COMPARATIVE ISOLATION AND CHARACTERISATION OF FUNGAL SPECIES ASSOCIATED WITH SPOILED TOMATOES FROM SELECTED MARKETS IN THE NORTHERN REGION OF GHANA

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ABSTRACT

Tomato is a common vegetable that is known to be susceptible to fungal spoilage due to its high-water content. Fungi which are mostly associated with food spoilage produce mycotoxins which can be detrimental to human health when consumed. This study isolated and characterised fungal species associated with tomatoes obtained from four major Markets in the Northern Region of Ghana: Kumbungu, Tolon, Savelugu, and Nanton. A total of 40 samples of tomatoes were purchased from the four markets (ten from each market). The tomatoes were then left for a five-day period under sterile condition to deteriorate. Morphological studies revealed the fungal members of the genus *Aspergillus, Mucor, Absidia* and *Rhizopus* species. The percentage occurrence of the various isolates shows *Rhizopus* species was the most dominant (57.50%), and the least was *Absidia* species (7.50%). Also, tomatoes from Tolon Market recorded the highest level of fungal isolates (32.10%) while tomatoes from the Savelugu market had the lowest (18.87%). Some of the isolated fungi are associated with mycotoxins production which has serious health implications for humans and animals. Hence, proper care, handling, and storage facilities should be employed to prevent tomato spoilage and prolong the shelf life.

Keywords: *Absidia*, fungal pathogens, health implications, tomatoes spoilage, *Rhizopus* species

Introduction

Tomatoes include essential growth factors such vitamins and minerals needed for optimal body metabolism thus, their importance to human nutrition cannot be overstated. However, as beneficial and healthy as fresh tomatoes are to the body, rotten tomatoes can be fatal if swallowed. According to Lou *et al*. (2013), the fruit's short lifespan is one of the limiting variables influencing its health and economic value. Tomatoes decay swiftly after harvest and, in some situations, do not reach consumers at ideal quality after transit and marketing. Spoilage of fresh tomato occurs during storage and transit. As indicated by some studies, fruit deterioration is mostly caused by dehydration, weight loss, colour changes, and microbiological contamination (Bartz *et al*., 2020; Voß *et al*., 2020; Chari *et al*., 2021). According to Somma *et al*. (2019), various parasitic and saprophytic fungus thrive in tomatoes' high concentration of minerals, vitamins, amino acids, and low pH, resulting in their rapid development and survival. Tomatoes are particularly sensitive to fungus spoiling due to biological and physical damage during the harvest and transportation phases, as well as a considerable volume of water and a fragile endocarp (Dimphna, 2016; Elise *et al*., 2016).

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Fungal proliferation is exacerbated by improper handling, exposure to high humidity, and poor storage conditions (Selumun *et al*., 2025). Food loss and waste are a worldwide problem with economic consequences, environmental concerns, and exacerbated social disparities (Ballan *et al*., 2025). Most fungi are saprobic, which means they can obtain nutrients from non-living organic materials, making them major food spoilage organisms (Snyder *et al*., 2019). These fungi are chemoheterotrophic and produce a variety of extracellular enzymes that collaborate to break down structural organic polymers during plant breakdown (Snyder *et al*., 2019). In tropical locations, where high temperatures and humidity promote fungal growth, these conditions are common during market exhibit and transportation (Centers for Disease Control and Prevention, 2024). Improved handling procedures, temperature control, and hygiene standards can significantly minimize fungal contamination and post-harvest losses (Dayok *et al*., 2024).

Fungi are associated with postharvest spoilage because they can grow in a variety of climatic conditions and substrates (Selumun *et al*., 2025). *Aspergillus, Rhizopus, Penicillium* and *Fusarium* were the most common fungal genera related with tomato decomposition (Selumun *et al*., 2025). These critters frequently enter the fruit through wounds or natural passageways, particularly when mechanical damage occurs during harvesting, sorting, or transportation (Selumun *et al*., 2025). Tropical market temperatures and humidity are optimal for their proliferation and sporulation (Huang *et al*., 2022).

