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RESEARCH ARTICLE OPEN ACCESS

Senior Seminar on Salmonellosis in Sheep and ITS Public Health Importance

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Abstract:

Ethiopia has about 14.7 million sheep providing 35% (148,850 tons) of meat for consumption together with goat. Salmonellosis is an infectious disease of primarily of animals but also is transmissible to humans.It is one of the most common causes of food-borne infection worldwide. Sheep salmonellosis is an acute contagious disease, characterised by gastroenteritis, diarrhoea, septicaemia, metritis, abortion, and recovery of carriers. The disease occurs in all breeds, sex and ages of sheep, being young and pregnant sheep are most susceptible. The diarrhoeal and septicaemia forms of clinical salmonellosis are commonly caused by *S.* Typhimurium, *S.* Bovismorbificans and *S.* Havana. Abortion may occur as a sequel to septicaemia with any *Salmonella* serotypes. The facultative anaerobic pathogen is primarily an intestinal bacterium; and can survive for months in wet, warm areas. its optimum growth temperature and PH is 37^{o}C and 6.5-7.5 respectively. And itgrows optimally at a water activity of 0.995. Different studies conducted in Ethiopia approved the presence of *Salmonella* in animals, humans, foodstuffs and environment with varying prevalences. And its prevalence is precipitated by stressful situations such as sudden deprivation of feed, transportation, drought, crowding, parturition, surgery, and administration of certain drugs. Salmonellae are carried in the intestinal tracts and associated organs of most farm and wild animals. Infected animals are the source of the organisms which they excrete and infect other animals directly or indirectly by contamination of the environment, primarily feed and water supplies. Because of the non-specific clinical symptoms and necropsy findings, a presumptive diagnosis has to be confirmed by the isolation of the organism either from tissues collected aseptically at necropsy or from faeces, rectal swabs or environmental samples. The control of *Salmonella* in meat animals and derived products is a very challenging task because of the complexity and interdependence of various aspects of animal husbandry, slaughtering, and processing. The application of the hazard analysis critical control point (HACCP) system throughout the food chain to identify the critical control points to eliminate or control growth or contamination with *Salmonella* is a pre-requisite for the effective and economic control of human and animal salmonellosis

Keywords Ethiopia, Salmonella and Ruminants

I. INTRODUCTION

Ethiopia has about 14.7 million sheep and 13.7 million goats. Small ruminants are important livestock resources in Ethiopia, providing 35% (148,850 tons) of meat consumption (Asfaw, 1997). Salmonellosis is an infectious disease of primarily of animals; but also is transmissible to humans.It is one of the most common causes of food-borne infection worldwide (Andria *et al*., 2014). According to Karin *et al*. (2011) study an approximate of 93.8 million human gastroenteritis cases and 155 thousand deaths occur due to *Salmonella* infection around the world each year. It is caused by one or more of the 2000 serotypes of the two species of *Salmonella* (*Salmonella enterica*, and *S. bongori*). *Salmonella* are facultative anaerobic gram-negative rods bacilli within the family of *Enterobacteriaceae.* They can grow both aerobically and an aerobically at an optimum temperature of 37^{o}C, and can be killed by temperature of 55^{o}C. They can be isolated from intestine of both animal and human and from food of animal origin such as meat and egg (Anderson, 1996). The members of this genus are motile by means of peritrichous flagella except *Salmonella gallinarum (*Plym and Wierup, 2006).*Salmonella* species are leading causes of acute gastroenteritis in several countries and salmonellosis remains an important public health problem worldwide, particularly in the developing countries. Sheep could be as a source of human infection with *Salmonella* through direct contact with them and their meat.

Sheep salmonellosis is an acute contagious disease, characterised by gastroenteritis, diarrhoea, septicaemia, metritis, abortion, and recovery of carriers. On a worldwide basis, the diarrhoeal and septicaemia forms of clinical salmonellosis is commonly caused by *S.* Typhimurium, *S.* Bovismorbificans, *S.* Havana and others with *S.* Typhimurium being the most frequent pathogen (Kimberling, 1988; Smith and Sherman, 1994). Abortion may occur as a sequel to septicaemia with any *Salmonella* serotypes. *Salmonella* Typhimurium, *S.* Abortusovis, *S.* Montevideo, and *S.* Dublin are the usual causative serotypes of abortion in sheep.

