

**SCHOOL OF PUBLIC HEALTH
COLLEGE OF HEALTH SCIENCES
UNIVERSITY OF GHANA**



**A PILOT STUDY TO TEST COCOA POD HUSK ASH SOLUTION ON MITE IN
ANIMAL MANGE AT ASAMANKESE**

BY

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**THIS DISSERTATION IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON
IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF
MASTER OF SCIENCE PUBLIC HEALTH MONITORING AND EVALUATION
DEGREE**



APRIL, 2023

DECLARATION

I, Eyume Lartey David, hereby declare that this thesis is the result of my own research and that no previous submission for a degree from elsewhere has been made here. Other researchers who provided information have been properly acknowledged with citations to their respective authors.



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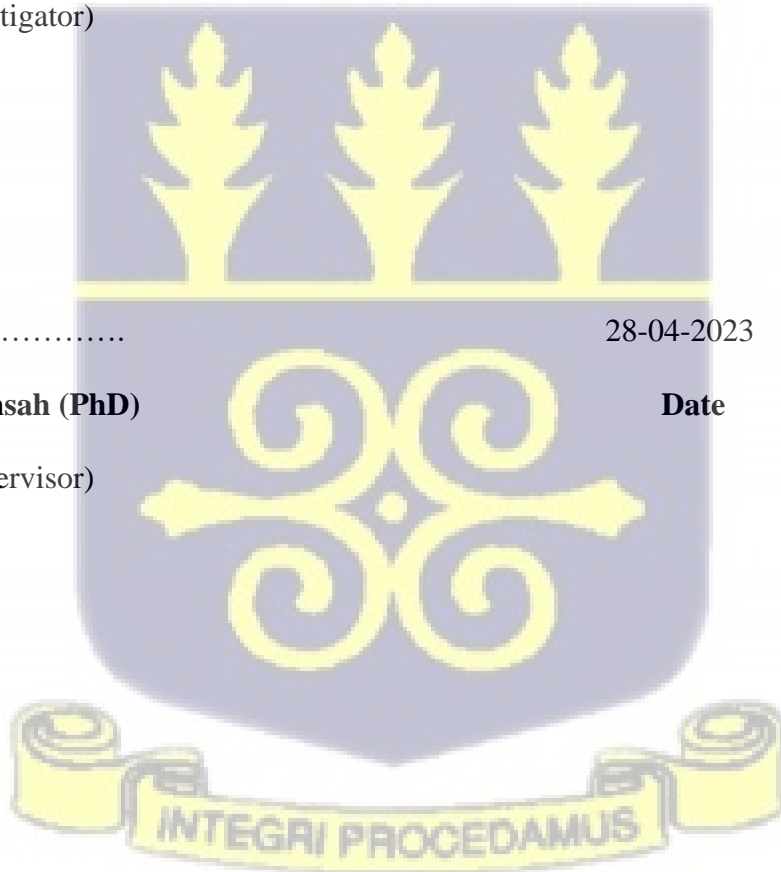


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LIST OF ABBREVIATIONS

PI	-	Principal Investigator
SPF	-	Specific Pathogen Free
US\$	-	United State Dollar
CPHs	-	Cocoa Pod Husks
%	-	Percentage
Kg	-	Kilogram
G	-	Gram
um	-	Micrometer
OP	-	Organophosphate
e.g.	-	For Example
SPs	-	Synthetic Pyrethroids
MLs	-	Macrocyclic Lactones
IPM	-	Integrated Pest Management
MI	-	Migration Index
BHC	-	Benzene Hexachloride
γ	-	Gamma
OCs	-	Organic Compounds
DDT	-	Dichlorodiphenyltrichloroethane
ChE	-	Cholinesterase
HCC	-	High Cis Cypermethrin
Kd	-	Knockdown
CRC	-	Controlled Release Capsule
GPS	-	Global Position System
CPS	-	Co-operative Seed Producers
m	-	minutes



ml	-	millilitres
H1	-	H10: House one -House ten
Wks	-	Weeks
KOH	-	Potassium hydroxide
rpm	-	Revolution Per Minutes
DW	-	Distilled Water
CLSI	-	Clinical and Laboratory Standard Institute
APVMA	-	Australian Pesticides and Veterinary Medicine
NRA	-	National Registration Authority
MRL	-	Maximum Residual Limit
Ach	-	Acetylcholinesterase
endo	-	Endoparasites
ecto	-	Ectoparasites
IMM	-	Integrated Mite Management
FDA	-	Food and Drug Authority
PAP	-	Parasitological Analysis Protocols
°C	-	Degree Celsius
~	-	Approximately
Pcs	-	Pieces
Spp	-	Species
S/N	-	Serial Number
SEM	-	Standard Error of Means
P-value	-	Probability-value
LC	-	Lethal Concentration
CSIR	-	Centre for Scientific and Industrial Research



- NMIMR- Noguchi Memorial Institute for Medical Research
- COT - Cost of Treatment
- GHS - Ghana Cedis
- MAT - Minimum number of Animal Treated
- ACP - Activated Charcoal Powder



ABSTRACT

Background

Mange is a contagious skin disease characterized by crusty, scaly skin, pruritus, skin wrinkling, wounds, necrosis, and alopecia. Mange mites are frequently seen, especially in rural areas and among the poor and marginalized people, where livestock makes up the majority of their sources of revenue and their primary source of food. An increase in the spread of mange in animals (e.g., goats) in Ghana coupled with the high cost of treatment with antiparasitic drugs has necessitated the need to search for a new and cheaper option.

Objectives

In this study, the feasibility of a cocoa pod husk (CPH) ash solution for the treatment of mange disease in goats was tested.

Method

This study was a cluster randomized controlled trial among 60 goats infested with mange in households in Quarshie, a rural community in the Asamankese district in the Eastern region of Ghana. A cocoa pod husk (CPH) ash solution was made by measuring 40g of cocoa pod husk ash powder and 60ml of distilled water (water for injection). A laboratory analysis of CPH ash solution for efficacy and safety was carried out at Animal Experimentation at the Noguchi Memorial Institute for Medical Research. The mange-infested goats were randomized into the treatment and control arms (1:1). Each goat in the treatment arm was treated with 5ml of CHP ash solution following the US Food and Drug Administration-Parasitological Analysis Protocol (FDA-PAP). The number of mites on goat skin was described using a histogram. The Wilcoxon rank sum test was used to compare the median number of mites found on goat skin in the treatment and control goats. The Kruskal-Wallis test was used to compare the difference in the median number of mites on the goat skin at baseline between the treatment and control arms.

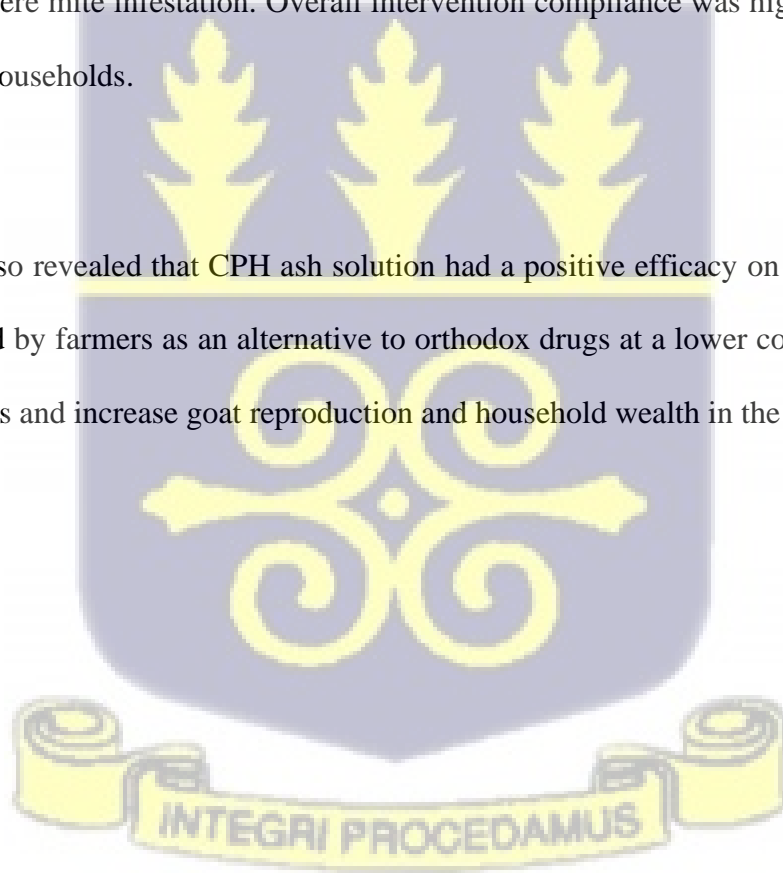
The quantile regression model was used to identify the factors associated with the number of mites on goat skin across the treatment and control arms.

Results

Predictors of mite infestation at baseline included wrinkle skin on the goat at the time of purchase and a lack of knowledge that mange is a disease among goat owners. Mite infestations in control goats ranged from moderate (11 - 19 mites per infested area) to severe (20+ mites per infested area); whereas in the treatment, goat mite infestation was severe. Fourteen days after treatment (that is, at the endline), 21 of the control goats had a severe mite infestation, and 9 had a moderate mite infestation. But in treatments, 29 of the 30 had mild mite infestations, and 1 had a severe mite infestation. Overall intervention compliance was high among control and treatment households.

Conclusion

The findings also revealed that CPH ash solution had a positive efficacy on the mites treated and can be used by farmers as an alternative to orthodox drugs at a lower cost to treat mange mite infestations and increase goat reproduction and household wealth in the community.



CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of research

Mange is a contagious skin disease characterized by crusty, scaly skin, pruritus, skin wrinkling, wounds, necrosis, and alopecia (Tadesse *et al.*, 2011). The mange disease manifests on the skin of animals and is acquired through direct contact between animals or indirect contact with residual mites in tags of wool or scab attached to fencing objects, making the development and spreading of mange as an acute one (Klompen, 1992; Bochkov, 2010). Mange can spread rapidly within confined situations of a feedlot but transmission at pasture is slower, especially in the summer when there is no close body contact and mites are in the quiescent phase of their life cycle stages (Meleney and Christy, 1978).

Mange is a form of allergic dermatitis initiated by allergens contained in the mite's secretory or excretory products, and mite exploits the allergic reaction with the heat and humidity produced by the inflammation forming the micro-climate needed for mite survival and the leakage of serous exudate forming the basis of the mite's nutrition source (Bates, 1981; Tolossa, 2014). There is an inflamed condition of skin breakage occurrence, mainly as a result of host scratching but also through small haemorrhages caused by the abrasive action of the mite's mouthparts, and the skin breakages result in increased leakage of serum, with accompanying scab formation and skin thickening of the animal body part (Raffert and Gray, 1987). Heavy mange infestations are readily detected, but light infestations are difficult to detect, especially during the early stages of disease, when lesions are very small on the body of the animal (Fisher *et al.*, 1986; Bates, 1997).

Mites infesting small ruminants belong to three important genera: *Sarcoptes*, *Psoroptes*, and *Demodex*, which are responsible for three forms of mange mite infestation in goats (Tolossa, 2014). Sarcoptic mange is caused by burrowing mites, Psoroptic mange is caused by non-

burrowing mites; and Demodectic mange is caused by mites that reside much deeper in the skin, cause severe pruritis, wool loss, reduced weight gain, and in some cases, death (Taylor *et al.*, 2007).

Global losses from mange disease on livestock production have been estimated to amount to US\$14.4 million (Drummond *et al.*, 1981).

In Ghana, mange mites are commonly seen, particularly in the local or rural areas and among the poor and marginalized people, where livestock form the greater portion of their source of income for living (Drummond *et al.*, 1981). This makes mange mite infestation an issue of concern to initiate action; therefore, there is the need to find alternative control interventions since the disease has a negative impact on the economies of both developed and developing countries as far as livestock and human populations are concerned (Drummond *et al.*, 1981; Klompen, 1992; Bates, 1993; Bochkov, 2010).

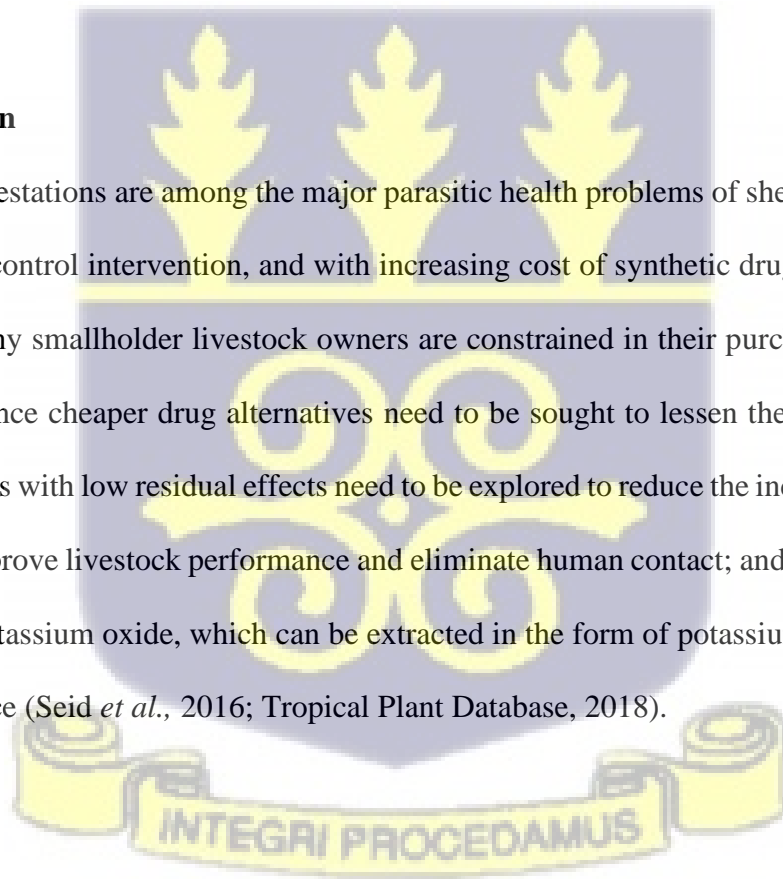
Theobroma cacao (cocoa) belongs to the family Malvaceae and is widely distributed in the north and south of the equator (Owra *et al.*, 2009; Tropical Plant Database, 2018). Cocoa pod husks causing environmental nuisance could be utilized for soap making, processed for feeding livestock in a limited quantity as a supplementary feeding, and used as an antiparasitic agent for treating skin disease in humans in local settings. Cocoa pod husk ash contains potassium oxide, which can be extracted in the form of potassium hydroxide as a medicinal source for treating skin problems in both animals and humans (Agyente-Babu and Oddoye, 2005; Tropical Plant Database, 2018). Therefore, this study was conducted to test the feasibility of the CPH ash solution against mange mite infestation in goats between day1 as pre-treatment samples and day14 as post-treatment samples (Bochkov and Mirovon, 2011).

1.2 Problem statement

Livestock farming is plagued with many parasites including mange mite infestation and this affects livestock productivity in Ghana and the indiscriminate use of acaricides or pesticides by farmers has also resulted in resistant parasites in small ruminant livestock, high animal parasite transmission to human and the need for cheap and alternative drugs (Bates, 1993; Bochkov, 2010). The poor and marginalized people do not have the luxury to purchase orthodox (synthetic) drugs and do not have sustainable control method of mange mite infestation on small ruminant livestock. Thus the need for cheap drugs that are sustainable and environmentally friendly to reduce the negative effect of the mite on animals and humans (Bochkov, 2010; Seid *et al.*, 2016).

1.3 Justification

Mange mite infestations are among the major parasitic health problems of sheep and goats that require urgent control intervention, and with increasing cost of synthetic drugs to curb mange infestation, many smallholder livestock owners are constrained in their purchasing power for these drugs, hence cheaper drug alternatives need to be sought to lessen their burden; whilst drug alternatives with low residual effects need to be explored to reduce the incidence of mange disease and improve livestock performance and eliminate human contact; and cocoa pod husks ash contains potassium oxide, which can be extracted in the form of potassium hydroxide as a medicinal source (Seid *et al.*, 2016; Tropical Plant Database, 2018).



1.4 Study Objective

1.4.1 General objective

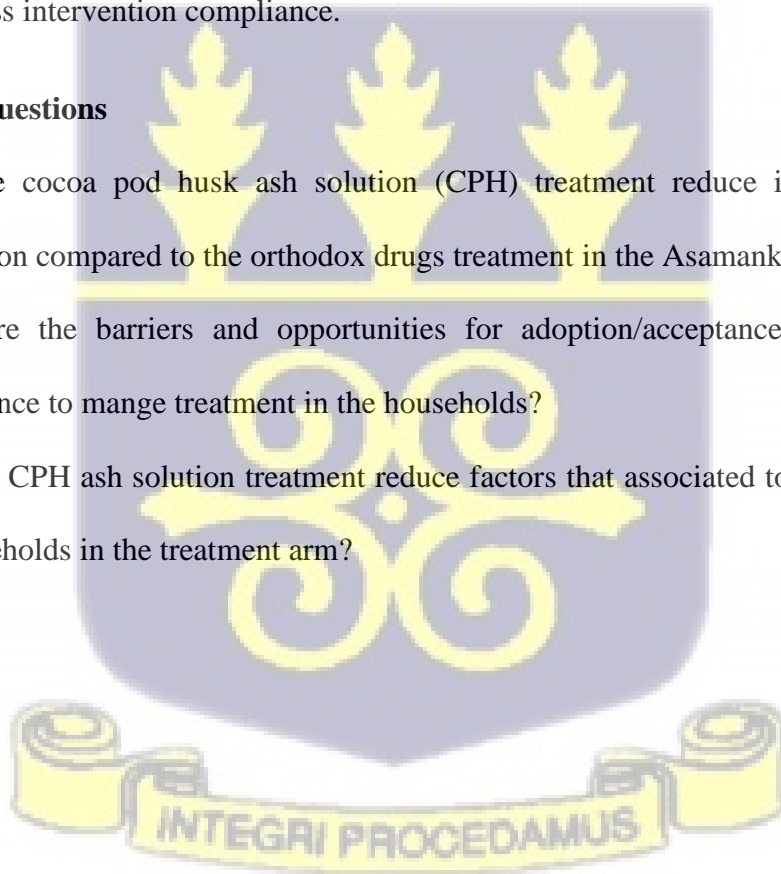
This pilot study was conducted in cluster randomized control trial (cRCT) to test the feasibility of cocoa pod husk (CPH) ash solution for the treatment of mange disease in goat to inform a future large-scale field trial at the Asamankese community.

1.4.2 Specific objectives

1. To identify factors, associated with mite infestation at baseline.
2. To compare intensity of mite infestation before and after intervention.
3. To assess intervention compliance.

1.5 Research questions

1. Will the cocoa pod husk ash solution (CPH) treatment reduce intensity of mite infestation compared to the orthodox drugs treatment in the Asamankese community?
2. What are the barriers and opportunities for adoption/acceptance of intervention compliance to mange treatment in the households?
3. Will the CPH ash solution treatment reduce factors that associated to mite infestation of households in the treatment arm?



CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Mange

Mange is a contagious skin disease, characterized by crusty, pruritic dermatitis and hair or feather loss. It is caused by a variety of parasitic mites burrowing in or living on the skin of animals and humans, and it is typified by hair or feather loss, crusty or scaly skin lesions, dermatitis, thickened skin, scurf, and pruritus in animals (Tadesse *et al.*, 2011). Mange diagnosis in domestic animals is based on clinical manifestations and the demonstration of mites or their developmental stages in host skin scrapings under laboratory findings or examinations (Kettle, 1995).

2.1.1 Classification of mange

Mange in small ruminants has been classified according to three important genera: *Sarcoptes*, *Psoroptes* and *Demodex*, which are responsible for the three forms of mange mite infestation in goats and sheep (Tolossa, 2014). Mange in domestic animals results from the host's physiological, immunological, and behavioural responses to infestation by certain mites in any of the families of Astigmata or Prostigmata (Krantz and Walter, 1999). Sarcoptic mange caused by burrowing mites, psoroptic mange caused by non-burrowing mites, and demodectic mange caused by mites that reside much deeper in the skin cause severe pruritis, wool loss, reduced weight gain, and in some cases, the death of the animals (Taylor *et al.*, 2009).

2.1.1.1 Sarcoptic mange

This is the disease state caused by *Sarcoptes* mites in the family of Sarcoptidae, which are obligate parasites, burrowing into the skin of mammals, and it is the itch mite (*Sarcoptes scabiei*) that causes scabies in humans and animals, Sarcoptic mange is found in a wide range

of domestic and wild mammals throughout the world, generally affecting the sparsely haired parts of the body of animals (Klompfen, 1992; Bochkov, 2010). Sarcoptic mange is likely to be present in all herds unless derived from specific pathogen free (SPF) sources (Dobson and Davis, 1992). Although sarcoptic mange infestation is generally subclinical, generalized infestation can occur as well (Bates, 1997).

2.1.1.2 Psoroptic mange

This is the disease state caused by *Psoroptes* mites, which are non-burrowing, cosmopolitan, and obligate ectoparasites, causing a debilitating dermatitis, involving hair or wool loss and a pruritic scab formation. Most infestations are subclinical and asymptomatic, and they are easily overlooked (Schillhorn van Veen and Williams, 1980; Bates, 2001). Transmission can occur between mother and offspring as early as five days after birth in animals and humans (Heath *et al.*, 1989). Infestations are generally confined to the external auditory canal, which can be plugged with a thick, brown, laminated scab, close to the tympanic membrane, although no damage to the tympanic membrane has been observed at postmortems of animals (Williams and Williams, 1978; Odiawo and Oga, 1987). *Psoroptes* infestations have also been recorded to involve the entire pinna or to spread to form body lesions, involving the poll, neck, withers, back, abdomen, pasterns, and inter-digital spaces of the animal (Munro and Munro, 1980; Lofstedt *et al.*, 1998).

2.1.1.3 Demodectic mange

Demodex are the causative agents of demodectic mange and are easily recognized by their annulate, vermiform, or worm-like shape, but may be overlooked on account of their small body size; they inhabit the hair follicles, sebaceous glands and meibomian glands of the skin of a number of wild and domesticated mammals, including humans, but generally, the disease

is of low incidence and of little importance as compared to that of sarcoptic mange (Desch, 1986).

Healthy animals almost never suffer from demodectic mange, but laboratory or domesticated hosts are the usual victims of the disease (Nutting, 1985).

2.2 Common factors influence mange infestation

Mange infestation is caused by the various mites that are found on small ruminants, including *Sarcoptes*, *Psoroptes*, and *Demodex* (Tolossa, 2014). Mites are influenced by various challenges and the factors that may affect their reproduction, survival, and spread from one host to another, rainfall, temperature, vegetation, competing species, and management/husbandry practices are key environmental factors that influence mange mite infestation in livestock; although husbandry practices where livestock from different communities are grazed together at a point have a key influence in general on the spread of mange mites (Asmaa *et al.*, 2014). Ideal temperature and availability of moisture are key factors for the life cycles of most mites on their host, and temperature has a potential influence during moulting periods of mites on their host for survival (Sonenshine *et al.*, 2006; DeClercq, *et al.*, 2013).

2.2.1 Processes of mange healing

Mange condition on the host is considered as wound caused by mites and the healing processes are assumed as wound healing which comprises of contraction (gradual approximation of the wound edges), restoration of the patient health and return of function to normal; although the wound healing processes are not yet fully understood, they are known to be chemically mediated and the healing of wound is by the deposition of connective tissue which is the primary unit of repair and it is a form of universal cement which appears whenever the host

tissues are wounded; meanwhile, wound healing does not take a single course of event, but rather a synopsis of events and changes that occur at the cellular and subcellular levels involving purely chemical, physical, biochemical, immunological and other processes; either one after the other or simultaneously and the process of wound healing begins immediately after the drug has been applied to the injury body part and all wounds go through a similar repair process of healing, though different tissues differ in their healing process as well as time taken to complete restoration and the pathway followed for the healing, vary quite differently in different tissues of the host; the phases of wound healing normally progress in a predictable, timely manner; and if they do not healed, the healing may progress inappropriately to either a chronic wound such as a venous ulcer or pathological scarring such as a keloid scar on the body part of the host (Douglas, 1963; Clark, 1993; Elliot, 1994; Hostettmann *et al.*, 1996; Martins, 1997; Velnar *et al.*, 2009).

