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Garlic (oil) in dog food

The internet carries controversy over garlic as foodstuff for dogs. Some people maintain that garlic is healthy for dogs, but others say it is toxic. The dispute extends to complete foods, treats and supplements with added garlic (oil). There is no scientific evidence that dietary garlic has any health benefits for dogs. Conversely, a study showed that a liquid garlic extract is toxic for dogs, but the ingested amount was way above the intakes with garlic-containing food products.

Garlic shows up in the ingredient lists of quite some complete, dry dog foods. Garlic type and amount are mostly undeclared. A cautious impression is that garlic powder is often used, and this at inclusion rates less than 0.2%. Few food products feature wild garlic. Occasionally, garlic is touted as immunity supporter, antioxidant or flavoring. The oil pressed from garlic cloves is also used as palatability enhancer for dog food. A major petfood company adds garlic oil to its kibbled chow products (Notes 1-5).

As from five days after daily oral administration of a garlic extract, dogs had deformed red blood cells associated with anemia. The garlic dose was excessive. It was equivalent to feeding a dry food with 11% whole-garlic powder. Another equivalence is a 20-kg dog ingesting 8 garlic cloves per day. At very high garlic intakes, the herb's organosulfur compounds can damage red blood cells. At a conservative estimate, based on four studies, garlic contents up to 1% in complete dry food do not induce visible clinical signs in dogs. One of those studies also showed that a dietary garlic level of 0.54% did not affect red blood cells. Garlic is often listed as a toxin for dogs, but it is toxic only at extremely high doses (Note 6).

Garlic is generally added to commercial dog food as flavoring agent, but proof of efficacy has not passed into the public domain. As a practical petfood ingredient, garlic is safe, but it has no substantiated health benefits. Ingested garlic extract is believed to provide flea relief for the dog by rendering its blood unpalatable to fleas. Seemingly at odds with "garlic breath" in humans, uncooked garlic has been suggested to reduce bad breath in dogs. The garlic applications as flea repellent and bad-breath remedy are endorsed by patents (1, 2), but the test designs fell short (Notes 7-10).

Organosulfur compounds

Fresh, peeled garlic bulbs have about 62% moisture (3). Their dry matter contains on average 2% diethyl-ether-extractable, crude fat, but with marked variation across cultivars (4-11, Note 11). Hydrodistillation of oven-dried garlic bulbs yielded 0.5% essential oil, comprising 42% diallyl trisulfide (DATS, bis-2-propenyl trisulfide, $C_6H_{10}S_3$) (12). Garlic (*Allium sativum*) holds a large number of organosulfur compounds, their amounts and types differing between preparations.

During processing of garlic (dehydration, crushing, cutting), alliinase is released. The enzyme converts alliin (S-allyl-L-cysteine sulfoxide, $C_6H_{11}NO_3S$) into two sulfenic acids that spontaneously react with each other to form allicin (diallyl thiosulfinate, $C_6H_{10}OS_2$). Allicin instantly decomposes

into a variety of fat-soluble, organosulfur compounds, including DATS. Concentrations of DATS in freshly crushed and cabinet-dried, powdered garlic may be about 2.2 and 1.3 g/kg dry matter (13).

The manufacture of aged-garlic extracts involves long-term incubation of crushed garlic in aqueous solutions. As a result, γ-glutamyl-L-cysteine, the precursor of alliin, turns into water-soluble organosulfur compounds, such as S-allyl-L-cysteine (SAC). Homogenized raw garlic contained 0.05 g SAC/kg dry matter (14). That level was 1.7 g in another study, and up more than fourfold after aging (15).

Garlic toxicosis

Intragastric administration of boiled, watery extract from de-skinned garlic bulbs caused anemia in dogs (16). The extract was given once a day for 7 days, the amount equaling 5 g of fresh whole garlic/kg body weight.day (bw.d). Other equivalents are about 8 cloves for a 20-kg dog and 11% garlic powder in dry food (Note 12). After five days of garlic-extract dosing, blood erythrocytes, hematocrit and hemoglobin began to drop, while erythrocytes with Heinz bodies and eccentrocytes appeared. Clinical signs were not reported.

