ASSESSMENT OF ANTIBIOTICS RESIDUES IN MILK SUPPLIED BY SMALLHOLDER FARMERS TO PROCESSORS IN KENYA: A CASE OF BOMET, NAKURU, AND NYERI COUNTIES

BY

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DECLARATION

This Dissertation is my original work and it has not been submitted for the award of a degree in any other university

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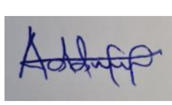
Signature:  **2022**

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DEDICATION

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ABBREVIATIONS AND ACRONYMS

EDTA	Ethylenediaminetetraacetic Acid
ELISA	Enzyme-linked Immunosorbent Assay
GDP	Gross Domestic Product
HLB	Hydrophilicï lipophilic Balance
HPLC	High-Performance Liquid Chromatography
KDB	Kenya Dairy Board
KMD	Kenya Meteorological Department
SPSS	Statistical Package for the Social Sciences
USA	United States of America

OPERATIONAL DEFINITIONS

Antibiotics	Type of antimicrobial substance active against bacteria.
Antibiotic residues	Metabolites found in trace amounts in edible portion of the animal product after the administration of the antibiotics.
Milk Acidity	Milk whose pH is below neutral
Milk adulteration	Adding unacceptable components in fresh-raw milk milked from animal, deteriorating its original value and qualityò
Milk density	Amount of substance in a unit volume of milk that determines weight
Organoleptic	Quality features that determine acceptance or unacceptance of milk
Smallholder farmers	Farmers owning between one to ten herds of dairy cattle

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ABSTRACT

The consumption of milk and milk products serves as a good source of complete food. In spite of that, the use of antibiotics by farmers for the treatment of domestic dairy animals has increased which has led to antibiotic residues in foods of animal origin such as milk due to antibiotic abuse. The main focus of the current study was to determine knowledge on the antibiotics, the usage, and general practices on handling the same by small holdersô milk producers. The study makes contribution towards improved quality and safety of commercially produced milk from the smallholders in Bomet, Nakuru and Nyeri counties in Kenya. The study was carried out using a mixed method approach where farmers, traders and cooperative society staffs were interviewed, and milk samples taken to determine antibiotic usage and levels. Data was recorded on chemicals and drugs used to treat dairy herds, milk hygiene and rejection of milk among farmers. The study alsodetermined the type of antibiotics and levels of residues in milk supplied by smallholders to processors. A total of 108 milk samples comprising raw milk purchased and sampled from farmers were analyzed for the presence of Beta-lactams, Tetracyclines, and sulphonamides residues using rapid tests in the field and High-Performance Liquid Chromatography (HPLC) for quantification in the laboratory. Majority (93.3%) of the respondents had basic education level of training on dairy management and diseases and reported dairy animals as frequently infected with diseases such as mastitis (86%), East Coast fever, and Foot and Mouth. Almost all (98%) farmers used manual method of milking, and more than half (66%) used aluminium cans during milking. Farmers practiced hygienic milking by cleaning the teats (97%). However, very few (2%) wore gloves during milking. Most farmers (85.9%) did not know the type of antibiotics they used. However, more than half of the farmers (55.6%) reported that milk from a treated cow was discarded, 22.7% of them used the milk to feed calves. Most farmers (93%) stated that they did not experience milk rejection; however, the few who had their milk rejected indicated acidity, bad flavour and adulteration as some of the causes. Antibiotics residues were detected in milk samples from all the counties, differing in concentration and no significant difference (PÓ 0.05) among the three Counties. The most commonly detected antibiotic was oxytetracycline while the common beta-lactam detected was ampicillin in all three sites. The sulphonamides detected were dapsone, sulfachlorpyridazine, sulfadiazine, sulfadimethoxine, sulfadoxine, sulfamerazine, sulfamethoxazole, sulfamethoxypyridazine, sulfamonomethoxine, sulfapyridine, sulfisoxazole, and sulfithiazole at different concentrations. More than half (55.6%) of samples collected tested positive for at least one antibiotic residue. The mean concentrations for oxytetracycline were 0.017mg/l in Bomet, 0.016mg/l in Nakuru and, 0.015mg/l in Nyeri. In conclusion, farmersô milk handling practices along the value chain was good and this is due to their good knowledge on hygienic practices, however there was lack of knowledge on the use of antibiotics and risks associated with the misuse of the same. The occurrences of such residues pose health risks to consumers hence the need for proper monitoring and control of antibiotics in the milk supply chain.

