Knowledge for Life

Resistant Starch – A Comparative Nutrition Review

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K-STATE Research and Extension

Personal Background
Education

- B.S. – Kansas State University
  - Animal Sciences & Industry
- M.S. – Oklahoma State University
  - Equine Nutrition
- Ph.D. – Kansas State University
  - USDA Fellow – Nutrition + Grain Science
    - Comparative Nutrition - Humans + Monogastric Animals

Personal Background Professional

- Technical Nutritionist – Nestle Purina
  - Began as nutritionist for Friskies, Purina One and Pro plan
  - Managed Purina Veterinary Diet product formulation and development
- Assistant Professor – Kansas State University
  - Equine Nutrition
  - Broad comparative research program
    - Digestive physiology, microbiome

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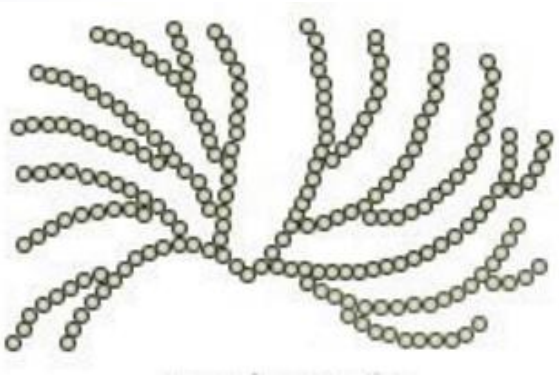
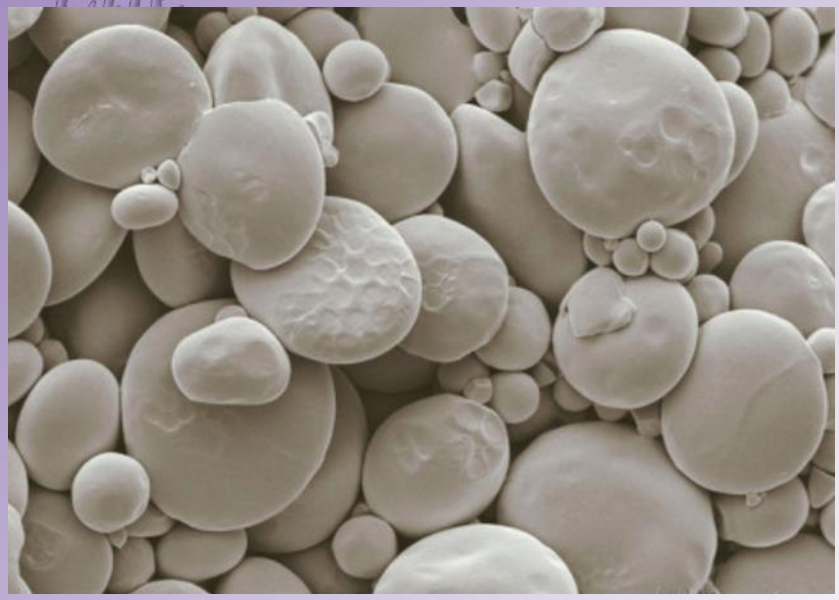
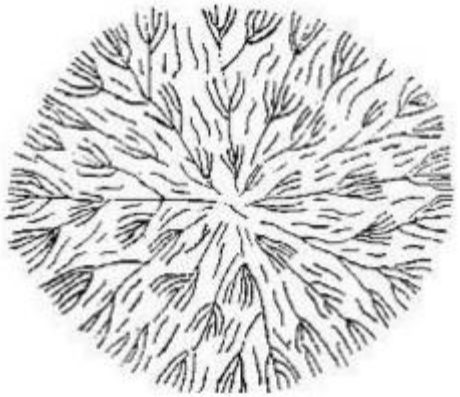
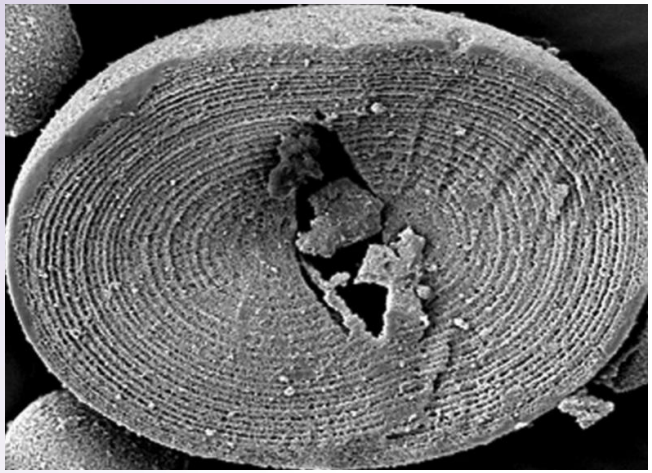
Starch

