarawak</td>
<td></td>
<td>2.62</td>
<td>2.75</td>
<td>2.89</td>
<td>3.26</td>
<td>3.83</td>
<td>4.12</td>
<td>4.25</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>895.06</td>
<td>975.81</td>
<td>1,067.13</td>
<td>1,155.53</td>
<td>1,275.92</td>
<td>1,373.17</td>
<td>1,416.04</td>
</tr>
</tbody>
</table>

**What is milk?**

Milk is a liquid comprising of water, fat, carbohydrates, proteins, minerals and vitamins.

It is a product of mammary glands of mammals.

It is also a source of nutrients and immunological protection for the neonate.

Nutrient composition of milk varies with species (Figure 4).
There are wide variations in production even within the same species, largely depending on:

- Purpose
- Breed & genetic quality
- Physiological conditions
- Environmental conditions
- Management of the animals

**Figure 4. Composition of milk (g/100g) of different species**

<table>
<thead>
<tr>
<th>Species</th>
<th>Water</th>
<th>Fat</th>
<th>Casein</th>
<th>Whey protein</th>
<th>Lactose</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>87.1</td>
<td>4.6</td>
<td>0.4</td>
<td>0.7</td>
<td>6.8</td>
<td>0.2</td>
</tr>
<tr>
<td>Cow</td>
<td>87.3</td>
<td>4.4</td>
<td>2.8</td>
<td>0.6</td>
<td>4.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Ruffiaio</td>
<td>82.2</td>
<td>7.8</td>
<td>3.2</td>
<td>0.6</td>
<td>4.9</td>
<td>0.8</td>
</tr>
<tr>
<td>Goat</td>
<td>86.7</td>
<td>4.5</td>
<td>2.6</td>
<td>0.6</td>
<td>4.4</td>
<td>0.8</td>
</tr>
<tr>
<td>Sheep</td>
<td>82.0</td>
<td>7.6</td>
<td>3.9</td>
<td>0.7</td>
<td>4.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Horse</td>
<td>88.8</td>
<td>1.6</td>
<td>1.3</td>
<td>1.2</td>
<td>6.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Rat</td>
<td>79.0</td>
<td>10.3</td>
<td>6.4</td>
<td>2.0</td>
<td>2.6</td>
<td>1.3</td>
</tr>
<tr>
<td>Donkey</td>
<td>88.3</td>
<td>1.5</td>
<td>1.0</td>
<td>1.0</td>
<td>7.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Reindeer</td>
<td>66.7</td>
<td>18.0</td>
<td>8.6</td>
<td>1.5</td>
<td>2.8</td>
<td>1.5</td>
</tr>
<tr>
<td>Camel</td>
<td>86.5</td>
<td>4.0</td>
<td>2.7</td>
<td>0.9</td>
<td>5.4</td>
<td>0.7</td>
</tr>
</tbody>
</table>

**Carbohydrates in milk**

Lactose is the major carbohydrate in the milk of most species.

Lactose is a disaccharide composed of the monosaccharides — glucose and galactose.

Lactose is a major, readily digestible source of glucose which provides energy for the neonate. Lactose intolerance can occur in adult animals or animals that do not have lactase activity in their intestines.
Proteins in milk

The protein concentration in milk varies between species and within breeds, and in proportion to the amount of fat in milk (Figure 4).

The total protein component of milk is composed of numerous specific proteins.

The two major groups of protein in milk are caseins and whey proteins (β-lactoglobulin and α-lactalbumin).

The major milk proteins, including the caseins, β-lactoglobulin and α-lactalbumin, are synthesised in the mammary epithelial cells and are only produced by the mammary gland.

The immunoglobulin and serum albumin in milk are not synthesized by the epithelial cells. Instead, they are absorbed from the blood.

Caseins are highly digestible in the intestine and are a high quality source of amino acids.

Most whey proteins are relatively less digestible in the intestine, although all of them are digested to some degree.

When substantial whey protein is not digested fully in the intestine, some of the intact protein may stimulate a localized intestinal or a systemic immune response. This is sometimes referred to as milk protein allergy.

Fats in milk

Milk fat is composed of a complex mixture of lipids.

Triglycerides are the major type of lipid in milk fat and are composed of three fatty acids covalently bound to a glycerol molecule by ester bonds.

Milk fat is the major source of lipid used by the neonate mammal for accumulating body adipose in the initial days after birth.

Most mammalian neonates are born with little body adipose for insulation or as a source of stored energy. A few days after birth most neonates begin to be able to metabolize milk fat as an energy source.

Milk fat is secreted from mammary epithelial cells as fat globules. There are so many fat globules that they also carry some of the milk protein to the top, so cream also contains a small amount of protein in addition to the milk fat component.
Minerals in milk
Calcium and phosphorous are the major minerals found in milk.
These minerals are required in large quantities by the rapidly growing neonate for
bone growth and development of soft tissues.
Some minerals, such as zinc (Zn), magnesium (Mg), iron (Fe), copper (Cu),
manganese (Mn), and molybdenum (Mo), are required by enzymes as cofactors.
- Fe is low in milk of many species relative to the needs of the neonate. Fe is
  essential for the neonate as part of hemoglobin. In many species the neonate
  is born with some liver stores of Fe; however, the piglet does not and needs a
  Fe supplement (injection) soon after birth. Fe in milk is bound to lactoferrin,
  transferrin, xanthine oxidase, and some to caseins.
- Zn in cow’s milk is mostly bound to casein, but some is bound to lactoferrin.
- Cu is bound to the caseins, to β-lactoglobulin, to lactoferrin, and some to the
  milk fat membranes.
- Mo is bound to xanthine oxidase, an enzyme associated with the cell
  membrane and on the inner surface of the milk fat globule membranes.
- Mn is associated with the milk fat membranes.
- Co is an essential part of vitamin B12.

Vitamins in milk
Milk contains all the vitamins required by mammals.
The fat soluble vitamins, A, D, E, and K, are found primarily in the milk fat; milk has
limited amounts of vitamin K.
The fat soluble vitamins (A, D, E, K) are associated with the milk fat globule.
- Vitamin A
  - Also known as retinol.
  - Yellow milk fat of Guernsey cows is due to lower efficiency of
    conversion of β-carotene to retinol.
  - In some countries milk is fortified with vitamin A.
- Vitamin D
  - Anti-rachitic activity.
- Involved in bone metabolism, Ca absorption in the intestine, and has other tissue functions.
- Milk is often fortified with vitamin D.

- Vitamin E
  - Also known as tocopherol.
  - Antioxidant, protects lipids.
  - Only low levels are present in milk.

The B vitamins are found in the aqueous phase of milk.

Colostrum
Colostrum is also known as “first milk” as it is produced immediately at the onset of lactation.

Transition from colostrum to milk is a rapid process (Figure 5).

Dramatic composition changes occurring during the first few hours after parturition and more gradual changes subsequently through the third day.

It is:
- Yellowish in colour
- Thick consistency
- High in protein
- Easy to digest

Colostrum also contains immunoglobulins, particularly IgG, IgM and IgA.
First milking colostrum contains 50x concentration of immunoglobulins than normal milk.

High variation in this level attributed to cow’s age as concentration of immunoglobulins is correlated with the amount of exposure to pathogens.
Figure 5. Average composition of colostrum and normal milk of Holstein-Friesian cows

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Colostrum percent</th>
<th>Normal milk percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casein</td>
<td>4.8</td>
<td>2.6</td>
</tr>
<tr>
<td>Albumin</td>
<td>1.9</td>
<td>0.6</td>
</tr>
<tr>
<td>Globulin</td>
<td>7.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Total protein</td>
<td>14.0</td>
<td>3.0 - 3.5</td>
</tr>
<tr>
<td>Fat</td>
<td>6.7</td>
<td>3.5 - 4.0</td>
</tr>
<tr>
<td>Lactose</td>
<td>2.7</td>
<td>4.9</td>
</tr>
<tr>
<td>Ash (minerals)</td>
<td>1.1</td>
<td>0.75</td>
</tr>
<tr>
<td>Total solids</td>
<td>23</td>
<td>12.6</td>
</tr>
<tr>
<td>Water</td>
<td>77</td>
<td>87.4</td>
</tr>
</tbody>
</table>

Mammary gland of cattle

*External structures (Figure 6)*

- Udder
  - Located in the inguinal region.
  - Covered with fine hair.
  - Teats devoid of hair.
  - Consists of four separate glands or quarters.
    - Fore (40 percent of milk) & rear (60 percent of the milk) (Figure 7).
    - Right & left halves separated by inter-mammary groove.
    - No interaction between quarters.
Figure 6. External structures of the mammary gland of cattle.

Figure 7. Fore and rear quarters of the udder.

- Teats
  - Usually one teat per quarter.
  - Vary in shape from cylindrical to conical.
  - Rear teats usually shorter than fore teats.
  - Each teat has one streak canal that allows milk to exit the gland. The size & shape of teats important to facilitate use of milking machines
- Sphincter in each teat should be tight so as to prevent milk leakage without slowing the flow.

**Interior structures (Figure 8)**

- **Streak canal**
  - Functions to keep milk in udder & bacteria out of udder.

- **Teat cistern**
  - Duct in teat with capacity of 30 – 45 ml.
  - Separated from streak canal by folds of tissue (Furstenberg's rosettes).

- **Gland cistern**
  - 100 – 400 ml. milk storage.
  - Duct systems drains into.
  - Used to detect end of milking.

- **Duct system (Figure 9)**
  - Drains secretory tissue.
  - No secretory function.

- **Alveoli**
  - Milk producing units.
  - Secretory cells, myoepithelial cells & capillaries, duct.

