

The role of fiber in companion animal diseases

Jennifer Larsen, DVM, PhD, DACVN
School of Veterinary Medicine
University of California, Davis



What is Fiber?



- **Varied group of compounds not digestible by mammalian enzymes**
 - Mostly complex carbohydrates (beta-linked chains of sugar molecules)
 - Also lignin, phytates, waxes
- **Usually categorized by solubility and/or fermentability**
- **Not considered nutritionally essential in dogs and cats**



Fiber characteristics

- **In general, soluble fibers:**
 - Are more fermentable
 - Are viscous
 - Slow GI transit
 - Ex: inulin, pectins, gums
- **Insoluble fibers:**
 - Adsorb water
 - Increase fecal bulk
 - Ex: wheat bran, cellulose



Fiber characteristics

- **Mixed fiber sources**
 - Provide some aspects of both soluble and insoluble
 - Ex: beet pulp, soybean fiber, pea fiber
- **Many complex diets provide a mixed fiber effect since different ingredients provide both types or a mixed source**



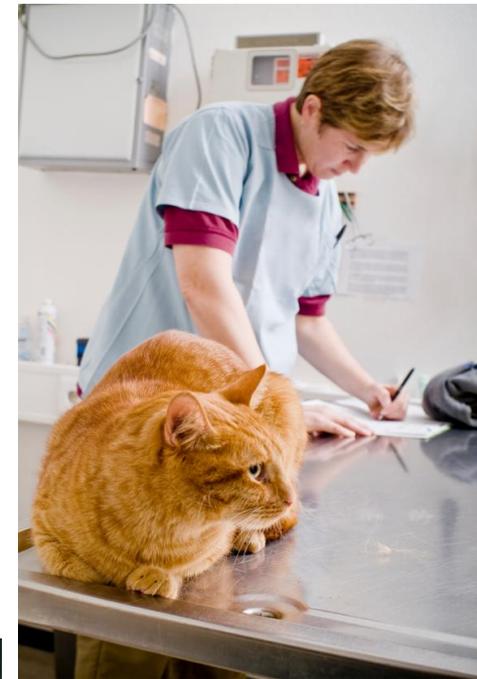
What does fiber do?

- **Goals of adding dietary fiber:**
 - **Achieve satisfactory and consistent stool quality**
 - **Satiety and decreased energy density of food**
 - **Modulation of gastric emptying & nutrient absorption**
 - **Fermentation to produce short-chain fatty acids**
- **Physiologic effects not uniform across types**



What does fiber do?

- These effects may be useful in the management of:
 - Obesity
 - Diabetes mellitus
 - GI disease (diarrhea)



Effect of fiber on obesity

- Both high and low fiber diets can be successfully used clinically provided energy is sufficiently restricted; this is supported by research data
- High fiber diets may increase compliance (volume perception for owner and pet, satiety)
 - Also consider diets with higher moisture, lower fat



Species differences?

- **Cats fed high fiber diets reduced energy intake whether energy restricted or not (Hand 1988)**
- **Cats fed higher fiber diets ad lib tend to eat less energy and lose weight (Oliveira et al. 2012 abs)**
- **Dogs fed restricted amounts of high vs. low fiber diets had the same degree of weight change despite no apparent impact on satiety (Butterwick & Markwell 1997)**
- **Dogs fed without restriction showed reductions in voluntary intake with high fiber diet (Jewell & Toll 1999; Jackson et al. 1997)**
- **Energy needs are stronger driver especially for dogs**



Effect of dietary insoluble fiber on control of glycemia in cats with naturally acquired diabetes mellitus

J Am Vet Med Assoc 2000;216:1082–1088

Richard W. Nelson, DVM, DACVIM; J. Catharine Scott-Moncrieff, MS, VetMB, DACVIM;
Edward C. Feldman, DVM, DACVIM; Susan E. DeVries-Concannon, DVM, DACVIM;
Philip H. Kass, DVM, PhD; Deborah J. Davenport, DVM, MS, DACVIM;
Christine T. Kiernan, BS; Larry A. Neal, BS