- Polysaccharides of alpha 1-4 and 1-6 linkages
- Starch granule consists of amylose and amylopectin
  - Amylose – linear polymer
  - Amylopectin – highly branched polymer



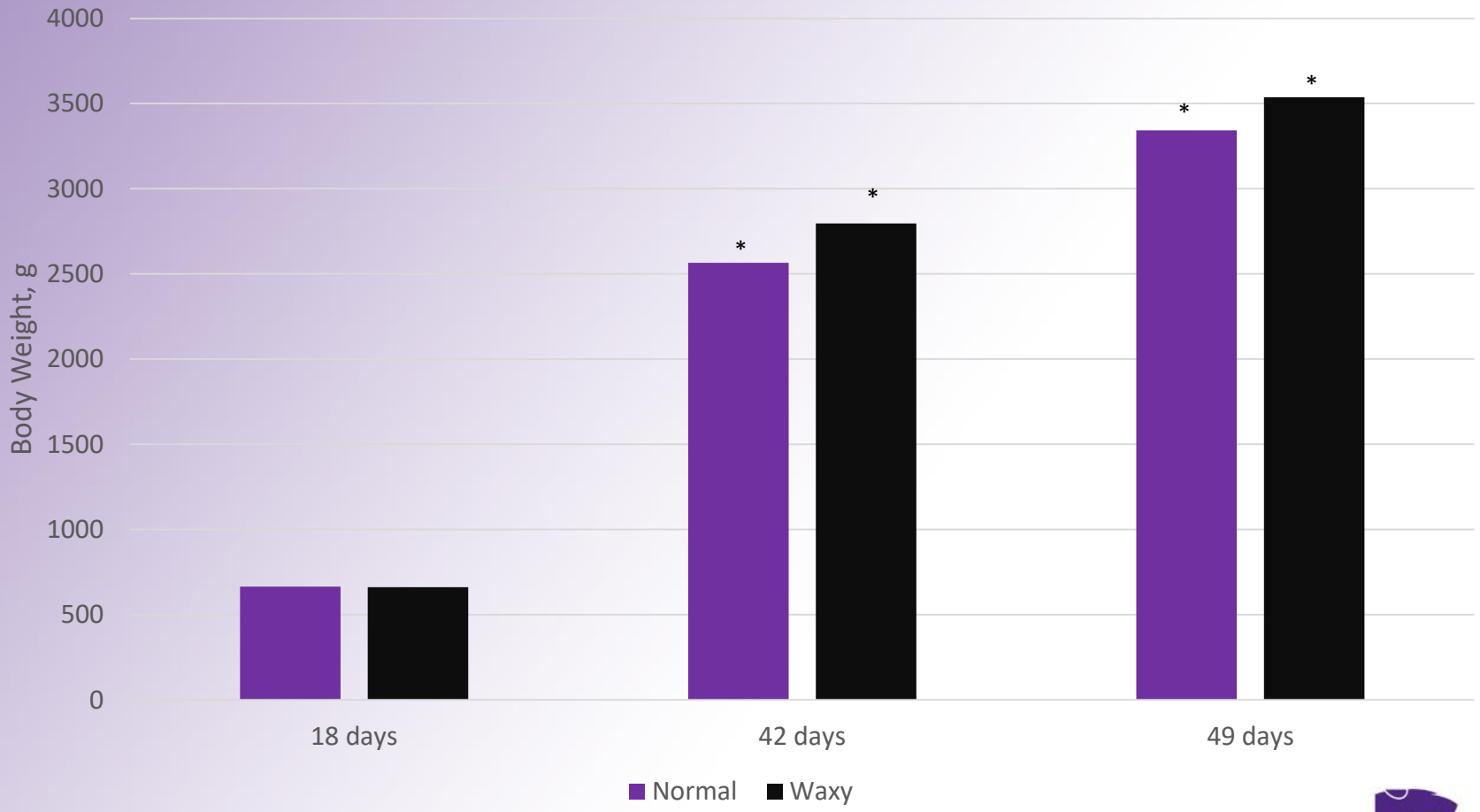






Effect of Waxy Corn on Broiler Performance

Collins et al. (2003)



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Types of Starch Based on Hydrolysis

- Rapidly Digestible Starch
  - Converted to glucose within 20 minutes of enzyme digestion i.e. cooked starch in a potato
- Slowly Digestible Starch
  - Completely digested in the SI but slower than RDS i.e. raw starch in a cereal grain
- Resistant Starch
  - Completely amylase resistant

Resistant Starch

- Fraction of starch which resists hydrolysis in the small intestine
- Thus, reaching the large intestine to undergo fermentation via the gut microbiome
  - Similar to a soluble, fermentable fiber
- Naturally found in
  - Cereal grains
  - Vegetables
  - Legumes
- Also synthetically made

Types of Resistant Starch

- Type 1
  - Inaccessible starch within cell wall other food matrixes
- Type 2
  - Native starch granules protected from digestion due to structure of the granule itself
- Type 3
  - Retrograded or nongranular starch formed after cooking and cooling
- Type 4
  - Chemically modified starch (cross linked, esterified, etc)
- Type 5
  - Amylose-lipid complex resistant to swelling and hydrolysis

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Is resistant starch an ingredient?

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In vitro digestibility of starch in a variety of foods (BNF 1990)

Food	% RDS	% SDS	% RS1	% RS2	% RS3
Flour, white	38	59	-	3	Traces
Bread, white	94	4	-	-	2
Peas, cooked	56	24	11	Traces	6
Kidney beans, cooked	25	-	-	15	60

Is resistant starch still resistant starch after extrusion or retort?

Nutritional Implications of RS

- Increased laxation/fecal bulking
- Prebiotic
  - Improved gut health
- Reduced postprandial glycemia/insulinemia
- Reduced caloric density
  - While maintaining acceptable mouth feel
- Improved serum lipid profile

Laxation/Fecal Bulking

Murray et al. (1998)

- Fecal wet and dry weights increased 75% for dogs consuming a RS diet when compared to the control
  - Dry weights approximately 59 g/d greater

Laxation/Fecal Bulking

- Contradicting data regarding fecal quality
- Feces from dogs receiving RS diet were better formed (Murray et al., 1998)
- Inverse relationship between fecal score and RS supplementation (Goudez et al., 2011)
  - But only occurred in large breeds; small breeds were unaffected

RS as a Prebiotic

- RS is fermented by hindgut microflora
  - Provides energy to 100's of bacterial species
- Produces SCFA (or VFA)
  - Acetate, propionate and butyrate
  - RS produces a high proportion of butyrate

RS as a Prebiotic

- Butyrate is the major energy substrate for colonocytes
- Butyrate inhibits initiation and growth of colon tumors
- Fermentable substrates promote the growth of commensal microflora
  - Lactobacilli and bifidobacteria

RS Improves Luminal Environment

Nofrarias et al. (2007)

