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The Concentration of Serum Trace Elements and Oxidant/Antioxidant Status in Persian Cats with Dermatophytosis in Comparison with Healthy Controls and other Dermatological Disorders.

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Abstract

BACKGROUND: Despite the high prevalence of dermatophytosis in cats, little is known about the impact of this disease on the antioxidant status and trace elements in these animals

OBJECTIVE: The present study aimed to investigate the concentration of serum trace elements (copper, iron, zinc, and selenium) and oxidant/antioxidant status (malondialdehyde, total antioxidant capacity, and thiol group) in Persian cats with dermatophytosis in comparison with healthy controls and other dermatological disorders.

METHODS: Three groups of cats were selected: cats with dermatophytosis (n = 13), cats with other dermatologic conditions (n = 6) and clinically and dermatologically healthy cats (n = 6). All 25 cats were subjected to clinical and dermatological examinations, including direct microscopic examination and fungal culture. Additionally, the possible contamination with feline immunodeficiency virus (FIV) and feline leukemia virus infection (FeLV) were also tested.

Results: Microsporum canis was the only dermatophyte species isolated from the affected cats, and only two of cats were infected with the FIV; one in the dermatophytosis and one in the other skin diseases group.

For trace elements, we did not detect differences between cats with dermatophytosis and healthy ones. However, copper levels were higher in other skin diseases groups compared with healthy

controls (P<0.05). Cats with dermatophytosis and other skin diseases revealed a decrease in total antioxidant capacity compared with the healthy controls (P<0.01).

Conclusion: The present study found variations in oxidative indices in cats with dermatophytosis and other skin disorders. This finding may support the hypothesis that improvement of the antioxidant status through dietary supplementation may be beneficial in the prevention and resolution of skin diseases in cats.

Keywords: Oxidative stress; Dermatophytosis; Cat; Trace elements; Dermatological disorders

Introduction

Dermatophytosis, a fungal infection of keratinized skin structures resulting in various skin lesions, alopecia, and pruritus, is a significant health concern for both animals and humans. (Moriello and Coyner, 2021; Shokri and Khosravi, 2016). Small animals are primarily affected by *Microsporum canis* (*M canis*), *M gypseum,* and *Trichophyton* species, with cats being the most susceptible species and *M canis* being the most prevalent. (Moriello, 2019; Abastabar et al., 2019). *M canis* is also considered as a frequent agent of tinea capitis, tinea corporis, and tinea manum in humans (Shokri and Khosravi, 2016; Moriello, 2019;; Abastabar et al., 2019; Ansari et al., 2016).

Several factors predispose animals to infection, including age, genetic susceptibility of certain breeds (particularly Persian cats), housing conditions, the host's immunity status (immunosuppressive diseases such as FIV or FeLV in cats, and immunosuppressive drugs), and nutritional status. (Al-Qudah et al., 2010; Beigh SA, et al., 2014; Moriello et al., 2017; Nikbakht; 2022; Ramezanpour Eshkevari; 2024). Due to its zoonotic status, pleomorphic clinical signs, infectious and contagious nature, dermatophytosis is an important issue in veterinary medicine (Moriello et al., 2017). Skin plays an important role in preventing the penetration of fungal pathogens, but it is also vulnerable to oxidative damage (Khan et al, 2022). There are a variety of defense mechanisms including non-enzymatic and enzymatic compounds in the skin that act as powerful antioxidants or oxidant-degrading systems (Portugal et al., 2007). During oxidative stress, the skin's defenses become overloaded, causing various skin disorders such as erythema, edema, wrinkles, hypersensitivity, and keratinization (Trouba *et al*., 2002). Dermatophytes can trigger the production of reactive oxygen species (ROS), either directly or indirectly. Following a dermatophyte infection, ROS are produced by immune cells such as neutrophils and macrophages to help eliminate the fungal infection (Pathakumar *et al*., 2020; Linnerz and Hall, 2020). Different enzymatic systems, such as the NADPH oxidase system, the mitochondrial respiratory chain, and the lipoxygenase path, can generate ROS in immune cells. These systems

