
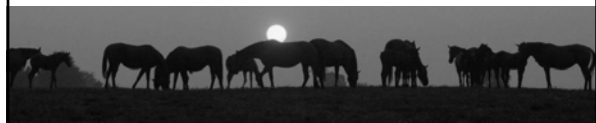



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Grasses, Sugars and Laminitis


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Carbohydrates & Equine Health


- Metabolic disorders
 - Insulin resistance
 - Obesity
 - Laminitis
 - Developmental orthopedic disease
- Digestive disorders
 - Colic
 - Laminitis
 - Diarrhea




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Words you should know

- Nonstructural carbohydrates
- Starch
- Sugar
- Glucose
- Insulin
- Glycemic index
- Glycemic response
- Insulinemic



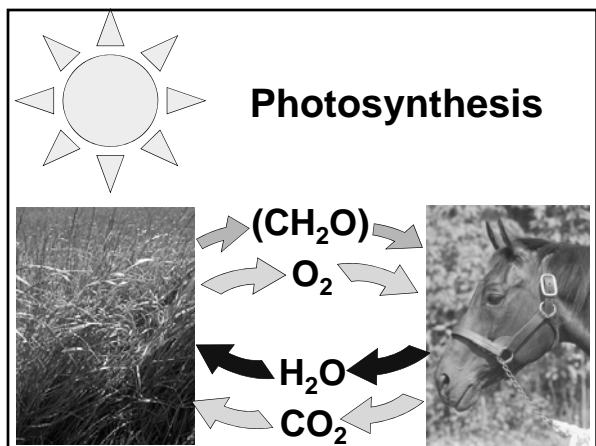
PENNSSTATE The Horse's Grazing Evolution



- Evolved in North America
- Extinction in Late Pleistocene
- Returned with Spanish missions in the early 1600's
- Rangelands
 - Low quality forage

GRAIN for Horses

- **ENERGY:**
 - more per unit weight, sustaining more **WORK:**
 - WAR (eg, Romans, 2 BC to 3 AD)
 - AGRICULTURE intensive (Europe, 17th C)
 - SPORT, hunting racing, polo
- **EFFICIENCY:**
 - less feces, urine, acid, heat
 - less bowel ballast;
 - “wasp waist” verses “hay belly”
- **COMMERCE:**
 - more consistent, easier transport



Photosynthesis

Carbohydrate Profiles in Plants

- Carbohydrates are major component of plant tissues
- Comprise 70-85% DM of forages

Structural Carbohydrates

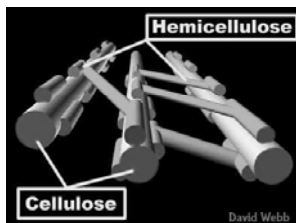
- Cell wall
- Cellulose
- Hemicellulose
- Lignin

Nonstructural Carbohydrates (NSC)

- Inside cells
- Sugar
- Starch
- Fructan

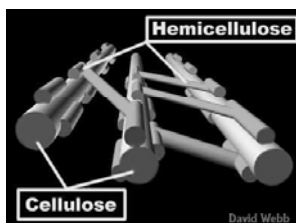
Hemicelluloses

- Structural carbohydrate
- Amorphous structure
- β 1-4 linkages
- NDF



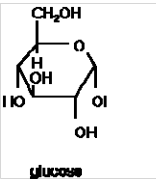
Celluloses

- Structural carbohydrate
- Long unbranched chains of glucose
- Fibers and microfibrils
- β 1-4 linkages
- NDF and ADF

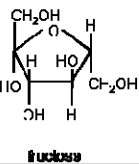


Sugars

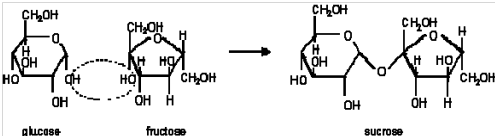
- Monosaccharides
 - Glucose
 - Fructose
- Disaccharides
 - Glucose + Fructose
 - Sucrose
 - Transport in plant
- Water soluble



glucose



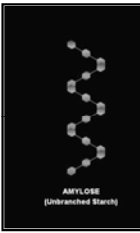
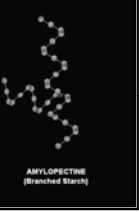
fructose



glucose + fructose → sucrose

Starches

- Polymers of glucose bound to one another by α 1-4 and α 1-6 linkages
- Important storage carbohydrate in all forages
- Main storage form in legumes
- Stored in chloroplasts of plant cells

Carbohydrate Analysis

% Acid Detergent Fiber	38.1	39.2
% Neutral Detergent Fiber	63.6	65.4
% NFC	13.4	13.8
% NSC	4.4	4.5
% Starch	1.4	1.4
% Sugar	3.0	3.0

