Email comments/questions to
compendium@medimedia.com
or fax 800-556-3288

CE **Article #3 (1.5 contact hours)**
Refereed Peer Review

Flatulence: Causes and Management Options

Hill's Science and Technology Center
Topeka, Kansas
Philip Roudebush, DVM, DACVIM

KEY FACTS

- More than 99% of intestinal gas is comprised of odorless gases, including nitrogen, oxygen, hydrogen, carbon dioxide, and methane.
- The characteristic unpleasant odor of intestinal gas comes from trace amounts of volatile sulfur compounds (e.g., hydrogen sulfide).
- Aerophagia and bacterial fermentation in the large intestine produce the largest amounts of intestinal gas.

ABSTRACT: Flatulence is defined as excessive formation of gases in the stomach or intestine. It is usually associated with noticeable flatus, belching, borborygmus, abdominal distention, or a combination of these signs. Excessive aerophagia is a risk factor for flatulence and is noted commonly in brachycephalic, working, and sporting breeds as well as in dogs with aggressive or competitive eating behaviors. The primary goal of dietary management of flatulence is to reduce the gas formation that results from bacterial fermentation of intestinal substrates.

Flatulence—excessive formation of gases in the stomach or intestine—is usually associated with noticeable flatus, belching, borborygmus, abdominal distention, or a combination of these signs. *Flatus*, rather than *flatulence*, is the term that should be used for gas expelled through the anus. *Belching* is the noisy voiding of gas from the stomach through the mouth, and *borborygmus* is a rumbling or gurgling noise caused by propulsion of gas through the intestines.

Excessive flatus is a chronic, objectionable problem that is common in dogs but less so in cats. Although belching, borborygmus, and abdominal distention are less common signs, pet owners may mention them if asked specifically about them. Flatus, belching, and borborygmus occur in healthy pets but may also develop as a consequence of gastric, small intestinal, or colonic disorders.

PRODUCTION OF INTESTINAL GAS

The tendency to treat flatus as a humorous topic has obscured appreciation of the complex physiology that underlies the formation of intestinal gas. The quantitatively important gases in the intestinal tract are nitrogen (N_2), oxygen (O_2), hydrogen (H_2), carbon dioxide (CO_2), and methane (CH_4).[1–4] These odorless gases make up more than 99% of the intestinal gas volume in humans and pets (Table 1). The characteristic unpleasant odor of intestinal gas arises primarily from the trace gases that contain volatile sulfur compounds such as hydrogen sulfide, methanethiol, and dimethylsulfide.[5] The noxious odor of flatus in both humans and dogs correlates most strongly with the concentration of hydrogen sulfide.[5,6]

Gas occurs naturally in the gastrointestinal (GI) tract and primarily results from the following four events[1,4,7]:

Table 1. Types and Sources of Intestinal Gas

Type of Gas	*Source*
Quantitatively Important Intestinal Gases	
Nitrogen	Aerophagia, diffusion from blood
Oxygen	Aerophagia, diffusion from blood
Hydrogen	Bacterial fermentation (large intestine)
Carbon dioxide	Diffusion from blood, Bacterial fermentation (large intestine), Gastric acid plus food, saliva, or bicarbonate
Methane	Bacterial fermentation (large intestine)
Odoriferous Gases	
Volatile sulfur compounds (hydrogen sulfide, methanethiol, dimethylsulfide)	Bacterial fermentation (large intestine)

- Aerophagia (O_2 and N_2)
- Interaction of gastric acid and alkaline food, saliva, or pancreatic bicarbonate (CO_2)
- Diffusion from the blood (CO_2, N_2, and O_2)
- Bacterial metabolism and fermentation (CO_2, H_2, and CH_4 and various trace gases, including volatile sulfur compounds)

Gases can be removed from the gut through passage from the esophagus or anus, diffusion into the blood, or consumption by bacteria. The net of these processes near a given site in the GI tract determines the volume and composition of gas passing that site.

Gas in the digestive tract is believed to result primarily from aerophagia,[4] during which air enters the stomach during swallowing of liquids or solids. Studies using ultrafast computed tomography in humans show that a mean of 17 ml of air accompanies the swallowing of 10 ml of water.[8] Given the quantity of food and fluid ingested each day, large amounts of air may normally enter the stomach. If not belched, the N_2 component of swallowed air passes through the GI tract with minimal absorption and is then passed per rectum.[3] Air can also be swallowed in the absence of food or water ingestion through the propulsion of a bolus of air into the pharynx. This can cause the excessive flatus commonly seen in many brachycephalic breeds. Vigorous exercise and rapid and competitive eating situations may exacerbate aerophagia. Intestinal transit time is considerably shorter for gases than for liquids or solids. Air introduced into the stomach can result in flatus within 15 to 35 minutes.[9] It has been estimated that gases can move 10 cm/sec through the GI tract. The interaction between hydrochloric acid and alkaline food, saliva, or bicarbonate secreted by the pancreas produces CO_2 in the stomach and intestines.[1] CO_2 also enters the GI tract through diffusion from the blood.[1] Belched gas is largely swallowed air plus variable quantities of CO_2.