- **Lobules**
  - 150 – 200 alveoli, common duct.

- **Lobes**
  - Group of lobules.
Figure 8. Cross-sectional view of an udder quarter showing the internal structures

Figure 9. Duct system
Ideal udder characteristics
An ideal udder is snugly attached, symmetrical and of moderate length. The quarters should be evenly balanced with medium sized teats placed squarely under each quarter (Figure 10). A side view of the udder should show a level udder floor without quartering with the median suspensory ligaments supporting the udder to the cow’s body (Figure 11). A strong suspensory attachment is essential for a satisfactory mammary system.

Figure 10. Transverse view of the udder

![Transverse view of the udder](image)

Figure 11. Ligaments that permit udder suspension

![Ligaments that permit udder suspension](image)
Dairy cattle breeds

- Temperate/Exotic dairy cattle breeds
  - High milk producers
  - Usually consume a large quantity of feed and therefore are expensive to maintain
  - Low tolerance to tropical diseases.

- Indigenous dairy cattle breeds
  - Low milk producers
  - Low feed consumers, cost less to maintain.
  - Better adapted to local environments
  - Higher tolerance to tropical bovine diseases.

- Crossbreeds
  - Combine best traits from both exotic and indigenous breeds.
  - Perform well in the tropics.
  - Breed Performance
  - Capacity of an animal to produce milk differs between species, breeds and lines.
  - Complex of inter-related factors in the animal husbandry will influence the animal's ability to utilize that capacity for growth, development and production.

Popular breeds of dairy cattle

- Friesian
  - Bos taurus breed
  - 90 percent of 10 million world’s dairy cattle population
  - Largest of the dairy breeds
  - High milk yield (3 – 4 percent milk fat)

- Jersey
  - Adapted to wide range of geographical and climatic conditions
  - More milk per unit of body weight
  - Highest feed-to-milk conversion efficiency
- **Brown Swiss**
  - Native of Switzerland (developed in the Alps)
  - Docile, high heat tolerance
  - Milk excellent for cheese

- **Red Sindhi**
  - *Bos indicus* breed
  - Hardy and heat resistant
  - High milk yield

- **Sahiwal**
  - Reddish brown to more predominant red colour
  - Hardy under unfavorable climatic conditions
  - Heaviest milker of all Zebu breeds

- **Friesian-Sahiwal**
  - Cross between Friesian and Sahiwal cattle
  - Crosses are resistant to ticks, heat tolerant and good milk producer
  - Improved Friesian-Sahiwal breed is the Mafriwal
DAIRY CATTLE MANAGEMENT

Dairy herd goals
Want year 'round calving to maximize facilities.
Want one year calving interval to have the cow at peak lactation as much as possible.

Calf Management
Immediately after birth, the calf's nose and mouth is cleared of mucous.
Since maternal antibodies are not transferred across placenta during gestation, therefore calves born with weak immune systems.
Intestinal absorption of antibodies declines rapidly after parturition and effectively ceases within 24 hours (Figure 1). Therefore, it is vital that sufficient colostrum is consumed by the calf within first hour after parturition.
In the event that the dam's colostrum supply is unavailable or of inferior quality, feed thawed frozen colostrum to the calf.

Figure 1. Efficiency of immunoglobulin absorption over time

Dairy calf management
Immediately after birth:
- Remove any mucoous from around the mouth and nose area.
- Ensure that the calf is dry and away from drafts.
- Feed calf colostrum.
- Treat the navel with a suitable disinfectant.

Calves are separated from cows 12 hours after parturition. Within this period, it is important that calves consume as much colostrum from their dams. Health and survival of the calf is dependent on how quickly and how much colostrum it drinks in its first few hours of life.

In the bovine, antibodies (immunoglobulins) cannot cross the placental wall and pass directly from the dam to the foetus. Instead, the calf receives immunity by consuming adequate amounts of colostrum within the first few hours after birth. During the first 24 hours after parturition, the calf can absorb antibodies directly from the gut into the bloodstream without digesting them.

**Birth to weaning**

Feed calves milk, milk replacer, or fermented transitional milk during the first month or two until their digestive systems are sufficiently developed to utilise grains and forages.

Best milk replacers contain at least 20 percent protein, 10 percent fat and low fibre levels. Calves during this period are usually group housed and therefore are fed using a bucket system (Figure 2).

**Figure 2. Group housed calves drinking milk from a communal bucket system**
Feed milk at the rate of 10 percent body weight per day. This amount can be fed in one or two feedings a day; however, feeding twice a day will encourage one to check for health problems more frequently and may give higher rates of weight gain.

Clean, fresh water should be provided *ad libitum* to the calves. Calves should be given free access to a calf coarse and/or pelleted starter grain mixture, as well as good quality forage a few days after birth, to encourage the calf to begin eating at an early age. This is critical, as it will stimulate the development of rumen papillae, essential to the development of a fully functional rumen. Silages and pasture are not recommended for calves under six months of age because these feeds contain too much bulk (60 – 80 percent water) for the calf's small developing rumen.

Calves are usually weaned from milk at between 4 and 8 weeks of age. During this time they can weigh between 65 and 70 kg. Calves are usually weaned according to their body weight rather than age. Every calf should be identified at birth with permanent visible identification. In replacement heifers, extra teats are removed. Calves are dehorned as soon as horn buttons felt.

*Dairy calf housing*

Keep calves in an environment that is clean, dry and free of drafts. Calves should also be housed away from older animals, as they are highly susceptible to contract disease at this young age. Calves may be either individual housed or reared in groups up to when they are weaned. At present, portable outside calf hutches are becoming popular in the industry.

*Dairy heifer management*

The objective of a feeding program for replacement heifers is to produce heifers that can be bred at an early age. This allows the heifer to calve at an earlier age so she can start returning a profit sooner.
Overly fat heifers have more difficulty in calving and give less milk than those of adequate size. This excess weight is more of a problem if it is gained before puberty rather than after breeding.

Undersized heifers have difficulty in calving, produce less milk, limit conception rates during the first lactation, and require extra feed for growth during the milking period.

*Dairy bull calf management*

May be sold for either veal or beef production.

Purebred bull calves from elite cows are put into progeny testing schemes to test potential to be used in breeding.

*Breeding dairy heifers*

Heifers have reached puberty when normal sexual behaviour is exhibited and ovulation occurs. Onset of puberty more closely relates to bodyweight than to age.

Heifers reach puberty when bodyweight is between 30 and 40 percent of the average adult weight, and should be ready to breed around 13 to 15 months of age.

The normal recommendation is to breed heifers at 15 months so they will calve at 24 months. Although this is a good goal, adequate skeletal size and weight of heifers at breeding and calving is more important than age. A general guideline is for the heifer to weigh 60 percent of the desired mature weight at breeding.

Calving heifers between 23 and 24 months of age is optimal for first lactation milk yields. Although heifers can calve between 19 and 21 months of age, they may experience dystocia and metabolic disorders.

Heifers are usually bred to genetically superior bulls. Occasionally they are bred artificially to top AI sires, where the semen from a group of high merit bulls are used on a group of heifers.

Artificial insemination (AI) has many advantages over natural service in the dairy industry whether the animal is a mature cow or young heifer.

A successful AI breeding program depends on successful heat detection and proper AI technique.

*Pregnant heifer feeding*
Between breeding and 2 months pre-calving, heifers are fed forages only. If the forage quality is average, a grain mixture is supplemented to meet energy requirements. Two weeks prior to calving, a special grain mixture containing supplemental calcium is provided to give protection against milk fever. Three to four weeks prior to calving, the heifer is separated and placed in clean, dry environment. The pregnant heifer is closely monitored during this period. Monitoring the birth process ensures that heifers and their unborn calves receive assistance if it is required. Assistance is given should the heifer fail to calve within 2 hours after onset of labour.

Lactation curve
Lactation curve (Figure 3) describes a cow's milk yield after colostrum to drying-off (about 300 days). Milk production gradually increases following calving, peaks at 45-90 days in milk and gradually declines until cow is dried off. First lactation cows have “flatter” lactation curves with lower peaks compared with older cows (third lactation, and over) that have higher peaks. Higher producing cows usually take longer to reach peak production. High production requires high peak & persistency.

Figure 3. Dairy cow’s lactation curve
Lactating cow management
The three main stages in lactation cycle of dairy cow are:

- **Early lactation (14 – 100 days)**
  - At the early lactation phase, the demand for energy is higher than amount consumed.
  - This causes the lactating cow to mobilise body reserves and in turn lose weight.
  - Cow should be bred to initiate a new pregnancy, 60-70 days after calving.
  - High forage quality with intakes of 1.5 percent of cow's body weight (dry matter basis) per day.

- **Mid lactation (100 – 200 days)**
  - High quality forage and effective fibre at a level similar to that provided during early lactation.
  - During this phase, cows are consuming at least 4 percent of their body weight.
  - Concentrates are supplemented to meet milk production requirements and to replace lost body weight during early lactation.

- **Late lactation (200 – 305 days)**
  - During this period lost weight is regained through proper feeding management of the cow and due to the growing foetus. Lost weight regained.
  - Feeding as in mid lactation.

Dry period
Cows are milked for about 305 to 365 days then they have a 60 day dry period (rest) prior to their next calving.
During this phase, cows are dried off through the gradually decline of milking.
DAIRY HOUSING SYSTEMS

Dairy housing objectives are to:

- Optimize cow comfort
  - Promote longevity of herd
  - Promote health & welfare of animal
  - Ensure profitability & sustainability of enterprise
- Keep cows clean
  - Ensure milk quality
  - Maintain cow health
- Optimize capital expenses

Choice of housing type & management will depend on:

- Size of your operation
- Availability of bedding
- Climate
- Existing facilities
- The degree of mechanization
- Personal preferences

In hot tropical conditions, sheds with good ventilation and able to maintain a cool environment is preferred.

