The Future of Pet Food and Pet Animal Nutrition: The Role of Dietary Fiber

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What Exactly is Dietary Fiber?

Ingredients:
Beef, Lamb Meal, Potatoes, Eggs, Sunflower Oil, Buffalo, Lamb, Venison, Beef Cartilage, Herring Oil, Natural Flavors, Apples, Carrots, Tomatoes, Alfalfa Sprouts, Garlic, Cottage Cheese, Potassium Chloride, Vitamins (Vitamin E Supplement, Betaine, Vitamin A Supplement, Niacin Supplement, Calcium Pantothenate, Beta Carotene, Vitamin B12 Supplement, Vitamin D3 Supplement, Riboflavin Supplement, Pyridoxine Hydrochloride, Thiamine Mononitrate, Biotin, Folic Acid), Minerals (Zinc Proteinate, Iron Proteinate, Copper Proteinate, Managanese Proteinate, Calcium Iodate), Ascorbic Acid, Dried Chicory Root, Direct-Fed Microbials (Dried Lactobacillus acidophilus Fermentation Product, Dried Lactobacillus casei Fermentation Product, Dried Bifidobaterium thermophilum Fermentation Product, Dried Enterococcus faecium Fermentation Product), Vitamin E Supplement, Lecithin, Rosemary Extract

Guaranteed Analysis:

Crude Protein (Min)	42%
Crude Fat (Min)	22%
Crude Fiber (Max)	2.5%
Moisture (Max)	10%
Linoleic Acid (Omega-6 Fatty Acid) (Min)	1.2%
Carbohydrates NFE (Max)	15%
Vitamin E (Min)	300IU/kg
Vitamin C (Min)*	500 mg/kg
Omega-3 Fatty Acids (Min)*	0.4%
Docosahexaenoic Acid (Min)*	0.1%
Total Microorganisms (Min)*	90,000,000 CFU/lb

(Lactobacillus acidophilus, Lactobacillus casei, Bifidobacterium thermophilum, Enterococcus faecium in equal parts)

*Not recognized as an essential nutrient by the AAFCO Dog Food Nutrient Profiles.

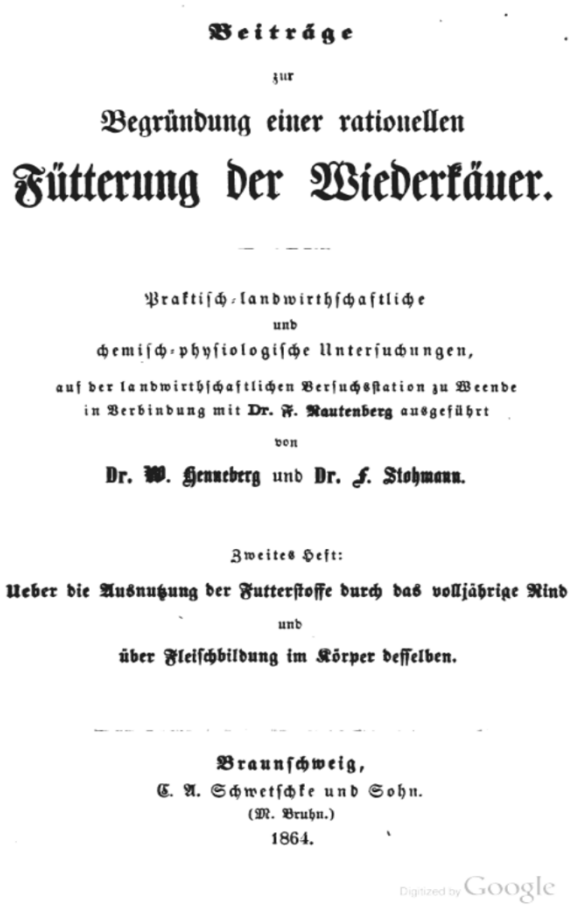
Calorie Content:
(Metabolizable Energy – Calculated)
4,035 kcal/kg
487 kcal/cup
1 cup = 4.26 oz (121g)

Crude fiber

Henneberg and Stohmann, 1864

Henneberg, W., and Stohmann. 1864. Beiträge zur Begründung einer rationellen Futterung der Wiederkäuer, Vol. II, Schwetschke and Sohn, Braunschweich.

Contributions to the creation of a rational feeding system for ruminants.



Beiträge

zur

Begründung einer rationellen

Fütterung der Wiederkäuer.

Praktisch-landwirthschaftliche

und

chemisch-physiologische Untersuchungen,

auf der landwirthschaftlichen Versuchsstation zu Weende

in Verbindung mit Dr. F. Nautenberg ausgeführt

von

Dr. W. Henneberg und Dr. F. Stohmann.

Zweites Heft:

Ueber die Ausnutzung der Futterstoffe durch das volljährige Rind

und

über Fleischbildung im Körper desselben.

Braunschweig,

C. A. Schwetschke und Sohn.

(M. Bruhn.)

1864.

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AOAC Official Method 930.10
Fiber (Crude) in Plants

- Digestion Method
- J. AOAC Int'l., 1916
- First Action, 1930

AOAC Official Method 962.09
Fiber (Crude) in Animal Feed and Pet Food

- Ceramic Fiber Filter Method
- First Action, 1962
- Final Action, 1971
- Revised First Action, 1982

Fiber (Crude)

- **Principle**
  - **Loss on ignition of dried residue remaining after digestion of sample with 1.25% (w/v) H_2SO_4 and 1.25% (w/v) NaOH**

NONNUTRIENT RESIDUES: A SYSTEM OF ANALYSIS FOR THE REPLACEMENT OF CRUDE FIBER. 1965

"A literature review of the use of crude fiber for the estimation of the poorly digestible part of feedstuffs … shows that crude fiber may be unsuitable for the evaluation of feeds".

"In the past, feed quality has been estimated by crude fiber content, a procedure known to have many defects".

"The discovery of the digestibility of cellulose … ruined the conceptual basis on which the method was originally advanced".

P.J. Van Soest



Detergent fibers

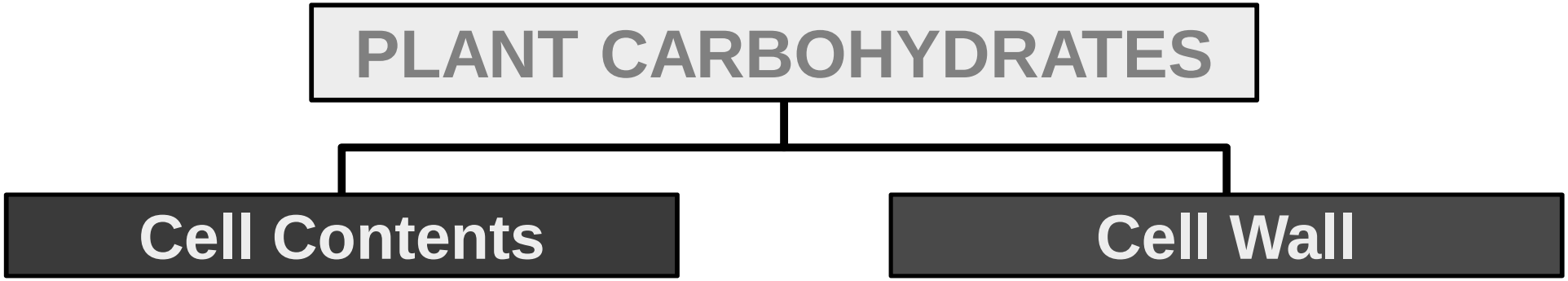
- **Fractions**
  - **Neutral detergent fiber (NDF)**
    - **Cellulose, hemicelluloses, lignin**
  - **Acid detergent fiber (ADF)**
    - **Cellulose and lignin**
  - **Acid detergent lignin (ADL)**
  - **Permanganate lignin (PL)**
- **Hemicelluloses can be determined by subtraction**
  - **NDF – ADF**
- **Cellulose can be determined by subtraction**
  - **ADF-ADL**
- **All are <u>insoluble</u> dietary fibers**