A large amount of gas is formed from bacterial fermentation in the colon. Substrates for bacterial gas production include dietary substances (e.g., fiber, poorly digestible protein, carbohydrates) and endogenous sources (e.g., mucin, bile acids). Foods that contain large amounts of nonabsorbable oligosaccharides (e.g., raffinose, stachyose, verbacose) are likely to produce large amounts of intestinal gas.[10–12] Dogs and cats lack the digestive enzymes needed to split these sugars into absorbable monosaccharides. Therefore, bacteria in the colon rapidly ferment these sugars, producing H_2 and CO_2.[10,11] Soybeans, beans, peas, and other legumes contain large quantities of nonabsorbable oligosaccharides and are often associated with excessive flatus. Many fibers used in pet foods are fermented by colonic microflora and may contribute directly to flatus. Rapidly fermentable fibers in pet foods include pectins and most gums. Fiber-containing foods may contribute to flatus indirectly through reduced dry-matter digestibility. Intestinal gas production is also increased by fresh or dried foods containing fructose, resistant starches, and fermentable fiber (e.g., apples, grapes, prunes, raisins, bananas).

Diseases that cause maldigestion or malabsorption are often associated with borborygmus, abdominal distention, and excessive flatus because large amounts of nonassimilated substrates are available for bacterial fermentation. Flatus is also common in adult dogs and cats fed excessive amounts of lactose-containing foods.

Sulfur-containing gases are the major malodorous components of human and canine flatus.[5,6] Dietary sources of sulfur (sulfates and sulfur-containing amino acids) and endogenous sulfur-containing compounds (e.g., mucin, taurocholate) are converted by sulfate-reducing bacteria to the odoriferous compounds hydrogen sulfide, methanethiol, and dimethylsulfide.[13] Onions, nuts, spices, cruciferous vegetables (e.g., broccoli, cabbage, cauliflower, brussels sprouts) and carrageenan contain high levels of sulfate and often increase production of malodorous gases; high-protein ingredients may also contribute to production of such gases.

PATIENT ASSESSMENT

Pet owners often express concerns with clinical manifestations of flatulence and may describe an

increase in frequency of belching, flatus or borborygmus, objectionable odor of flatus, or abdominal distention. In one study,[14] 47 of 110 dog owners (43%) reported flatus in their otherwise-healthy dogs and 14 owners (13%) reported objectionable odor associated with the flatus episodes. Dogs housed indoors and less active dogs were more likely to have evidence of flatus.[14] Temperament, frequency of feeding, specific diet, eating habits, age, gender, and history of previous GI disease were not found to be risk factors for flatulence in this particular study.[14]

A history of dietary change or dietary indiscretion may be associated with the flatulence. Specific foods, primary food ingredients, treats, supplements, and opportunities for dietary indiscretion should be evaluated. A thorough assessment should also include verification of the current feeding method. Factors to consider include feeding frequency, amount fed, how food is offered, access to other food, relationship of feeding to exercise, and who feeds the animal.

There is widespread belief that some individuals are consistently more flatulent than others. Studies in humans have shown great variability in the frequency of flatus, and such variation probably occurs in animals as well.[15,16] Rectal gas excretion rates in humans range from 400 to 1500 ml/day (mean 705 ml/day).[1,15,16] Humans, eating their usual diet, passed gas per rectum an average of 8 to 10 times per day with an upper normal limit of 20 times per day.[1,15,16] In general, frequency of flatus correlates with the volume of intestinal gas; thus increases and decreases in episodes of flatus can be used to obtain a relative idea of changes in intestinal gas volume.[2] Studies of rectal gas excretion rates in pets whose owners complain of flatus have not been conducted.

Occasionally, belching, abdominal distention, and flatus develop in conjunction with other GI signs, including weight loss, diarrhea, and steatorrhea. This history is very suggestive of an underlying small intestinal disorder. Examples of chronic intestinal disorders often associated with flatulence include exocrine pancreatic insufficiency, inflammatory bowel disease, small intestinal bacterial overgrowth, wheat-sensitive enteropathy, food sensitivity, and lymphangiectasia. In one study, 18 of 70 cats (26%) with chronic diarrhea and/or vomiting had flatus and 8 cats (11%) had abdominal distention.[17] Cats with clinical evidence of flatulence should always be closely evaluated for underlying chronic GI problems such as inflammatory bowel disease or food sensitivity.