Roof-top water sprinklers may assist cooling of the surrounding.

Floors should be of suitable material/substrate that is not harsh on the animal’s hoof, non-slippery, non-toxic and easy to clean.

Types of housing

- Pasture system
  - Extensive management.
  - Low capital investment.
  - Low input/low output.
- Not practical in the most climates.
- Example: New Zealand dairy system.

- **Dry lot**
  - Low capital investment
  - Shelter provided by temporary structures.
  - May reduce hoof and joint problems.
  - Environmental factors are a challenge.
    - Control mud during wet season.
    - Lots must be scraped & manicured.
  - This type of system is costly to maintain.

- **Tie-stall barn**
  - Long narrow stall just wide enough for single cow to stand or lay in while secured to a post with a chain or rope.
  - Cows are tethered most of the day.
  - Provide greater protection from environment.
  - Excellent setting for research.
  - Very labour intensive.
  - Allows for fine-tuned management.
  - Does not always optimize cow comfort.

- **Free-stall barn**
  - Maximises management of cow environment.
  - Each cow has a "bed", but is free to choose where she lies down.

- **Compost barn**
  - Loose housing system
    - Lower capital investment costs
    - Works in colder climates
  - Use manure pack as bedding
  - Must maintain cleanliness of barn and bedded pack needs to be aerated
UNIT 7

BEEF INDUSTRY

Introduction

This module is designed to provide information of beef industry in Malaysia; The Malaysian beef industry produces meat worth more than RM 220 million annually and spent about RM500 million importing it from other countries. The growth of the industry is almost negligible in the last 30 years.

Learning outcomes

At the end of this unit, students able to:

1. Gain a greater understanding of beef industry in Malaysia
2. Describe the major beef operation in Malaysia
3. Describe the various production system
4. Identify different breeds of cattle

Main points

1. Background
2. Major Beef operation
3. Population, market and demand of cattle in Malaysia
4. Production System
5. Breeds of cattle
Background

**Major Beef Operations:**

1. Purebred operations
2. Commercial operations

**Purebred operations**

- Purpose is to produce seed stock cattle. These cattle are used as the dams and sires of the calves that will be grown to market weight.
- Growing purebred stock allows breeders to concentrate on improving and accentuating (noticeable) the advantages of a particular breed.

**Commercial operations:**

- Most calves produced are crossbreeds from purebred parents of different breeds.
- Segments in Commercial Operations:
  - Cow-calf operations
  - Stocker operations
  - Feedlot operations

**Cow-Calf operations:**

- Cows are manage on free range - sometimes not fenced in until calving, at weaning time all stock is rounded up for the calves to be sold.
- Calves are usually sold at weaning weight, around 200 pounds. Buyers prefer calves that have been castrated and vaccinated and are in good condition.
Stocker operations:

- Provide a step between the weaning of calves and the finishing or fattening of the animals prior to slaughter.

- Weaned calves are placed on pasture and fed a ration to allow for skeletal and muscular growth. Before calves are sold to a feedlot for finishing they must be physically mature.

Feedlot operations:

- Many feedlot operators are also stockers. Final phase before the animals are sent to slaughter.

- Animals are fed a highly concentrated ration which is designed to put the proper amount of fat cover on the animals. Producers usually want sufficient fat cover to allow the animals to grade low choice.

- Feedlots range in size from feeding fewer than 100 heads to those feeding thousands of head each year.

- When animals reach the proper degree of finish, they are sold to slaughter. Usually around 18 to 24 months, weighing 400 to 700 kg depending on breed and body type.
## POPULATION OF BREEDER CATTLE AND BUFFALOES IN P MALAYSIA (1970-2005)

![Graph showing population of Breeder Cattle and Buffaloes in P Malaysia (1970-2005)](image)

**Growth Beef Population = 2.5% per year**

### Beef Production Process Flow and Supporting Units

<table>
<thead>
<tr>
<th>Production Units/Goal</th>
<th>Process Flow</th>
<th>Supporting Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Imported Animals</td>
<td></td>
<td>1. Administrative: Accounting, logistic, Record keeping, Health, Reproductive &amp; Advisory Services, etc.</td>
</tr>
<tr>
<td>- Suited to the tropics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Calf-calf</td>
<td></td>
<td>2. Organic Fertilizer</td>
</tr>
<tr>
<td>- High calf-calf - 85%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Heavy weaning weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Replacement Heifers</td>
<td></td>
<td>3. Shedding and Feed Processing Plant</td>
</tr>
<tr>
<td>- Achieved 65% of mature weight by 15 months; 40% mature wt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Calved between 24-27 monts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Reached maximum body conformation by 24 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Feedlot</td>
<td></td>
<td>5. Processing plant to process product - burgers, hotdogs, sausages, meatball, etc.</td>
</tr>
<tr>
<td>- Depends on the target market</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- High growth rate, efficient</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Good cutability</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Live animal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quarter carcass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beef in the box, offal, and other beef products</td>
</tr>
<tr>
<td>7. Carcass fabrication, processing and packaging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Wholesale / Consumer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Notes
- Administrative: Accounting, logistic, Record keeping, Health, Reproductive & Advisory Services, etc.
- Organic Fertilizer
- Shedding and Feed Processing Plant
- Abattoir
- Processing plant to process product - burgers, hotdogs, sausages, meatball, etc.
- Marketing: Live animal, Quarter carcass, Beef in the box, offal, and other beef products
PRESENT AND ESTIMATED MEAT / BEEF DEMAND AND SELF-SUFFICIENCY RATE IN P. MALAYSIA

<table>
<thead>
<tr>
<th>Year</th>
<th>MT Meat / Beef Demand</th>
<th>No. Heads Equiv. million</th>
<th>Estimated % Self-sufficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>121,000</td>
<td>1.01</td>
<td>12.0</td>
</tr>
<tr>
<td>2010</td>
<td>160,000</td>
<td>1.33</td>
<td>11.5</td>
</tr>
<tr>
<td>2015</td>
<td>190,000</td>
<td>1.58</td>
<td>10.8</td>
</tr>
<tr>
<td>2020</td>
<td>240,000</td>
<td>2.00</td>
<td>10.0</td>
</tr>
</tbody>
</table>


Total consumed = 127,000 MT
## Beef Market Segment and Its Potential Market Size

<table>
<thead>
<tr>
<th>MARKET SEGMENT</th>
<th>PRODUCE</th>
<th>POTENTIAL MARKET SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Premium beef</strong></td>
<td>Chilled &amp; frozen primal cuts &amp; certain offal</td>
<td>RM'000 165,000</td>
</tr>
<tr>
<td>Supermarkets/ Hypermarkets</td>
<td>Chilled loin cuts &amp; selected other primal cuts</td>
<td>70,000</td>
</tr>
<tr>
<td>Restaurants &amp; hotels, (higher end, 5 star), Food service industry</td>
<td>Frozen primal cuts</td>
<td>180,000</td>
</tr>
<tr>
<td>(e.g. Fast-food chains, caterers)</td>
<td>Frozen forequarter cuts</td>
<td>65,000</td>
</tr>
<tr>
<td>Food processing industry</td>
<td><strong>Subtotal</strong></td>
<td>480,000</td>
</tr>
<tr>
<td>(premium processed meats)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fresh beef</strong></td>
<td>Fresh beef</td>
<td>RM'000 208,000</td>
</tr>
<tr>
<td>Pasar Tani</td>
<td>All types of offal</td>
<td>82,000</td>
</tr>
<tr>
<td>Wet Markets</td>
<td>Bones</td>
<td>28,000</td>
</tr>
<tr>
<td>Pasar Malam</td>
<td><strong>Subtotal</strong></td>
<td>310,000</td>
</tr>
<tr>
<td>Selected Hypermarkets</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Indian Buffalo Meat</strong></td>
<td>Frozen, de-boned &amp; de-glanded</td>
<td>RM'000 240,000</td>
</tr>
<tr>
<td>Supermarkets/ Hypermarkets, Restaurants &amp; hotels, Food service industry</td>
<td>Pre-packed block meats</td>
<td>80,000</td>
</tr>
<tr>
<td>Local industry, Food processing industry</td>
<td>Tenderloin, Primal cuts</td>
<td>480,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td>800,000</td>
</tr>
</tbody>
</table>

## Beef Market

<table>
<thead>
<tr>
<th>Imported Meat</th>
<th>12,376 MT (10.6%)</th>
<th>RM 93.25 Mil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chilled / Frozen</strong></td>
<td>from <strong>Aust. &amp; NZ</strong></td>
<td>Special High-End Market</td>
</tr>
<tr>
<td>Local Meat</td>
<td>23,965 MT (20.5%)</td>
<td>RM 354.37 Mil</td>
</tr>
<tr>
<td>Fresh</td>
<td>Local Fresh Beef Market</td>
<td></td>
</tr>
<tr>
<td>Imported Meat</td>
<td>80,417 MT (68.9%)</td>
<td>RM 327.69 Mil</td>
</tr>
<tr>
<td><strong>Frozen from India</strong></td>
<td>Local-End Market Buffalo meat</td>
<td></td>
</tr>
<tr>
<td><strong>Total Market for Beef</strong></td>
<td>136,056 MT</td>
<td>Equivalent to 1,029,612 Head Cattle</td>
</tr>
</tbody>
</table>
PRODUCTION TARGET

- Target in the 9th Malaysian Plan is to increase self-sufficiency level to 28% (45,000MT) by the year 2010
- National beef policy (NBP) to increased self-sufficent level to 40% (96,000MT) by the year 2015

Ruminant Production Systems in Malaysia

1. Extensive system
   a. Extensive systems (smallholders)
      o Practiced by villagers along the coastal plains.
      o Livestock are owned in small numbers
      o Cut fodders are prepared for night supplemental feeding.
      o Few farmers plant improved pastures as more than 60% of these farmers have no land.
      o They search for green forages on a daily basis, often from several kilometers away.
   b. Extensive systems (Government owned farm)
      o Animals are let to graze on improved pasture
      o Well fenced Some supplementation are also given
2. **Systems combining livestock with arable crop:**
   - Paddy and annual cropping areas.
   - Some fodders are grown in backyards and some crop residues are used for supplementary stall feeding.
   - During the off season, animals are free to roam or are tethered for grazing.