CHAPTER ONE: INTRODUCTION

1.1 Background information

Dairy industry remains dynamic and plays a major role in nutrition and economic aspects of many lives including milk producers, hawkers, consumers, and processors; hence milk safety and quality will determine good health, stable and a prosperous economy. Milk is one of the complete foods that supply lactose, high quality protein and is an excellent source of lipids as well as calcium (Singh and Gandhi, 2015). Consumers of milk cut across from infants to adults hence the need to provide wholesome, clean, safe, and nutritious milk and milk products to the users. Milk production takes place in a number of countries worldwide with India taking the lead at 127 Million tonnes per year(Upadhyay *et al.*, 2014). Kenya's annual milk production stands at 3.43 billion litres. The dairy sector contributes 14% of agricultural GDP and 6-8% of the countryꞌs GDP (Odero-Waitituh, 2017). There are, however, regional differences in milk production in the country, a situation that is determined by climatic conditions. The Central region of Kenya has the highest concentration of dairy cattle, but the Rift Valley region has the largest number of cattle as well as the highest milk production (Odero-Waitituh, 2017).

The present study is however, focusing on Kenya as a country with a sufficient milk production to its domestic consumers, second only to South Africa (Wambugu *et al*., 2011).The liberalization of dairy farming in Kenya in the year 1992 led to rapid growth in the Dairy sector since then there has been significant increase in GDP by 3.5% of the total collection by the Government (Wambugu *et al*., 2011). Liberalization allowed many players to take part in milk production, as a result, new arrangements that exist today came in. The arrangements involved collection of milk at designated centres, processing and eventually marketing to the consumers.

In Kenya, the smallholders produce 70% of milk that is finally marketed via Kenya Dairy Board and processed for final consumption (Wambugu.*et al*., 2011). However, there is lack of information on the safety and hygiene assurance of the milk produced by the farmers and sold to the public regarding the use of antibiotic drugs and unauthorized preservatives especially fromthe smallholders in Bomet, Nakuru and Nyeri counties. The use of antibiotic drugs and unauthorized preservatives (adulterants) is common in developing countries to prolong shelf life hence meeting milk demand (Singh and Gandhi, 2015). Since these unlawful practices have been identified in other parts of the world(Upadhyay *et al.*, 2014) , there is the need to investigate the sources, use, levels and types of antibiotics and unauthorized preservatives in the milk produced in the Kenyan market. A case study of Bomet, Nakuru and Nyeri counties in Kenya.

1.2 Statement of the Problem

Milk and milk products serve as a good source of complete food. However, there has been increased misuse of antibiotics in the treatment of domestic dairy animals by farmers which has led to antibiotic residues in foods of animal origin like milk(Marth, 2018). Antibiotic residues in milk has become a health concern because of potential carcinogens as classified by the International Agency for Research(Singh and Gandhi, 2015).Besides this, development of antibiotic resistance has increased in animals and therefore subjecting human beings to exposure to antibiotics through consumption of animal foods such as milk and milk products. By treating animals, farmers aim to achieve good health of animals and high milk production,however, farmers are known not to observe the instructions of manufacturers such as the withdrawal periods due to lack of knowledge on the usage and effects of antibiotics leading to the development of superbugs which cannot be easily treated (Priyanka *et al.*, 2017).

1.3 Justification of the study

The study is in line with Big Four Agenda on food security and food nutritionand will come up with policies that will ensure that the milk and milk products produced, packaged, and commercially traded are fit for consumption. The study will also contribute towards generating knowledge that will promote the consumption of safe and hygienically produced milk hence increase in health benefits gains by the consumers and other stakeholders. The study will also inform the farmers, Kenya Dairy Board, Policy makers and public about the adverse health effects attributed to the violation and improper use of antibiotics in dairy industry. The consumers will be protected by gaining knowledge about the exposure to unsafe milk. By producing safe and clean milk, farmers will benefit by getting high value pay hence improved living standards due to economic income generated. The researchers will equally benefit by getting new information on the safety of the marketed milk in the three counties.

Increase annual processed milk from 630 million litres to 1 Billion litres by June 2022

1.4 The Aim of the Study

The aim of the study is to contribute towards improving the quality and safety of commercially produced milk from the smallholder farmers in developing countries.

1.5 Purpose of the Study

The purpose of the study is to generate data on antibiotic and other drug residues, and use of preservatives in milk supplied by smallholder farmers in Kenya.

1.6 Objectives

1.6.1 Broad objective

To assess antibiotic and other drug residues, and use of preservatives in milk supplied by smallholder farmers to processors in Bomet, Nakuru and Nyeri counties.

