

ECTOPARASITICIDAL EFFECT OF VIRGIN COCONUT (*Cocos nucifera*) OIL SHAMPOO IN DOGS

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ABSTRACT

This study was conducted with the following objectives: a) to determine the efficacy of VCO shampoo against ectoparasites in dogs; b) to determine the most effective concentration of VCO shampoo against ectoparasites in dogs; c) to identify the species of ectoparasites affected by VCO shampoo; and d) to analyze the cost of producing VCO shampoo as compared with the commercial ectoparasiticide dog shampoo.

A total of 60 dogs (30 dogs for ticks, lice and fleas and 30 dogs for mites), regardless of sex, age and breed were used in the study. The experimental dogs were distributed into five treatments and replicated three times with two dogs per replicate using Complete Randomized Design (CRD) for ticks, lice and fleas and Randomized Complete Block Design for mites. The treatments were as follows: T₀.negative control(plain shampoo); T₀₊. positive control (commercial dog shampoo); T₁ (60% VCO shampoo); T₂ (70% VCO shampoo); T₃ (80% VCO shampoo).

Prior to treatment, collection and identification of ectoparasites were done to determine the presence of ticks, fleas and lice. Skin scraping samples were taken to determine the species of mite present, and the mean pre-treatment mite count.

The experimental dogs were observed an hour and 24 hours after the application of VCO shampoo to determine the presence or absence of ticks, fleas and lice. Post-treatment mite count was done every after 2 weeks of application. The data gathered were tabulated using means and percentages. The Duncan's Multiple Range Test (DMRT) and Analysis of Variance (ANOVA) were used to determine the level of significance and the differences among the five treatments respectively.

The result of the study revealed that VCO shampoo is highly effective against ticks, fleas, lice and mites in dogs. Eighty percent (80%) VCO shampoo is the most effective concentration in eliminating and reducing the mite count as early as 6th week of treatment and other ectoparasites. However, Analysis of Variance revealed no significant difference among the various VCO shampoo concentrations in eliminating the ectoparasites. Virgin Coconut Oil shampoo is more economical compared to commercial dog shampoo against ectoparasites (ticks, fleas, lice and mites) in dogs.

INTRODUCTION

The use of medicinal plants or herbs has been gaining popularity these past few years in the Philippines and worldwide as more clinical proof emerges that validates many of the age-old alternative medicines used by Filipino folks that has been passed on from generation to generation.

Herbal medicine is the use of plant's seed, berries, roots, leaves, bark and flowers. Herbal plants are fit for this medicinal purpose. In the Philippines, there are thousands of herbal plants that folklore has attributed medicinal benefits. Studies in search for scientific validity involved only a handful of them. As of now, there are 360 species in the List of Philippine Herbal Medicinal Plants Site and coconut is one of them (<http://www.herbalmedicine.philsite.net>).

Coconuts are the largest seed known. Early Spanish explorers called it *coco*, which means "monkey face" because the three indentations or eyes on the hairy nut resemble the head and face of a monkey. Coconuts are the fruit of the coconut palm, botanically known as *Cocos nucifera*, with *nucifera* meaning "nut-bearing".

Virgin coconut oil (VCO) is one of the products derived from the coconut meat. It is the natural oil obtained from fresh mature kernel of the coconut by mechanical extraction.

Virgin coconut oil is now getting global reputation as the healthiest and most versatile oil in the world. The Philippines is one of the best sources of virgin coconut oil and its popularity in the country is legendary.

Virgin coconut oil and regular coconut oil is rich in lauric acid, an essential fatty acid that is only found in high concentrations in mother's milk which supports the body's immune system. When taken internally, lauric acid turns into a compound known as monolaurin. It is a compound that is believed to fight viral pathogens, protects the body from bacteria, and infections from parasites of dogs.

History suggests that the dog was one of the earliest of tamed animals, having lived in close with humans for about 10,000 years. Following domestication, dogs were selectively bred for specific purposes other than as pets. Keen senses of hearing and smell have made dogs valuable in hunting and tracking and for guard, security, and search purposes. Dogs also herd livestock and serve as guide dogs for the blind, as sled dogs, and as racing dogs. Their positive effect on people is well proven; they have been used in programs for treating the mentally ill (<http://library.thinkquest.org/J002692/dog.html>). In gratitude, man in turn is endowed with a responsibility to protect them from diseases that take advantage of their health and well-being as well.

One of the most bothering problems of dogs is ectoparasitic infestation caused by mange mites, fleas, lice and ticks. Ectoparasite infestation affects the health of the host animal in several ways. Dogs may be so preoccupied with the itching and irritations caused by ectoparasites that feeding becomes irregular and, consequently, the host dog may lose weight or growth is delayed. Such "parasite worry" is a problem in almost all infestations. Animals may become emaciated and susceptible to various illnesses, such as bacterial and viral diseases. Heavy infestations can cause serious blood loss. Perhaps

the most serious aspect of ectoparasite infestation is the ability of some ectoparasites to transmit other serious diseases, including canine thrombocytopenia, canine babesiosis, and Rocky Mountain spotted fever.

Arthropods damage their host in a variety of ways. Their feeding on the host's skin may cause intense itching, as in the case of mites. In scratching for relief, dogs damage the skin. The open wound that result from the scratching and/or the original arthropod bites allow bacteria present on the skin to infect the animal and cause disease. Damage by mites causes the skin disease called mange which is characterized by raw, thickened skin that has lost its hair.

Alternative medicine is the practice that consists of treatments or various healing systems not included in the standard medicinal curricula. This may include herbal medicine, which is the traditionally-based medical practice of using plants and plant extracts. Such practice is not part of conventional veterinary training. However, the use of herbal plants in veterinary medicine is gaining attention. In connection, this study will be conducted to determine and validate the efficacy of virgin coconut oil extract in the treatment and control of external parasites in dogs.

Researches has proven a variety of clinical uses of virgin coconut oil in man such as astringent, antimicrobial, antiviral, antiprotozoal, antiparasitic, skin moisturizer and many more. This study aims to prove its medicinal value in animals. Favorable results will ultimately address less expensive, easy to prepare and readily available medicines for veterinary use in the country side.