II. SALMONELLOSIS IN SHEEP

Sheep salmonellosis is an acute contagious disease, characterised by gastroenteritis, diarrhoea, septicaemia, metritis, abortion and recovery of carriers. On a worldwide basis, the diarrhoeal and septicaemia forms of clinical salmonellosis is commonly caused by *S.* Typhimurium, *S.* Bovismorbificans, *S.* Havana and others; with *S.* Typhimurium being the most frequent pathogen (Kimberling, 1988; Smith and Sherman, 1994). Abortion may occur as a sequel to septicaemia with any *Salmonella* serotypes. *Salmonella* Typhimurium, *S.* Abortusovis, *S.* Montevideo, and *S.* Dublin are the usual causative serotypes of abortion in sheep. These species may also cause enteric salmonellosis. These bacteria commonly reside in the alimentary tracts of carrier animals and contaminated feed and water (Kimberling, 1988; Radostits*et al.,* 1994; Smith and Sherman, 1994).

The disease occurs in all breeds, sex and ages of sheep, however, young and pregnant sheep are most susceptible (Kimberling, 1988; Smith and Sherman, 1994). Because of universal distribution and high incidence within infected flocks, the disease has major economic importance to the entire sheep industry. Economic losses result from abortions, stillbirths, deaths and damaged wool and from the cost of expensive treatment, prevention, extra labor, and disposal of dead sheep. Additional losses come from incapacitation, discomfort, and treatment of infected people (Kimberling, 1988; Smith and Sherman, 1994; Radostits*et al.,* 1994).

In animals which survive the disease, localization of salmonellae organism occurs in gastrointestinal tract, mesenteric lymph nodes, liver, spleen and the gall bladder. In healthy adults there may be no clinical illness when infection first occurs but there may be localization in abdominal viscera. In either instance the animals become chronic carriers and discharge salmonellae intermittently (Radostits*et al.,* 1994). Numerous *Salmonella* serotypes have been isolated from the faeces of healthy goats and sheep and from viscera at slaughterhouses around the world (Kumar *et al.*, 1973; Nabbut and Al-Nakhli, 1982; Smith and Sherman, 1994). This suggests that the carrier state is common in sheep and goats and there is considerable concern about the zoonotic potential of salmonellae contamination of sheep and goats meat in countries where it is widely consumed acting as a source of infection for man (Kumar *et al.*, 1973; Nabbut and Al-Nakhli, 1982; Smith and Sherman, 1994).

A. *Etiology and Characteristics*

Salmonellosis has been recognized in all parts of the world. The facultative anaerobic pathogen is primarily an intestinal bacterium, commonly found in an environment subjected to fecal contamination. The organisms may survive for months in wet, warm areas. Rodents and wild birds are also sources of infection for domestic animals (Walter, 2016).

The cells are typically 0.7-1.5 µm by 2-5 µm. They grow at 7-48^{o}C with an optimum growth at 37^{o}C (mesophile) and at pH 4.05-9.5 with an optimal growth at pH 6.5-7.5 (neutrophile).

Salmonella grows optimally at a water activity of 0.995 and are chemo-organotrophs. They have both fermentative and oxidative metabolism. The primary route for metabolism of carbohydrates is the Embden-Meyerhof pathway (glycolysis). They ferment glucose to formate (with the production of gas) and to ethanol, acetate, or lactate (Craig DE. and James MS 2006)

Strains of genus *Salmonella* are the group of family *Enterobacteriaceae*, they are straight rod usually motile with peritrichous flagella (except *S. pullorum*and*S. gallinarum*), facultative anaerobe, ferment glucose usually with production of gas (except *S. typhi*and*S. dublin*) (Johnson *et al*., 2007). *Salmonella* multiply optimally at a temperature of 35oC to 37oC, pH about 6.5-7.5. They are also able to multiply in the environment with low level or no oxygen (Kemal, 2014). The bacteria are sensitive to heat and will not survive a temperature above 70^{o}C; so it is sensitive to pasteurization, but resist to drying even for years. Especially in dried feces, dust and other dry materials such as feed and certain food (Radostitiset *al*., 2007).

Although many other *Salmonella*spp may cause enteric disease in sheep, the more common ones are: *S*Typhimurium, *S* Dublin, *S*Abortusovis, *S*Anatum, and *S* Montevideo.