1.6.2 Specific Objectives

1. To determinethe usage of antibiotics and practices of handling milk by smallholder milk producers in Bomet, Nakuru and Nyeri counties, Kenya
2. To determine the type of antibioticsand levels of residues in milk supplied by smallholders milk producers to processors

1.7 Hypotheses of the study

1. Smallholder milk producers in Bomet, Nyeri and Nakuru counties do not have knowledge on antibiotics, their usage and general handling practices.
2. Milk supplied by farmers to processors do not have antibiotics and their residues.

CHAPTER TWO: LITERATURE REVIEW

2.1 Global View of Dairy Industry

The Food and Agriculture Organization of the United Nations (2019) reports that milk, cheese, and butter are the most commonly consumed dairy products in the world. However, milk is the major dairy product with an estimated global production of 828 million tonnes in 2017 (FAO, 2019). Milk ranks third in terms of tonnage but tops the list of agricultural commodities in value terms. Based on the global quantity of milk produced, (Jones, 2015) posits that it not only contributes significantly to the world economy but that it promotes good health among the people. The global dairy sector is estimated to generate revenues worth US $ 442.4 billion in 2019 with milk and other dairy products accounting for 14% of global agricultural trade (FAO, 2019). Milk is a global product whose demand is ever increasing due to population growth, thereby supporting the development of the world's dairy industry (Balatsky *et al*., 2015). Cow milk represents 82.7% of global milk production followed by milk from buffaloes (13.3%), goats (2.3%), sheep (1.3%) and camels at 0.4%(Food and Agriculture Organization of the United Nations, 2019). This industry is observed to be growing fast and that it is projected to increase by 177 million tonnes by 2025 indicating an annual growth rate of 1.79% per annum (FAO, 2019).

The dairy sector is heterogeneous in that milk is derived from different animals as mentioned above, and the animals are reared in four main production systems: specialized landless systems, market-oriented, subsistence-oriented integrated dairy-crop systems and the pastoral system(Kraatz, 2012). The aim of the specialized landless system is milk production whereas market-oriented, and subsistence-oriented integrated dairy crop systems are designed for the production of various outputs like meat, crops and milk (Kraatz, 2012). The pastoral system, on the other hand, depends on mobility for milk production as well as other livestock products. It is estimated that there are 150 million farmers worldwide with at least one milk-producing animal (Zingone *et al*., 2016). For this reason, the industry supports the livelihoods of many people in the world, both directly and indirectly. Farmers directly sell their milk and other milk products to earn cash. They are other traders who are not farmers but deal in the products produced by the farmers. (Wright & Annes, 2016) also note that milk production promotes the empowerment of women because livestock is popularly kept by women in the rural parts of the world. Whether the women own the animals or not, it is observed that they play a critical role in their feeding, milking, and cleaning them. About a quarter of the world's women have acquired employment in agriculture, and 80 million women are involved in dairy farming(Wright & Annes, 2016). The dairy sector has, therefore significantly created numerous job opportunities for the world's population resulting in eradication of poverty and stimulation of global economic growth (Wright & Annes, 2016).

Even though dairy farming is beneficial in terms of job creation and the promotion of a healthy diet, there is the danger of zoonotic and foodborne diseases. Based on such a situation, (Grout *et al*., 2020) state that the dairy industry has a big role to play in public health. Some diseases are animal-borne and can be transmitted to humans when the dairy products of such animals are consumed by people or when there is physical contact. Some of such diseases that are even fatal include brucellosis and anthrax (John *et al*., 2008; Yantitima & Makarov, 2019). Due to such diseases, many farmers treat their animals with antibiotics that have been shown to remain in the dairy products when there is excessive intake of the drugs. Consumption of the products of such animals contributes to anti-microbial resistance in human beings.

There is also a significant relationship between animal keeping and the environment. Scholars posit that dairy herds contributes to greenhouse gas emissions, particularly by rumination in which 3.1 gigatonnes of carbon dioxide equivalence is generated per year by dairy animals and accounts for 40% of global livestock emissions(Rotz, 2018). Enteric methane is also a significant product of dairy animals (Rotz, 2018). Carbon dioxide is a long-lived pollutant, whereas methane is short-lived, but it is 84 times more potent in trapping heat compared to carbon dioxide (Rotz, 2018). Reduction of the negative consequences on climate requires efficient feeds use, proper management of the manure and promotion of good animal health and husbandry (Van Middelaar *et al*, 2013).