generate a variety of ROS, including hydroxyl radicals (OH), hydrogen peroxide (H2O2), and superoxide anion (O2) (Brieger *et al*., 2012). Furthermore, oxidative stress can lead to the activation of the transcription factor NF-kB, which regulates the expression of genes involved in inflammation and immune response (Celestrino *et al*., 2021). NF-kB activation can further increase ROS production by immune cells, leading to a positive feedback loop that amplifies the immune response and oxidative stress (Linnerz and, Hall 2020). In addition to immune cells, dermatophytes themselves can produce ROS as part of their processes of metabolism. Fungal cell walls contain enzymes such as NADPH oxidase and lipoxygenase, which can produce ROS while breaking down nutrients. ROS produced by dermatophytes can cause damage to host tissues and contribute to the pathogenesis of the infection (Hogan and Wheeler, 2014). Trace minerals such as iron, copper, zinc, and selenium are essential for proper immune function and skin health. These micro-nutrients are components and cofactors of certain endogenous antioxidants. Cytoplasmic superoxide dismutase (SOD) enzyme contains copper and zinc metals as cofactors; glutathione peroxidase enzyme contains selenium and catalase contains iron (Sloup et al., 2017). Iron and Zinc play a crucial role in immune cell development, differentiation, and function (Maggini *et al*., 2007; Gombart *et al*., 2020; Seyednejad *et al*., 2023). Selenium is a crucial trace element that is frequently used as an antioxidant to protect skin against ROS attack

(Zhu *et al*., 2015). Selenium also plays a role in immune regulation by affecting the proliferation and function of immune cells such as T lymphocytes and natural killer cells (Avery and Hoffmann, 2018). Copper participates in the regulation of wound healing, melanin production, and defense against oxidative stress in animals (Park K. 2015). Selenium deficiency has been associated with skin disorders, including impaired wound healing and increased vulnerability to UV-induced skin damage (lv *et al*., 2020). Likewise, zinc deficiency has been linked to a range of dermatological issues, encompassing cutaneous lesions, impaired wound healing, and heightened vulnerability to infections (Nosewicz *et al*., 2022). Previous studies indicated that some animals like dogs and calves suffering from skin disorders have altered trace element concentrations and compromised antioxidant defenses (Al-Qudah *et al*., 2010; Beigh *et al*., 2014; Beigh SA, *et al*., 2016).

Despite the high prevalence of dermatophytosis in cats, little is known about the impact of this disease on the antioxidant status and trace elements in these animals. The present study aimed to investigate the concentration of serum trace elements (copper, iron, zinc, and selenium) and oxidant/antioxidant status (malondialdehyde, total antioxidant capacity, and thiol group) in Persian cats with dermatophytosis in comparison with healthy controls and other dermatological disorders.

Additionally, the researchers checked the cats for "FIV" and "FeLV" infections in order to minimize the potential effect of these immunosuppressive diseases on the incidence of dermatophytosis.

Materials and methods

Animal selection

This study was approved by the Ethics committee of Ferdowsi University of Mashhad (FUM), Mashhad, Iran. A total of 25 cats enrolled in this study were admitted for clinical and dermatological examination to the FUM Vet Hospital from September 2017 to February 2019. To minimize probable breed differences only Persian cats were included in this clinical study. Cats diagnosed with dermatophytosis based on clinical signs and positive wood's lamp followed by a positive mycological culture and microscopic identification of the fungus were included in this study only when the presence of other probable dermatological diseases or other problems were ruled out. Following analysis of the dermatologic data collected, 25 privately owned Persian cats were divided into three groups as follows:

1. Healthy control group: six adult healthy cats (4 males and 2 females), with an age group of 6-84 months (mean ± SD; 38.5 ± 32.6). These cats presented to the hospital for routine checkups

and vaccination. Healthy control cats had no history of ear or skin diseases and were negative for any dermatophytes.

2. Cats with dermatophytosis: 13 cats with dermatophytosis (4 males and 7 females, 2 not determined) with an age group of 1-17 months (mean ± SD; 7.5 ± 6 months) were selected.

3. Cats with other dermatologic conditions: six cats (1 male and 5 females) with various skin problems but dermatophyte-negative with an age group of 12-126 months (mean ± SD; 46.5 ± 42 months) were involved in the study.

The diseased cats had a history of dermatological problems for at least 4–5 weeks before the presentation. All the cats included in the study were medication-free at least 30 days prior to the collection of blood samples and had lived exclusively in domestic environments.

Dermatological examination

The techniques evaluated for the dermatologic diagnostics evaluation of cats were skin scrapings, trichograms, tape strips, Wood's lamp and direct sampling for fungal culture, direct examination of the exudates from pustules or draining tracts, bacteriological tests, and skin biopsies. In order to gather debris, skin scrapings samples were collected with sharp or dull scalpel blades. Debris were then examined under the microscope at low magnification. For the trichogram study, an area of 1 cm was plucked with forceps in the direction of the hair growth

and placed in a drop of mineral oil on a slide. In the present study, flea and/or food allergy presents as a concurrent problem in some cats, and some others could not be ruled out owing to owner compliance issues.