B. *Epidemiology*

Studies conducted in Ethiopia indicated the presence of *Salmonella* in animals, humans, foodstuffs and environment. Salmonellae were isolated from man, chicken, cattle, camels, sheep, goats and food (Nyeleti*et al*., 2000; Tibaijuku, 2003; Woldemariam, 2003). In a study conducted by Pegram*et al.* (1981), 27 *Salmonella* serotypes were isolated from samples of animal origin in different parts of the country. Molomo (1998) recorded 19.8% average mortality rate caused by the *Salmonella* in commercial poultry farms. Molla*et al.* (1999a) reported 19.0% contamination rate of retailed food (chicken and minced beef) by *Salmonella* in Addis Ababa. In a study carried out in selected site of Addis Ababa isolation rate of 10.6%, 19.6%, 9.8%, 11.9%, from cattle faeces and mesenteric lymph nodes, abdominal and diaphragmatic muscle respectively and 6%, from abattoir personnel were recorded (Nyeleti*et al*., 2000). In and around Debre-Zeit, 3.1% of diaphragmatic muscles, 2.8% of abdominal muscles, 3.1% of faecal and 4.5% of mesenteric lymph node contamination rate of cattle were reported (Alemayehu*et al*., 2003). A prevalence of 42% from raw '*kitfo*' (minced meat) samples in Addis Ababa was reported by Tegegne and Ashenafi (1998). In sheep and goats, Woldemariam (2003) reported a 6.4% prevalence of salmonellosis at ElforaDebreZeit abattoir. According to Woldemariam (2003), out of the 642 samples from apparently healthy sheep (n=282) and goats (n=360) examined for *Salmonella,* 33 *Salmonella* isolates consisting of 9 different serotypes were identified. Ten (3.5%) of apparently healthy slaughtered sheep and 23 (6.4%) of goat samples were found to be contaminated with *Salmonella*. The serotype identified were *S.* Infantis (45%*), S.* Butantan(24.2%), *S.* Braenderup, *S.* Kingabwa (each 6%), *S.* Zanzibar, *S.* Kottbus, *S.* Anatum, *S.* Typhimurium and *S.* Hadar (each 3%). Ejeta*et al*. (2004) also isolated five different serotypes (*S.* Infantis (25%), *S.* Braenderup (42%), *S.* Anatum (8.3%), *S.* Bovismorbificans (17%), and *S.* I: 47, z_4, z_{23}) from mutton.

In another study *Salmonella* isolation rate of 4.5% was recorded from stool specimens of diarrhoeal out-patients from various hospitals and clinics in Addis Ababa (Ashenafi and Gedebou, 1985). Furthermore Mache (2002) reported a prevalence of 15.4% from paediatricdiarrhoeal out-patients in Jimma hospital and Jimma health centre. The habit in this country to consume, raw meat as a traditional food poses a high risk of acquiring Salmonellosis as well as other zoonotic diseases (Molla*et al.,* 1999a; Molla*et al.,* 2003a).

The prevalence is commonly precipitated by stressful situations such as sudden deprivation of feed, transportation, drought, crowding, parturition, surgery, and administration of certain drugs, including oral antibiotics. Greater susceptibility in the very young may be the result of high gastric pH, absence of a stable intestinal flora, and limited immunity (wray and Linklater, 2000).

C. Source of infection and ways of transmission

The usual route of infection in enteritis is fecal-oral, although infection through the upper respiratory tract and the conjunctiva have also been reported. After ingestion, the organism colonizes the digestive tract and invades and multiplies in enterocytes and tonsillar lymphoid tissue. Penetration of bacteria into the lamina propria contributes to gut damage and diarrhea. The cellular infection results in activation of a host alarm process through signalling molecules as a result of the detection of bacterial surface proteins, which in turn induces a strong inflammatory response that generally is able to restrict the bacteria to the intestine. Some serotypes also become localized in the reproductive tract. Serotypes that are able to cause typhoid can modulate the initial host response and suppress the inflammatory response. As infection progresses, a true septicemia may follow, with subsequent localization in brain and meninges, pregnant uterus, joints and distal aspects of the limbs, and tips of the ears and tails, which can result in meningoencephalitis, abortion, osteitis, and dry gangrene of the feet, tail, or ears respectively.

The organism also frequently localizes in the gallbladder and mesenteric lymph nodes, and survivors intermittently shed the organism in the feces. Infection may also persist in lymph nodes or tonsils, with no salmonellae in the feces. Latent carriers may begin shedding the organism or even develop clinical disease under stress (kemal, 2014).