Excessive aerophagia is a risk factor for flatulence and is seen with brachycephalic, working, and sporting dogs as well as those with aggressive and competitive eating behaviors. Dietary indiscretion and ingestion of certain pet food ingredients may be risk factors for some individual animals. Excessive belching, rapid eating, and aerophagia have also been identified as risk factors for gastric dilatation–volvulus and should be considered important clinical findings in dogs at risk for this disorder.[18,19]

In most cases, physical examination findings in dogs and cats with flatulence are unremarkable. Intestinal gas can often be detected during abdominal palpation, but assessing the quantity of gas from palpation alone is difficult. Laboratory testing is usually not indicated. Animals may be in poor body condition if objectionable flatus is secondary to an underlying GI condition. Further evaluation is in order if vomiting, diarrhea, or weight loss are also present.

FEEDING PLANS FOR PATIENTS WITH FLATULENCE

Dietary management of flatulence is primarily concerned with decreasing the intestinal gas that results from bacterial fermentation of undigested food (Table 2). Animals with excessive or objectionable flatus generally benefit from highly digestible foods (dry-matter digestibility >90%) offered in small, frequent meals. This protocol reduces the food residues available for bacterial fermentation in the large intestine and should reduce gas production.

Certain protein, carbohydrate, and fiber ingredients or levels may affect flatus production in individual animals. Of the numerous foods alleged to enhance flatus in humans, baked beans are the only natural food that has been carefully studied. A diet deriving half of its calories from baked beans increased flatus in humans from a basal level of 15 to 176 ml/hour.[1] Flatulent animals may benefit from eating foods that do not contain sources of legumes (e.g., soybean meal, soybean mill run, soy hulls, peas, pea fiber, pinto beans).

Changing the source of dietary protein or carbohydrates may benefit some flatulent animals. In general, aerophagia and dietary carbohydrate are the primary contributors to the volume of intestinal gas, whereas dietary protein contributes to the odoriferous gases. Reports have confirmed that a diet in which all carbohydrates are supplied by white rice reduces intestinal gas formation in humans.[20,21] Studies[22,23] in dogs also suggest that less intestinal gas is produced when the primary source of carbohydrates is rice than when it is other sources of carbohydrate such as wheat or corn (Figure 1).[23] Therefore, suggesting the use of commercial or homemade foods containing rice as the primary or only source of carbohydrate for flatulent dogs and cats is a prudent recommendation (Table 3).

Table 2. Management of Patients with Flatulence

Control Aerophagia
- Feed several small meals daily
- Discourage rapid or competitive eating
- Feed a mixture of moist and dry foods
- Surgically correct stenotic nares and elongated soft palate in brachycephalic dogs

Decrease Substrates That Cause Noxious Gas Production
- Change the dietary protein sources
- Decrease dietary protein levels
- Eliminate vitamin, mineral, or fat supplements
- Avoid onions, nuts, spices, or cruciferous vegetables (broccoli, cabbage, cauliflower, brussels sprouts)
- Avoid canned pet foods that contain carrageenan

Decrease Intestinal Gas Production
- Feed a highly digestible food (dry-matter digestibility >90%)
- Change to foods with rice as the sole or predominant carbohydrate source
- Avoid foods containing ingredients from legumes such as soybean meal, soybean mill run, peas, and pea fiber
- Eliminate vitamin, mineral, or fat supplements
- Avoid foods or treats containing lactose (e.g., cheese, milk, ice cream)
- Avoid fresh or dried fruit

Increase Activity and Exercise (which generally results in fewer problems with flatus)
- Walk dogs outdoors within 30 minutes of meals to encourage defecation and elimination of intestinal gas

For example, changing from a commercial dry food that contains corn, chicken meal, and soybean meal to a dry food that contains lamb meal, rice, and barley may be helpful.

Vegetable-based foods containing strongly flavored, sulfur-containing vegetables or legumes should be avoided in flatulent patients. In some cases, reducing dietary protein content alleviates odoriferous flatus. In most cases, vitamin–mineral supplements should be avoided because these products can alter intestinal microbial activity. Because lactose in food and treats (e.g., cheese, ice cream, milk) may contribute to flatulence in adult animals, foods containing lactose should be eliminated from the diet. Foods that are high in fructose, resistant starch, and/or fermentable fiber should also be avoided. A series of dietary trials is often successful in finding a food that reduces excessive flatulence or objectionable flatus in individual pets.