Mycological examination

All cats with suspected skin lesions of dermatophytosis were closely examined including observation and palpation of the skin for any kind of primary and/or secondary skin lesions. Hair samples were collected according to clinical signs and with the help of Wood's lamp examination. The method of hair sampling was chosen according to clinical signs and was either by the toothbrush technique when lesions were generalized or by using hair pluck of the margins of localized lesions (Moriello et al, 2017). All samples were examined for fungal elements under a light microscope at 40 x magnification using 20% potassium hydroxide (KOH) / dimethyl sulfoxide (DMSO) (Merck Co., Darmstadt, Germany). All samples were also inoculated onto Mycosel agar (Merck Co., Darmstadt, Germany). The plates were incubated at 27˚C and examined daily for four weeks. Dermatophyte isolates were identified by colony morphology and microscopic examination with lactophenol cotton blue preparation.

Collection of blood and serum samples

Blood samples were obtained by jugular or cephalic venipuncture from each cat. Five ml of blood without anticoagulant was centrifuged at 1800 g for 10 mins. Serum was collected and stored at −20°C until analysis.

FeLV and FIV examination

All cats selected to this study were tested for FIV and FeLV with ELISA (SensPERT FIV/FeLV Rapid Test; VetAll Laboratories), which detects the presence of the FeLV p27-antigen (with a sensitivity of 98.6% and specificity of 98.2%) and FIV antibodies (with a sensitivity of 93.5% and specificity of 100%).

2.5. Measurement of serum trace elements

Serum levels of copper, iron, zinc and selenium were measured by commercial kits (Pars Azmoon, Iran for iron; Giesse Diagnostics, Italy for zinc; EliTech diagnostics, France for copper) using an autoanalyser (Biotecnica, Targa 3000, Rome, Italy). Selenium concentration was determined using atomic absorption spectrophotometry (Perkin Elmer 3030, USA). Control serum (Randox control sera, Antrim, UK) was used for controlling measurement accuracy.

2.6. Measurement of oxidant/antioxidants

2.6.1. Malondialdehyde (MDA)

The concentration of MDA in serum was determined as thiobarbituric acid reactive substances according to Placer *et al*. (1966). The method is dependent on forming a color complex between MDA and thiobarbituric acid (TBA). Briefly, 0.2 ml of serum was added to 1.3 ml of 0.2 mol/l tris, 0.16 mol/l KCl buffer (pH 7.4). TBA (1.5 ml) was added and the mixture was heated in a boiling water bath for 10 min. After cooling, 3 ml of pyridine–butanol (3:1, v/v) and 1 ml of 1 mol/l NaOH were added. The absorbance was read at 548 nm against bidistilled water as a blank. The nmol of MDA per ml of serum was calculated using 1.56 x 105 as extinction coefficient.

2.6.2. Thiol groups

Total thiol groups of serum samples were measured based on a spectrophotometric assay using 2,2-dithiobisnitrobenzoic acid (DTNB or Ellman's reagent) (Hu, 1994). After adding tris buffer to serum sample, first absorbance was read at 412 nm (A1). Then DTNB was added and second absorbance at 412 nm was done (A2). The concentration of total thiol groups was calculated and expressed as mmol/l.

2.6.3. Total antioxidant capacity

The total antioxidant capacity of the serum sample was measured using ferric-reducing ability of plasma (FRAP) assay (Boligon et al., (2014), which depends upon the reduction of ferric tripyridyltriazine (Fe(III)-TPTZ) complex to the ferrous tripyridyltriazine (Fe(II)-TPTZ) by a

reductant at low pH. Fe (II)-TPTZ has an intensive blue color and can be monitored at 593 nm. The FRAP values were determined by extrapolation from the standard curve and were expressed in mmol/l.

Statistical analysis

All the statistical analysis was processed using statistical program of Social Science (SPSS) for windows, Version 26. Values of the measured parameters were expressed as mean value ± SD. After testing data for normal distribution, difference between the groups was determined by using one-way analysis of variance (ANOVA). Significance was considered at $P<0.05$. Bonferroni test was used for comparison between groups.

Results

3.1. Demographic characteristics

Study participants included Persian cats living exclusively in domestic environments and fed mostly commercial dry food. Sex and age of all 25 studied cats are summarized in Table 1.