D. Clinical Sign

Infection with localization of the pathogen in tonsils or the GI tract that is not associated with clinical disease is a common form of salmonellosis termed as the carrier state. Carrier animals are chronically infected and may shed salmonellae intermittently into the environment. Carrier animals can develop clinical disease whenever the immune function is compromised or concurrent infection with another pathogen occurs. Symptoms of salmonella infection in sheep vary greatly depending on serotype, infection dose, and immune status of the animals that become infected. Symptoms described in sheep are similar to other species: such as diarrhoea, abortions, fever, depression, decreased appetite, blood poisoning, and death. Often there are no clinical symptoms (Walter- Gruenberg, 2016).

E. **Post mortem findings**

There may be no gross lesion in animals that have died peracutely but extensive submucosal and subserosal petechial heamorrhage are usually evident (Radostitis*et al.,* 2007). In adults,a typical case reveals acute muco/necrotic enteritis, especially of the ileum and large intestine. The wall is thickened and covered with yellow-grey necrotic material overlying a red, granular surface. The mesenteric lymph nodes and spleen may be enlarged. In youngs, the small intestine typically shows a diffuse mucoid or mucohaemorrhagic enteritis and the mesenteric lymph nodes are oedematous, congested and greatly enlarged (Wray and Davies, 2000).

F. Diagnosis of Salmonellosis

The diagnosis of salmonellosis presents a considerable difficulty in the living animal largely because of the variety of clinical syndromes which may occur and the variations in necropsy findings. Mostly because of the non-specific clinical symptoms and necropsy findings, a presumptive diagnosis has to be confirmed by the isolation of the organism either from tissues collected aseptically at necropsy or from faeces, rectal swabs or environmental samples (Radostits*et al.*, 1994).

1. *Conventional cultural isolation techniques*

According to the International Organization for Standardization (ISO 6579, 1998) it is customary to use three stage processes: pre-enrichment, selective enrichment and selective plating to isolate *Salmonella*.

Pre-enrichment: Pre-enrichment allows the resuscitation and multiplication of sub-lethally damaged *Salmonella* cells (Blackburn, 1993). Non-selective media such as buffered peptone water and lactose broth are most widely used for resuscitation;

buffered peptone water being recommended for routine purposes. The need for resuscitation is now widely accepted for all types of samples and not merely those which have been dried or frozen (Varnam and Evans, 1991).

Selective enrichment: Selective enrichment helps to increase the ratio of *Salmonella* to competitor organisms. Many types of inhibitors have been proposed for the selective enrichment of *Salmonella,* the most widely used of which bile, tetrathionate, selenite and dyes are including brilliant green and malachite green. Various formulations of selenite and tetrathionate broths have been widely used, although in recent years there has been increasing use of the malachite green based Rappaport-Vassilliadis (RV) broth (Varnam and Evans, 1991; Blackburn, 1993).

Selective plating: Plating on selective agar media enables the recognition of *Salmonella* colonies while suppressing the growth of the back ground microflora. A wide range of media has been devised for selective plating. Selective plating media for *Salmonella* all contain a diagnostic system to permit differentiation of the organisms from non-*Salmonella.* This is commonly based on the inability of most salmonellas to ferment lactose and, in some cases, other carbohydrates such as sucrose and salicin. Bile containing media often employ a second diagnostic system based on the ability of *Salmonella* to produce hydrogen sulphide. Where competition from other bacteria is insignificant, a general-purpose medium such as MacConkey agars may be used. In many cases, greater selectivity is required and it is necessary to use a medium devised specially for *Salmonella*, such as brilliant green agar, *Salmonella-Shigella*agar, xylose lysine desoxycholate agar and Rambach agar (Blackburn, 1993; Quinn *et al*., 1994).

2. *Biochemical tests*

Colonies characteristic for *Salmonella* on the selective/indicator media are inoculated singly onto a triple sugar iron (TSI) agar slope and lysine decarboxylase broth. The typical reactions for *Salmonella* in TSI agar is a red (alkaline) slant, yellow (acid) butt and superimposed (black) H_2S production (R/Y/ H_2S^+). Salmonellae typically produce an alkaline (purple) reaction in the tube of lysine decarboxylase broth. If the reaction in TSI agar and lysine decarboxylase broth is equivocal, further biochemical tests such as indole (negative), methylred (positive), citrate (positive), urease (negative), Voges-Proskauer test (negative) and others should be carried out or an identification system used such as API 20E (analytab products) or Enterotubes (RoheDiagnostica) (Doyle and Cliver, 1990; Quinn *et al*., 1994).