Two case reports concern Schnauzers that vomited, produced dark urine, had anemia and eccentrocytosis within two days after garlic consumption. One dog had eaten dumplings with chive and garlic, but allium intake was unknown (17). The other dog had accidently ingested about 60 g baked garlic (18), corresponding with 8% garlic in dry food (Note 13). A Rottweiler with anemia and signs of vomiting, diarrhea, abdominal pain and anorexia, had a history of eating garlic, but further details are not given (19).

Toxic actions

Various organosulfur compounds from garlic are able to induce methemoglobin formation in isolated canine erythrocytes (20-22). Given its abundance (12) and potency (20), DATS might be a major culprit. Garlic's water- and fat-soluble organosulfur constituents can oxidize hemoglobin, leading to methemoglobin, Heinz bodies, eccentrocytes and hemolytic anemia (Note 14).

Cellulose, dehydrated raw or boiled garlic powder were sprayed directly onto the stomach mucosa of anesthetized dogs, at a level of 40 mg per site (23, Note 15). Cellulose was effectless. Raw and boiled garlic, respectively, caused erosion-associated damage and mucosa reddening. The way of ingestion differs from intake of garlic embedded in food, but resembles that of garlic as dietary supplement.

Safety

For 12 weeks, dogs were fed selenium-enriched garlic at levels equivalent to 0, 4.5, 9 and 18% garlic powder in dry food (24, Note 16). The highest dose caused intermittent vomiting, anorexia and increased serum bilirubin. The inclusion level of 4.5% was without adverse effects.

For 45 and 15 days respectively, healthy (25) and alloxan-diabetic dogs (26) received 100 mg dehydrated garlic/kg bw.d, which is equivalent to dry food with 0.6% garlic (Note 17). No abnormalities were reported. Oral administration of dried, aged-garlic extract (45 or 90 mg/kg bw.d) for 12 weeks did neither induce hematological changes nor clinical signs (27).

Metabolism

Ingested SAC is absorbed effectively by dogs and may undergo N-acetylation and S-oxidation in liver and kidney. Net urinary excretion of SAC and its metabolites is slow due to substantial renal reabsorption (28-30, Note 18). Canine metabolism of DATS remains undescribed.

Note 1

At least 25, distinct, complete, dry dog foods, presumably produced by different manufacturers, declare garlic in their ingredient lists. The 25 dry foods given below describe their garlic ingredient as garlic only (n = 17), garlic powder (n = 5), dehydrated garlic (n = 2) or powdered, dried garlic (n = 1).

Blue Buffalo Life Protection	Addiction Dog Wild Kangaroo & Apples
CopRice Family Dog Food	Honest Kitchen Dehydrated Chicken Recipe
Ellie's Dog Food Working Dog Premium	Wellness Complete Health Natural
Akela Original Complete Working Dog Food	Lotus Oven Baked Chicken Recipe
Meals for Mutts Dry Dog Food Salmon and Sardine	Ultra Fish & Potato Sensitive Formula
Nature's Recipe Healthy Skin Vegetarian Recipe	Kennel Blend All Stages Dog Food
Pure Vita Turkey & Sweet Potato Entrée Grain Free	Optimum Dehydrated Wild Caught Salmon
Picart Select Adult Chicken & Rice	Futures Adult & Puppy Dry Dog Food
Canadian Naturals Turkey and Salmon	Artisan Chicken Freeze Dried
Dr. Gary's Best Breed Holistic All Breed	Dad's Kibble Select
Pinnacle Chicken & Oatmeal Formula	Evolution Diet Gourmet Fondue Dog
A La Carte Adult & Puppy All Breed	Natural Health Dog Carnivore
Kibbles Monge Natural Superpremium Speciality	

Note 2

Only two foods named in the table of Note 1, disclose the inclusion percentage of garlic, the amounts being 0.2% (Ellie's Dog Food Working Dog Premium) and 0.01% (Akela Original Complete Working Dog Food).

Note 3

The use of garlic is amplified by two foods listed in Note 1. Picart Select Adult Chicken & Rice claims that the added garlic contributes to strengthening the immune system. Wellness Complete Health Natural says to use garlic as it is valued for its antioxidant properties and enjoyable flavor. A dry dog food not mentioned in Note 1 (Yourdog Galgo Espanol), declares herbs as ingredient and clarifies that garlic is one of the herbs' components that benefits cardiovascular health of the dog.

