How the digestive system works

Ingestion of food

• Need to watch for predators as they eat
• Wide visual field
• Don’t see what they eat

Teeth

• Adapted for a fibrous diet
• All teeth continually grow and erupt through life
• 'Peg teeth' are a feature of lagomorphs
• Brown staining on teeth is normal in rabbits that eat grass

Dental terminology -based on human teeth

CROWN
Part of the tooth that protrudes into oral cavity. Encompassed in enamel

NECK
Junction between crown and root

ROOT
Section of tooth that is buried in jaw. Differentiated from crown by lack of enamel

APEX
Apex - point of cone - refers to tip of conical root of tooth buried in jaw

Terminology in relation to rabbit teeth

• Whole tooth encompassed in enamel
• No neck
• No distinct root and crown
• Has led to some complex terminology

“Correct” terminology in relation to rabbit teeth

• Whole tooth is 'anatomical crown'
• Reserve or clinical crown
• Apex
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**Terminology used in this presentation**

- **Occlusal surface**
- **Crown**
- **Root**
- **Apex** (even though it is not conical)

**'Open-rooted'- what does it mean?**

- Apex of tooth is open i.e. pulp cavity is not enclosed in dentine.
- Pulp cavity contains blood and nerve supply.
- Also cells that form new dental tissue.
- In rabbits this cells remain active throughout life.
- Teeth continually grow.

**Continual eruption- what does it mean?**

- Eruption means 'breaking out' or 'becoming visible'.
- Horse's teeth (and many other mammals) erupt but don't grow.
- The tooth is fully formed but continues to erupt throughout life.
- Rabbit's teeth erupt and grow throughout life (open-rooted).

**Structure of the teeth**

- Large incisors.
- Premolars and molars are indistinguishable and form a row of cheek teeth.
- Each tooth is grooved so it is locked into the socket.

**Function of incisors**

- Biting through stems before moving food to cheek teeth.
- Gnawing.
- Fighting.
- Removing dead hair during grooming.

**Enamel ridges in cheek teeth**

- Normal cheek teeth have a fold of enamel fold in the centre.
- Forms a sharp ridge across the occlusal surface.
- Acts as a blade to cut through plant material during chewing.
Function of enamel ridges

- Ridges occlude with enamel edges of opposing teeth
- Act like a series of sets of scissors
- Food can also be crushed between the upper and lower teeth

Points

- The edge of each ridge form a point at the side of the tooth that is nearest the tongue
- Regular vertical points are normal
- Sign of good dentition
- Don’t need to be removed

Dental wear

- Teeth need to be worn away because they are continually growing and erupting
- Dental wear is affected by:
  1. Teeth wearing against each other i.e tooth-to-tooth contact
  2. Nature of material that is chewed i.e tooth-to-food contact
  3. Time spent chewing

Maintaining the shape of the teeth

- Fibrous food wears teeth down but also blunts them
- Tips of incisors and enamel ridges need to be kept sharp
- Shape of occlusal surfaces is maintained by periodic jaw movements made at rest
- Shape of incisors is maintained by protruding jaw

Tooth grinding to maintain the shape of the cheek teeth

- Occlusal surfaces of cheek teeth are maintained by periodic grinding movements
- Keeps enamel ridges sharp
- Movements are seen when rabbit is at rest
- Not same as tooth grinding that occurs in association with pain

Plants: the rabbit’s natural diet

Plants consist of:
- Roots
- Leaves
- Stems
- Flowers
- Seeds
- Fruit
Rabbits eat all these parts
Chewing and swallowing

- Food is cut into small pieces before it is swallowed
- Need good teeth to do this
- Size of the pieces of food probably affects digestion

Stomach

- Always contains food
- Usually contains caecotrophs
- Very distensible
- Strong cardiac sphincter that seals entrance to stomach
- Rabbits cannot vomit or eructate (burp)

Digestion in stomach and small intestine

- Same as in other species
- Protein broken down to amino acids that are absorbed
- Lipids are absorbed
- Starches are broken down to sugars
- Sugars are absorbed in the small intestine