In terms of global milk production, India is the worldös largest milk producer accounting for 21% of global production. Such a situation is largely contributed by the big population of 1.3 billion people(FAO, 2019). Other countries that also significantly produce a lot of milk are USA, China, Pakistan, and Brazil (FAO, 2019). However, milk production in Africa is developing at a slower rate than other regions of the world(Bjornlund *et al*., 2020). Poverty and poor climatic factors in the continent are to blame for such a poor performance in milk production compared to other parts of the world(Bjornlund *et al*., 2020). The Sahara Desert has proved to be a setback in animal production. There are also other deserts in various parts of Africa that discourage dairy farming. There are countries in the world with a significant surplus in milk with New Zealand, USA, Germany, Australia, Ireland, and France having the highest surpluses

(FAO, 2019). On the other hand, China, Italy, Russia, Algeria, Indonesia, Algeria, and Mexico have the worldôs highest milk deficits (FAO, 2019). Such data indicate that even through dairy farming is a global industry, there are nations that underperform regarding production, which is not commensurate to the population. (Bird *et al*., 2019) however note that South Asia has shown significant expansion in milk production since 1970. At the moment, the region is the major driver of growth in milk production in the developing world (Bird *et al*., 2019) . A good climate in the area and economic growth are some of the factors that are contributing to the expansion in milk production in the South Asian sub-continent (Bird *et al*., 2019).

2.2 Dairy Industry in Africa

The dairy industry in Africa is not as robust as other parts of the world due to poverty and the unfavourable climatic conditions (Alary *et al*., 2010). The highest milk producing countries in the continent are Ethiopia, South Africa, Kenya, Egypt, and Sudan out of which Ethiopia has the highest number of cows whereas South Africa boasts of the highest milk production per cow(University of Kentucky College of Agriculture, Food and Environment, 2019). Of the five milk producing nations, only Ethiopiaôs, South Africaôs and Kenya's production are enough for their population (University of Kentucky College of Agriculture, Food and Environment, 2019). Many countries in the continent have an acute shortage of milk that cannot sustain their population, a situation that significantly contributes to malnutrition, especially in the Sub-Saharan region. (Baudron *et al*., 2014) note that such deficits depict the need to expand dairy production in the continent rather than importing dairy products. There is underperformance in Africaôs dairy sector in terms of the number of cows as well as farmers involved in dairy farming

(Wambugu *et al*., 2011). Even in areas with good climatic conditions, little dairy farming is done, which is a level that is significantly suboptimal (Wambugu *et al*., 2011). A good example is the equatorial regions that are often characterized by conflicts like in the case of the Democratic Republic of Congo (Okeudo, 2008).

Africa has two different dairy models: modern and smallholder. A good example of the modern system is in South Africa and is like the one in the United States. South Africa has many dairy farms with over 500 cows per farm where there is the use of the TMR feeding system (University of Kentucky College of Agriculture, Food and Environment, 2019) 60 per cent of the milk produced through the model undergoes liquid consumption while the rest is processed into concentrated products (University of Kentucky College of Agriculture, Food and Environment, 2019). There is however no government support of South Africaôs modern system dairy farming, a situation that results in ótrue market systemô whereby there are no structures for the pricing of milk (University of Kentucky College of Agriculture, Food and Environment, 2019). South Africa's modern system of dairy farming is said to milk production of 35-44 pounds per cow. For the smallholder system of dairy farming, Kenya presents a good example. In such a system, most of the dairy farms have few cows. For the case of Kenya, 80% of the dairies have less than five cows per farm (University of Kentucky College of Agriculture, Food and Environment, 2019). Such a system puts Kenya to be having about 600000 smallholder dairies compared to 45000 in the United States of America (University of Kentucky College of Agriculture, Food and Environment, 2019).

The modern dairy system is by far the most effective approach in increasing milk production hence the reason why South Africa is among the continentsô largest milk producers (Ndambi *et al*., 2008). Such technological advancement is lacking in many African countries to spear high milk production. (Ogemah, 2017) observed that the fact that Africa is lagging in technology is affecting other spheres of life, such as the agricultural sector of which the dairy industry is a significant part. However, poor governance and lack of good political will are to blame for the continentøs poor agricultural development and poverty. According to Haggblade (2011), Africa can effectively compete in the global dairy industry regardless of the climatic conditions if effective measures are employed to spur production. Most dairy farmers in African employ the open grazing method, an approach that manifests among pastoralists. However, the problem of overgrazing that is seen among many cattle keepers in Africa has significantly reduced the production per cow. Further, there is a slow level of skills among African dairy farmers, which also subsequently affects milk production in terms of quantity and quality. Bingi and Tondel(2015)therefore conclude that a lot still needs to be done in Africa to improve the status of the dairy industry in the region.