Objectives of the Study

The study was conducted with the following objectives:

1. To determine the efficacy of VCO shampoo against ectoparasites in dogs;
2. To determine the most effective concentration of VCO shampoo against ectoparasites in dogs;
3. To identify the species of ectoparasites affected with VCO shampoo; and
4. To analyze the cost of producing VCO shampoo as compared with the commercial ectoparasitocidal dog shampoo.

METHODOLOGY

The Experimental Animals

A total of 60 dogs (30 dogs for ticks, lice and fleas; 30 dogs for mites) regardless of sex, age and breed were distributed into five treatments, replicated three times with two dogs per replicate using the Complete Randomized Design (CRD) for ticks, lice and fleas and Randomized Complete Block Design (RCBD) for mites.

The animals were classified into light, moderate and severe infestation. In light infestation, lesions are present on one region of the body; either on the head, thoracic, abdomen or limbs. In moderate infestation, lesions are present on two regions of the

body; either on the head and thoracic region or head and abdomen or the abdomen and thoracic region. In severe infestation, describes a generalized infestation; lesions are present on the head, thorax, abdomen and/or the limb region.

The animals were properly labeled based on the treatment applied. The following treatments were used:

- T₀- plain shampoo
- T₀₊ – commercial dog shampoo (Amitraz)
- T₁ – 60% VCO shampoo
- T₂ – 70 % VCO shampoo
- T₃ – 80% VCO shampoo

Collection and Identification of Parasites

The lice, fleas and ticks were collected from the different parts of the body by hand picking or with the use of forceps. The collected ectoparasites were placed in properly labeled vials containing 10 percent formalin as preservative prior to identification. Identification was based on the anatomical features of the parasites with the aid of magnifying lens and microscope.

Skin Scraping Technique

Skin scrapings were performed prior to the application of the different treatments to identify and count the mites infesting the experimental animals.

Hairs were clipped to expose the skin lesions. Typically an area of 4 x 4 centimeters was prepared. Mineral oil was applied thinly over the sampling sites. Using a sterile surgical blade, the sampling area was scraped by holding the blade vertically and with a gentle sweeping motion, the area was scraped, covering as much as the clipped area as possible until slight capillary hemorrhage was evident. The scraped sample was spread evenly on a clean glass slide where a drop of mineral oil was previously placed. A cover slip was placed over the sample and was labeled according to treatment. The samples were examined under the microscope for positive identification of mange mites and were counted for pre-treatment mite count.

Skin scrapings were also taken at 2nd, 4th, 6th, 8th and 10th week post-treatment for mite count.

Preparation of Virgin Coconut Oil

Matured coconut was selected for the preparation of VCO. The coconut meat was grated and placed in a clean basin. With clean hands, the grated coconut meat was squeezed and a handful of the coconut mixture was placed on a cheese cloth and was wringed 2 to 5 times to separate the cream. The procedure was repeated for the rest of the coconut meat. The coconut cream was filtered and was allowed to stand for 24 hours to allow the oil to separate from the cream and fluid. The cream and oil were allowed to harden by placing it in the refrigerator for 3 to 4 hours. The liquid portion was

discarded and the remaining hardened cream and oil were placed on a cheese cloth and were hanged. The oil that drops from the cheese cloth were collected and filtered until the oil is clear.

Preparation of Shampoo

Preparation of Surfactant

The surfactant was prepared by dissolving 6 grams caustic potash to the desired amount of water to make a lye solution. The desired amount of oil was added to the lye solution slowly and carefully and stirred until the mixture become quite viscous. Once the mixture become viscous, it was covered and set aside overnight.

Preparation of Plain Shampoo

Plain shampoo was made by adding the surfactant to the thickener and stirred. After which ten milliliters of diluent was added to the mixture and was gently stirred. Sixty milliliters palm oil was added to the mixture and stirred again until it turned into a homogenous solution. The pH was adjusted by using buffer. The mixture was poured into the container and was allowed to cure for a week.

Preparation of VCO Shampoo

The desired amount of VCO was then added to the plain shampoo and stirred again until it turns into a homogenous solution. Finally the mixture was dispensed into the containers and cured for one week.

Preparation of Dog Cages

Prior to application of VCO shampoo to dogs to be treated for ticks, lice and fleas, the cages and the surroundings were scrubbed with soap and water to ensure that the area was free of ticks, lice and fleas. The cage was wiped dry and sprayed with insecticide including the surroundings to make sure that no reinfestation will occur during the observation period.

Application of VCO Shampoo

The experimental dogs were bathed with tap water and detergent soap to remove the dirt. The VCO shampoo was lathered throughout the body of the animal for five minutes. The lather was allowed to remain in the coat for at least 15 minutes before it was rinsed. The dogs were placed in a big basin before rinsing in order to collect the rinse. The rinse was strained to collect the parasites and was examined to confirm the death of the parasites. Results were recorded at an hour and 24 hours after the application of the treatments.

In case of mites, same procedure was followed in the application of VCO giving emphasis on the affected area. The dogs were observed at one hour after application. The animals were bathed two times weekly for eight weeks.

Data Gathered

Species of Ectoparasites Present

Species of lice, ticks and fleas present. The types of ectoparasites were identified with the aid of magnifying lens based on their morphological features before treatment with VCO shampoo.

Species of mites present. The types of mites were identified based on morphological features by examining the skin scraping samples under the microscope before treatment with VCO shampoo.

Pre-treatment Mite Count. This was taken by counting the number of mites prior to first application of VCO shampoo divided by three, the number of sites of skin scraping.

Post-treatment Mite Count. This was taken by counting the number of mites at 2nd, 4th, 6th, 8th weeks of treatment, and two weeks after the last treatment with VCO shampoo. The total number of mites was divided by three, the number of sites of skin scraping.

Percent Efficacy of VCO shampoo

Percent efficacy of VCO shampoo against lice, ticks and fleas. This was determined by subtracting from the total the number of animals with ectoparasites pre-treatment the total number of animals without ectoparasites post-treatment divided by the total number of animals treated multiplied by 100.

