Skin and Coat in Cats

KEY POINTS

- **The skin is particularly sensitive to alterations in its nutrient supply, but its response to dietary changes may take several months to appear. Nutritional deficiencies are rare but may occur if the diet is poorly formulated or stored, if the animal's intake is reduced or if it cannot absorb or utilize the nutrient as a result of disease or genetic factors.**
- **Most nutrient deficiencies produce a similar range of clinical signs reflecting an impairment of keratinization, sebum production and hair growth.**
- **Typical signs are those of seborrhea and include excessive scale, erythema, alopecia or poor hair growth, greasy skin, secondary pyoderma, and pruritus.**
- **Some nutrients may be administered in supraphysiologic doses to produce a therapeutic effect in certain nutrient-responsive dermatoses.**
- **Dietary sensitivity is rare but may present as a pruritic skin disorder or with other cutaneous signs.**
- **Protein malnutrition is most likely to occur following reduced intake, failure to compensate for transiently increased requirements, or increased protein losses in chronic disease.**
- **Essential fatty acid deficiency may result from feeding poor quality, low-fat dry foods or inappropriate home-prepared diets, following oxidative damage to fatty acids in food, or as a sequel to fat malabsorption.**
- **Therapeutic supplementation with essential fatty acids may help in the management of certain skin disorders associated with abnormalities of fat metabolism or hypersensitivity (e.g., feline miliary eczema, flea allergic dermatitis, eosinophilic granuloma complex, dietary hypersensitivity). In the case of pruritic skin disease, essential fatty acids (particularly omega-3 fatty acids) may help to attenuate the inflammatory response through their effect on eicosanoid production.**
- **Vitamin A deficiency is rare in cats, but hypervitaminosis A can result from oversupplementation of the diet with liver, vitamin A or cod liver oil.**
- **Pansteatitis (yellow fat disease) is associated with a vitamin E deficiency in cats that**

are habitually or exclusively fed high fat diets, particularly canned red tuna or other oily fish.

- **Biotin deficiency may occur if the diet contains large amounts avidin, contained in raw egg white. The vitamin has also been used as a supplement in the treatment of various dermatoses and disorders of keratinization.**
- **Deficiencies of other B-complex vitamins, including riboflavin, niacin, and pyridoxine, may also result in the development of skin lesions.**

The skin is the largest organ in the body and performs a multiplicity of functions. Its high level of metabolic activity creates a heavy physiological demand for protein and other nutrients and makes it particularly sensitive to subtle changes in its own nutrient supply. Dietary factors can therefore have a significant effect on skin and coat condition in dogs and cats and may impact the etiology and therapy of skin disease in three areas:

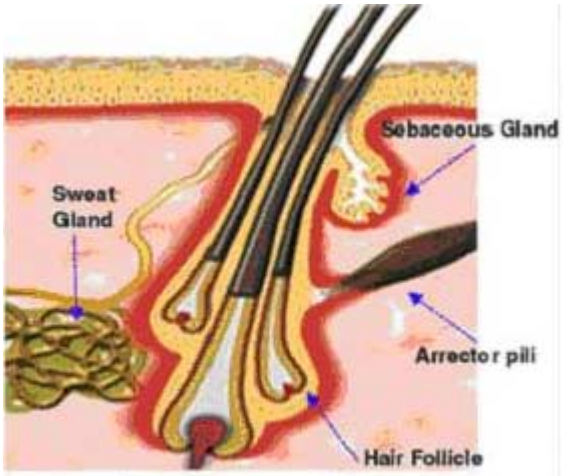
- Nutrient deficiency or imbalance
- Nutritional supplementation for therapeutic effect
- Dietary sensitivity

ANATOMY

Skin

Adult skin is composed of three layers:

- The **epidermis**
- The **dermis**
- The **hypodermis or subcutis**



Cross-section of skin

Epidermis

The epidermis is the outermost layer of the skin. All epidermal cells are derived from the basal membrane *(stratum basale),* which is composed primarily of keratinocytes, although other cells, including melanocytes, are also present. Keratinocytes produced by the basal membrane differentiate sequentially to form:

- The prickly cell layer ***(stratum spinosum)***
- The granular layer ***(stratum granulosum)***
- The clear layer ***(stratum lucidum)***, only in the footpads and the nose
- The outermost horny layer ***(stratum corneum)***, which consists of nonnucleated, fully keratinized cells

Keratinocytes have many functions, including:

- Production of keratin, a fibrous, sulphur-containing protein
- Production of a lipid secretion that plays an integral role in the regulation of the stratum corneum barrier function and desquamation

Dermis

The dermis supports the epidermis and consists of a matrix of collagen and reticular and elastic fibers in a ground substance of chondroitin sulphate and hyaluronic acid. Cells present in this layer are fibroblasts, mast cells, and histiocytes, although other cell types may be present in certain disease conditions.