Once tomatoes become rotten, they harbour micro-organism, which is mostly fungi. These fungi produce mycotoxins which are deadly and induce cancer, damage the immune deficiency in living things (Pinto & Patriarca, 2017). Mycotoxin is a poisonous chemical generated by a fungus that can cause disease and death in humans and other animals (Mailafia *et al*., 2017). Some bacteria, like mold and other fungus, nevertheless create mycotoxins of different sorts under refrigeration that are dangerous to consumers (Omolaran *et al*., 2016). Some fungi create dangerous secondary metabolites and mycotoxins with low molecular weight. They are harmful even in little amounts, and their ability to survive heat makes them extremely toxic.

According to Saleh and Al-Thani (2019), the damaging effect of consuming rotten tomatoes is enormous and, in fact, not instant but happens gradually. Fungi were shown to be the main rotting organisms for tomato fruits, according to research on the microbes responsible for tomato deterioration (Omolaran *et al*., 2016). These organisms could be of public health concern because some are associated with toxin production, causing severe health issues when ingested in dietary products. Four organs (liver, kidney, intestinal tracts and skin) in the human body are responsible for the elimination of toxins. The challenge is that all these organs begin to diminish in function once introduced to rotten tomatoes, and then the body's immune system breaks down, resulting in a lot of illness (Somma *et al*., 2019).

Although the information that is now available indicates that fruit is becoming more and more important every day, the frequency of microbial attacks on tomatoes deserves attention. Even though, researchers such as Obeng *et al*. (2018) and Gyasi *et al*. (2020), have indicated the increased consumption of rotten tomatoes in the country, studies that seek to identify and isolate fungi in rotten tomatoes are limited. Several people, who constitute the majority and are low-income earners have no option than to buy rotten tomatoes for their meals because of the

low cost. The consumption of these spoiled tomatoes can lead to food-borne illness and jeopardise the consumers' health (Saleh & Al-Thani, 2019; Somma *et al*., 2019; Gyasi *et al*., 2020; MacArthur *et al*., 2021). To reduce the possibility of fungi spoiling tomatoes, proper research in this area is very relevant. There is a need to assess those fungi associated with spoiled tomatoes to solve the problem of food-borne illness, which can be pathogenic to humans.

Additionally, Ghana's climate in general, particularly its high moisture content, encourages the growth of rotting molds on fruits and vegetables (Mensah *et al*., 2014; Obeng *et al*., 2018). As indicated by Sani *et al*. (2018) tomato fruits quickly degrade following harvest and whilst being stored, caused by microbial attacks, physiological breakdown, and environmental factors such as high temperatures. In many parts of Ghana, studies such as Obeng *et al*. (2018) and Gyasi *et al*. (2020) have documented instances where commercial food vendors, restaurants and poor urban inhabitants use rotten tomatoes. Being among one of the poor regions in Ghana, Melomey *et al*. (2019) indicated the prevalence use of rotten vegetables including tomatoes in the Northern Region. Microorganisms, notably fungus, destruct fruits, reducing their availability for eating and the money gained from fruit sales. In order to lower the danger of contamination and infection associated with handling and consuming these fruits, it is necessary to identify these microorganisms, particularly those that are pathogenic to humans. As a result, the goal of this study was to isolate and identify fungi linked to spoiled tomatoes marketed in Kumbungu, Nanton, Tolon and Savelugu in the Northern part of Ghana, as well as create public health awareness about the predominance of fungal organisms. The research is significant since it gives one of the first comparative characterizations of market tomato-associated fungal communities from Nanton, Savelugu, Tolon, and Kumbungu, resulting in baseline data on the prevalence and diversity of spoilage fungi in Ghana's Northern Region. This information is necessary to assess regional differences in fungal contamination and to develop effective postharvest management strategies to reduce economic losses and public health dangers.

Experimental

Materials and Methods

Study area

One of Ghana's sixteen regions is the Northern Region. Up to December 2018, when the Savannah Region and Northeast Region were formed from it, it was the largest of the sixteen regions, covering an area of 70,384 square kilometres or 31% of Ghana's total area (Abankwa *et al*., 2009). The Northern Region is divided into 16 Districts. The region's capital is Tamale. The study population comprised all the 16 Districts in the Northern Region of Ghana. However, the study was conducted among four communities out of the 16 Districts.

Sampling and Data Collection

The tomatoes samples were purchased (Plate 1) from the main markets of Tolon, Kumbungu, Savelugu and Nanton communities during their market days. The sample was selected using the purposive sampling technique. Purposive sampling is a technique used in selecting respondents based on criteria. These four communities were chosen because they are farming communities and are known to be the producers and suppliers of farmed products to the main township (Tamale).

