Importance of fibre in diet

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Dietary fibre comes in many different forms, with different attributes and sources. They are carbohydrate macronutrients, which differ from starches and sugars; they resist enzymatic digestion in the mammalian small intestine.

Examples include cellulose, pectins, gums and lignin. Resistant starches are sometimes classified with fibre as they are similarly resistant to digestion. Resistant starches include different types; some are formed when starchy foods are cooked and then chilled, some are starches that occur in a form inaccessible to digestive enzymes, some are granular, and some are chemically modified to resist digestion (Lupton and Trumbo, 2006).

Pet food labelling

Table 1. Features of some fibre types

Fibre type	Fermentation rate	Solubility
Gums	Variable, usually rapid	Variable, usually soluble
Pectin	Moderate	Soluble
Resistant starch	Moderate	Variable
Hemicellulose	Moderate	Insoluble
Cellulose	Slow	Insoluble
Lignin	Not fermented	Insoluble

Table 1. Features of some fibre types.

Crude fibre, the term required on pet food labels, is largely comprised of insoluble fibres, such as cellulose. Crude fibre may represent 0% to 90% of the insoluble fibre and little to no soluble fibre (Farcas et al, 2015).

Total dietary fibre includes most soluble and insoluble fibre, but is rarely included on pet food labels. The ingredient list should provide some information about what fibre sources are used.

Features of fibre

Fibre sources vary in solubility, fermentability, effects on gastrointestinal (GI) transit and GI microbiome, water holding capacity, viscosity, free radical scavenging and cationic exchange properties (**Table 1**).

Different fibres are fermented to varying degrees by microbes in the colon. Rapidly fermentable fibres produce more short-chain fatty acids (SCFA) and gases than those that ferment less, such as cellulose and hemicelluloses. Most rapidly or highly fermentable fibres are considered to be “soluble”, meaning they will disperse in water. Conversely, less fermentable fibres, such as cellulose, are usually relatively “insoluble” (**Table 1**). Insoluble fibres generally have more of a “bulking” effect on stools, especially if they have good water holding capacity. Soluble fibres are more likely to increase GI transit time (for example, ingesta moves more slowly). The more viscous a fibre, the more it will slow nutrient absorption, a feature that can be used beneficially in diabetes mellitus, but also can be detrimental in some cases.

Many dietary fibre sources are “mixed” fibres with mostly soluble fibre characteristics; for example, psyllium is a mixed fibre with excellent water holding capacity.

Dietary fibre and microbiome

A relationship exists between soluble dietary fibre and gut microbiota. Soluble fibre functions as prebiotics to enrich probiotic bacteria, especially Lactobacillus and Bifidobacterium, which are beneficial for digestive function, mucosal integrity and immune response. The fermentable prebiotic fructooligosaccharides (FOS) is often added to pet foods. Adding FOS has been helpful in treating secretory diarrhoea in pigs (Oli et al, 1998).

Studies on FOS in healthy cats using FOS found no effect on duodenal bacteria (Sparkes et al,1998a), but did alter the faecal microbiota, increasing Lactobacillus and Bacteroides species and decreasing Escherichia coli and clostridia species (Sparkes et al, 1998b); however, a study in dogs did not show the same effects (Willard et al, 2000).

Table 2. Fibre content of some canine commercial diets for weight loss, diabetes mellitus and gastrointestinal disease

Manufacturer	Product	% CF as fed	% CF DMB	Dietary fibre as fed (DMB)	Main fibre sources	Calories/ 100g as fed	Calories /100g DMB
Hill's	r/d (dry)	12	13.1	–	Beet pulp, pea bean meal	302	approx 330
	r/d (canned)	5.2	21.3	–	Cellulose	72	297
	w/d (dry)	14.3	15.6	–	Cellulose, pea bean, beet pulp	299	approx 325
	w/d (canned)	3	11.3	–	Cellulose	95	360
Purina	CDO (dry)	6.5	7.1	–	Beet pulp	330	approx 360
Royal Canin	Gastro Intestinal (dry)	1.6	approx 1.7	3.52	Beet pulp	407	approx 445
	Gastro Intestinal (canned)	1.5	6	1.9 (7.6)	Vegetable fibres	109	436
	Gastro Intestinal Moderate Calorie (dry)	2.3	approx 2.5	7	Beet pulp	361	approx 395
	Gastro Intestinal Low Fat (dry)	1.7	approx 1.8	8.6	Wheat, barley, beet pulp	345	approx 380
	Gastro Intestinal Low Fat (canned)	1.7	6.5	2.9 (11.2)	Cellulose, beet pulp	92	354