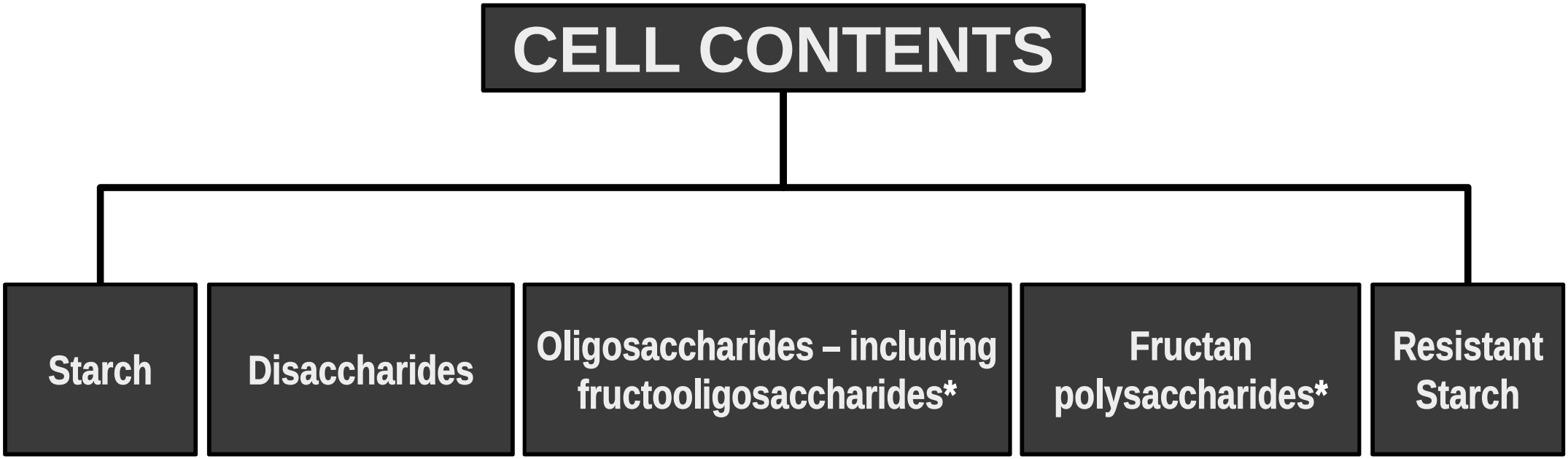
What is the Problem with Detergent Fiber Methods?

***Do not measure soluble dietary fiber fractions**

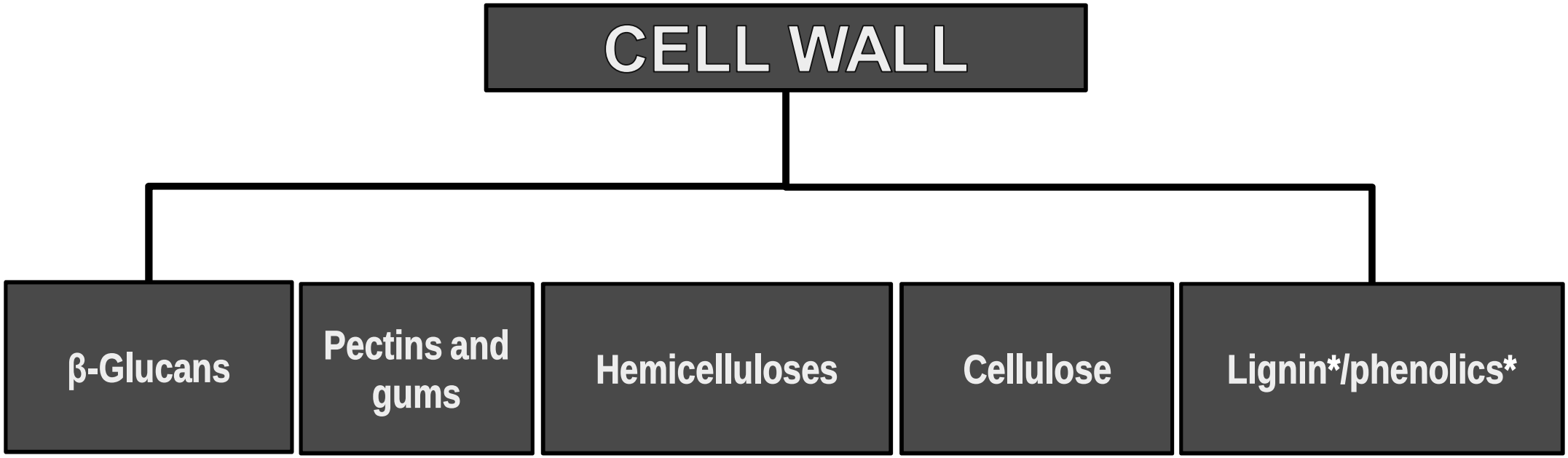
- ***Pectins**
- ***Gums**
- ***Beta-glucans**
- ***Soluble hemicelluloses**
- ***Oligosaccharides**
- ***Novel carbohydrates**

What is the Relevance of the Terms “Insoluble” and “Soluble” Dietary Fiber?