Ten (10) samples each were collected from each of the four districts, making a total of 40 samples to be used for the study. They are collected in labelled sterile polythene bag to avoid contamination. Questionnaire was also prepared to which were used for the tomatoes vendors to help assist and gain more information needed for the study. The samples were transported to the central veterinary laboratory in Pong-Tamale and left for five days for spoilage to occur.



Plate 1: Tomato fruits purchased from Kumbungu Market

Preparation of Media and Processing

The nutrient media used for the study is potato dextrose agar. Potato dextrose agar is a versatile media for identifying and growing yeasts and mold. For the inhibition of bacterial growth, it is usually supplemented with acid or antibiotics. This media is infused with chloramphenicol to inhibit bacterial growth. 39 grams of powdery potato dextrose agar was measured into the disposable cup using the plastic spoon and beam balance for measurement. Distilled water was transferred into a calibrated glass jar using a funnel. The 39 grams of measured potato dextrose agar (Plate 2) was suspended into the distilled water and jiggled in an upwards, downwards rotation. This made the mixture uniform. The mixture was then placed in an autoclave operating under pressurized steam of 121 ℃ for 15 minutes to sterilise the mixture. The molten nutrient media was allowed to cool at room temperature.



Plate 2: Mixture of PDA ready for sterilisation

Isolation of Fungi and Cultivation

These procedures were carried out in a safety cabinet to avoid contamination during working and procedures. 40 plastic petri dishes were properly labelled and arranged according to the order of samples collected in the safety cabinet. An appropriate amount of the molten nutrient agar was carefully poured into each petri dish slowly to avoid bubbles formation. This was allowed to cool down for 24 hours to a gelatinous form. The infected fruits were wiped with a sterile tissue to clean off formed growing microorganisms. Using a disposable

sterile scalpel blade, a portion of the diseased tomato was cut and with the help of a plastic disposable forceps placed in the center of the nutrient agar to allow spread and growth of microorganisms.

Tapes were used around the opening of the petri dishes to seal and avoid contamination during incubation. The contents were kept for a maximum of six (6) days for total growth of isolated fungi. They were stored at room temperature of 25 ℃ to 30 ℃. The Petri dishes are invented to prevent formation of bubbles or traps of evaporated air during incubation.

Characterisation and Identification of the Isolates

On the sixth day of cultivation, the cultures were observed macroscopically. They were characterised based on colony morphology. The identification of the isolates by colony morphology are, surface texture, center and margin cultures, colour of colonies, exudates and colony tint surface. Lacto-phenol cotton blue staining was used for the microscopic viewing of the isolates. Additionally, it is employed to create fungi-based semi-permanent microscopic preparations. It discolors the fungus' cytoplasm and creates a pale blue background that makes it easy to observe the hypae's walls. The working area was disinfected, and paper towels were spread for the procedure. A goggle and mask were worn to protect one against the corrosive nature of the solution**.** Each microscopic slide was labelled in relation to the samples being viewed. A drop of the Lacto-phenol cotton blue was dropped in the middle of the microscopic slide. Using a needle, the small portion of cultures were taken and placed in the drop on the Lacto-phenol cotton blue. Inoculation loops were used to spread even the isolated on the lacto-phenol blue stain. Microscopic cover slides were placed carefully avoiding air bubbles. They were kept for about 10 to 15 minutes to dry before viewing under the light microscopic. To identify hyphae, spores, and other distinct structures, they were initially observed through a low-resolution objective of x10 and subsequently through a high-resolution objective of x40.



Plate 3: Microscopic slides ready for viewing under the microscope

Qualitative data

A questionnaire was designed specifically ask the vendors questions related to the hygiene and practices of tomatoes they sell. Thus, a total of forty vendors answered the questionnaire giving insights on how they handle tomatoes for consumers and how they handle, general knowledge of fungi contaminations and what happens to contaminated or spoiled tomatoes.

Data analysis

The data for the prevalence of fungal isolates were determined using a Microsoft excel and presented as a table.

Results and discussion

Macroscopic Characteristics of Fungi Isolates from Kumbungu, Tolon, Nanton and Savelugu Markets

Isolation and identification of fungal contaminants associated with tomato spoilage was conducted where four fungal pathogens were identified based on macroscopic (colony appearance) and microscopic identification (Table 1) using the standard mycology atlas. Macroscopic view and micro-morphology presentation of isolates (Plate 4 to 8).

