Glycemic Response, Insulin Resistance and Fructans in Horses

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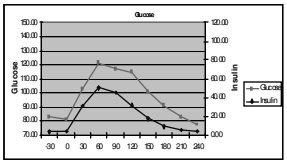
Glycemic

- ✓A food's ability to elevate blood glucose levels

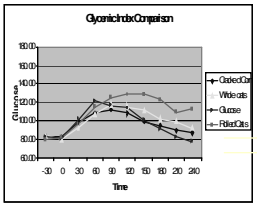
Glycemic Response vs Glycemic Index

- ✓Glycemic Response – how glucose is digested and absorbed into the blood. Physiological response
  - Magnitude
  - Time



Glycemic Response vs Glycemic Index

- ✓Glycemic Index – takes into account the glycemic response of different ingredients and compares them on a relative basis



Glycemic Index			
	Glucose	Corn	Rolled oats
Glucose	100	119	48
Cracked Corn	84	100	41
Whole Oats	136	162	66
Rolled Oats	208	247	100

Glycemic Index (GI)

- ✓Ranks foods according to their effect on blood glucose
  - In humans
    - Straight glucose = 100
  - In horses
    - Typical" baseline feed = oats(not as pure as sugar)

Limitations of GI

- ✓Scientific research
- ✓Wide variation in GI measurements
  - Horse baseline - oats???
  - Individual difference
  - Eating behaviour
  - Feeding management

Factors Affecting Glycemic Response

- ✓ Amount of NSC (Non-structural Carbohydrates)
  - Sugar/Starch content
- ✓ Other nutrients such as fiber and fat
- ✓ Meal size
- ✓ Starch source (oats, barley & corn)
- ✓ Processing
- ✓ Intake rate – eating behaviour
- ✓ Physiological state of the animal
  - Pregnancy, age & obesity
- ✓ Gastric emptying - fat
- ✓ Digestibility – source, processing & fibre

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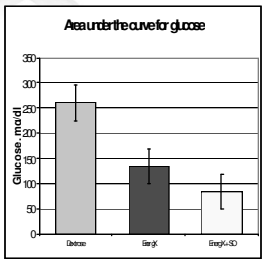
Effect of Fat on GI



- ✓2 modes of action
  - Slows gastric emptying
  - Negative effect on starch digestion

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Effect of Fibre on GI

- ✓Long stemmed fibre increases passage rate of grain (starch) through the small intestine. Thereby decreasing starch digestibility
- ✓What about fibre (soy hulls & beet pulp) in feed ?

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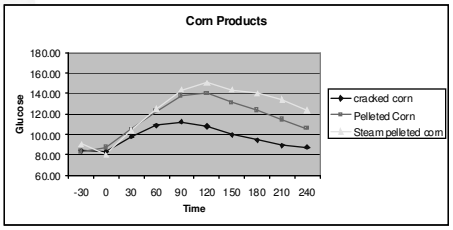
Glycemic Response due to Processing



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Conclusion on Processing

- ✓Processing does affect glycemic response and seems to flow with starch gelatinization
  - Processing increases GI
- ✓Initial ingredient does make a difference
  - Corn vs oat vs mixed grain products (more impact on higher starch ingredients)

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Glycemic Response

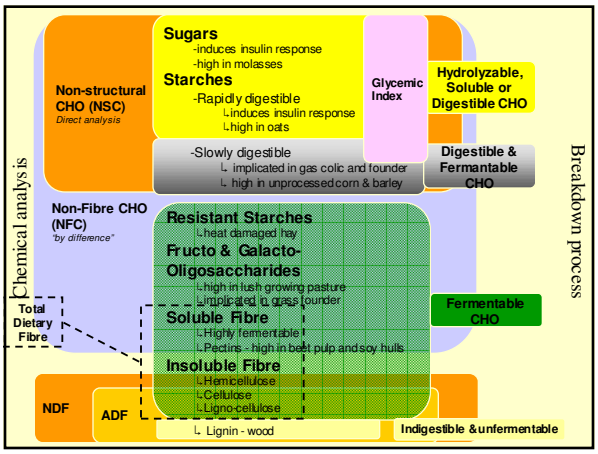
Area under the curve (AUC) of glucose response and glycemic index relative to whole oats in different feeds and varying degrees of processing