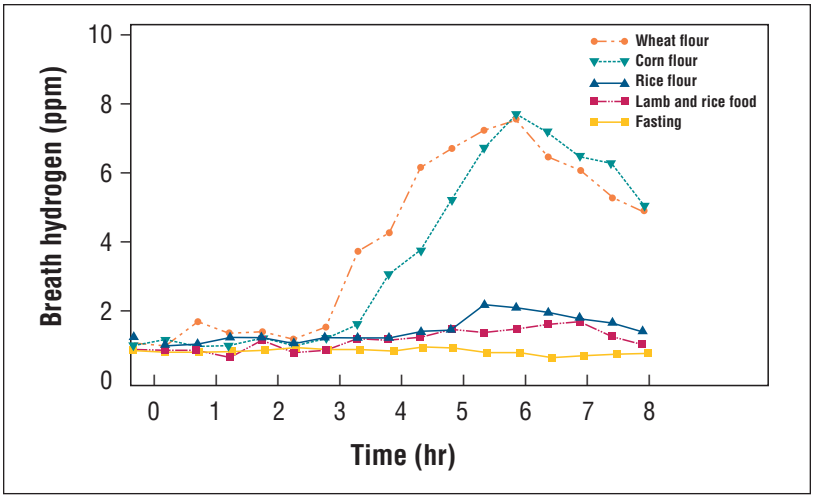

Figure 1—Mean breath hydrogen concentrations in dogs after fasting; ingestion of a therapeutic food containing lamb and rice; and ingestion of flour derived from rice, wheat, or corn. Hydrogen can be produced in the body only through bacterial fermentation of carbohydrate sources. As a result, breath hydrogen concentrations correlate with overall production of intestinal gas. Gas production is minimal with fasting, ingestion of rice flour, and ingestion of foods containing lamb and rice as the major ingredients. (Adapted from Washabau RJ, Strombeck DR, Buffington CA, Harrold D: Evaluation of intestinal carbohydrate malabsorption in the dog by pulmonary hydrogen gas excretion. *Am J Vet Res* 47:1403–1404, 1986.)

Reducing aerophagia is important to control flatulence in dogs, especially brachycephalic breeds. Several small meals should be given daily to discourage rapid eating and gulping of air. Feeding in a quiet, isolated location eliminates competitive eating and reduces aerophagia. These same feeding methods plus feeding a mixture of moist and dry foods may be helpful in reducing the risk of gastric dilatation–volvulus in dogs.[18,19] Surgical correction of stenotic nares and overlong soft palates may help reduce aerophagia in some brachycephalic dogs.

Simple changes to feeding routines may also reduce objectionable flatus. If possible, dogs should be walked outdoors within 30 minutes of meals. This encourages defecation and elimination of intestinal gas. Less active dogs are at higher risk for objectionable flatus.[14]

Table 3. Commercial Pet Foods with Rice as the Sole or Predominant Carbohydrate Source[a]

Dry Dog Foods
Hill's® Science Diet® Lamb Meal & Rice Formula Canine Growth®[b]
Hill's® Science Diet® Lamb Meal & Rice Formula Canine Adult
Hill's® Science Diet® Sensitive Stomach Adult Dog
Hill's® Science Diet® Sensitive Skin Adult Dog
Hill's® Prescription Diet® Canine d/d® Rice & Egg
Hill's® Prescription Diet® Canine d/d® Rice & Duck
Hill's® Prescription Diet® Canine d/d® Rice & Salmon
Hill's® Prescription Diet® Canine g/d®
Hill's® Prescription Diet® Canine k/d®
Purina Veterinary Diets™ LA Limited Antigen™ Canine Formula[c]
Nutro® Natural Choice™ Lamb Meal & Rice Formula[d]
Nutro® Natural Choice™ Lite
Nutro® Natural Choice™ Senior
Nutro® Natural Choice™ Dental Care Lamb Meal & Rice Formula

Moist Dog Foods
Hill's® Prescription Diet® Canine d/d® Lamb & Rice
Hill's® Prescription Diet® Canine d/d® Whitefish & Rice
Iams® Beef & Rice Formula[e]
Iams® Chicken & Rice Formula
Iams® Active Maturity™ Beef & Rice Formula
Iams® Active Maturity™ Chicken & Rice Formula

