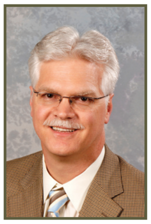
Petfood Industry
Special Supplemental Section

Functional ingredients add fiber, protein, other benefits to petfoods



By Greg Aldrich, PhD

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Pea fiber: a functional petfood ingredient

Pea fiber can be found in an increasing number of petfoods, especially in the premium, holistic and alternative format products. This ingredient is relatively new to petfoods and may be a strategic addition to counteract a growing consumer discontent with beet pulp and an absolute resistance to any of the functional fibers derived from wheat (e.g., bran), corn (corn bran) or soy (soyhulls).

These fiber sources are commonly perceived as cheap fillers by the diamond-studded collar and leash set. While this impression about the functional utility of these standard fibers is a long way from the truth, it certainly underscores that consumer perception rules the day.

As a potential alternative, pea fiber might fit in with tomato pomace and oat bran as an ingredient intended to evoke an image of consistent stools and healthy colonic fermentation. While the pea fiber name may be label and consumer (pet owner) friendly, is there evidence to support its use in petfoods, and does it perform equal to the task?

With a label-friendly name, pea fiber offers an effective, reasonable alternative fiber source for companion animal diets.

To start, it may be important to understand what pea fiber is. There are essentially two types on the market. One is derived from the seed coats and hulls separated from the seed in a "dry" process; the other comes from a "wet" process that separates pea starch from fiber. In the dry process, coats and hulls are removed as part of normal cleaning and handling operations, with the seed separated by particle density and size exclusion through a sieve to fractionate the fibrous hull and seed coats from the rest of the pea cotyledon.

In the wet process, the seeds are ground, then water is used to separate and float out (decant) the cotyledon fibers. This is part of the same process used to produce purified pea starch and pea protein isolate.

The coat-and-hull dry process pea fiber contains a higher concentration of dietary fiber (more than 85% total dietary fiber, or TDF) rich in xylose sugar; the wet process cotyledon-based pea fiber is slightly lower in dietary fiber (approximately 65% TDF) but rich in arabinose/rhamnose, cellibiose and galactose sugars (Dalgetty and Baik, 2003). Both types of pea fiber are high in insoluble fiber (more than 75%) with 5% to 25% as soluble fiber.

Where these attributes matter is in the gastrointestinal tract and the effect they have on elimination and fermentation. Since pea fiber has a substantial water-holding and oil-binding capacity, it is often used as a natural extender in human foods. In this manner, it holds moisture and imparts texture to low-fat foods.

But not so in petfoods. In this application, it is used as a nutritionally functional fiber due partly to the laxation effects imparted from the water-holding capacity (about 13 mL water per g pea fiber) of the insoluble fiber and partly for the fermentability of its soluble fiber.

Bench-top fermentation tests of pea fiber have shown that under artificial stomach and intestinal digestion parameters (*in vitro*), the degree of degradation and subsequent short-chain fatty acid production (such as butyrate, the target short-chain fatty acid for colonocytes) are comparable to other fibers like tomato pomace and psyllium husk. However, pea fiber does not produce as much gas as other vegetable fibers like citrus pectin or carrot pomace (Swanson *et al*., 2001) or sugar beet fiber (Titgemeyer *et al*., 1991).

Using pea fiber in petfoods is fairly straightforward. It is a white to cream colored, nearly odorless, free-flowing powder. Pea fiber is bland to the taste and does not affect palatability or override normal signals to satiety in dogs (Butterwick *et al*., 1994). It mixes well with both dry and wet ingredients and has been used to bind water and fat, as well as serve as a thickener in wet food preparations.

Pea fiber is extremely low in fat (less than 0.25%) and high in crude fiber (pushing 35% to 40%). For this reason alone, it can be a significant contributor to lowering the calorie content of "diet" foods.

In addition, because of its high insoluble fiber content, adding a meaningful amount of pea fiber to the diet has been shown to modulate the glycemic response in diabetic dogs (Graham *et al*., 1994; Maskell *et al*., 1994). Pea fiber ash content ranges from 2% to 3%, with potassium being the most significant single mineral and the content of magnesium sufficient enough to be a minor impediment when formulating a low-calorie, low-magnesium cat food.