3.2. Dermatological manifestations

Of the 13 dermatophyte-positive cases, all were positive for fungal elements by direct microscopic examination and culture-positive. According to the culture results, *M canis* was the only dermatophyte species isolated from the cats. *M canis* produces a yellow-greenish

fluorescence in hair, in addition to small ectothrix spores. Its colonies are white to buff in color with a characteristic yellow to orange-brown reverse. The macroaleuriospores are numerous, spindle shaped, with thick walls and 6–15 cells; the microaleuriospores are rare, small, clavate to elongate, and single-celled (Carter, 1990).

In the present study, 77% of dermatophytosis-positive cats had dermatological manifestations, which included one or more irregular or annular areas of alopecia, scaling, crusting, erythema, ringworm lesions, diffused dermatitis, 'stud tail' and conjunctivitis. All 13 dermatophyte-positive cats were wood-positive.

The affected regions based on fungal culture results were: The head and neck 41% (9/13), limbs 27% (6/13), dorsal midline and tail 18% (4/13) and the abdomen 14% (3/13). On the head, mainly the areas around the eyes, mouth, nose and ears were involved. In comparison to hindlimbs, the forelimbs were affected most often (5 out of 6 affected limbs). Overall, most of the infected cats revealed the generalised distribution pattern of the disease.

Among six cats with different skin conditions (dermatophyte-negative cats) were feline acne (2/6), food hypersensitivity (1/6), moderate facial and otic pruritus due to otodectic mange (2/6) and traumatic alopecia (1/6).

3.3. Trace elements

The level of serum copper was higher in cats with other skin diseases (2.31 ± 0.7 ppm) than those of healthy controls (1.48 ± 0.7 ppm)(P<0.05). No differences were detected for serum trace elements between dermatophytosis-affected cats and healthy control group (Tables 2).

3.4. Oxidant/antioxidant parameters

A significant decrease in total antioxidant capacity (measured by using ferric-reducing ability of plasma (FRAP) assay) was detected in cats with dermatophytosis (120.31 ± 33.7) and other skin diseases (94.54 ± 37.8) in comparison with healthy cats (187.06 ± 47) (P<0.01; Table 3).

Discussion

Dermatophytosis is an important disease of the skin in small animals, and has a high prevalence in Persian cats in particular. It is a zoonotic disease with a public health impact, causing skin infections that can be contagious, chronic, and significantly affect the quality of life for those affected (Shokri and Khosravi, 2016; Moriello, 2019; Gordon et al., 2020; Khodadadi et al., 2021). Among immunocompetent hosts, dermatophytosis is a self-limiting skin disease within weeks to months (Moriello and Coyner, 2021). An important step towards preventing this disease and improving treatment is identifying factors that influence its occurrence.

Previous studies identified *M canis* as the predominant dermatophyte isolate in affected cats (Moriello, 2019; Katiraee *et al*., 2021; Cafarchia *et al*., 2013; Lavari *et al*., 2022). Our results are

consistent with previous research, in which *M canis* was the only fungal species identified in cats with dermatophytosis.

Dermatophytes have been shown to possess multiple enzymatic properties, which can vary according to the strain of fungus. The keratinase secreted from *M canis* may be associated with more inflammation and pruritus (Dahl, 1994). This inflammatory reaction can cause extreme amounts of reactive oxidants, which can cause oxidative stress (Beigh *et al*., 2014). Trace elements have been reported to be required for the activity of several enzymes, including antioxidant enzymes (Chow; 2019). Although trace element status and antioxidant imbalance in feline dermatophytosis has not been studied, similar research have investigated a variety of infectious and inflammatory skin disorders in other animals, including canine dermatophytosis (Beigh *et al*., 2014; Ural *et al*., 2009; Nafie *et al*., 2021), sarcoptic mange (Beigh *et al*., 2016), demodicosis (Dimri et al., 2008) and bovine dermatophytosis (Al-Qudah et al., 2010; Nisbet et al., 2006; Pasa and Kiral, 2009).

Oxidative stress is caused by excessive production of free radicals, inadequate antioxidants, or a combination of both. It can contribute to the pathogenesis of various infectious, inflammatory and degenerative diseases including skin disorders (Al-Qudah *et al*., 2010; Beigh *et al*., 2014; Beigh *et al*., 2016; Dimri *et al*., 2008; Saleh *et al*., 2011). Our study indicated that cats with skin

diseases including dermatophytosis were found in a state of significant oxidative stress, as indicated by reduced total antioxidant capacity compared with healthy controls. The observed decrease in total antioxidant capacity in cats with dermatophytosis and other skin disorders might be related to the overconsumption of antioxidants during the infestation. Due to this insufficient antioxidant capacity, excess free radicals can damage cellular compounds such as lipids, proteins and DNA (Halliwell, 1999).