The manufacturer of Artisan Chicken Freeze-Dried/Grain-Free Dog Food (Note 1) writes the following: "Garlic has many benefits to dogs with cancer, diabetes, liver, heart and kidney disease, uncontrollable staph infections and a host of other conditions, but also with incredible anti-parasitic properties, making it a great flea repellent. It tastes great too!" (https://www.grandmalucys.com/pages/faq).

Note 4

A supplementary food for dogs (Dry Raw Complete Menu Rabbit with Courgette, Amaranth and Wild Garlic) features wild garlic in its name and states 0.3% bear's garlic in the ingredient list. An odd dog treat also highlights wild garlic (Carnilove Sardines with Wild Garlic, Happy Dog Supreme Snacks).

Note 5

Feed-grade garlic powder is available (http://www.chinafooding.com/Garlic_Extract). Garlic oil (Just Right® Garlic Oil Palatants) is marketed as palatant for dog food (https://www.justrightpetfood.com /ingredients/palatants/garlic-oil).

Garlic oil is found in the dry foods under the umbrella brand names of Purina Dog Chow (https://www.purina.com/dog-chow/dry-dog-food/complete-adult-real-chicken) and Purina ALPO (https://www.purina.com/alpo/dry-dog-food/prime-cuts-beef). The inclusion percentages are not declared.

The public domain appears to lack experimental data on efficacy testing of garlic powder or garlic oil as palatability enhancer for (dry) dog food. Existing information is inaccessible. Thus, the impact of garlic powder/oil (in the base mixture or coating of kibbled dog food) on food acceptance or preference cannot be assessed.

Note 6

Garlic often occurs in lists of toxic foods for dogs (a-d). Excessive garlic amounts have ill effects indeed, but the amounts of garlic in commercial dog foods are safe.

a. Anne EA. 10 common foods that are extremely toxic to dogs. https://www.womansday.com/life/pet-care/a3775/pet-health-101-10-toxic-foods-for-dogs-77184/

b. Slideshow: Foods your dog should never eat. https://pets.webmd.com/dogs/ss/slideshow-foods-your-dog-should-never-eat

c. Schenker M. 28 foods not to feed to your dog (and a list of those you can). https://www.caninejournal.com/foods-not-to-feed-dog/

d. 13 human foods that are poisonous to dogs. https://www.vets-now.com/2017/01/foods-poisonous-to-dogs/

Note 7

In addition to the belief that ingestion of garlic by dogs makes their blood unpalatable to fleas, it is also thought that certain garlic-derived compounds secreted by the skin keep away fleas. Those repelling compounds would be present as such in garlic and/or be metabolites synthesized by the dog (1).

Note 8

Garlic has been asserted to either reduce (e, Note 10) or cause (f) bad breath in dogs.

e. Home remedies for bad dog breath. https://trudog.com/home-remedies-bad-dog-breath/

f. Rogers J. Natural home remedies for your dog's bad breath. https://www.naturalalternativeremedy.com/natural-home-remedies-for-your-dogs-bad-breath/

Note 9

In a non-controlled, non-blinded study (1), the effect of ingested garlic powder or oil on the number of fleas found on 10 dogs was studied. The study involved multiple, successive treatments, but without design-wise taking into account possible carry-over effects. Compared with baseline flea counts, the average number of fleas per dog was lower during garlic treatment (650 mg/dog.day or 0.26% garlic powder or oil in dry food). However, those lower counts were comparable to those during treatment with thiamine prior to garlic feeding. The study does not provide solid proof that dietary garlic is effective in flea repelling.

Note 10

"Garlic breath" in humans relates to metabolites of fat-soluble, organosulfur compounds derived from ingested garlic. Allyl mercaptan, allyl methyl sulfide, and allyl methyl disulfide have been detected in human breath after garlic consumption (31). Thus, dietary garlic as promoter of pleasant breath in dogs is counterintuitive. However, a patent claims that garlic reduces bad breath in dogs (2).

The patent holder noted that the feeding of table scraps and cooking samples reduced bad breath in her dogs (2). The patent describes that six dogs were then subjected to a series of tests over periods of two days each. Various ingredients were placed upon ground beef. It was found that feeding broiled, ground beef sprinkled after cooking with uncooked garlic powder resulted in the elimination of all offensive dog breath odor. Subsequently, garlic powder was administered to two adult dogs and 10 puppies and found to eliminate bad breath in all animals.