The contribution of protein from pea fiber is relatively insignificant, ranging from 6% to 12%. The amino acid profile is high in lysine, and it also contains a fair level of tryptophan (often a first-limiting amino acid in complete petfoods); but, methionine is limiting as it relates to the ingredient's amino acid balance.

While pea fiber and pea hulls are not defined in the Association of American Feed Control Officials *Official Publication*, *per se*, given they are derived from the common yellow and green field pea (which are not described either), one would surmise that pea fiber is permitted under the "common name" exception. Fortunately, there is some precedence for recognition as a fiber source by the Food and Drug Administration as part of the Nutrition Labeling and Education Act.

Conspicuously absent are any data on the effects pea fiber has on stool consistency in either species.

In the case of pea fiber, unlike a number of other ingredients we commonly encounter in petfoods, there are at least a few published studies in which the ingredient has been fed to companion animals and nutritionally characterized. The only gaps in this understanding are an absence of any work feeding pea fiber to cats, and conspicuously absent are any data on the effects pea fiber has on stool consistency in either species.

Anecdotal evidence from customer service phone lines at companies presently using pea fiber and from ingredient suppliers suggests there are no issues—most state that it performs comparable to rice bran or beet pulp for these purposes. However, it would certainly be helpful to all users if hard data were available on pea fiber's signature feature: stool quality.

Short of this one omission, given that pea fiber appears effective, it would seem a reasonable alternative fiber source for companion animal diets. ■

Is L-carnitine beneficial in 'diet' petfoods?

L-carnitine is a supplemental amino acid (ingredient) commonly found in low-fat, "light" or so-called diet foods for both dogs and cats. For the most part, the body produces an adequate amount of carnitine (L-isomer metabolite) to fulfill its role in the conversion of fatty acids into usable energy. So, what do we know about supplemental L-carnitine? Does adding it to the diet benefit weight control?

Though L-carnitine may be a relatively new ingredient to most petfood purchasers, carnitine has been recognized for more than a century. It was first isolated from meat extracts (thus the Latin prefix *carni-*) in 1905 and a few years later was shown to be a growth factor for the meal worm (*Tenebria molitor*) for which it was subsequently branded vitamin BT. Given that most mammals are able to produce carnitine in sufficient quantities, it never became a full-fledged vitamin. However, there are times when it may be beneficial or even conditionally essential.

Carnitine is a quaternary amine (beta-hydroxy-gamma-trimethylammonium butyrate) that is synthesized in the liver and kidney using peptide bound lysine as a starting material. The peptidyllysine is then methylated by three methionines to form trimethyllysine, which is cleaved apart by an ascorbic acid dependent hydroxylation to yield carnitine (the L-isomer). Coenzymes and cofactors such as nicotinamide, vitamin B_6 and iron are also involved. This resulting compound is hygroscopic and readily soluble in water. It can be found in the circulation, major organs and muscle as both free carnitine and esterified to various acyl compounds.

Because carnitine is stored in muscle, the food sources with highest concentrations are meats. For example, beef and lamb levels are reported at approximately 600 to 2,000 mg/kg, chicken at about 50 to 100 mg/kg and organ meats like kidney and liver at approximately 20 mg/kg carnitine (Mitchell, 1978). Carnitine concentrations are much lower in milk, vegetables, nuts and yeast (about 5 to 20 mg/kg). Bioavailability of carnitine from the diet ranges from the mid-50% to 80% and is somewhat dependent on the adaptation of the individual to the dietary carnitine source.

Supplementation with commercially produced L-carnitine is available to make up for gaps after accounting for endogenous production, conservation by the kidney and dietary sources. Unlike endogenous production, commercial chemical synthesis produces an all-racemic mixture of D- and L-carnitine. Only the L stereoisomer can be utilized for beneficial purposes; the D-isomer can cause serious side effects. Thus, modern chemistry

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hasn't been the answer for commercial production of this compound.

Instead, virtually all commercial L-carnitine is derived from fermentation by specially selected bacteria (e.g., US Patent No. 5,028,538). The resulting L-carnitine ingredient is a white crystalline powder or granule and is generally available (per definition) as 97% L-carnitine with a stated maximum amount of the D-isomer of less than 0.5%.