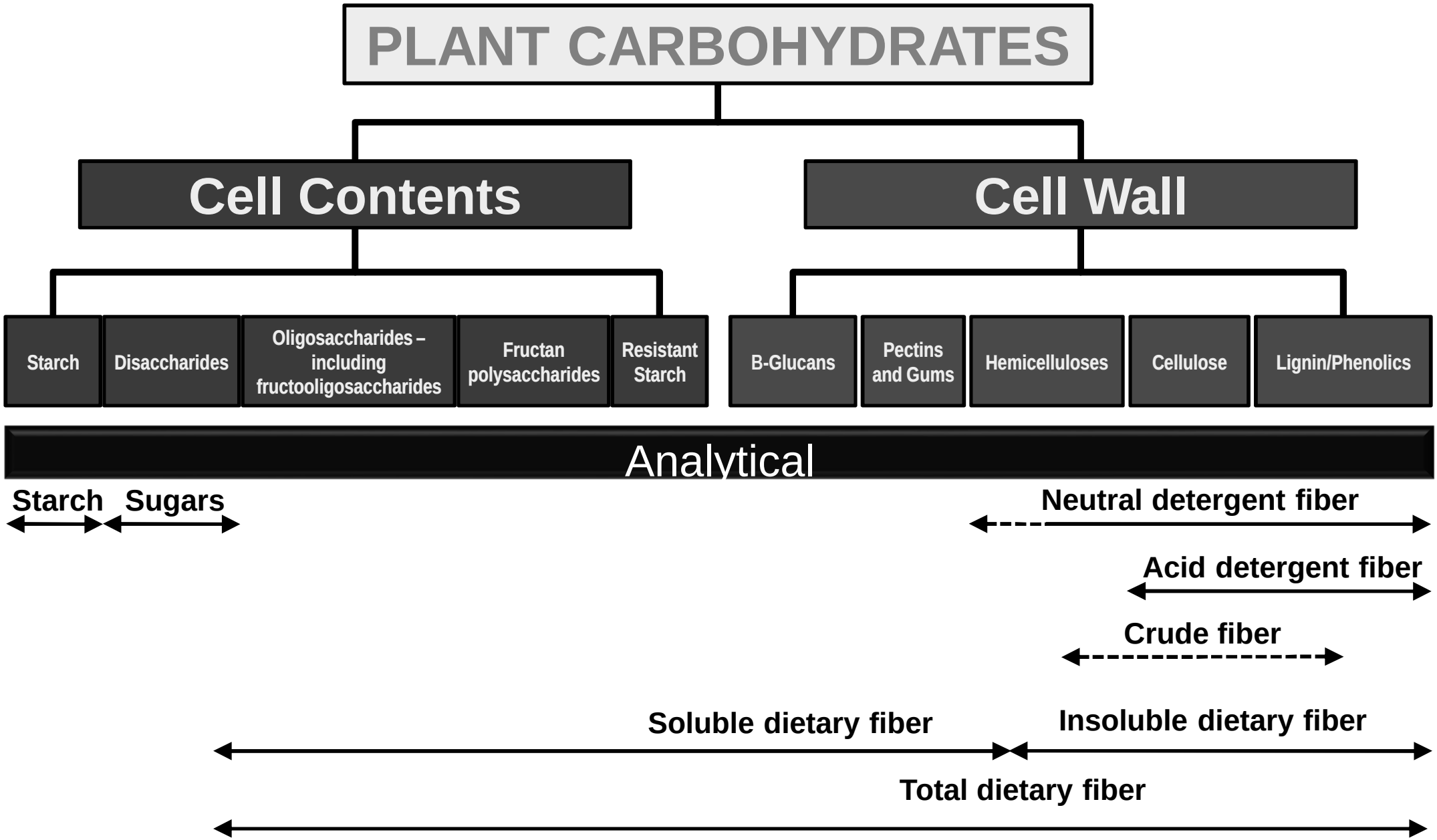

PLANT CARBOHYDRATES
Cell Contents
Cell Wall



*** Specific fructans can be categorized as either fructooligosaccharides or fructan polysaccharides depending on degree of polymerization**



*** Some non-carbohydrate components are included here as they are components of the specific analytical fractions**

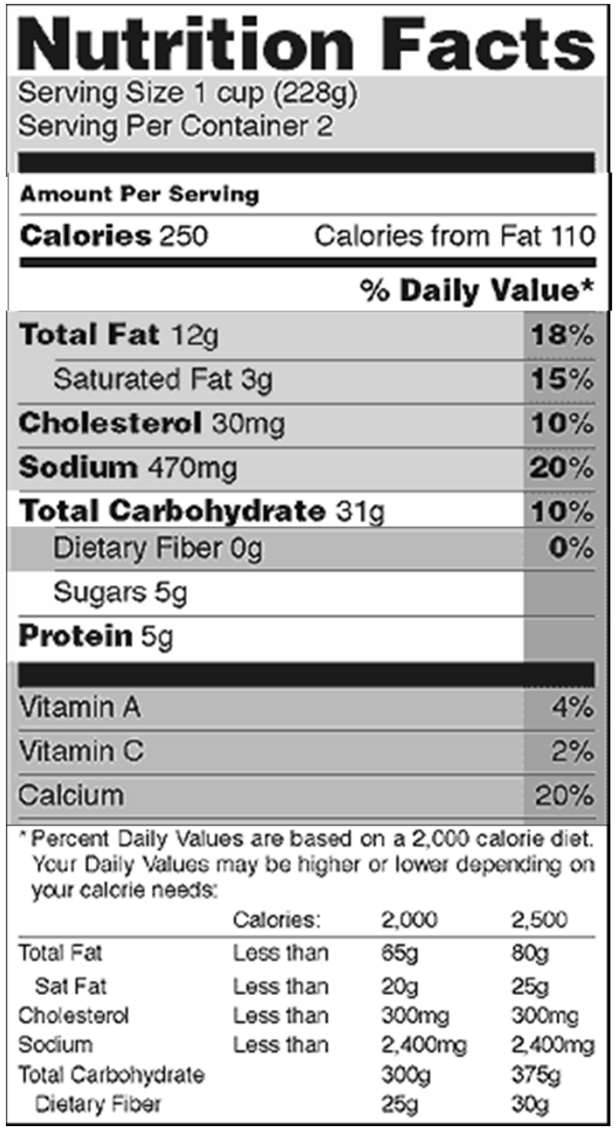


Dashed lines indicate that recovery of included compounds may be incomplete

Fiber Categorization

- **In the U.S., there is no formal definition of dietary fiber**
  - **The Nutrition Labeling and Education Act (1990) required Dietary Fiber to be on the nutrition label**