2.3 Mites

The majority of mange mites are weakly sclerotized, slow-moving, and very small (100-900 μ m), and they remain permanently attached to their hosts; however, the average life cycle of mites lasts 1–5 weeks and includes four stages, including an egg, a six-legged larva, an eight-legged nymph, and an eight-legged adult, both male and female, as specialized illustrated diagnostic keys under laboratory findings or examinations (Gaud and Atyeo, 1996; Krantz and Walter, 1999; Bochkov, 2010).

2.3.1 Classification and description of mites

The mites in the Acari classification are an extremely diverse, abundant, and ubiquitous group of arachnid arthropods with approximately 55,000 described species in the higher level of Acari classification; it is still an unsettled construct, but the following is a consensus system about

the mites: Acari consists of two major evolutionary lineages, Parasitiformes and Acariformes, and only certain acariform mites cause mange disease in domestic animals; in both lineages, though, mites are present, including Trombidiformes and Sarcoptiformes within the Acariformes. Trombidiformes includes the major suborder Prostigmata, which has numerous superfamilies and many families, five of which contain mites; Sarcoptiformes includes the major suborder Oribatida, which has numerous cohorts, superfamilies, and families, but only 11 constituted families in Astigmata, contain mites; however, some other mites may cause less severe dermatitis (Krantz and Walter, 2009; Bochkov and Mironov, 2011).

2.3.1.1 Astigmata

Astigmatan mites are typically small, globose or oval in shape, thin-skinned, and covered in distinctively shaped and placed setae, spines, pegs, or scales; adults also frequently have eight legs and anterior mouthparts that include paired palps and chelicerae used for cutting and feeding; the legs attach proximally to the body through distinctive cuticular epimeres or coxal apodemes and terminate distally in a variety of setal forms or in a pretarsal empodium that may be shaped like either a claw or a bell-like sucker like caruncle or ambulacrum; although Astigmatan mites lack true, paired pretarsal claws, it is usually possible to tell the sexes apart and distinguish between different mite species by observing the shape and placement of setae and empodia on the legs; simple, supple, and translucent ovoids known as fertilized eggs are laid by mated females through a midventral ovipore process (Giesen, 1990; Krantz and Walter, 2009).

2.3.1.1.1 Sarcoptidae (*Sarcoptes*)

With more than 100 known species of infected hosts present worldwide in at least 10 mammalian orders and 26 families, this *Sarcoptes* mite in the Sarcoptidae family is the source

of sarcoptic mange or scabies in humans and other mammals; sarcoptic mange in dromedaries is a particularly distressing chronic condition with high morbidity, and it may predispose afflicted hosts to other infectious diseases but the anus of *S. scabiei* is posterior in both sexes, and the first pair of epimeres is fused in a midventral Y-shape; each tarsus bears one or two highly modified setae in the form of short spurs and nymphs, which are similar to females but smaller and lacking an ovipore; the remaining legs all end in long, hair-like setae (Yunker, 1973; Arian *et al.*, 1994; Zahler *et al.*, 1999; Bornstein *et al.*, 2001; Taylor *et al.*, 2009).

2.3.1.1.2 Psoroptidae (*Psoroptes*)

Several species of *Psoroptes* (*P*) among the mites that cause psoroptic mange worldwide in wild and domestic ungulates but *P. ovis* and *P. capae* are on the bodies of sheep and goat respectively, meanwhile, distinctions between the species were based primarily on host and anatomical site infestation and on the morphology of the males and the description for *Psoroptes* mites is that for *P. ovis*, making this the proper designation for all mange mites on all domestic hosts; but the nomenclatural situation in *Psoroptes* becomes similar to that in *Sarcoptes*, with one morphologically and genotypically variable species occurring worldwide, albeit on a smaller spectrum of hosts and with a bit less stringent host specificity among the variants, two other named *Psoroptes* spp. remain as tentatively valid taxa occurring only on wild mammal hosts (Bochkov, 2010). Psoroptic mange in both sheep and goat seems to vary in its severity according to the variant present with the most severe form of condition but has been eradicated although it still persists in many other parts of the world and for further eradication efforts against psoroptic mange in sheep and goat, genotypic analysis of the involved mites may be an especially valuable tool for eradication (Falconi *et al.*, 2002).

Mature female *Psoroptes* are 550–750 µm long, with a striate cuticle and four long and 16 short dorsal somatic setae and a noticeable anterodorsal cuticular plate is present behind the

mouthparts, and the midventral ovipore is an inverted U-shape but males are about one-fourth smaller; and they have an additional, larger posterodorsal cuticular plate, a pair of posteroventral adanal suckers, and two terminal posterior lobes, each equipped with four setae of varying lengths and structures while nymphs and larvae are somewhat similar to adults but progressively smaller and all *Psoroptes* are pearly white in colour; meanwhile in all stages, the anterior two pairs of legs are thicker and more robust than the posterior pairs, which are thinner in the male, shortened in the fourth pair; but legs I and II terminate in pretarsal empodial suckers on long, segmented pedicels in both sexes, with similar structures on legs IV of the female and legs III of the males and the female's third tarsus ends in two long, whip-like setae; and the male has a single short seta on tarsus IV, with a long, thin seta accompanying the empodial sucker on tarsus III (Tadesse *et al.*, 2011; Tolossa, 2014).

2.3.1.2 Prostigmata

Prostigmata are a group of mites that exhibit tremendous morphological and biological diversity, making generalizations about them is difficult; however, all of the prostigmatan mange mites belong to either of two superfamilies, *Cheyletoidea* (comprising seven families) and *Myobioidea* (one family) and together, these eight families include nearly 1,100 named mite species, but there are hundreds of undescribed species as well; eventhough the anterior mouthparts in this group may be variously modified by palpal segment elaboration or reduction and by basal cheliceral fusion and extension into elongate, needle-like stylets used to pierce the host's tissues for feeding but some prostigmatan mange mites have paired, elongate, dorsal respiratory peritremes above the mouthparts and the body usually is elongate; sometimes very much so, and usually soft and thin-skinned; but sometimes with sclerotised plates which adults usually have eight legs that vary in length and morphology according to the habits of the family; but they each usually terminate distally in a pair of pretarsal claws and a linear empodium that

often is equipped with numerous sticky hairs; but proximally, the legs may articulate with simple coxal fields or sclerotised somatic apodemes and the ovipore is a longitudinal; usually mid- or posteroventral slit, whereas, the genital pore in males is dorsal and sometimes equipped with a long aedeagus (Gaud *et al.*, 1988; Kettle, 1995).

2.3.1.2.1 Demodecidae (*Demodex*)

The Demodecidae comprise of more than 150 species of parasitic mites in seven genera from hosts in 11 mammalian orders but *Demodex* is the only genus of importance for domestic hosts; and it contains at least 70 named species with many more that are unnamed and undescribed, although other genera display their own unique features; adult *Demodex* are elongate, spindle-shaped, or vermiform mites, 250–850 μm long, that live in the host hair follicles, sebaceous glands, meibomian glands, and occasionally in epidermal pits; meanwhile they have short anterior mouthparts with two-segmented palps and retractable needle-like stylets used to puncture surrounding host tissues and feed on predigested cellular fluids; but the normal four pairs of legs are usually short, stumpy, composed of three segments each, and terminate distally in paired pretarsal claws; usually with a linear empodium which the coxal fields occupy much of the anteroventral surface of the body where the legs attach; but the palps or one pair of legs of some stages of some species may be greatly elongated or otherwise modified; primarily as holdfast organs, the very thin cuticle of the body and appendages is all but devoid of setae, but the opisthosoma is usually transversely striate which befitting the confines of their narrow follicular or glandular habitats, and the immature stages including the eggs of *Demodex* spp. are usually spindle-shaped or elongate oval, sometimes extremely so; but *Demodex* species are very host specific, only rarely inhabiting more than one species of congeneric mammal host, however, it is not uncommon for a host species to harbour two to four different species of parasitic *Demodex* and the transfer between hosts occurs only by very close contact between

individuals or most probably mother to neonate, making transmission between animal species or from animals to humans very unlikely but their very thin cuticles mean that demodecids cannot survive away from their hosts for more than a few hours; but on occasion, because of stress or other poorly understood factors, resident mite populations explode in numbers that result in a pathological condition known as demodectic mange and healthy animals almost never suffer from *demodex* and laboratory or domesticated hosts are the usual victims (Nutting, 1985; Bochkov and Mirovon, 2011; Tadesse *et al.*, 2011).

2.4 Morphology and identification of mites

The length of legs and presence of hair between bases of the first and second pairs of legs, the presence or absence of setae on the cephalothorax, the presence or absence of fattened scales on the body, the length of the body either prolonged behind or balloon-shaped, the position of the anal opening, and the shape either pointed or blunt of the scales and spines were the morphological features used for mite identification mostly (Wall and Shearer, 2001; Taylor *et al.*, 2007).

2.4.1 Epidemiology of mites

The prevalence of animals presenting mange lesions within infested flocks can vary between 7.8% and 60.0% in large flocks, and the prevalence of sub-clinical lesions can be between 10.0% and 90.0%, but sub-clinical disease is generally asymptomatic, and symptoms if they do occur include occasional episodes of restlessness, rubbing against fence posts, soiled and stained areas of wool, which can be found particularly on the shoulders, head tossing, and deranged or tagged fleece (Bates, 1999). In the later stages of *Psoroptes* infestations, rubbing and head tossing become more evident, areas of wool loss appear together with open, bleeding wounds, animals rapidly lose condition, and epileptiform seizures may be evident (Bygrave *et*

al., 1993). The transmission of mange occurs through direct contact between animals or indirectly through contact with residual mites in wool tags or scabs attached to fencing objects. Although *Psoroptes* spp. mites are obligate parasites, and they are still capable of surviving off the host for 15 to 16 days before succumbing to starvation and desiccation (O'Brien *et al.*, 1994). Infestations can spread rapidly through lowland flocks with restricted grazing but may be spread more slowly through extensively grazed hill flocks that are thinly spread over common grazing and infrequently mustered (Kirkwood, 1986). Although the origins of the outbreaks were fully explained in over 73% of cases, the origins of infestation remained obscure in 18.5% of flocks, disease recrudesced in 0.7% of flocks, and animal mange mites were once thought to migrate to the cryptic sites, that is, the ears, infra-orbital fossae, inguinal pouches, and crutch, in order to survive the summer (Bates, 1999; Bates, 2000). Mites have been recorded in only 7% of animals with detectable infestations in one or more cryptic sites during the summer as compared to mites over-summering on the broad body surfaces of 32% of all animals examined but long periods of latency and a sudden increase in vigour and pathogenicity of a mite strain could account for unexplained outbreaks of disease and distinct populations of mites were identified, varying in population reduction in the summer, tolerance to organophosphate (OP) acaricides, survival off the host and relative rate of spread through animal herds, and similar studies have been carried out but all the geographical isolates of mite which were compared produced a progressive lesion, characteristics of sheep and goat mange lesion, but the extent of the lesion produced with time varied considerably between the isolates but some created slow chronic infestations while others produced fast over the same time period frame (Roberts and Meleney, 1971; Roberts *et al.*, 1971; Bates, 1999).

2.4.2 Mite infestation

Mite infestation is a form of allergic dermatitis initiated by allergens contained in the mite's secretory or excretory products, and the mite exploits the allergic reaction, with the heat and humidity produced by the inflammation forming the micro-climate needed for mite survival and the leakage of serous exudate forming the basis of the mite's nutrition source (Bates, 1981). In this inflamed condition, of skin breakages occur, mainly as a result of host scratching but also through small haemorrhages caused by the abrasive action of the mite's mouthparts, and the skin breakages result in increased serum leakage, with accompanying scab formation and skin thickening of the animal body part (Raffert and Gray, 1987). Mites infestation can have profound effects on the health, welfare and economics of infested flocks through the effects on animal fertility, weak or still born foetus, reduced foetal growth and death of breeding stock through debility and exhaustion, dehydration, secondary bacterial infections or hypothermia; but the yield and quality of by-products such as leather and fleece are also adversely affected; meanwhile mite infestation begins as moist plaques of hair over the withers, followed by intense pruritus with active rubbing against fixed equipment, leading to loss of hair, serum exudation, ulceration and bleeding; afterwards, thickened, scabby lesions, oozing blood and serum, progress over the withers and tail-head, before extending along the back and down the flanks and the legs of the animal involved (Linklater and Gillespie, 1984). Mite infestation can be life threatening to young animals under one-year-old, but deaths rarely occur in older animals, although infested animals are predisposed to pulmonary infections and may die; mite infestation is considered a winter disease, but clinical outbreaks are sometimes observed in July or August (Losson, 1996). Heavy infestations are readily detected, but light infestations are difficult to discern, especially during the early stages of disease, when lesions are very small on the body of the animal (Fisher *et al.*, 1986; Bates, 1997). Mite infestations can spread rapidly within confined situations in a feedlot, but transmission at pasture is slower, especially in the

summer when there is no close body contact and mites are in the quiescent phase of their life cycle stages (Meleney and Christy, 1978).

2.5 Antiparasitic agents' susceptibility of mites

Antiparasitic agents resistance is mainly detected through field experience and when after a failure of a particular treatment; which it must be understood that in the case of mites, proper treatment and control measures can only be implemented in conjunction with an accurate diagnosis; and failure of treatment is often difficult to detect as mites can survive on the host without showing any sign of their presence on skin of the animals and a practical definition of resistance to a given product is a decreased susceptibility of an ectoparasites to an insecticide or acaricide at concentrations on or above a defined threshold but the defined threshold concentration being the dose stipulated by the manufacturer for its use, printed on the product label for instance the maintenance concentration for plunge dips, basically this means that if all the instructions are followed to the fullest and the product is still ineffective following controlled investigations, the parasite can be considered to be resistant to that product used (Bates, 1998; Bates, 2000).

2.5.1 Antiparasitic agents use in the medical field for mange treatment

The decision on which method of control to use depends on government policy, the size of the flock, the age of the animal, whether the animals are pregnant or lactating, the use to put them like meat, wool, milk or breeding, the availability of labour and facilities like handling pens, dip baths, weather, geography and the presence of other parasites like nematode worms, lice, ticks, keds and blow flies; meanwhile the current available tools for mange control consist of chemical technology, relying on treatments with different application methods and/or

formulations of acaricides and these can be used with or without the benefit of local epidemiological knowledge put in place (Bates, 1993).

Antiparasitic agents are chemical substances used for ectoparasites control which focus on occupational health and safety, environmental and trade-related issues with specific evaluations; and a broader review of goat or sheep antiparasitic agents have recommendations for removals, restrictions on and specific use patterns for certain products in use; and an additional study into acceptable disposal practices for used in products will also potentially affect the use of certain antiparasitic agents; but it is important not to overlook the value of antiparasitic agents to productivity and animal welfare in the livestock industry; these products have enabled primary producers to efficiently and economically manage antiparasitic agents on food and fibre-producing animals but more than US\$60 million was spent on ectoparasites treatments for food and fibre animals consumed by humans (NRA, 2000; APVMA, 2003; APVMA, 2004).

2.5.2 The role of medicinal plants in mange treatment

Several arthropod reproductive inhibitors and repellents have been extracted from certain plants since ancient times, and these extracts affect the feeding behaviour and life cycle of parasites on their host, such as animals and humans (Tooning *et al.*, 1988; Green *et al.*, 1991; Wells *et al.*, 1993; Perich *et al.*, 1995; Mägi *et al.*, 2006). As pesticides of synthetic origin may have a negative impact on the environment, pests can become resistant to toxic chemicals after repeated applications, which has made the use of natural products more popular; For example, pyrethrins are insecticides derived from the chrysanthemum plant, are common ingredients in parasite control products, and are neurotoxic at high levels (Hansen *et al.* 1994; Mägi *et al.*, 2006). In Ghana, there are numerous medicinal plants described for treatment of many diseases, and herbal medicine is considered an integral part of the Ghanaian culture and plays

a pivotal and indispensable role in the current public healthcare system as well as animal healthcare, where over 50% of all modern clinical drugs are of natural product origin (Mägi *et al.*, 2006; Kirbag *et al.*, 2009). Natural products play a dominant role in the development of novel drugs that are used for the treatment and prevention of diseases in animals and humans (Newman *et al.*, 2003; Gilani and Rahman, 2005; Mägi *et al.*, 2006).

2.5.2.1 *Theobroma cacao* (cocoa) pod husk

Theobroma cacao belongs to the family Malvaceae and is widely distributed in the north and south of the equator (Owra *et al.*, 2009; Tropical Plant Database, 2018). Cocoa pod husk causing environmental nuisance could be utilized for soap making, skin disease treatment, and processing for feeding livestock in a limited quantity as a supplementary feeding for the benefit of the animals in general and as an antiparasitic agent for treating skin disease in humans at the local settings, and cocoa pod husk ash contains potassium oxide, which can be extracted in the form of potassium hydroxide as a medicinal source in treating skin problems in both animals and humans (Agyente-Badu and Oddoye, 2005; Tropical Plant Database, 2018). *Theobroma cacao* (cocoa) plant with fresh pods and fresh pod husks are shown in figure 2.1 and 2.2 respectively:

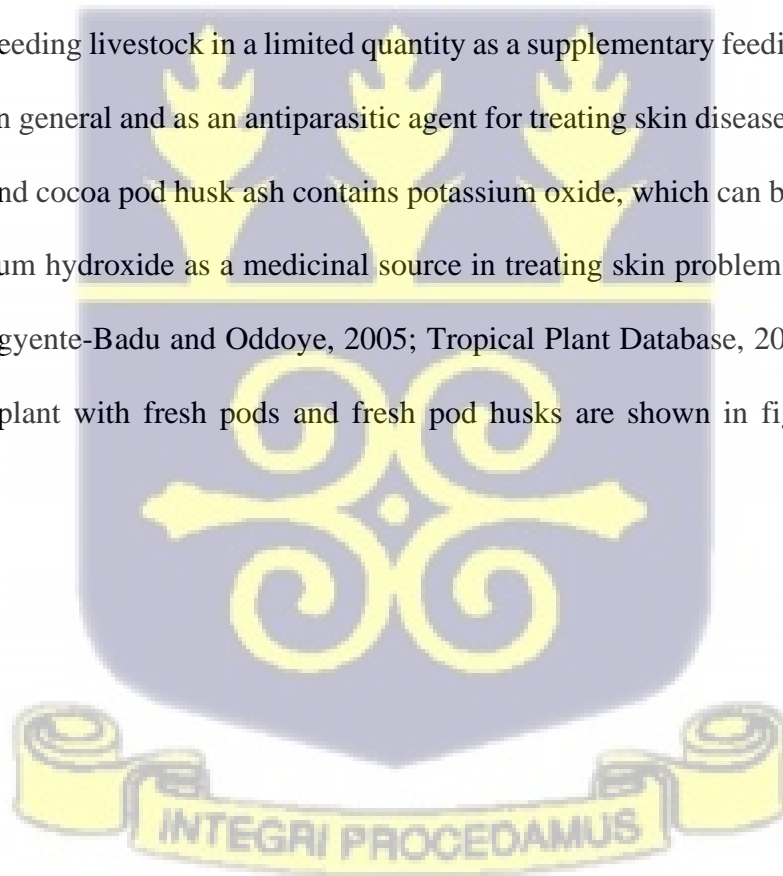




Figure 2.1: *Theobroma cacao* (cocoa) plant with fresh pods

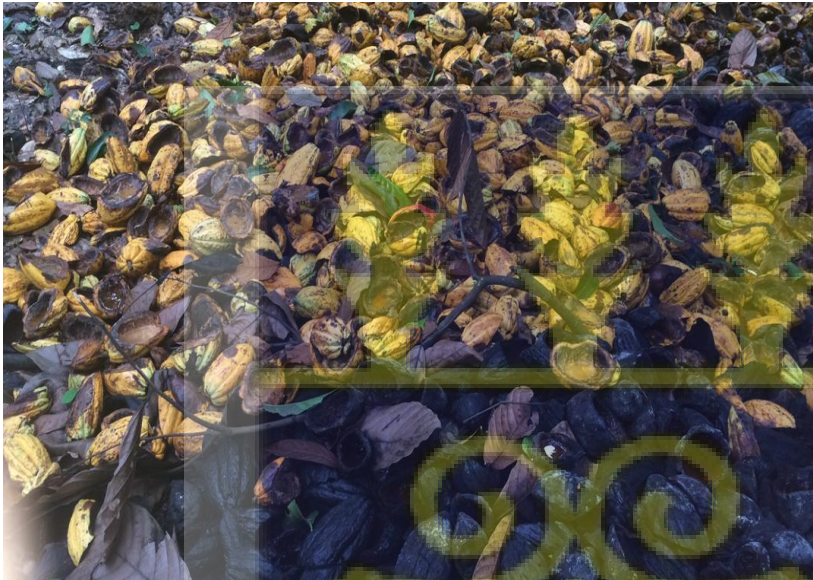


Figure 2.2: *Theobroma cacao* (cocoa) fresh pod husks

Each ton of the dry cocoa beans generates or produces ten (10) tonnes of cocoa pod husks, and this causes environmental problem in the cocoa growing areas in the local settings of the world and the pod husks also serve as a potential source of disease transmission when used as mulch in cocoa farms, whereas in West Africa, a very small proportion is used for traditional soap making and as a fuel source in the local settings (Oddoye *et al.*, 2010; Tropical Plant Database, 2018). The use of *Theobroma cacao* pod husk derived biofertilizer is safe since it poses neither ecological nor human health risks (Famaye *et al.*, 2013). The cocoa pod husk has a low alkaloid

content, while tannin is practically absent but crude fibre content is low as completely unligified and compares favourably with *Panicum maximum* and *Centrosema pubescens* as fodder and the cocoa-pod husk can be hydrolysed under pressure for fermentation build up into alcoholic drinks (Tropical Plant Database, 2018).

2.5.3 Administration of antiparasitic agents

The choice of formulation and method of application of the acaricide naturally depends on the size of the farm and the management system; but small-scale farming operations facing management problems might achieve control by using spray or pour-on formulations; meanwhile medium and large farms with more facilities and equipment, might use immersion dips or injectable formulations and in-feed preparation for other alternatives; but an ideal acaricide should be economically acceptable, easily applicable and should have good efficacy with sufficient residual effect to protect animals from re-infestation and it should not select for resistance due to its gradual decay on the animal; that is, it should have a sharp cut-off in efficacy with time; and in addition, it should have a minimal toxicological effect on animals and man, and with only minimal residues in meat and milk; but unfortunately, such an ideal acaricide has not yet been produced in the chemical production system (Bates, 1993; Thullner, 1997; Bates, 1998).

2.5.3.1 Plung Dips Method

Plunge dips method remains one of the most efficient and reliable method for routine acaricide applications at farm level, and with this procedure, the animals are completely wetted, all parts of the body having adequate contact with the acaricide solution and problems with maintenance of the correct concentration of the acaricide are common and elaborate installations for handling of animals are necessary but there can be environmental pollution from the run-off

liquid when the animals are emerged and from the dip, and the facilities are very expensive to build and they are not appropriate for some acaricide of environmental stability and other reasons of acaricide usage (Downing, 1994; Lund *et al.*, 1998; Sherwood *et al.*, 1999).

2.5.3.2 Wash/Spray

The application of acaricide on sheep and goat can be carried out using various modes of spraying devices, like spray races or corridors, motorized pumps, backpack manual pumps and if carried out correctly, animals receive more individual treatment and the amount of the acaricide applied is controlled and the concentration of the acaricide is adequate, and spraying or washing is also generally less expensive per head than dipping, and the chemical group can easily be changed and no stabilizer is required for Amitraz if it is used immediately; but the animals are not always completely wetted, especially in the lower body parts and insides of the ears; meanwhile, animals must be appropriately secured during the operation, with the backpack manual pump, it is time-consuming and fatiguing for the operator; but the use of manual spray pumps may well be the simplest method of acaricide application to animals, but not necessarily the most effective and its success depends very much on the operator's skills and the effectiveness of restraining the animals and there is the risk of environmental pollution, increased risk of intoxication to the operators and frequent problems with blocking of the spray nozzles in the process of usage (Higgs *et al.*, 1994; Sinclair, 1995; Levot and Lund, 2004).