2.3 Milk Production in Kenya

Kenya's annual milk production stands at 3.43 billion litres, which constitutes three per cent of the eighteen percent global production by Sub-Saharan Africa. For this reason, Kenya is an important player in Africa's milk industry (Odero-Waitituh, 2017). Kenyaøs dairy sector contributes to 14% of agricultural GDP and 6-8% of the countryøs GDP (Odero-Waitituh, 2017). Milk production contributes about US $ 2 billion to Kenyaøs economy (Odero-Waitituh, 2017). There are, however, regional differences in milk production in the country, a situation that is determined by climatic conditions as well as the nature of the community residing in the region.(Bebe, 2003) report that some

Kenyan communities have a higher tendency to engage in agricultural production than others hence illustrating the current distribution of milk production across the country. The Central region of Kenya has the highest concentration of dairy cattle, but the Rift Valley region has the largest number of cattle as well as the highest milk production (Odero-Waitituh, 2017). The Coast, Eastern and North-Eastern regions have the lowest production as well as several dairy animals kept per squarekilometre(Odero-Waitituh, 2017) . However, even with such significant variations in the country, Kenya can produce milk that is sufficient for her population (Odero-Waitituh, 2017).

Milk production in Kenya is mainly by small scale farmers who produce about 80% of the countryǿs total milk production. The widespread adoption of dairy cattle in the country is attributed to several factors: conducive government policies, a good tropical climate suitable for dairy farming and the existence of communities that traditionally kept cattle as a source of milk. The Kenyan government has significantly aided farmers efforts as regards to dairy farming, a step that has promoted the growth of the sector compared to other African countries (Rademakers *et al*., 2016). Some of the measures taken by the government include a reduction in the cost of production through subsidies. Kenya is one of the African nations with a significant population of pastoralists that keep dairy animals for milk and meat. An example of communities that have been keeping livestock as a cultural practice is the Maasai who have persisted in their practices thereby contributing to the countryǿs expansion of the dairy sector and milk production (Wambugu *et al*., 2011). However, the central highlands are the greatest producers of milk produced and consumed by Kenyans (Wambugu *et al*., 2011). Such areas were occupied by the white settlers and farmers in these highlands conduct commercial dairy farming as opposed to mere animal keeping like the pastoralist communities of Kenya. Compared to South Africa, Kenya's main competitor in the milk production, the country has a lower average milk production per cow which stands at 8-10 litres whereas that of South Africa is 12.7 litres (Wambugu *et al*., 2011).

The large volume of milk production has led to the emergence of highly profitable and some of Africa's performing dairies. They include Brookside, Githunguri Dairy Co-operative Society, Sameer Agriculture and Livestock and the new KCC (Gachango & Andersen, 2014). There are also other numerous dairies with small processing capacities in the country, such as Kinangop, Razco Ltd and Meru Dairy Co-operative. Data indicates that there are 40 dairies with active production in Kenya (Gachango & Andersen, 2014).

Kenyan farmers keep a variety of breeds for milk production which includes local breeds, exotic breeds, and crosses between the two breeds owned by about one million farmers. The main breeds for milk production in the country are Jersey, Guernsey, Friesian, Ayrshire, and their crosses. Kenyan dairy cattle population accounts for 85% of Eastern Africa dairy cattle population (Odero-Waitituh, 2017). It is estimated that about 54% of Kenyan households with one acre of land or less keep cattle, with 73% of the farmers practicing integrated crop dairy production (Odero-Waitituh, 2017). Dairy farming in Kenya employs the extensive, semi-intensive and intensive systems of production. The practice of the various systems is determined by the availability of land. (Odero-Waitituh, 2017) notes that the high population densities in the Kenyan highlands are one of the factors that promote the adoption of the intensive system in cattle keeping, which is characterized by zero grazing. The country's milk production costs are largely brought about by the fodder and feed that are the most common form of feeding in the intensive system of dairy farming (Odero-Waitituh, 2017).

Even though Kenya is among the top four milk producers in Africa, there are many challenges that beset the industry, which makes it not to perform as desired. Some of the challenges in the countryøs milk production include seasonal fluctuation of production since farmers heavily rely on rainfall for growing animal feeds. For this reason, productivity is unpredictable, especially with the ever-changing climatic conditions characterized by the extreme of weather. According to Ojango and Pollott (2006), high cost of production, poor quality of milk, poor infrastructure and informal milk trade are some of the challenges that are affecting milk production and making it hard to perform as well as most of the developed nations.