CF = crude fibre, DMB = dry matter basis.
Note diet formulae change; the numbers are an indication and may not be accurate. This table is intended as a reference guide only and is not exhaustive.

Table 2. Fibre content of some canine commercial diets for weight loss, diabetes mellitus and gastrointestinal disease.

Dietary fibre fermentation by gut bacteria also produces metabolites for energy and signalling needs. SCFAs are produced by the predominant phyla Firmicutes and Bacteroidetes, and provide energy for colonocytes. Studies have also revealed novel mechanisms, whereby SCFAs act on membrane receptors and nutrient sensors to regulate physiological processes including glucose homeostasis.

Microbes deconjugate bile acids in the distal ileum and convert them into secondary bile acids. Alteration of the gut microbiome by diet (or antibiotics) changes the bile acid composition. Increasing evidence shows the bile acids have a role in the regulation of glucose and lipid metabolism, and their manipulation may have an effect on insulin sensitivity (Webster, 2014)

Uses of dietary fibre

Disorders in dogs and cats where dietary fibre has shown to be therapeutically important include obesity, large intestinal diarrhoea, constipation, and diabetes mellitus.

Satiety and obesity

Increased dietary fibre may reduce hunger and decrease food intake. Increased satiety is partially attributed to delayed gastric emptying and a subsequent feeling of fullness. Mixed fibres can also promote gastric distension and a slower ileal transit time. Gastric distension stimulates cholecystokinin release, a satiety hormone that decreases hunger.

In rats, fermentable fibre decreases plasma ghrelin, a hormone that increases hunger. The SCFA produced by fibre fermentation may also have actions on the production and secretion of GI satiety hormones.

Inclusion of fermentable fibre in canine diets increases the production of glucagon like peptide-1 (GLP-1), a hormone which slows gastric emptying and prolongs intestinal transit time (Deng et al, 2013). However, in dogs, a highly fermentable fibre (sugar beet pulp combined with inulin) versus a fibre of low fermentability (cellulose) did not show any treatment effects for peptide YY, GLP-1, or ghrelin (Bosch et al, 2009).

Studies on the use of fibre on food intake in dogs and cats have shown variable results, but indicate potential benefits (Jewell and Toll, 1996; Cline et al, 2012; Weber et al, 2007; Mitsuhashi et al, 2013).

In humans, consuming fibre as part of a weight-reducing diet may assist in weight loss, and high dietary fibre intake is associated with a lower incidence of obesity (Maskarinec et al, 2006). Fibre has fewer calories per gram than other nutrients, ranging from 0kcal/g to 2kcal/g compared to protein and carbohydrates, which have 3.5kcal/g and fat at 8.5kcal/g. Increasing the fibre content of the food results in “calorie dilution”, for example, the calories per 100g of diet are decreased.

A study of obesity in dogs showed crude fibre was positively associated with protein intake and lean dogs received significantly more crude fibre than overweight dogs (Heuberger and Wakshlag, 2011).

Figure 1. High-fibre diets are often recommended for overweight dogs, as shown in the WSAVA Global Nutrition Committee’s body condition chart.

Another canine study looking at a high-protein, high-fibre diet for weight loss showed the percentage and rate of weight loss and the percentage of fat loss were greater compared to feeding a high protein, medium fibre diet (German et al, 2008; **Figure 1**);

In cats on a weight loss programme, those on a higher fibre diet (5g/100kcal) versus a lower fibre (0.6g/100kcal) and lower carbohydrate diet were less likely to pace or beg at the food bowl, and less likely to forage or steal food. Owners of the cats on the high-fibre diet were more satisfied with their cats' weight loss programme than those with cats on the low fibre diet (Cline et al, 2012).