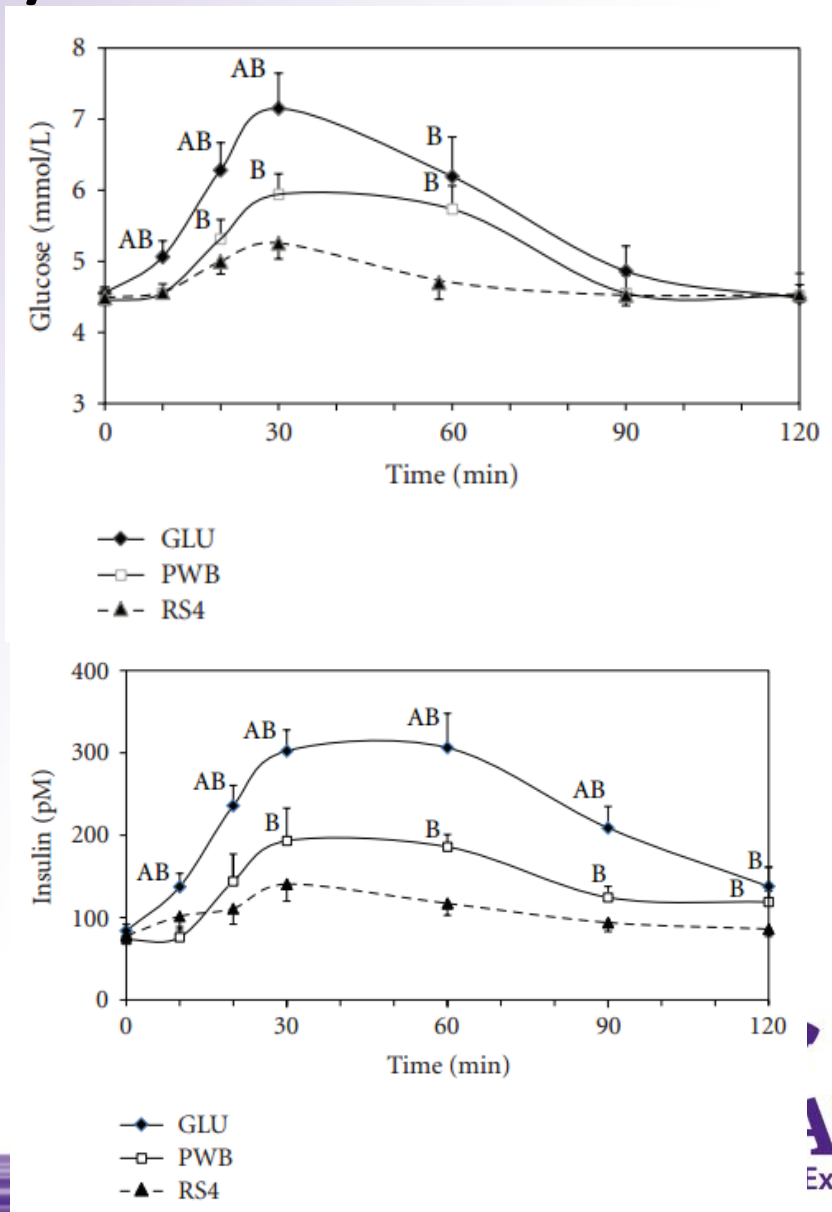
- 16 pigs fed raw potato starch (RPS) or corn starch (CS) for 14 wks
- Observations ($P < 0.05$) in RPS pigs
  - Colon butyrate concentration was two-fold higher
  - Reduced apoptosis in intestinal crypts
  - Increase mucin sulfatation
    - Indicates greater mucin maturity and increased protection of intestinal epithelium
  - Reduced luminal magnesium
    - Associated with reduced epithelial cell damage
  - Lower colonic pH

Symbiotic with Probiotics

- Probiotics encapsulated to protect against environmental and GI factors
- Iyer and Kailasapthy (2005)
  - Hi-maize™ provided maximum protection when compared to Raftiline® and Raftilose®
    - Viable counts of Lactobacillus increased significantly
    - Significantly increased survivability under in vitro acidic and bile salt conditions

Improve Glucose/Insulin Kinetics

- Many studies show decreased postprandial blood glucose and insulin due to RS
  - Most fail to maintain equal amount of available carbohydrate
- Al-Tamimi et al. (2010) controlled for non starch ingredients and available CHO
  - 80 g RS4 significantly reduced postprandial glucose and insulin levels