2027 SULLYBROOK HILL RD
MIDDLEBURG, VA 20117-9201

Body wt = 1500 Fat % = 3.7 Tarsal % = 3.1

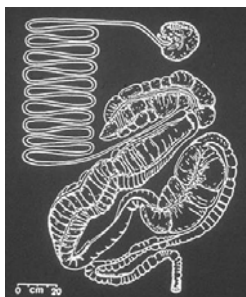
ENERGY TABLE - MEC 2001

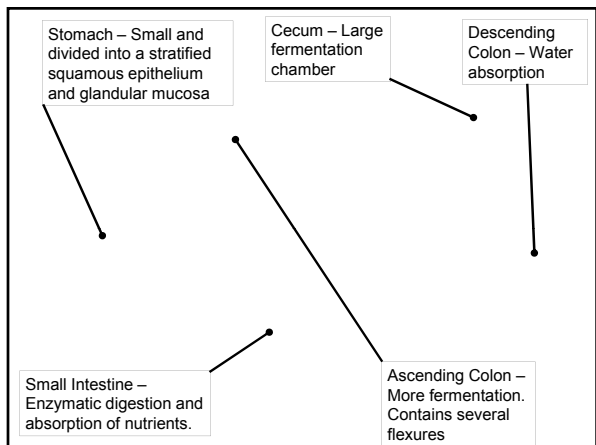
Milk, lb	MEC, Mcal/lb	MEC, Mcal/kg	Milk, kg	MEC, Mcal/lb	MEC, Mcal/kg
Dry	0.59	1.30	Dry	0.59	1.30
60	0.56	1.24	60	0.56	1.24
80	0.51	1.13	80	0.51	1.13
100	0.48	1.05	100	0.48	1.05
1200	0.44	0.97	1200	0.44	0.97
WBCR	0.36	0.79	WBCR	0.36	0.79
NEC3R	0.30	0.67	NEC3R	0.30	0.67
Milk	0.36	0.79	Milk	0.36	0.79
DLIX	1.16	2.55	DLIX	1.16	2.55
TDM18.8	1.56	3.45	TDM18.8	1.56	3.45

MEC, Mcal/lb	MEC, Mcal/kg	MEC, Mcal/lb	MEC, Mcal/kg
WFC	12.4	27.4	27.4
WNC	4.4	9.7	9.7
Starch	1.4	3.1	3.1
Sugar	3.0	6.7	6.7
Crude Fat	1.8	4.0	4.0
Ash	8.86	19.5	19.5
TDM	55	122	122
NEC1, (Mcal/lb)	0.46	1.02	1.02
NEC2, (Mcal/lb)	0.32	0.71	0.71
NEC3, (Mcal/lb)	0.22	0.49	0.49
Relative Feed Value	0.66	1.46	1.46
Calcium	0.10	0.22	0.22
Phosphorus	0.03	0.07	0.07
Magnesium	0.03	0.07	0.07
Potassium	2.61	5.80	5.80
Sodium	0.06	0.13	0.13
Iron	191	424	424
Zinc	15	33	33
Copper	5	11	11
Manganese	68	150	150
Niobium	0.00	0.00	0.00
Chloride, ion	0.40	0.88	0.88
Non-Nitrogen	42	93	93
Non-Nitrogen	0.94	2.08	2.08

Carbohydrate Analysis

- What to look for:
 - Generally a starch / content of less than 15% (yst et al., 1999)
- Think outside the box
 - Feed more than 2 meals per day
 - Simple glucose (SAG)
- A combination is necessary





Health and the Equine GI

- Evolved to utilize low to medium quality forage
- Stomach is divided and prone to ulcers
- Nutrients are “generally” exposed to enzymatic digestion prior to fermentative
- The gastrointestinal tract is not divided into “black and white” digestive regions, but is more likely “shades of grey”

Carbohydrate Digestion

The diagram illustrates the process of carbohydrate digestion. On the left, a horse's head and a horse's digestive tract are shown. An arrow points from the digestive tract to a chemical reaction diagram. The reaction shows a starch chain of four glucose units (represented by circles) with hydroxyl groups (HO-) on the left and hydrogen atoms (-H) on the right. A water molecule (H₂O) is added, and the chain is broken into two shorter chains, with a hydrogen atom (H) and a hydroxyl group (HO-) being released. An arrow points from this reaction to a stainless steel fermenter on the right.