Diarrhoea and constipation – effects of fibre on the intestine

The effects of fibre on the GI tract are physical, fermentative and microbial. Some types of fibre may increase the number of goblet cells and mucus in the small intestine, some gel-forming fibres slow gastric emptying and small intestinal transit time, and some insoluble fibres hasten gastric emptying and small intestinal transit time. In some dogs, a "normalisation" of GI transit time occurs on a cellulose-containing diet, for example, slow transit times become faster and rapid transit is slowed.

The SCFAs formed from fibre fermentation, especially butyrate, provide more than 70% of the energy for colonocytes, important for cell renewal and repair. Butyrate also appears to directly inhibit tumour formation in the large intestine. Increased SCFAs increase colonic absorption of sodium, chloride and water, which may improve some types of diarrhoea. Increased SCFA also increases colonic ammonia absorption by decreasing the pH and trapping the ammonium ions (ionised particles are less able to cross cell membranes). The decreased pH discourages the growth of some pathogenic bacteria, for example, *Clostridium perfringens*, *Salmonella* and pathogenic *E coli*. A study has shown the faecal microbiota of dogs with chronic diarrhoea became similar to that of normal dogs after the addition of a fibre blend (Jia et al, 2010).

Insoluble fibre dilutes colonic content by its bulking activity, adsorbs colonic bile acids and other mucosal irritants, and often improves faecal consistency. Increased dietary fibre also has a role in irritable bowel syndrome (Kanauci et al, 2010), although some individuals may have increased bloating (Dapoigny et al, 2003).

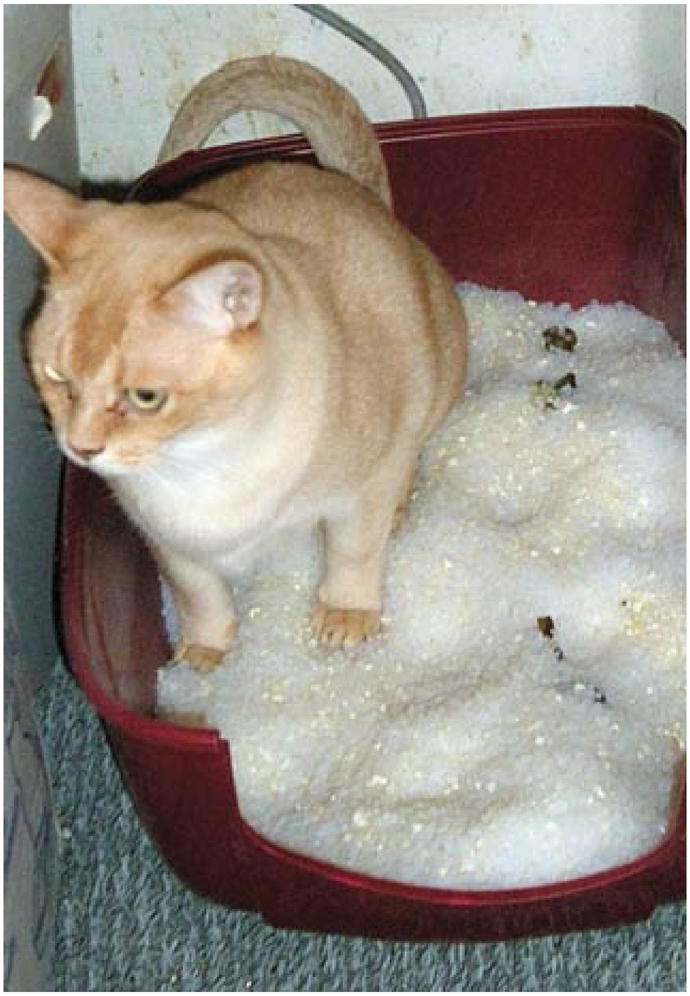

Figure 2. Increased soluble fibre – for example, psyllium – is recommended in constipated cats.