Dry Cat Foods
Hill's® Science Diet® Feline Adult Savory Recipes
Hill's® Science Diet® Sensitive Stomach Adult Cat
Hill's® Science Diet® Sensitive Skin Adult Cat
Hill's® Prescription Diet® Feline g/d®
Hill's® Prescription Diet® Feline k/d®
Eukanuba® Chicken & Rice Formula Cat Food[e]
Eukanuba® Kitten Chicken & Rice Formula
Eukanuba® Lamb & Rice Formula Cat Food
Nutro® Natural Choice™ Cat

Moist Cat Foods
Hill's® Prescription Diet® Feline d/d®
IVD™ Select Care™ Feline Control Formula[f]
Eukanuba® Veterinary Diets® Low–Residue™ Adult/Feline
Eukanuba® Veterinary Diets® Low pH/S™/Feline
Eukanuba® Veterinary Diets® pH/O™/Feline
Iams® Chicken Formula Cat Food
Iams® Chicken & Rice Active Maturity™
Iams® Chicken & Rice Senior Formula

[a]This list contains specialty and therapeutic brand pet foods readily available in North America. Other pet foods may also be appropriate. For more information, consult the ingredient list on the pet food label or contact the manufacturer.
[b]Hill's Pet Nutrition, Inc., Topeka, KS.
[c]Ralston Purina, St. Louis, MO.
[d]Nutro Products, Inc.; City of Industry, CA.
[e]Iams and Eukanuba products are manufactured by The Iams Company, Dayton, OH.
[f]Innovative Veterinary Diets (IVD), Pittsburgh, PA.

MEDICAL THERAPY

Carminatives are medicines or preparations that relieve flatulence. Various herbal and botanical preparations have been used for thousands of years as carminatives. More recently, commercial products have been introduced that claim to reduce or control flatulence. Such products include activated charcoal, bismuth subsalicylate, zinc acetate, simethicone, *Yucca schidigera* preparations, α-galactosidase, and pancreatic enzyme supplements; these products can be used in conjunction with an altered feeding plan. Nonabsorbable antibiotics, such as neomycin, have also been shown to reduce flatulence and the number of flatus episodes in healthy humans and dogs.[10,11,24] However, routine use of nonabsorbable antibiotics in otherwise-healthy pet animals with flatulence is not indicated.

Dry activated charcoal adsorbs virtually all odoriferous gases when mixed directly with human feces and flatus gas.[5,25] However, ingestion of activated charcoal in humans has not been effective in reducing the number of flatus events, volume of released intestinal gas, fecal odor, or breath H_2 excretion after bean ingestion.[5,25,26] In vitro studies suggest that ingested charcoal fails to reduce liberation of volatile sulfur compounds because of saturation of charcoal binding sites during passage through the gut.[25] Wetting activated charcoal can slow uptake of sulfur-containing gases considerably. Activated charcoal is found in several commercial canine treats purported to control flatulence.[27]

Bismuth subsalicylate (BSS) reduces the odor of feces and flatus in humans when taken frequently (four times daily).[28] Bismuth is the active ingredient and avidly adsorbs hydrogen sulfide, forming insoluble bismuth sulfide.[28] Bismuth sulfide imparts a characteristic black color to feces. Bismuth also has antibacterial activity, which may account for some of the effects. BSS contains 50% bismuth by weight and is found in various commercial veterinary antidiarrheal–adsorbent products as well as in over-the-counter antidiarrheal products for human use (e.g., Pepto-Bismol®, Procter and Gamble, Cincinnati, OH). There appears to be a striking dose-dependent response with BSS: 400 mg/100 g of dry food completely suppresses cecal hydrogen sulfide release in rats, whereas one fifth of this concentration has no demonstrable effect.[28] This agent may be effective in controlling objectionable flatus in pets but probably needs to be given several times per day, which precludes practical, long-term use. It should be used with caution in cats because of concerns with salicylate toxicosis.

Similar to bismuth, zinc acetate binds sulfhydryl compounds and has also been shown to reduce volatile sulfur compounds when exposed directly to gas from

human flatus.[5] Adding zinc acetate to food (1% total diet) decreased fecal hydrogen sulfide concentrations and improved flatus odor in rats.[29] One report[27] showed that an oral treat containing zinc acetate, activated charcoal, and *Y. schidigera* extract reduced highly odoriferous episodes of flatus in dogs.

Simethicone (dimethylpolysiloxane) is an antifoaming agent that reduces surface tension of gas bubbles and is found in commercial veterinary products and over-the-counter products for human use.[30] The mechanism of effect of simethicone in flatulent patients has not been determined—perhaps the altered gas bubbles are more effectively eliminated. A few controlled trials of simethicone treatment have been conducted in humans.[31–33] In general, simethicone had no effect on total daily flatus volume, number of flatus episodes, or average volume per flatus event.[31–33] Simethicone may help reduce gastric accumulation of gas and alleviate upper GI signs. The effectiveness of simethicone in controlling flatulence in pets is unknown, and it would not be expected to control objectionable flatus odors.

