Equine Digestive Physiology & Reading Your Own Hay Analysis

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Digestive Physiology

The Unique Features of the Equine Digestive Tract

The Equine Gastrointestinal Tract

- Hindgut Fermenters
- ~ 30 meters long & 200L volume
- Similar foregut (stomach and small intestine) to other monogastrics (humans, dogs, cats)
- Similar hindgut (cecum and large colon) to rumens of ruminants (cows, sheep, goats)
- Similar GIT to rabbits and elephants (also hindgut fermenters)

The Foregut: Enzymatic Digestion

- Includes Mouth, Stomach & Small Intestine
- Teeth grind and break up feed into boluses
- Salivary glands produce 35-40L saliva daily
  - Higher production with grass and hay
  - Lower production with grains and pellets
- Saliva
  - Virtually no digestive enzymes
  - Acid buffers ★
  - Electrolytes
  - Lubrication

Foregut: Enzymatic Digestion cont.

- Stomach
  - 8-15 L capacity
  - Mucous and Acid production
  - Liquefies feed
  - Partial breakdown of proteins
  - No digestion or absorption of major nutrients

Foregut: Enzymatic Digestion cont.

- Small Intestine
  - ~20 meters long, 60L capacity, 30% GIT
  - Rate of passage 45 -120min
  - Neutralizes acid from stomach
  - Enzymatic digestion of protein, starch, sugar, fat
  - Absorption of amino acids, simple sugars, fat, vitamins & minerals

Accessory Organs

- Pancreas
  - Produces Acid Buffers, Released into SI
  - Produces Digestive Enzymes, Released into SI
  - Produces Insulin, Released in bloodstream
- Liver ★
  - Bile Production for Fat Emulsification
  - Glucose and VFA Processing
  - Protein and Fat Processing

The Hindgut: Fermentation

- Site of Microbial Digestion thru Fermentation
- Includes Caecum, Large and Small Colons
- ~ 7 meters long, 125L capacity, 60% GIT
- Up to 48 hour rate of passage
- Horses do not have enzymes to digest fiber
  - Nor do any vertebrates!!
- Maintained in a relatively neutral pH (6-7)

The Hindgut: Fermentation cont.

- Caecum
  - ~1.2 m long, 30 L capacity, 15% GIT volume
  - Fermentation of Fiber: Structural CHO found in plant cell walls
  - Fermentation of excess/undigested NSC: starches, fructans
  - Volatile Fatty Acid (VFA) absorption
  - All B vitamin synthesis

The Hindgut: Fermentation cont.

- Large Colon
  - Right Ventral, Left Ventral, Left Dorsal, Right Dorsal
  - 3-3.5 m long, 75L capacity
  - Same function as Caecum, H2O absorption
- Small Colon
  - 3-3.5 m long, 20 L capacity
  - H20 absorption & digests segmentation

The Hindgut: Fermentation cont.

- Microbiology is important!
- Each ml of caecal fluid contains:
  - 10-50 billion bacteria, 1 million protozoa, variable yeasts and fungi
  - ~ 400 different species of microbes
- Complex interactive web between organisms
  - Waste products of some are food for others
  - Population of some affect population of others

Main Nutrients

Where and How Nutrients are Digested

Protein

- Requirements vary with age, development, level of exercise, pregnancy etc..
- Sources: grass, hay, soybean meal, flax meal, canola meal, hemp meal
- Digested and Absorbed in SI only

Non-Structural Carbohydrates (NSC)

- Simple sugars, starch and fructans
- Sources: grains, pellets, treats, interior of plant cells
- Cereal starches highly digestible (oats highest, corn and barley lowest)
- Physical and heat processing increases digestibility
- Intact/Untreated seeds, shells and plant cells are not digested★
- Simple sugars and starch digested and absorbed in SI only
- Fructans are not digested in the SI**

Structural Carbohydrates (SC) = Fiber

- Fiber fermented in hindgut
- Components of plant cell walls: cellulose, hemicellulose, pectin
- Sources: beet pulp, grasses, hays, soy hulls and other grain shells/hulls
- Plant components not fermented in hindgut: lignin, silica and some cellulose

Fermentation end products: VFA

- Main Types: acetate, propionate & butyrate
- Minor Types: lactate and succinate
- Rapidly absorbed in the hind gut
- VFA ratio vary with feed & cell structure
- Converted to either energy or glucose
- Slowly released into the horse's system

Microbiology Balancing Act

- Rate of fermentation depends on type of fiber
  - Less complex are fermented quicker: starch and fructans
  - More complex are fermented more slowly: cellulose and hemicellulose
- Different microbes use different types of fiber
- Diet affects hindgut pH and microbial populations

Nutrient Analysis

What It All Means

"As Fed" vs "Dry Matter"

- As Fed includes the moisture content of feed
- Dry Matter (DM) excludes the moisture content
- Feeds may be compared equally on a DM basis only
- Moisture Content should be <10% in hay

CP (Crude Protein)

- Does not indicate protein quality
- Acceptable range 10-14%
- Varies with age, development, workload etc.