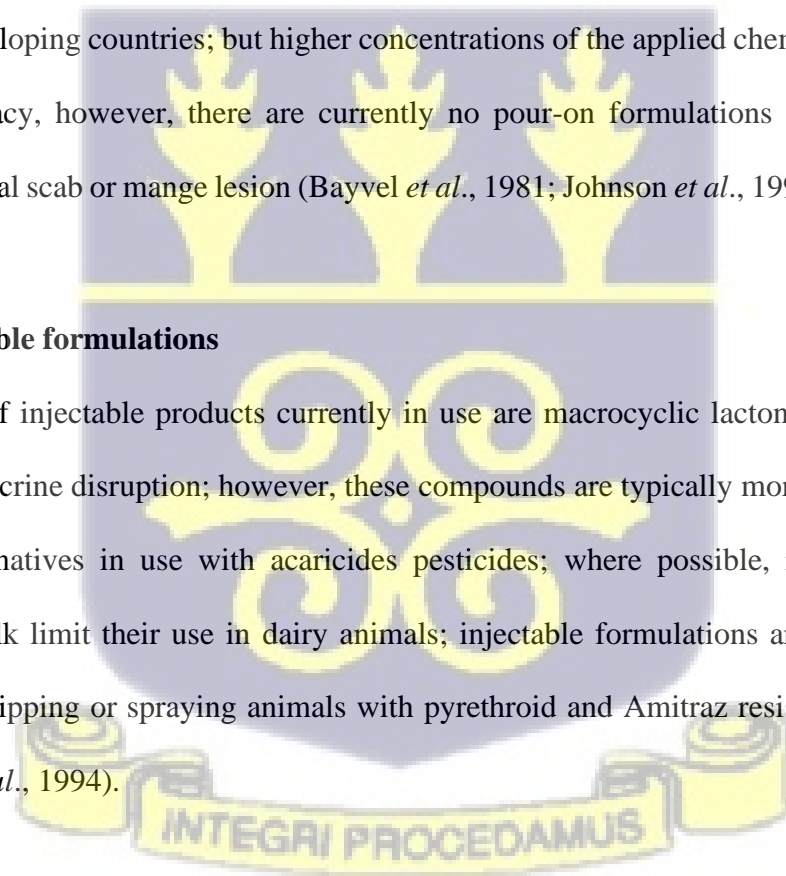
2.5.3.3 Pour-on Method

The introduction of this pour-on method of acaricide application was a remarkable advance in technology for applying acaricides; but a volume of the acaricide proportional to the weight of the animals is applied along/on the dorsum of the animal, from where it dissipates over its body surface to kill infesting mites; but in the case of some synthetic pyrethroids (SPs) depending

on their residually active period, they could also offer continuing lethal and repellent protection against subsequently arriving mites and in the case of macrocyclic lactone (ML) compounds, the method permits the parasiticide to be absorbed and to act systemically; meanwhile acaricides are easy to apply, environmental pollution is reduced, it is a very practical method especially where no dip tanks are available and in circumstances when the producer wishes to avoid dipping some of the infested animals like pregnant females, just a few animals need to be treated; but some of the SP compounds can be applied with this formulation and new formulations of MLs and other compounds employing this method of application are being introduced and offer an alternative for the control of pyrethroid resistant strains of animal mite; meanwhile, the higher cost of these new compounds may be an initial limitation for many farmers in developing countries; but higher concentrations of the applied chemicals are needed for good efficacy, however, there are currently no pour-on formulations available for the control of animal scab or mange lesion (Bayvel *et al.*, 1981; Johnson *et al.*, 1995; James, 2002).

2.5.3.4 Injectable formulations

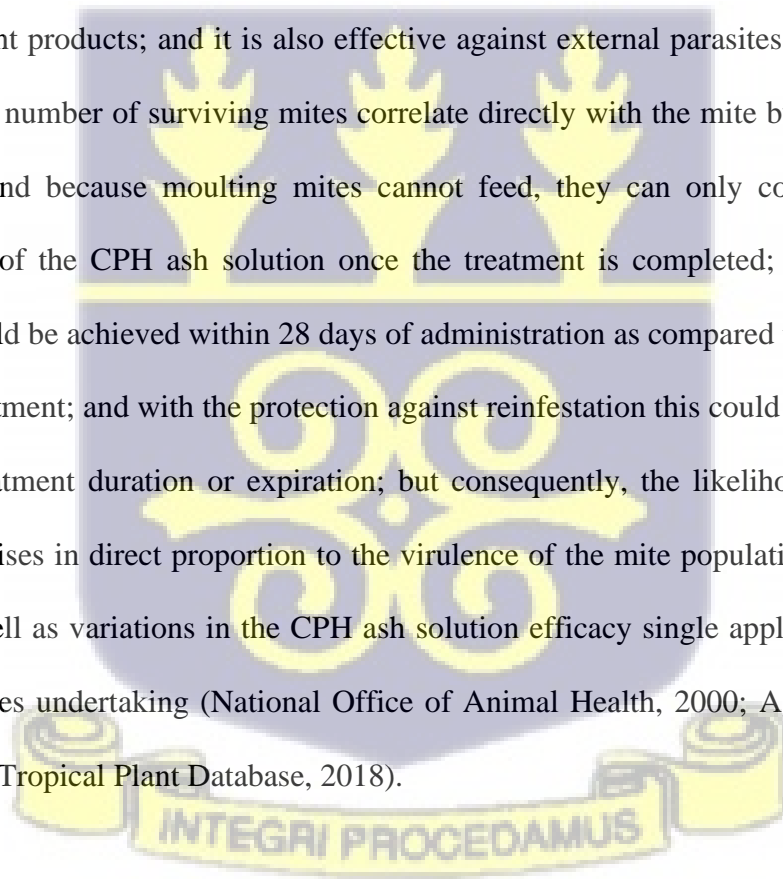
The majority of injectable products currently in use are macrocyclic lactones (MLs), which cause less endocrine disruption; however, these compounds are typically more expensive than the other alternatives in use with acaricides pesticides; where possible, residues of such products in milk limit their use in dairy animals; injectable formulations are another useful alternative to dipping or spraying animals with pyrethroid and Amitraz resistant mite strains (Thompson *et al.*, 1994).



2.5.3.5 Topical treatment method of CPH ash solution

Cocoa pod husk (CPH) ash solution contains potassium hydroxide as a medicinal source for treating skin problems in both animals and humans; the CPH ash solution is an antiparasitic agent use in the treatment of skin disease in the rural or local settings by formulating it into local soap to bathe in and also smearing it on the affected skin part in cases like rashes (Agyente-Babu and Oddoye, 2005; Tropical Plant Database, 2018).

The CPH ash solution is quicker and safer to use, causing less stress to sheep and goat, including pregnant ewe and nanny respectively; and does not require any special handling facilities or fixed equipment like dip baths; but rather tooth brush is used to apply CPH ash solution topically on the skin; in addition, there are no environmental concerns regarding the disposal of spent products; and it is also effective against external parasites as ectoparasites; meanwhile, the number of surviving mites correlate directly with the mite burden at the time of treatment, and because moulting mites cannot feed, they can only consume sublethal concentrations of the CPH ash solution once the treatment is completed; a complete mite eradication could be achieved within 28 days of administration as compared to mite load after the 14days treatment; and with the protection against reinfestation this could begin from 21 to 28 days of treatment duration or expiration; but consequently, the likelihood of using this method could rises in direct proportion to the virulence of the mite population at the time of treatment as well as variations in the CPH ash solution efficacy single application and good hygiene practices undertaking (National Office of Animal Health, 2000; Agyente-Babu and Oddoye, 2005; Tropical Plant Database, 2018).



2.6 Side effects of antiparasitic agents

The resistance to current chemical compounds of insecticides or acaricides as a side effect of antiparasitic drugs is an undeniable threat to the animal health system's long-term viability

(Hennessey and Andrew, 1997). Producers' access to insecticides and acaricides will most likely decline faster than new compounds are registered; however, producers must be given access to alternative control measures if residue issues result in the deregistration or further regulation of acaricide or pesticide use (Levot, 2000). Control and eradication campaigns continue to rely heavily or entirely on acaricides or pesticides despite increased efforts to establish integrated pest management (IPM) or integrated mite management (IMM); which can jeopardize their effectiveness and eventually become a barrier to global trade, particularly when maximum residue levels (MRLs) are exceeded; but MRLs are not exceeded and farmers may respond by increasing the dosage or frequency of application; which results in further resistance of susceptible parasites or pests and an increase in susceptible individual parasites or pests; meanwhile, irrational countermeasures can increase residues in meat, milk, wool, or hides, as well as the environmental impact of processing the latter, even if the next step is to smother the remaining parasites or pests with the same type of persistent application and resistance to the new chemical evolves in the same way (Kunz and Kemp, 1994; Thullner, 1997).

2.6.1 Chemical compounds of antiparasitic agents

There are various chemical compounds used to control ectoparasites depending on resistance and how they are administered to hosts; currently, there are no known techniques for analyzing Psoroptes mite resistance to ingested acaricides like doramectin, ivermectin, or moxidectin; however, techniques for analyzing Sarcoptes mite resistance have been discovered, and these tests are based on Sarcoptes migrational ability, but the test is accurate, sensitive, and simple to conduct; however, accurate determination of the acaricide concentration in the substrate is also necessary, as with all acaricide resistance assays; mite activity is expressed as a migration index (MI) and compared to a known standard, but good results were obtained for the

organophosphates (OPs) parathion, phosmet, phoxim, and ivermectin (Brimer *et al.*, 1993, 1995).

2.6.1.1 Inorganic compounds

For the control of scabs or lesions, inorganic compounds with one of four active ingredients, such as tar acid/tar oil dips, arsenic dips, lime-sulphur dips, or tobacco dips, were previously used; all of these substances required a second dip within 14 days to kill the emerging larvae that had hatched from the eggs (Lund *et al.*, 1998).

2.6.1.2 Organochlorine compounds

The previously organochlorine (OC) compounds developed as a group of insecticides or acaricides were the organochlorines and cyclodienes, such as gamma benzene hexachloride (BHC), aldrin, and dieldrin; although their exact mechanism of action was unclear, OCs were known to disrupt the delicate sodium and potassium balance within cells, which interfered with regular nerve impulse transmission; but plunge dip formulations with BHC were created, and these were efficient at a single dipping, getting rid of mites and leaving enough chemical on the fleece and skin to get rid of hatching parasites for a few weeks after dipping (Lund *et al.*, 1998). The main acaricide or pesticide used in the fight against mites was dip dipping in BHC wash, which was used all over the world until it was voluntarily withdrawn due to residues in meat and strains of mite resistance to BHC were developed, hampered mite control, but eventually mites congregated to the use of organophosphate-based formulations, which are currently in use (Kirkwood, 1986; Nuñez, 1977).

2.6.1.3 Organophosphate compounds

Organophosphate compounds were the first generation of insecticides or acaricides to come into use; they work by inhibiting cholinesterase (ChE) enzymes and preventing the removal of acetylcholinesterase (ACh), whereas the latter blocks the circuit by accumulating by interfering with the neuromuscular junction, but Diazinon was approved for mite control (Kirkwood and Quick, 1981; Kirkwood and Quick, 1982).

2.6.1.4 Synthetic pyrethroids

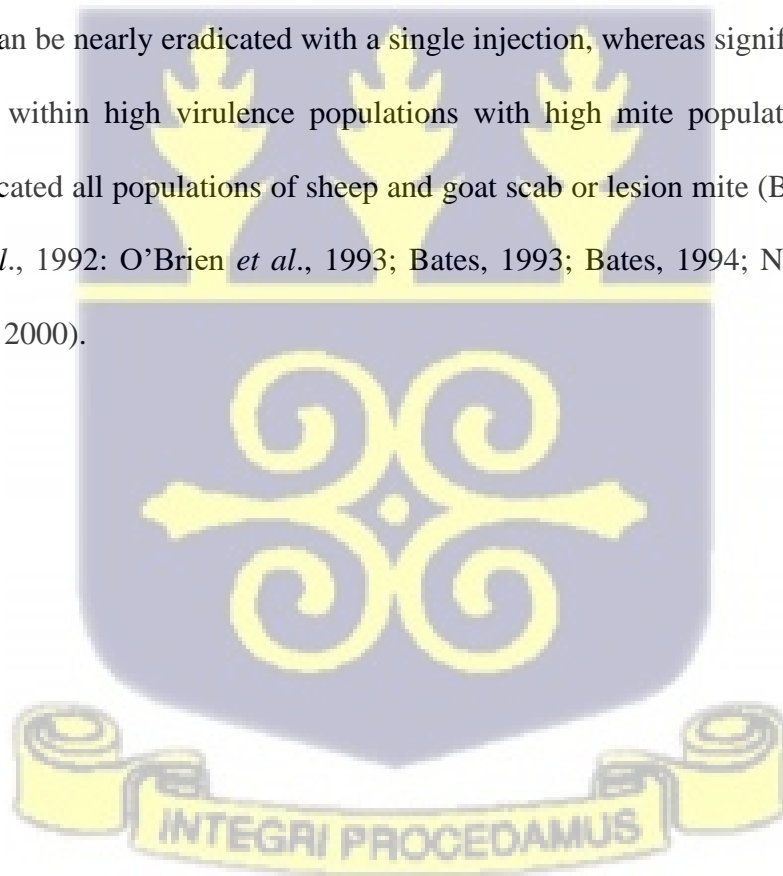
The first non-organophosphate (OP) dips used to control mites were synthetic pyrethroids (SPs), which contained the synthetic pyrethroid flumethrin; high cis cypermethrin (HCC) was also used, and SPs have the advantage of excellent selection, high toxicity on arthropods, and relative safety to mammals; however, SPs affect the neuronal membrane by changing sodium channels, possibly preventing protein conformational changes at the lipid-protein interface, and in a manner similar to organochloride (OC) compounds; many people believed that the development of DDT resistance by pests or mites around the world portended a similar fate for SPs, despite the fact that SPs and DDT have striking similarities and both have two types of insecticide effects: (a) an initial rapid knockdown, rendering the insect motionless, and (b) a subsequent lethal effect (Kirkwood and Bates, 1987; Kirkwood and Bates, 1987b; Miller, 1988; O'Brien *et al.*, 1997). Amitraz and other acaricides have been proven to be effective against mite infestation, but they are very expensive and are only used as OP resistance breakers; additionally, the dip wash must be stabilized in the dip bath using calcium hydroxide, and less expensive generic amitraz products are now readily available; the use of OP sebacil or phoxim for mite control (Meerman, 1978; Muñoz Cobenas *et al.*, 1978; Curtis, 1985; Worbes, 1995). This means that mites in the ears could therefore survive during dipping, and their exposure to sublethal concentrations of an acaricide or pesticide could select for resistance; however, SPs

plunge dips were generally more effective than pour-on formulations, not just due to their acaricidal or pesticidal effects; the SP pour-ons were ineffective against sheep and goat mites, and their widespread use for ectoparasite control may have induced resistance to SP dips and enhanced existing SP tolerance in a population; additionally, stock owners, particularly those suffering from the toxic effects of OPs, were no longer required to use plunge dips and were faced with a wider selection of products for the control of ectoparasites (Bates, 1993; Bates, 1998).

2.6.1.5 Systemic injections

Avermectins like ivermectin and doramectin, as well as milbemycins like moxidectin, which have higher potency and a broader spectrum antiparasitic activity than their fermentation precursors abamectin and nemadectin, respectively, are produced by soil microorganisms through systematic injections of macrocyclic lactones (MLs), which are chemically modified fermentation products but Ivermectin, which is derived from *Streptomyces avermitilis*, was the first endectocide used for mite control; it was administered via two subcutaneous injections separated by seven days during animal treatment, but sadly, it has provided little to no residual protection against reinfestation, so sheep and goats should not be returned to infested pens or pastures for at least 17 days; however, it has been demonstrated that single or double subcutaneous injections of milbemycin and moxidectin, both derived from *Streptomyces cyaneogriseus*, cure mites and offer residual protection against reinfestation for 28 days of duration; doramectin, another avermectin, was used for mite control and was curative after a single intramuscular injection (O'Brien *et al.*, 1994, 1996; Williams and Parker, 1996; Parker *et al.*, 1999). Plunge dipping is quicker and safer to use, causing less stress to sheep, including pregnant ewes, and does not require any special handling facilities or fixed equipment like dip baths; additionally, there are no environmental concerns regarding the disposal of spent

products; the endectocides, also known as MLs, are effective against both internal as endoparasites and external as ectoparasites; meanwhile, the number of surviving mites correlated directly with the mite burden at the time of treatment, and because moulting or pharate mites cannot feed, they can only consume sublethal concentrations of the acaricidal once the treatment is completed; ivermectin has been studied as an intra-ruminal controlled release capsule (CRC), but complete mite eradication was achieved within 28 days of administration, with protection against reinfestation for 21 to 28 days of treatment duration or expiration, but consequently, the likelihood of using this evasive tactic rises in direct proportion to the virulence of the mite population at the time of treatment as well as variations in the effectiveness of ivermectin single injections, meanwhile, low virulence populations with low mite numbers can be nearly eradicated with a single injection, whereas significant numbers of mites survived within high virulence populations with high mite populations, but double injections eradicated all populations of sheep and goat scab or lesion mite (Bates and Groves, 1991; Soll *et al.*, 1992; O'Brien *et al.*, 1993; Bates, 1993; Bates, 1994; National Office of Animal Health, 2000).



CHAPTER THREE

3.0 METHODS

3.0 Introduction

This chapter describes all of the methods used to achieve the study's objectives. It discusses the study setting and location, randomization, treatment arm, control arm, study participant inclusion criteria, sample size and sampling strategies used, mite processing and identification, samples of before and after goats treated, and statistical methods used for analysis.

3.1 Study Setting and Location

The research was carried out in the Asamankese district of the Eastern Region. Asamankese has 104 communities; from 2004 to 2020, over 100 communities have benefited from mange disease intervention or management; however, there are 4 communities that have never benefited from this program. These communities were: 1. Dogo, 2. Lartey, 3. Anomabo, and 4. Quarshie; these communities have similar characteristics and interests. This current study targeted one of these communities that has severe mange infestation. The Quarshie community was randomly selected among these 4 communities. The Quarshie community has 40% mange infestation rate among goats, land area size of 0.5 mile square (312 acres), is not fully developed, but development is ongoing, and has a goat population of 1,737 with 45 completed houses, 100 households, and only 80 of which rear goats. The Lartey and Dogo communities have 5% mange mite infestation rate among goats, and very close in terms of proximity or land demarcation and have land area size of 0.25 mile square (156 acres) each and reason being that, land size of 0.5 mile square shared among 2 persons, informed by contact person and having goat population of 220 and 206 respectively and houses of 25 and 22 which comprised of 46 and 32 households respectively, but it was 20 and 18 households raised goats. The Anomabo community has a 5% mange infestation rate among goats, a land area size of 0.125 mile square

(78 acres), a goat population of 216, 13 completed houses, 31 households, 24 of which rear goats. Mange was by far the most common disease in these communities, though some households experienced severe open wound complications as a secondary infection (Personal Diagnosis and Communication with Participants). Mange was prevalent during the rainy season, but nearly all households either enclosed or freely opened their goats during the dry season (Asmaa *et al.*, 2014).

3.2 Study design

The study design applied cluster randomized control trials (cRCT) at the Quarshie community in the Asamankese district. The study design consisted of these three phases: (i) stakeholder engagement, (ii) scoping survey, and (iii) household recruitment. The stakeholder engagement was to explain the rationale behind the programme and grant permission. The scoping survey was to identify households in the community and those who met the inclusion criteria (Section 3.3). Household recruitment was to identify household owners who were willing to take part in the intervention program. From the survey conducted, 60 households met the inclusion criteria (Section 3.3). The households' numbers were used to randomize a 1:1 ratio of treatment and control. Households were randomized into treatment and control arms at the cluster level. A cluster was defined in this study as a household. In each household, the treatment-control ratio was 1 to 1. The goats in the treatment arm received cocoa pod husk (CPH) ash solution of 5ml, applied on the skin using a sterile tooth brush, and the goats in the control arm received placebo of 5ml, applied on the skin using sterile tooth brush, in accordance with the US FDA-PAP protocols or procedures. Data was collected at the baseline of day 1 and endline of day 14.

3.3 Inclusion criteria

A survey was conducted house by house to inform whether households met the inclusion criteria such as (i) intensive housing management (keeping goats indoors throughout the programme), (ii) good hygienic practices by cleaning the pen daily, (iii) goats housed in a well-constructed and roofed pen, and (iv) if household goats were not treated with any extract, then the purpose of the study was explained to the household head or a representative.

3.4 Sample size and sampling methods/procedures

The sample size was not determined to demonstrate an intervention effect for the primary outcomes because the study was designed as a feasibility trial to inform a future large-scale field trial. However, the study sample was to provide a sufficient indication of the relationship between a decrease in household goat mange infestation and improved goat skin health outcomes across and among interventions (treatment arm). In addition, the study sample allowed for the combination of qualitative and quantitative data collection, daily goat monitoring, and household compliance with hygiene practices follow-up.

The sampling methods and procedures were to include households that had pens for goats, reared goats indoors or intensively and cleaned the pen daily. A census was conducted to count households that met the criteria and were issued identification numbers. Based on the inclusion criteria, goat farmers were recruited from households to discuss the reasons for the research. Hair loss, crusty or scaly skin lesions, dermatitis, thickened skin, and pruritus were signs and symptoms of mange and were all observed in the goats (Tadesse *et al.*, 2011). The US FDA-PAP was used to select goats for cages from each household. The larger skin infestation spots were scraped for laboratory analysis; the larger the infested skin spot, the more mites are found, and the smaller the infested skin spot, the few mites are found. Despite the fact that the sizes of the infested skin spots may vary slightly between households, this was the guiding principle

in selecting one goat per household. The Vet. field worker visited eligible participants in their homes to administer the questionnaire, the questionnaire was divided into four (4) sections: (i) home environment, (ii) socioeconomic status, (iii) household feed use, and (iv) questions on household used of any extract in mange treatment; The home environment questions focused on grazing practices, goat housing and roofing material type, and signs of damage in the goat house; sources of drinking water, feed availability, and general cleanliness of the goat house; Socioeconomic status addressed the availability of assets in the household, and inquired about goat treatment practice; this question was also designed to inform about household methods of treating goats. This stage of the project was carried out among eligible households based primarily on labour intensity, budget, and time constraints.

3.5 Randomization

Randomization is the process of assigning participants to treatment and control groups, assuming that each participant has an equal chance of being assigned to any group. Each household was assigned an identification number, which would be used to inform the randomization of households, and households that were not chosen for the study were informed. A statistician who was blinded (unaware) to the households randomized an equal number of the households into treatment and control arms. Households of 60 were randomized into the treatment arm of 30 goats and the control arm of 30 goats by using numbers that were generated on a computer.

3.6 Treatment arm

The cocoa pod husk (CPH) ash solution was subjected to two analyses:

(1) phytochemical constituents, physicochemical data, and organoleptic properties at the Centre for Plant Medicine Research at Mampong Akwapim in the Eastern Region. The test was

carried out to prove CPH ash solution as a potent plant medicine, while the owner of the product (drug) would not be permitted or explained the laboratory test processes or procedures to, and would only be authorized to pay for the cost and assigned the date of test results collection.

(2) In-vivo Acaricidal Test (Efficacy Test) and Acute Dermal Toxicity Test (Safety Test) at Animal Experimentation-Noguchi Memorial Institute for Medical Research (NMIMR) in the University of Ghana, Legon. Here, Efficacy test was conducted on mice infested with mange, and 5ml of the CPH ash solution was applied to each of the mice after taking mange lesion samples as pre-treatment samples at day1 and taking them to the laboratory to find out the number of mites present. After waiting 14days, the second sample was taken as post-treatment samples to compare the number of mites before and after the test to see whether the CPH ash solution efficacy was enough to affect the mite load on goat skin. The Safety test was conducted on the mice which were treated with CPH ash solution, and the mice were slaughtered, and organs such as the lungs, kidneys, liver, and skin portion were analysed for toxic effects. The two (2) test results are placed in the appendix.