Extracts of the *Y. schidigera* plant have been used to control malodorous feces in animal-waste lagoon systems.[34–36] The mechanisms of action are poorly understood and may include "binding" of ammonia or alterations in microbial activity. In the United States, yucca preparations are approved only as flavoring agents in pet foods and it is unknown whether they effectively control flatulence or objectionable flatus odors when ingested by pet animals. An oral treat containing *Y. schidigera* extract, activated charcoal, and zinc acetate reduced highly odoriferous episodes of flatus in dogs.[27]

Products containing α-galactosidase are available as human (Beano®, AkPharma, Pleasantville, NJ) and veterinary (CurTail™, AkPharma) products. These products reduce flatus volume by improving digestion of the nonabsorbable oligosaccharides found in soybeans, beans, peas, and other legumes.[37] These products would not be expected to improve excessive flatus resulting from other causes (e.g., aerophagia) or to reduce the odor of flatus. Anecdotal reports suggest that these products may be beneficial in some animals.

Pancreatic enzyme supplementation has been shown to decrease abnormal intestinal gas production in dogs with exocrine pancreatic insufficiency.[22] Pancreatic enzyme preparations have also been widely used for bloating and abdominal distention in humans. Because ingestion of these preparations should add little to the enzyme output of the pancreas in otherwise-normal individuals, no solid rationale exists for their use in flatulent patients without pancreatic disease. Nevertheless, a recent study showed that a microencapsulated pancreatic enzyme preparation significantly reduced postprandial symptoms of bloating and abdominal distention in healthy humans ingesting a high-calorie, high-fat meal.[38] This finding suggests that pancreatic enzyme supplements might benefit some patients with flatulence.

More than 30 herbal and botanical preparations have been listed as carminatives.[39] Grape seed extract containing proanthocyanidins is one botanical preparation that has been shown to alter GI microflora and decrease fecal release of volatile sulfur compounds in human patients.[40] The dosage, safety, and efficacy of this and other botanical preparations in pets with flatulence have not been established.

To date, the best evidence exists for short-term use of BSS, zinc acetate, and nonabsorbable antibiotics as carminatives. Less evidence exists for use of activated charcoal, simethicone, digestive enzyme preparations, yucca extract, and grape seed extract. Changing the feeding plan (food and feeding method), rather than using carminatives, offers the best opportunity for successful long-term management of flatulence in pets.

MONITORING PATIENTS WITH FLATULENCE

Patients should be evaluated for evidence of malassimilation if the feeding methods and ancillary therapy outlined here are not successful in reducing or controlling flatulence. Relapse in animals that have been previously asymptomatic often indicates dietary indiscretion. The prognosis for control of flatulence is good in most cases. However, pet owners should be educated about normal intestinal gas production and not expect complete cessation of flatulence, especially in pets with excessive aerophagia.[41] In some cases, the following advice may still be necessary: "After trying empirical therapy for pets with chronic flatulence, sound advice for the client is to always stand upwind from the patient."[42]

REFERENCES

1. Strocchi A, Levitt MD: Intestinal gas, in Feldman M, Scharschmidt BF, Sleisenger MH (eds): *Gastrointestinal and Liver Disease,* ed 6. Philadelphia, WB Saunders Co, 1998, pp 153–160.
2. Suarez F, Furne J, Springfield J, Levitt M: Insights into human colonic physiology obtained from the study of flatus composition. *Am J Physiol* 272:G1028–G1033, 1997.
3. Levitt MD, Furne J, Aeolus MR, et al: Evaluation of an extremely flatulent patient: Case report and proposed diagnostic and therapeutic approach. *Am J Gastroenterol* 93:2276–2281, 1998.
4. Suarez FL, Levitt MD: An understanding of excessive intestinal gas. *Curr Gastroenterol Rep* 2:413–419, 2000.
5. Suarez FL, Springfield J, Levitt MD: Identification of gases responsible for the odour of human flatus and evaluation of a device purported to reduce this odour. *Gut* 43:100–104, 1998.
6. Giffard CJ, Collings SB, Stoodley RM: Ability of an anti-

flatulence treat to reduce the hydrogen sulfide content of canine flatulence. *J Vet Intern Med* 14:349, 2000.