Dietary fiber



Nutrition Facts

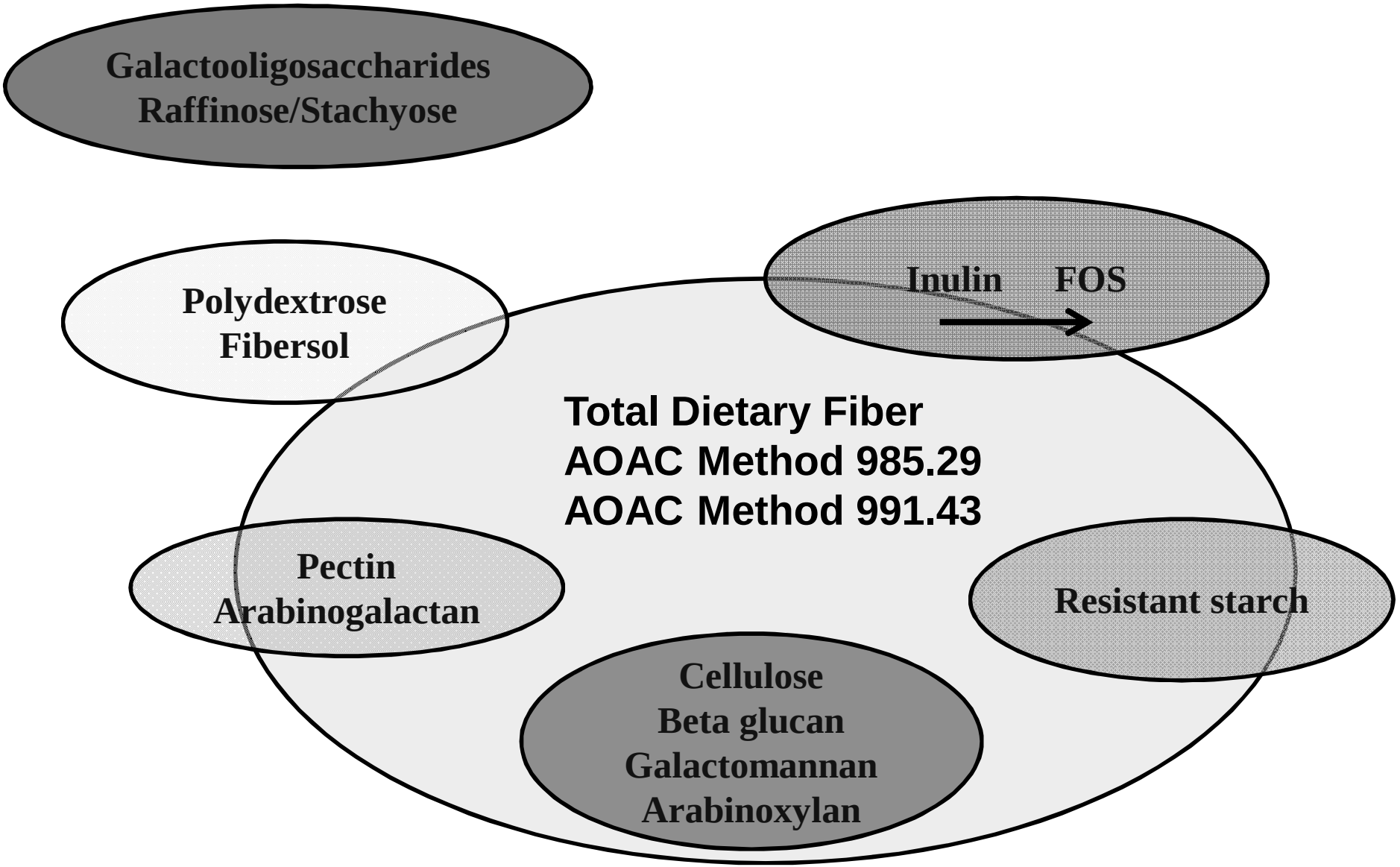
Serving Size 1 cup (228g)
Serving Per Container 2

Amount Per Serving	
Calories 250	Calories from Fat 110
	% Daily Value*
Total Fat 12g	**18%**
Saturated Fat 3g	**15%**
Cholesterol 30mg	**10%**
Sodium 470mg	**20%**
Total Carbohydrate 31g	**10%**
Dietary Fiber 0g	**0%**
Sugars 5g	
Protein 5g	
Vitamin A	4%
Vitamin C	2%
Calcium	20%

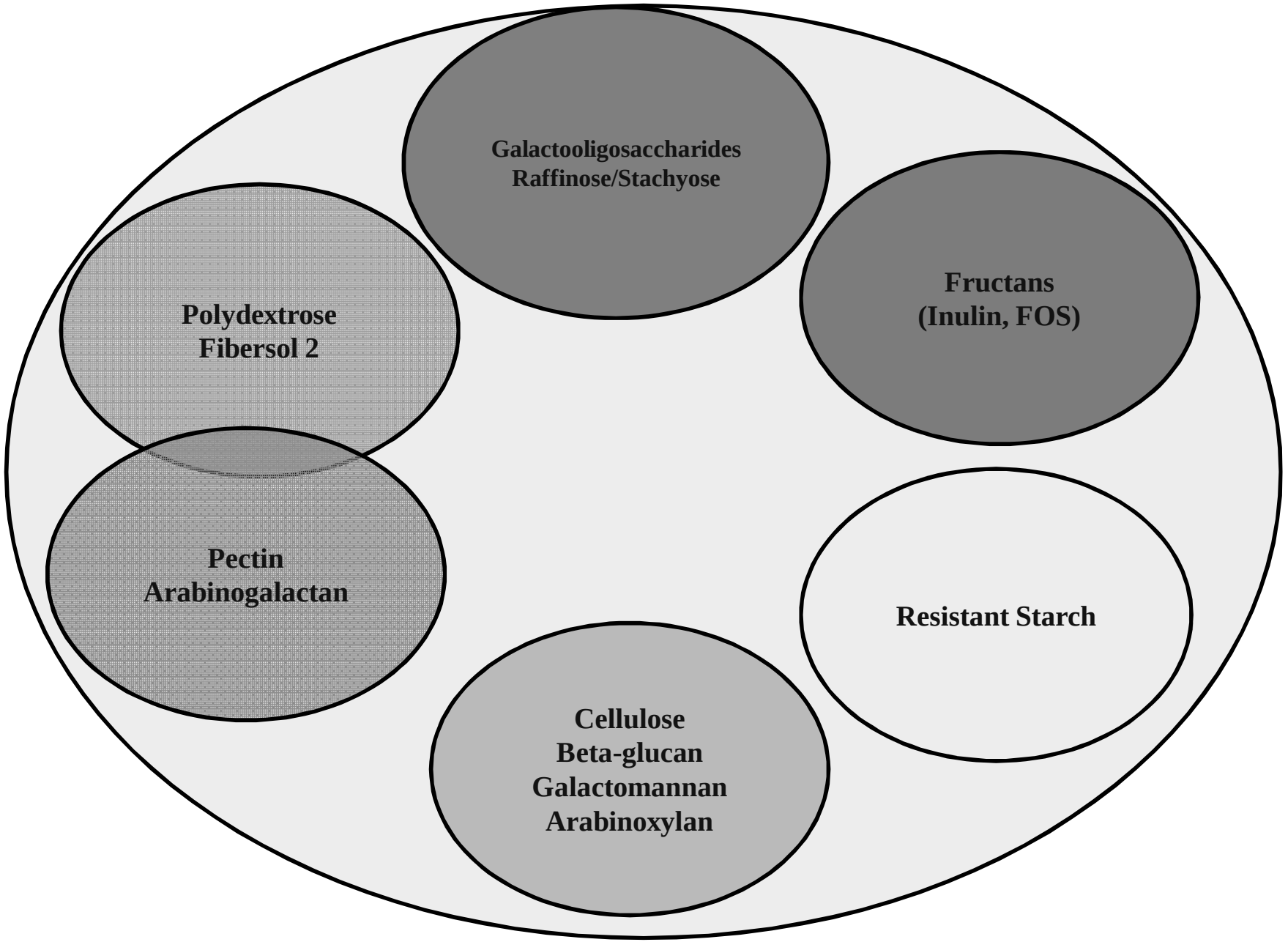
* Percent Daily Values are based on a 2,000 calorie diet. Your Daily Values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Components measured and not measured by AOAC Official Methods 985.29 and 991.43 (taken from Cereal Foods World 56:122, 2011)



Components measured by AOAC Official Method 2009.01 (taken from Cereal Foods World 56:122, 2011)



Megazyme

INTEGRATED TOTAL DIETARY FIBRE ASSAY PROCEDURE

INCLUDING
RESISTANT STARCH
AND NON-DIGESTIBLE
OLIGOSACCHARIDES

K-INTDF 02/2011

AOAC Method 2009.01

(100 Assays per Kit)

Megazyme

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Carbohydrate kits

- **Kits for several components are available**
  - **http://secure.megazyme.com/Homepage.aspx**
  - **Many of the kits are AOAC-approved methods**
  - **Evaluated available literature to develop the best procedure possible**
- **Assays available**
  - **β-glucan (K-BGLU; K-YBGL)**
  - **Fructans (K-FRUC; K-FRUCHK)**
  - **Galactomannans (K-GALM)**
  - **Pectin (K-PECID)**
  - **Raffinose (K-RAFGL)**
  - **Resistant starch (K-RSTAR)**
  - **Total dietary fiber (K-TDFR)**
  - **Total starch (K-TSTA)**
  - **Individual sugars**

What Dietary Fibers Do We Find in Pet Food?