Percent efficacy of VCO shampoo against mites. This was measured by subtracting the mean post-treatment mite count from the mean pre-treatment mite count divided by mean pre-treatment count multiplied by 100.

The efficacy of the VCO shampoo for mites was based on the standard criteria by Riek and Kieth (1975) which are the following:

- a. 81 – 100% reduction of the count is highly effective.
- b. 60 – 80% reduction of the count is effective.
- c. Less than 60% reduction of the count is ineffective.

Cost Analysis. This was determined by the total cost of production of the virgin coconut oil shampoo compared to the cost of commercial ectoparasiticide shampoo.

Other Observations

The experimental dogs were observed for 20 minutes after bathing with VCO shampoo to determine any reactions of the dogs to the VCO shampoo. Changes observed on the duration of the experiment were properly noted.

Statistical Analysis

The data gathered were tabulated using means and percentages. Analysis of Variance (ANOVA) was used to test the level of significance and Duncan's Multiple Range Test (DMRT) was used to determine the differences among the five treatments.

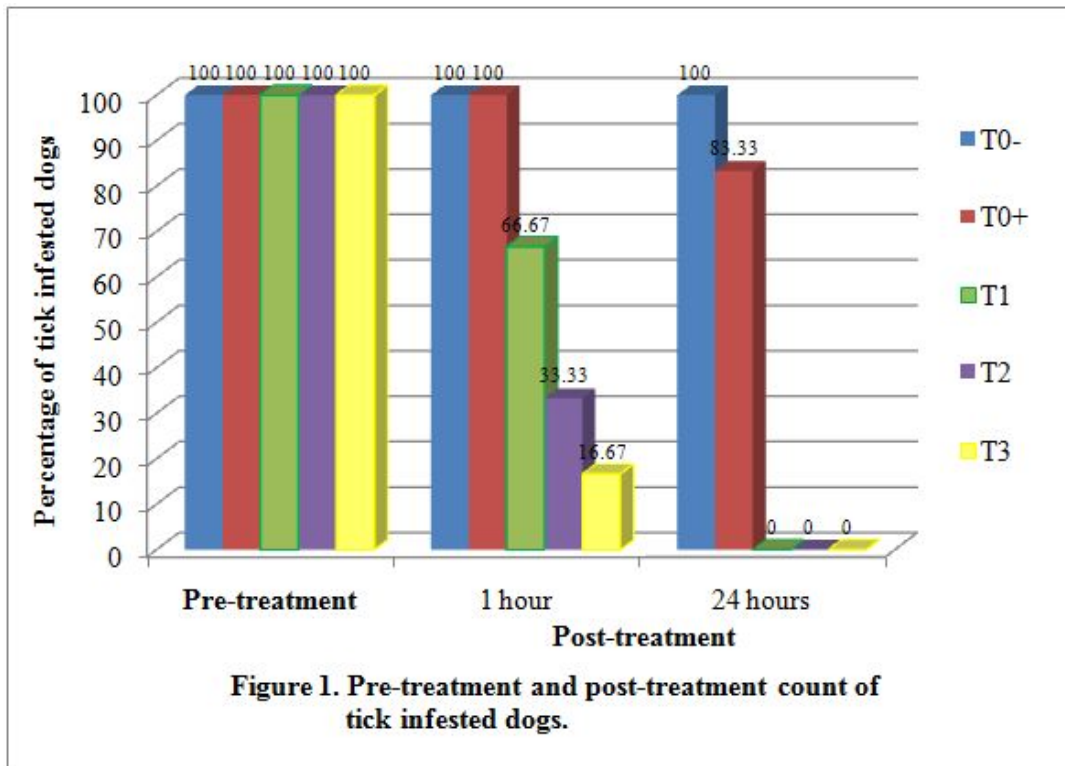
RESULTS AND DISCUSSION

Efficacy of VCO Shampoo Against Ectoparasites

Ticks. The efficacy of the various concentrations of VCO shampoo in reducing the tick infested dogs is shown in Figure 1. The percent decrease in dogs infested with ticks an hour and 24 hours post-treatment implies that VCO shampoo were effective in eliminating or killing ticks in dogs.

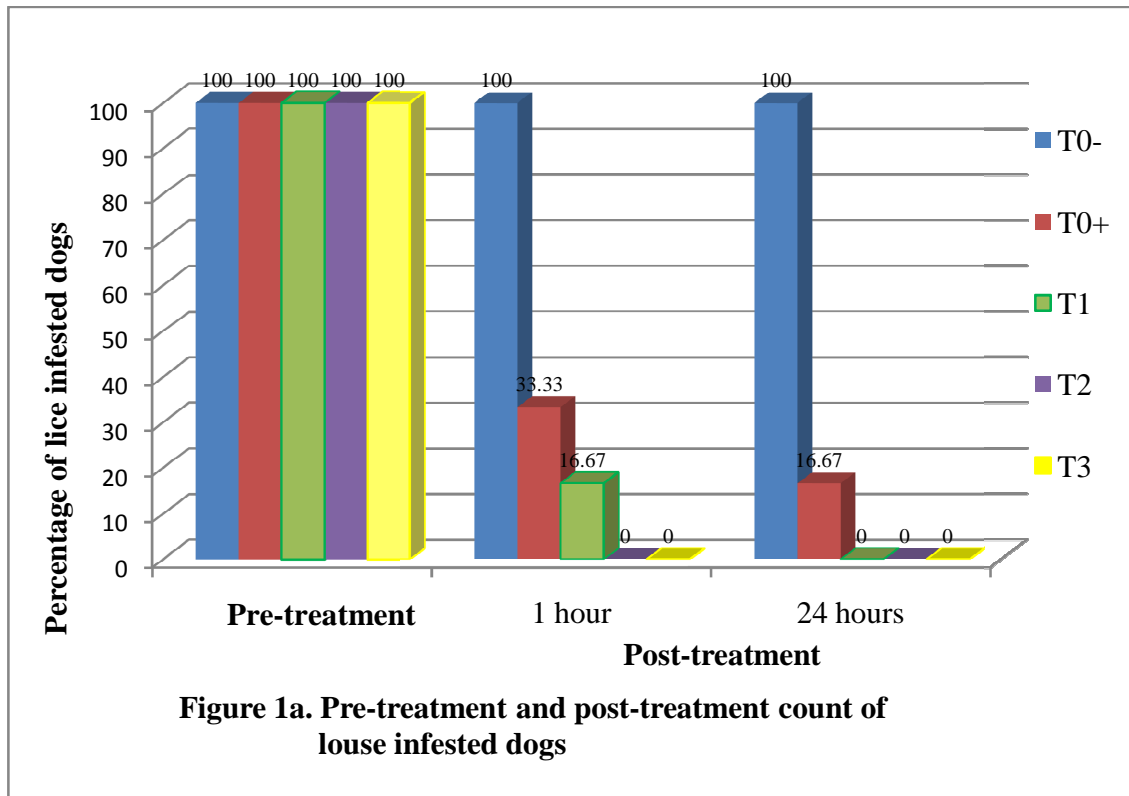
An hour post-treatment with plain shampoo (T_{0-}) and commercial dog shampoo (T_{0+}), 100% of the treated dogs remained infested with ticks while the dogs treated with VCO shampoo decreased to 66.67%, 33.33% and 16.67% for 60% (T_1), 70% (T_2) and 80% (T_3) VCO shampoo, respectively. This means that an hour post-treatment, the different concentrations of VCO shampoo were effective at varying degrees while commercial dog shampoo (T_{0+}) and plain shampoo (T_{0-}) were ineffective against ticks.