The tensile strength and elasticity of the skin is largely attributable to the dermis, which is also responsible for the maintenance and repair of the skin and modifies the structure and function of the epidermis.

Hypodermis

The underlying hypodermis is made up of loose connective tissue, elastic fibers and variable amounts of fat. This layer acts as an energy reserve, an insulator, protective padding, and maintains the body contours.

Hair

Three types of hair are present in cats:

- The primary or guard hairs

- The fine secondary hairs
- The tactile or sinus hairs, including the whiskers, which are responsible for touch

Each hair is divided into a free part or shaft, and a proximal par or root. The hair shaft consists of:

- The **inner medulla**, forming an axial cord of cells
- The **cortex**, composed of tightly packed keratin and pigment
- The **cuticle**, a single layer of flat, cornified cells that overlap and are tightly pressed to the cortex

The hair is housed in an epithelial pit called a hair follicle and is attached, via the hair bulb, to the dermal papilla in the base of the follicle. It is here that mitotic activity occurs, which leads to the production of the hair matrix. Melanocytes, which produce the pigment melanin, are situated in the hair bulb.

Associated with the hair follicles are:

- **Sebaceous glands**, except in the footpads or on the nose, which produce sebum
- An **erector pili muscle**, which elevates the hair and helps in the expression of sebum
- **Apocrine sweat glands** (except in the skin of the footpads and nose), which have predominantly pheromonal rather than a thermoregulatory function
- **Eccrine sweat glands** (only in the skin of the footpads), which are activated under nervous control, particularly in stressed or nervous cats

FUNCTION

Major functions of the skin and coat include:

- Maintenance of an enclosed natural barrier between the animal's internal environment and the outside world
- Preservation of the animal's shape
- Protection against water loss
- Protection from physical, chemical and microbial injury imposed by external agents
- Nutrient storage
- Sensory perception
- Thermoregulation
- Vitamin D synthesis
- Important indicator of health status
- Significant role player in communication (e.g., pilo erection, excretion of pheromones)

The protective function of the skin and coat is enhanced by the presence of an emulsion of sebum and sweat which permeates the cells of the *stratum corneum*. This emulsion also:

- Provides a physical barrier
- Maintains skin hydration to keep it soft and pliable
- Spreads over the hair coat to produce a glossy sheen
- Contains antimicrobial substances
- Is immunologically active

The presence of pigment, immunocytes, and the normal skin microflora also contributes to the skin's defense system.

Hair Growth

Hair growth in the cat is cyclic and each cycle consists of:

- **Anagen** - the active growing phase
- **Catagen** - the transitional phase
- **Telogen** - the resting phase

In cats, hair replacement occurs in a mosaic pattern so there is no synchronized single period of hair shedding. Neighboring follicles are in different phases of the hair cycle at any one time. Domestic cats tend to molt continuously throughout the year, with peaks of activity occurring during spring and autumn.

Factors that affect hair growth in cats include:

- Length of day
- Ambient temperature
- Hormonal status
- Health status
- Nutrition

CLINICAL DISORDERS

Nutritional factors play a role in the etiology and management of skin disease in three broad areas:

- Nutritional deficiency or imbalance
- Nutritional supplementation for therapeutic effect
- Dietary sensitivity

Nutrient Deficiencies or Imbalances

Nutritional deficiencies are now rarely encountered in companion animals due to the widespread feeding of balanced and complete pet foods. Deficiencies may occasionally arise:

- When the animal's intake is reduced
- When the diet is poorly formulated or stored
- When the animal is unable to digest, absorb or utilize the nutrient as a result of disease or genetic factors

Dietary interactions that reduce nutrient availability can result from:

- Errors in formulation
- Prolonged storage
- Oversupplementation of an otherwise balanced diet

Where dietary errors are identified, it is usually simpler to feed a balanced commercial diet than to attempt to correct single deficiencies in a poorly formulated diet.