3. *Serological tests*

Serological tests have been developed for the diagnosis of *Salmonella* infection. They are used to identify unknown cultures with known sera and may also be used to determine antibody titers in patients with unknown illness (Jawetz*et al.,* 1995;OIÉ, 2000). Slide agglutination test is one of the serological techniques used for the diagnosis of *Salmonella.* An agglutination reaction occurs when antibody reacts with particular antigen and cross-links surface antigen determinants. A drop of polyvalent antiserum is added to a suspension of bacteria in saline. A control of the bacterial suspension without antiserum is also used to eliminate autoagglutination. After the addition of antiserum the slide is rocked gently and the result is read within 3 minutes. Clumped bacteria indicate a positive reaction. Serological identification is made more precise by typing with monospecific serums (Quinn *et al*., 1994).

G. Treatment and prevention in sheep

Uncomplicated cases of salmonellosis do not warrant treatment with antibiotics. This is because antibiotics can favor the persistence of *Salmonella* spp. in the intestines after recovery, affect the intestinal flora, and increase the emergence of antibiotic-resistant strains. But fluid replacement, correction of electrolyte imbalances and other supportive care is important in cases of enteritis. Septicemic salmonellosis can be treated with a number of antibiotics. http://www.cfsph.iastate.edu/DiseaseInfo/factsheets.php

In all animals, the risk of clinical salmonellosis can be decreased by good hygiene and minimizing stressful events. Biosecurity is the cornerstone of *Salmonella* prevention on the farm. The risk of introducing the bacterium into a herd/flock can be decreased by buying animals from *Salmonella*–free sources; isolating newly acquired animals; and practicing all-in/all-out herd or flock management are appropriate. Rodent control is also important. During a herd outbreak, carrier animals should be identified and either isolated and treated, or culled. Treated animals must be re-tested several times to ensure that they no longer carry *Salmonella*. Mixing of animals should also be avoided to decrease the spread of infection. Fecal contamination of feed and water supplies should be prevented. Contaminated buildings and equipment should be cleaned and disinfected, and contaminated material should be disposed off. In many cases, elimination of *Salmonella* infections is impractical, and control is limited to preventing illnesses in animals and/or the transmission of bacteria to humans. http://www.cfsph.iastate.edu/DiseaseInfo/factsheets.php

III. DISEASE IN HUMANS

Salmonellosis is an important global public health problem causing substantial morbidity and thus also has a significant economic impact. Although most infections cause mild to moderate self-limited disease, serious infections leading to deaths do occur (De-Jong and Ekdahl, 2006). In spite of the improvement in hygiene, food processing, education of food handlers and information to the consumers, foodborne diseases still dominate as the most important public health problem in most countries (Domínguez et al., 2002).

The Centers for Disease Control and Prevention (CDC) estimates that salmonellosis causes more than 1.2 million illnesses each year in the United States of America, with more than 23,000 hospitalisations and 450 deaths (CDC, 2013). Even though the focus of this review is up on salmonellosis in sheep, the source of the disease to humans is not restricted to this animal only. The most common cause of infection with *Salmonella* is eating contaminated foods including raw or under cooked eggs or egg products, meat, poultry, contaminated fresh fruit and vegetables and soft cheeses made from unpasteurized milk (OIE, 2016). *Salmonella* can also be spread to people through contact with infected birds, livestock, reptiles, amphibians, and dogs and cats. These animals may carry the bacteria even when apparently healthy. Many serovars, including some that are host-adapted such as S. Choleraesuis and S. Dublin, have been shown to cause serious disease in humans. Abattoir workers, animal attendants and veterinarians may be infected directly during the course of their work when in contact with infected animals. Laboratory personnel may also acquire the infection if safe working practices are not implemented (OIE, 2016).