Weight Management

- Reducing caloric intake
  - Reduced caloric density of the diet
  - Increased satiety
  - Increase luminal viscosity
- Caloric value is almost half that of digestible starch
  - 1.9 kcal vs. 3.6 kcal
  - SCFA yield approximately 60-70% of the caloric value of glucose

Reduced Caloric Intake

- Pigs consuming 35% pregelatinized starch (PS) or 34% retrograded starch (RS) (Souza da Saliva et al., 2014)
  - RS diet resulted in a 3% reduction in ME intake and less time at the feeder
- Adults consuming 48 g of RS or placebo (Bodinham et al., 2009)
  - RS diet resulted in in a 10% reduction in 24 h caloric intake

Altered Lipid Metabolism

- Many studies show improved lipid metabolism with RS containing diets
  - Decreased LDL and total cholesterol
  - Decreased TG
    - Conflicting data – many studies show TG increasing
  - Decreased NEFA
- Many fail to maintain isocaloric diets
  - Unable to make inferences – is it the RS or simply a decrease in caloric intake

Altered Lipid Metabolism - Mechanisms

- Increased post prandial fat oxidation (PPFO)
  - 5.4% RS increased PPFO by 23% (Higgins et al., 2004)
    - 10.7% had no effect
  - Howe et al. (1996) found no effect on fat oxidation due to RS over a 10 wk period