At 24 hours post-treatment, the plain shampoo (T_{0-}) remained ineffective against ticks as it did not reduce (100%) the number of tick infested dogs while the commercial dog shampoo (T_{0+}) decreased from 100% to 83.33%. Virgin Coconut Oil further proved its efficacy as the different concentrations (60%, 70% and 80%) were all successful in eliminating the ticks (zero infestation) in all the experimental dogs 24 hours post-treatment. Results imply that VCO shampoo is 100% effective against ticks in dogs at 24 hours post-treatment which was far more effective than the commercial dog shampoo (T_{0+}) and more so with the plain shampoo (T_{0-}).



Lice. There was no decrease in the lice infested dogs treated with plain shampoo (T_{0-}) as shown in Figure 1a. Lice infested dogs treated with commercial dog shampoo (T_{0+}) decreased from 100% to 33.33% and 16.67% for 60% VCO shampoo. None of the dogs treated with 70% VCO shampoo (T_2) and 80% VCO shampoo (T_3) had lice an hour post-treatment. This means that all the dogs were lice free an hour post-treatment with 70% (T_2) and 80% (T_3) VCO shampoo indicating efficacy against lice in contrast to the commercial dog shampoo (T_{0+}) and plain shampoo (T_{0-}) that failed to reduce the number of infested dogs to zero.

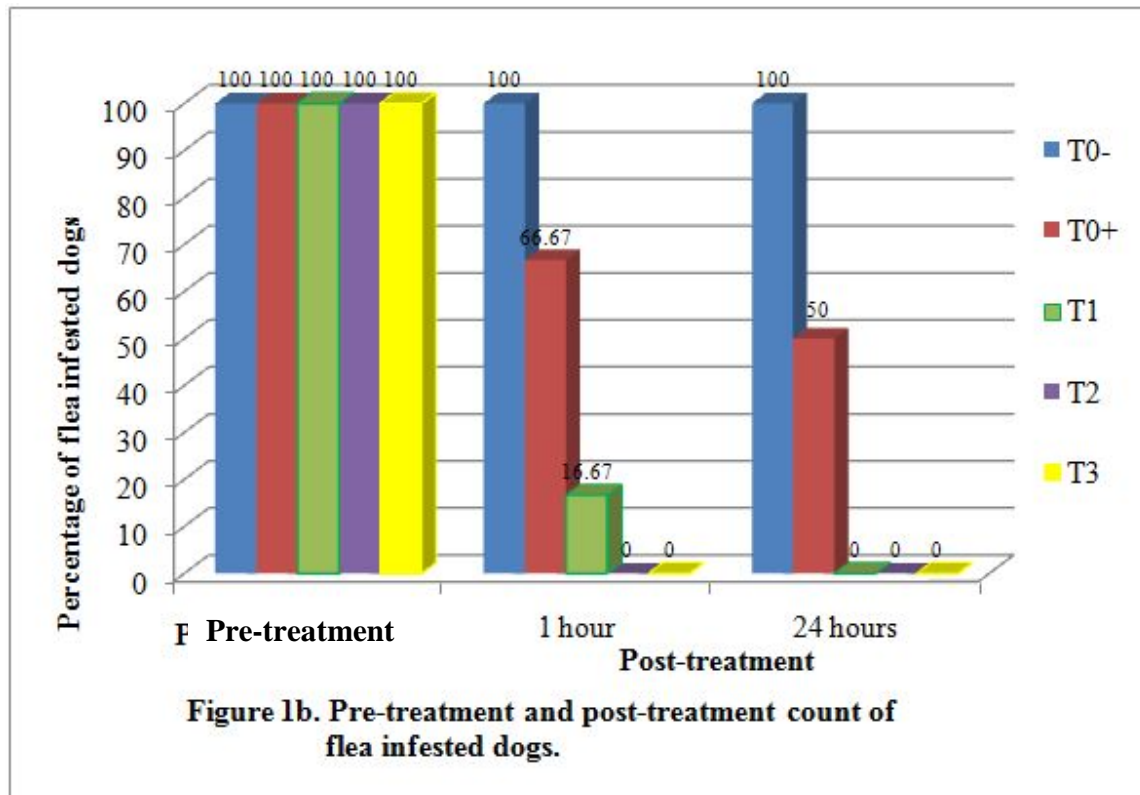
At 24 hours post-treatment, 16.67% of the experimental dogs treated with commercial dog shampoo (T_{0+}) were still infested with lice whereas all the dogs treated with 60% VCO shampoo (T_1) were lice free. On the other hand, those dogs treated with 70% VCO shampoo (T_2) and 80% VCO shampoo (T_3) remained lice free from an hour to 24 hour observation period. This indicates that the 60% VCO shampoo (T_1) was able to effectively reduce the number of dogs infested with lice by 100% 24 hours post-treatment, in contrast with the commercial dog shampoo (T_{0+}) which is less effective than the VCO shampoo and the plain shampoo (T_{0-}) which remained ineffective against lice.