ADF (Acid Detergent Fibre)

- Represents the least digestible/fermentable part of the plant: Cellulose and Lignin
- Higher ADF% = Lower Digestibility = Lower Energy
- More mature plants have higher ADF% (1st cut hay)
- Acceptable range <40%

NDF (Neutral Detergent Fiber)

- Represents total cell wall content of feed
- Includes Cellulose, Hemicellulose, Lignin but not pectin
- Higher NDF% = Lower feed intake
- Desirable range 50-60%
- NDF – ADF = ~hemicellulose% = 15-25%

Starch

- Digested in SI to simple sugars and absorbed in SI
- Limited enzyme production affects starch digestion in the SI
- Undigested starch overflows into the caecum causing digestive disturbances**
- Acceptable range is <1.2%

WSC (Water Soluble Carbohydrates) & ESC (Ethanol Soluble Carbohydrates)

- WSC = Simple Sugars and Fructans
  - Acceptable range is <14%, and <11% for EMS horses
- ESC = Simple Sugars only
  - Best indicator of effect on blood sugar levels
  - Acceptable range is <12%, and <8% for EMS horses

NSC (Non-Structural Carbohydrates)

- NSC = WSC (Simple sugars and Fructan) + Starch
- Feed primarily digested in SI and absorbed as simple sugars ★
- Acceptable range is <14%, and <11% for EMS horses**

Fructans

- Associated with laminitis
  - Rapidly fermented in caecum
  - Decreases caecal pH and increases Lactic Acid production and Lactobacillus spp.
  - Leads to death of protozoa (and other favourable microbes)
  - Endotoxin release and Lactic Acid Acidosis
  - Can lead to colic, diarrhea and laminitis
- WSC (simple sugar & Fructan) – ESC (simple sugar) = Fructan content
- Acceptable range is <4%

The Hay Analysis

Interpreting The Good, The OK, and The Garbage

Why so many variations in grass hay?

- Do not assume same hay analysis year to year
- Nutrient composition in hay varies on many factors
  - soil quality, weather conditions, water availability, fertilization, daylight hours, changes in temperatures (highs and lows), maturity of plant, time of day it is cut, time of year it is cut, number of times hay is cut, weather conditions pre-bailing, storage of hay, etc.
- Do not assume an unfertilized field = low sugar hay

How to Balance your Hay

- Mix hays to balance rations BY WEIGHT
  - Hay 1 has 6% CP and 16% NSC
  - Hay 2 has 18% CP and 8% NSC
  - Feeding 50% of each BY WEIGHT = CP 12% and NSC 12%
- Soak hays for 30-60 min to reduce sugar content
- Add hay cubes to increase protein content
- Use beet pulp or soy hulls to improve fiber content
- Don't buy poor quality hay!

How to Sample Hay for Analysis

- Gold Standard : Hay Drill
- Alternative:
  - Collect one handful from INSIDE of 10-12 hay bales
  - Thoroughly mix ALL hay samples together in dry bucket
  - Collect sub-sample to fill large Ziploc bag
- Hay Analysis is only as good as your sampling technique!

Take Home Messages

Straight from the horse's mouth

Hay: Major Diet Component

- Start with finding a GOOD QUALITY hay, dust free and mould free
- Should be MINIMUM of 50% in horses' diet BY WEIGHT
- Alfalfa should be MAXIMUM of 50% of hay fed BY WEIGHT
- Don't forget the importance of adequate FRESH WATER, vitamins and minerals
- Mix or add other hays or feeds when needed and know WHY you are giving them

Get a Hay Analysis

- Use hay analyses in choosing the right hay
- Use hay analyses in balancing different hays
- Hay analyses VARY from year to year
- Hay analyses are as good as their sampling technique

Other Feeding Instructions

- Cereal grains (and other NSCs) add rapidly available energy (sugars) for performance
  - No more than 4-5 lbs in one feeding (starch overload) for 500kg horse
- Fiber sources add slowly released energy and help with digestion and weight gain
- Fat sources help with weight gain and slowly released energy
  - Should be slowly incorporated in diet
- Consult your veterinarian for other special considerations

Grains & Pelleted Feeds

There's a place for them too

EAA (Essential Amino Acids)

- 12 of 22 AA are synthesized by the horse (Non-Essential AA)
- 10 others must be found in feed (Essential AA)
  - Lysine, Arginine, Histidine, Isoleucine, Leucine, Methionine, Phenylalanine, Threonine, Valine, Tryptophan
- The most deficient AA are called Limiting AA
- Building blocks for body's protein needs (muscles, milk, enzymes)
- Quantity of most limiting EAA affects protein development
- Protein Source Quality vs Quantity

Take Home Msg: Pellets & Supplements

- Read the ingredient list: Protein, Fat, Fiber, NSC, Vitamin or Mineral?
- Read the nutrient analysis or consult your veterinarian
- Don't forget about the NSC not listed
- Feed max 4-5 lbs in one feeding for 500kg horse★
- Case selection: Purpose? Risk? Deficiencies? Surplus?