Depends on the Pet Food Category

Categories of Pet Food

U.S. and Europe

* Generic brands
* Popular brands
* Premium brands
* Super-premium brands
* Veterinary brands

South America

* Economic (basic) brands
* Standard brands
* Premium brands
* Super-premium brands
* Veterinary brands emerging

Critical Points

* Those who feed higher end foods are most concerned about the ingredients, including the dietary fiber, in their pet's diet

  * "Pet parents"
  * Health-focused
  * Food cost not an issue

* Higher end foods have specialized dietary fiber types

  * Novel carbohydrates
  * Prebiotics
  * Resistant starch

Fibrous Ingredients in Petfoods

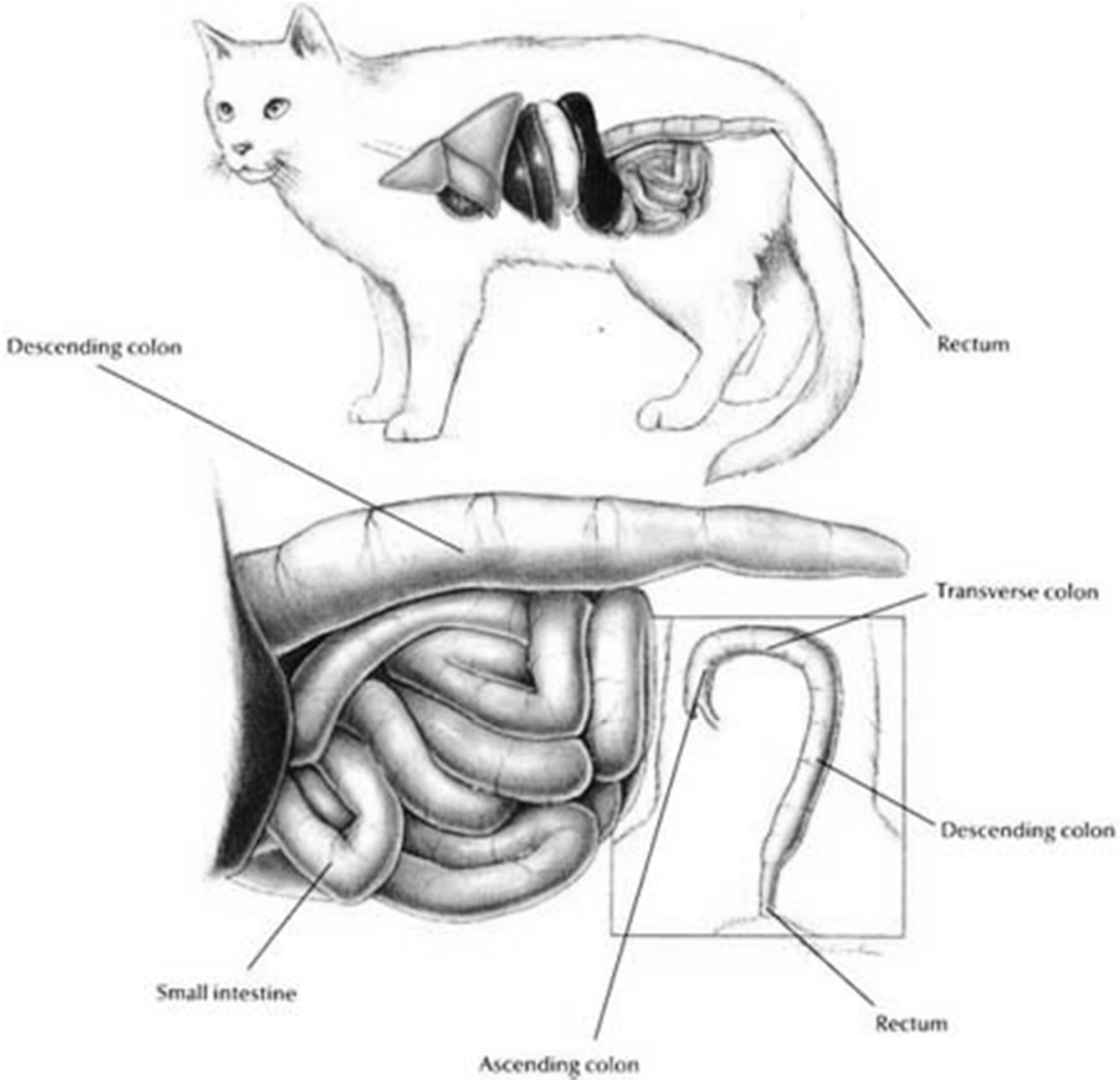
- **Petfoods contain dietary fiber in their grain and protein ingredients**
  - **Wheat, corn, barley, soybean meal, meat and bone meal, poultry byproduct meal**
- **Fibrous ingredients added to petfoods**
  - **Beet pulp, wheat midds, wheat bran, cellulose, gums, oligosaccharides, prebiotics, novel carbohydrates, others**

What is the Importance of Dietary Fiber in Petfoods?

- Currently recognized for health-promoting effects in pets, and for positively impacting stool quality