Previous studies conducted on dogs and calves also found alterations in oxidant/antioxidant balance in animals with dermatophytosis (Al-Qudah et al., 2010; Beigh et al., 2014) and in diabetic rats (Shahsavari *et al*., 2023). In 2014, Beigh *et al*. reported a decrease in the activities of superoxide dismutase (SOD) and catalase and an increase in MDA levels in dermatophytosis-affected dogs. The results from this study, however, did not report association between reduced glutathione and MDA levels with dermatophytosis in cats. Several authors have demonstrated an exhausted antioxidant system in other skin diseases in dogs, including sarcoptic mange (Beigh *et al*., 2016) and demodicosis (Dimri et al., 2008). Nevertheless, their possible role in feline skin diseases has not been studied yet.

Trace minerals are essential components in the living organisms. They are now recognized as being essential to health and play a vital role in antioxidant defense (Evans and Halliwell, 2001).

Deficit of trace elements may lead to dermatophytosis in cats by suppressing their immune system and lowering the activity of antioxidant enzymes containing copper, zinc, iron and selenium as cofactors. There are many studies in the literature that show the relationship between the level of micronutrients and pathogenicity of infectious and inflammatory skin diseases in dogs and calves (Al-Qudah *et al*., 2010; Beigh *et al*., 2014; Beigh *et al*., 2016; Dimri *et al*., 2008; Nisbet *et al*., 2006). In 2014, Beigh *et al*. observed lower concentration of copper and zinc and higher levels of iron in dermatophytosis affected dogs. In 2010, researchers studied trace elements copper, zinc and selenium in calves. They found that the levels of these elements in the blood of calves with dermatophytosis were lower than in healthy controls (Al-Qudah *et al*., 2010). Dogs suffering from demodicosis also indicated a reduction in zinc and copper concentrations (Dimri *et al*., 2008). However, the results of two other studies did not show a connection between zinc and copper concentrations and dermatophytosis in dogs (Ural et al., 2009; Nafie et al., 2021). Similarly, in the present study, no differences were detected for serum trace elements between dermatophytosis-affected cats and healthy control group.

According to the findings of this study, serum copper levels were higher in cats with other skin diseases compared with healthy controls ($P<0.05$). Both copper and zinc are cofactors of the SOD enzyme (Evans and Halliwell, 2001) and studies have shown that zinc and copper

concentrations correlate with SOD activity in both dermatophytosis and healthy dogs (Beigh, 2014; Nafie T, et al., 2021). Therefore, the increase in serum copper levels in feline dermatoses may be a consequence of a probable increase in superoxide dismutase activity.

Conclusion:

The present study found variations in oxidative indices in cats with dermatophytosis and other skin disorders. This finding may support the hypothesis that improvement of the antioxidant status through dietary supplementation may be beneficial in the prevention and resolution of skin diseases in cats. Nevertheless, in the current study trace minerals and oxidative stress indices in the skin were not investigated; which can be analyzed in further research. Future therapeutic trials are also needed to determine the role of minerals and antioxidants in treatment of dermatophytosis.

Conflict of interest: The authors declare that there is no conflict of interest with respect to the research, authorship and publication of this article.

Ethical approval: This work involved the use of non-experimental animals only (including owned or unowned animals). Established internationally recognized high standards ('best practice') of individual veterinary clinical patient care were followed. Ethical approval from a committee, while not necessarily required, was nonetheless obtained, as stated in the manuscript.

Informed consent: Informed consent (either verbal or written) was obtained from the owner or legal custodian of all animals described in this work for the procedures undertaken. No animals or humans are identifiable within this publication and therefore additional informed consent for publication was not required.

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مقایسه غلظت سرمی عناصر کمیاب و مقادیر اکسیدانی/آنتی اکسیدانی در گربه های دچار درماتوفیتوز با گربه های سالم و گربه های دچار سایر بیماری های جلدی

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چکیده

زمینهٔ مطالعه: به رغم شیوع بسیار درماتوفیتوز در گربه‌ها، اطلاعات کمی در خصوص اثر این بیماری بر مقادیر آنتی اکسیدانی و عناصر کمیاب در گربه‌های مبتلا وجود دارد.