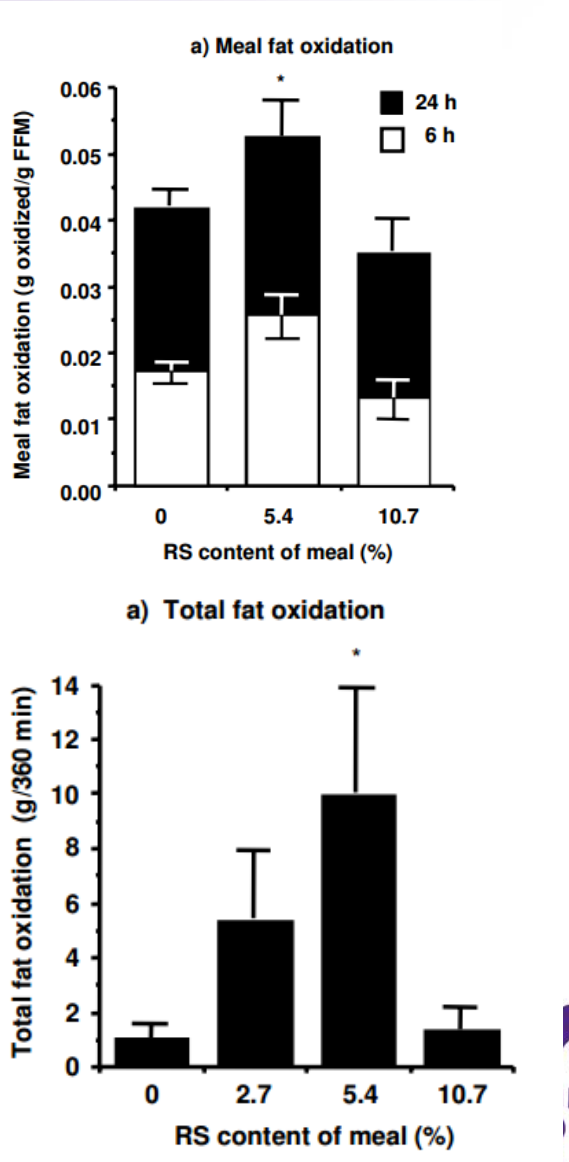
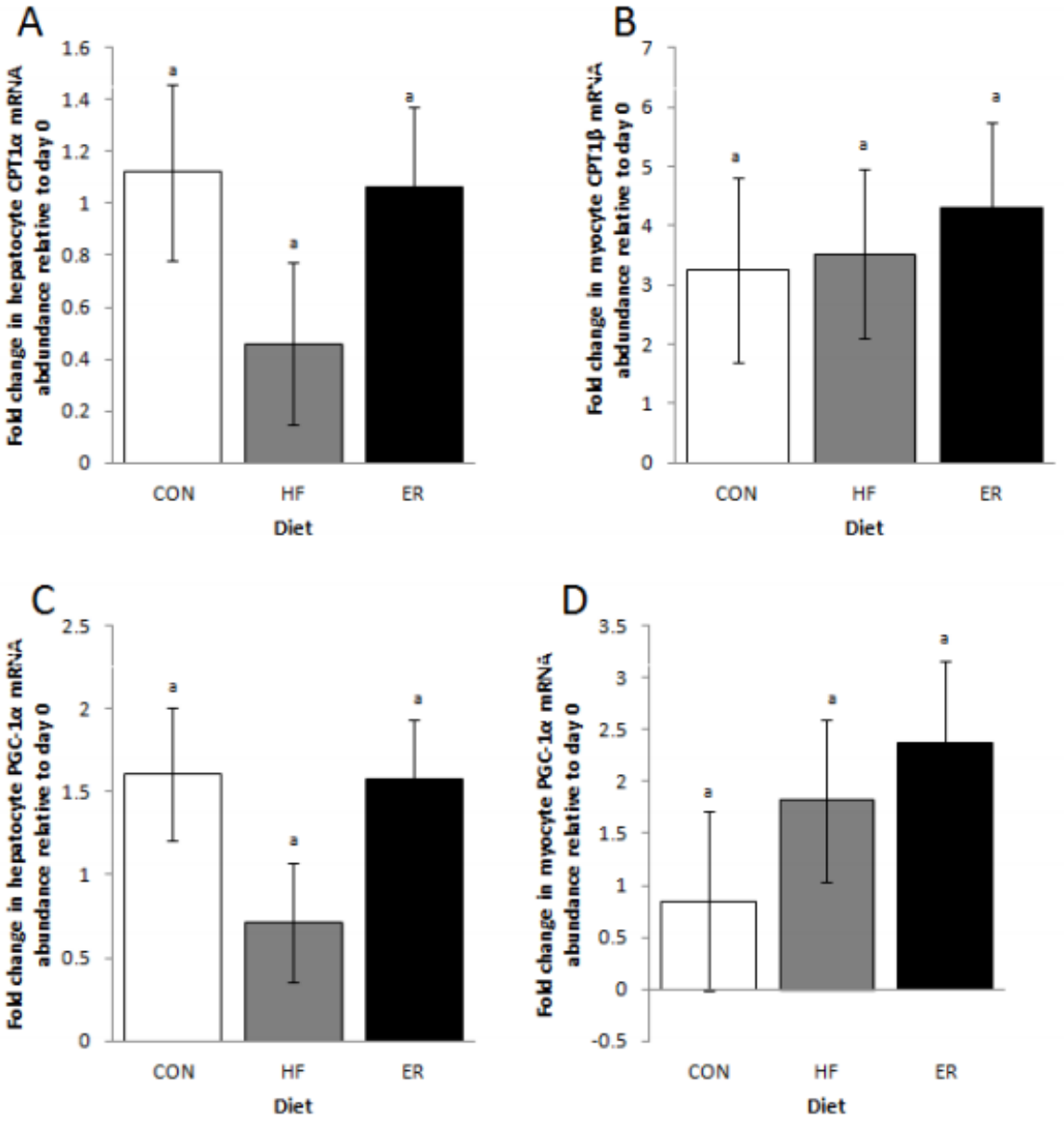