Fleas. As shown in Figure 1b, one hour post-treatment the 70% VCO shampoo (T₂) and 80% VCO shampoo (T₃) decreased the number of flea infested dogs to zero percent while the 60% VCO shampoo (T₁) decreased from 100% to 16.67% as compared to 66.67% for commercial dog shampoo (T₀₊) and plain shampoo (T₀₋) which remained 100% infested. This indicates that 70% (T₂) and 80% (T₃) VCO shampoo were effective against fleas in contrast to the commercial dog shampoo (T₀₊) which were less effective than the VCO shampoo and the plain shampoo (T₀₋) which remained ineffective in reducing the flea infested dogs.

At 24 hours post-treatment with commercial dog shampoo (T₀₊), 50% of the experimental dogs were still infested with fleas as compared to those treated with 60% VCO shampoo (T₁) which reduced the infested dogs to zero percent. Dogs treated with 70% (T₂) and 80% (T₃) VCO shampoo remained flea free up to 24 hours observation. This implies that the 60% VCO shampoo (T₁) is effective against fleas while the commercial dog shampoo (T₀₊) and the plain shampoo (T₀₋) remained ineffective against fleas at 24 hours post-treatment.

Results indicate that the various concentrations of VCO shampoo (60%, 70% and 80%) used were effective in killing ticks, lice and fleas while the commercial and plain shampoo failed to match the effect of VCO shampoo on all the species of ectoparasites subjected to the various treatments. It is also essential to note that all the concentrations of the VCO shampoo acted at a faster rate and greater degree of effectiveness than the commercial dog shampoo (T₀₊) and plain shampoo (T₀₋).



The efficacy of VCO on ectoparasites could be attributed to two medium chain fatty acids present. First, is the myristic acid which is used as a treatment against external parasites especially lice and fleas. Myristic acid works by dissolving the wax that covers the exoskeleton of the parasites, killing them by dehydration (http://www.answers.com/topic/myristic_parasites). It acts hand in hand with caprylic acid by dissolving the cell membrane causing changes in fluidity and permeability that lead to disaggregation as postulated by Fife (2001). He further claimed that the principal components of VCO have no undesirable or harmful side effects, unlike drugs.

Moreover, result could also be attributed to the VCO's major constituent, lauric acid and its derivative monolaurin. Monolaurin is the main active composition that makes the VCO an effective agent in killing the ectoparasites of dogs by deeply penetrating into the skin (Kabara, 2004). It dissolves the lipid envelope that protects most pathogenic bacteria and viruses and attacks pathogenic yeast and parasites (Mercola, 2006).

Mange Mites. Likewise, the VCO shampoo proved its efficacy as ectoparasiticide. As shown in Table 2, the mite counts decreased every after two weeks treatment with VCO shampoo. The decrease in mite count indicates the efficacy of VCO shampoo in reducing mange mites of dogs.

Washing with plain shampoo (T₀) resulted in a decrease in the number of mites from 34.11 to 26.72 with a mite count difference of 6.66 10 weeks post-treatment. The slight difference could be due to the 60% vegetable oil present in the shampoo.

Treatment with commercial dog shampoo (T_{0+}) decreased mite count from 36.22 to 0 with mite count difference of 36.22 on the 10th week of observation, while treatment with 60% VCO shampoo (T_1) decreased mite count from 45.72 to 0.11 with total mite count difference of 45.61. Treatments with 70% VCO shampoo (T_2) and 80% VCO shampoo (T_3) decreased mite count from 51.67 to zero and 48.11 to zero on the 6th and 8th week of treatment respectively. It can be gleaned from Table 2 that 80% VCO shampoo (T_3) did not only lower the mite count but totally eliminated earlier than commercial shampoo (T_{0+}).

Results imply that all animals subjected to the different concentrations of VCO shampoo responded favorably to the treatment which is similar to the commercial dog shampoo, however at a faster rate than its commercial counterpart. This coincides with the findings of Mamauag (2007) that 70% VCO soap was effective for the treatment of mange in dogs.

Table 2. Mean pre-treatment and post-treatment mite count of dogs.

Treatment	Percent Efficacy						Mite count difference
	Pre-treatment	Post-treatment (Week)					
		2 nd	4 th	6 th	8 th	10 th	
T_{0-}	34.11	33.67 bc	32.11 a	30.67 a	28.67 a	27.45 a	6.66
T_{0+}	36.22	32.50 c	23.39 b	14.33 b	3.83 b	0.00 b	36.22
T_1	45.72	40.56 a	29.78 b	21.06 c	3.39 b	0.11 b	45.61
T_2	51.67	40.11 ab	26.06 b	9.95 d	0.22 c	0.00 b	51.67
T_3	48.11	38.33 abc	20.33 b	0.00 e	0.00 c	0.00 b	48.11

*All means followed by the same letter are not significantly different at 0.01 level, DMRT.

The advantage of VCO over other anti-mange preparations aside from destroying the mites, is the presence of lauric acid which is an antimicrobial fatty acid (Mercola, 2006). This inhibits growth of bacteria which is essential in facilitating healing of wounds inflicted by mites (Cueva, 2007). Triclosan which is an anti-bacterial beta (β) monoglyceride (MG) present in VCO was shown to be effective in reducing and controlling bacterial contamination. It acts as biocide, with multiple cytoplasmic and membrane target bacteria mainly by inhibiting fatty acid synthesis (http://www.pcarrd.dost.gov.ph/nestdetail_farmnews_biotech).

Further, the emollient, lubricant, exfoliant and anti-itch (Fife, 2001) effect of the essential fatty acids present in VCO such as caproic acid, myristic acid, oleic acid, linoleic acid and stearic acid, moisturizes and softens the skin to aid the removal of crust and scab to expose the deeper layers of the skin where mange mites hide, to effect greater degree of efficacy.