3. **Systems integrated with tree cropping:**
   - Slowly being taken up by both the larger plantation owners and smallholders.
   - Grazing with proper management under tree crops saves 20-40% of weeding costs, reduces the use of weedicides.
   - Improves production of the tree crop – 20%
Integration – Cattle Under Oil Palm
INTEGRATED OIL PALM-BASED AGROFORESTRY SYSTEMS

- Characterised by diversity of mixed crop-animal farming systems
- Provide 90% of the milk, 77% of the ruminant meat, 47% of pork and poultry meat, and 31% of the eggs
- Past growth trends indicate:
  - Mixed farming systems (2.2% / yr)
  - Industrial systems (4.3% / yr), and Pastoral systems (0.7% / yr).
- Systems combining animals and annual cropping are of two sub-types:
  - Systems involving non-ruminants, ponds and fish eg. Vegetables- pigs
    - ducks- fish systems (Vietnam), Rice- maize- vegetables- sweet potatoes- pigs – dairy cattle (China)
- Systems combining animals and perennial cropping are of two sub-types:
  - Systems involving ruminants eg. Coconuts – sheep integration (Philippines); oil palm – cattle integration (Malaysia)
  - Systems involving non-ruminants eg. Oil palm – chickens integration (Malaysia).
- Forage DM availability: 2.99- 2.16 mt/ ha for 3 and 5 year old palms reducing to 435-628 kg/ ha for 10-29 year old palms (Chen et al., 1991)
- 60-70 forage species in young palms, which are reduced by about 66% in older palms
- Carrying capacity: 3 steers / ha in 3-4 year old palms to 0.3-0.4 steers /ha with over 7 year old palms,

Types of ruminant-livestock integration

1. Beneficial effects of shade on livestock
2. Draught animal power on land preparation and crop growth
3. Effects of dung and urine on soil fertility and crop growth tree cropping.
4. Use of crop residues from trees in situ
5. Use of native vegetation and effects on cost of weed control, crop management and crop growth, and
6. Type of animal production systems (extensive, systems combining arable cropping, and systems integrated with plantation)
Economic Impact

Summary from 21 case studies involving cattle:

1. **Increased animal production and income**
   - Due to increased productivity and meat off-takes

2. **Increased yield of FFB and income**
   - By about 30%, and measures of 0.49 – 3.52 mt/ha/yr.

3. **Savings in weeding costs**
   - By about 47-60%, equivalent to 21 – 62 RM/ha/yr.

4. **Internal rate of return (IRR)**
   - The IRR of cattle under integration was 19% based on actual field data.

5. **Potential further income**
   - Integration with goats can potentially further increase income.

Include *inter alia* the following:

- Poor awareness of the potential of integrated systems eg. oil palm and ruminants
- Resistance by the crop-oriented plantation sector
- Inadequate technology application
- Problems in the supplies of animals
• High prices for crude palm oil
• Unattractive investment climate
• Weak inter-agency-private sector collaboration, and
• Absence of policies to promote integrated systems.

➢ Integrated ruminant – oil palm systems are potentially very important and are underestimated
➢ Ruminants enhance increased animal protein supplies, value addition in the oil palm and sustainable development
➢ Wider adoption of the systems is constrained by a lack of policy, high prices for crude palm oil, complacency, and inadequate technology application

➢ The economic impacts are considerable and are highlighted in several case studies
➢ Demonstrable environmental sustainability is evident
➢ Overcoming the constraints and building partnerships between various agencies and the private sector constitute the challenges for the immediate future.

4. **Intensive or feedlot system (Beef cattle):**

• Practiced in large commercial lots and on smaller scale on various farms throughout the country.
• Fast growing cattle are housed in an enclosed area whereby feed and all amenities are provided in a cost-efficient manner.
• Feeder cattle are fattened between 90 to 150 days and finished between 350 to 500 kg depending on the initial weight and the desired target market
Animals on concrete lot

Feedlot operation
Intensive System
Breed of beef cattle

**British Breeds**

- Angus, Hereford, Shorthorn - they represent the largest segment of the beef industry.
Continental

- Limousin, Simmental, Charolais, Chianina, desired for their size and ability to grow
American Breeds

- Scientifically classified as Bos indicus, the most common type of American Breed is the Brahman.

American Breeds

- Other breeds developed from this line include; Brangus, Santa Gertrudis and Beefmaster (Synthetic breeds).
Exercise 1 / Activity 1

1.
2.
3.

Discussion 1

1.
2.
3.

Answers to Exercise 1

1.
2.
3.
4.

Answers to Discussion 1

1.
2.
3.
UNIT 8
POULTRY

Introduction

This module is designed to provide information of poultry production in Malaysia. Poultry industry has been transformed from a cottage industry to a dynamic, fully coordinated system of production, processing, and marketing. Poultry applies to chickens, turkeys, geese, ducks, pigeons, peafowls, and guineas. The success of modern poultry operation depends on many factors: Hatchery operators must care for breeding stock properly so that the eggs of good quality are available to the hatchery, and they must incubate eggs under environmental conditions that ensure the hatching of healthy and vigorous birds. Feeding, health, and financial programs are also essential to sound poultry management.

Learning outcomes

At the end of this unit, students able to:

1. Gain a greater understanding of poultry production in Malaysia
2. Understand the various types of poultry
3. Understand the management of poultry, different type of poultry production system
4. Gain knowledge in contract farming and integration
5. Gain knowledge in egg production (Layer industry) in Malaysia
Main points

1. Overview of poultry production in Malaysia
2. Types of poultry
3. Poultry Management
4. Housing type
5. Contract Farming
6. Egg production (Layer industry)

OVERVIEW OF POULTRY PRODUCTION SYSTEM

• Status of poultry industry in Malaysia
  o Leads the livestock sector
  o Contributes more than 70% of the subsector output value
  o Highly commercial oriented, from small independent farmers to large multinational integrators with farm-food processing-retailing integration

• Importance of livestock industry in Malaysia
  o Poultry industry is dynamic
  o Short period required for growth and marketing
  o Can adjust rapidly to changing economic factors: feed availability, cost, number of birds on feed
  o Other livestock require longer length of time to market
  o Poultry convert feedstuff to food efficiently
  o Layers provide continuous source of food
  o Presently Malaysia is self sufficient in meeting the country’s demand for broiler meat
  o Malaysia has one of the highest per capita consumption rates in the world for chicken

• Current marketing structure of poultry industry:
  o 70% of broilers go through wet market
  o >99% of table eggs reach customer as fresh in-shel eggs
  o Short farm to consumer market chain
- Present customer of the industry
  - Malaysian population of 29 million
  - Singapore population of 4.48 million
  - Export small quantities of poultry to Brunei and Japan
  - Export surplus table eggs to Indonesia and Hong Kong
- Products from poultry

**FRESH PRODUCTS**

<table>
<thead>
<tr>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live broiler chicken (white)</td>
</tr>
<tr>
<td>Live kampong chickens (include brown broilers)</td>
</tr>
<tr>
<td>Culled layers</td>
</tr>
<tr>
<td>Processed chickens (whole birds)</td>
</tr>
<tr>
<td>Spring chickens</td>
</tr>
<tr>
<td>Caponised chickens</td>
</tr>
<tr>
<td>Regular eggs</td>
</tr>
<tr>
<td>Kampung chicken eggs</td>
</tr>
<tr>
<td>Designer eggs</td>
</tr>
<tr>
<td>Organic chickens</td>
</tr>
<tr>
<td>Residue-free chickens</td>
</tr>
</tbody>
</table>

**SEMI-PROCESSED PRODUCTS**

<table>
<thead>
<tr>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut-up parts</td>
</tr>
<tr>
<td>Deboned meat</td>
</tr>
<tr>
<td>Minced meat</td>
</tr>
<tr>
<td>Chicken legs</td>
</tr>
<tr>
<td>Internal organs</td>
</tr>
<tr>
<td>Salted eggs</td>
</tr>
<tr>
<td>Desiccated egg yolks</td>
</tr>
<tr>
<td>Eggs from hatcheries</td>
</tr>
<tr>
<td>Liquid eggs</td>
</tr>
<tr>
<td>Powdered eggs</td>
</tr>
</tbody>
</table>
Processed products

- Number has increased dramatically since 1970s because of low cost of poultry and its versatile, bland flavour
- Processing of poultry products into convenience foods
- Burgers, nuggets, bologna, smoked chicken,
- Satay, fritters, chicken frankfurters, chicken
- meatballs, chicken cocktail sausages
- Fully cooked range of quick-serve products
- Frozen marinated chicken
- Chicken floss
- Chicken BBQ products

- Chicken Vocabulary

  o Species: Gallus gallus
  o Cock: Male chicken
  o Hen: female chicken
  o Pullet: female under six months, non laying
  o Capon: neutered male chicken
  o Broiler: Raised for meat
  o Layer: egg production
  o Brooding: the raising of baby chicks