What purpose does carnitine serve? Long-chain fatty acids cannot directly enter into the mitochondria for conversion into energy. They require a special transporter or shuttle. That shuttle is carnitine.

The first step in shuttling the fatty acid into the mitochondria starts in the cell cytoplasm where the "free" fatty acid gets connected to coenzyme A in a thiolase catalyzed reaction. Then a specialized acyl-transferase exchanges the CoA moiety for a carnitine to form a fatty acyl-carnitine. In this form, carnitine ferries the long-chain fatty acids into the mitochondria for utilization via beta-oxidation. A separate acyl-transferase is then required for transport of carnitine and spent acyl compounds back out of the mitochondria and into the cell cytoplasm.

Because of this ability to improve the utilization of fatty acids for energy and shuttle spent compounds out of the mitochondria, supplemental L-carnitine has found a number of applications in medicine:

- Hemodialysis in late stage kidney failure;
- Improvements to male fertility;
- Improvements to insulin sensitivity in type II diabetics;
- Fortification of parenteral neonatal formulas; and
- Retention of cognitive function associated with Alzheimer's disease.

In dogs, L-carnitine supplementation has been supportive in rare carnitine synthesis disorders and extreme working conditions. However, no dietary requirement for carnitine has been identified for dogs or cats under normal physiological conditions.

Given that carnitine supports the oxidation of fatty acids, its use in "light" or "weight loss" diets is based on the hypothesis that L-carnitine supplementation "stimulates" fatty acid oxidation without compromising muscle mass. Several studies seem to support this position.

Home feeding studies would help determine if this ingredient is a practical tool for combating pet obesity.

Gross *et al.* (1998) reported that obese Beagles fed a calorie restricted diet supplemented with 300 ppm L-carnitine retained greater lean body mass. In a similar fashion, obese Beagles lost more body fat than controls when supplemented with 50 and 100 ppm L-carnitine (Sunvold *et al.*, 1999).

For obese cats, supplementation with 250 mg L-carnitine led to more rapid weight loss without adverse effects (Center *et al.*, 2000). So, while not required per se, L-carnitine may provide benefits under the right conditions.

L-carnitine is permitted in complete dog foods at levels up to 750 ppm and in complete cat foods at levels up to 1,000 ppm. Since it is a pricey ingredient, the amount used in foods is more in line with the "diet" research (about 100 to 300 ppm). At these levels it appears supplemental L-carnitine is effective in weight management petfoods under controlled conditions. Confirmation in home feeding studies will help determine if it is a practical tool for combating the long-term obesity issues faced by today's pets. ■

Rosemary extract acts as natural antioxidant

Rosemary extract is a common ingredient found on dry petfood labels, typically at or near the bottom of the ingredient listing. While rosemary extract is generally viewed with favor by pet owners, it doesn't provide nutritional fortification, it doesn't provide medicinal support for any specific ailment, nor does it enhance the taste appeal of the food (for pets). In fact, pets don't really like the taste or smell at all. So what exactly is rosemary extract and why is it in petfood?

Rosemary extract is the oily resin derived from the leaves of the rosemary plant (*Rosmarinus officinalis L.*). This plant is a woody evergreen perennial shrub from the *Limiaceae* family that grows readily in warm arid climates around the world. There are hundreds of varieties, each with its own aesthetic value, growing characteristics, seasoning profile and functional utility.

Aside from recreational gardeners and farm-to-market suppliers for the restaurant and culinary trade, industrial scale cultivation occurs in only a few regions of the world—most notably the Mediterranean countries such as Morocco, Spain and Turkey. In the US, agricultural production of rosemary is growing from a small base principally in the Southwest.

On commercial rosemary farms, the leaves and stem tips are harvested in a way similar to pruning a hedge, and the clippings are shipped to extraction facilities. Most industrial scale extraction plants use organic solvents such as acetone, hexane or methanol in a process not too different from extracting oil from soybeans or canola.