Feed	Glucose Response (AUC, mg*min*dL^{-1})	Glycemic Index
From Pagan JD, Harris PA, Kennedy MAP, et al., 1999 [93]		
Sweet feed [a]	2,073	129
Whole oats	1,602	**100**
Cracked corn	1,438	90
Fiber mix [b]	1,378	86
Sweet feed+10% corn oil	898	56
Alfalfa	733	46
From Hoekstra KE, Newman K, Kennedy MAP, et al., 1999 [23]		
Cracked corn	1,734	108
Ground corn	1,887	118
Steam flaked corn	2,500	156

[a] The sweet feed contained 45% each of cracked corn and whole oats, and 10% molasses.
[b] The fiber mix contained 25% each of rice bran, soybean hulls, wheat bran, soaked beet pulp.

Applications in Horses

- ✓ Growth
  - Glucose/insulin and OCD
- ✓ Performance
  - Maintain glucose & for glycogen loading
- ✓ Broodmares
  - Insulin resistance during gestation
- ✓ Disease
  - Insulin resistance, EPSM & founder
- ✓ Attitude
  - RER
- ✓ Age
  - Cushing's Disease



Equine Metabolic Syndrome

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Primary Symptoms EMS

- ✓Hirsuitism, changes in the hair coat with long, curly hair and delayed shedding.
- ✓Weight loss or muscle wasting.
  - not in all cases of EMS
- ✓Polyuria or an increase in urine production.
- ✓Polydipsia or an increase in water consumption.
- ✓Pot bellied appearance.

Primary Symptoms EMS

- ✓Laminitis and hoof abscesses
- ✓Diabetes mellitus
  - high blood glucose
  - Insulin resistance
- ✓Infertility
- ✓Chronic infections
- ✓Cresty neck – abnormal fat deposits

Insulin Resistance

- ✓State in which a normal concentration of insulin fails to elicit a normal physiological response

Insulin Sensitivity Affected by:

- ✓Cortisol levels (natural and synthetic)
- ✓Obesity
- ✓Meal size
- ✓High starch and sugar intake
- ✓Pregnancy
- ✓Exercise
- ✓Age
- ✓Genetics

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Glycemic response of old or young horses

- ✓ Mich. State Univ.
- ✓ 18 ingredients were tested using 16 horses
- ✓ Trial lasted 16 weeks
- ✓ Normal procedures for glycemic response were used
- ✓ 8 old horses
  - Mean Age - ~14 yrs
  - Mean weight – 1087 lbs
- ✓ 8 young Horses
  - Young horses Mean age - ~3 years
  - Mean weight – 910 lbs

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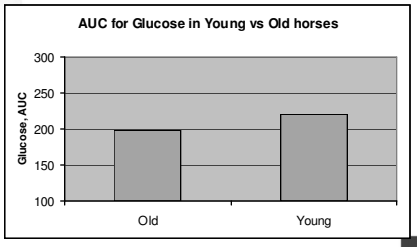
Glycemic index of old versus young horses



Glucose – No effect

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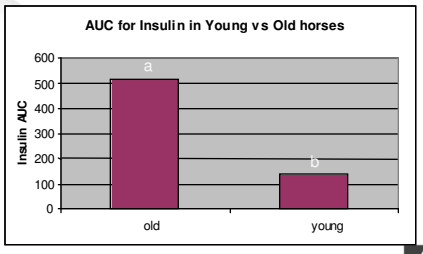
Glycemic index of old versus young horses



Insulin: Old was significantly higher than young, P < 0.001

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Insulin Resistance Influences:

- ✓Onset of Laminitis
- ✓Exertional rhabdomyolysis
- ✓Osteochondrosis
- ✓Reproductive efficiency
- ✓Health status