Many nutrient deficiencies may be associated with skin disorders, but most produce a range of similar clinical signs. In general, nutrient deficiencies produce seborrheic skin changes that reflect impairment of the fundamental metabolic processes of:

- Keratinization
- Sebum production
- Hair growth

Typical signs of a nutritional dermatosis include:

- Excessive scale
- Erythema
- Alopecia or poor hair growth
- Greasy skin, often accompanied by a secondary bacterial infection and pruritus

It is generally accepted that signs become evident only after deficient diets are fed for several weeks to months.

The following nutrients are crucial in maintaining optimal skin and coat condition:

- **Protein**
- **Essential fatty acids**
- **Zinc**
- **Vitamin A**
- **Vitamin E**
- **B-complex vitamins**

Nutritional Supplementation for Therapeutic Effect
Although nutritional supplements may be used to treat skin disorders arising from nutrient deficiency or imbalance, dietary correction is achieved more effectively by feeding a high quality commercial diet that is nutritionally complete and balanced. Supplementation with specific nutrients may, however, be beneficial in the management of certain nutrient-responsive dermatoses. In such cases, supraphysiologic doses of the nutrient are required and its action is likely to be of a pharmacologic nature rather than merely correcting a deficiency.

Protein

Etiology

Protein deficiency is rare in clinical practice but is occasionally encountered following:

- Starvation
- Disease-induced inappetence and anorexia
- Prolonged feeding of a poorly formulated or inappropriate diet

In the short term, primary protein deficiencies are most likely to occur when requirements are transiently increased (e.g., in young, growing animals and in pregnant or lactating females).

Alternatively, protein malnutrition may be associated with excessive protein loss, which may occur in certain chronic illnesses such as:

- Protein-losing nephropathy
- Protein-losing enteropathy
- Excessive exudative disorders, such as pyothorax or burns

Protein malnutrition may also be seen in critically ill animals with increased protein requirements and decreased intake.

Pathophysiology and Clinical Signs

The protein requirement for normal growth of hair and keratinization of the skin may account for between 25-30% of the animal's daily protein requirement. Failure to meet this demand results in the cutaneous manifestations of protein malnutrition including:

- Brittle, depigmented hair that is easily shed and slow to regrow
- Excessive scaling
- Thin, inelastic and hyperpigmented skin

Dietary Management

Dietary correction involves supplementation with high quality protein sources such as meat, eggs, and milk, but the prognosis may be complicated by the presence of underlying disease.

Essential Fatty Acids

Etiology

Dietary deficiencies of essential fatty acids (EFA) are uncommon but may occasionally occur in association with:

- Poor quality, low fat dry foods or inappropriately formulated home-prepared diets
- Oxidative destruction of EFA in food due to prolonged storage or insufficient inclusion of antioxidants, such as vitamin E
- Fat malabsorption due to hepatic, pancreatic or gastrointestinal disease, although this is rare

Pathophysiology

Fatty acids of the ***omega-6 and omega-3 series*** perform a range of functions, many of which are vital for maintaining normal skin structure and function. They:

- Play a structural role in cell membranes
- Are involved in the maintenance of the cutaneous water permeability barrier
- Act as precursors for eicosanoids, such as prostaglandins
- Regulate epidermal proliferation

Cats are unable to synthesize linoleic acid and, because they exhibit low delta-6-desaturase activity, they are also unable to meet their physiologic requirement for arachidonic acid through biosynthetic pathways. Cats, therefore, require a dietary source of both linoleic and arachidonic acids, from which other physiologically active metabolites may be derived. There may also be a subtle dietary requirement for omega-3 fatty acids in some physiologic states, and it has been implicated that docosahexaenoic acid (DHA) plays an important role in the development of retinal and brain tissue in the developing animal (Innis 1991).

Clinical Signs

Following the introduction of a deficient diet, cutaneous signs of EFA deficiency may appear within two to three months and are related to abnormalities of keratinization. Initially, surface lipid production decreases while sebum production increases.

Early signs include:

- Dull, dry coat
- Fine scale

If prolonged, EFA deficiency results in:

- Alopecia
- Greasy skin, particularly in the ears and between the toes
- Pruritus
- Secondary pyoderma

Severe cases may also present with systemic signs including:

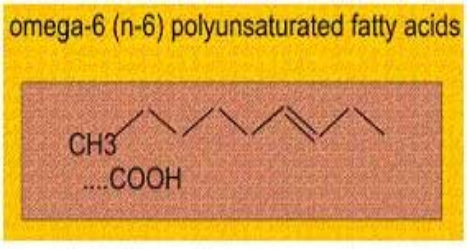
- Poor wound healing
- Reduced immunocompetence
- Growth retardation
- Infertility

Dietary Management

Dietary correction of EFA deficiency may be achieved by:

- Changing to a higher fat, premium quality diet
- Supplementing the diet with oils
- Administering proprietary fatty acid supplements

Where the deficiency is uncomplicated by other factors, a response is usually visible within three to eight weeks.