هدف: مطالعهٔ حاضر با هدف بررسی غلظت عناصر کمیاب سرم (مس، آهن، روی و سلنیوم) و شاخص‌های اکسیدانی/آنتی اکسیدانی (مالون دی آلدئید، ظرفیت تام آنتی اکسیدانی و گروه تیول) در گربه‌های پرشین مبتلا به درماتوفیتوز و مقایسه آنها با گربه‌های مبتلا به سایر بیماری‌های جلدی و نیز گربه‌های سالم صورت پذیرفت.

روش کار: بدین منظور سه گروه از گربه‌ها انتخاب شدند: 13 گربهٔ مبتلا به درماتوفیتوز، 6 گربهٔ مبتلا به سایر بیماری‌های پوستی و 6 گربهٔ سالم. پس از معاینه فیزیکی همهٔ گربه‌ها، ارزیابی جامع درماتولوژیک و نمونه گیری برای آزمایش مستقیم میکروسکوپی و کشت قارچ صورت گرفت. همچنین، احتمال آلودگی همهٔ گربه‌ها با ویروس‌های FIV و FeLV بررسی شد.

نتایج: در گروه گربه‌های دچار درماتوفیتوز، تنها گونهٔ درماتوفیت جدا شده *میکروسپوروم کنیس* بود. در میان کل گربه‌های مورد مطالعه، تنها دو گربه (یکی از گربه‌های دچار درماتوفیتوز و یکی از گربه‌های مبتلا به سایر بیماری‌های پوست و مو)، FIV مثبت بودند. هیچگونه تفاوتی در مقادیر سرمی عناصر کمیاب بین گربه‌های مبتلا به درماتوفیتوز و گربه‌های سالم وجود نداشت. با این حال، مقدار سرمی مس در گروه گربه‌های مبتلا به سایر بیماری‌های جلدی در مقایسه با گروه سالم، بالاتر بود ($P<0.05$). گربه‌های دچار درماتوفیتوز و گربه‌های مبتلا به سایر بیماری‌های جلدی، در قیاس با گربه‌های سالم، دارای کاهش ظرفیت آنتی‌اکسیدانی کل بودند ($P<0.01$).

نتیجه‌گیری نهایی: مطالعهٔ حاضر تغییراتی را در شاخص‌های اکسیداتیو در گربه‌های مبتلا به درماتوفیتوز و سایر اختلالات پوستی نشان داد. این یافته ها ممکن است از این فرضیه حمایت کند که بهبود وضعیت آنتی اکسیدانی با افزودن مکمل‌های غذایی به رژیم غذایی گربه‌ها، ممکن است در پیشگیری و رفع بیماری های پوستی آنها مفید باشد.

واژه‌های کلیدی: درماتولوژی؛ آنتی اکسیدان؛ گربه؛ عناصر کمیاب؛ اختلالات درماتولوژیک

Table 1

Sex and age of all 25 studied cats

parameters	Dermatophytosis group	Other skin diseases group	Control group
Sex	4 males, 7 females	1 male, 5 females	4 males, 2 females
Age (mean ± SD, months)	7.5 ± 6	46.5 ± 42	38.5 ±32.6

Table 2

Serum trace minerals profile in cats affected with dermatophytosis, other skin diseases, and healthy control (Mean ± SD).

parameters	Dermatophytosis	Other skin diseases	Control group

	group	group	
Copper (ppm)	1.26 ± 0.38[a]	2.31 ± 0.7[b]	1.48 ± 0.7[a]
Zinc (ppm)	0.92 ± 0.4	1.4 ± 0.6	1.39 ± 0.9
Iron (ppm)	15.34 ± 11.8	14.46 ± 9.5	18.93 ± 12.5
Selenium (ppm)	0.38 ± 0.1	0.44 ± 0.1	0.39 ± 0.1

Values having different superscripts along the column differ significantly (P<0.05).

Table 3

Oxidative stress parameters in cats affected with dermatophytosis, other skin diseases, and healthy control (Mean ± SD).

parameters	Dermatophytosis group	Other skin diseases group	Control group
FRAP (mmol/l)	120.31 ± 33.7[a]	94.54 ± 37.8[a]	187.06 ± 47[b]
MDA (mmol/l)	0.8 ± 0.1	0.75 ± 0.1	0.88 ± 0.1
Total thiol groups (mmol/l)	1.44 ± 0.6	1.13 ± 0.5	1.48 ± 0.7

Values having different superscripts along the column differ significantly (P<0.01).
FRAP, ferric reducing ability of plasma; MDA, malondialdehyde.