TYPES OF POULTRY

- Layer chicken
- Broiler chicken
- Breeder chicken
- Bantam chicken
- Village chicken
- Ducks
- Quail
- Swiftlet
- Turkey
- Goose
- Guinea fowl
- Rhea
- Pheasant
- Emu

<table>
<thead>
<tr>
<th>Uses of poultry</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken</td>
<td>Meat, eggs, feathers, ornamental</td>
</tr>
<tr>
<td>Duck</td>
<td>Meat. Eggs, feathers</td>
</tr>
<tr>
<td>Quail</td>
<td>Meat, egg</td>
</tr>
<tr>
<td>Turkey</td>
<td>Meat feathers</td>
</tr>
<tr>
<td>Ostrich</td>
<td>Meat, feathers, leather, oil</td>
</tr>
<tr>
<td>Goose</td>
<td>Meat, feathers, eggs, guard</td>
</tr>
<tr>
<td>Guinea fowl</td>
<td>Meat, alarm calling</td>
</tr>
<tr>
<td>Rhea</td>
<td>Meat, leather, oil, eggs</td>
</tr>
<tr>
<td>Pheasant</td>
<td>Meat, ornamental, game</td>
</tr>
<tr>
<td>Emu</td>
<td>Meat, leather, oil</td>
</tr>
</tbody>
</table>

**CHICKEN BREEDS**

**DUAL PURPOSE**

- Rhode Island
- Delaware
- Malans
- Plymouth Rock
- Brahma
- Rhode Island White
**TURKEY BREEDS**

in US and Canada 2nd only to chicken

- Black
- Bourbon
- Bronze
- Slate
- White
- Royal Palm
- Narragansett

---

**QUAIL BREEDS**

- Over 100 wild quail breeds mostly in Asia & N. America - 2 main groups - New World Quail and Old World Quail
- Old World Quail - members of phasianidae family - most popular is Japanese Quail - most modern domesticated quail has been bred from Japanese strains
- Common breeds include:
  - Japanese Quail
  - Bobwhite Quail
  - Californian Quail
BROILER PRODUCTION

- Meat-type chicken reared for meat production
- Mainly white-feathered
- Bred for fast growth
- Male and female
- Attain 2 kg as early as 40 days
- Market age 35-42 days
- Very efficient – FCR 1.7-1.9 over 40 days
- High livability - > 95%
- Major hybrids – Cobb, Ross, Arbor Acre, Hubbard, Avian

- Rearing System
  - Free range – very rare, non-commercial
  - Semi-intensive – rare - brown broilers
  - Integration / mixed – rare – brown broilers
  - Intensive – open-house, litter or raised floor
  - Intensive – closed – current practice

1. Semi-intensive
  - practised for brown broilers and kampong chicken
  - Litter floor shed
  - 18-19 birds/sq meter
  - Chicken are free within fence in-area
  - Feed and water provided in the shed
2. Intensive System

- Practised for all white broilers and some brown broilers
- Chicken are confined throughout their life
- Raised floor or litter floor open shed
- 1-storey or 2-storey closed house
- Feed and water provided in the shed

<table>
<thead>
<tr>
<th>Advantages of Raised Floor</th>
<th>Disadvantages of raised floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Low occurrence of breast blisters</td>
<td>- High construction cost</td>
</tr>
<tr>
<td>- Good air flow and ventilation</td>
<td>- Feed wastage due to spillage</td>
</tr>
<tr>
<td>- Higher stocking density of litter floor</td>
<td></td>
</tr>
<tr>
<td>- No litter problem</td>
<td></td>
</tr>
<tr>
<td>- Ease of management of droppings (feces)</td>
<td></td>
</tr>
<tr>
<td>- Ease of cleaning sheds</td>
<td></td>
</tr>
<tr>
<td>- Minimum parasitic infection</td>
<td></td>
</tr>
<tr>
<td>- Shed dry</td>
<td></td>
</tr>
<tr>
<td>- Low accumulation of ammonia</td>
<td></td>
</tr>
</tbody>
</table>
Litter Floor

Advantages of Litter Floor
- Less feed wastage
- Low constriction cost

Disadvantage of Litter floor
- Problem in supply of litter material
- Occurrence of wet litter when there is a leakage in the drinking system
- Litter needs to be well managed
- Breast blisters
Closed house

Advantages of closed house
- Easy to control disease and manage birds
- Minimum fly and odor problem
- Improve growth performance

Disadvantage of closed house
- High cost
3. Integration system

- Rearing of chickens together with crops or other animals
- At least one component/commodity benefit from the system
- Crops provide shed to the chicken while droppings provide organic fertilizer to the crops
- Integration of chicken with major crops such as rubber, oil palm, coconut—10,000 birds/hectare
- Integration with aquaculture—chicken shed built at the corner of the pond

Broiler Integration

- Production of more uniform birds
- Professional approach in production, processing and marketing activities
- Improve overall efficiency
- Integrator performs all or most of production aspects
- Integrator owns breeders, hatchery, feed mill, processing plant
- Integrator provides chicks, feed, medication, technical advice
- Integration reduces cost by coordinating stages of production—control of resources and facilities for maximum efficiency
Advantages of Integration

- High cost efficiency
- More uniform flock
- Professional approach in processing and marketing activities
- Reduced management responsibilities of farmers
- Lessen production risk and risk of income loss
- Relatively fixed income – insulation against price changes
- Less operating capital

Disadvantages of integration

- Possibility of limited growth opportunity
- New building and expansion dictated by integrator
- Pressure to keep up with technological advances
- Possible lack of bargaining power

CONTRACT FARMING

- A business arrangement between integrator and individuals who own farm
  - Integrator agrees to
    - supply chicks, feed, medication and advisory services at agreed prices on credit
    - undertakes to buy back market age chickens at preagreed prices
- The contract farmer agrees to rear the birds and sell them to integrator at agreed prices
- Farmer’s income is from the difference between sale of chickens and all input costs provided by integrator
- Income determined by efficiency of production - growth rate, FCR, mortality
- Efficient production – min. 30,000 per crop/flocks
• Most efficient farmer – 5.5 crops/year

**Well-known Integrators**

- Leong Hup Holdings Bhd – Ayam A1
- Ayamas Food Corporation Bhd (KFC Holdings (M) Bhd) – Ayamas
- Charoen Pokphand (M) Bhd, Avian Farm – 5 Star, Ayam Pertiwi
- Sinnah Food Resources – Farm’s Best
- Malayan Flour Mill Bhd – Ayam Dindings

**Production Economics**

- Production costs – fixed costs + operational costs
- Fixed costs – land, house, farm equipment, office, store, workers’ quarters
- Operational costs – chicks, feed, labour, utilities, labour, medication, vaccines
- Costs – chicks (21%), feed (70%), miscellaneous (9%)
- Gross income = sale – operational costs
- Net income = gross income – fixed costs (annual)

---

**INDUSTRY FLOW CHART**

- Parent stock
- Hatchery
  - Day-old chicks (Broilers and layers)
  - Feed
    - Nutrition
    - Animal management
    - House & feeding management
    - Vaccines
  - Antibiotic & medicaments
  - Poultry meat and eggs
  - Equipment companies
    - Product processors
  - Feed suppliers and pharmaceuticals
    - Feed ingredients suppliers
    - Feed millers

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LAYER CHICKEN PRODUCTION

- According to the Federation of Livestock Farmers of Malaysia, there are approximately 374 layer farms in the country, producing 7,772 million eggs per annum.
- Six companies are thought to product in excess of 1 million eggs each day.
- All eggs are marketed through wholesalers as fresh in shell eggs, and there are presently two egg processing plants in operation producing various forms of liquid eggs for the bakery and confectionary industries.
- The DVM reports slightly different figures, reporting that egg production stood at 7,629 billion last year, an increase of 1.5% compared with the year before. For 2010, this is expected to climb to 8,295.
- Production on a daily basis ranged from 15.40 million to 25.03 million, and this is expected to stand at between 19.19 million and 26.78 million this year.
- Feeds account for 70-75% of production cost of chickens (layers).
- Malaysia exported almost 1.2 billion table eggs in 2010, which is about 14% of its total production and up by 43% on 2009 (833.64 million eggs). The bulk of these exports were to Singapore (763.32 million eggs - 63.9% of total exports). Malaysia has been the largest egg exporter to Singapore for several years. A far smaller but still significant amount of eggs is also exported to Indonesia (4.35 million eggs - 0.4%) and Hong Kong (1.53 million eggs - 0.1%). These exports were worth around RM 346.84 million.
- There are four egg processing plants with Veterinary Health Mark certification in Malaysia. However, there are no figures available for the export of liquid eggs in 2010.
- Malaysia also exports fertile eggs to Brunei and Sarawak. Around 849,900 fertile eggs were exported in 2010, with 59% destined for Brunei (345,900 eggs). This is a dramatic drop on 2009, when the country exported 3.19 million fertile eggs. Exports to Indonesia have been the main cause for this decline, accounting for 2.7 million eggs in 2009 and none in 2010. Around 970,000 day-old layers were exported to Singapore, Brunei, Sabah and Sarawak.
- Despite its healthy export trade, Malaysia imports a small amount of eggs and egg products: 3,268 metric tons of egg products and 149,400 specific pathogen-free eggs in 2010. In 2009, the country only imported 195 metric tons of egg products.