The resulting extract is a complex mixture of compounds rather than a specific defined chemical entity. The dark black-green extract contains aromatic "essential oils" (such as cineol or eucalyptol, pinene and camphor) and antioxidant diterpenes (such as carnosic acid, rosmarinic acid and their metabolites). This crude extract is further processed to a uniform consistency (viscosity) and activity.

This common ingredient is most effective in dry petfoods that use high levels of polyunsaturated fats and marine oils.

In so-called natural petfoods, rosemary extract is added to retard fat oxidation (rancidity). Though we can't claim it as such, rosemary extract functions like a preservative and is purported to work in synergy with the mixed tocopherols. Hard evidence of this latter aspect is lacking in petfoods, but that doesn't detract from its

Rosemary extract, a common ingredient in dry petfoods, is the oily resin derived from the leaves of the rosemary plant.

own unique antioxidant effects.

Rosemary extract has been found to be most effective in petfoods that use high levels of polyunsaturated vegetable and marine oils to meet essential fatty acid requirements or label claims. In the course of petfood production, the rosemary extract is added to these polyunsaturated fats and oils as a blend or premix. In addition to the rosemary extract, these oily liquid premixes commonly contain mixed tocopherols, citric acid, emulsifiers like lecithin or mono- and di-glycerides and a vegetable oil carrier.

The level of rosemary extract in one of these blends can range anywhere from trace amounts to 20% or more depending on the preparation and intention. In most cases, the deciding factor for the amount that gets added depends on the intensity of the residual aroma, cost and antioxidant capacity. The final concentration of rosemary extract in a petfood resulting from this delivery route ranges from 1 to 500 ppm.

Rosemary is safe, with a long history of use in human foods, household cleaners, personal care products, folk medicine and even insect repellents. It is popular in aromatherapy, and recent research would suggest that rosemary essence (or aroma) may improve long-term memory (Moss *et al.*, 2003).

Rosemary may even play a role in cancer therapy. For example, Dorrie *et al.* (2001) reported that carnosic acid from rosemary promoted apoptosis (programmed cell death) in a leukemia cell line. Toxicity testing in rodents revealed that it is very well tolerated in large doses (Anadon *et al.*, 2008) and for long periods (EFSA, 2008). No contradictory toxicity data was found for pets.

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Despite its recognized utility and safety, there have been a few owners of epileptic dogs expressing concerns to petfood companies and their suppliers that rosemary extract might trigger seizures in their pets. This is a rare condition in dogs and generally understood to be an inherited disorder. However, in humans and rodents, the essential oils like eucalyptol (cineole), camphor and pinenes (but not the antioxidant diterpenes) have been implicated as an epileptic seizure trigger (Burkhard, 1999).

No cases were found in the literature substantiating a similar association between rosemary and canine seizures. At this stage, the cause and effect appears to be an extrapolation across species. If there is a link, and if the essential oils are a trigger, then dose is likely a factor. To that end, the estimated amount of these essential oil compounds in a petfood is likely less than a few parts per billion.

In the regulatory world, rosemary is considered a spice and/or seasoning (21CFR582.10) and is permissible as an essential oil (21CFR582.20). Since this is the extent of its definition, how well rosemary extract functions is completely dependent on the quality and dependability of the supply stream and the intended petfood application. Developing methods to assure a consistent supply and periodic verification for efficacy are vital to its sustained success.

In the end, incorporating rosemary extract into petfoods reflects the state of the art in natural functional ingredients for the maintenance of fresh products designed for modern distribution systems and convenient product placement on store shelves. It also represents the types of technologies needed to ensure safe, healthy and sustainable petfoods for the next generation. ■

Pulses: new ingredients for petfoods?

With the availability of quality ingredients declining, perhaps we need to explore this category.

In the search for new, high quality raw material sources with consumer appeal and a solid nutritional pedigree, pulses are one class of ingredient that the petfood industry has all but completely overlooked. Is that because of limited availability, poor acceptability by the pet, misperceptions about acceptable ingredients for pets or some other intrinsic nutritional or health issue?

Direct answers may be hard to find. But given that we are facing issues regarding the availability of quality ingredients and a shrinking list of alternatives, maybe it is time we explored this class of ingredients to see if they provide options worth considering.