What rabbits eat

- Rabbits eat all parts of plants including seeds, flowers and fruit
- Seeds and fruit contain sugars, starches, oils and protein
- These can be broken down and digested in stomach and small intestine

End of small intestine

- Small intestine ends in dilation called sacculus rotundus
- Feature of lagomorphs
- Contains a one-way (ileocolic) valve

T-junction with caecum and colon

- Sacculus rotundus opens into a T-junction
- Caecum one way
- Colon (large intestine) the other
- Caecum and colon are 'hindgut'
**Hindgut fermentation**

- Rabbits are ‘hindgut fermenters’ like horses, guinea-pigs, chinchillas
- All herbivores rely on microbes to break down plant material
- Ruminants (cattle, sheep) have large fore-stomachs
- Hindgut fermenters have large caecum full of microbes
- Each species is slightly different

**Hindgut in rabbits**

- Adapted to convert plant material to nutrients efficiently
- Colon is can separate contents into large and small particles and send them in opposite directions
- Means that material that can’t be broken down is swiftly expelled from the body

**Material that reaches the hindgut**

- Dietary fibre - i.e strands of plant material that cannot be broken down by digestive enzymes in stomach and small intestine
- Fur - this is also not broken down by digestive enzymes

**What is dietary fibre?**

- Strands of plant cell walls and substances that glue them together
- Mainly:
  - Gums
  - Pectins
  - Hemicellulose
  - Cellulose
  - Lignin

**Microbial digestion**

- Microbes can break down molecules that are not broken down by digestive enzymes
- Can convert plant material into nutrients
- Basis of herbivore digestive physiology

**Components of dietary fibre**

Some molecules are easily broken down by bacteria. Others aren’t
Structure of molecule

- Gums and pectins:
  - Easy for microbes to break down.
  - Soluble in water i.e. ‘soluble fibre’
- Hemicellulose and cellulose
  - More difficult to break down
  - ‘Insoluble fibre’
- Lignin
  - Impossible to break down
  - Often bound to cellulose
  - Included in ‘crude fibre analysis

‘Soluble fibre’ is fattening for rabbits

‘Low calorie’ foods for humans (such as fruit, peas, root vegetables) have a high soluble fibre content that is easily converted into energy sources and ultimately fat in rabbits.

Lignin

- Substance that provides rigidity to plants
- Lignin content increases with age
- Hay has more lignin than grass
- Wood has more lignin than hay
- Lignin has no nutritive value
- Cannot be broken down by microbes
- Cellulose that it is bound to can be broken down

Effect of particle size

- Microbes adhere to fibre particles to break them down.
- The greater the surface area, the more space for microbes
- Small particles have a larger surface area so they are broken down more easily than large particles
- Large particles tend to be composed of lignified material that is harder to break down.

Separation of particles in colon

- Colon adapted to separate contents into large and small particles
- Large particles (lignified fibre, fur) go through the colon to be expelled as hard faecal pellets
- Small particles go in the opposite direction into caecum

Hindgut motility

- Colon separates particles into large and small particles that are simultaneously sent in opposite directions
- Caecum slowly contracts to mix the contents
Meanwhile - in the caecum

- Caecum is full of microbes
- Nourished by nutrients and fluid entering it
- Buffered (maintaining correct acidity) by bicarbonate
- Contents are gently mixed by contractions
- Water and nutrients can be absorbed from caecum across the wall

Caecal microflora

- Huge range of organisms - bacteria, protozoa, yeasts
- Convert small particles into volatile fatty acids, amino acids, vitamins etc.
- Not all have been identified
- Lactobacillus and Saccharomyces cerevisiae (yeast) are not normal inhabitants (in some probiotics)

Balance of caecal microflora

- Affected by molecular structure of molecules that are present
- ‘Healthier’ on a high fibre diet
- Disruption of balance can cause disease
- Disease (enteritis) can cause disruption
- Some antibiotics can disrupt the caecal microflora
- ‘Dysbiosis’ means disruption of the microflora