### Requirements for Layer Chicks and Pullets

<table>
<thead>
<tr>
<th>Nutrient / feed</th>
<th>Starter</th>
<th>Grower</th>
<th>Pre-lay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein, %</td>
<td>18-21</td>
<td>15-16.5</td>
<td>15-16</td>
</tr>
<tr>
<td>ME, kcal/kg</td>
<td>2800-2870</td>
<td>2750</td>
<td>2750</td>
</tr>
<tr>
<td>ME, MJ/kg</td>
<td>11.7-12.0</td>
<td>11.5</td>
<td>11.5</td>
</tr>
<tr>
<td>Ca, %</td>
<td>0.9-1.1</td>
<td>1.0-1.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Available P, %</td>
<td>0.4-0.5</td>
<td>0.35-0.4</td>
<td>0.4-0.45</td>
</tr>
<tr>
<td>Feeding guide</td>
<td>0-6 weeks</td>
<td>6-15 weeks</td>
<td>16-17 weeks</td>
</tr>
<tr>
<td>Form of feed</td>
<td>mash or crumble</td>
<td>mash or crumble</td>
<td>mash</td>
</tr>
</tbody>
</table>

### Egg Production Curve

![Egg Production Curve Graph](image-url)
Performance Indicators

- Feed conversion ratio – amount of feed (wt) to produce amount of egg (kg) – 2.0-2.2
- Hen-day production – (egg no. in a day / hen no. in the day) x 100
- Hen-house production – (egg no. in a day / original no. of productive hen) x 100
- Egg size or grade
- Others – mortality rate, egg quality

Factors Influencing Production

- Genetics – big size hens p.o.l. 20 weeks, small size hens p.o.l. 18 weeks
- Nutrition
- Lighting - > 12 h increases production
- Environment – high temp. heat stress
- Management – GMP
- Health – vaccination, disease monitoring

Layer Production Targets

- Weight of birds at point of lay (pol) age 20 weeks – 1.6-1.7 kg
- Age at 50% production 20-21 weeks
- To achieve targets – monitor body weight
- Mortality = grower stage - < 5%, laying stage - < 11%

Layer Production

Layer chicks
day-old (38 g)

Debeaking
Vaccination

Point of lay
19-21 weeks
Weight 1.5-1.7 kg

Feed 45-46 kg
Mortality 10%
300 eggs/bird

End of economic laying
Culling
Weight 2.2 kg
**Nutrient Composition of Eggs**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Egg</th>
<th>Big LTK omega plus</th>
<th>Regular</th>
<th>Medium LTK omega plus</th>
<th>Regular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kcal)</td>
<td>83.3</td>
<td>84.1</td>
<td>74.2</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Protein, g</td>
<td>6.75</td>
<td>6.73</td>
<td>6.00</td>
<td>6.00</td>
<td></td>
</tr>
<tr>
<td>Total fat, g</td>
<td>5.65</td>
<td>5.73</td>
<td>5.10</td>
<td>6.20</td>
<td></td>
</tr>
<tr>
<td>Saturated fat, g</td>
<td>1.35</td>
<td>1.46</td>
<td>1.25</td>
<td>1.35</td>
<td></td>
</tr>
<tr>
<td>Monounsaturated fat, g</td>
<td>1.76</td>
<td>1.95</td>
<td>1.60</td>
<td>1.73</td>
<td></td>
</tr>
<tr>
<td>Polyunsaturated fat, g</td>
<td>1.21</td>
<td>0.86</td>
<td>1.10</td>
<td>0.79</td>
<td></td>
</tr>
<tr>
<td>Total omega-6, mg</td>
<td>850</td>
<td>790</td>
<td>760</td>
<td>725</td>
<td></td>
</tr>
<tr>
<td>Total omega-3, mg</td>
<td>360</td>
<td>69</td>
<td>320</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Omega-3 ALA, mg</td>
<td>280</td>
<td>29</td>
<td>236</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Omega-3 EPA+DPA+DHA, mg</td>
<td>100</td>
<td>40</td>
<td>84</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Vitamin E, mg</td>
<td>3.00</td>
<td>0.75</td>
<td>2.70</td>
<td>0.68</td>
<td></td>
</tr>
</tbody>
</table>

**DESIGNER EGGS**

- One of the ways to market a new product is to change the old product.
- The contents of the chicken egg can be changed in such ways as to be more healthful and appealing to a segment of our consumers who are willing to pay for those changes in the egg.
- "Designer eggs" are those in which the content has been modified from the standard egg.
- Lower cholesterol eggs (25% less than regular)
- Altering fats and fatty acids
Shell

- Egg’s outer covering
- 9-12% of total weight
- The shell is the egg’s first bacterial contamination
- Made of mostly calcium carbonate
- Shell strength is determined by a hens diet (particularly calcium) and thickness by a hens age.
Shell Membrane

- Inner and outer shell membrane.
- Protect against bacterial penetration
- Air cell forms between the two membranes.

Air Cell

- Empty space between the albumen and the shell.
- At the large end of the egg.
- When egg is first laid it is warm, as it cools, the content contracts and the inner shell membrane separates from the outer shell membrane forming the air cell.
- Air cell becomes larger with age
- Size of air cell is used in determining grade of egg.
**Albumen**

- Also known as “egg white.”
- Contains more than half the eggs total protein, potassium and sodium.
- More opalescent that white.
- Cloudy appearance comes from CO2 which escapes as the egg ages, so older eggs are clearer than fresh eggs.
- Tends to thin out with age.

---

**Germinal Disc**

- The entrance leading into the center of the yolk.
- Slight depression on the yolk
- If the egg were to be fertilized-the sperm would enter through the germinal disc.
- Where the females genetic material is found.
**Chalaza**

- Ropey strands of egg white which anchor the yolk in place in the center of the egg white.
- The more prominent the chalaza, the fresher the egg.
- Does not need to be removed.

**Vitelline Membrane**

- Also known as the yolk membrane.
- Clear seal which holds egg yolk.
- Protects the yolk from breaking.
- Is weakest at the germinal disc and weakens with age.
Yolk

- Yellow portion of egg.
- 33% of the liquid weight of the egg.
- Contains all of the fat in the egg and a little less than half of the protein.
- Contains more vitamins than the egg white.
- The yolk is a source of food for the embryo.

Grading of Eggs

- Grade is determined by interior and exterior egg quality.
- Grade is designated by letters: AA, A, B.
- AA is the best grade.
- There is no nutritional difference between the grades.
- Most B grades are used by institutional egg users and never make their way to the grocery store.
## Grades of Egg (Malaysia)

Genetics, nutrition, environment influence grade

<table>
<thead>
<tr>
<th>GRADES</th>
<th>EGG WEIGHT (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>&gt;70</td>
</tr>
<tr>
<td>A</td>
<td>65-70</td>
</tr>
<tr>
<td>B</td>
<td>60-65</td>
</tr>
<tr>
<td>C</td>
<td>55-60</td>
</tr>
<tr>
<td>D</td>
<td>50-55</td>
</tr>
<tr>
<td>E</td>
<td>45-50</td>
</tr>
<tr>
<td>F</td>
<td>&lt; 45</td>
</tr>
</tbody>
</table>

### Exercise 1 / Activity 1

1. 
2. 
3. 

### Discussion 1

1. 
2. 
3.
Answers to Exercise 1

1.
2.
3.
4.

Answers to Discussion 1

1.
2.
3.
UNIT 9
OTHER BREEDS OF LIVESTOCKS

Introduction

Deer is a protected wildlife animal that has a great potential for commercialization. Deer industry is a growing industry in Malaysia with the existence of several deer farms in Malaysia. Introduction of imported species from various countries in the industry indicate growing interest in this industry. Traditionally, buffaloes were raised by small farm holders for multipurpose in agriculture production. The local swamp buffalo have low meat and milk production and low reproductive efficiency due to long gestation period, long calving interval, silence heat and low conception rate. Introduction of various types of buffalo particularly river type buffalo from India and Pakistan has highly benefited the buffalo industry in Malaysia.

The swiftlet farming industry has the potential to grow into a multi million ringgit industry due to the industry’s relatively profitable risk-return profile as well as a continuously growing demand for edible birds nests by wealthy overseas countries.

Learning outcomes

At the end of this module, students will:

- Be able to identify the breed of livestock commercially reared in Malaysia
- Gain knowledge on population of each livestock species, characteristics and contribution to local industry
- Gain knowledge on the swiftlet industry and challenges
Important points

1. Main species of deer and buffalo reared in Malaysia and their production system
2. Population of deer and buffalo throughout the country, major farms
3. Products from deer and buffalo industry
4. Swiftlet industry and its contribution to local livestock industry

1. DEER INDUSTRY

- Generally kept in captivity by zoos and parks (eg: Palace, DBKL, Wildlife Dept)
- Commercial deer farms established by Department of Veterinary Services, private farms
- As an alternative for diversification of livestock industry
- Rapid development of the industry, with large importation of deer and venison from various countries

Purpose of deer farming in Malaysia

- Food – Venison
  Venison is the perfect red meat, with tremendous health benefits. Besides being a great source of protein and other necessary nutrients in the body, it is the perfect choice of health-conscious meat consumers

- Conservation
  The sambar deer particularly is in a unsecure situation. Previously categorised as Least Concern on the IUCN Red List, it has recently been upgraded to the Vulnerable category, due its decline. It faces a real threat of extinction. Conservation work by Department of Wildlife has focuses on
breeding program of Pure Sambar deer with the ultimate aim is to release breeding stocks of these animals back into their native environments to naturally increase wild population. Eg Sungkai Wildlife Reserve

- Velvet antler -- alternative medicine
  Deer velvet antler has been found to contain a variety of complex elements, including amino acids, enzymes, minerals, vitamins, fats. Deer velvet antler is now proving to be one of the most beneficial products in alternative medicine. Oriental physicians have regarded it as an essential health and energy.

- Breeding
  Breeders primarily breed deer for stock. Deer may be sold to other breeders who are bringing in new stock or who are just getting started.