Further, Carandang (2007) points to linoleic acid's affective properties when applied topically on the skin, i.e. anti-inflammatory, moisture retention. These fatty acids complement with the action of potassium hydroxide (KOH) in cleaning the surface of the skin to get rid of the dead skin to enhance healing.

Moreover, the small molecular structure of the coconut oil which allows easy absorption through the skin gave added points to the faster effect of VCO.

Effective Concentration of VCO Shampoo Against Ectoparasites in Dogs

Ticks, Lice and Fleas. The effect of the various concentrations of VCO shampoo against ectoparasites in dogs is shown in Table 3. It can be gleaned from the table that 80% VCO shampoo (T₃) registered the highest percent (83.33%) reduction in the number of dogs free of ticks an hour post-treatment followed by 70% VCO shampoo (T₂) with 66.67% and 60% VCO shampoo (T₁) with 33.33%. None among the commercial dog shampoo (T₀₊) and plain shampoo (T₀₋) treated dogs were free of ticks an hour post-treatment.

Comparison among treatments using ANOVA revealed that an hour post-treatment 80% VCO shampoo (T₃) recorded the highest percent efficacy which is significantly different from 70% VCO shampoo (T₂) and 60% VCO shampoo (T₁). This means that 80% VCO shampoo (T₃) is the most effective concentration in eliminating ticks an hour post-treatment.

However, at 24 hours post-treatment with VCO shampoo, all the concentrations (60%, 70% and 80%) registered 100% efficacy against ticks in contrast to the commercial dog shampoo (T₀₊) which showed a low efficacy of 16.67%.

Analysis of variance revealed that all the concentrations (60%, 70% and 80%) of VCO shampoo are comparable to each other but they are significantly different from those of commercial dog shampoo (T₀₊) and plain shampoo (T₀₋). This implies that all the VCO concentrations at 24 hours post-treatment are equally effective against ticks as compared to the commercial dog shampoo (T₀₊) and plain shampoo (T₀₋).

Table 3. Mean percent efficacy of VCO shampoo against ectoparasites

Treatment	Ectoparasites					
	Ticks		Lice		Fleas	
	1 hour	24 hours	1 hour	24 hours	1 hour	24 hours

T ₀₋	0 a	0 a	0 a	0 a	0 a	0 a
T ₀₊	0 a	16.67 b	33.33 b	50 b	33.33 b	83.33 b
T ₁	33.33 b	100 c	16.67 c	100 c	83.33 c	100 b
T ₂	66.67 c	100 c	100 d	100 c	100 c	100 b
T ₃	83.33 d	100 c	100 d	100 c	100 c	100 b

*All means followed by the same letter are not significantly different 0.01 level, DMRT.

Table 3 also shows that an hour post-treatment, 70% (T₂) and 80% (T₃) VCO shampoo had the highest percent efficacy of 100% against lice and fleas followed by commercial dog shampoo (T₀₊) with 33.33% efficacy. The lowest concentration of VCO (60%) registered percent efficacy of 16.67% against lice and 83.33% against fleas.

Comparison among treatment using ANOVA revealed that the higher concentrations of VCO shampoo (70% and 80%) gave comparable results at 1 hour post-treatment but differs significantly from commercial dog shampoo (T₀₊) and similarly with 60% VCO shampoo (T₁). This indicates that 70% VCO shampoo (T₂) and 80% VCO shampoo (T₃) are equally effective in killing lice as compared with commercial dog shampoo (T₀₊) and plain shampoo (T₀₋) an hour post-treatment.

Twenty-four hours post-treatment against lice and fleas, the different concentrations 60% (T₁), 70% (T₂) and 80% (T₃) VCO shampoo recorded 100% efficacy. Commercial dog shampoo (T₀₊) had lesser efficacy of 50% for lice and 83.33% for fleas.

Statistical analysis using ANOVA revealed that at 24 hours post-treatment, the different concentrations of VCO shampoo significantly differed from commercial dog shampoo and likewise with the plain shampoo (T₀₋). This means that all the concentrations of VCO shampoo are equally effective and superior over commercial dog shampoo (T₀₊) and plain shampoo (T₀₋) in eliminating lice and fleas. It is also worthy to mention that VCO shampoo out-shadowed the effect of commercial dog shampoo (T₀₊) in terms of pace and efficacy against lice and fleas.

In summary, all the concentrations of VCO shampoo were effective in eliminating ticks, lice and fleas, however 80%VCO shampoo (T₃) acts at a faster rate than the other concentrations. This proves the claim of Poutinen (2004) that VCO kills harmful bacteria, viruses, parasites, yeast and fungi. Enig (2000) also claimed that VCO expels or kills tapeworms, lice, giardia and other parasites.

Mange Mites. The percentage efficacy of VCO shampoo against mange mites in dogs based on mite count every two weeks of treatment is presented in Table 3a. It can be noted that as early as 4th week of treatment, 80% VCO shampoo (T₃) already proved its efficacy where it recorded 61.58% reduction in mite count which is higher than the commercial shampoo (T₀₊). On the 6th week of treatment it registered 100% efficacy and maintained it till the 10th week of observation. It was able to effectively eliminate both Sarcoptic and Demodectic mites (Table 3a). This was followed by 70% VCO shampoo (T₂) with 83.82% reduction on the 6th week to 99.17% on the 8th week and

100% on the 10th week of treatment. Similarly, it also killed both Sarcoptic and Demodectic mites effectively at a slower pace. Sixty percent VCO shampoo (T₁), however registered the lowest percent efficacy of 89.20% on the 8th week to 98.68% on the 10th week of observation. It failed to kill *Demodex spp.* however, based on the trend of its efficacy, had the treatment been extended it could have possibly reduced the mite count to zero.

As to the mean percent efficacy of VCO shampoo ANOVA revealed that the different concentrations of VCO shampoo (60%, 70% and 80%) did not differ from the commercial dog shampoo (T₀₊) but they differ with plain shampoo (T₀₋) on the second week of treatment. This means that the efficacy of VCO shampoo is similar to the commercial dog shampoo (T₀₊) despite the variation in numerical value.

On the 4th week of treatment, comparison of means showed that the 80% VCO shampoo (T₃) is significantly different from the rest of the treatments. This indicates that the 80% VCO shampoo (T₃) with percent efficacy of 61.58% is the most effective concentration on the 4th week of treatment. It has been rated effective based on the standard criteria of Riek and Keith.