‘Caecal dysbiosis’

- Sugars and starches are meant to upset caecal microflora and cause ‘caecal dysbiosis’
- Extrapolated to concept of ‘caecal diarrhoea’
- Widespread belief but no evidence
- Probably originates with carbohydrate overload theory

Carbohydrate overload theory

- Originates from commercial rabbits where 20% can die from enteritis
- Enteritis is caused by coccidiosis, viruses and other pathogens
- Pre-disposed by stress
- Linked with low fibre diets
- Someone came up idea that dietary carbohydrate may play a part

Originates with enterotoxaemia

- Enterotoxaemia is an acute, fatal diarrhoea
- Haemorrhagic
- Can be caused by several types of bacteria
- Usually Clostridia species
- Produce enterotoxins
- Enterotoxaemia is part of ‘enteritis complex’ of diseases that causes loss in commercial rabbits

Rare in pet rabbits
**Clostridium spiroforme**

- *Clostridium spiroforme* is a cause of enterotoxaemia in rabbits
- Proliferates if caecal microflora is disrupted
- The bacteria needs glucose to produce enterotoxin
- This has been extrapolated to the belief that high amounts of glucose will cause ‘caecal dysbiosis’

**Reasons why it doesn’t hold true for pet rabbits**

- Only ever a theory
- Applies to commercial rabbits not pets
- No evidence
- Adult rabbits digest starch and sugars so 99% is absorbed before it reaches caecum
- Caecal microflora naturally produces glucose
- *Clostridium spiroforme* causes fatal enterotoxaemia not soft caecotrophs

**Carrots aren’t dangerous**

- If it were true...
  - There would be a lot of dead pet rabbits

**Problem with fruit and sweet foods**

- Any food with a high soluble fibre content is fattening for rabbits
- Anything that can be pureed i.e. apples, pears, bananas, carrots, parsnips

**Products of microbial fermentation in caecum**

- Volatile fatty acids - acetate, lactate, propionate, butyrate
  - Energy source
  - Smell strongly
- Amino acids
- Vitamins
- Glucose and other sugars
- Gas

**Phases of digestion**

- Mixing and separating particles is the ‘hard faeces phase’ of digestion
- During this phase, rabbits are intermittently eating and filling their GI tract and expelling hard faeces
- Hard faeces are composed of large particles - mostly lignified fibre and fur
- Continues for most of day
### Soft faeces phase - caecal contraction

- Once (or twice) daily the gut motility alters
- Colon stops mixing and separating ingesta
- Caecum contracts to expel most of its contents into colon
- Expelled as ‘caecotrophs’

### Caecotrophs

- Mucus encapsulated
- Full of bacteria and other micro-organisms
- Smell strongly because of VFA (volatile fatty acid) content
- Smooth pasty consistency - look like diarrhoea
- Source of nutrients that are constantly available
- ‘Packed lunch’ rather than faeces

### Ingestion of caecotrophs

- Occurs during periods of rest
- Usually morning in pet rabbits
- Ingestion of caecotrophs is stimulated by hunger, smell and sensation
- Rabbits need to be able to reach their anus in order to consume caecotrophs

### Obesity as a cause of ‘caecal diarrhoea’

- Obesity prevents rabbits reaching anus to ingest caecotrophs
- Sugars and starches cause obesity
- More likely to be the link between ‘soft stools’ and starchy foods
- ‘Soft stools’ are caecaotrophs that haven’t been ingested

### Consistency of caecotrophs

- Probably not affected by sugar or starch content of diet
- Is affected by fibre content, especially lignified fibre that cannot be broken down
- Residual particles make caecotrophs firm

### Volume of caecotrophs

- Caecum is huge
- Comprises 60% of GI tract
- Most of its contents are expelled each day as caecotrophs
Digestion of caecotrophs

- Caecotrophs remain in fundus protected by mucus
- Microbial digestion continues to produce lactates and glucose
- Eventually digested and nutrients absorbed from stomach and small intestine

The end