- Both dogs and cats can ferment dietary fiber
  - Dog > cat

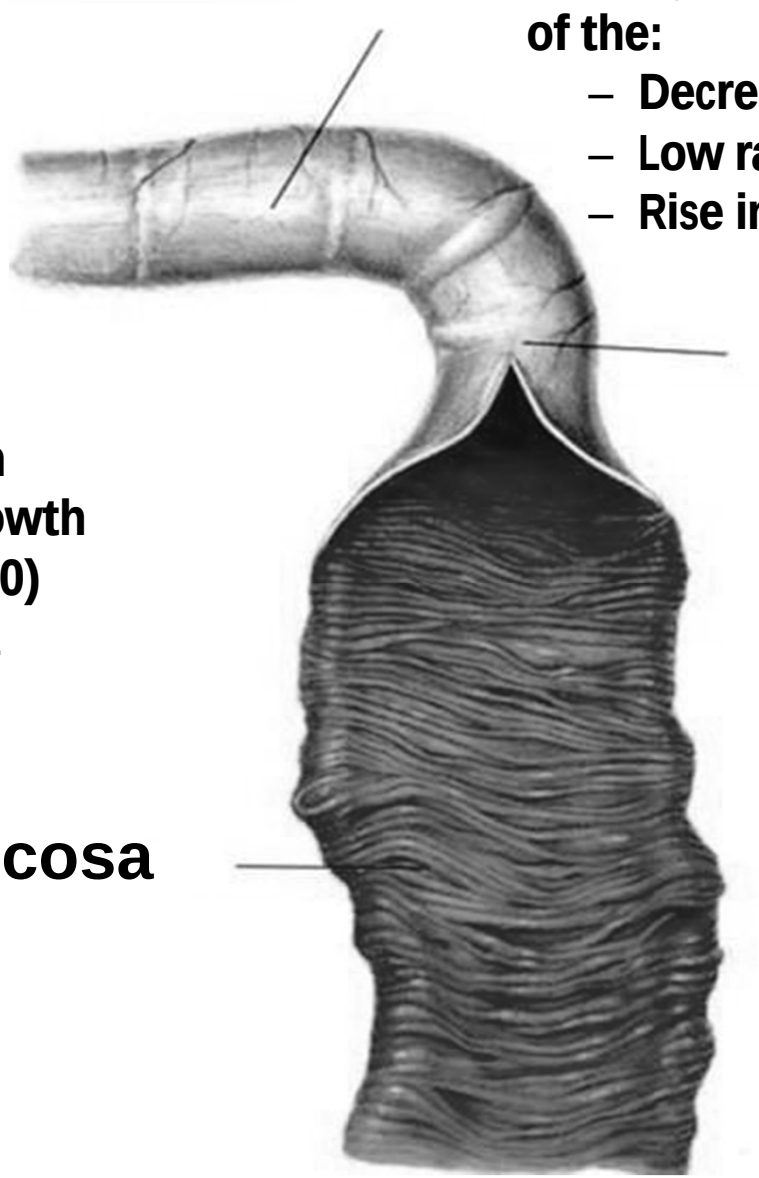

Descending colon
Rectum
Transverse colon
Descending colon
Small intestine
Ascending colon
Rectum

Transverse colon

- Slowing of the fermentation rate as a result of the:
  - Decrease in available substrate
  - Low rate of bacterial growth
  - Rise in pH of the intestinal contents

Ascending colon

- Very active fermentation
- High rate of bacterial growth
- Acidic pH (approx. 5.5-6.0)
- Saccharolytic microbiota

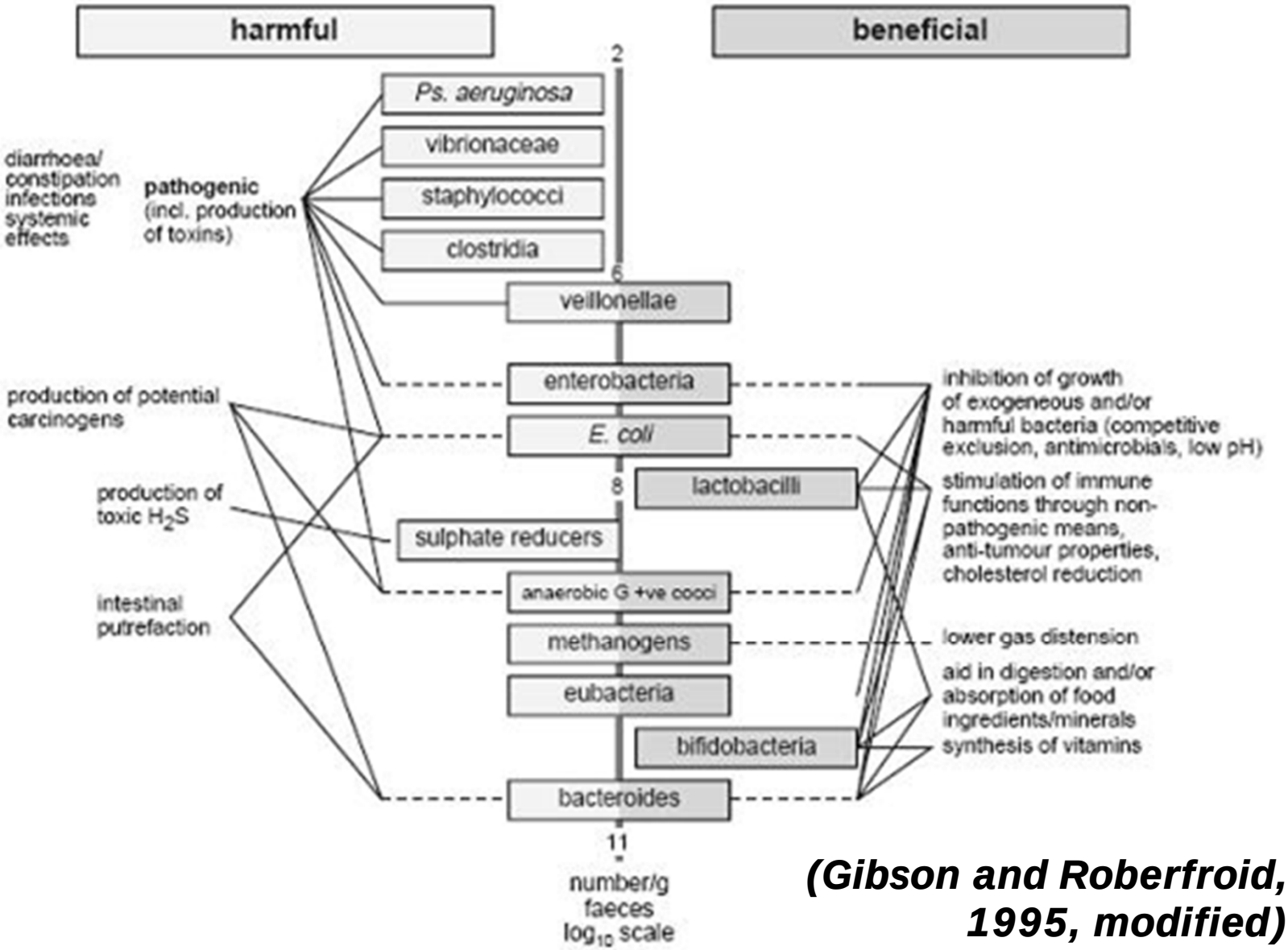


Descending colon

- Limited carbohydrate fermentation
- Limited bacterial growth
- pH approaching neutral
- High rate of protein fermentation

Normal mucosa

Colonic Microbiota



(Gibson and Roberfroid, 1995, modified)

Dietary Fiber and Fecal Characteristics

- **Stool quality is critically important to pet owners**
- **Amount and type of dietary fiber can impact stool volume and consistency**
  - **Excess fermentable fiber can result in loose stools**
  - **Nonfermentable fiber increases fecal volume**
- **Goal is to prevent constipation without large increases in stool volume or formation of soft stools**

Effects of selected fibers on intestinal transit time and fecal characteristics of dogs and (or) cats

Type	Fermentable	Fecal volume	Fecal moisture	Intestinal transit time
Psyllium	N	↑	↑	↑
Guar gum	P	↑	↑	↑
Pectin	C	↑	↑	↓
Cellulose	N	↑	↑	↔
Beet pulp	P	↑	↑	↓
Wheat bran	P	↑	↑	↔