2.4 Evaluation of the Dairy Sector

Based on the literature discussed above, (Wambugu *et al*., 2011) argues that the dairy sector is the backbone of the economy of developing countries that venture into the industry. Egypt, Kenya, Sudan, Ethiopia, and South Africa are some of the African countries that have seen economic growth that is contributed by the dairy sector. The dairy sector is also linked to significant research work on livestock. A lot of research work is conducted in various institutes regarding the best breeds for each climatic condition to promote dairy production across the world. The International Livestock Research Institute (ILRI) co-hosted by Kenya and Ethiopia is one of the global organizations that is concerned with research and promotion of knowledge in the dairy sector. According to (Lukuyu *et al*., 2011) , the need for higher dairy production subsequently promotes extensive research to be created and states that this is one of the indirect ways in which the dairy industry has immensely created jobs. Further, the sector has played a significant role in increasing professionals in the field of veterinary medicine, food scientists, and animal pharmaceuticals, among others.

2.5 Smallholder Milk Production

Eighty per cent of the world's milk production is from small scale dairy producers. Kenya is one of the countries with a good proportion of its milk production coming from the small-scale farmers. Smallholder milk production is often carried out with few cows per ranch because of the limited size of land as well as capital for large scale milk production. According to Hafeez (2014), smallholder milk production is often promoted by the need to earn a livelihood by the individuals who venture into the industry. Even though there are people who solely depend on smallholder milk production as a source of income, there is quite a significant proportion of the population that do it as an additional economic activity (Hafeez & Rahman, 2014). In such cases, they are not directly involved in the daily activities of the production but instead have hired people to do so and only provide the needed capital.

(Abdulahi *et al*., 2015) note some of the activities that smallholder farmers engage in to realize maximum profits, which include proper feeding and disease control and management. Healthy and well-fed cows produce the most quantity of milk, which is often the aim of the farmers. Diseases are of utmost significance in the context of dairy farming for the smallholder farmers. It should be borne in mind that such situations always need the input of veterinary doctors that at times, may be costly for farmers. Caggiano*et al*. (2019) report that the high cost of medical care for the dairy animals has made many farmers to treat their animals by themselves without involving veterinary doctors. The practice of doing self-treatment for oneǿs own dairy animals is a matter that jeopardizes the quality of milk that is produced and released to the market. Further, it depicts the need to involve public health officials more than when veterinary doctors are included in the rearing and management of the diseases suffered by the dairy animals (Hueston, 2016). It is for this reason that Kivaria, Noordhuizen and Kapaga (2006) conclude that smallholder milk production poses the greatest public health problem to the population.

2.6 Antibiotics and Preservatives Use in Milk Production

There are often common diseases that affect the dairy animals both for the small-scale and large-scale dairy farming systems. In Kenya, some of the common diseases affecting animals are mastitis, milk fever, ketosis, bloat acidosis and sore hooves-laminitis (Maitho & Kinyua, 2015). Most of such diseases are often infectious; hence, the use of antibiotics in their treatment. According to (De Briyne *et al*., 2014) , oxytetracycline is the most commonly used antibiotics in dairy animals. Globally, tetracyclines are used more than any other class of antibiotics(Mitka, 2012). Other antibiotics that are also used to a great extent include fluoroquinolones, beta-lactams and cephalosporins(Sawant *et al*., 2005). Researchers have noted that there has big an increased use of antibiotics in Kenya over the past decade, a situation that is attributed to the increased levels of awareness among small scale farmers (Olila *et al*., 2002). Further, some cases of government interventions have been in drug subsidy that eventually makes it easy for farmers to purchase the drugs and administer to their livestock (County *et al*., 2016) .

East African countries have experienced disease outbreaks in the past few years. Some of such diseases are Rift valley fever and hand-foot-and-mouth disease and led to an increase in the use of antibiotics among farmers (Gikungu *et al*., 2016). Kumar *et al* (2021) posit that many farmers often use antibiotics in the presence of any symptom. However, it should be noted that some of the dairy animal diseases are caused by viruses and other organisms hence may not necessarily benefit from the antibiotics administered. Such is the result of uninformed treatment of animals without the involvement of qualified veterinary officers in the treatment of the dairy animals. Groot and vanâtHooft (2016) agree to such a finding by noting that there is inappropriate use of antibiotics among dairy farmers, especially in developing countries such as Kenya. There is, therefore, need for more veterinary officers in such situations to promote the appropriate use of the antibiotics(Otieno, 2016). Veterinary doctors make the best decision regarding the diagnosis and the medication to be administered to sick dairy animals.