3.6.1 Preparation of cocoa pod husk (CPH) ash solution

The fresh and healthy cocoa pod husks were collected from the Asamankese cocoa production station in the West Akim Municipality. A GPS (etrex VISTA H, GARMINI Germany) reader was used to take the geographical coordinates (05.50'55,9" N) and (000.40'47,8" W) indicating the exact location of the plant sample collection site.

The cocoa pod husks were dried in an oven at a temperature of 80°C for 24 hours in the cooperative seed producers (CSP) drier. The dried cocoa pod husks were placed on an aluminium sheet and set on fire. It was then burned into ash powder and allowed to cool to room temperature. The ash powder was collected and sieved with a rubber net to have a fine coarse

(cocoa pod husk ash powder); finally, it was transferred into transparent polythene bags for extraction (Newman *et al.*, 2003).

In a sterile conical flask, 60ml of distilled water (DW) was added to 40g of CPH ash powder, forming a solution. The solution was thoroughly mixed in the sterile conical flask with a rubber stirring rod for five minutes, yielding a lethal concentrated solution. The CPH ash solution was filtered through Whatman No. 1 filter paper, and the filtrate was obtained in the form of a black liquid solution, and dispensed into a sterile rubber container, tightly covered, and stored at room temperature for later use (Newman *et al.*, 2003).

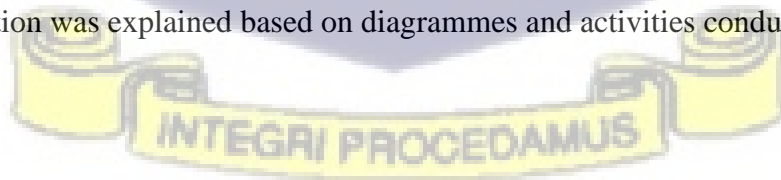
3.7 Control arm

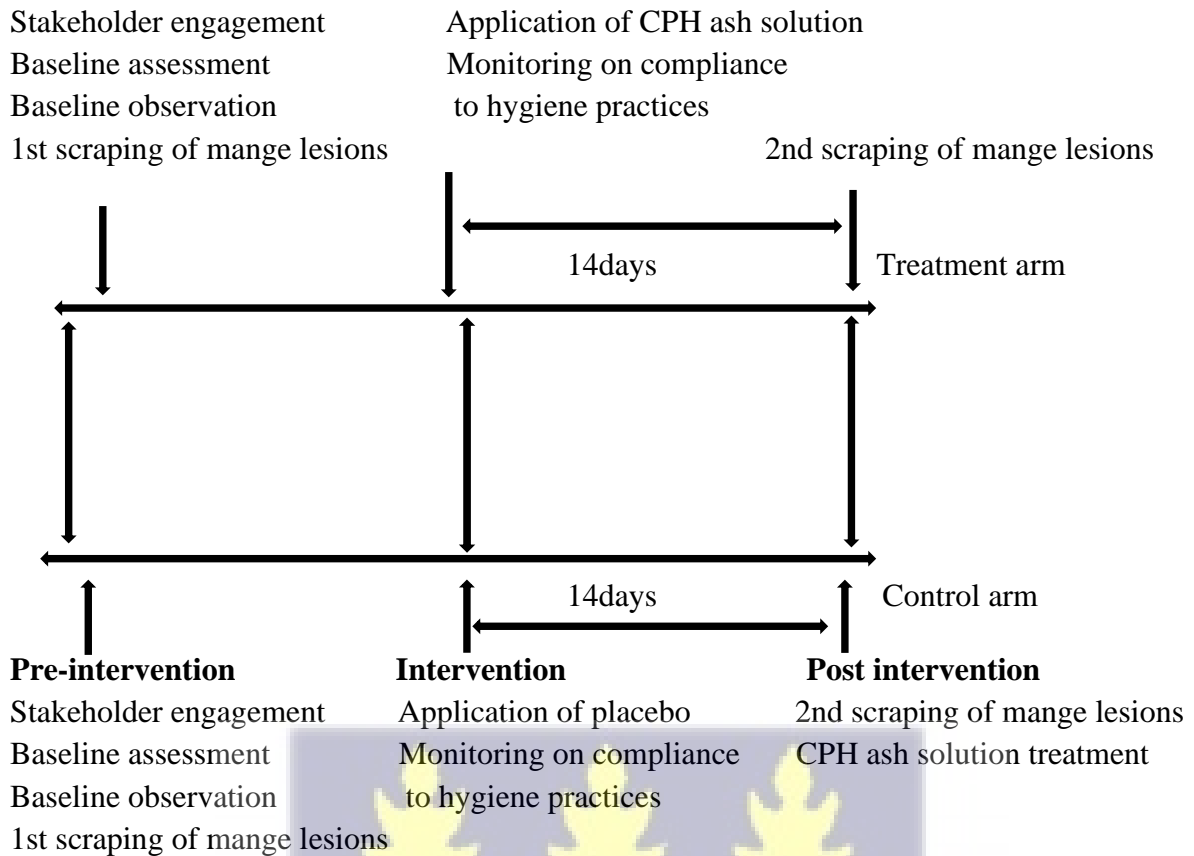
3.7.1 Preparation of Placebo Solution

Placebo was prepared by measuring 60ml of DW and 40g of activated charcoal powder (ACP) in a conical flask and stirring for 5 minutes with a rubber rod to produce a black liquid solution that was then filtered with Whatman No. 1 filter paper. A placebo solution prepared was then dispensed into a sterile rubber container, tightly covered, and stored at room temperature for later use. The goal of the ACP is to have a black solution, similar to the CPH ash solution, so that participants are blinded to differences in the drugs (Newman *et al.*, 2003).

3.8 Data collection

The data collection was explained based on diagrammes and activities conducted as follow:





3.8.1 Pre-intervention assessment

The pre-intervention assessment includes the following activities that were carried out at the community and households level within a period of 10days:

3.8.1.1 Stakeholder engagement

The research team (PI and Veterinary field worker) were led by a community member (contact person) with extensive knowledge of the local area to meet with local chiefs, community elders, opinion leaders, and community groups to inform them about the project and seek permission to carry it out, and summary of the project was provided and this lasted for 1day.

3.8.1.2 Baseline assessment

The research team conducted a scoping survey over two days after informing stakeholders and obtaining permission for the following purposes: (i) to inform the community about the project; (ii) to count households in each participating house to inform selection of households for the proposed study; and (iii) to map out the study area; A questionnaire was developed to collect the following data: household goats' mange treatment requirements based on household size to inform the amount of CPH ash solution required per household per treatment and the quantity of feeding trough required to feed these goats; type of feed use, feed sources, feed consumption pattern and household goat structure (pen), mange treatment pattern, and household income or wealth.

A field worker (a veterinary field worker) received three days of training at Asamankese from 08:30 a.m. to 3:30 p.m. The field worker was trained on the dos and don'ts of field projects, research project management, his roles in the project, ethical issues such as study participant rights, and interview techniques on the first day; On the same day, he participated in exposure monitoring practical sessions, which included locating an appropriate location in the goats' confinement and quality monitoring, as well as assisting participants in easily accessing the goats in pen cleaning, feeding, and watering; On day 2, field worker learned how to scrap mange lesions into sample containers with a scalpel blade dipped in olive oil, how to store samples in an ice chest for laboratory examinations, how to record data in the provided field note book, and how to apply or smear the CPH ash solution and placebo on the goats' skin using sterile tooth brushes; On day 3, the administration of questionnaires to conduct interviews was thoroughly discussed, and benefits and drawbacks of adhering to treatment protocols with the two households (Treatment; Controls) at the community level (Taylor et al., 2007).

3.8.1.3 Baseline observation

A baseline observational check list was conducted after households were randomized into two to address the feedback from the questionnaires administered, which lasted for 1 day, and also to start the construction of the intervention cages for the treatment and control arms, which lasted for 3 days.

3.8.1.4 First (1st) scraping of the mange lesions

This took place on day1 prior to the intervention phase and was done for the goats in both treatment and control arms at the same time. The mange lesions were scraped with a scalpel blade dipped into olive oil, placed in individual labelled sample containers bearing goat ID numbers, and were packaged into a large vaccine carrier and sent to the Veterinary Services Directorate (VSD) Laboratory LA, Accra. Figure 3.2 shows mange disease that was scraped, and figure 3.3 shows the sample container used in mange lesions collection:



Figure: 3.2 Images of mange disease on goats



Figure: 3.3 Image of a labelled sample container with scraped mange lesions samples and convey for Lab. examination

3.8.2 Intervention

The intervention was to apply CPH ash solution and placebo treatments to the treatment arm and control arm, respectively. In the treatment arm, one goat from one household was selected. Households received hygiene practices such as feeding, watering, and pen cleaning, and these were observed every day to ensure compliance with the intervention trial. Numbers were used to identify the goats throughout the 14-days period, and to ensure animal welfare and minimize pain, the goats were not ear-tagged; instead, ink paint was used to number the goats on the body side (flank) as Id 1, 2, 3, and up to 30, while the goats were housed in the treatment cages. CPH ash solution was used for mange treatment and applied to the goat skin using a sterile tooth brush dipped into 5ml doses. The goats in each household were completely treated on their entire body to reduce mite reinfestation before being selected into 15 cages, and 2 goats were kept in each cage. The veterinary field worker who administered the CPH ash solution was blinded (unaware) to the extract (drug) in terms of the difference (colour) in the drug to treatment because it was black in appearance, but was only instructed to administer it to cages (Taylor *et al.*, 2007). These goats were properly restrained before CPH ash solution application and collection of mange lesions with a scalpel blade dipped in olive oil and scraped into sample containers bearing goat identification numbers at day 1 and day 14; the olive oil was used to

soften the lesion scrapings and make collection easier. Pre-treatment samples were collected for laboratory examination at day 1. Post-treatment samples were collected on day 14 and sent to the laboratory for analysis. Data was collected at day 1 baseline and day 14 endline (Jones *et al.*, 2016).

In the control arm, one goat from one household was selected. Households received hygiene practices such as feeding, watering, and pen cleaning, and these were observed every day to ensure compliance with the intervention trial; Numbers were used to identify the goats throughout the 14-days period, and to ensure animal welfare and minimize pain, the goats were not ear-tagged; instead, ink paint was used to number the goats on the body side (flank) as Id 1, 2, 3, and up to 30, while the goats were housed in control cages. Placebo was applied to the goat skin using a sterile tooth brush dipped into 5ml doses at the site where mange was spotted on the body before selecting 1 goat per household into 15 cages, and 2 goats were kept in each cage. The veterinary field worker who administered the placebo was blinded (unaware) to the extract (drug) in terms of the difference (colour) in the drug to treatment because it was black in appearance, but was only instructed to administer it to cages (Taylor *et al.*, 2007). These goats were properly restrained before placebo application and collection of mange lesions with a scalpel blade dipped in olive oil and scraped into sample containers bearing goat identification numbers at day 1 and day 14; the olive oil was used to soften the lesion scrapings and make collection easier. Pre-treatment samples were collected for laboratory analysis at day 1. Post-treatment samples were collected on day 14 and the goats in cages were treated with CPH ash solution before lesions were sent to the laboratory for examination. Data was collected at day 1 baseline and day 14 endline (Jones *et al.*, 2016). Figure 3.4 shows a mange goat treated with cocoa pod husk (CPH) ash solution:



Figure 3.4: Pre-treatment sample of mange infested goat after CPH ash solution was applied

3.8.2.1 Monitoring

This began after baseline activities had ended, and this continued on a daily basis for 13 days in the treatment arm and control arm to see if both arms complied with the hygiene practices (Table 5). The goal was to see if hygiene practices were followed and could have a correlation with mite reduction or increase.

3.8.3 Post-intervention

The post- intervention was to carry out the following activities on the goats:

3.8.3.1 Second (2nd) mange lesions scraping

This was done in the treatment and control arms at the same time, and mange lesions were collected for laboratory examination.

3.8.3.2 CPH ash solution treatment

After lesions had been scraped, the control arm goats were treated with the CPH ash solution before samples were sent to the laboratory for examination to compare the count of the 1st and 2nd lesions examined to deduce whether mite numbers increased or decreased.

Figure 3.5 and figure 3.6 show after mange infested goats were treated (Figure 3.2 and 3.4) respectively:



Figure 3.5: Post-treatment sample of mange treated goat

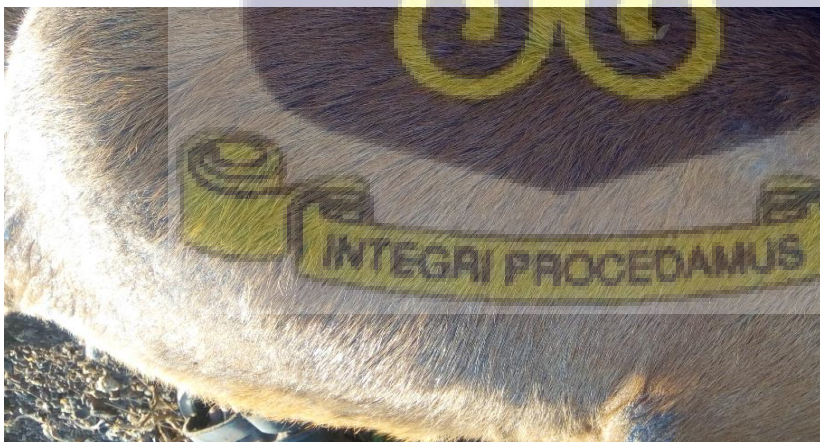


Figure 3.6: Post-treatment sample of mange treated goat

3.9 Processing and identification of mites at the laboratory

The Veterinary Services Directorate (VSD) Laboratory LA, Accra, performed parasitological analysis in accordance with the US Food and Drug Administration-Parasitological Analysis Protocol (US FDA-PAP); mange lesions were aseptically scraped into sample containers with a sterile scalpel blade, tightly wrapped, packed into an ice chest container, and sent to the laboratory for analysis (Hendrix, 1998; Chauhan and Agerwal, 2006). Samples were transferred to test tubes with beard labels with the goats' identification numbers in the laboratory. The mange lesion samples were digested in ten millilitres (10ml) of 10% potassium hydroxide (10% KOH), and the test tubes were packed into a glass beaker containing fifty millilitres (50 ml) of water and placed on an electrical hot metal plate to boil for two minutes (2min) at 100 °C. The test tubes were removed from the glass beaker and placed in a rubber container containing 100 millilitres (100ml) of water for five minutes (5min) to cool the samples; the test tubes were then removed and placed in a centrifuge at two thousand revolutions per minute (2000 rpm) for five minutes (5min) to allow the samples to settle, which is the sedimentation method (Hendrix, 1998; Chauhan and Agerwal, 2006). The suspended potassium hydroxide solution was poured out of the test tubes, leaving the sediment samples at the bottom, and the samples were drawn with a pipette. Two drops were placed on glass slides and covered with cover slides (Hendrix, 1998; Chauhan and Agerwal, 2006; AL-Kardi, 2013). Mites were examined and counted to determine the number of mites in a mange lesion, (Wall and Shearer, 2001; Taylor *et al.*, 2007). Figure 3.7 shows how images of mites were viewed under the microscope:

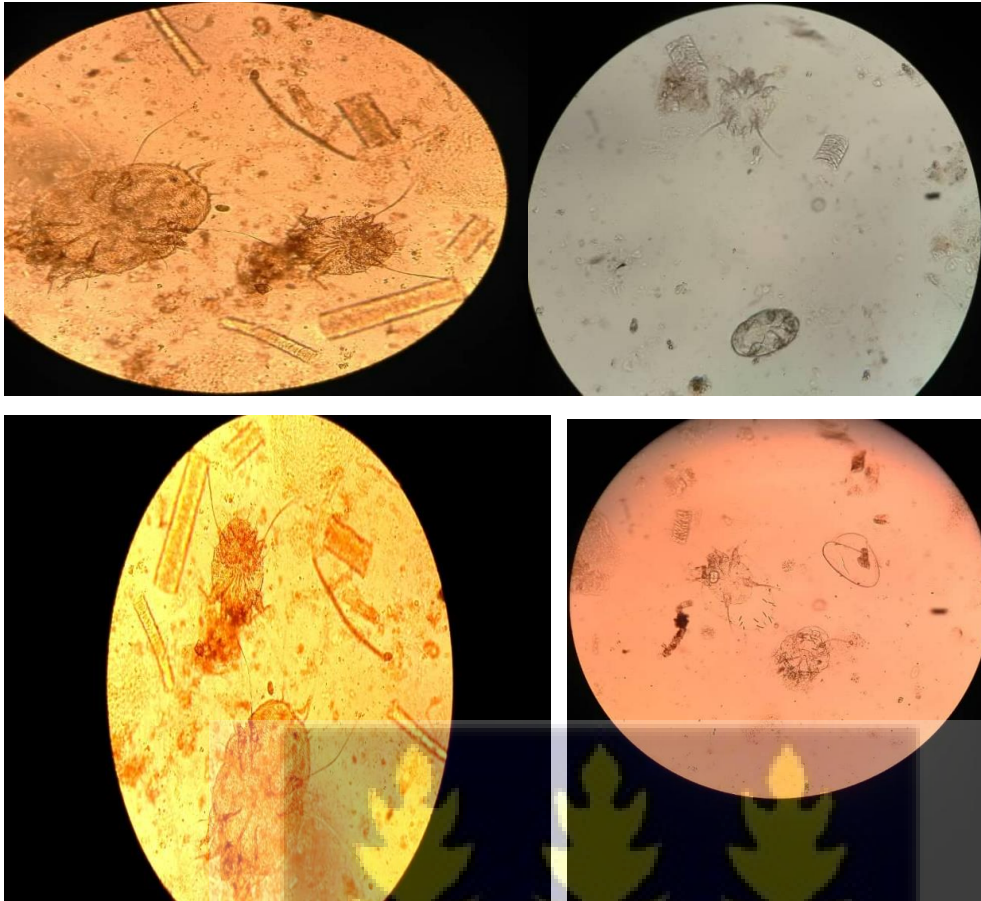


Figure 3.7 Images of mites viewed with the aid of a compound microscope at 10X magnifications

Source: Images of mites viewed with the aid of a compound microscope (Wall and Shearer, 2001; Taylor *et al.*, 2007).

3.10 Statistical method/Data analysis

Stata IC version 17 was used to analyze the data in this study (Stata Corp. College Station, TX, USA). The study's baseline characteristics were described using frequency and percentages. The Fisher's exact test was used to compare baseline characteristics between households in the control arm and those in the treatment arm in order to assess associations. The number of mites on goat skin was described using a histogram, with the minimum, maximum, median, and interquartile range of mites estimated. The Wilcoxon rank sum test was used to compare the median number of mites found on goat skin in two groups. The Kruskal-Wallis test was used to compare the difference in the median number of mites on goat skin at baseline between

categories of variables with three or more levels. The quantile regression model was used to identify the factors associated with the number of mites on goat skin across baseline household characteristics. Only variables from the bivariate analysis with a p-value less than 0.200 were considered in the adjusted quantile regression model. The results table also included the corresponding 95% confidence interval (CI) and p-values for the median coefficient estimate.

The box and whisker plots were used to compare the distribution of the number of mites on the skin of the goats by control and treatment at baseline and endline. The Wilcoxon rank sum paired test was used to compare the number of mites in the control and treatment arms before and after treatment. The Wilcoxon rank sum test was also used to compare the difference in mite numbers between the control and treatment arms.

The quantile regression model was used to estimate the effect of treatment on the change in the number of mites. Variables adjusted in the multivariable quantile regression model were those from the bivariate analysis of the baseline analysis with a p-value less than 0.200. All statistical analyses in this study were considered significant if the p-value was less than 0.005. The mathematical expression:

$$\text{Average difference} = \text{Pretreatment samples (day1)} - \text{Posttreatment samples (day14)}$$

$$\text{Percentage change (\%)} = \text{Average difference} / \text{Pretreatment samples} * 100$$

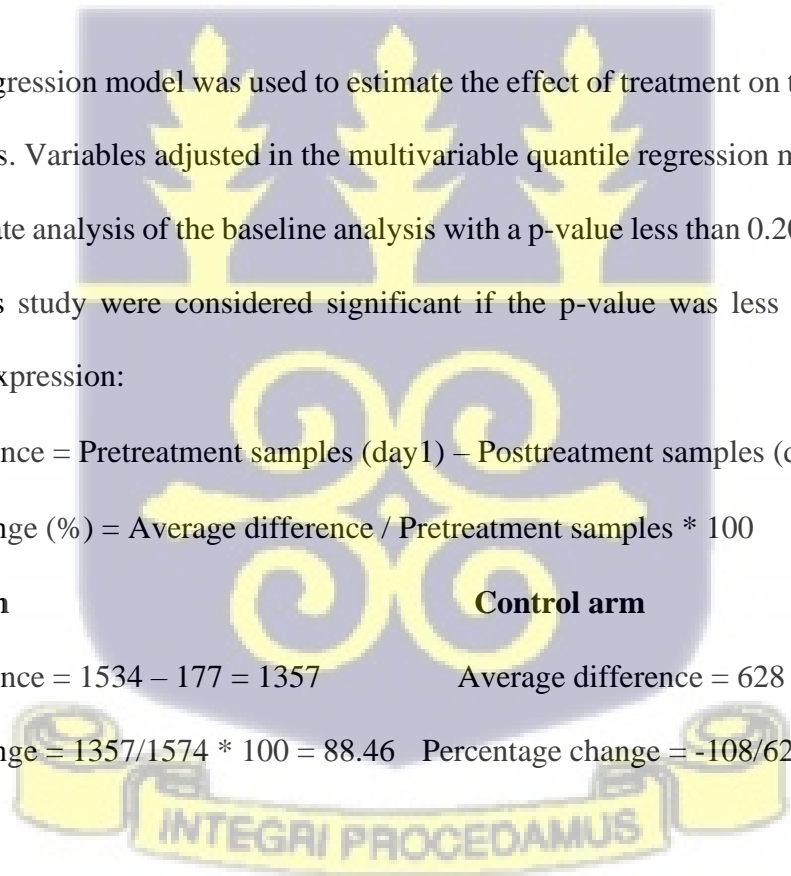
Treatment arm

Control arm

$$\text{Average difference} = 1534 - 177 = 1357$$

$$\text{Average difference} = 628 - 736 = -108$$

$$\text{Percentage change} = 1357/1574 * 100 = 88.46 \quad \text{Percentage change} = -108/628 * 100 = -17.20$$



3.11 Ethical considerations/issues

The University of Ghana Institutional Animal Care and Use Committee (UG-IACUC) granted ethical approval to the proposed research project. Participants were informed that their

information would be kept confidential and that any complaints should be directed to the project's field coordinator.



CHAPTER FOUR

4.0 MONITORING AND EVALUATION ISSUES OF THE STUDY

4.0 Introduction

This chapter discussed the monitoring and evaluation of a mange treatment intervention trial on goats using cocoa pod husk (CPH) ash solution, as well as the indicators to be measured and the study frameworks.

4.1 Description of the programme/project/guideline

The overall programme goal of the office international des epizootes (OIE) or world organization for animal health (WOAH) is to reduce the mange morbidity and mortality by 70% by the year 2030 using 2010 as the baseline (CTA, 2006; OIE, 2010; WOAH, 2013). The specific objectives of the WOAH towards the reduction of the mange burden by the year 2030 is listed below.

- To protect at least 90% of the animal population with effective mange prevention interventions.
- To provide a parasitological diagnosis to all suspected mange cases and provide prompt and effective treatment to 100% of confirmed mange cases.
- To strengthen the systems for surveillance and monitoring and evaluation to ensure timely availability of quality, consistent and relevant mange data at all times.
- To increase awareness and knowledge of the entire population on mange prevention and control to improve uptake of all interventions.

4.2 Type of evaluation

The two main types of evaluation are process evaluation and impact or outcome evaluation. Process evaluation is commonly used to describe program activities and perceptions during the development and early implementation stages of a program. On the implementation side, process evaluation entails a systematic assessment of the availability, allocation, and utilization of resources, activities undertaken, and related immediate outputs of a project or program. The first three of the logic model's five components, namely Input, Activities, and Output, are the primary focus of process evaluation. Impact evaluation is a set of procedures and methodological approaches used to demonstrate how much a change in intermediate or outcomes or impact can be attributed to the program. Impact or outcome evaluation, on the other hand, focuses on the final two components, namely, outcome and impact; impact evaluation seeks to quantify the benefits attributable to only the intervention implemented by the program or project, while excluding all other interventions or confounders (Gage *et al.*, 2016).