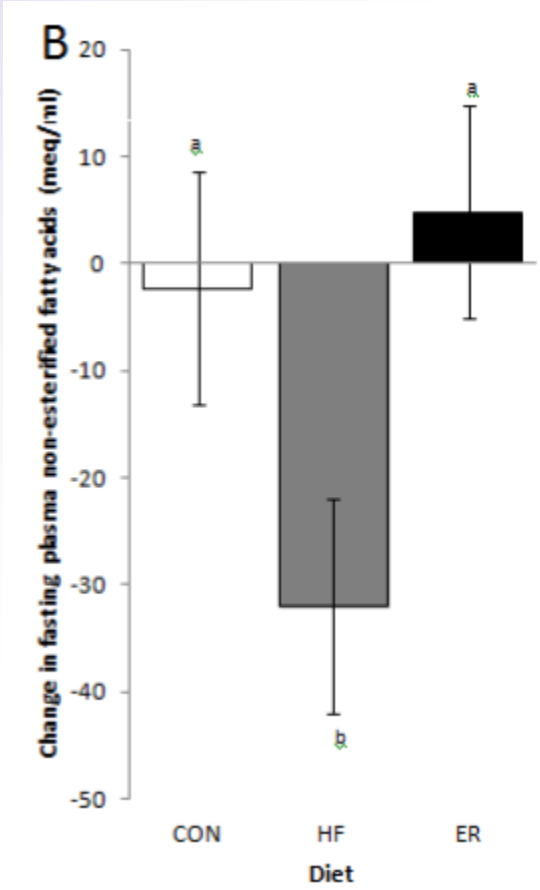