In a study conducted by (Manyi-Loh *et al*., 2018)regarding the use of antibiotics by Kenyan farmers, it was noted that majority of the smallholder milk producers used antibiotics for all the symptoms that they noted in their livestock. Further, only a few farmers included the services of a veterinary officer in the management of their dairy animals (Richard *et al*., 2015). The observation of higher milk production among treated animals has also significantly encouraged farmers to use antibiotics in the treatment of their animals in a bid to increase their yield and subsequently improve their income (Sawant *et al*., 2005). Availability of antibiotics in Kenya without strict prescription laws is also to blame for the high inappropriate use of antibiotics. Ease of acquiring the drugs is promoted by the presence of many drug-selling outlets in the country (Olila *et al*., 2002). Such a scenario is also observed in other parts of the world with similar trends of antibiotic use in dairy animals.

There is a growing concern of human antibiotic resistance, especially in the developing countries (Paphitou, 2013). Several factors have been implicated, such as overusing antibiotics by medical professionals as well as inappropriate use by the general population. However, recent studies have shown that resistance is likely to be brought by the consumption of antibiotics in dairy products such as milk and meat. The Kenyan population is one that largely consumes such dairy products, thus stand at great risk of developing antibiotic resistance (El-zubeir *et al*., 2009).

Smallholder milk producers, especially in developing countries like Kenya, sell their milk directly to consumers through the retail outlets. Often such milk does not undergo public health assessment because there are no effective systems to control the illegal sale of milk to the public. (Pyz-Ǧukasik *et al*., 2015) observed that the quality of milk sold directly to the consumers is often questionable because it does not pass through the quality assurance processes to be approved as fit for human consumption. According to a study conducted by (Kosgey *et al*., 2018) it was noted that some farmers sell their milk produced from sick cows. Reasons for such are often the fear of making loss coupled with the high cost of treatment and hiring of veterinary services. Profit-making in this sector thus depends on the quantity of milk sold to the consumers. It is for this reason that (Ndungu *et al*., 2016) found out that some farmers add water to increase the quantity of milk sold in the market.

However, Kenya is one of the countries in Africa that overproduces milk for her population, which has led to the need to keep the milk in a good state for a long time. The use of preservatives in milk is thus a practice that some farmers carry out to ensure that the milk does not go bad. Some of the preservatives used by Kenyan dairy farmers as well as milk vendors are formalin and hydrogen peroxide (El-zubeir & Owni, 2009b). Such preservatives stay in the milk for a very long time since their metabolism in such a state is limited. The longevity of the milk is therefore assured with the use of the hydrogen peroxide and formalin, enabling some farmers and milk vendors to avoid the loss of disposing off bad milk. (Singh & Gandhi, 2015) implicate certain factors that promote the use of preservatives in milk particularly in the developing countries which include overproduction coupled with the difficulty in exporting the excess and low purchasing power of the local market. Corruption in some countries such as Kenya further manifests in the use of unscrupulous methods of conducting business for which the use of illegal preservatives is a part (Afzal *et al*., 2011). Other better of preservation such as refrigeration is underutilized in many developing countries like Kenya due to the cost involved hence people using other approaches that appear to be cheaper. (Tufa, 2015) that the availability of such preservatives promotes their use in milk by some dairy farmers and milk vendors. Moreover, the government faces a big challenge in instating control measures such cases hence the practice of illegal preservation of milk is strongly embedded among dealers in the country.

2.7 Antibiotic Residues in Milk

Appropriate use of antibiotics is recommended to treat certain diseases in dairy animals, and some period should be allowed before using milk for such animals depending on the manufacturerǿs instruction (Cox, 2006). Failure to abide by such instructions is implicated in the presence of antibiotic residues in milk. (Darwish *et al.*,

2013) report that some of the factors that make farmers disregard the instruction regarding the period one should take to milk the antibiotic-treated animals is ignorance and desire to make profits. In developing countries where a good proportion of farmers are illiterate, the manufacturerϕs instructions are not looked into, hence milking is done even immediately after administration of antibiotics.

A study conducted (Kosgey *et al*., 2018) in Eldoret, western Kenya revealed that 24% of the milk from milk vending machines and 24% of that from street vendors also had antibiotic residues. However, the study observed no antibiotic residue in commercial milk (Kosgey *et al*.,2018). The Government agencies easily control and monitor commercial outlets, which contributes to high quality of milk sold to the public (Oloo, 2016). Such a reason explains the observation made by (Kosgey *et al*.,2018) regarding the absence of antibiotic residues in commercial milk. Kenya is likely to experience a high presence of antibiotic residues in milk because most of the production (80%) comes from small-scale private producers that the Kenya Dairy Board cannot control (Gachango & Andersen, 2013). For those countries that have a higher production through large and controlled farming systems, the incidence of antibiotics residues in milk is low as observed in the United States and most parts of Europe.