Typically, omega-6 fatty acids are obtained from plant seed sources or terrestrial animal flesh, whereas omega-3 fatty acids are principally found in marine lipid and some terrestrial plant sources. Although vegetable oils, such as sunflower oil, are a rich source of linoleic acid, appreciable quantities of its derivative arachidonic acid are found only in animal fats.

A general recommendation for dietary supplementation with essential fatty acids is based on supplying 1.5-2.5 ml of vegetable or fish oil for a 4kg cat. Increasing the dietary polyunsaturated fatty acid (PUFA) content simultaneously increases the requirement for vitamin E and may also increase the requirement for other vitamins and minerals involved in fatty acid utilization. In most cases it is preferable to feed a better quality prepared pet food or to provide a balanced veterinary supplement containing essential fatty acids, vitamin E, and zinc.

Therapeutic Supplementation

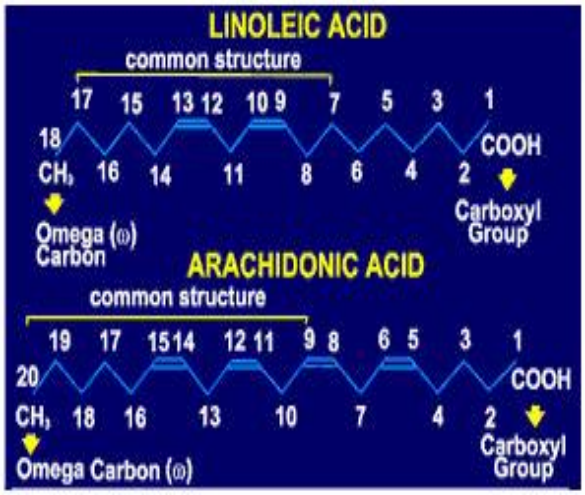
Essential fatty acid supplements also have been used therapeutically in the management of a number of skin disorders, particularly those associated with hypersensitivity reactions or with abnormalities of fatty acid metabolism (Campbell 1993). In the cat, conditions that may respond to EFA supplementation include:

- Symmetrical alopecia
- Feline acne
- Feline miliary eczema
- Flea-allergic dermatitis
- Atopy
- Dietary hypersensitivity
- Idiopathic pruritus
- Feline eosinophilic granuloma complex

In the management of these inflammatory skin disorders, supplementation with dietary PUFA may help to control clinical signs and can reduce or eliminate the requirement for corticosteroids or other therapies. Their effect may be partly attributable to the role of PUFA in the production of eicosanoids, which are important mediators of inflammation in the cat.

It is thought that manipulation of dietary PUFA may alter the balance of pro- and anti-inflammatory eicosanoid production, with eicosanoids deived from dihomo-g-linolenic acid and from omega-3 PUFA being either anti-inflammatory or less inflammatory than those derived from arachidonic acid.

Supplementation with gamma-linoleic acid, in the form of evening primrose oil, and/or eicosapentenoic acid, as marine fish oils, may help to attenuate the inflammatory process when administered at relatively high doses. Although it has been suggested that a low omega-6:omega-3 fatty acid ratio is important in the dietary management of inflammatory disease, it is now thought that the absolute amount of dietary omega-3 fatty acid intake may be a greater determinant of the magnitude of the clinical response (Hwang et al. 1997).



ZINC

Zinc plays a critical role in regulating many aspects of cellular metabolism such as maintaining a healthy coat and skin. It is an integral component of a wide range of metalloenzymes and, as a cofactor for RNA and DNA polymerases, is of particular importance in rapidly dividing cells, including those of the epidermis. Zinc is also essential for the biosynthesis of fatty acids, participates in both the inflammatory and immune systems, and is involved in the metabolism of vitamin A.

Naturally occurring zinc deficiency has not been reported in cats, but experimentally induced skin lesions including thinning of the hair coat, scaly skin, slow hair growth, and ulceration of the buccal margins have been reported.