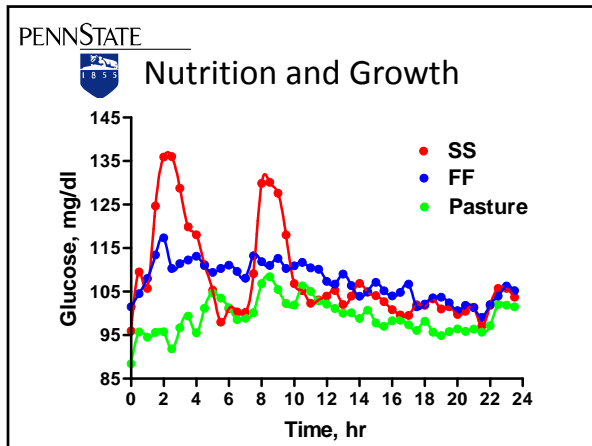
Digestion of Starch

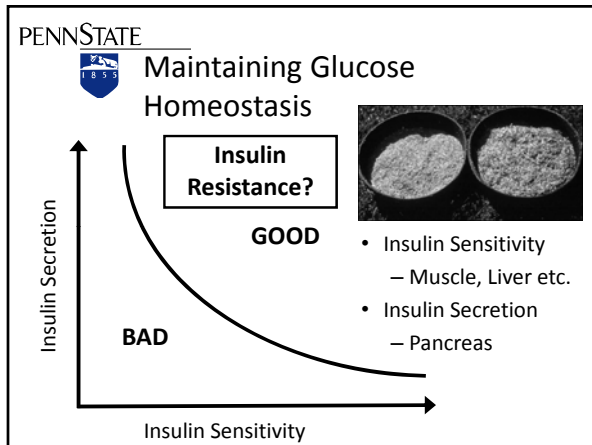
- **4 g/kg BW per meal; 2 kg / 500 kg H;**
Potter et al Pferdeheilkunde 1992
- **2 g/kg BW per meal !**
Meyer et al Z Vet Med 1995
- **Starch digestion** Massey et al *ENPS* 1985:
 - Intake 770 g
 - Prececal, 76%; Postileal, 24%

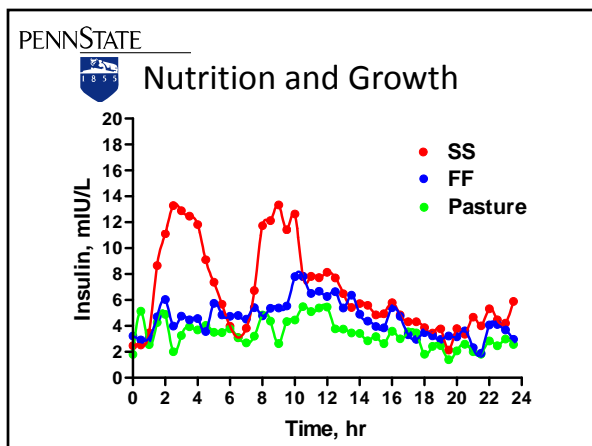
Fermentation

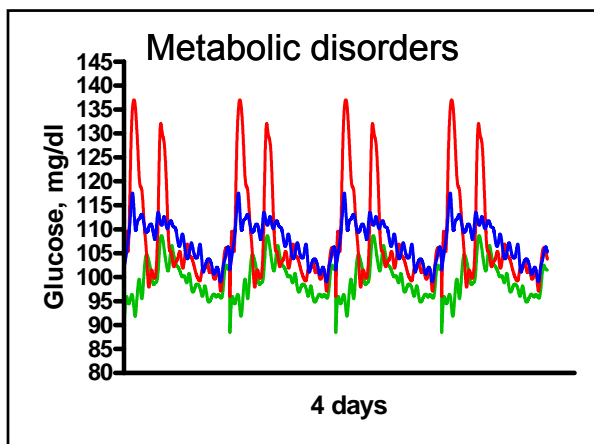
- All carbohydrates
- Cellulolytic fermentation
 - β – linkages (fructans, hemicellulose, cellulose)
 - **Slower rate and higher pH**
- Amylolytic fermentation
 - α – linkages (di, oligo, polysaccharides)
 - **Rapid rate and lower pH**

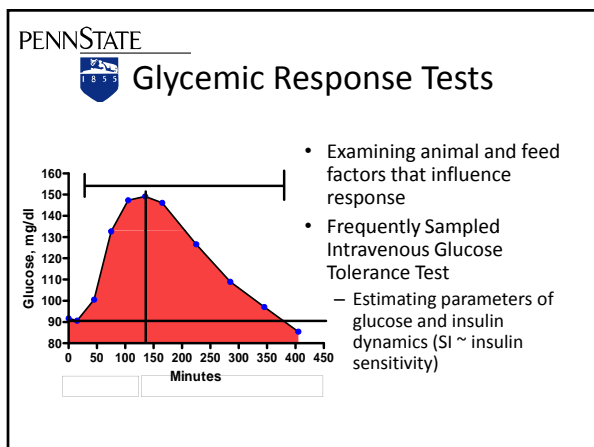
A photograph of a stainless steel fermenter, a large cylindrical tank with a lid and various ports, supported by a tripod stand.