TABLE 1

Colony appearance and macroscopic characteristics of fungi identified

Colony appearance	Fungal species identified
Cotton and hairy like texture with white background and black tops of colonies, colonies are fluffy rise and fast growth. (KF01 - KF04)	*Rhizopus* spp.
Powdery whitish growth with flat elevations, ciliate margins with radiate growth pattern. (KF10)	*Mucor* spp
Powdery with centered water-soaked growth of colony, whitish with flat elevations. (KF05 - KF08)	*Mucor* spp
Black mass at the center of the dish with fluffy rise of whitish and black colonies. And at the edge has greenish spores developed on the mass. (KF09)	*Rhizopus* spp *Aspergillus* spp
Very thick mass black background mass covering the entire dish, with greyish spores at the top and at the edge a greyish green mass. (TF01 - TF03)	*Rhizopus* spp *Aspergillus* spp
Center water-soaked with powdery greenish edges. (TF04 -TF05)	*Mucor* spp
Very thick and black center and around the center are circular colonies mixed with a few greenish grey colonies. (TF06, TF07, TF010)	*Rhizopus* spp *Aspergillus* spp
Black background with fluffy rise of both black and grey or white colonies. (TF09)	*Mucor* spp
Half of the dish has a complete white fluffy colony and the other has a hairy-like mixture of white colonies with black spores at the top. (TF08)	*Rhizopus* spp *Absidia* spp
Powdery green-like growth in the center region and at the edge's growth spotted with black colour. (NF06)	*Aspergillus* spp *Rhizopus* spp
White powdery growth in the middle and black spots growth at the edges. (NF01 - NF05)	*Rhizopus* spp *Mucor* spp

Water-soaked colonies with a thick grey colour. (NF07 -NF010)	*Mucor* spp
Fine hairy-like white fluffy growth with a separate colony of powdery spotted black growth. (SF01, SF03)	*Rhizopus* spp *Absidia* spp
Black mass of spotted growth surrounded with water-soaked colonies. (SF07, FS08, SF10)	*Rhizopus* spp *Mucor* spp
Entire colony is water-soaked with a bit of white powdery like growth. (SF02, SF04, SF05, SF06, SF09)	*Mucor* spp

Note: KF 01 - 10 = samples from Kumbungu market; TF01 - 10 = samples from Tolon market; NF01 - 10 = samples from Nanton market; and SF01 - 10 = samples from Savelugu market