VITAMIN A

Etiology

Both deficiency and excess of vitamin A can give rise to a similar range of cutaneous signs. The cat requires a dietary source of pre-formed vitamin A since, unlike the dog, it is unable to utilize its precursor, ß-carotene. Nevertheless, vitamin A deficiency is rare in companion animals and a toxicity state, with its accompanying skeletal changes, is more likely to occur. Hypervitaminosis A is seen predominantly in cats which are fed large amounts of liver or following prolonged oversupplementation of the diet with vitamin A or cod liver oil.

Pathophysiology and Clinical Signs

Vitamin A (retinol and its derivatives) has many physiologic functions and is involved in the regulation of cellular growth and differentiation. It is essential to maintain the

integrity of epithelial tissues and it is particularly important for the keratinization process. Both deficiency and excess of vitamin A can give rise to cutaneous lesions of:

- Hyperkeratinization and scaling
- Alopecia
- Poor hair coat
- Increased susceptibility to microbial infections

Hyperkeratinization of the sebaceous glands can result in occlusion of their ducts and the formation of firm, papular eruptions.

Dietary Management

Dietary supplementation may be required to correct vitamin A deficiency, but care should be exercised to avoid the risk of toxicity. In true deficiency syndromes, vitamin A therapy should not exceed 400 IU/kg/day orally for 10 days.

Therapeutic Supplementation

Synthetic retinoids, which are structurally related to vitamin A, have been used in the management of certain disorders that are characterized by defects in keratinization, such as feline acne (Harvey 1993). However, the cost and potential toxicity of these compounds limit their use in veterinary medicine.

VITAMIN E

Etiology

Pansteatitis (yellow fat disease) is associated with a deficiency of vitamin E in cats, which are habitually or exclusively fed high fat diets, particularly canned red tuna or other oily fish. Vitamin E is a natural antioxidant and, together with selenium, is important for maintaining stability of cell membranes. As a free radical scavenger, it protects cells from the potentially damaging effects of toxic oxygen radicals, a major source of which is lipid metabolism.

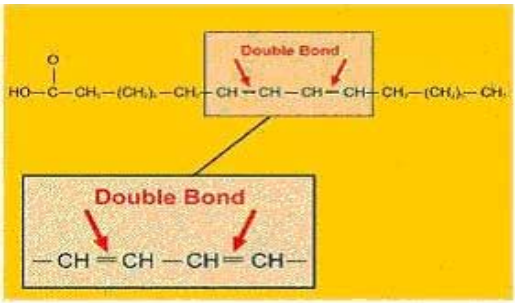


Diagram of Polyunsaturated Fatty Acid

The dietary requirement of vitamin E is, therefore, linked to the dietary intake of PUFA, and high fat diets can induce a relative deficiency of vitamin E. Similarly, levels of vitamin E may be depleted following the oxidation of fat during processing or prolonged storage of food.

Pathophysiology and Clinical Signs

In affected cases, low levels of vitamin E relative to the PUFA content of the diet result in the accumulation of ceroid, a product of lipid peroxidation, in subcutaneous and intra-abdominal fat. Necrosis and subsequent inflammation of the affected tissues produce firm, nodular masses whereby the cat may exhibit considerable pain on palpation and movement.

Dietary Management

Treatment of ***pansteatitis*** consists of dietary correction together with vitamin E supplementation (10 mg/kg/day) and supportive therapy, but the prognosis for the untreated or severely affected cat is poor.

B-COMPLEX VITAMINS

Etiology and Pathophysiology

The B-complex vitamins are involved as cofactors in many metabolic functions, especially energy metabolism and synthetic pathways. Being water-soluble, they are not stored in the body, but the animal's daily requirements can normally be met from a combination of dietary sources and intestinal microbial biosynthesis. However, deficiencies may occur following prolonged oral antibiosis, anorexia or when water loss is increased as in polyuric conditions or enteritis.

Occasionally, deficiencies of individual B-complex vitamins arise as a result of interaction with other dietary components.

Clinical Signs

In general, skin lesions associated with deficiencies of B-complex vitamins include dry, flaky seborrhoea and alopecia.

- **Biotin** deficiency produces a characteristic alopecia around the face and eyes with crusting in severe cases. This condition may occur after feeding large amounts of raw egg whites, which contain avidin, a protein that binds biotin and prevents its gastrointestinal absorption.

- **Riboflavin** deficiency produces cheilosis in addition to seborrhoea but will not occur if the diet contains meat or dairy products.