Pulses are the dried seeds found in pods of leguminous plants. These legume seeds include various dry beans from the *Phaseolus* and *Vigna* genus (e.g., pinto beans, navy beans, kidney beans, black beans) along with lentils, peas, chickpeas (also known as garbanzo beans), field beans, cow peas and several minor families. Pulses do not include seeds grown for oil production such as peanuts and soybeans, "greens" such as fresh or succulent peas and green beans or leguminous forage seeds such as clover and alfalfa.

Pulses are grown on each of the continents with arable land and in about every type of climate and soil. There are at least 11 primary pulses recognized and a multitude of varieties or accessions within each group.

Global production exceeds 40 million metric tons annually, with India, Canada, Brazil and China being the largest producers. The dry beans make up nearly half the annual production, peas about 25% of the mix, chickpeas around 20% and lentils less than 10% (Food and Agricultural Organization of the United Nations, 2006).

These ingredients contain about twice as much protein as grains (approximately 20-25%) and have been described by some as "the poor man's meat" because of their quality amino acid profile. As it relates to cat and dog nutrition, the sulfur amino acids, methionine and (or) cysteine, are the first-limiting amino acids.

With the exception of chickpeas, most pulses are low fat. However, the fat is rich in the nutritionally important linoleic (C18:2n6) acid with small amounts of omega 3 linolenic (C18:3n3) acid as well. The ash (mineral) content of pulses is two to three times that of common grains like wheat and corn, but relative to protein level, pulses carry half to a third of the "ash penalty" compared to rendered animal protein meals.

Regarding minerals, pulses are rich in potassium and phosphorus, but bioavailability can be an issue. Pulses are also a rich source of fiber, ranging from 10-25% total dietary fiber.

The starch content ranges from 30-60% depending on the variety. The starch found in pulses has been characterized as slowly digested (Bednar *et al*., 2001), which may benefit glucose-insulin metabolism in both dogs and cats (de-Oliveira *et al*., 2008; Carciofi *et al*., 2008).

Like other plant-based ingredients, pulses are known to possess a number of compounds that can affect their utilization. For the most part, these are active plant defenses against predation by microbes and insects. In large doses, they can negatively affect nutrient usage in mammals, but some have the potential to be beneficial under the right circumstances (Champ, 2002).

The list includes digestive enzyme inhibitors such as trypsin inhibitors and amylase inhibitors, lectins (phytohaemagglutinnins) that can agglutinate red blood cells, phytates and oxalates that impede mineral utilization, various phenolic compounds with flavor, digestive, antioxidant and physiological effects (e.g., tannins, lignins, isoflavones, lignans) and saponins with emulsifying properties. These may sound unhealthy, but to put this in perspective, these compounds appear in many common food and petfood ingredients.

Further, the protease inhibitors and lectins are denatured by heat treatment so they aren't an animal health issue in processed petfoods. For diets with a large amount of pulses, accounting for available phosphorus and supplementing accordingly is the most direct work-around to the phytate issue. Conversely, phytate-bound phosphorus could be a route to restrict phosphorus in kidney diets.

Oxalate content of pulses is around one-fiftieth of that found in spinach, so it is not a real issue outside of an oxalate-urinary tract health diet for cats. The phenolics like tannins are a tenth of that found in sorghum and isoflavones a hundredth of that found in soy, so the dose is inconsequential even if a physiological effect were desired.

Pulses are grown on each of the continents with arable land and in about every type of climate and soil.

While these are certainly things to keep in mind from a customer relations and education perspective, the biggest hurdle to using pulses in petfoods is likely the sub-fraction of fiber that gets blamed for flatulence—specifically the oligosaccharides raffinose, stachyose and verbescose. The sum of these is about 2.5-5% of dry matter (Canadian Grain Commission, 2004). They have been linked in veterinary literature with gas production (mostly hydrogen sulfide) via fermentation in the colon (Roudebush, 2001).

The content varies with type of pulse, variety and growing conditions, and animal response varies with individual. But less is better, so selecting the right pulses, along with adequate evaluation, are key.

Pulses are known to mill and mix well with other ingredients. Plus, the starch and protein possess functionality that can be effectively exploited in extrusion. By European rules, pulses require thermal processing for use.