- **Insoluble fiber vs starch added to same canned diet in 16 cats, crossover design**
 - Total dietary fiber: 61 vs 11 g/Mcal
 - Digestible carbohydrate: 29 vs 37% ME
- **No difference: Calorie intake, insulin dose, BW**
- **12/16 cats fed higher fiber diet showed lower blood glucose measurements**



Effects of insoluble and soluble dietary fiber on glycemic control in dogs with naturally occurring insulin-dependent diabetes mellitus

J Am Vet Med Assoc 2000;216:1076–1081

Susan E. Kimmel, DVM; Kathryn E. Michel, DVM, MS, DACVN; Rebecka S. Hess, DVM, DACVIM;
Cynthia R. Ward, VMD, PhD, DACVIM

- **7 dogs, crossover design, product testing**
 - low fiber: CF 1.9 g/Mcal, TDF unknown
 - high insoluble: CF 5.1, TDF 73 g/Mcal
 - high insoluble+soluble fiber: CF 4.5, TDF 56 g/Mcal
- **No difference: Calorie intake, insulin dose, BW**
- **Lower mean and max blood glc AUC for high insoluble**
- **High soluble: diarrhea and flatulence reported**



Other studies in dogs with DM

- **Graham et al. 94**
 - Dogs fed diet high in insoluble fiber (14 g TDF/Mcal) showed reduced post meal variation in blood glucose vs baseline
 - No difference in glucose AUC or mean increase overall
- **Nelson et al. 91**
 - Dogs w/ induced DM fed high insoluble (cellulose; 70 g TDF/Mcal), high soluble (pectin; 55 g TDF/Mcal), or low fiber (24 g TDF/Mcal) experimental diets
 - High fiber diets resulted in lower blood glucose
- **Fleeman et al. 09**
 - Diets with 18-20 g TDF/Mcal had no advantage vs. diet with 14 g TDF/Mcal (all mostly insoluble)



Use of fiber in GI disease

- **Little research data, mostly clinical use**
- **Trial and error (amount and type)**
- **Useful for both diarrhea and constipation**
 - Maintenance of normal stool quality
 - Effects on motility
 - Water absorption/adsorption
 - Microbiota effect
- **Fermentable fiber (typically oligosaccharides)**
 - Prebiotic effect: selective fermentation by GI bacteria produces short-chain fatty acids (SCFAs) which are food source for enterocytes



Use of fiber to prevent and manage disease

- Its clear there are benefits to dietary fiber
- Exact amounts and types to use in populations or individual animals remains unclear
- How do we compare and categorize commercial diets based on fiber content?



Quantifying Fiber

- Diets vary in the amount and type of fiber they provide
- No standardized test
- Crude fiber (CF)
 - Used almost exclusively for pet food
- Total dietary fiber (TDF)
 - Used in human food for 30 years
- Other measures used in large animals

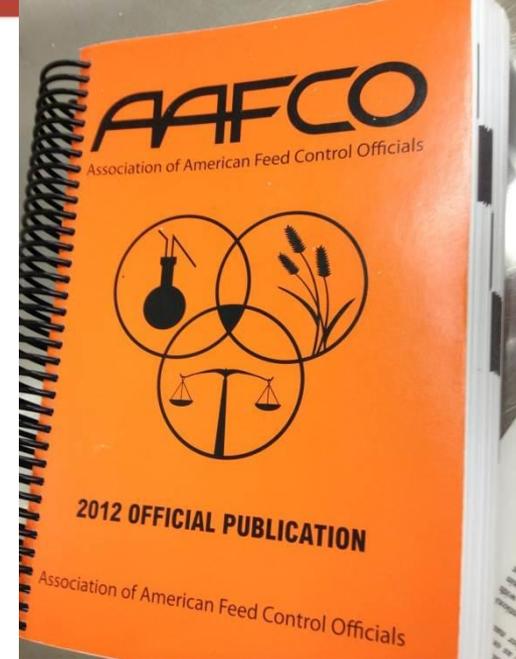
Nutrition Facts	
Serving Size 172 g	
Amount Per Serving	
Calories 200	Calories from Fat 8
% Daily Value*	
Total Fat 1g	1%
Saturated Fat 0g	1%
Trans Fat	
Cholesterol 0mg	0%
Sodium 7mg	0%
Total Carbohydrate 36g	12%
Dietary Fiber 11g	45%
Sugars 6g	
Protein 13g	
Vitamin A 1%	Vitamin C 1%
Calcium 4%	Iron 24%
<small>*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.</small>	
NutritionData.com	