The type of evaluation measured in the study would be an impact evaluation. The goal of this study is to see how the long-term (day 14) benefit of the project affects the average difference and percentage change in pre-treatment and post-treatment sample outcomes tabulated on the treatment and control arms, respectively. Pre-treatment and post-treatment samples are the results of laboratory examinations or findings on both the treatment and control arms (Soll *et al.*, 1992).

The treatment and control arms (T and C) of 1-60 goats were all examined at day 1 as pre-treatment samples of T: 1-30 and C: 1-30 goat samples, respectively, and the same was applied to the post-treatment samples on day 14. Post-treatment results are subtracted from pre-treatment results, yielding average differences. The percentage change is calculated by dividing

the average difference by the pre-treatment findings and multiplying by 100 (Tolossa, 2014).

The mathematical expression:

Average difference = Pre-treatment samples (day1) – Post-treatment samples (day14)

Percentage change (%) = Average difference / Pre-treatment samples * 100

4.3 Study Frameworks

The study used two frameworks, the conceptual framework and the logic model, to describe the concept and the relationship between the average difference and percentage change of the pre-treatment and post-treatment samples; these frameworks also demonstrated how these interventions and other factors contributed to the reduction or increase of mite load in pre-treatment and post-treatment samples of the treatment and control arms, respectively, among household goats (McGaghie *et al.*, 2001).

4.3.1 The Conceptual Framework

The conceptual framework demonstrates how, theoretically, socio-demographic factors such as livestock farming, poor and marginalized farmers, small ruminant farmers, goats, and mites influence mange healing; the framework also demonstrates how accessibility factors implemented such as extraction from cocoa pod husks, availability of cocoa pod husks, distilled water (water for injection), mange disease detection, and aseptic brush affect mange healing (McGaghie *et al.*, 2001).

The need factors involving the CPH ash solution, knowledge on extract use, hygiene practices in the goat pen, well feeding of the goat, and enough clean water served to the goat are expected to have an effect on mange healing among household goats in the treatment arm of the study; the detection of mange disease, extraction from cocoa pod husks, how to use CPH ash solution, hygiene practices, and a well-served feed and water would have a significant reduction in mite

load, increased goat reproduction, and improved wealth among community households (McGaghie *et al.*, 2001). (Figure 4.1).

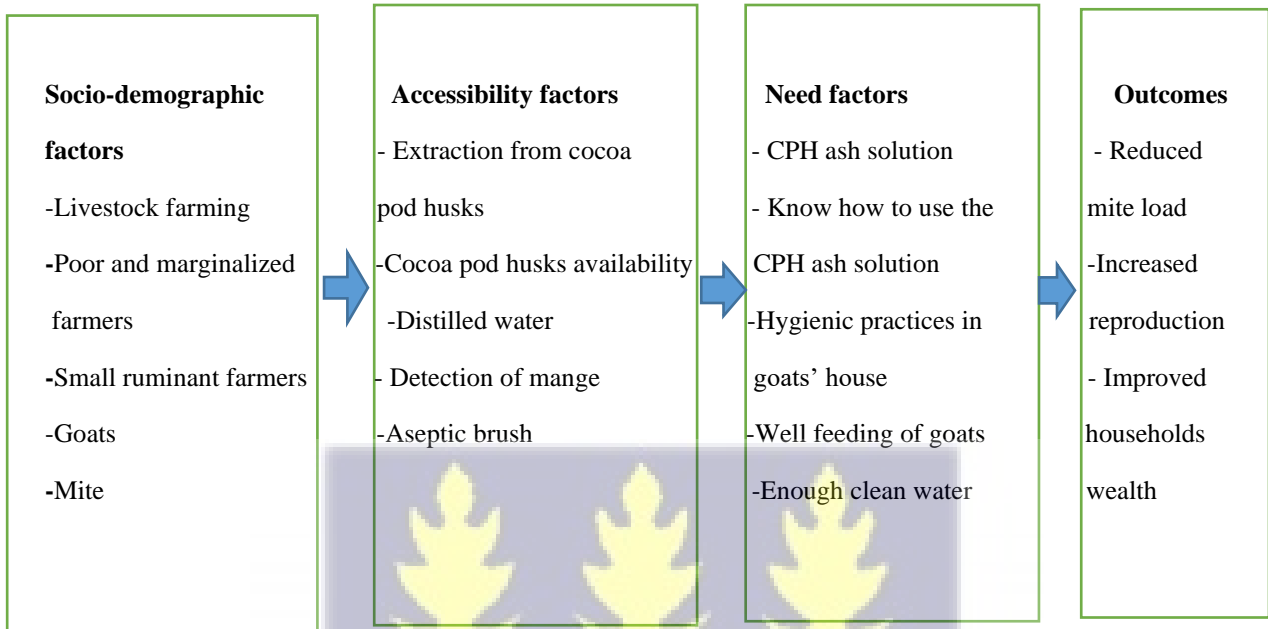


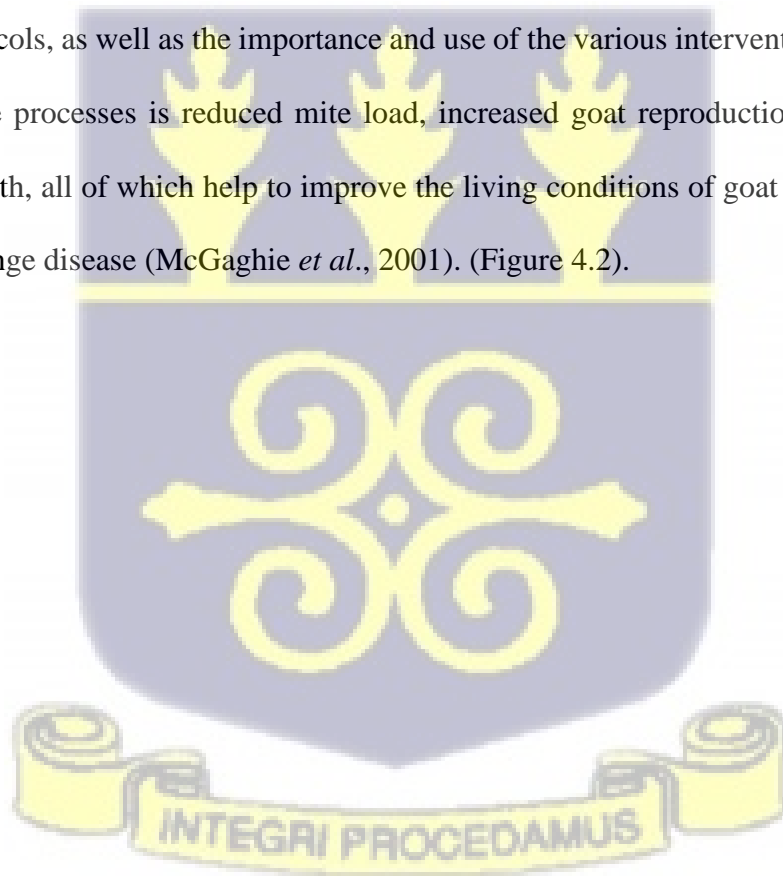
Figure 4.1 Conceptual Framework

4.3.2 Logic Model of intervention trial of the program

Resources and various inputs and processes, are required in the intervention trial program for goat mange disease treatment. Figure 4.2 depicts a simple logic model that is intended to depict some selected resources and processes that are required to achieve certain outputs, which ultimately leads to an overall reduction in mite load in mange infestation on the goat population at risk. There are resources available in the program such as CPH ash solution use on goats, mange message distribution, personnel distribution, goat distribution into cages, and hygiene practices among households (McGaghie *et al.*, 2001).

Finally, funding is the most important driving force in the treatment of goat mange disease. Once the necessary resources are obtained, processes and activities are initiated to put them to

use for the intended purpose. Activities and resources may include treating mange disease in household goats with CPH ash solution, educating households about mange disease, training personnel to treat mange, stocking cages with goats from various households, and practicing hygiene among community households. The number of mange-infested goats treated, the number of households educated on mange, the number of personnel trained to perform mange treatment, the number of cages stocked with goats, and the number of households practicing hygiene are the immediate outputs of these activities. The resources, processes, and activities are all aimed at achieving specific objectives. Throughout the input, process, and output stages, certain immediate outcomes are expected. These outcomes could include increased knowledge of goat owners at risk of contracting mange disease in terms of protection measures and treatment protocols, as well as the importance and use of the various interventions. Finally, the impact of these processes is reduced mite load, increased goat reproduction, and improved household wealth, all of which help to improve the living conditions of goat owners at risk of contracting mange disease (McGaghie *et al.*, 2001). (Figure 4.2).



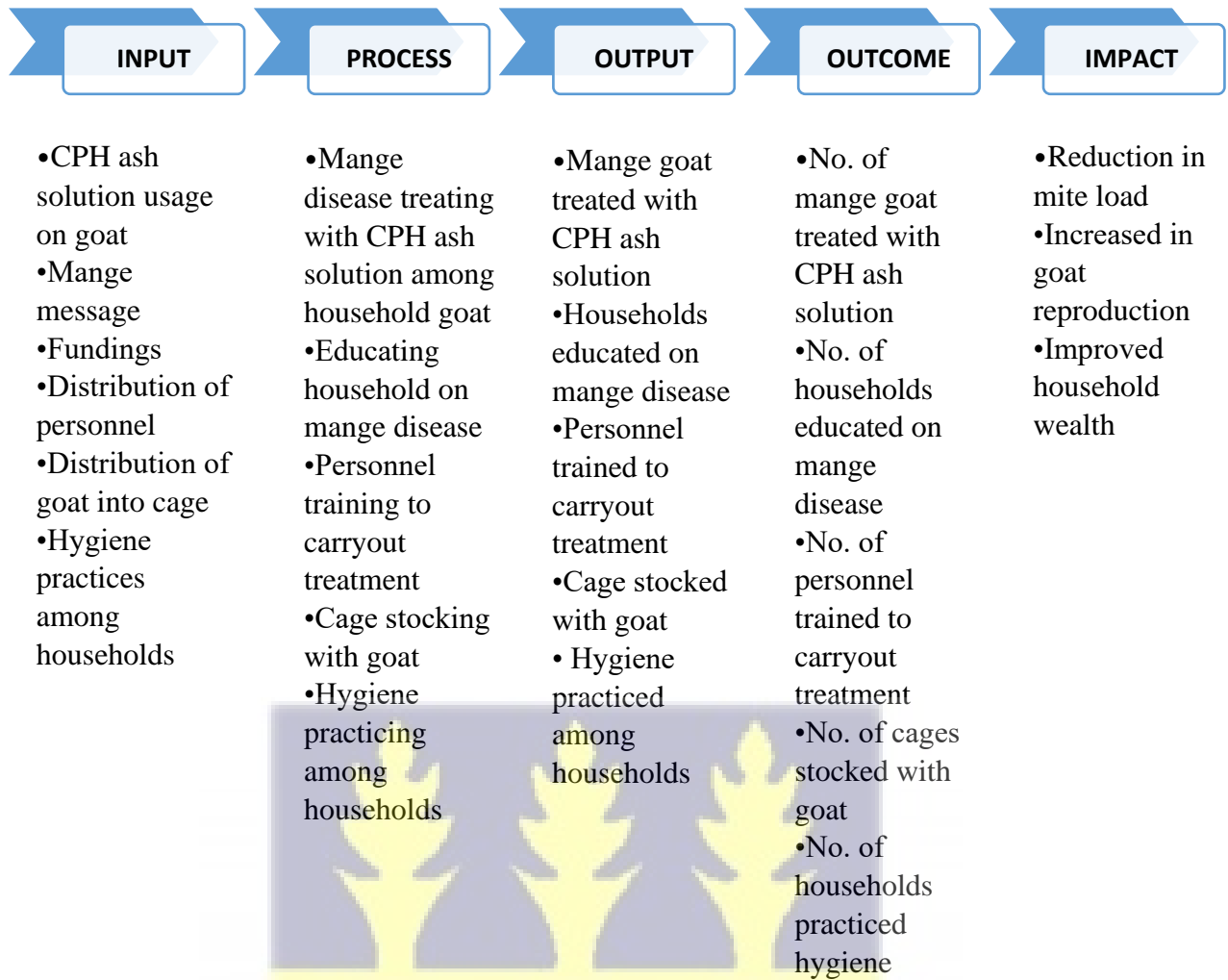


Figure 4.2: Logic model of mange mite infestation treatment programme

4.4 Definition of Major Indicators for the Study

Table 1 shows the definition of the main indicators, both outcome and interventions, that were assessed by this study defining the numerators and denominators. (Table 1).



Table 1: Definition of the major indicators for the study

<p>Mite reduction by CPH ash solution treatment on household goat Definition: This refers to the percentage of household goats who have access to at least one CPH ash solution treatment that can lead to mite reduction. Numerator: The total number of household goats who have access to at least one CPH ash solution treatment. Denominator: The total number of household goats.</p>
<p>Compare CPH ash solution and Placebo treatment on household goat Definition: This refers to the percentage/proportion of household goats who have been treated with CPH ash solution or Placebo at baseline of day1 and endline of day14. Numerator: The total number of household goats who have been treated at baseline of day1 and endline of day14. Denominator: The total number of household goats.</p>
<p>Reduction by good characteristics of goat in the households Definition: This refers to the percentage/proportion of reduction by good characteristics of goat in the households. Numerator: The total number of reduction by good characteristics of goat in the households of the study. Denominator: The total number of good characteristics of goat.</p>
<p>Improvement in hygiene practices on observation Definition: This refers to the percentage/proportion of households in treatment arm and control arm who participated in the improvement of hygiene practices during observation. Numerator: The total number of households who participated in the improvement of hygiene practices in treatment arm and control arm. Denominator: The total number of households in treatment arm and control arm.</p>
<p>Changes in personal hygiene practices between treatment arm and control arm Definition: This refers to the percentage/proportion of households who had undertaken personal hygiene practices between treatment arm and control arm. Numerator: The total number of households who have undertaken personal hygiene practices between treatment arm and control arm. Denominator: The total number of households in the treatment arm and control arm.</p>
<p>Proportion of mite infestation in the goats Definition: The percentage/proportion of mite infestation in the goats in treatment arm and control arm at baseline and endline. Numerator: The total number of mite infestation in the goats in treatment arm and control arm at baseline and endline. Denominator: The total number of mite infestation in treatment arm and control arm.</p>

CHAPTER FIVE

5.0 RESULTS

5.0 Introduction

This chapter summarizes the study's findings. It describes the intervention trial of the various indicators and the study's outcome variables. In this chapter, the factors associated with mite infestation in the various interventions are determined based on frequency and percentage.

The study's baseline characteristics were described using frequency and percentages. The Fisher's exact test was used to compare baseline characteristics between households in the control arm and those in the treatment arm in order to assess associations. The number of mites on goat skin was described using a histogram, with the minimum, maximum, median, and interquartile range estimated. The Wilcoxon rank sum test was used to compare the median number of mites found on goat skin between two groups. The Kruskal Wallis test was used to compare the difference in the median number of mites on goat skin at baseline between variables with three or more levels in each category. The quantile regression model was used to identify the factors associated with the number of mites on goat skin across baseline household characteristics. Only variables from the bivariate analysis with a p-value less than 0.200 were considered in the adjusted quantile regression model. The results table also included the corresponding 95% confidence interval (CI) and p-values for the median coefficient estimate. Examination of pre- and post-treatment samples was done, and the results were placed in the appendix.

The box and whisker plots were used to compare the distribution of the number of mites on the skin of the goats by control and treatment at baseline and endline. The Wilcoxon rank sum paired test was used to compare the number of mites in the control and treatment arms before and after treatment. The Wilcoxon rank sum test was also used to compare the difference in mite numbers between the control and treatment arms. The quantile regression model was used

to estimate the effect of treatment on mite population change. Variables from the bivariate analysis of the baseline analysis with p-values less than 0.200 were adjusted in the multivariable quantile regression model. If the p-value is less than 0.005, all statistical analyses in this study are considered significant.

Table 1: Baseline characteristics of goats in the treatment arm and control arm

Characteristics	Total		Control goat		Treatment goat		p-value
	N	%	N	%	N	%	
How does the skin coat of the goat look like							
Wrinkled	1	1.7	0	0.0	1	3.3	0.230
Hairless	56	93.3	30	100.0	26	86.7	
Sores	2	3.3	0	0.0	2	6.7	
Scaly	1	1.7	0	0.0	1	3.3	
What is the physical appearance of the goats							
Active	2	3.3	2	6.7	0	0.0	<0.150
Dull	58	96.7	28	93.3	30	100.0	
Place of goat purchase from							
Same community	9	15.0	5	16.7	4	13.3	0.72
Outside community	51	85.0	25	83.3	26	86.7	
Any sign of mange on goat skin at time of purchase							
Yes	14	23.3	14	46.7	0	0.0	<0.001
No	46	76.7	16	53.3	30	100.0	
Symptoms of mange on skin of goat							
Hairless skin	45	75.0	20	66.7	25	83.3	0.10
Scaly skin	4	6.7	1	3.3	3	10.0	
Wrinkled skin	1	1.7	1	3.3	0	0.0	
Sore on skin	10	16.7	8	26.7	2	6.7	
Do you see condition (mange) as a disease							
Yes	10	16.7	4	13.3	6	20.0	0.49
No	50	83.3	26	86.7	24	80.0	
How long has the condition been on the goat skin							
4 weeks	38	63.3	19	63.3	19	63.3	1.00
3 months	22	36.7	11	36.7	11	36.7	
Which of the sexes of goat condition is frequently							
Female	52	53.3	19	63.3	13	43.3	0.12
Male	28	46.7	11	36.7	17	56.7	

Table 1: Continues							
Category of goat which condition (mange) is frequent							
Kids	24	40.0	6	20.0	18	60.0	0.003
Weaners	15	25.0	9	30.0	6	20.0	
Young adults	14	23.3	12	40.0	2	6.7	
Adults	7	11.7	3	10.0	4	13.3	
Have goat pen in household							
Yes	60	100.0	30	100.0	30	100.0	
No	0	0.0	0	0.0	0	0.0	
Number of times pen is cleaned							
Once a day	60	100.0	30	100.0	30	100.0	
Twice a day	0	0.0	0.0	0.0	0.0	0.0	
Housing practices of keeping goat							
Intensive	41	68.3	29	96.7	12	40.0	<0.001
Semi-intensive	19	31.7	1	3.3	18	60.0	
What is used to serve food/feeds to the goat							
Wooden box	54	90.0	30	100.0	24	80.0	0.010
Woven basket	6	10.0	0.0	0.0	6	20.0	
What type of feed/food is given to goat							
Grasses	38	63.3	12	40.0	26	86.7	<0.001
Cassava leaf/peel	21	35.0	18	60.0	3	10.0	
Plantain leaf/peel	1	1.7	0	0.0	1	33.3	
Number of times goat is fed in pen per day							
1	58	96.7	28	93.3	30	100.0	0.15
2	2	3.3	2	6.7	0	0.0	
Source of the feed for goat							
Farm	60	100.0	30	100.0	30	100.0	
Roadside	0	0.0	0	0.0	0	0.0	
What is used to serve water to goat							
Plastic bowl	1	1.7	0	0.0	1	3.3	0.31
Aluminium saucepan	59	98.3	30	100.0	29	96.7	
Where is the source of water for the goats							
Community borehole	60	100.0	30	100.0	30	100.0	
Household borehole	0	0.0	0	0.0	0	0.0	
Number of times goat is watered in pen per day							
1	55	91.7	30	100.0	25	83.3	0.020
2	5	8.3	0	0.0	5	16.7	
Grazing practices undertaken by farmers							
Zero grazing	59	98.3	30	100.0	29	96.7	0.31
Free range grazing	1	1.7	0	0.0	1	3.3	

The study enrolled 60 households, 30 in the control group and 30 in the treatment group. At baseline, the characteristics of household goats were investigated. The majority of households (93.3%) goats skin was hairless, (96.7%) goats' physical appearance was dull, (85.0%) purchased the goat from outside their community, (23.3%) had something on the goat's skin at the time of purchase, 75.0% of household goats have symptoms on the skin, and 83.3% do not consider the condition (mange) to be disease. Every household had a goat pen that was cleaned once a day; water for the goats was provided from a community borehole; feed was provided from the farmers' farm; and grazing practices were followed. At baseline, the characteristics of the goats were observed in both the treatment and control arms (Table 1).

Mite infestation at baseline

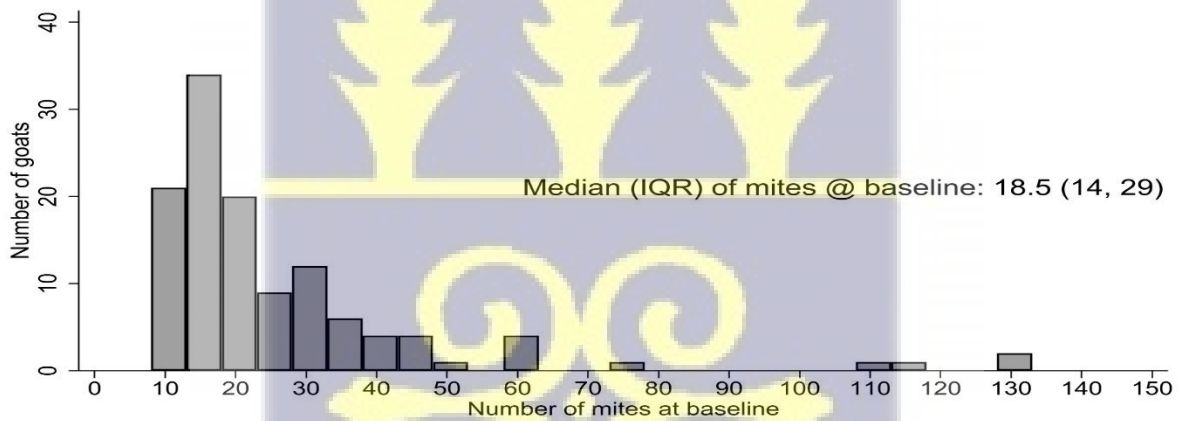


Figure 5.1: Number of mites on goats at baseline

At baseline, the median number of mites on goat skin was 18.5 mites, with an interquartile range of 14 to 29 mites. All of the goats had at least one mite, making mites prevalent on the goats' skin. The goats' skin had an average of 8 mites and a maximum of 131 mites (Figure 5.1).