7. Bell AJ, Ciclitira PJ: Managing bloating, flatus and flatulence. *Practitioner* 244:301–311, 2000.
8. Poderoux P, Gulchin EA, Shezang L, et al: Esophageal bolus transit imaged by ultrafast computerized tomography. *Gastroenterology* 110:1422–1428, 1996.
9. Levitt MD: Volume and composition of human intestinal gas determined by means of an intestinal washout technique. *N Engl J Med* 284:1394–1398, 1971.
10. Richards EA, Steggerda FR: Production and inhibition of gas in various regions in the intestine of the dog. *Proc Soc Exp Biol Med* 122:573–576, 1966.
11. Richards EA, Steggerda FR, Murata A: Relationship of bean substrates and certain intestinal bacteria to gas production in the dog. *Gastroenterology* 55:502–509, 1968.
12. Suarez FL, Springfield J, Furne JK, et al: Gas production in humans ingesting a soybean flour derived from beans naturally low in oligosaccharides. *Am J Clin Nutr* 69:135–139, 1999.
13. Levitt MD, Furne J, Springfield J, et al: Detoxification of hydrogen sulfide and methanethiol in the cecal mucosa. *J Clin Invest* 104:1107–1114, 1999.
14. Jones BR, Jones KS, Turner K, et al: Flatulence in pet dogs. *N Z Vet J* 46:191–193, 1998.
15. Furne JK, Levitt MD: Factors influencing frequency of flatus emission by healthy subjects. *Dig Dis Sci* 41:1631–1635, 1996.
16. Tomlin J, Lowis C, Read NW: Investigation of normal flatus production in healthy volunteers. *Gut* 32:665–669, 1991.
17. Guilford WG, Jones BR, Markwell PJ, et al: Food sensitivity in cats with chronic idiopathic gastrointestinal problems. *J Vet Intern Med* 15:7–13, 2001.
18. Elwood CM: Risk factors for gastric dilatation in Irish setter dogs. *J Small Anim Pract* 39:185–190, 1998.
19. Glickman LT, Glickman NW, Schellenberg DB, et al: Multiple risk factors for the gastric dilatation–volvulus syndrome in dogs: A practitioner/owner case–control study. *JAAHA* 33:197–204, 1997.
20. Kerlin P, Wong L, Harris B, et al: Rice flour, breath hydrogen and malabsorption. *Gastroenterology* 87:578–585, 1984.
21. Levitt MD, Hirsch P, Fetzer CA, et al: H_2 excretion after ingestion of complex carbohydrates. *Gastroenterology* 92:383–389, 1987.
22. Washabau RJ, Strombeck DR, Buffington CA, Harrold D: Use of pulmonary hydrogen excretion to detect carbohydrate malabsorption in dogs. *JAVMA* 189:674–679, 1986.
23. Washabau RJ, Strombeck DR, Buffington CA, et al: Evaluation of intestinal carbohydrate malabsorption in the dog by pulmonary hydrogen gas excretion. *Am J Vet Res* 47:1402–1406, 1986.
24. DiStefano M, Strocchi A, Malservisi S, et al: Non-absorbable antibiotics for managing intestinal gas production and gas–related symptoms. *Aliment Pharmacol Ther* 14:1001–1008, 2000.
25. Suarez FL, Furne J, Springfield J, Levitt MD: Failure of activated charcoal to reduce the release of gases produced by the colonic flora. *Am J Gastroenterol* 94:208–212, 1999.
26. Potter T, Ellis C, Levitt M: Activated charcoal: In vivo and in vitro studies of effect on gas formation. *Gastroenterology* 88: 620–624, 1985.
27. Giffard CJ, Collins SB, Stoodley NC, et al: Administration of charcoal, *Yucca schidigera* and zinc acetate to reduce malodorous flatulence in dogs. *JAVMA* 218:892–896, 2001.
28. Suarez FL, Furne JK, Springfield J, Levitt MD: Bismuth subsalicylate markedly decreases hydrogen sulfide release in the human colon. *Gastroenterology* 114:923–929, 1998.
29. Suarez F, Furne J, Springfield J, Levitt M: Production and elimination of sulfur-containing gases in the rat colon. *Am J Physiol* 274:G727–G733, 1998.
30. Brecevic L, Bosan–Kilibarda I, Strajnar F: Mechanism of antifoaming action of simethicone. *J Appl Toxicol* 14:207–211, 1994.
31. Lifschitz CH, Irving CS, Smith EO: Effect of a simethicone-containing tablet on colonic gas elimination in breath. *Dig Dis Sci* 30:426–430, 1985.
32. Jain NK, Patel VP, Pitchumoni S: Activated charcoal, simethicone, and intestinal gas: A double-blinded study. *Ann Intern Med* 105:61–62, 1986.
33. Friis H, Bode S, Rumessen JJ, et al: Effect of simethicone on lactulose–induced H_2 production and gastrointestinal symptoms. *Digestion* 49:227–230, 1991.
34. Headon DR, Dawson D, Fallon R: *Yucca schidigera*: Definitive mode of action and application in animal feed. *Feed Compounder*:32–34, Feb 1991.
35. Lowe JA, Kershaw SJ: The ameliorating effect of *Yucca schidigera* extract on canine and feline faecal aroma. *Res Vet Sci* 63:61–66, 1997.
36. Lowe JA, Kershaw SJ, Taylor AJ, Linforth RS: The effect of *Yucca schidigera* extract on canine and feline faecal volatiles occurring concurrently with faecal aroma amelioration. *Res Vet Sci* 63:67–71, 1997.
37. Solomons N, Vasquez A, Grazioso C: Orally-ingested, microbial alpha-galactosidases produce effective in vivo, intraintestinal digestion of the bean oligosaccharide, raffinose. *Gastroenterology* 100:A251, 1991.
38. Suarez FL, Levitt MD, Adshead J, Barkin JS: Pancreatic supplements reduce the symptomatic response of healthy subjects to a high fat meal. *Dig Dis Sci* 44:1317–1321, 1999.
39. *PDR for Herbal Medicines,* ed 2. Montvale, NJ, Medical Economics Co, 2000.
40. Yamakoshi J, Tokutake S, Kikuchi M, et al: Effect of proanthocyanidin-rich extract from grape seeds on human fecal flora and fecal odor. *Microbial Ecology Health Dis* 13:25–31, 2001.
41. Cho S: *The Gas We Pass: The Story of Farts.* Brooklyn, NY, Kane/Miller Book Publishers, 1994.
42. Lorenz MD: Flatulence in small animals, in Kirk RW (ed): *Current Veterinary Therapy V: Small Animal Practice.* Philadelphia, WB Saunders Co, 1974, pp 95–99.