From a regulatory and labeling perspective, pulses are a bit ill-defined, with dried beans and sweet lupin meal being described but no direct definition for peas, lentils or chickpeas (AAFCO, 2009). Peas are currently more common in petfoods, with beans finding their way into vegetarian and elimination diets. This suggests that with proper oversight of the oligosaccharides issue, other pulses might be a nice fit in petfoods, too. ■

Functional fiber with color

According to the US Department of Agriculture, tomatoes are the second most popular vegetable crop behind potatoes, with an annual average per capita consumption of 71 pounds going into juice, sauce and paste. The backstory is that 10-30% of this is seeds, skin and pulp, with no ready market in the human food aisle. This translates into an estimated 750,000 metric tons of dried tomato pomace potentially available to pet and livestock feed markets.

Considering tomato pomace only for its fiber contribution may miss a big part of the story.

Given that the US ranks about fifth in the world acreage of tomatoes grown, tomato pomace could be a readily available ingredient for petfood. To that end, we are seeing a growing number of petfoods for which tomato pomace appears on the ingredients list.

Is this growing popularity a function of cost and availability, or does tomato pomace impart some nutritional benefit to petfood? Yes and yes.

From vine to powder

Tomato pomace is commonly traded on an air-dry basis (approx. 5-10% moisture) at a composition of around 20% protein, 13-15% fat, 3-5% ash and 25-35% crude fiber. The Association of American Feed Control Officials defines it as "the dried mixture of tomato skins, pulp and crushed seeds."

Tomato pomace starts with the processing of whole tomatoes into juice, sauce or paste. The tomatoes are pressed to expel the juice, then separated from the seeds, skins and most of the pulp. The resulting residue contains enough moisture (approx. 60-70%) that it must be dried to keep from spoiling.

Once dried, the residue is ground or pulverized into a powder. Besides producing a consistent particle size, the grinding also liberates the oils found in the seeds. These tomato seed oils are substantial (about 35% of the seed) and predominately unsaturated (approximately 82%; Giannelos *et al*., 2005) which makes them susceptible to oxidation. So after grinding, an antioxidant preservative is often added for long-term storage. The final product is an orange to pink, finely ground, almost dusty, freely flowable tomato-smelling powder.

Functional fiber option

One of the first research papers published evaluating tomato pomace in pet diets reported that when dogs were fed a corn and soybean meal diet supplemented with tomato pomace, digestibility was comparable to those diets supplemented with beet pulp or grape pomace (Allen *et al*., 1981). A few years later, Fahey *et al*. (1990) reported that the total dietary fiber (a measure of nutritionally functional fiber) found in tomato pomace was comparable to beet pulp and wheat bran. When tomato pomace was included in dog diets at a similar level to other fiber sources, the digestibility, elimination frequency and fecal volume were similar.

More recently, Swanson *et al*. (2001) reported that tomato pomace had a total dietary fiber content of approximately 57% and a majority of this fiber was insoluble (53% vs. 4% soluble). Following 24 hours of bench-top (*in vitro*) fermentation, 35% of the tomato pomace was degraded. Short-chain fatty acid production was moderate relative to other fiber sources and resulted in high proportions of the beneficial short-chain fatty acid butyrate. A major concern with fiber sources is whether they lead to flatulence. These researchers reported that gas production during the 24-hour period was significantly less than from most other fiber sources.

Tomato pomace is commonly incorporated in dry formulas at 3-7% of the ingredient mix and has little to no impact on food processing.

Color is meaningful

Considering only this fiber contribution may miss a big part of the story—the tomato's positive connection to human health. Tomatoes and their content of the antioxidant carotenoid lycopene have been linked to preventing numerous human diseases, including some forms of cancer and coronary artery disease, via a reduction in cholesterol.

Lycopene is the pigment responsible for tomatoes' red color, and unlike many other vegetable carotenoids, it persists through processing. For example, the content of lycopene in tomato pomace has been reported at 281 mg/kg (Botsoglou *et al*., 2004).