- **Niacin** deficiency results in ulceration of mucous membranes, diarrhea, and emaciation, and occasionally, in pruritic dermatitis of the hind legs and ventral abdomen. Although the cat is unable to convert tryptophan to niacin, a deficiency is rare and only seen when the diet is low in animal protein.

- **Pyridoxine** deficiency may cause a dull, waxy, unkempt coat with fine scales and patchy alopecia but has only been reproduced in experimental studies.

Dietary Management

Treatment of B-vitamin deficiency involves dietary correction, where appropriate, and supplementation with the entire vitamin B group to compensate for reduced intake or increased losses. Oral supplementation with brewer's yeast and/or parenteral administration of B-vitamins is usually effective.

Biotin supplementation also has been used with limited success in the treatment of various dermatoses and disorders of keratinization (Scott et al. 1995).

SUMMARY

The skin has a high physiologic demand for protein and other nutrients, making it particularly sensitive to alterations in its own nutrient supply. Nutritional factors play a significant role in the maintenance of skin and coat condition in cats and may contribute to the etiology and management of skin disease in the areas of nutrient deficiency or imbalance, therapeutic supplementation and dietary sensitivity.

Nutritional deficiencies are rare when a balanced and complete diet is fed. However, deficiencies may occur when the diet is poorly formulated or stored, when the animal's intake is reduced, or when the animal is unable to digest, absorb or utilize the nutrient due to disease or genetic factors. Cutaneous signs are not usually apparent until after several months of feeding the deficient diet, and are generally characterized by the development of seborrheic skin changes. Typical signs include excessive scale, erythema, alopecia, or poor hair growth and greasy skin, which are often accompanied by secondary bacterial infection and pruritus.

Deficiencies of protein, essential fatty acids, and vitamin A appear to be the most important causes of nutritional dermatoses in the cat. Secondary deficiencies of certain nutrients, such as vitamin E, fatty acids and biotin, may occur due to their interaction with other nutrients in the diet, or as a result of impaired nutrient absorption or metabolism by the individual animal. It is usually more effective to feed a high quality, balanced commercial diet rather than trying to improve a poorly formulated diet that may be deficient in many aspects.

Supplementation with specific nutrients in supraphysiologic doses may be beneficial in the management of certain nutrient-responsive dermatoses. In such cases, their action may be considered pharmacologic rather than a correction of a simple deficiency. Examples of nutrients used in cats for their therapeutic effect include essential fatty acids, vitamin A, and biotin.

Adverse reactions to food are rare in the cat, but may also result in cutaneous disease. In most cases, dietary sensitivity manifests as a pruritic skin disorder accompanied by varying degrees of associated self-trauma. Diagnosis and management of the condition involve identification of the offending ingredient(s) and its removal from the animal's diet.

REFERENCES

Kendall PT (1983). Influence of Nutrition on Coat Condition in Dogs and Cats. Pedigree Digest. 10, 1: 4-7.

Rainbird AL (1987). Influence of Nutrition on Skin and Coat Condition in Dogs and Cats. Clinical Insight. 12, 2: 695-696.

Ruedisueli FL, Eastwood NJ, Gunn NK, Watson TDG (1996). The Measurement of Skin pH in Normal Dogs of Different Breeds. [Abstract] Veterinary Dermatology 3rd World Congress (Book of Abstracts).

Ruedisueli FL, Eastwood NJ, Gunn NK, Watson TDG (1996). The Measurement of Skin pH in Normal Dogs of Different Breeds. Veterinary Dermatology. 3, 523-524.

Ruedisueli FL, Coe SL, Watson TDG, Finlan HA, Cross MJ (1998). A Comparative Study on the Effect of Shampoos on Skin pH and Transepidermal Water Loss of Dogs. International Symposium on Bioengineering and the Skin.

Ruedisueli FL, Cross MJ, Finlan HA, Watson TDG (1998). The Effect of Dietary Supplementation with Zinc and Linoleic Acid on the Transepidermal Water Loss in Dogs. International Symposium on Bioengineering and the Skin.

Watson TDG (1997). Diet and Skin Disease in Dogs and Cats. [Abstract] WALTHAM International Symposium: Pet Nutrition & Health in the 21st Century – Orlando, Florida. 94.

Watson TDG (1998). Diet and Skin Disease in Dogs and Cats. Journal of Nutrition. 128, 2783-2789.

Wills JM, Marsh KA (1999). Skin and Coat Companion Animal Practice (Jap. Journal). 116, 24-26.