P = partial; C = complete; N = not; ↑ = increase; ↓ = decrease; ↔ = no effect

Effects of Selected Fibers on Digestibility

		Digestibility			
		Ileal		Total tract	
Type	Fermentable	DM	CP	DM	CP
Pectin	C	↔	↔	↓	↓
Cellulose	N	↔	↔	↓	↔
Beet pulp	P	↔	↔	↓	↔

C = complete; N = not; P = partial; ↑ = increase; ↓ = decrease; ↔ = no effect

Effects of Selected Fibers on Indices of Intestinal Health

Type	Fermentable	Intestinal	
		Structure	Function
Pectin	C	↑	↑
Cellulose	N	↔	↔
Beet pulp	P	↑	NI

C = complete; N = not; P = partial; ↑ = increase; ↓ = decrease; ↔ = no effect; NI = no information available

Proposed Mechanisms of Fiber Action as Related to Colonic Health

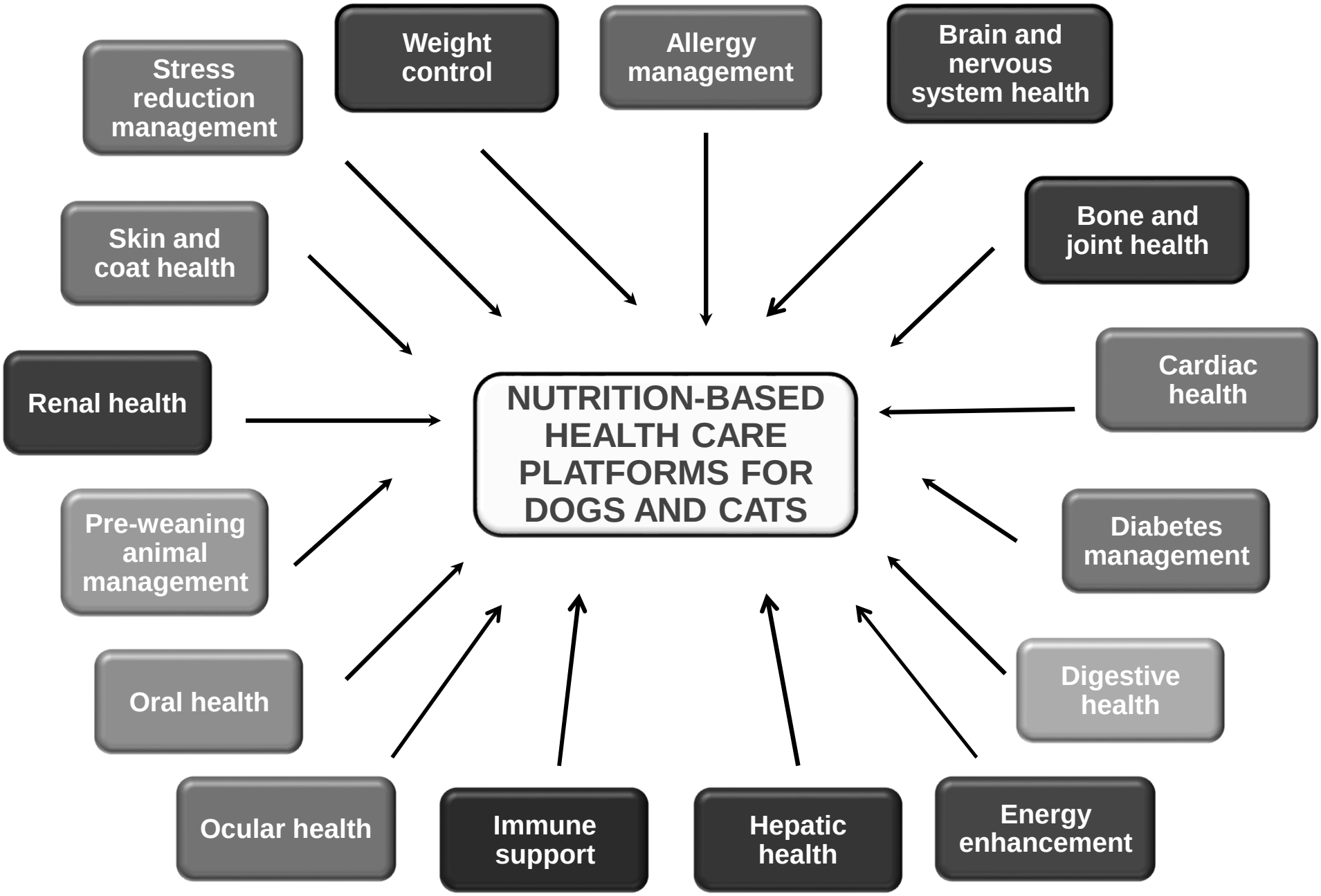
- **Increased dietary fiber intake increases water-holding capacity and stool volume, and dilutes toxins present in the colon**
  - **Larger, softer, more fluid stool easier to pass and is less abrasive**
  - **Faster transit means less time for toxins to interact with the colon wall and less production of secondary bile acids and other potential carcinogens (ammonia, phenols, indoles, amines)**

SCFA Production

- **Colonic fermentation increases SCFA production**
  - **Butyrate production especially important as it is the major energy source for colonic cells and is a signaling molecule for a wide range of metabolic events**