Table 2: Factors associated with number of mites on skin of goat at baseline

Variables & categories	Bivariate analysis			Quantile regression model			
	N	Median (IQR)	P-value	Unadjusted estimates u β [95% CI]	P-value	Adjusted estimates a β [95% CI]	P-value
Overall	120	18.5 (14, 29)					
Place of goat purchase from			0.977 ^W				
Same community	18	19.5 (14, 28)		0.00 [reference]		-	
Outside community	102	18 (14, 29)		-2.00 [-8.24, 4.24]	0.527	-	
Anything on goat skin at time of purchase			0.013 ^W				
Yes	28	16 (13, 21)		0.00 [reference]		0.00 [reference]	
No	92	20.5 (15, 34)		5.00 [0.56, 9.44]	0.028	-2.00 [-9.28, 5.28]	0.587
Symptoms on skin of goat			0.334 ^K				
Hairless skin	90	19.5 (14, 30)		0.00 [reference]		0.00 [reference]	
Scaly skin	8	20.5 (12.5, 47)		8.00 [-21.50, 37.50]	0.592	20.00 [-16.30, 56.30]	0.277
Wrinkled skin	2	12.5 (10, 15)		-10.00 [-19.44, -0.56]	0.038	-14.00 [-28.43, 0.43]	0.057
Sore on skin	20	17 (15, 23.5)		-3.00 [-7.24, 1.24]	0.164	-1.00 [-6.02, 4.02]	0.693
Do you see condition (mange) as a disease			0.041 ^W				
Yes	20	26 (17, 39)		0.00 [reference]		0.00 [reference]	
No	100	18 (14, 28)		-10.00 [-19.95, -0.05]	0.049	-6.00 [-10.92, -1.08]	0.017
How long has condition been on the goat skin			0.885 ^W			-	
4 weeks	76	18.5 (15, 28.5)		0.00 [reference]		-	
3 months	44	18.5 (14, 31)		0.00 [-5.91, 5.91]	1.000	-	
Which sex of goat with condition frequently			0.388 ^W			-	
Female	64	18 (14, 28)		0.00 [reference]		-	
Male	56	19 (14.5, 31.5)		1.00 [-4.57, 6.57]	0.723	-	
Which category of goat condition is frequent			0.220 ^K			-	
Kids	48	22 (14.5, 38.5)		0.00 [reference]		-	
Weaners	30	17.5 (15, 28)		-4.00 [-11.61, 3.61]	0.300	-	
Young adults	28	17 (12.5, 23.5)		-5.00 [-12.65, 2.65]	0.198	-	
Adults	14	20 (14, 37)		-1.00 [-11.11, 9.11]	0.845	-	
Housing practices to keep goats			0.055 ^K				
Intensive (closed goat)	82	18 (13, 26)		0.00 [reference]		0.00 [reference]	
Semi-intensive (opened goat)	38	22.5 (16, 43)		5.00 [-3.61, 13.61]	0.253	2.00 [-6.66, 10.66]	0.648
What is used to serve food/feeds to the goats			0.180 ^W				
Wooden box	108	18 (14, 28.5)		0.00 [reference]		0.00 [reference]	
Woven basket	12	25.5 (16.5, 36)		10.00 [-4.04, 24.04]	0.161	1.00 [-10.98, 12.98]	0.869
What type of feed/food is given to goats			0.036 ^K				
Grasses	76	20.5 (15.5, 32.5)		0.00 [reference]		0.00 [reference]	
Cassava leaf/peel	42	16 (13, 21)		-5.00 [-9.63, -0.37]	0.034	-1.00 [-9.70, 7.70]	0.820
Plantain leaf/peel	2	29.5 (23, 36)		15.00 [-8.41, 38.41]	0.207	13.00 [-13.62, 39.62]	0.335
Number of times goat is fed in pen per day			0.994 ^W			-	

Table 2: Continues

1	116	18.5 (14, 29)		0.00 [reference]		-
2	4	19.5 (16.5, 23)		2.00 [-2.84, 6.84]	0.415	-
What is used to serve water to goats			0.291 ^W			-
Plastic bowl	2	27.5 (23, 32)		0.00 [reference]		0.00 [reference]
Aluminium saucepan	118	18 (14, 29)		-14.00 [-30.20, 2.20]	0.090	-12.00 [-28.78, 4.78] 0.159
Number of times goats is watered in pen per day			0.414 ^W			-
2	10	14.5 (11, 42)		0.00 [reference]		-
3	110	19 (15, 29)		3.00 [-5.30, 11.30]	0.476	-
			0.056 ^W			-
Grazing practices						-
Zero grazing	2	17 (16, 18)		0.00 [reference]		-
Free range grazing	118	19 (14, 29)		1.00 [-3.66, 5.66]	0.671	-
			0.794 ^W			-

W: Wilcoxon rank sum test p-value.

K: Kruskal Wallis test p-value.

u β : unadjusted coefficient of the median difference.

a β : adjusted coefficient of the median difference.

CI: confidence interval.



5.1 Factors associated with mite infestation at baseline

More on the factors associated with the number of mites on the skin of goats is presented in Table 2.

The bivariate and multivariable quantile regression models of factors associated with the number of mites on goat skin at the study's baseline are shown in Table 2. According to the bivariate analysis, the presence of anything on goats' skin at purchase ($p=0.013$), the condition seen on the skin being a disease ($p=0.041$), goat housing practices ($p=0.018$), and goat food or feed ($p=0.036$) were the factors associated with the number of mites on goat skin (Table 2). According to the unadjusted quantile regression model, the median number of mites on goats with nothing on their skin at the time of purchase increased by 5 (95% CI: 0.56, 9.44). However, in the adjusted model, this was not significant. Furthermore, the unadjusted estimate revealed that goats with wrinkled skin had 10 fewer mites (95% CI: -19.44 - -0.56) than goats with hairless skin. According to the unadjusted estimates, the median number of mites was lower by 10 (95% CI: -19.95, -0.05) among disease goats. In the adjusted model, the number of mites was reduced by 6 (95% CI: -10.92, -1.08) among disease goats. (Table 2).

5.2 Compare the intensity of mite infestation between the treatment arm and the control arm before and after intervention

Based on the infestation rate in the treatment and control arms, the intensity of mite infestation in goats was calculated with the goal of determining the number of mites on goat skin based on laboratory examination results. Based on laboratory results from the treatment and control arms, the mite infestation rate in this study was categorized as severe (S), moderate (Mo), and mild (Mi)

in accordance with the United States Food and Drug Administration – Parasitological Analysis Protocol (US FDA-PAP). The mite infestation rate was calculated as follows: severe infestation rate (S): 20+, moderate infestation rate (Mo): 11 – 19, mild infestation rate (Mi): < 10.

Table 3: Mite infestation in treatment arm and control arm at baseline and endline of intervention

	Treatment arm			Control arm		
	Mild (Mi)	Moderate (Mo)	Severe (S)	Mild (Mi)	Moderate (Mo)	Severe (S)
Baseline	0	0	30	2	14	14
Endline	29	0	1	0	9	21
Change in intervention	0%	0%	96.7%	0%	35.7%	-50%

At baseline in the treatment arm, no goat was recorded under mild infestation or moderate infestation, and 30 goats were recorded in severe infestation.

At endline in the treatment arm, 29 goats were recorded as having mild infestation, no goat was recorded as having moderate infestation and 1 goat was recorded as having severe infestation.

A change in intervention in the treatment arm indicated that, the mild and moderate infestation rates recorded 0% and the severe infestation rate recorded 96.7% of intervention improvement.

At baseline in the control arm, 2 goats were recorded as having a mild infestation, 14 goats were recorded as having a moderate infestation, and 14 goats were recorded as having a severe infestation.

At endline in the control arm, no goat was recorded as having mild infestation, nine goats were recorded as having a moderate infestation, and 21 goats were recorded as having a severe infestation.

A change in intervention in the control arm indicated that mild infestation recorded 0%, moderate infestation recorded 35.7%, and severe infestation recorded -50% of poor intervention improvement (Table 3).

5.2.1 Comparison of number of mites by control and treatment arm at pre- and post-treatment of the study

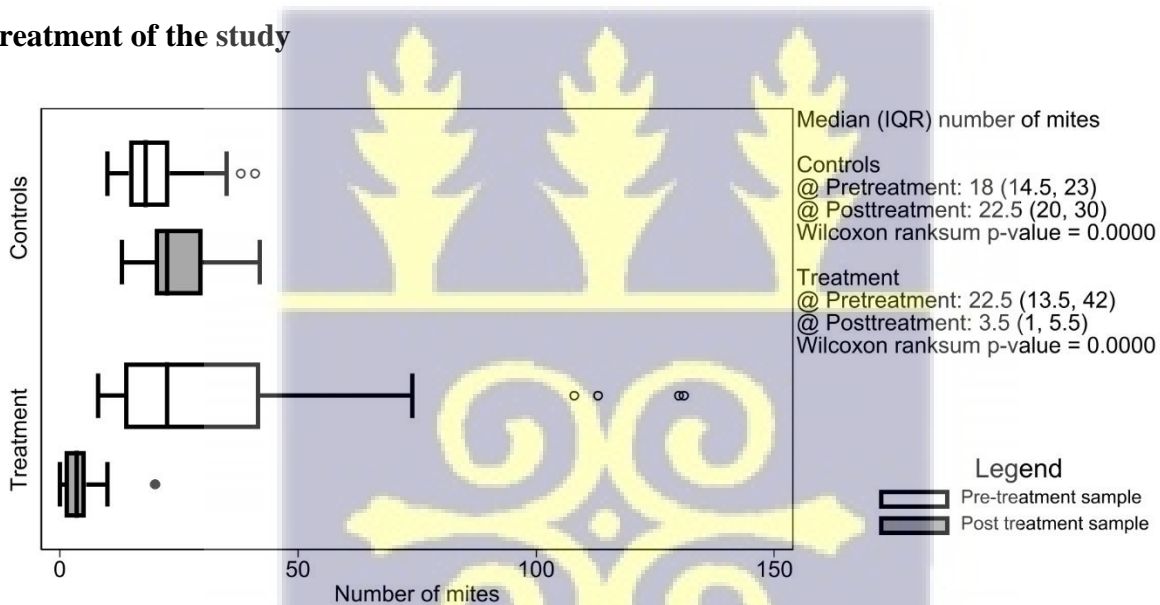


Figure 5.2: Median number of mites on goat pre-treatment and post-treatment by controls and treated group

In the control arms, the median number of mites on goats was 18 (IQR: 14.5, 23) before treatment and 22.5 (IQR: 20, 30) after treatment, with a difference of -4.5 mites. After the experiment, there was a significant increase in the number of mites among the controls ($p < 0.001$). The median number of mites on goats in the treatment arms, on the other hand, was 22.5 (IQR: 13.5, 42) pre-treatment

and 3.5 (IQR: 1, 5.5) post-treatment, with a difference of 19 mites. After the experiment, the number of mites in the treatment arm decreased significantly ($p=0.001$) (see Figure 5.2).

5.2.2 Comparison of the change in number of mites by control and treatment arm at pre- and post-treatment in the study

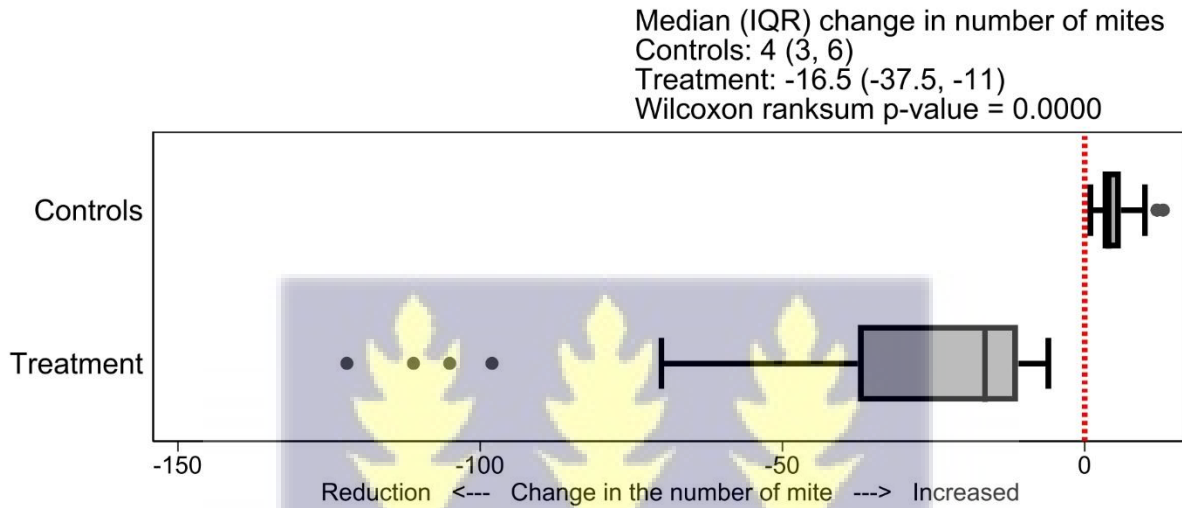


Figure 5.3: Absolute change in the number of mites on goat skin after experiment

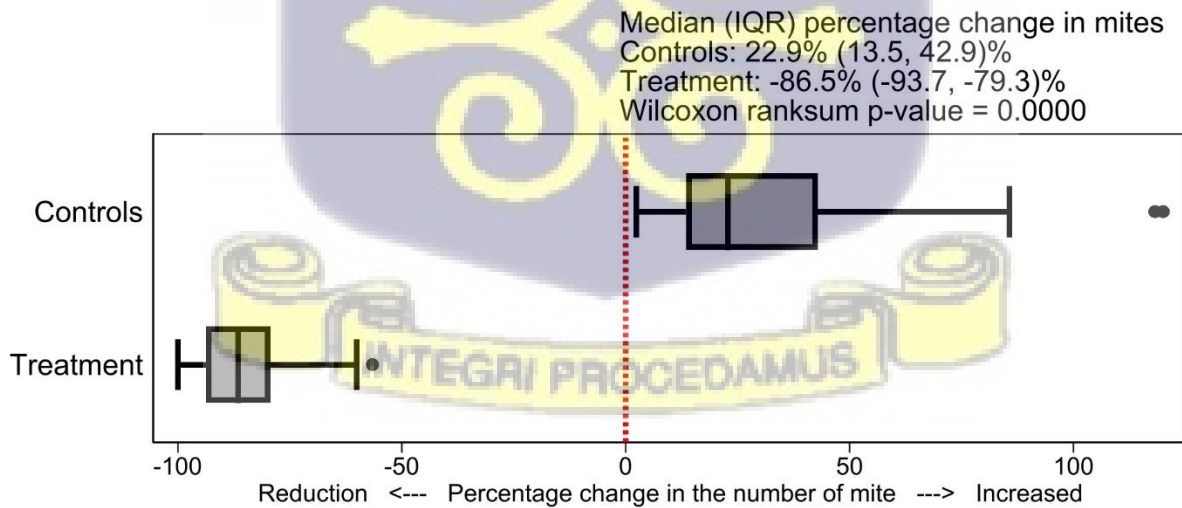


Figure 5.4: Percentage change in the number of mites on goat skin after experiment

At the end of the experiment, the median number of mites in the control arm increased by 4 (IQR: 3, 6), while the number of mites in the treatment arm decreased by 16.5 (IQR: -37.5, -11). The difference in change between the control and treated arms varied significantly (p0.001). (See Figure 5.3.)

In terms of percentage change, the median number of mites in the control arm increased by 22.9% (IQR: 13.5%, 42.9%), while the number of mites in the treatment arm decreased by 86.5% (IQR: -93.7%, -79.3%) at the end of the experiment. The percentage change difference varied significantly between the control and treated arms (p0.001). (see Figure 5.4).

5.2.3 Multivariable quantile regression model of the effect of treatment on reduction in number of mites on goat skin

Table 4: Quantile regression model of the effect of treatment on the absolute and percentage reduction in mites on skin of goats in the study

Study arm	Unadjusted estimates		Adjusted estimates	
	uβ [95% CI]	P-value	aβ [95% CI]	P-value
Absolute change				
Control	0.00 [reference]		0.00 [reference]	
Treatment	-21.00 [-27.52, -14.48]	<0.001	-18.00 [-27.51, -8.49]	<0.001
Percentage change				
Control	0.00 [reference]		0.00 [reference]	
Treatment	-109.89 [-117.51, -102.28]	<0.001	-100.52 [-107.83, -93.20]	<0.001

uβ: Unadjusted coefficient. aβ: adjusted coefficient. CI: confidence interval.

Variables controlled: The adjusted model included the existence of anything on the skin of the goat at the time of purchase, goats having disease at the time of purchase, the number of goats kept in the pen of the household, cleaning of the pen, the housing practice of goats, food or feed served to goats, items used to serve food or feed to goats, water served to goats, items used to serve water, the time grasses are cut to feed goats, goat waste disposal, and treatment of goats when sick.

After controlling for potential confounders, the adjusted quantile regression model revealed that the median number of mites in the treatment arm was reduced by 18 (95% CI: -27.51, -8.49, p0.001) compared to the control arms. In terms of percentage, the treatment arm reduced the number of mites by 100.5% (95% CI: -107.83%, -93.20%, p0.001) compared to the control arm.

5.3 Assess intervention compliance among the treatment arm and control arm

Table 5: shows the results of changes in personal hygiene practices among the treatment arm and control arm in the study.

Variables	Total		Baseline				Endline			
	n	%	Control n %	Treatment n %	p-value	Control n %	Treatment n %	p-value		
Number of times pen is cleaned										
Once a day	60	100.0	30 100.0	30 100.0		30 100.0	30 100.0			
Twice a day	0	0.0	0 0.0	0 0.0		0 0.0	0 0.0			
Housing practices to keep goats										
Intensive	41	68.3	29 96.7	12 40.0	<0.001	30 100.0	30 100.0			
Semi-intensive	19	31.7	1 3.3	18 60.0		0 0.0	0 0.0			
What is used to serve food/feed to the goats										
Wooden box	54	90.0	30 100.0	24 80.0	0.010	30 100.0	30 100.0			
Woven basket	6	10.0	0 0.0	6 20.0		0 0.0	0 0.0			
What type of feed/food is given to goats?										
Grasses	38	63.3	12 40.0	26 86.7	<0.001	15 50.0	27 90.0	<0.001		
Cassava leaf/peel	21	35.0	18 60.0	3 10.0		14 46.7	2 6.7			
Plantain leaf/peel	1	1.7	0 0.0	1 3.3		1 3.3	1 3.3	0.31		
Number of times goat is fed in pen per day										
2	58	96.7	28 93.3	30 100.0	0.15	29 96.7	30 100.0			
1	2	3.3	2 6.7	0 0.0		1 3.3	0 0.0			
Source of the feed										
Farm	60	100.0	30 100.0	30 100.0		30 100.0	30 100.0			
Roadside	0	0.0	0 0.0	0 0.0		0 0.0	0 0.0			
What is used to serve water to goats										
Plastic bowl	1	1.7	0 0.0	1 3.3	0.31	0 0.0	0 0.0			
Aluminium saucepan	59	98.3	30 100.0	29 96.7		30 100.0	30 100.0	0.15		
Source of water										
Community borehole	60	100.0	30 100.0	30 100.0		30 100.0	30 100.0			
House hold borehole	0	0.0	0 0.0	0 0.0		0 0.0	0 0.0			
Number of times goats is watered in pen per day										
1	5	8.3	0 0.0	5 16.7	0.020	0 0.0	0 0.0			
2	55	91.7	30 100.0	25 83.3		30 100.0	30 100.0	0.15		
Time grass is cut to feed goats in pen										
6am-7.30am	1	1.7	0 0.0	1 3.3	0.31	0 0.0	0 0.0			
8.30am-9.00am	59	98.3	30 100.0	29 96.7		30 100.0	30 100.0			
Grazing practices										
Zero grazing	59	98.3	30 100.0	29 96.7		30 100.0	30 100.0			
Free range grazing	1	1.7	0 0.0	1 3.3	0.13	0 0.0	0 0.0			

The assessment of compliance to hygiene practices was strictly enforced on a daily basis among the treatment and control arms for a period of 13 days following the collection of baseline samples at day 1 to correlate the CPH ash solution and placebo results to the hygiene practices among the two goats in each of the 15 cages of the treatment and control arms. These were the hygiene practices: (i) no goats were released from their cages; (ii) goats were fed twice daily at 9.00 a.m. and 1.00 p.m.; (iii) adequate clean and fresh water was served daily; and (iv) the pens, feed, and water troughs were cleaned daily. The goal was to see if the treatment protocol would have a positive effect on mite load treatment outcomes at pre-treatment of day 1 and post-treatment of day 14 samples and to compare it to the control arm, which focused on hygiene strictness every two days rather than daily. To reduce their exposure to mite reinfestation, the goats were not allowed to be released from their cages, which could have a negative effect on the research results and have poor research implications. The feeding of goats twice daily was required to stabilize the health status and improve the goats' immunity to withstand the research design in order to improve the results. To improve the goats' health and achieve the best results in the study, a sufficient amount of clean and fresh water was served on a daily basis to increase the level of body water requirement. Cleaning the pens, feed, and water troughs was necessary to reduce reinfestation and improve the study's results. The treatment arm met the four key requirements, and the goats (T:1-30) improved, which influenced the results of the pre-treatment and post-treatment samples examined. The four key requirements were less strictly followed in the control arm, and no improvement was observed among the goats (C: 1-30), with no positive effect on the outcomes of the pre-treatment and post-treatment samples examined (Table 5).

5.3.1 Changes in personal hygiene practices between the treatment arm and the control arm

The study enrolled 60 households: 30 in the control group and 30 in the treatment group. These were the baseline questions about hygiene practices (Table 5) and whether any changes would occur following the baseline study. It was unclear whether all households kept goats in pens, cleaned the pens once a day, sourced water for goats from a community borehole, served water to goats once daily, sourced feed from farmers' farms, and fed the goats twice daily at the baseline and endline. Based on the percentage change in the study, how many households in the control and treatment arms complied, adhered, or did not?

The outcomes of hygiene practices among the households in the control arm and treatment arm at baseline and endline were expressed in percentages and the respective p-values (Table 5).

5.3.2 Improvement in hygiene practices on observation

Prior to the study, the hygiene improvement was discussed with the involved households, and agreement was reached for all study arms to fully participate in hygiene practices, which should be continued after the project ends. The project was followed and monitored on hygiene practices after it began on day 1 and continued on a daily basis until it ended on day 14, that is, the project was followed and monitored on hygiene practices for 13 days and an obvious improvement was detected through behavioural expressions on the study subjects, as well as the manifestation of environmental cleanliness, to ascertain the improvement in hygiene practices among household heads since adherence was noticed. Apart from the 30 cages for the experiment, there was a significant improvement in hygiene practices among the participating households in the study arms' community after the 14-day project period.

The improvement in hygiene practices in the treatment arm resulted in a reduction in mite load in the intervention arm, and laboratory examination results on three (3) of the goats in the study revealed that there was a 100% improvement in hygiene practices.

When compared to the treatment arm, the control arm had an increase in mite load from day 1 to day 14, whereas the treatment arm had a decrease in mite load from day 1 to day 14 because much effort was put into hygiene practices during intervention implementation and strict compliance monitoring was done every day in both the control and treatment arms. The poor results in the control arm could be attributed to poor hygiene practices and mites that were not susceptible to the placebo treatment, according to the laboratory examination. (Table 5).



CHAPTER SIX

6.0 DISCUSSIONS

6.0 Introduction

The findings of this study are discussed in this chapter in comparison to the findings of the intervention trial (treatment and control arms). This chapter focuses on the study's findings and discusses them with others from the literature.

6.1 Factors associated with mite infestation at baseline

The factors associated with mite infestation at baseline in the households (Table 2) have all indications that the CPH ash solution must be used in conjunction with hygiene practices in the households' goat pen, as well as provision of house or pen for the goats, intensively housing of the goats, and daily cleaning of the pen; wooden box must be used to serve feed to the goats, grasses must be cut as the main feed for the goats, the feed source must be the farm, the water must be sourced from a community borehole, water must be provided for goats at least once daily, feeding goats twice in the pen is sufficient to sustain them, an aluminum saucepan must be used to serve water to the goats, and grazing practices such as cutting feed for the goats are the best; female goats were the most commonly infected, while younger goats were also the most frequently infected, implying that farmers must exercise extreme caution with female goats to limit the spread of the mange disease, and younger goats must be given special attention because mange can kill them at such a young age due to a lack of immune system development; the CPH ash solution can successfully treat mange disease to stop reinfestation in various households and if the good characteristics of the goats are followed (Gilani and Rahman, 2005; Kirbag *et al.*, 2009).

In this study to determine the continued presence of mites in the community's various households, the factors related to the number of mites on goats at baseline were mostly significant.

These factors (Table 2), such as where the goats were purchased from, determined the source of the mange disease because the majority were purchased from outside the community, and those with symptoms on the goats that were purchased were also the majority, and those who purchased the goats with symptoms on the goats were aware of the condition. Because mange disease is contagious and spreads over time, it has spread to other goats in the same or different households, thereby increasing the mange disease coverage area. Now that they have been educated on the subject, households should stop failing to recognize mange as a disease (Newman *et al.*, 2003; Gilani and Rahman, 2005).

There were all indications that, the goats had a lot of mites at baseline, putting them in an uncomfortable situation that could cause their health to deteriorate and eventually kill them.

6.1.1 Baseline characteristics of goats in the treatment arm and control arm

The study enrolled 60 households, 30 in the control group and 30 in the treatment group. At baseline, household goat characteristics in the treatment arm and control arm were investigated. Among the treatment and control arms, indicators were outlined, and per the stated indicators, there were all indications that the mange was introduced into the community through goat purchasing, and this burdened the beginning of the intervention trial with a lot of problems and challenges; that needed to be solved, and the intervention trial has actually lifted the huge burden from the participants in the community; in addition, the baseline characteristics of the various indicators must be adhered to, especially the hygiene practices to reduce the mite population.