Comparison among treatment means on the 6th week of treatment further proved the superior effect of VCO shampoo where the 70% (T₂) and 80% (T₃) VCO shampoo were significantly different from the other treatments with 83.82% and 100% efficacy respectively. This means that the 70% (T₂) and 80% (T₃) VCO shampoo surpassed the effect of all the other treatments and thus considered the most effective concentration. Both concentrations were highly effective at 6th week of treatment as compared with the commercial dog shampoo (T₀₊) and plain shampoo (T₀₋) which was found ineffective based on the standard criteria of Riek and Keith. The 80% VCO shampoo (T₃) had the highest percent efficacy of 100% and was able to eliminate both Sarcoptic and Demodectic mange (Table 3a) as early as the 6th week of treatment.

Analysis of variance on the 8th week of treatment revealed that the 70% (T₂) and 80% (T₃) VCO shampoo are significantly different from 60% VCO shampoo (T₁) and commercial dog shampoo (T₀₊) which also differed significantly from the plain shampoo (T₀₋). Results indicate that the 70% (T₂) and 80% (T₃) VCO shampoo were the most effective concentrations of VCO on the 8th week of treatment against mites. The 60% VCO shampoo (T₁) is comparable with the commercial dog shampoo (T₀₊) with efficacy of 89.20% and 85.70% which was rated highly effective against mites as compared to plain shampoo (T₀₋) with 11.06% efficacy which was rated ineffective based on the standard criteria of Riek and Keith.

Table 3a. Mean percent efficacy of VCO shampoo against mange mites in dogs

Treatment	Percent Efficacy				
	2 nd	4 th	6 th	8 th	10 th
T ₀₋ (plain shampoo)	-0.87 a	6.12 a	2.42 a	11.06 a	10.45 a

T ₀₊ (commercial shampoo)	14.06 b	33.00 b	43.28 b	85.70 b	100 b
T ₁ (60% VCO shampoo)	23.59 b	29.49 ab	29.49 c	89.20 b	98.68 b
T ₂ (70% VCO shampoo)	20.15 b	43.49 cb	83.82 d	99.17 d	100 b
T ₃ (80% VCO shampoo)	29.39 b	61.58 d	100 d	100 d	100 b

*All means followed by the same letter are not significantly different at 0.01 level, DMRT.

Finally, on the 10th week of treatment, analysis of variance revealed that all the concentration of VCO shampoo (60%, 70% and 80%) were not significantly different at 0.01 level of significance but differ significantly from the plain shampoo (T₀). Results indicate that at 10th weeks of treatment, VCO shampoo was as effective as the commercial dog shampoo (T₀₊) which was rated very effective based on the standard criteria of Riek and Keith. However, it is worthy to claim that the 80% VCO shampoo (T₃) is the most effective concentration against mites due to its unsurpassed effect as early as the 4th week of treatment and the 100% efficacy on the 6th week of treatment killing both Sarcoptic and Demodectic mange mites compared to the commercial dog shampoo (T₀₊) that attained 100% efficacy only on the 10th week of treatment.

Species of Ectoparasites Affected by VCO Shampoo

Ticks, Lice and Fleas. The ectoparasites infesting dogs collected and identified were two species each of ticks the *Rhipicephalussanguineus* and *Argaspersicus*; lice identified as *Trichodectuscanis* and *Linognathussetosus*; and fleas which are the *Ctenocephalidesfelis* and *Ctenocephalidescanis* (Table 4).

It can be noted that all the aforementioned species of ectoparasites were present in all the dogs in all the treatments from plain shampoo (T₀) to 80% VCO shampoo (T₃) prior to application of the different treatments. The plain shampoo (T₀) did not affect any of the species that infested the dogs in this treatment. The commercial dog shampoo (T₀₊) failed to eliminate the ticks, lice and fleas. The species recovered were a combination of all of the species identified.

Table 4. Species if ticks, lice and fleas affected by VCO shampoo

Treatment	Pre-treatment					Post-treatment						
	Ticks		Lice		Fleas	Ticks		Lice		Fleas		
	<i>R. sanguinues</i>	<i>A. persicus</i>	<i>T. canis</i>	<i>L. setosus</i>	<i>C. felis</i>	<i>C. canis</i>	<i>R. sanguinues</i>	<i>A. persicus</i>	<i>T. canis</i>	<i>L. setosus</i>	<i>C. felis</i>	<i>C. canis</i>

T ₀ ⁻	+	+	+	+	+	+	+	+	+	+	+	+
T ₀ ⁺	+	+	+	+	+	+	+/-	+/-	+/-	+/-	+/-	+/-
T ₁	+	+	+	+	+	+	-	-	-	-	-	-
T ₂	+	+	+	+	+	+	-	-	-	-	-	-
T ₃	+	+	+	+	+	+	-	-	-	-	-	-

Legend: - eliminated + not eliminated +/- not totally eliminated

The 60% VCO shampoo (T₁) eliminated majority of the species of ticks, lice and fleas (Table 4) however, at a slower pace than the higher concentrations of VCO shampoo. Only one species of tick the hard tick (*Rhipicephalus sanguineus*) was recovered in one dog 24 hours post-treatment (Figure 1).

The 70% (T₂) and 80% VCO shampoo (T₃) eliminated all the species of ticks, lice and fleas in all the dogs treated.

This proves that the VCO shampoo eliminated the ticks, lice and fleas, in all the concentrations. This further proves the superior anti-ectoparasitic effect of VCO shampoo over the commercial shampoo tested.

Mange Mites. The types of mite infesting the experimental dogs from plain shampoo (T₀⁻) to 80% VCO shampoo (T₃) were *Sarcoptes spp.* and *Demodex spp.* as shown in Table 4a.

It can be noted that the dogs in all the pre-treatment replications were infested with a combination of *Sarcoptes* and *Demodex spp.*

Post-treatment with plain shampoo (T₀⁻) revealed that both species of mites were recovered from the dogs treated. The commercial dog shampoo (T₀⁺) failed to eliminate *Demodex spp.* on the 8th week but totally eliminated it on the 10th week of treatment.