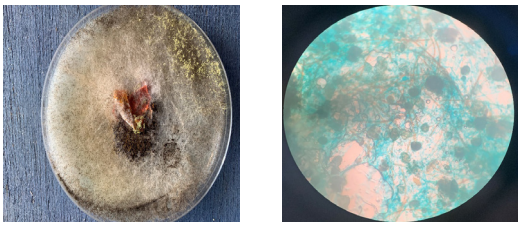


Plate 4: Macroscopic view and micro-morphology presentation of isolate KF01

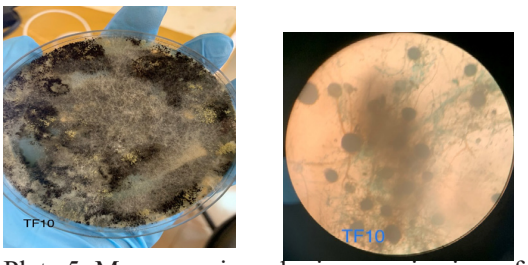


Plate 5: Macroscopic and microscopic view of isolate TF10

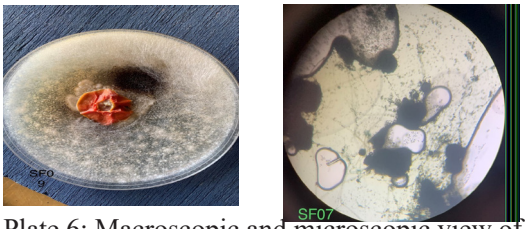


Plate 6: Macroscopic and microscopic view of isolate SF09

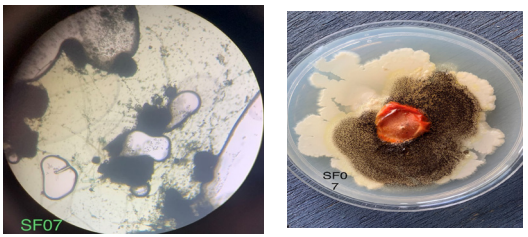


Plate 7: Macroscopic and microscopic view of isolate SF07

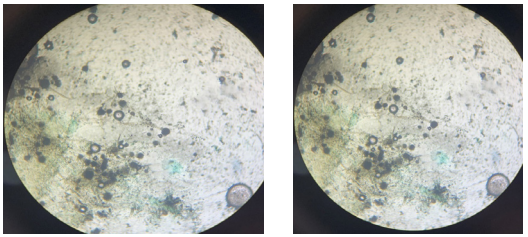


Plate 8: Macroscopic and microscopic view of isolate SF10

Occurrence of Fungi Isolates in Various Spoiled Tomatoes

A total of four fungi isolates were identified during characterization. *Mucor* species was isolated from KF02, KF05, KF06, KF07, KF08, KF10, TF04, TF05, TF06, TF08, NF01, NF02, NF04, NF05, NF06, NF07, SF02, SF04 and SF07. *Aspergillus* species was isolated from KF03, TF01, TF03, TF05, TF09, TF10 and NF09. *Rhizopus* species was isolated from KF01, KF02, KF03, KF04, KF05, KF07,

KF10, TF01, TF02, T03, TF07, TF08 TF09, TF10, NF01, NF07, NF08, NF09, NF10, SF01, SF07, SF09 and SF10, whilst *Absidia* species was only present in samples TF09, SF01 and SF03. Some samples have more than one isolates, and others have no isolates.

The percentage occurrence was highest at Tolon Market site (32.10%), followed by Kumbungu Market having a percentage occurrence of 26.42%, Nanton Market showing 22.64%, and the least percentage was recorded from Savelugu Market (18.87%) (Table 2).

TABLE 2

Percentage of fungi isolates from Kumbungu, Tolon, Nanton and Savelugu

Markets	*Mucor* spp	*Rhizopus* spp	*Aspergillus* spp	*Absidia* spp	Total	% Occurrence
Kumbungu	6	7	1	0	14	26.42%
Tolon	4	7	5	1	17	32.10%
Nanton	6	5	1	0	12	22.64%
Savelugu	4	4	0	2	10	18.87%
Total	20	23	7	3	53	100%
% Isolates	37.74%	43.39%	13.21%	5.66%	100%	

Percentage occurrence of each isolate from the sample

The percentage occurrence of the various isolates on the samples shows that *Rhizopus* species was the most common (57.50%), followed by *Mucor* species (50%), *Aspergillus* species (17.50%) whilst *Absidia* species was the least with the occurrence of 7.50% (Table 3).

TABLE 3

Percentage of isolates

S/N	Isolates	Number examined	Number positive	Percentage
1	*Mucor* spp	40	20	50%
2	*Rhizopus spp*	40	23	57.50%
3	*Aspergillus* spp	40	7	17.50%
4	*Absidia* spp	40	3	7.50%

Storage and handling practices

The study observed that 28% of the natives stored their loads of tomatoes on the floor in their rooms and 72% store theirs in either boxes or metallic basins in rooms with other goods. Also, 67% of the respondent do not often wash or clean the crates used for the arrangement and display of tomatoes in the market, they only do when the crates start to get dirty whilst 33% rarely wash the crates. An important information gathered in the questionnaire states that 61% of the respondents sell these rotten or infected tomatoes to food vendors or any available buyers at very cheap prices compared to the uninfected fruit.

Characteristics of isolate fungi from spoilt tomatoes from Kumbungu, Tolon, savelugu and Nanton Markets

The fungal isolated from the tomato fruit sold in the four communities were *Aspergillus* species, *Mucor* species, *Rhizopus* species and *Absidia* species. *Rhizopus* species occurring the most among the isolates. The tomato

fruits are known to have very high amount of nutrients and dietary often increases its demand by the public. The high-water content facilitates its susceptibility to fungal spoilage which can lead to foodborne infection or food poisoning and intoxication. This results goes to agree with the previous research conducted by Akinro *et al*. (2015) who stated that tomato soft rot is caused by the fungi *Fusarium spp*. and *Rhizopus spp.* Similarly, studies by Alberio *et al*. (2015) stated the common fungus occurring as airborne spores and found naturally in soils is *Rhizopus*. Another research work conducted in Nigeria, Uyo Metropolis approximately had one-third of their samples contaminated with *Rhizopus* spp and *Aspergillus* spp (Saleh and Al-Thani, 2019).