GUARANTEED ANALYSIS: Crude Protein Min. 10.0%, Crude Fat Min. 5.0%, Crude Fiber Max. 0.5%, Moisture Max. 78.0%, Ash Max. 1.9%, Magnesium Max. 0.025%

Guaranteed analysis

- **Pet foods must include Guaranteed Analysis on label**
 - Min % for crude protein and crude fat
 - Max % for moisture and crude fiber
 - May include other nutrients
 - Displayed on an “as fed” basis



GUARANTEED ANALYSIS

CRUDE PROTEIN MIN8.0%
CRUDE FIBER MAX3.0%
CRUDE FAT MIN 3.0%
MOISTURE MAX76.0%



Guaranteed analysis

Guaranteed Analysis:	
Crude Protein (Min)	7.5%
Crude Fat (Min)	10.0%
Crude Fiber (Max)	1.0%
Moisture (Max)	78.0%
Vitamin E (Min)	100 IU/kg

- “Crude” refers to the laboratory measurement method, not the quality of the fiber, protein, or fat
- Crude fiber only represents a fraction of the insoluble and none of the soluble fiber in a food
 - Primarily cellulose, some lignin and a little hemicellulose



Total dietary fiber (TDF)

- TDF represents the insoluble and most soluble fiber present in a food (AOAC method 991.43)
 - +/- low molecular weight soluble dietary fiber (includes oligosaccharides; AOAC method 2011.25)
- A few pet food companies provide TDF in product guides for some veterinary therapeutic diets



Evaluation of fiber concentration in dry and canned commercial diets formulated for adult maintenance or all life stages of dogs by use of crude fiber and total dietary fiber methods

JAVMA, Vol 242, No. 7, April 1, 2013

Amy K. Farcas, DVM, DACVN; Jennifer A. Larsen, DVM, PhD, DACVN; Andrea J. Fascetti, VMD, PhD, DACVN, DACVIM

Objective:

To determine measured TDF and measured CF in commercial foods for adult dogs, and to compare claimed and measured CF



Evaluation of fiber concentration in dry and canned commercial diets formulated for adult maintenance or all life stages of dogs by use of crude fiber and total dietary fiber methods

Amy K. Farcas, DVM, DACVN; Jennifer A. Larsen, DVM, PhD, DACVN; Andrea J. Fascetti, VMD, PhD, DACVN, DACVIM

Study Design:

20 canned and 20 dry dog foods formulated for maintenance or all life stages.

Parameters measured:

CF and TDF (without oligosaccharides)

Label information reviewed and compared



Results

- Reported maximum CF > measured CF values ($p < 0.001$)
- Measured CF < measured TDF for all diets ($p < 0.001$)

	Median TDF	Median CF
Dry diets	10.3% DM	2.9% DM
Canned diets	6.5% DM	1.1% DM

- For dry diets, CF captured ~28% of the TDF
- For canned diets, CF captured ~17% of the TDF



Evaluation of fiber concentration in dry and canned commercial diets formulated for adult maintenance or all life stages of dogs by use of crude fiber and total dietary fiber methods

Amy K. Farcas, DVM, DACVN; Jennifer A. Larsen, DVM, PhD, DACVN; Andrea J. Fascetti, VMD, PhD, DACVN, DACVIM

Results:

Lots of variation -

Over 6 fold difference in TDF and over 31 fold difference in CF among diets

Energy density was not well correlated with TDF for either dry or canned diets ($r^2 \leq 0.4$).