Figure 2.8. Fold change in hepatocyte CPT1α (A), mycocyte CPT1β (B), hepatocyte PGC-1α (C), and myocyte PGC-1α (D) mRNA abundance relative to day 0 in gilts after 42 d of a control (CON), high fiber (HF), or energy restricted (ER) diet[1,2,3]



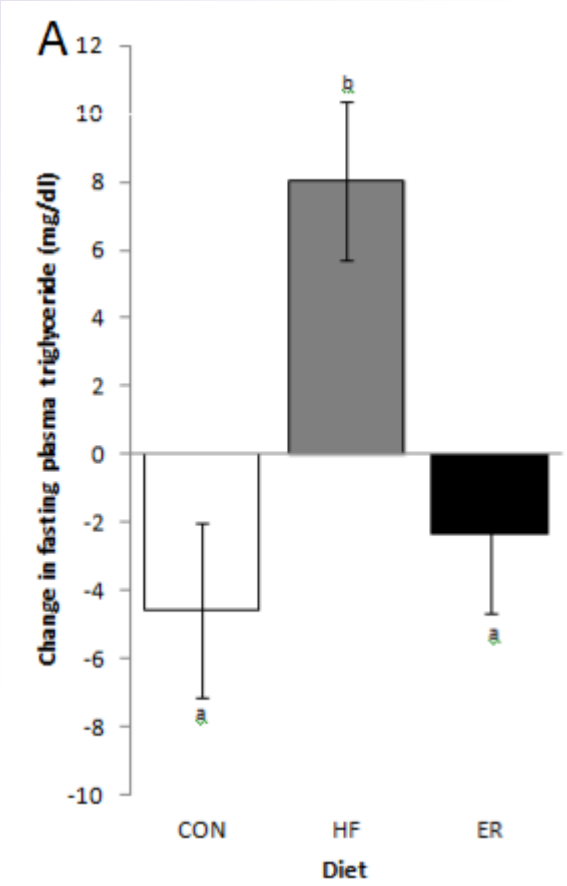
Altered Lipid Metabolism - Mechanisms

- Decreased circulating NEFA concentrations
  - Decreased competition with glucose
- Increased bile secretion
  - Reducing total and LDL cholesterol



Altered Lipid Metabolism

- Several studies show an increase in plasma TG levels
- Likely due to increased de novo lipogenesis via increased acetate



Implications of RS in Pet Food

- Effective prebiotic and synergistic with probiotics
  - Gut health claim?
- Decreased caloric density
  - Weight maintenance diets
- Attenuates postprandial glycemia/insulinemia
  - Therapeutic vet diets
- Alters serum lipid profile
  - Therapeutic vet diets
- Enhanced texture and acceptability

Implications of RS in Pet Food

- How much RS does it take to make a claim?
- Does its efficacy really differ to that of a soluble fiber
  - Cheaper options
- Will consumers accept it?
  - Starch is a four letter word
- Does it comply to “natural” products?

Questions


Coffee
ss
CARTOONSTOCK .com
Search ID: kben99
"Large coffee and three bran muffins... hopefully to go!"