In this present study, *Absidia* spp were isolated as part of fungi responsible for tomatoes spoilage. This species is hardly reported by many researchers as by to be responsible for fruit spoilage. However, they belong to the family *Zygomycetes* (*Mucor, Mortierella* and *Rhizopus*) which are known to be most relevant in food spoilage. It will not be a surprise that species of *Rhizopus* spp and *Absidia* spp predominantly occur on stored grain, fruit and vegetables (Dijksterhuis *et al*., 2006).

Prevalence and Distribution of Fungal Populations from Spoilt Tomatoes in the Northern Region of Ghana

Majority of them store theirs in either boxes or metallic basins in rooms with other goods whilst few of the natives stored their tomatoes on the floor in their rooms. It can there be concluded that heat and microorganisms are the major factors responsible for spoilage in these communities due to their mode of storge. Also, majority of the vendors do not often wash or clean the crates used for the arrangement and display of tomatoes in the market, they only do when the crates start to get dirty whilst few rarely wash the crates. Majority of the respondents sell these rotten or infected tomatoes to food vendors or any available buyers at very cheap prices compared to the uninfected fruit.

The results of fungi prevalence in the various communities showed Tolon Market recorded the highest number of fungi isolates whilst Savelugu Market recorded the least number of fungi isolates. The presence of higher number of fungi isolates from Tolon market may be due to the improper handling and hygienic practices. This suggests that Tolon Market is not as hygienic as compared to Savelugu Market. From the survey, most of the natives store the load of tomatoes in their living spaces spread on floor. This is due to lack of storage unit cause of poor standard of living and spreading the tomatoes on the floor is their way no reducing the rate of spoilage due to heat. In Savelugu, all respondents have a storage unit for their tomatoes hence the reasons for low number of tomato fungi contamination.

The high prevalence of *Rhizopus, Mucor* and also, the presence of *Absidia* species which all belong to the class *Zygomycetes* is alarming to economical income and losses to the various communities and region at large. These species are known to cause rapid softening and postharvest molds in fruits and vegetables which shortens life span. Also, their asexual propagation which involves spore production aids these fungus in rapid production and easy transferring from one vegetable to another. Their presence in the four communities studied concludes that is high and rapid.

The consumption of these contaminated tomatoes containing the isolated fungus may lead to severe food poisoning. Studies has proven that zygomycetes are associated with diabetes, cellulites and

gastrointestinal diseases in humans. According to Muszewska *et al*. (2014), the clinical manifestation of *Zygomycetes* in humans are pulmonary, cutaneous and allergic diseases.

Conclusion

This study identified *Rhizopus* species, *Aspergillus* species, *Mucor* species and *Absidia* species as fungi associated with spoilage of tomatoes in Kumbungu, Tolon, Nanton and Savelugu Markets. Some vendors sell crashed and semi-spoilt tomatoes to food vendors which may lead to serious food poisoning. Almost all the fungi isolated have adverse effect on the economic progress due to the rapid deterioration of tomatoes in the region whilst others are associated with mycotoxins productions which has serious health implications in humans and animals. Tomato is known for its high dietary and nutritional value for consumption. High deterioration results in loss of economic resources. To lower the rate of fungus contamination and lower the potential public health risks associated with consumption of these contaminated vegetables, producers and marketers must use effective quality control methods during handling, storage, and sales of the vegetable. To reduce the risk of deterioration of tomatoes and mycotoxins produced by fungi that are deleterious to human health, frequent inspection of tomatoes for sales by food inspectors should be conducted. This will lessen the chance of infection by these fungi and also lessen any potential public health problems associated with eating inexpensive tomatoes that have gone bad.

Acknowledgements

We acknowledge and thank Dr. Emmanuel Allegye-Cudjoe, the Director at the Central Veterinary Laboratory in Pong-Tamale for the opportunity and space to perform the laboratory work. For assistance and support during my laboratory experiment, we are really grateful to Mr. Clement and Mr. Musah.

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Received 30 Jul. 24; revised 08 Jul. 26.