Evaluation of fiber concentration in dry and canned commercial diets formulated for adult maintenance or all life stages of dogs by use of crude fiber and total dietary fiber methods

Amy K. Farcas, DVM, DACVN; Jennifer A. Larsen, DVM, PhD, DACVN; Andrea J. Fascetti, VMD, PhD, DACVN, DACVIM

Limitations:

- **Small sample size, only canine OTC diets**
- **No attempt to correlate findings to ingredients**
- **TDF method used does not account for oligosaccharides**



Relevance

- **CF did not reflect TDF content and is likely not a reliable indicator of effects on intestinal health, fecal quality, satiety, etc.**
- **Wide variability in crude fiber content of diets and lack of information for proportions of insoluble and soluble types means this cannot be used for comparisons among diets**



Total dietary fiber and oligosaccharides in feline diets for obesity and diabetes mellitus

Tammy J. Owens¹, Jennifer A. Larsen², Amy K. Farcas³, Richard W. Nelson⁴, Andrea J. Fascetti²

¹Veterinary Medical Teaching Hospital, School of Veterinary Medicine, University of California, Davis, ²Department of Molecular Biosciences, School of Veterinary Medicine, University of California, Davis, ³Department of Animal Science, University of California, Davis, ⁴School of Veterinary Medicine, Department of Veterinary Medicine and Epidemiology, School of Veterinary Medicine, University of California, Davis

Objectives:

- Determine TDF (including oligosaccharides) in feline therapeutic diets labeled for obesity and diabetes mellitus and in a limited number of OTC diets
- Compare results within groups and to manufacturer information

Abstract: American Academy of Veterinary Nutrition Clinical Nutrition and Research
Symposium, 2013
Publication in press, JAVMA



Materials & Methods

- **Therapeutic feline diets; 10 dry, 12 canned diets**
 - Purchased from clinics or solicited from pet owners
- **OTC feline diets; 3 canned diets**
 - Often recommended for use in cats with DM
 - Purchased from local retail outlet
- **Represented 5 manufacturers**
- **Samples analyzed for dry matter and TDF (AOAC method 2011.25)**



Results

- **Difference between median TDF and reported CF**
 - Dry diets: 4.3-10.7%
 - Canned diets: -0.05-8.2%
- **Diets labeled for obesity were higher in TDF and lower in energy density than diets for diabetes**
- **Diets marketed as low carbohydrate did not differ in TDF, insoluble, soluble, or oligosaccharide content, but they were 13% higher in energy density**



Results

- **Large difference in fiber amount/type between dry and canned versions of the same diet (up to 78% different)**
- **No difference in any fiber type, including low molecular weight soluble fiber, between diets with a separate purified oligosaccharide source disclosed vs not**
 - **Oligosaccharides may be inherent in many ingredients**
 - **Addition of purified sources may not be providing desired effects compared to diets without**



Comparing fiber content among diets



- **Together, these findings reinforce that there are marked differences among diets, and even between different versions of the same diet**
 - **Considerations for clinical trial planning and when making recommendations for individual animals**
- **More complete information for diets would also enable more accurate estimates of energy and of carbohydrate content**



Comparing diets



- **How does inaccurate information about fiber content affect estimates of energy and carbohydrate?**
- **Dry matter**
 - ◉ **Controls for moisture content only**
- **Calorie basis**
 - ◉ **Controls for moisture, fiber, and ash (components that don't provide energy)**



Comparing diets: Calorie basis

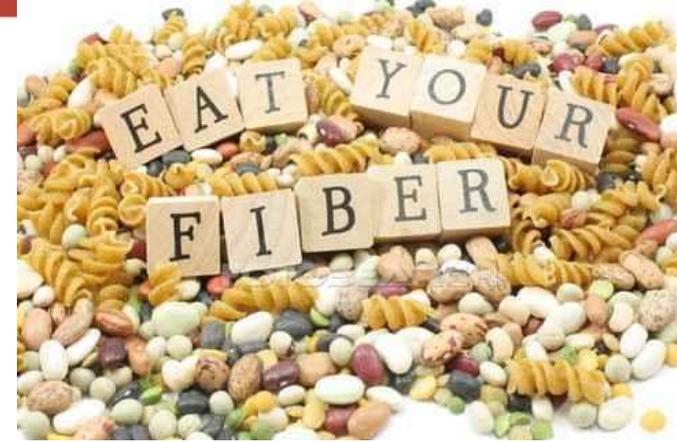
- **Limitations of using guaranteed analysis when calculating proportions of energy coming from protein, fat, and carbohydrate**
 - ◎ **Ash not required: estimate or inquire**
 - ◎ **Label gives max and min, not actual values**