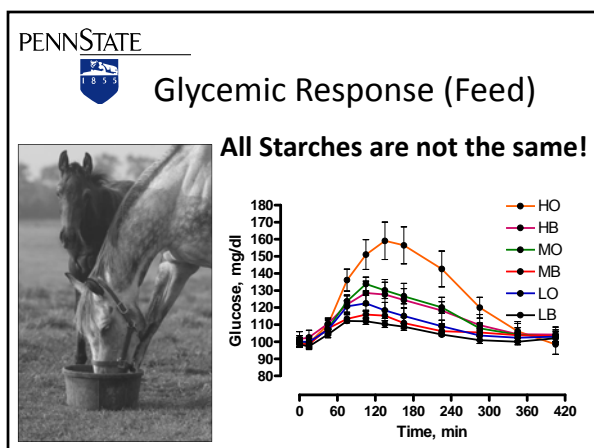




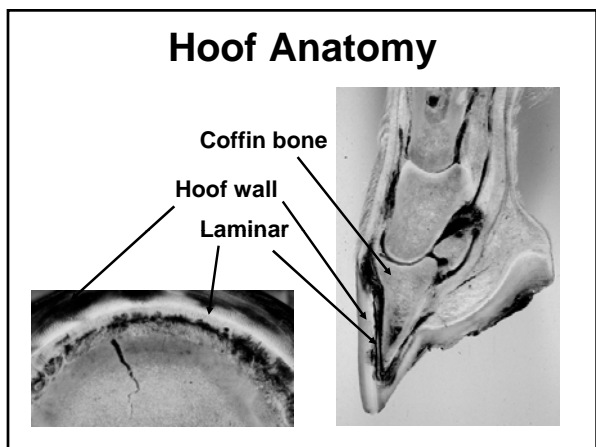














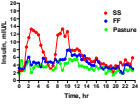
What is Laminitis?

- **A PAINFUL AND DISABLING DISEASE**
- Inflammation of the laminae of the hoof.
- Failure of the connective tissue that binds the inside of the hoof wall to the coffin bone (pedal bone, distal phalanx).

Politt, 1996



PENNSSTATE  **Pasture Laminitis / Carbohydrate Overload**

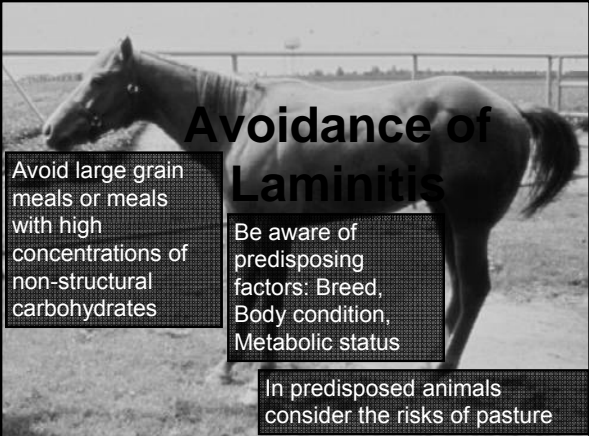
- Excess nonstructural carbohydrates
 - Sugars, Starches, and Fructans
- These carbohydrates have impact in two locations
 - Metabolic
 - Digestive



PENNSSTATE  **Forage Factors**

- Factors affect sugar content:
 - Temperature, species, nutrient status, water status, plant part, stage of growth, conditions during hay curing
 - Intensity and duration of sunlight (Think about time of day)
- Dry Lot or muzzle to control grass intake
- Choice of grass varieties may offer some solutions






Avoidance of Laminitis

Avoid large grain meals or meals with high concentrations of non-structural carbohydrates


Be aware of predisposing factors: Breed, Body condition, Metabolic status


In predisposed animals consider the risks of pasture

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Words you should know


- Nonstructural carbohydrates
- Starch
- Sugar
- Glucose
- Insulin
- Glycemic index
- Glycemic response
- Insulinemic




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Take-home Message

- Carbohydrates are an excellent source of energy for the horse
 - Be aware of advantages and disadvantages
- Dietary carbohydrates have both metabolic and digestive effects
- Nutrition during gestation and early development may impact future health and performance



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Take-home Message

- Low Starch < 15 % on a dry matter basis maybe even 10 %!
- Low Glycemic can only be determined by testing and is difficult to define
- There are numerous ways to address the concerns of laminitis in grazing horses
 - Restricted intake
 - Grass varieties
 - Exercise