The amount of garlic powder is not defined (2). For meaningful application of garlic powder as breath deodorizer for dogs, the study outcome should be reproducible and stand up to scrutiny. Those requirements imply repetition of the study, but using a placebo-controlled, blinded design.

Note 11

Reported proximate composition of peeled garlic bulbs, expressed as g/100 g dry matter

Ref.	Protein	Fat	Fiber	Ash	NFE
4		0.6^			
5	40.5	0.7		22.7	
6	18.2	0.7		4.3	76.8*
7	16.1	0.8	2.2	4.3	76.6
8	8.2	3.3	11.0	10.8	66.7
9	20.6	1.8	0.5	3.5	73.6
10	4.9	0.7	2.7	1.7	90.0
11	20.9	8.7	0.6	3.6	66.2

^Chloroform-methanol extracted lipids; *Including crude fiber

Note 12

A fresh garlic clove may weigh 13 g and contain 38% dry matter. Thus, 5 g fresh, whole garlic/kg bw.d equals 7.7 cloves and 38 g dry matter/20 kg bw.d. For a 20-kg dog consuming 300 g dry matter/day, the amount of dry garlic corresponds with 12.7 % of dietary dry matter, or 11.4% in dry food (90% dry matter) as fed.

Note 13

The male Schnauzer possibly weighed 18 kg and may have consumed 270 g dietary dry matter/day (15 g dry matter/kg bw.d). The amount of 60 g baked garlic, or 22.8 g dry matter, is equivalent with 8.4% of dietary dry matter, or 7.6% in dry food as fed.

Note 14

Organosulfur compounds isolated from an aqueous ethanolic garlic extract, including DATS, induced methemoglobin formation in isolated canine erythrocytes (20-22). Accumulation of methemoglobin, which is incapable of binding oxygen, caused the erythrocytes to be destroyed. After intragastric administration of a boiled, watery garlic extract, dogs showed a transient increase in blood methemoglobin, followed by the appearance of erythrocytes with Heinz bodies and eccentrocytes (16).

When iron^{II} in hemoglobin is oxidized into iron^{III}, methemoglobin is formed. That may occur when hemoglobin oxidation is increased or when methemoglobin reduction by reduced glutathione is decreased. In dogs forced-fed the garlic extract, erythrocyte reduced glutathione concentration was markedly elevated (16). Therefore, it seems that garlic-induced hemolytic anemia is caused by oxidants in the garlic extract, their power outranking the protective effect of reduced glutathione. It is remarkable that aged garlic extract is promoted on account of its antioxidant activity (32).

Note 15

With the use of an endoscopic air-powder delivery system, cellulose, dehydrated raw and boiled garlic powder were delivered directly into the stomach (23). There were three application sites per test material (40 mg) within each dog (n = 6).

Note 16

The article (24) is in Chinese with an abstract in English. In the abstract, the garlic doses used are given as 0.75, 1.50 and 3.00 g/kg. In addition, there was a solvent control. The abstract states that “Dogs in the high dose group vomited intermittently, and appetite was decreased” and that “The dose of 0.75 g/kg had no obvious toxicity reaction”. It is unlikely that 0.3% garlic in dry food caused adverse reactions (25, 26, Note 17). Thus, the doses are most likely expressed as g/kg body weight. The amounts would then be equivalent to 0, 4.5, 9 and 18% garlic powder in dry food, assuming a dry food intake of 16.7 g/kg body weight per day.

Note 17

At a dry food intake of 16.7 g/kg bw.d, the dose of 100 mg dehydrated garlic/kg bw.d, which was used in two studies (25, 26), conforms to dry food with 0.6% garlic powder. That dose was not reported to be toxic.

Note 18

Amano et al. (29) concluded that the measured, low renal clearance values for SAC in dogs point to extensive renal reabsorption, which in turn explains its long half life. Slower elimination could imply higher risk of intoxication. In dogs, the feeding of aged garlic increased expression of antioxidant enzymes via the Nrf2-dependent pathway (27), which was perhaps associated with activating the biotransformation of garlic's organosulfur compounds. In the rat, metabolites of DADS have been identified (33).

Note 19

Garlic also holds non-sulfur phytochemicals, but relatively little is known about their biological activities. Those phytochemicals, include flavonoids, steroid saponins, organoselenium compounds, and allixin.

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