At baseline, all of the goats had at least one mite, making mites prevalent on the goats' skin by putting goat health at risk causing growth retardation (Bates, 1998; Bates, 2000). This gives an indication that, the mite infestation in the household goats was significant since goat health was paramount to look at, in the area of growth and reproduction; households should use CPH ash solution for the treatment to improve health of goats in the community.

6.2 Compare intensity of mite infestation between treatment arm and control arm before and after intervention

The intensity of mite infestation in goats was determined in accordance with the United States Food and Drug Administration-Parasitological Analysis Protocol (US FDA-PAP), which classified the goats into three categories: severe infestation rate, moderate infestation rate, and mild infestation rate. At baseline and endline, the Severe detects the presence of 20 or more mites on the goat skin. At baseline and endline, Moderate detects 11 to 19 mites on goat skin. At baseline and endline, the Mild detects 0 to 10 mites on goat skin (Table 3).

At baseline of intervention in the treatment arm, all of the goats examined were in the severe infestation rate group.

At endline, almost all of the goats were in the Mild infestation rate group, with a single goat in the severe infestation rate group (Table 3). This suggests that the mites in the study's treatment arm were susceptible to the CPH ash solution treatment. According to the Clinical and Laboratory Standard Institute-CLSI (2005), any plant material should be considered an effective therapeutic agent if the extract kills the organism against which it is used; In general, the higher the concentration of a therapeutic agent, the more effective it is against target organisms. According to Abdu *et al.* (2000), the antiparasitic efficacy of an extract is concentration-dependent.

At baseline of intervention in the control arm, less than half of the goats in the control arm were in the severe infestation rate group, with less than half of the goats in the moderate infestation rate group, and a few of the goats in the mild infestation rate group.

At the endline, more than half of the goats were in the severe infestation rate group, while a few of the goats were in the mild infestation rate group (Table 3). This means that the mites in the study's control arm were not susceptible to the placebo treatment.

6.2.1 Comparison of number of mites by control and treatment arms at pre- and post-treatment of the study

The median number of mites in the control arm increased at the end of the experiment, while the number of mites in the treatment arm decreased. The variation in number of mites between the control and treated arms was significant (see Figure 5.3). The percentage difference between the control and treatment arms varied significantly. The difference and percentage change in mites indicated that the CPH ash solution was successful in treating mange disease in household goats (NRA, 2000; APVMA, 2003).

6.2.2 Comparison of the change in number of mites by control and treatment arms at pre- and post-treatment of the study

The variation in change in number of mites between treatment and control arms was very significant (Table 3). At the end of the experiment, the median number of mites in the control arm increased, while the median number of mites in the treatment arm decreased; the percentage change and difference between the control and treatment arms varied significantly; this emphasizes

the importance of CPH ash solution as a useful alternative drug for community households to use (Abdu *et al.*, 2000).

6.3 Assess intervention compliance among treatment arm and control arm

In both the treatment and control arms, compliance with the treatment protocol/hygiene practices (Table 5) was assessed.

In the treatment arm, strict adherence to the treatment protocol was critical, and the goal was to determine whether the treatment protocol had a positive effect on mite load treatment outcomes between the pre-treatment sample on day 1 and the post-treatment sample on day 14. Compliance with the treatment protocol resulted in positive laboratory results, with the mite count decreasing from a severe to a mild infestation rate; the treatment protocol was followed, which resulted in an improvement among the goats in the treatment arm by influencing the results of pre-treatment and post-treatment samples (Table 3).

In the control arm, strict adherence to the treatment protocol was critical (Table 5), and it was intended to determine whether the treatment protocol had a positive effect on mite load treatment outcomes between pre-treatment samples at day 1 and post-treatment samples at day 14; due to full attention paid to compliance to treatment protocols but low placebo efficacy, the laboratory examination produced negative results by increasing mite count from severe infestation rate to severe infestation rate (Table 3); the treatment protocols were fully adhered to, which resulted in no improvement among the goats in the control arm by not influencing the outcomes of pre-treatment and post-treatment samples (Abdu *et al.*, 2000).

6.3.1 Changes in personal hygiene practices between treatment arm and control arm

A total of 60 households were included in the study (Table 5) on the variables pertaining to hygiene practices at baseline and endline, resulting in 100% achievement in the cleaning of the pen once a day for both treatment and control arms, 100% achievement in the source of water for goats from a community borehole for both treatment and control arms, 100% achievement in serving water to goats once daily at endline for both treatment and control arms, and 100% achievement in the serving of water to goats once daily at endline for both treatment and control arms. At baseline and endline, there was 100% achievement in the source of feed from farmers' farms for both treatment and control arms, 100% achievement in the grazing practice as zero grazing for both treatment and control arms, and 100% achievement in what is used to serve feed to goats in the pen as a wooden box for both treatment and control arms. These were the households that performed best in the key variables, which benefited the study, particularly in the treatment arm.

6.3.2 Improvement in hygiene practices on observation

The improvement in hygiene practices (Table 5) had an effect on mite load outcomes in the intervention trial, and the results recorded in pre-treatment and post-treatment samples of the treatment and control arms demonstrated that there was an improvement in hygiene practices via laboratory examination analysis results in three goats' mite load in the treatment arm of the study. The study aimed to see if day 1 samples of mite load examined in the laboratory in the treatment and control arms, and day 14 samples of mite load examined in the laboratory in the treatment and control arms, could show a decrease at baseline and endline (Tables 3); as a result, at day 1, samples from the treatment arm revealed three (3) samples with zero (0) reduction in mite load from the post-treatment samples at day 14, indicating that improvements in hygiene practices had a positive

effect on the outcomes of before and after samples when compared to the control arm, which had an increase in mite load from day 1 to day 14; this means that hygiene practices in community households must be improved in order to reduce the spread of mange disease (National Office of Animal Health, 2000)



CHAPTER SEVEN

7.0 CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

The baseline of the goats in treatment and reduce the exposure of goats to manage mite infestation in the households.

At baseline of mite infestation, the maximum number of mites on the goats' skin was ten times higher than the US FDA-PAP standards (Figure 5.1), indicating the goats' high infestation rate. Because mite multiplication is rapid within two weeks, all of the goats had at least one mite on their skin, indicating that the prevalence of mites is very high and calling for early mange treatment.

Factors associated with mite infestation in the households at baseline should be practiced and encouraged among households and extended to the entire community in order to reduce mange disease outbreaks and transmission. Participants should be aware of this in order to reduce mite infestation by detecting and treating mite infestations early, putting mites in an uncomfortable situation, reducing the mite population, and making goat reproduction a profitable enterprise.

The difference in the intensity of mite infestation in the goats between the treatment and control arms of the study, as measured by infestation rate, revealed that, at the endline, goats' recovery rate in the treatment arm was very encouraging due to CPH ash solution's high efficacy, and households should continue to practice mange disease treatment with it to improve goat reproduction in the households; to increase household wealth and community development.

Because of the low efficacy of the placebo, the recovery rate of goats in the control arm at the endline was not encouraging.

The number of mites in the household goats before and after treatment was depicted by comparing the number of mites by treatment and control arms in the study's pre- and post-treatment periods. This showed that there was a significant difference in the intervention between the CPH ash solution and placebo treatments and that households should be encouraged to continue treating mange disease with the CPH ash solution.

The assessment of compliance with hygiene practices produced positive results in the treatment arm but negative results in the control arm, indicating that households must maintain the seriousness attached to hygiene practices in order to produce good results in the CPH ash solution treatment.

Furthermore, the differences in personal hygiene practices between the treatment and control arms at baseline were due to both arms participating fully to expect better outcomes, but at endline, the treatment arm produced better outcomes as compared to the control arm, which produced the worst outcomes despite adhering to hygiene practices until the end of the programme, because of low placebo efficacy.

Finally, participants are encouraged to apply what they have learnt and keep up the good work, to benefit the goat rearing enterprise in the Asamankese community and Ghana as a whole.

7.2 Recommendation

Based on the findings of this study, the following recommendations are suggested:

1. A research into the extraction of the cocoa pod husk (CPH) ash with alcohol should be carried out in the treatment of animal mange.
2. A further analysis should be carried out to explore the potential of the CPH ash solution in the treatment of specific mite species.

3. A further analysis should be carried out to explore the potential of the CPH ash solution in a parallel treatment in the treatment and control arms.
4. A further analysis should be carried out to explore mite and egg examination at pre-treatment and post-treatment samples in the study.
5. A further analysis should be carried out to determine the sample size calculation for the study.



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APPENDICES

Appendix 1: Ethical Clearance by University of Ghana-Institutional Animal Care and Use Committee (UG-IACUC)

University of Ghana Institutional Animal Care and Use Committee (UG-IACUC)

Phone: P.O. Box LG 581

Email: UG-IACUC@ug.edu.gh Legon, Accra Ghana

Office Location: Department of Animal Experimentation Building, Noguchi Memorial Institute for Medical Research (NMIMR),

University of Ghana.

15/02/2023

ETHICAL CLEARANCE

(UG-IACUC 019/21-22)

Your protocol for an ethical clearance has been reviewed by the University of Ghana Institutional Animal Care and Use Committee and has been approved as follows:

TITLE OF PROTOCOL: A pilot study to test Theobroma cacao pod husk extract (CPH) on mite in animal mange at Asamankese.

PRINCIPAL INVESTIGATOR: David Lartey Eyume

Please note that the final review report must be submitted to the Committee at the completion of the study.

Your research records may be audited at any time during or after the implementation.

Any modification of this research project must be submitted to UG-IACUC for review and approval prior to implementation.

Please report all serious adverse events related to this study to UG-IACUC within seven days verbally and in writing within fourteen days.

This certificate is valid till 14th February, 2024.

You are to submit annual reports for continuing review.

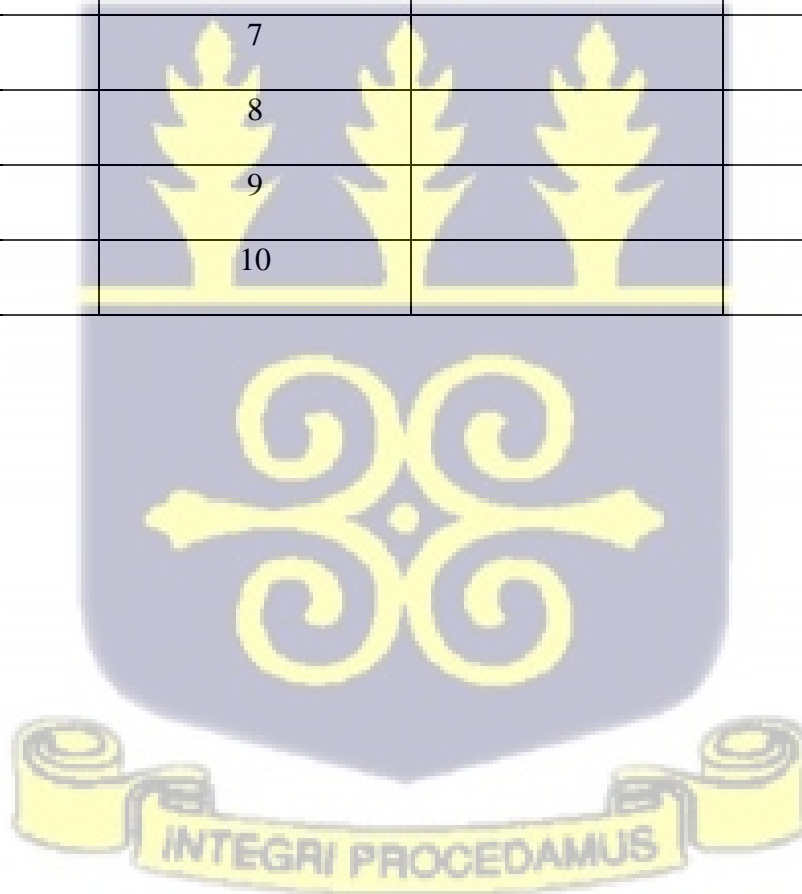


Signature of Chairperson
Prof. Major (Rtd.) George A. Asare



Appendix 2: Record on mange lesions collection for LC4 treatment –Lab results

Cage ID	Sample ID	Pretreatment samples (at day1)	Posttreatment samples (at day14)
T1	1		
T1	2		
T1	3		
T1	4		
T1	5		
T1	6		
T1	7		
T1	8		
T1	9		
T1	10		



Appendix 3: Record on mange lesions collection for Placebo treatment –Lab results

Cage ID	Sample ID	Pretreatment samples (at day1)	Posttreatment samples (at day14)
C2	1		
C2	2		
C2	3		
C2	4		
C2	6		
C2	7		
C2	8		
C2	9		
C2	10		



Appendix 4: Questionnaire on household as baseline data

Question	Number of households (60) response	Comment
1. Where did you purchase the goats from?		
In the same community		
Outside the community		
2. Did you see anything on the goat's skin during purchasing?		
Yes		
No		
3. What symptom of the condition (mange) did you see on the skin of the goat?		
Hairless skin		
Scaly skin		
Wrinkled skin		
Sore on skin		
4. Did you see the condition as a disease?		
Yes		
No		
5. How long has the condition been on the goat skin?		
1week ago		
4weeks ago		
3months ago		
6months ago		
6. In which of the goat sex group do you see the condition most?		
Female		
Male		

7. In which of the goat categories do you see the condition?		
Kids		
Weaners		
Young adults		
Adults		
8. Do you have a goat pen in the household?		
Yes		
No		
9. How many times do you clean the pen in a day?		
Once /day		
Twice /day		
Thrice /day		
10. In which of the housing practices do you keep the goats?		
Intensive		
Semi intensive		
Extensive		
11. What do you use to serve feed/food to the goats?		
On the floor		
Wooden box		
Weaven basket		
Aluminum saucepan		
12. What type of feed/food do you give to the goats?		
Grasses		
Cassava leaf/peel		

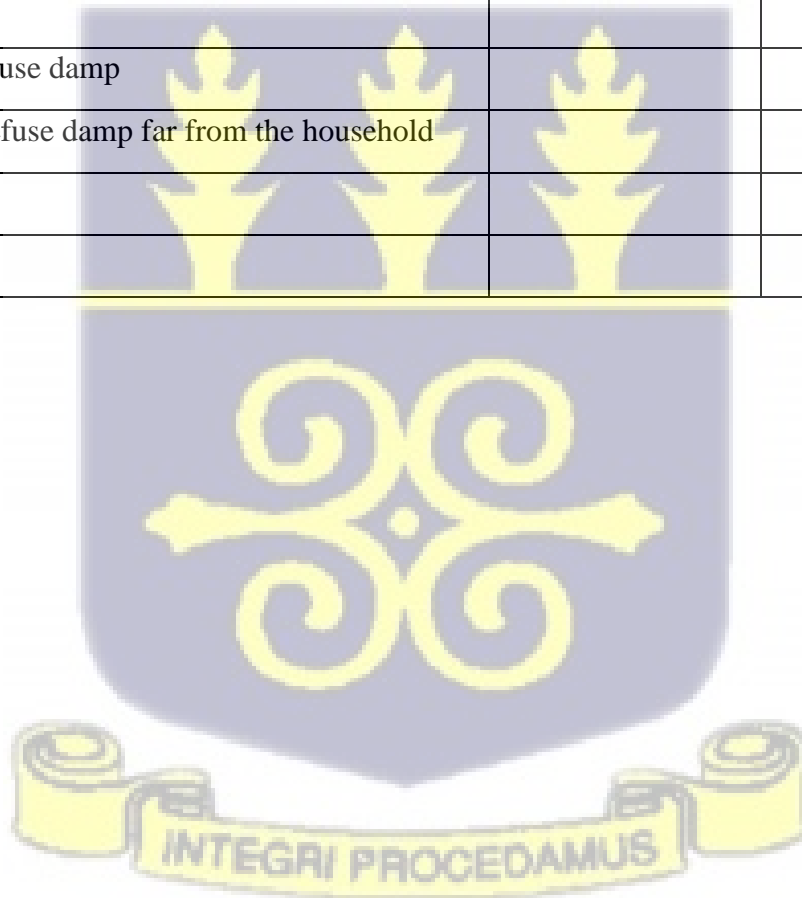
Plantain leaf/peel		
13. How many times do you feed the goats in the pen per day?		
1		
2		
3		
14. What is the source of the feed?		
From the farm		
Along road side		
In the forest		
From the chop bar/restaurant		
15. What do you use to serve water to the goats?		
Plastic bowl		
Aluminum saucepan		
Plastic bucket		
Aluminum bucket		
16. Where is the source of the water?		
Community borehole		
Household borehole		
River/Lake/ Stream		
17. How many times do you serve water to the goats in the household pen?		
1		
2		
3		
18. What grazing practices do you undertake in the household?		
Zero grazing		
Free range grazing		

Appendix 5: CHECKLIST

Observation	Sixty households	Comment
1. How does the skin coat of the goats look like?		
Wrinkled		
Hairless		
Sores		
Scaly		
2. What parasites found on the skin of the goats?		
Ticks		
Fleas		
Lice		
Mite		
3. What is the physical appearance of the goats?		
Active		
Dull		
Weak		
4. Are the goats kept in pen?		
Yes		
No		
5. Is the pen cleaned?		
Yes		
No		
6. How do the goats socialize in the pen?		
In isolation due to fear		
Group during feeding		

7. Do the goats have enough space in the pen to exercise?		
Yes		
No		
8. Is the average dimension of the pen in the household accurate in accommodating 4goats?		
Yes		
No		
9. What material is used for building the pen?		
Wood and related product		
Landcrete/stone with mud		
Cement blocks/bricks		
10. What material is used for the roofing of pen?		
Thatch/palm leaf/bamboo		
Asbestos/slate		
Aluminum sheet		
11. What material is used for the floor of the pen?		
Laid with wooden slabs		
Cemented		
Bare		
12. What feed is given to the goats in the pen?		
Grass		
Plantain leaf/peel		
Cassava leaf/peel		
13. What is used to serve feed to the goats?		
Wooden box		
Woven basket		

14. What is the source of the feed?		
Farm		
Roadside		
15. What is used to serve water to the goats?		
Plastic bowl		
Aluminum saucepan		
16. What is the source of the water?		
Community borehole		
Household borehole		
17. Where does the waste of the goats disposed?		
Farm		
Community refuse damp		
18. Is the refuse damp far from the household		
Yes		
No		



Appendix 6: Hygiene practices among households in the study

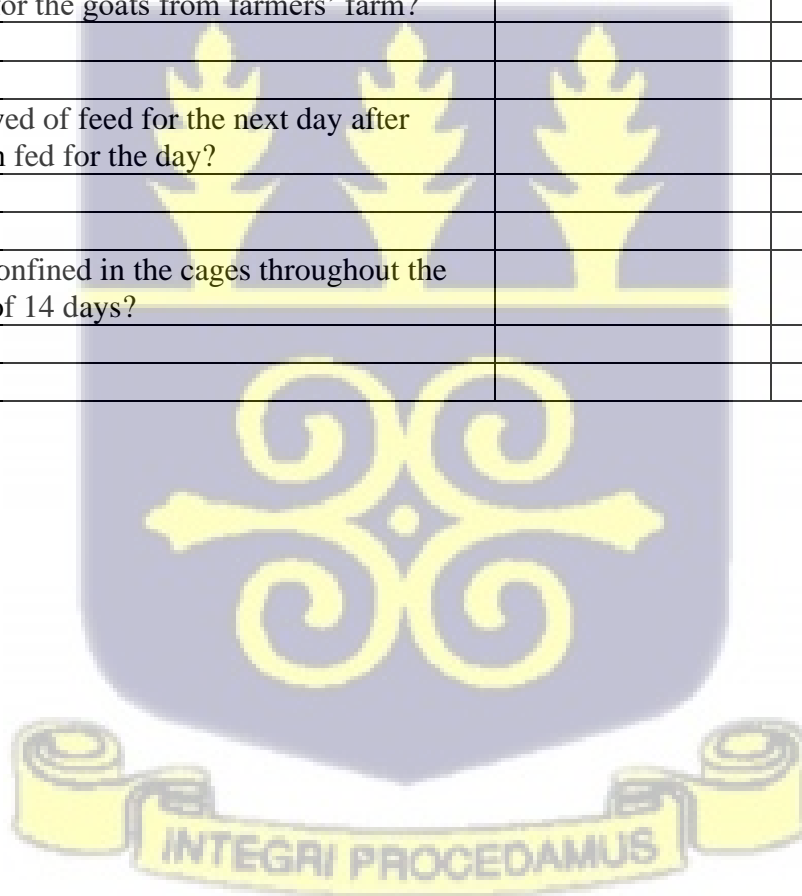
Questionnaire on hygiene practices

Question	Number of household responses	Comment
Was the goat kept in the cage?		
Yes		
No		
Was the cage clean daily?		
Yes		
No		
How many times was the cage clean per day?		
Once		
Twice		
Where was the goat waste disposed?		
Community refuse damp		
Farm		
How many times was the goat fed in the cages per day?		
Once		
Twice		
Where was the source of the feed for the goats in the cages?		
Farm		
Roadside		
Where was the source of the water?		
Community borehole		
Household borehole		
How many times was water served to the goat in the cage per day?		
Once		
Twice		



Appendix 7: Monitoring and Evaluation on intervention delivered

Observation	4goats/cage (120goats/30 cages)	Comment/day (day2-day14)
Are the goats fed very well in the cages?		
Yes		
No		
Is water served daily to the goats in the cages?		
Yes		
No		
Are the cages cleaned daily?		
Yes		
No		
Is the disposal of the waste properly done?		
Yes		
No		
Is the feed cut for the goats from farmers' farm?		
Yes		
No		
Is there a reserved of feed for the next day after goats have been fed for the day?		
Yes		
No		
Are the goats confined in the cages throughout the project period of 14 days?		
Yes		
No		



Appendix 8: Sample container to collect samples and convey for Lab examination



Experimentation, University of Ghana Legon

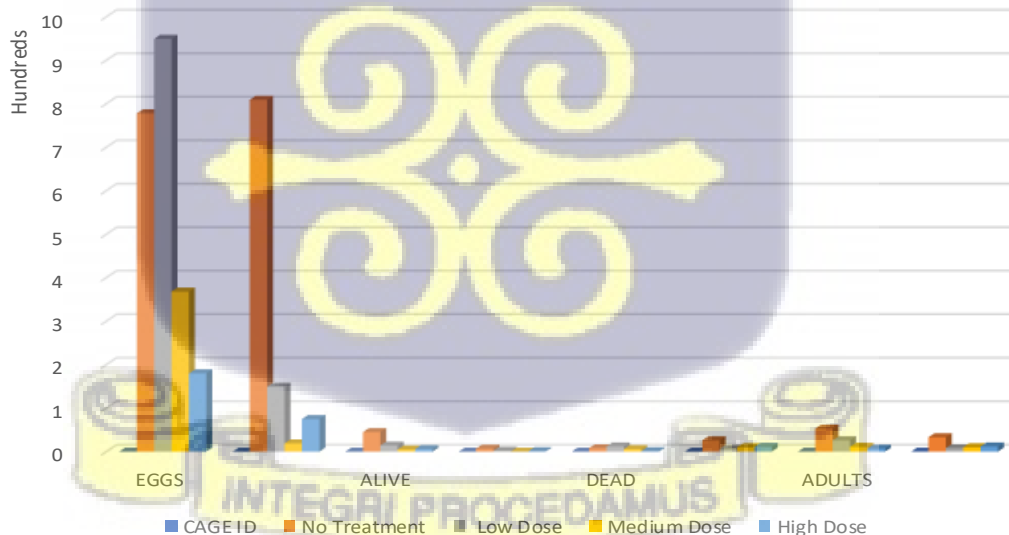
MITES INFESTATION ON MICE TREATMENT 2


WEIGHT OF MICE (Kg)				
IDs	CAGE 1	CAGE2	CAGE3	CAGE4
HEAD	40	33	30.5	42
BACK	39.5	30.5	35	38
TAIL	36.5	35.5	35.5	39

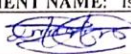
CAGE 1 : CONTROLS - NO TREATMENTS
CAGE 2 : EXTRACT A - LOW DOSE
CAGE 3 : EXTRACT A - MEDIUM DOSE
CAGE 4 : EXTRACT B - HIGH DOSE

CAGE ID	EGGS		ALIVE		DEAD		ADULTS	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
No Treatment	778	809	45	7	8	26	53	33
Low Dose	949	149	14	2	12	6	26	8
Medium Dose	368	19	5	0	6	10	11	10
High Dose	180	75	6	1	1	11	7	12
	1.039846	0.055624	0.155556	1.142857	3.25	2.038462	0.622642	
	0.157007	0.12	0.88			243		
	0.05163							
	0.416667						0.484726	

A BAR GRAPH SHOWING RESULTS FROM TABLE ABOVE



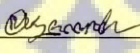
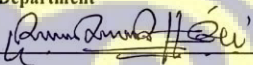
	NOGUCHI MEMORIAL INSTITUTE FOR MEDICAL RESEARCH		
	DEPARTMENT OF ANIMAL EXPERIMENTATION		
	Document Name		Results Form
Document Number:		Version Number	

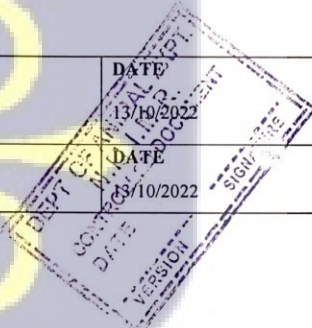
ANALYSIS		DAE LABORATORY USE ONLY	
SAMPLE SOURCE:		ANALYSIS ID: DAE008/2022	
NAME OF OWNER: David Larley		LOCATION Secretariat	DOCKET NO. 008/22
ADDRESS: School of Public Health, UG		DATE SAMPLE SUBMITTED	PRIORITY
TEL: 0246397145			ROUTINE URGENT
NAME OF PRODUCT: Cocoa Pod Husk Ash Extract			
Purpose (expected):			
SAMPLE SUBMITTED		SAMPLE PREPARATION TIME	
#	Type And Description/ Remarks		AM PM
	State: Liquid		<input checked="" type="checkbox"/> AM <input type="checkbox"/> PM
	Colour: Dark grey / Blackish	RECIPIENT NAME: Isaac Ackah	
TESTS REQUESTED:		SIGN: 	
	In vivo Acaricidal Test		
	Acute Dermal Toxicity Test		

TEST RESULTS	
ANALYSIS	RESULTS
1. In vivo Acaricidal Test	The numbers of adult mites decreased, however, there was increase in the number of eggs observed under the microscope after application of the extract. This indicates that the extract was not effective against mites on mice at the doses administered.
2. Acute Dermal Toxicity Test	No adverse skin reactions were observed No adverse effects on weight were observed

Comments:

- The dose volumes and dose rate for application on animals should be reconsidered.
- Per the results obtained from the acute dermal toxicity test, the extract is safe on the skin and does not lead to weight loss for one time application. However, this is not conclusive, a sub-acute toxicity test should be conducted to evaluate the safety of prolonged use of the extract in animals.