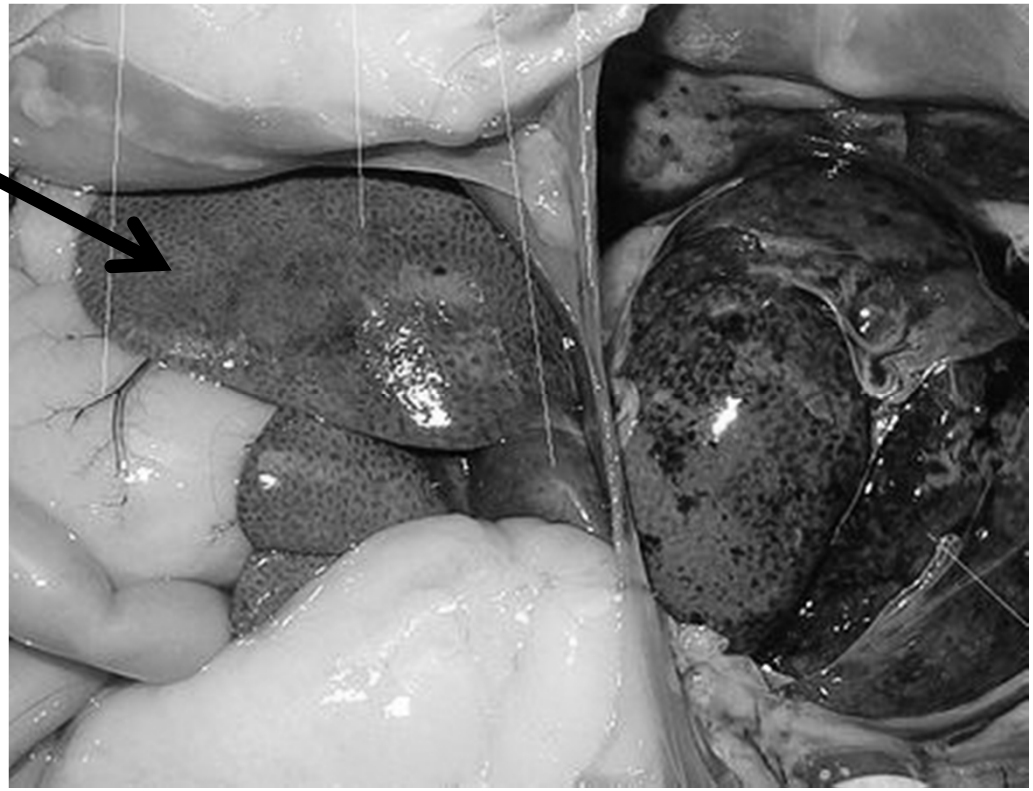
SCFA Production

- **SCFA lower pH, thus lowering disease risk and altering gut microbiota such that more healthful microbes (bifidobacteria, lactobacilli) thrive at the expense of less healthful microbes (clostridia, salmonella, *E. coli*, etc.)**
- **This is the classic “prebiotic effect”**


NUTRITION-BASED HEALTH CARE PLATFORMS FOR DOGS AND CATS
Weight control
Allergy management
Brain and nervous system health
Stress reduction management
Skin and coat health
Bone and joint health
Renal health
Cardiac health
Pre-weaning animal management
Diabetes management
Oral health
Digestive health
Ocular health
Immune support
Hepatic health
Energy enhancement

Hepatic Lipidosis

- **“Fatty liver”**
- **Caused by excessive accumulation of triglycerides in the liver cells**



Why Does It Happen?

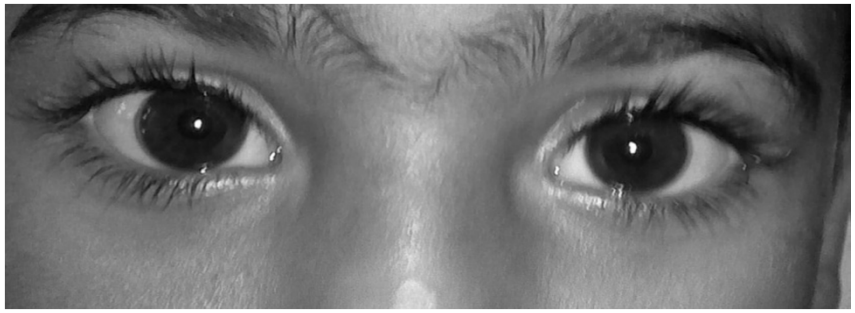
- **Often follows period of anorexia or starvation (2 weeks)**

- **Body is energy-deprived→ mobilizes fat stores for energy → fat carried to liver for processing**

What Happens in the Liver?

- **Liver unable to metabolize the fats → liver stores the fat in its cells**
- **Fat builds up in liver cells and bile ducts → bile cannot empty from the liver → animal becomes jaundiced (icteric)**





Hepatic Lipidosis

- **Related to causes of starvation → stress**
- **Secondary to IBD, pancreatitis, diabetes, hyperthyroidism, renal disease, and neoplasia**
- **Most likely to occur in obese animals**
- **Prevention is important, especially in weight loss programs**

Toby →



Milly →



What Can Be Done Using Nutritional Interventions?

- **Protein** — **good quality; adequate amounts; avoid foods that contain purines and uric acid precursors (e.g., shellfish, fish meal, spleen, thymus, liver, etc.)**
- **Fat** — **need supplemental carnitine to transport LCFA's**
- **Vitamins A, C, and E** — **must be adequate or super-adequate; antioxidant effects, too**
- **Dietary fiber** — **previously not recommended; now thought to be beneficial**

- **Feed a blend of dietary fibers high in soluble fibers (e.g., citrus pectin, psyllium) and prebiotic fibers (e.g., fructans)**
  - **Increase bifidobacteria and lactobacilli that will reduce ammonia production (becomes trapped as NH_4^+) and increase short-chain fatty acid production**
  - **Modulate de novo lipogenesis, protecting against the toxic effects of hepatic lipidosis**

- **Don’t feed too much dietary fiber such that food intake and nutrient digestion are suppressed**
  - **5-6% total dietary fiber max**
  - **2-3% units insoluble max; 3% units soluble**



Obesity/Overweight

- **Most common health problem today in dogs and cats**
  - **Up to 50% of dogs and cats in U.S. are overweight or obese**
  - **Owners overfeed in spite of specific feeding instructions on the food container**
  - **More high fat foods available today than ever before**
  - **More treats available than ever before**



What Can De Done Using Dietary Fiber Intervention?

- **Add fiber blends to foods that will aid in satiety and result in weight loss, if needed. Use fibers that affect gut peptide concentrations (e.g., GLP-1, PYY) that will subsequently affect the “ileal brake”.**



Nutritional Management

- **Very high fiber diets (i.e., 25-30% TDF) are effective in promoting weight loss. Insoluble fibers work best.**
- **For pets with weight control issues, a 10-12% TDF diet is adequate for preventing/ameliorating weight gain. A combination of insoluble and soluble dietary fibers, along with a prebiotic fiber (e.g., fructans), works best for animal satiation, especially in combination with high concentrations of good quality protein.**
- **For obese pets, target a 2-2.5% reduction in BW/week.**

Practical Recommendations Related to the Use of Dietary Fiber

* **Pay no attention to the crude fiber value on the guaranteed analysis section of the pet food label**
* **Recognize that detergent fiber values represent insoluble fibers only**
* **Consider using “total dietary fiber” as your estimator of dietary fiber concentration**
* **Select fiber inclusion levels that maintain or improve palatability and optimal stool quality**

Practical Considerations (cont'd)

* **Blend fiber sources to achieve an optimal balance between insoluble and soluble dietary fibers (70:30 to 80:20)**
* **Consider use of "functional fibers" that can elicit health benefits beyond laxation and calorie reduction**
* **Recognize the potential adverse effects of traditional fibers**
  * **Highly variable in chemical composition, resulting in formulation difficulties**
  * **Result in diet palatability problems**

Practical Considerations (cont'd)

- **Produce a large volume of gas and stool (major problem for pets housed indoors)**
- **Result in poor fecal consistency**
- **Result in a reduced nutrient digestibility (problem for growing, gestating, and lactating animals)**

* **Recognize the potential of supplementing traditional fibers with novel fibers, prebiotic oligosaccharides, and resistant starches to produce a fiber blend that will optimize pet animal health and well being**

Summary

* **In the case of dogs and cats, nutrition and health are tightly linked**
* **Nutrition affects health, and health condition drives the nutritional intervention strategy (ies) used to promote pet animal health and well being**
* **Dietary fibers are important ingredients in dog and cat foods, especially those in the premium/super-premium marketing sectors, as they have a strong influence on many critical health outcomes**

Summary (cont'd)

* **Recommended dietary fiber inclusion level in dog and cats diets depends on:**
  * **Marketing sector in which the food resides**
  * **Diet matrix constituents**
  * **Dog vs. cat considerations**
  * **Animal life stage**
  * **Animal health condition**