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Insulin Resistance - 3 Possible Conditions

- ✓Cushing's Disease
  - No negative feedback for cortisol
  - Cortisol from pituitary
- ✓Insulin Resistance
  - Obese horse/pony
  - Cortisol from fat cells
- ✓Stressed horse – could be drug induced
- ✓Poorly fed horse
  - Not enough nutrition (vitamins & minerals)

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Diagnosis & Treatment of Cushing's

- ✓ Dexamethasone suppression test is.
- ✓ Diet
- ✓ Medications of choice are currently Pergolide, a dopamine antagonist or Cyproheptadine. These drugs change the hormone secretion from the tumors and are NOT chemotherapy. Fairly expensive.

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Horse Obesity

(Feedstuffs, July 16, 2007; Research by Virginia-Maryland College of Veterinary Medicine and Virginia Tech University)

- ✓ 51% of horses in a study were found to be overweight or obese
  - BCS greater than 6 = 51%
  - BCS greater between 6 and 8 = 32%
  - BCS of 8 to 9 = 19%
- ✓ Major causes are overeating and lack of exercise
- ✓ In 1998 the number of overweight horses was ~5% (based on an owner survey)

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Glycemic-Insulin Dynamics in Horses

Hoffman et al. (2003) JAS 81:2333-2342

- ✓ Nonobese horses - BSC ~5 to 5.9 (n = 4)
- ✓ Moderately obese - BSC 6 – 6.9 (n = 3)
- ✓ Obese – BSC of 7 to 9 (n = 3)
- ✓ Different diets were used from low starch versus highs starch and sugar

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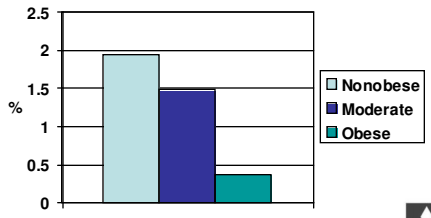
Glycemic-Insulin Dynamics in Horses

Insulin Sensitivity



Obese horses were significantly higher, P < 0.01

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EMS – Dietary Treatment

- ✓ Low glycemic feed - Cushing's ONLY
  - Hi-Fat Hi-Fibre or ????
  - Small frequent feedings
  - NO FEED for FAT horses!!! – Equilizer only
- ✓ Balanced ration – a must & optimum vitamins and minerals
  - Equilizer
  - Horse Plus
  - Kelp meal – for iodine for obese horse mostly
- ✓ Added Fat – essential fatty acids ??
  - 2 cups of ground/boiled flax per day ??

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EMS

- ✓ Low glycemic hay ???
  - < 10% NSC
  - low Fructans – hay & pasture
  - wet hay to remove sugars
- ✓ Chromium ??
  - 5 mg / day
  - no research
  - not registered for horse – suggest not recommend
- ✓ Magnesium (magnesium oxide)
  - 10 mg/day

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Fructans

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Fructans

- ✓ Starch
  - Fructose
  - Fructo-oligosaccharides
- ✓ Plant Storage Carbohydrates
- ✓ Involved in the aetiology (research) of equine laminitis
  - A dose of 7.5 g/kg (of body weight) results in laminitis 48 hours later; (this is) one-half the amount of starch (such as found in sweet feed) required to induce laminitis."
- ✓ Not digested (no enzyme) in the small intestine & in large intestine quick fermentation disrupts normal micro-flora

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Fructans

- ✓ Horse seek out grass varieties rich in fructan, greedily consuming the sweet stems, sometimes unwittingly to their own detriment.
- ✓ In Australia, where an estimated 50% of laminitis cases are attributed to grass

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Fructans

- ✓ Horse grazing from 9:00 a.m. to 3:00 p.m. could consume approximately 2 kg of fructan. Conversely, those grazing from 3:00 p.m to 9:00 p.m. could potentially ingest only 500 g or one-fourth of that consumed during midday grazing Horses grazing certain pastures could devour approximately 5 kg of fructan in one day.
- ✓ Horses grazing certain pastures could devour approximately 5 kg of fructan in one day.