- Research
  Research on deer are conducted to develop scientific basis for sustainable management and production of deer. These research may includes but not limited to ecology, genetics, reproduction, nutrition, and behavior.

- Craft
  Shed antlers have been used by craftspeople since ancient times to make tools, weapons, ornaments, and toys.

Deer species

- Sambar deer (Cervus unicolor) - indigenous to Malaysia
- Rusa deer (Cervus timorensis)
- Red deer (Cervus elaphus)
- Sika deer (Cervus nippon)
- Fallow deer (Damma-damma)
- Chital deer (Axis-axis)
Production System

- Free range system
  - Animals are allowed to grazed on pasture and rotated in the paddocks at a stocking rate of 10 -14 animals per hectare
  - Most popular system
  - Adopted by government and state farms since land is not a constraint

- Semi wild system
  - Adopted by Department of Wildlife and National Parks
  - Conservation of forest
  - The undergrowth is cleared and suitable pasture is cultivated
  - Supplementation of feed and salt licks are provided regularly

- Integrated farming
  - Deer are raised under permanent crop like coconut and oil palm
  - Not very popular system

- Intensive farming
  - Also not very popular
  - Reason:
    - Venison for export market fetches high price only when it is raised under wild or semi wild condition
    - The deer must be tame if any success is to be achieved

2. BUFFALO INDUSTRY

Historical perspective:

The water buffalo is an economically important animal in South East Asia both for draught and meat purpose. Buffalo used to be the source of draft on traditionally wet paddy rice production system and oil palm harvesting. The swamp buffalo does not produce sufficient milk to allow it to be classified as a milk animal but is regarded as an excellent meat type. The river type is exemplified by the Indian and sub-continent
breeds, which is considered under dairy category because it possesses high genetic capacity for milk production.

In Malaysia, the domestic water buffalo, has been classified into the River and Swamp types. In early 2000, the total population of buffaloes in Malaysia was about 170,000. They were mostly concentrated in the rice growing states of Kelantan, Terengganu, Kedah and Pahang in West Malaysia (60 percent). The Swamp buffalo is used for ploughing, harrowing and working in the rice fields. At the end of its working life, the Swamp buffalo is slaughtered and in this way accounts for about 16 percent of the current meat supply in Malaysia.

The population of River buffaloes is less than 2,000 head of Murrah buffaloes brought by Indian immigrants at the beginning of the 20th Century. However, with the importation of various types of buffalo particularly river type buffalo from India and Pakistan by Department of Veterinary Services has highly benefited the buffalo industry in Malaysia.

**Buffalo production after 1970’s**

- Reduced preference for buffalo as drought animal
- Substitution of buffaloes with farm tractors in rice lands and in palm oil plantations
- Rapid decline in buffalo population

**Current status**

- Transforming the swamp buffalo to producers of milk and meat by organized crossing and backcrossing with the river type
- Commercialization of other by-products – hides and skin, hairs, horns
- A need for conservation

**Factors of reduction in buffalo production**

Over the past two decades, there has been an alarming decline in the buffalo population in Malaysia with an average rate of population decline of 1.2 percent per year. This decline has been attributed to the displacement of buffalo by machinery for draught power in the rice fields, a low reproduction rate and a high extraction rate. Most farmers in rice-growing areas
discontinued the rearing of buffaloes due not only to labour shortages, but also to the limited availability of grazing land. Lack of superior breeds, reproductive problems and susceptibility to endemic diseases (HS, FMD)

**Types of buffalo**

1. Swamp buffaloes are from China, Southeast Asia, Philippines, and Indonesia. These animals are used primarily for draft purposes and have broad, wide horns, a chevron on the chest, legs lighter in color, and larger hooves. eg. Kerbau sawah (Malaysia), Ai Tui (Thailand), kerbau rawa (Indonesia)

   **Characteristics of Swamp buffalo**

   - Black or dark brown skin.
   - A white line beneath neck and throat.
   - Poor heat tolerance, like to soak in water.
   - White from knee caps down.
   - Crescent shape horns.
   - Dual-function: Milk and meat, but milk yield is low
   - Male body weight at 2-year old 415Kg , Female body weight at 2-year old 398Kg
   - Chromosome constituent, 2n = 48

2. River/water buffaloes are from India and Pakistan. These animals are used primarily for dairy products and meat production, have tightly curled horns, and hold their heads high.

   **Examples of river/water buffalo:** Murrah, nili-Ravi, Surti, Kundhi (India & Pakistan), Binhu (China), Carabao (Philippines)

   **Characteristics of Murrah buffalo**

   - Body: Sound built, heavy and wedge shaped
   - Body colour: Jet-black. White markings on face and leg extremities may be there
   - High resistance to diseases and adapt well to hot weather
- Dual-function: Milk and meat
- Meat production ~50% from body weight
- Produce high butterfat (16%), basis for Mozarella cheese production
- Milk production ~ 1500 -1800L/lactation
- Chromosome constitution: 2n=50

**Buffalo Production system**

- Intensive

- Extensive (open pasture)

- Semi-intensive
• Integration under oil-palm

Source: MARDI
3. SWIFTLET INDUSTRY

Historical perspective

The swiftlet farming industry in Malaysia only started to gather momentum after the Asian Economic Crisis of 1997-1998. During that period, many businesses, especially small to medium sized businesses, experienced hard times and a great number of them closed down throughout the country.

The premises that these businesses were located in were left empty due to the fact that no other businesses had sprung up to take their place as a result of the depressed economic environment at that time. Rather than leave their properties idle, quite a number of the landlords for these properties then had decided to convert their untenanted properties into swiftlet farms.

Current status

Five years ago, the number is less than 1,000, to date it is nearly 50,000. In recent years, due to the high growth of the industry, efforts of swiftlet ranching, improvement of swiftlet farms’ environment such as humidity and temperature inside the houses and techniques to increase the quantity of swiftlets have contributed to the success and continuous development in the industry. Currently, the business of swiftlet farming essentially involves the conversion of people-centric buildings into buildings used to house a certain species of swiftlets (i.e. the white edible birds’ nests swiftlets or the Aerodramus Fuciphagus species of swiftlets) that can only be found in the South East Asian region as well as the design and construction of these purpose-build buildings for the purposes of accommodating such swiftlet populations as well.

A continuous vocalization of swiftlet chirps are played throughout each and every day using speakers and audio systems installed within the buildings in order to attract the swiftlets into the buildings to mate and make their new home. Most swiftlet farms produce white edible birds' nests.
Major Areas of swiftlet farming

Located mostly in secondary and tertiary townships where food source is in abundance and pollution levels are relatively low or at minimum level.

Malaysia is currently the third largest producer of edible birds’ nests (7% of gross supply value) in the world, behind Indonesia (60%) and Thailand (20%). In 2006, a kilogram of unprocessed white edible birds’ nests is able to fetch around RM4,500 while a kilogram of processed white edible birds’ nests is able to fetch retail level price of RM15,000 to RM25,000.
Challenges in swiftlet industry that leads to failure

- Ignorant, adopt the wrong techniques for swiftlet farming
- Lack of understanding and misconceptions about swiftlets and swiftlet farming
- Selection of location for swiftlet farming
- Design of swiftlet houses
- "Copy-cat" or emulate the others
- Cease operation due to actions taken by local authority's

Such failure is attributable to the lack of proper and reliable information with regards to the nature of the industry, insufficient capital in establishing productive swiftlet farms and lack of access to proper and effective swiftlet farming equipment.

Conclusion

Buffalo, deer and swiftlet are among other breeds of livestock that economically important for Malaysian Agricultural Industry particularly livestock production to a sustainable food supply and other related industries.

Activity 1

1. Name two commonly reared deer species in Malaysia
2. What are the two types of buffalo
3. List major locations with high swiftlet population
Group discussion

1. Discuss the production systems commonly practiced in deer production
2. Discuss factors that contribute into the declining of buffalo population in Malaysia
3. Discuss the major challenges faced by swiftlet farmers that could lead to failure

Answer activity 1

1. Sambar deer and rusa timorensis
2. River/water buffalo and swamp buffalo
3. Lumut, Klang, Melaka, Johor Bahru, Kota Bharu, Port Dickson, Kuala Terengganu

Answer group discussion

1. Production System of Deer in Malaysia
   - Free range system
     Animals are allowed to grazed on pasture and rotated in the paddocks at a stocking rate of 10 -14 animals per hectare
     Most popular system
     Adopted by government and state farms since land is not a constraint

   - Semi wild system
     Adopted by Department of Wildlife and National Parks
     Conservation of forest
     The undergrowth is cleared and suitable pasture is cultivated
Supplementation of feed and salt licks are provided regularly

- Integrated farming
  Deer are raised under permanent crop like coconut and oil palm
  Not very popular system

- Intensive farming
  Also not very popular due to the reason that:
  Venison for export market fetches high price only when it is raised under wild
  or semi wild condition, the deer must be tame if any success is to be
  achieved

2. Factors that contribute into the declining of buffalo population in Malaysia

- Increased mechanization
- Preference of cattle over buffalo – higher productivity
- Lack of suitable land for extensive farming
- Lack of superior breeds
- Reproductive problems
- Susceptibility to endemic diseases (HS, FMD)

3. Challenges in swiftlet industry that leads to failure

- Ignorant, adopt the wrong techniques for swiftlet farming
- Lack of understanding and misconceptions about swiftlets and swiftlet farming
- Selection of location for swiftlet farming
- Design of swiftlet houses
- "Copy-cat" or emulate the others
- Cease operation due to actions taken by local authority’s
UNIT 10
ANIMAL WELFARE

Learning Outcomes
At the end of this unit, students able to:

1. Able to understand the need for provision of optimum animal welfare

OUTLINE

1. Introduction
2. Animal welfare
3. Attitudes to welfare in agriculture
4. Welfare principles
5. 5 Freedoms
6. Significance of 5 Freedoms
7. How important are the 5 Freedoms?
8. Welfare problems
9. Why should we care about farm animals?
Introduction
Religious and legal rules are conditioned by historical, geographical and cultural contexts.
These rules are also expressed in terms of collective representations.
People of the Indus Valley civilisation (3000 - 1500 BC) believed that their ancestors will be reincarnated in animal form, brought about the religious belief that all animals must be treated with the respect.
The compassion for all life, both human and non-human exists in various cultures and religions, example, Native American traditions, Jainism, Hinduism, Buddhism and Islam.
For humans, the domestication of animals implies fine observation of their behaviour. This in turn induces changes in the perception of animals, and modifies the image and status of animals.