NAME and Signature of Technologist/ Veterinarian/Research Assistant	DATE
Richard Obeng-Kyeremeh 	13/10/2022
NAME/ Signature – Head of Department	DATE
Dr Samuel Adjei 	13/10/2022



**Appendix 10: Centre for Scientific and Industrial Research (CSIR) - Centre for Plant
Medicine Research at Mampong Akwapim, Eastern Region.**



REPUBLIC OF GHANA
(MINISTRY OF HEALTH)



CENTRE FOR PLANT MEDICINE RESEARCH

Tel: 03421 95766 / 0342292257 Email: info@cpmr.org.gh Website: www.cpmr.org.gh

*In case of reply, the
number and date of this
letter should be quoted*

*P. O. Box 73
Mampong - Akwapem
Eastern Region, Ghana*

My Ref. No.: CPMR.....
Your Ref. No.:

August 30, 2022

The Manager
David Lartey Eyume
EV 0214-0252
ASAMANKESE.

Dear Sir/ Madam,

REPORT OF ANALYSIS ON COCOA POD HUSK EXTRACT.

Please find attached results of phytochemical analysis on "Cocoa Pod Husk Extract", an herbal medicinal product submitted for testing on August 1, 2022.

Product Type: Extract (Ex/004/22)

Claims on label: Manages diseases

Summary of attached Results

1. Phytochemical Analysis

Cocoa Pod Husk Extract contains reducing sugars and phenolic compounds indicating that it may be plant-based. **The pH of the product falls outside the acceptable range.**

Dr. Daniel Boamah
(Deputy Executive Director)

INTEGRI PROCEDAMUS



SN - Ex1084/21/220727

**CENTRE FOR PLANT MEDICINE RESEARCH
PHYTOCHEMISTRY DEPARTMENT**

Product Code	Dosage Form	Date Received	Date Analysed
Ex/004/22	Extract	1 st August, 2022	23 rd August, 2022

TECHNICAL INFORMATION

(A) Organoleptic Properties

Dosage Form	Extract
Colour	Black
Odour	Odourless
Clarity	Cloudy

(B) Physicochemical Data

Specific Gravity	1.0850
pH	11.72 @ 25.3 °C
Total Solid Residue	16.65 ± 0.23 % w/v
Volume of Product	95.5 ± 0.5 mL

(C) Phytochemical Constituents

Reducing sugars, Phenolic compounds.

REMARKS

The presence of the above-mentioned phytochemical constituents indicates that the product may be plant-based. The pH of the product falls outside the acceptable range of 4.00 - 10.00.

Analyzed By

Mr. Peter Bolah
Laboratory Technologist

Approved By

Dr. Maxwell Sakyiamah
Head of Department

INTEGRI PROCEDAMUS

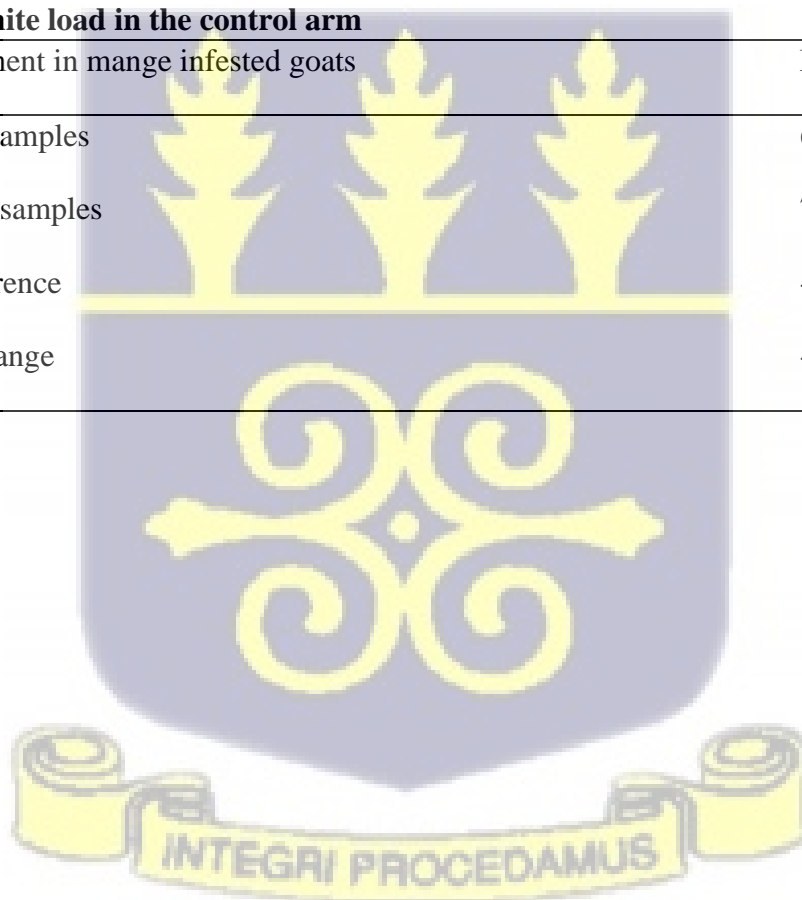
Appendix 11: Estimated intensity of mite load in treatment arm and control arm

Intensity of mite load in the treatment arm

LC4 treatment in mange infested goats	Mite count
Pretreatment samples	1534
Posttreatment samples	177
Average difference	1357
Percentage change	88.46%

Intensity of mite load in the control arm

Placebo treatment in mange infested goats	Mite count
Pretreatment samples	628
Posttreatment samples	736
Average difference	-108
Percentage change	-17.20%



Appendix 12: Shows the intensity distribution of mite load in pretreatment and posttreatment samples of treatment arm (T: 1-30) and control arm (C: 1-30)

ID	Pretreatment samples (at day1)	Posttreatment samples (at day14)	Average difference	Percentage change (%)
T: 1	36	3	33	91.67
T: 2	33	4	29	87.88
T: 3	108	10	98	90.74
T: 4	29	4	25	86.21
T: 5	113	8	105	92.92
T: 6	45	6	39	86.67
T: 7	48	4	44	91.67
T: 8	46	8	38	82.61
T: 9	42	1	41	97.62
T: 10	43	3	40	93.02
T: 11	22	2	20	90.91
T: 12	23	10	13	56.52
T: 13	32	7	25	78.13
T: 14	28	10	18	64.29
T: 15	36	5	31	86.11
T: 16	60	0	60	100.0
T: 17	31	5	26	83.87
T: 18	131	20	111	84.73
T: 19	35	0	35	100.0
T: 20	42	6	36	85.71
T: 21	130	8	122	93.85

Table: Continues

ID	Pretreatment samples(at day1)	Posttreatment samples (at day14)	Average difference	Percentage change (%)
T: 22	74	4	70	94.59
T: 23	62	4	58	93.55
T: 24	46	1	45	97.83
T: 25	28	7	21	75.00
T: 26	26	7	19	73.08
T: 27	37	0	37	100.0
T: 28	58	3	53	91.38
T: 29	28	5	23	82.14
T: 30	62	3	59	95.10
Total	1534	177	1357	88.46
C: 1	26	28	-2	-7.69
C: 2	29	31	-2	-6.90
C: 3	30	32	-2	-6.67
C: 4	16	20	-4	-25.0
C: 5	17	21	-4	-23.53
C: 6	19	26	-7	-36.84
C: 7	10	15	-5	-50.0
C: 8	14	17	-3	-21.43
C: 9	41	42	-1	-2.44
C: 10	35	40	-5	-14.29
C: 11	26	30	-4	-15.38
C: 12	12	16	-4	-33.33
C: 13	18	19	-1	-5.56
C: 14	29	35	-6	-20.69

Table: Continues

ID	Pretreatment samples (at day1)	Posttreatment samples (at day14)	Average difference	Percentage change (%)
C: 15	11	13	-2	-18.18
C: 16	13	15	-2	-15.38
C: 17	21	26	-5	-23.81
C: 18	26	31	-5	-19.23
C: 19	28	31	-3	-10.71
C: 20	31	32	-1	-3.13
C: 21	10	15	-5	-50.0
C: 22	15	17	-2	-13.33
C: 23	29	35	-6	-20.69
C: 24	16	17	-1	-6.25
C: 25	17	21	-4	-23.53
C: 26	21	26	-5	-23.81
C: 27	18	21	-3	-16.67
C: 28	15	21	-5	-33.33
C: 29	14	20	-6	-42.86
C: 30	21	23	-2	-9.52
Total	628	736	-108	-17.20

KEY: Treatment (T):1 and Control (C):1= T:1 and C:1

H1-H30: Household 1 to household 30

ID: Identification number of T: 1-30 (Treatment arm: 30 households); H1- T:1; H2- T:2; H3- T:3, up to H30- T:30) and C: 1-30 (Control arm: 30 households); H1- C:1; H2- C:2, H3-C:3, up to H30-C:30).

This indicates that, one goat was selected from each household into T and C for the intervention.

Appendix 13: Shows intensity of mite infestation in the treatment arm and control arm

ID	Baseline of mite on goat skin	Infestation rate	Endline of mite on goat skin	Infestation rate
T:1	36	S	3	Mi
T:2	33	S	4	Mi
T:3	108	S	10	Mi
T:4	29	S	4	Mi
T:5	113	S	8	Mi
T:6	45	S	6	Mi
T:7	48	S	4	Mi
T:8	46	S	8	Mi
T:9	42	S	1	Mi
T:10	43	S	3	Mi
T:11	22	S	2	Mi
T:12	23	S	10	Mi
T:13	32	S	7	Mi
T:14	28	S	10	Mi
T:15	36	S	5	Mi
T:16	60	S	0	Mi
T:17	31	S	5	Mi
T:18	131	S	20	S
T:19	35	S	0	Mi
T:20	42	S	6	Mi
T:21	130	S	8	Mi

T:22	74	S	4	Mi
T:23	62	S	4	Mi
T:24	46	S	1	Mi
T:25	28	S	7	Mi
T:26	26	S	7	Mi
T:27	37	S	0	Mi
T:28	58	S	3	Mi
T:29	28	S	5	Mi
T:30	62	S	3	Mi

KEY: Mild infestation rate (Mi) and Severe infestation rate (S)

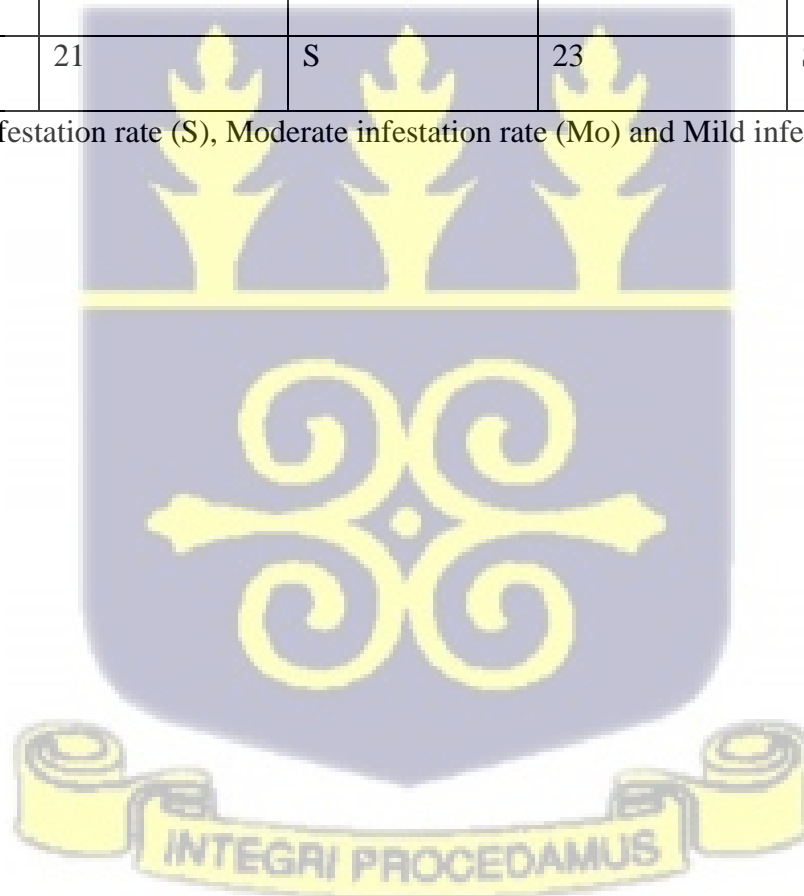


Intensity of mite infestation in the control arm

ID	Baseline of mite on goat skin	Infestation rate	Endline of mite on goat skin	Infestation rate
C:1	26	S	28	S
C:2	29	S	30	S
C:3	30	S	32	S
C:4	16	Mo	20	S
C:5	17	Mo	21	S
C:6	19	Mo	26	S
C:7	10	Mi	15	Mo
C:8	14	Mo	17	Mo
C:9	41	S	42	S
C:10	35	S	40	S
C:11	26	S	30	S
C:12	12	Mo	16	Mo
C:13	18	Mo	19	Mo
C:14	29	S	35	S
C:15	11	Mo	13	Mo
C:16	13	Mo	15	Mo
C:17	21	S	26	S
C:18	26	S	31	S
C:19	28	S	31	S
C:20	31	S	32	S

C:21	10	Mi	15	Mo
C:22	15	Mo	17	Mo
C:23	29	S	35	S
C:24	16	Mo	17	Mo
C:25	17	Mo	21	S
C:26	21	S	26	S
C:27	18	Mo	21	S
C:28	15	Mo	21	S
C:29	14	Mo	20	S
C:30	21	S	23	S

KEY: Severe infestation rate (S), Moderate infestation rate (Mo) and Mild infestation rate (Mi)



Appendix 14: Observational check list

Characteristics	Total		Control goat		Treatment goat		p-value
	N	%	N	%	N	%	
How does the skin coat of the goat look like?							
Wrinkled	1	1.7	0	0.0	1	3.3	0.230
Hairless	56	93.3	30	100.0	26	86.7	
Sores	2	3.3	0	0.0	2	6.7	
Scaly	1	1.7	0	0.0	1	3.3	
What parasites are on the skin of the goats?							
Ticks	1	1.7	0	0.0	1	3.3	0.310
Mite	59	98.3	30	100.0	29	96.7	
What is the physical appearance of the goats?							
Active	2	3.3	2	6.7	0	0.0	<0.150
Dull	58	96.7	28	93.3	30	100.0	
Are the goats kept in pen?							
Yes	60	100.0	30	100.0	30	100.0	
No	0	0.0	0	0.0	0	0.0	
Is the pen cleaned?							
Yes	60	100.0	30	100.0	30	100.0	
No	0	0.0	0	0.0	0	0.0	
How do the goats socialize in the pen?							
In isolation due to fear	1	1.7	1	3.3	0	0.0	0.310
Group during feeding	59	98.3	29	96.7	30	100.0	
Do the goats have enough space in the pen to exercise?							
Yes	57	95.0	28	93.3	29	96.7	0.550
No	3	5.0	2	6.7	1	3.3	
Is the average dimension of the pen in the household accurate in accommodating 4goats?							
Yes	59	98.3	29	96.7	30	100.0	0.310
No	1	1.7	1	3.3	0	0.0	
What material is used for building of the pen?							
Wood and related product	56	93.3	30	100.0	26	86.7	0.038
Land Crete/stone with mud	4	6.7	0	0.0	4	13.3	
What material is used for the roofing of pen?							
Thatch/palm leaf/bamboo	57	95.0	27	90.0	30	100.0	0.076
Aluminium sheet	3	5.0	3	10.0	0	0.0	

What material is used for the floor of the pen?							
Laid with wooden slabs	57	95.0	27	90.0	30	100.0	0.076
Bare floor	3	5.0	3	10.0	0	0.0	
What feed is given to the goats in the pen?							
Grass	60	100.0	30	100.0	30	100.0	
Plantain leaf	60	100.0	30	100.0	30	100.0	
cassava leaf	60	100.0	30	100.0	30	100.0	
What is used to serve feed to the goats?							
Wooden box	57	95.0	28	93.3	29	96.7	0.550
Woven basket	3	5.0	2	6.7	1	3.3	
What is the source of the feed?							
Farm	55	91.7	29	96.7	26	86.7	0.160
Roadside	5	8.3	1	3.3	4	13.3	
What is used to serve water to the goats?							
Aluminium saucepan	56	93.3	26	86.7	30	100.0	0.120
Plastic bowl	2	3.3	2	6.7	0	0.0	
Plastic bucket	2	3.3	2	6.7	0	0.0	
What is the source of the water?							
Community borehole	58	96.7	28	93.3	30	100.0	0.150
Household borehole	2	3.3	2	6.7	0	0.0	
Where does the waste of the goat disposed?							
To the farm	1	1.7	0	0.0	1	3.3	0.310
Community refuse damp	59	98.3	30	100.0	29	96.7	
Is the refuse damp far from the household							
Yes	1	1.7	1	3.3	0	0.0	0.30
No	59	98.7	29	96.7	30	100.0	

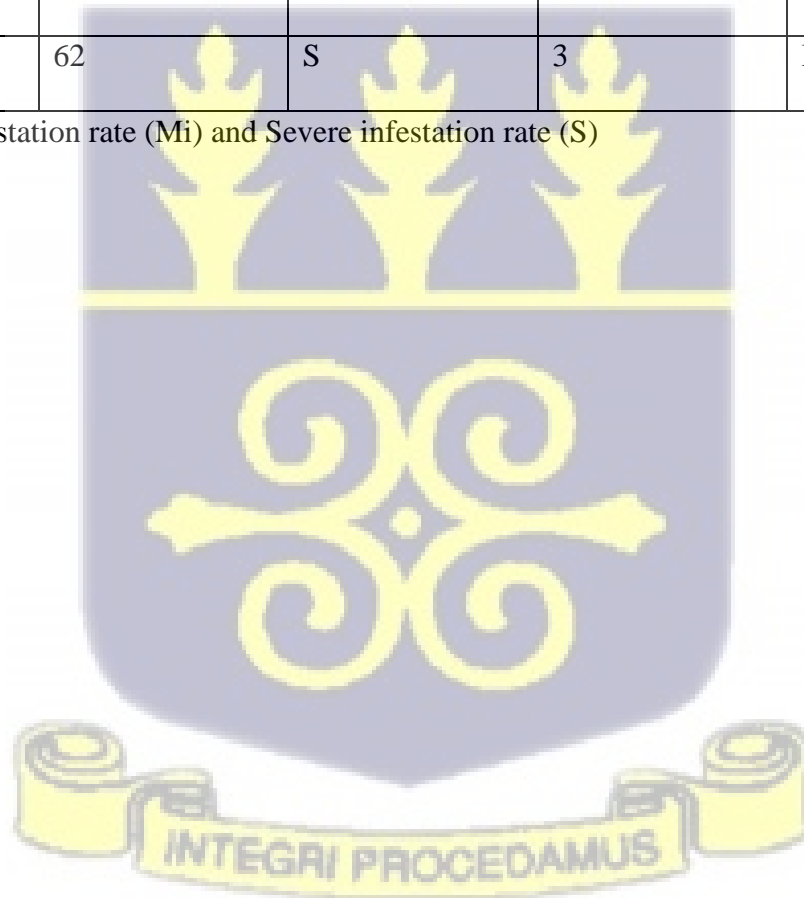


Appendix 15: Shows intensity of mite infestation in the treatment arm and control arm

ID	Baseline of mite on goat skin	Infestation rate	Endline of mite on goat skin	Infestation rate
T:1	36	S	3	Mi
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T:5	113	S	8	Mi
T:6	45	S	6	Mi
T:7	48	S	4	Mi
T:8	46	S	8	Mi
T:9	42	S	1	Mi
T:10	43	S	3	Mi
T:11	22	S	2	Mi
T:12	23	S	10	Mi
T:13	32	S	7	Mi
T:14	28	S	10	Mi
T:15	36	S	5	Mi
T:16	60	S	0	Mi
T:17	31	S	5	Mi
T:18	131	S	20	S
T:19	35	S	0	Mi
T:20	42	S	6	Mi

T:21	130	S	8	Mi
T:22	74	S	4	Mi
T:23	62	S	4	Mi
T:24	46	S	1	Mi
T:25	28	S	7	Mi
T:26	26	S	7	Mi
T:27	37	S	0	Mi
T:28	58	S	3	Mi
T:29	28	S	5	Mi
T:30	62	S	3	Mi

KEY: Mild infestation rate (Mi) and Severe infestation rate (S)



Intensity of mite infestation in the control arm

ID	Baseline of mite on goat skin	Infestation rate	Endline of mite on goat skin	Infestation rate
C:1	26	S	28	S
C:2	29	S	30	S
C:3	30	S	32	S
C:4	16	Mo	20	S
C:5	17	Mo	21	S
C:6	19	Mo	26	S
C:7	10	Mi	15	Mo
C:8	14	Mo	17	Mo
C:9	41	S	42	S
C:10	35	S	40	S
C:11	26	S	30	S
C:12	12	Mo	16	Mo
C:13	18	Mo	19	Mo
C:14	29	S	35	S
C:15	11	Mo	13	Mo
C:16	13	Mo	15	Mo
C:17	21	S	26	S
C:18	26	S	31	S
C:19	28	S	31	S
C:20	31	S	32	S

C:21	10	Mi	15	Mo
C:22	15	Mo	17	Mo
C:23	29	S	35	S
C:24	16	Mo	17	Mo
C:25	17	Mo	21	S
C:26	21	S	26	S
C:27	18	Mo	21	S
C:28	15	Mo	21	S
C:29	14	Mo	20	S
C:30	21	S	23	S

KEY: Severe infestation rate (S), Moderate infestation rate (Mo) and Mild infestation rate (Mi)