While a link between tomato/lycopene and cancer prevention or heart-health benefits has not been demonstrated for dogs and cats, experiments with dogs have shown that following an oral dose, lycopene is readily absorbed and distributed throughout body tissues (Korytoko *et al*., 2003). Inclusion of tomato pomace at 1% of the diet, along with other antioxidant fruits and vegetables, aided cognitive function retention in older dogs (Milgram *et al*., 2005).

The final product is an orange to pink, finely ground, almost dusty, freely flowable tomato-smelling powder.

Tomato pomace has also been reported to contain relatively large concentrations of vitamin E (224 ppm) and total mixed tocopherols (2,059 ppm), along with other phytosterols such as campesterol, stigmasterol and B-sitosterol (King and Zeidler, 2004).

Fit for the formulator

While we know a fair amount about tomato pomace, we still lack reports evaluating it in cat diets, and studies on the differences among supply channels are conspicuously absent.

Some critics may suggest tomatoes are unsafe due to their membership in the nightshade family or that tomato pomace is a bio-accumulator of pesticides and herbicides. These suggestions have no validity. Rather, tomato pomace appears to be safe and effective, with a demonstrated record as a functional fiber and viable source of bioactive antioxidant vitamins and carotenoids.

As an ingredient in the formulator's toolbox, tomato pomace is a cost-competitive, readily available ingredient that reads well on the label and fits nicely in a petfood formula. ■

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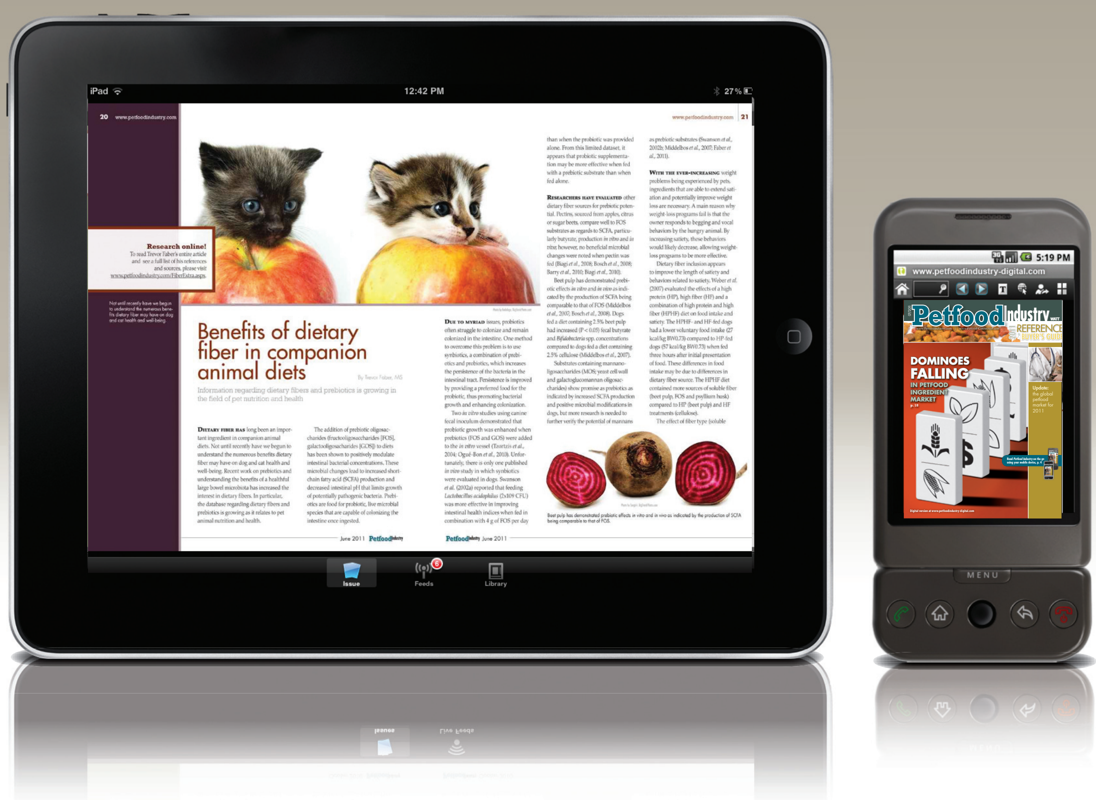

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