A. *Clinical Signs in Human*

The incubation period depends on the number of bacteria ingested and varies from 5-72 hours. Affected individual's experience sudden nausea, vomiting and watery fowl smelling diarrhea which is in most case last only a few hours. If the colon is affected, the stool may also contain blood and or mucus. Fever up to 39^{o}C is not uncommon. Convalescences within 1-2 days but the illness may last for 5-7 days (Krauss *et al.*, 2003). More severe symptom may occur in people who are at high risk like those extreme age groups (the young because their immune system are immature and the elderly because the immune system are declining), person with decreased gastric acidity (because gastric acid is the first line of defense for the ingested *Salmonella*), person with altered gastric intestinal bacteria (including those taking broad spectrum antibiotics, purgatives or who have had bowl surgery) and person taking opiate drug in which the bowl movement is decreased. In these highest risk groups of people *Salmonella* may invade beyond the gastrointestinal tract (GIT) to cause severe systematic illness (Krauss *et al.*, 2003).

Salmonella gastroenteritis is usually a self-limiting illness and fatality is uncommon. Biopsy and endoscopic examination have demonstrated the colon to be a major site of infection. The change in the colon ranges from edema of lamina propria with a focal or diffuse inflammatory infiltrate to a more intensive inflammation with disruption of the surface epithelium and multi-focal micro abscesses. In more severe cases, vascular congestion, infiltration of the lamina proporia with polymorphonuclear leucocytes and abscess formation has been recorded (Wray, 1994).

B. ***Prevention and control in human***

There is no vaccine to prevent salmonellosis in human whereas, vaccine against *Salmonella* typhi has been developed, especially in children, but is only 60% effective. A person given this vaccine would still have a strong chance of developing salmonellosis. It is not expected that there will be a single vaccine that is effective against all the different forms of Salmonella soon. Ongoing research is investigating what can be done to produce a useful human vaccine for *Salmonella* (Danielle, 2006). People should not eat raw or uncooked meat, they should not drink raw milk or unpasteurized dairy product, cross contamination of food should be avoided. Uncooked meat should be kept separate from cooked food ready to eat. Hands, cutting boards or knifes and other utensils should be washed thoroughly after handling uncooked food. Hands should be washed before handling any food and in between handling different food items. People should have to wash their hands after contact withanimal'sfeces (Arun and Bhunia, 2008). Pasteurization of milk and treating municipals water supply for reducing risk of *Salmonella* infection, improvement in farm animal hygiene in slaughter process in food harvesting and in packaging operation have helped to prevent salmonellosis (Hans *et al*., 2006). A periodic surveillance of the level of *Salmonella* contamination in different food product and environment is necessary to control spread of the pathogen. Reducing Salmonella prevalence requires comprehensive control strategy in animal and animal foodstuff with restriction in the infected flock until they have been cleaned from infection. In addition mandatory testing before slaughter should be conducted. Ensuring safe food production requires knowledge on the nature and origin of animal, animal feed, the health status of animals at the farm, the use of veterinary medicinal data regarding antimortem and postmortem findings and the risk association with post harvests production strategies (Kemal, 2014).

IV. CONCLUSIONS AND RECOMMENDATION

Sheep salmonellosis is an acute contagious disease, characterised by gastroenteritis, diarrhoea, septicaemia, metritis, abortion, and recovery of carriers. The disease occurs in all breeds, sex and ages of sheep, being young and pregnant sheep are most susceptible. Salmonella is a leading cause of foodborne disease in human and consumption of both meat and milk has been implicated in salmonellosis outbreaks of people. Having animals and raw products it is not possible to be free from zoonotic agent; however the occurrences can be minimized by applying high standard of hygiene in all steps of the food production. Infected animals can present with a great variety of clinical symptoms, and risk factors for transmission to humans clearly differ by animal species, age groups, animal purpose and geographic region. A high degree of interaction between medical and veterinarian surveillance is needed. Finally, implementing basic and applied research to the agent that cause foodborne salmonellosis will be a crucial point for new approaches to prevent and control the disease.

Depending on the above facts the following points are recommended:

- Strict hygiene of the slaughter house and lairage
- People should not eat raw meat and should not drink unpasteurized milk or milk products too
- Education of food handlers
- Vaccination of animals /if any/
- Maintenance of cold chains
- Sanitary examination of the product
- Collaboration between government agencies, professional organizations and special interest groups

ACKNOWLEDGMENT

My special thanks go to Animal Product, Veterinary Drug and Feed Quality Assessment Center for sponsoring my study and giving me study leave permission.

I would like to thank my advisor, Dr. GezahegnMamo for his guidance, constructive comments and careful correction of the seminar and for his contribution to attach me with project in my thesis work too.

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