A study of canine chronic idiopathic large intestinal diarrhoea showed a good to excellent response to the addition of psyllium in 96% of dogs (Leib, 2000). However, feeding a novel protein or hydrolysed protein diet, and then adding a fibre source if the response is inadequate, may also be tried. The type of fibre to use varies among animals and the initial choice is empiric. A source of mixed soluble and/or fermentable (for example, psyllium vegetable fibres) and less soluble fibre (for example, cellulose) may be beneficial in many cases. Remember, the crude fibre on the label does not include all fibre types.

The response of constipation to fibre is variable and can depend on the underlying cause. Increased insoluble, less fermentable fibres increase faecal bulk, which may stimulate colonic and rectal contractions and increase frequency of defecation, but may worsen constipation in an animal with colonic dysmotility. Fibre-producing viscous gels, such as psyllium, will increase the faecal water and faecal bulk, and the SCFA produced may stimulate colonic smooth muscle contractions. Increasing faecal bulk can help dogs who struggle to empty their anal glands.

In studies in cats with constipation, 82% to 93% showed improvement on a psyllium-enriched diet (**Figure 2**; Freiche et al, 2011). Many of the cats required less or no cisapride and lactulose. However, diets with increased fibre should not be used in cats with severe obstipation.

Fibre and diabetes mellitus

While dogs nearly always have type 1 diabetes mellitus and require insulin injections, glycaemic control can sometimes be improved with weight loss and/or increased dietary fibre.

Increased fibre may help glycaemic control by slowing gastric emptying and slowing carbohydrate absorption from the intestinal tract. Several studies have indicated high-fibre diets, often insoluble fibre, improve glycaemic control compared to low fibre diets (Chastain et al, 2000). One study comparing high to moderate mixed fibre diets showed no significant improvement with the higher amounts of fibre (Fleeman et al, 2009).

Table 3. Fibre content of some feline commercial diets for weight loss, diabetes mellitus and gastrointestinal disease

Manufacturer	Product	% CF as fed	% CF DM	Dietary fibre as fed (DMB)	Main fibre sources	Calories /100g as fed	Calories /100g DMB
Hill's	m/d (dry)	3.6	3.8	–	Cellulose	391	416
	m/d (canned)	1.5	6	–	Cellulose	101	405
	r/d (dry)	14.1	15.1	–	Cellulose	305	328
	r/d (canned)	3.7	15.4	–	Cellulose	77	319
	w/d (dry)	8.5	9.2	–	Cellulose, pea bran, beet pulp	322	347
	w/d (canned)	2.5	10.6	–	Cellulose	88	372
Purina	OM (dry)	7.5	8	–	Pea fibre	310	331
	OM (canned)	1	4.76	–	Cellulose	80	380
Royal Canin	Gastro Intestinal (dry)	5.2	approx 5.6	11.1	Vegetable fibres, beet pulp	407	approx 437
	Gastro Intestinal (canned)	0.8	4	0.57 (2.9)	Cellulose	93	465
	Gastro Intestinal Moderate Calorie (dry)	5	approx 5.4	11.1	Vegetable fibres	372	approx 400
	Gastro Intestinal Moderate Calorie (canned)	1	5.7	2 (11.4)	Cellulose	71	405
	Fibre Response (dry)	2.9	approx 3.1	11.7	Psyllium husks and seeds, chicory pulp, FOS	389	approx 418
	Satiety (dry)	13.9	approx 14	23.6	Vegetable fibres, psyllium husks and seeds	306	approx 325
	Obesity (dry)	6.4	approx 7	14.7	Vegetable fibres, psyllium husks and seeds	356	approx 380
	Obesity (canned)	1.5	9.4	1.5 (9.4)	Cellulose, FOS	64	403

CF = crude fibre, DMB = dry matter basis.
Note: diet formulas change, the numbers are an indication and may not be accurate. This table is intended as a reference guide only and is not exhaustive.

Table 3. Fibre content of some feline commercial diets for weight loss, diabetes mellitus and gastrointestinal disease.