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Fructans Accumulation

- ✓ Accumulate with photosynthesis and slowed growth
  - warm days & cool nights
  - drought conditions – 7 fold increase
- ✓ Grasses of the world's temperate climates (i.e. neither tropical nor polar) store carbohydrate as fructans
- ✓ Conditions that affect the amount of sucrose and fructan in grass include intensity of sunlight, duration of sunlight, temperature, water availability, soil fertility, developmental and genetic characteristics of species of grass, and the overall health of the grass.

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Fructans Accumulation

- ✓ Orchardgrass varieties that best survived a long-term drought under Mediterranean conditions were found to have sugar and fructan levels up to 63% of dry matter in the green, living leaves.
- ✓ Sugar and fructan levels increased seven-fold in the grass crowns and roots under drought stress compared to irrigated control plots.

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Fructans Accumulation

- ✓Weeds can also accumulate sugar, starch, or fructan under drought stress
- ✓Dandelion, thistles and chicory are common weeds often relished by horses even under normal conditions. All three contain inulin, the same form of fructan used to induce laminitis in clinical studies

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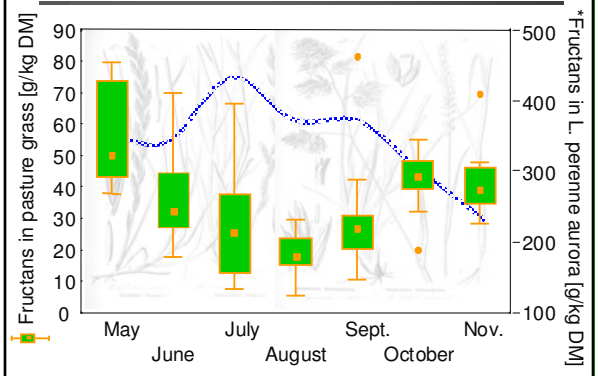
Seasonal fructan variation in pasture grass

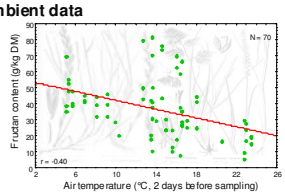


Time: P<0.05

*Longland et al. (1999)

Predictability of fructan content in grass?

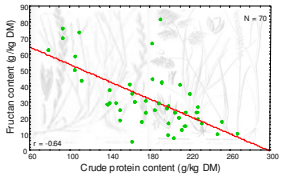
Ambient data



Influencing factor	Impact fructans
▪ Air temperature ↓:	↑
▪ Ground temperature ↓:	↑
Range r: -0.39 to -0.45	
▪ Sunshine duration, humidity, rainfall:	↔

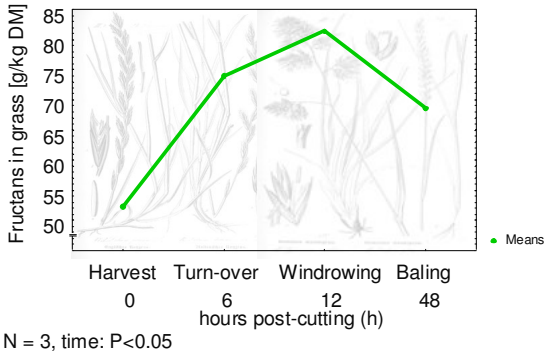
Nutrient content in grass

Influencing factor	Impact fructans
▪ Crude protein ↑:	↓
▪ Ca, P, Mg, K, Cl ↑:	↓
▪ Cu, Zn ↑:	↓
Range r: -0.29 to -0.64	
▪ Crude fiber, NDF, ADF, ADL:	↔



↑: high ↓: low ↔: no correlation

Fructan development during hay harvesting



N = 3, time: P<0.05

- ✓Soak your hay for about 60 minutes, as fructans are water soluble

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