Animal Welfare
Animal welfare is a consideration of living, not dead animals, as it refers to a characteristic of the individual at a particular time.
The welfare of animals varies from very good to very poor, based on the attitude of people towards animal welfare (Figure 1).
An animal's welfare can be assessed scientifically using a variety of indicators.

Attitudes to welfare in agriculture
Animal welfare is a relatively new concept.
The attitude shapers normally refers to:
- Traditional practices.
- Economics.
- Practical imperatives.
- Only an issue for ‘animal rights extremists’.
• Hidden from scrutiny as insulated by the farm gate.
• Lack of opportunities for improvement.

Figure 1. Attitude of people towards animal welfare

Welfare principles
In 1965, Prof. Roger Brambell was commissioned by the British government to address the issues of intensively farmed animals that were highlighted by Ruth Harrison in her book Animal Machines, which was published in 1964. Harrison’s book criticised the way animals were farmed in Britain at that period. Issues that were raised by Harrison in her book were:
• Use of antibiotics.
• Intensive feeding programs.
• Indoor animal production.
• Space restriction.
Images of how animals were farmed in Britain in Harrison’s book sparked a great interest among the British public to demand for the then elected government to look into this disturbing situation.
The Brambell Committee established:

- The first guideline that recommended that “animal require the freedoms to "turn around, to groom themselves, to get up, to lie down and to stretch their limbs”.

The Brambell Committee emphasised the importance of behaviour and this has become the basis of laws in Europe and Scandinavia that require animal production systems to be designed and managed so as to allow animals to behave naturally, according to species-specific needs.

The Committee also founded the 5 Freedoms, which is internationally accepted as the starting points for good animal welfare.

At present, animal welfare societies who are concerned with:

- Quality of life issues.
- Minimizing suffering.
- A cost-benefit approach.

Animal welfare must not be mistaken as animal rights.

Animal rights followers:

- Adopt a non-consequential approach.
- Believe that there are certain actions we “must” do despite the consequences, hardships, or our disinclination to do it.

Animal rights doctrine are animals are not ours to eat, to wear, to experiment on, to use for entertainment and/or to abuse in any way.

The difference between animal welfare and animal rights is that animal welfare supporters are concerned with preventing suffering and cruelty to animals while animal rights groups intend to end all human exploitation of animals.

5 Freedoms

The 5 Freedoms are:

- Freedom from hunger and thirst.
  - By ready access to fresh water & food to maintain health & activity
- Freedom from discomfort.
- By providing a suitable environment including shelter, rest area etc.
- Freedom from fear and distress.
  - By ensuring conditions and treatment that avoid mental suffering.
- Freedom from pain, injury or disease.
  - By prevention or rapid diagnosis & treatment.
- Freedom to express normal behavioural repertoire.
  - By providing adequate space, proper facilities, company of animal’s conspecific etc.

In some circumstances it may be more appropriate to assess the inputs (husbandry resources) than assess the outputs (effects on the animal).
- For example, assessment of freedom from thirst can be made by looking for an easily-accessible water supply.
- However, assessment of fear would best be achieved by behavioural observations and measurement of the physiological stress response which are both outputs.

The Five Freedoms provide a convenient list of aspects that are considered to be important for all animals (Figure 2).

**Figure 2. Animal’s quality of life equated to the 5 Freedoms**

![Diagram showing the five freedoms from poor to good](image)

Figure 2 shows different freedoms across a scale from poor to good. The ‘poor’ side of the spectrum signifies that the particular need has not been met – on moving towards the ‘good’ end, we can show that the need (or freedom) has been fulfilled.

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An animal may have different levels of each of the five freedoms – some of the aspects may be good, while others may be poor.

**Significance of 5 Freedoms**

Welfare should be considered in terms of the 5 Freedoms.

The 5 Freedoms give an initial indication of what should be assessed and what should be provided to animals.

It does not define the minimum standards as it is extremely difficult to always provide all the Freedoms.

**How important are the 5 Freedoms?**

There was a greater proportion (70%) of extreme importance responses for hunger and thirst and pain, injury and disease than the other aspects.

However, overall at least 80% of all farmers thought that great or extreme importance should be placed on providing all 5 Freedoms.
This demonstrates that this group of individuals report a high level of concern for welfare.

**Welfare problems**

- Environmental challenge
  - Compare the environment of a wild animal versus that of an animal in captivity.
  - The wild environment is natural and unpredictable while the captive environment is artificial (unnatural) and predictable.
  - Wild animals are usually more active than the captive counterparts as the wild environment offers novelty and potential information(acquirement).
  - Environmental challenge is an essential part of behavioural development and welfare.
  - In the absence of environmental challenge, it gives way to lack of interest and boredom.
  - Example:
    - Extensive research on laying hens indicates that they have strong motivations to roost at night, to dust-bathe (grooming), and to nest when they lay eggs. The traditional barren “battery” cage does not have the space or the furniture to permit any of these highly motivated behaviours. Housing hens in large groups in barns, with perches, allows them to roost. However, if the birds are not raised with perches, they are unable to land properly when they fly up onto the bars, and many of them fracture their keel bone, partly because their high egg production predisposes them to osteomalacia. This problem may be prevented by ensuring that hens are exposed to perches when they are young chickens.
    - An alternative to a barren cage is the enriched cage developed in Edinburgh. This provides a dust-bath, a nest area, and a perch. The nest area slopes so the eggs that are laid roll out into a channel at the front and are easy to collect. The enriched cage still holds between 4 and 5 birds, but the quality of the confined
space that they are in is much higher than in a battery cage. 
Nevertheless they do not have the freedom of movement that 
hens kept outside do.

- **Hunger and thirst**
  - Hunger and thirst are the most basic, primitive and continuous of all 
motivating forces.
  - Complete failure to eat/drink will result in a reasonably rapid death.
  - Failure to satisfy any essential nutrient requirement will in due course 
result in illness, deterioration and in the end, death.
  - Mild deprivation of nutrients and water has little effect on health, activity 
or welfare.
    - No adverse physiological effects were observed when *ad libitum*
      water intake of experimental animals was reduced by 70 – 80%
      according to a study by Forbes in 1995.
  - Farm animal breeding stock selected for fast growth, so as to increase 
adult body size, are fed *ad libitum*. This practice increased the 
frequency of disease and reduced reproductive performance.

- **Pain and injury**
  - In livestock production, trauma may be induced or accidental.
  - This will modify the animal’s behaviour as pain renders individual 
unable to eat, ambulate etc.
  - The occurrence of pain may be a natural circumstance or may be 
caused by husbandry practices.
  - It is therefore importance for us to be able to recognise pain in animals, 
to enable appropriate steps to be taken to alleviate pain.

- **Fear and distress**
  - Fear is an emotional response to apparent threat which may be a 
response to novelty, innate threats and/or a previous experience.
  - An animal can either adapt or fail to adapt as a response to threat.
  - Assessment of fear can be done either physiological or behaviourally.
  - A fearful animal will have an impact on not only its welfare but also how 
the animal is managed on the farm.
- Fear can be alleviated by either providing an enriched environment, frequent handling or contact between the animal and the stockperson, and/or through selective breeding of calm less fearful animals.

- Behavioural restriction
  - The normal behavioural repertoire of an animal is suppressed due to the way the animals are managed or due to confinement.
  - All farming systems restrict normal behaviour to some extent.
  - Examples:
    - Fences and housing restrict normal ranging behaviour.
    - Controlled breeding restricts normal sexual behaviour.
  - Some restrictions of normal behaviour, such as farrowing crates, are obvious (Figure 3a).
    - Farrowing crates restrict movement (in order to prevent piglet crushing) and this prevents many aspects of normal behaviour, such as maternal behaviour and social interaction with other adults.
  - However, some restrictions are only highlighted after scientific investigation. For example, the lying surface in a cubicle shed can affect the lying time as much as the design of the cubicles (Figure 3b).
    - The animal performs a series of body postures where the centre of gravity of the animal is moved along the longitudinal axis to ease the load on the limbs and hooves, and to utilise the momentum of the body movement to accomplish rising actions (Figure 4).
Figure 3. Restriction of normal behaviour (a) farrowing crate and (b) dairy cattle cubicle shed.

Figure 4. Body postures of a rising cattle

Why should we care about farm animals?
Is it because:

- They are capable of feeling pain?
- They have a certain level of intelligence?
• We value life?
• They are worthy of respect?
• Healthier animals mean healthier food?

Attitudes are changing because:
• There is a great expectation from the community and consumers.
  - Community can change policies by voicing out their opinions to their community’s elected representatives.
  - Consumers’ behaviour has an effect on the livestock market.
• More research are currently being conducted linking welfare and productivity, and evaluating risks and finding solutions to improve farmed animals’ welfare.
• Resources are available to fund various researches to improve and promote welfare standards of farmed animals.

References