Comparing diets: Calorie basis

- ⦿ **Carbohydrate determined by mathematical difference, not by laboratory analysis**
- ⦿ **Therefore, all errors dumped here**
 - ⦿ **Laboratory method inaccuracies**
 - ⦿ **Rounding**
 - ⦿ **Assumptions...**





Major assumption

- ◎ **Crude fiber does not reflect true fiber content**
- ◎ **“Hidden” fiber (some insoluble and all soluble) will be assigned to carbohydrate fraction**
 - Soluble fiber can be significant in some diets (up to over 8% DM)
 - Overestimates carb content
 - Overestimates energy content



Comparing diets: Calorie basis calculation example

GUARANTEED ANALYSIS

CRUDE PROTEIN MIN8.0%
CRUDE FIBER MAX3.0%
CRUDE FAT MIN 3.0%
MOISTURE MAX76.0%

- **$100 - (8+3+3+76) = 10$**
- **This 10% represents ash and carb**
- **Estimate ash or ask manufacturer: 3% in this case**
- **Difference is 7, so diet is 7% carb as fed**



CRUDE PROTEIN MIN8.0%
CRUDE FIBER MAX3.0%
CRUDE FAT MIN 3.0%
MOISTURE MAX76.0%

Comparing diets: Calorie basis

	grams per 100 g food		kcal per gram		total kcal per 100 g food
Protein	8	x	3.5	=	28
Fat	3	x	8.5	=	25.5
Carb	7	x	3.5	=	<u>24.5</u>
					78

• **78 kcal per 100 g food**



Comparing diets: Calorie basis

CRUDE PROTEIN MIN8.0%
CRUDE FIBER MAX3.0%
CRUDE FAT MIN 3.0%
MOISTURE MAX76.0%

- Calculation estimates calorie content of food as well as proportion of calories coming from protein/fat/carb
- If using calculation method to estimate energy content, AAFCO requires use of CF
- Since carb was overestimated, total energy was also overestimated



Overestimation of carb - does it matter?

- **We looked at the impact in our study of feline diets**
 - **Low carbohydrate diets often recommended for feline diabetics**
- **Using CF instead of TDF overestimated carb by up to 93% (median 21% higher when using CF)**
- **Results in inaccurate categorizations of diets based on carb content**
- **Many appropriate options may be unnecessarily omitted**



Does using TDF give the most accurate estimate of carb?

- De Oliveira et al (2011) found that for experimentally produced dog and cat kibbles, carb as estimated by TDF vs CF more closely approximated starch content, but for cat kibble the gap was bigger
- More work need to refine estimates (or measurement) of carbohydrate (starch) in pet foods



Considerations for measuring and reporting fiber in pet food

- **Current regulations for reporting fiber content and calculating energy density are for crude fiber**
- **Crude fiber is a poor representation of the fiber amount and types in food**
- **Use of crude fiber overestimates carb and energy content of food**



Considerations for measuring and reporting fiber in pet food

- Few companies provide TDF data, and none provide proportions of fiber types
- This information is also not commonly provided in research reports of dietary clinical trials or other prospective research
- The effects of fiber on the outcomes in these studies may confound results and cannot be fully assessed



Fiber and the future

- **Fiber has known and unknown effects in health and disease**
- **Full understanding of these effects are challenging to assess without information necessary to apply these principles both clinically and when planning and interpreting research data**
- **Laboratory analysis of TDF as insoluble, soluble, and low molecular weight soluble fibers is available yet potentially underutilized**



Questions