Table 4a. Species of mites affected by VCO shampoo

Treatment	Pre-treatment Replication			Post-treatment Application				
	I	II	III	2 nd	4 th	6 th	8 th	10 th
T ₀ ⁻	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D
T ₀ ⁺	S/D	S/D	S/D	S/D	S/D	S/D	D	--

T ₁	S/D	S/D	S/D	S/D	S/D	D	D	D
T ₂	S/D	S/D	S/D	S/D	S/D	D	D	--
T ₃	S/D	S/D	S/D	S/D	D	--	--	--

Legend: D - *Demodex spp.* S/D - *Sarcoptes spp.* and *Demodex spp.* -- none

Treatment with 80% VCO shampoo (T₃) and 70% VCO shampoo (T₂) totally eliminated the *Sarcoptes spp.* as early as 6th week of application but 60% VCO shampoo (T₁) failed to eliminate *Demodex spp.* till the 10th week of treatment while 70% VCO shampoo (T₂) killed all the *Demodex spp.* on the 10th week of application. The 60% VCO shampoo (T₁) failed to kill all the *Demodex spp.* which is the species of mite difficult to eliminate. The 80% VCO shampoo (T₃) eliminated all the *Sarcoptes spp.* after the 2nd week of treatment and *Demodex spp.* after 4th week of treatment.

Results revealed that among all the VCO concentrations 80% VCO shampoo (T₃) eliminated both *Sarcoptes* and *Demodex* species of mites faster than the commercial dog shampoo (T₀₊) indicating its faster effect and superior degree of efficacy.

Economic Analysis of Using VCO Shampoo

Table 5 summarizes the cost of preparing 110 milliliters (ml) of VCO shampoo and the cost per application as compared to the commercial dog shampoo.

Table 5. Total cost of producing 110 milliliters VCO shampoo at different concentrations (Php)

Preparation	Cost/110ml (Php)	Cost/treatment (5-10 ml) (Php)
Commercial dog shampoo	185.00	8.41-16.82
60% VCO shampoo	74.66	3.40-6.80
70% VCO shampoo	75.79	3.45-6.90
80% VCO shampoo	76.86	3.50-7.00

It can be noted that to prepare a 110 ml of 60% (T₁), 70% (T₂) and 80% (T₃) VCO shampoo would cost Php 74.66, Php 75.79, Php 76.86 respectively, as compared to the cost of equal amount of commercial dog shampoo (T₀₊) at Php 185.

Based on the production cost of VCO shampoo, the cost per application can be estimated from Php 3.40 to Php 7.00 from the lowest to the highest concentration which cost more than 50% less than the commercial dog shampoo (T₀₊) which was estimated at Php 8.41 to Php 16.82 per application.

Results indicate that it is more affordable to use VCO shampoo considering both cost and efficacy of the shampoo.

Other observations

Since ticks, lice and fleas are biting insects, they inflict injury to the skin. It was observed that in heavily infested dogs the skin shows fresh bleeding injuries from recent bites by lice and fleas and scabs for healing injuries. Damage to the skin was also noted as a result of intense irritation and scratching that lead to inflammation, excoriation and alopecia. An evidence of secondary bacterial infection was also noted. Flea dirt was also evident and abundant on the breeding places usually on the neck, lumbo-sacral area, abdomen and inguinal area.

One hour after treatment with VCO shampoo, the skin was clear showing no dead skin and scab with no evidence of bleeding. This could be attributed to the emollient and exfoliant effect of VCO. Twenty-four hours post-treatment the inflammation subsided and the moist areas were dry showing evidence of initial healing. This could be due to the anti-inflammatory and antimicrobial effect of VCO. All the lice and fleas were gone. Ticks inflict wounds and suck blood. As the female tick sucks, the area becomes red and engorged with blood as it collects and finally sucked by the tick. Inflammation subsided within 24 hours post-observation.

Before the application of the VCO shampoo, thick, rough crust manifested on the mite infested part of the skin. The dogs were listless especially those with moderate and severe infestation. Immediately after bathing, the dog rubbed its body on the ground, did self-scratching and self-licking. As an aftermath of intense pruritus, excoriations and erythema had occurred. Crust and scales were observed after the hair has dried up.

Every week after the application of VCO shampoo, the degree of mange infestation was reduced. Crust and scales were gone exposing fresh lesions. Hair growth was noticed on bald areas of the body particularly the feet, ear margins, elbows and hocks and body region. After the last application, it was observed that the lesions in the body of the experimental dogs were no longer evident. It was also observed that the dogs became active, evidence of crust and scales has faded, and dried pus on the body of some experimental dogs was no longer evident.

It was also observed that the dull coats of the experimental dogs became healthy and glossy which could have been due to the claim of Peat (1996) that on the skin the medium

chain fatty acids in the coconut oil are identical to the fats found in sebum. Normal flora that lives on the skin and keeps it healthy will actually live on the glycerol unit of the triglycerides, creating free fatty acids identical to those found in sebum. This allows the skin to have a slightly acidic pH ideal for keeping pathogens away and keeping the skin healthy.

CONCLUSIONS

Based on the results of the study, the following conclusions were derived:

1. VCO shampoo is highly effective against ectoparasites (ticks, lice, fleas and mange mites) in dogs.
2. Eighty percent (80%) VCO shampoo is the most effective concentration in eliminating the ectoparasites in dogs.
3. VCO shampoo could kill two species each of ticks, lice, fleas and mites in dogs.
4. VCO shampoo is more economical compared to commercial dog shampoo against ectoparasites of dogs.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were formulated:

1. Eighty percent (80%) VCO shampoo is recommended for the treatment and control of ectoparasites in dogs.
2. Information dissemination should be conducted to inform dog owners on the efficacy of VCO shampoo against ectoparasites.
3. Commercialization of VCO shampoo against ectoparasites in dogs.
4. A similar study should be conducted using other animals like goat.
5. Further study should be conducted to determine the efficacy of VCO shampoo against other skin diseases of dogs.
6. Another study should be conducted to determine the efficacy of VCO against endoparasites in dogs and other species.

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