As dogs on the higher-fibre diets lost weight compared to the more moderate fibre diets, the choice of diet may depend on if weight loss is desired. Thin, diabetic dogs should usually not be fed a high-fibre diet. As noted previously, the increased SCFA and bile acid effects may also affect appetite and insulin responses.

Diet and pharmacological management of type 2 diabetes results in remission (resolution of the requirement for insulin) for up to 50% to 70% of diabetic cats. Remission is aided by weight loss in overweight cats and control of blood glucose concentrations with insulin to eliminate glucose toxicity. Two types of food are recommended for diabetic cats: high fibre-high complex carbohydrate or high-protein low-carbohydrate. Diabetic cats on either type of diet have shown improvement (Kirk, 2006).

As in dogs, the recommendation for increased dietary fibre content is due to the GI and nutrient absorption effects. Foods high in fibre may aid in weight control or loss. The use of increased fibre in normal weight or thin cats should be avoided or used cautiously. Recommendations for dietary management now usually includes the use of high-protein low-carbohydrate diets, which have shown very good evidence for improved glucose control and good rates of remission (Bennett et al, 2006).

Side effects of fibre

While fibre is beneficial in many conditions, there are potential side effects. As it is low in calories, high-fibre diets can result in unintentional weight loss. Other potential and undesirable side effects include decreased absorption of nutrients, poor palatability, increased flatulence and faecal volume.

Sources of fibre

Table 4. Characteristics of dietary fibre in some common foods

Fibre source	Total dietary fibre/100g	Calories /100g as fed	% water	Predominant fibre type
Wheat bran (raw)	42.8	216	9.89	Insoluble
Wheat bran (cereal)	17.5	318	3	Insoluble
Oat bran (raw)	15.4	246	6.55	Mixed
Rice bran (raw)	21	316	6.13	Insoluble
Psyllium	55.56	370	<10	Mixed (S)
Chia seeds	38	490	<10	Soluble
Oat bran (cooked)	2.6	40	84	Soluble
Pumpkin (canned)	2.9	34	89.97	Mixed (S)
Courgettes/ zucchini (raw)	1.1	21	92.73	Mixed
Raw apple (Gala) with skin	2.3	57	85.56	Mixed (I)
Artichokes (boiled)	5.7	51	84.08	Soluble (I)
Banana (raw)	2.6	89	74.91	Mixed (S) and resistant
Baby carrots	2.9	35	90.35	Mixed
Oat cereal (cooked)	10.1	379	83.61	Mixed
Peeled cucumber (raw)	0.7	12	96.7	Mixed (I)

There is no definition for mixed fibre; for this table when either insoluble or soluble fibre comprises less than about 2/3, but for more than half of the fibre source it is indicated by (I) or (S) as the predominant fibre source in a mixture. Solubility is only one characteristic of fibre and others may also vary. Drier foods are listed at the top, with moister foods listed at the bottom (USDA Food Composition Database, Balanceit.com)
Note this table does not constitute recommendations for these sources.

Table 4. Characteristics of dietary fibre in some common foods.

Many commercial diets for weight loss or control, diabetes and colonic disease contain increased fibre. An analysis of pet foods for obesity, diabetes mellitus management and fibre-responsive diseases showed a range of total dietary fibre from 10.2% to 27.5% on a dry matter basis (Fracas et al, 2015). Canned and dry versions of the same food also differed in fibre content and composition (**Tables 2** and **3**).

Ingredients that can add soluble fibre include oat bran and fruits, and those which include insoluble fibre include some vegetables, whole wheat and wheat bran (**Table 4**). Psyllium husks are an excellent source of mixed fibre. The amount to add depends on the pet and diet it is on. It is best to start low and increase gradually.

Summary

Many types of dietary fibre exist with differing attributes. Often categorised as soluble or insoluble, which may or may not reflect fermentability, gel-forming tendencies or other characteristics.

The crude fibre listed on labels does not reflect the total dietary fibre, as it omits many of the more soluble fibre types. Disorders that may benefit from increased fibre in the diet include obesity treatment or prevention, some types of diarrhoea and constipation, and some animals with diabetes mellitus. Therapy for each animal must be considered on an individual basis and, in some cases, may require trial and error with different fibre types.

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