ARTICLE #3 CE TEST

The article you have read qualifies for 1.5 contact hours of Continuing Education Credit from the Auburn University College of Veterinary Medicine. *Choose the best answer* to each of the following questions; then mark your answers on the postage-paid envelope inserted in *Compendium.*

1. Which of the following terms is best used for expulsion of intestinal gas through the anus?
   a. flatulence
   b. flatus
   c. borborygmus
   d. belching
   e. carminative

2. The characteristic unpleasant odor of intestinal gas correlates most strongly with concentration of which of the following?
   a. methane
   b. methanethiol
   c. nitrogen
   d. hydrogen sulfide
   e. carbon dioxide

3. Which of the following is believed to contribute most to the volume of gas in the digestive tract?
   a. aerophagia
   b. interaction of hydrochloric acid with alkaline food, saliva, and pancreatic bicarbonate
   c. diffusion of gases from the blood
   d. bacterial metabolism and fermentation in the large intestine
   e. bacterial metabolism and fermentation in the small intestine

4. Hydrogen and methane found in intestinal gas are only produced by which of the following?
   a. aerophagia
   b. interaction of hydrochloric acid with alkaline food, saliva, and pancreatic bicarbonate
   c. diffusion of these gases from the blood
   d. bacterial metabolism and fermentation

5. Which of the following is a nonabsorbable oligosaccharide commonly found in legumes?
   a. galactose
   b. fructose
   c. sucrose
   d. raffinose
   e. xylose

6. Which of the following was found to be a risk factor for flatus in dogs?
   a. frequency of feeding
   b. age
   c. gender
   d. history of previous GI disease
   e. less activity

7. Rapid eating, aerophagia, and belching have been identified as risk factors for which of the following conditions?
   a. pancreatitis
   b. gastric dilatation–volvulus
   c. inflammatory bowel disease
   d. small intestinal bacterial overgrowth
   e. lactose intolerance

8. Intestinal gas production is lowest for which of the following ingredients?
   a. rice
   b. corn
   c. wheat
   d. soybean meal
   e. barley

9. Products containing α-galactosidase would be expected to control flatulence associated with which of the following ingredients?
   a. lamb meal
   b. corn
   c. soybean meal
   d. wheat
   e. beet pulp

10. Changing the dietary protein source or decreasing dietary protein levels will do which of the following?
   a. help control aerophagia
   b. decrease the amount of intestinal gas
   c. decrease production of malodorous gases
   d. encourage defecation and elimination of intestinal gas
   e. discourage rapid or competitive eating situations