The pharmacologic properties of the commonly used antibiotics also play a big role in causing the problem of the drug residues in milk. Research shows that the elimination of oxytetracycline can go up to 57-108 hours, thereby making the drug to stay for long in the animal's body before it is completely eliminated (Lees & Toutain, 2012). In such cases, the drug products remain in the tissues such as body fluids like milk as long as elimination is not complete (Lees & Toutain, 2012).Jackson (2001) also saw that majority of the drugs commonly used in the treatment of dairy animals have longer elimination half-lives than other classes of drugs, a finding that further contributes to the presence of antibiotic residues in milk. The manufacturersô recommendation on the use of the antibiotics is based on the pharmacological properties of the antibiotic agents. Hill (2017) therefore argues that the problem of antibiotic residues in milk cannot be easily solved if people do not abide by the instructions on the drug labels and there are no effective control measures.

According to (Navrátilová *et al*., 2009) high demand for milk is also to blame for the incidence of antibiotic residues in the milk. However, in such cases, the most common source is often from milk vendors rather than the commercial outlets. It should be noted that the processed milk that is sold in the commercial outlets is often slightly more expensive than that sold by the milk vendors or in the milk vending machines. The lower costs coupled with the low purchasing power of most of the people make the population to demand and rely more on the unprocessed milk that has not gone through the monitoring channels to assess for quality. It is for such a reason that Kenya is said to be among those countries that suffer significantly from this problem. (Kosgey *et al*., 2018) look at it in the aspect of corruption and fraud that is strongly embedded in the Kenyan society. The study supports such a perspective by considering the examples of reported cases of individuals selling dog and cat meat in the butcheries for human consumption in some parts of the country. It is seen that the drive for money and profit-making underlies many business activities, including the dairy sector and milk selling in the country.

CHAPTER THREE

USAGE OF ANTIBIOTICS AND PRACTICES OF HANDLING MILK BY SMALLHOLDER MILK PRODUCERS IN BOMET, NAKURU AND NYERI COUNTIES, KENYA

Abstract

Antibiotic residues and illegal preservatives such as formalin and hydrogen peroxide in milk have become a health concern because of their potential carcinogens. This study was carried out to understand the awareness level of farmers and cooperative members on the residues within the milk products and to investigate the chemicals and drugs commonly used in dairy herds and the residues most frequently detected in milk. The study was carried out by interviewing farmers, traders, and cooperative societyçs staff. Data was recorded on chemicals and drugs used to treat dairy herds, milk hygiene and rejection of milk among farmers. Majority (93.3%) of the respondents had basic education level of training on dairy management and diseases and reported dairy animals as frequently infected with diseases such as mastitis (86%), East Coast fever, Foot and Mouth. Almost all (98%) farmers used manual method of milking, and more than half (66%) used aluminium cans during milking. Farmers practiced hygienic milking by cleaning the teats (97%), however, very few (2%) wore gloves during milking. Most farmers (85.9%) did not know the type of antibiotics they used. However, more than half of the farmers (55.6%) reported that milk from a treated cow was discarded, (22.7%) of them used the milk to feed calves. Most farmers (93%) stated that they did not experience milk rejection, however, the few who had their milk rejected indicated acidity, bad flavour and adulteration as some of the causes. From the results, there is need for education of the farmers on the use of antibiotics to ensure food safety. Farmersô hygienic handling of milk from production was good and this is due to their good

knowledge on hygienic practices, however there was lack of knowledge on the usage of antibiotics and risks associated with the misuse of the same

3.1 Introduction

Dairy industry plays important roles in nutrition and economic aspects. Many lives ranging from milk producers, hawkers, consumers, and processors depend on it hence milk safety and quality will determine good health, stable and a prosperous economy. Milk is one of the nutritionally complete foods that supply lactose, high quality of protein and excellent source of lipids as well as calcium (Singh & Gandhi, 2015). Consumers of milk range from infants to adults hence the need to provide wholesome, clean, safe, and nutritious milk and milk products. Milk production takes place in a number of countries worldwide with India taking the lead at 127 Million tons per year. (Upadhyay *et al*., 2014). The study is focusing on Kenya, as a country with a sufficient milk production for its domestic use after South Africa (Wambugu *et al*., 2011).

In Kenya, the smallholders produce 70% of milk that is finally marketed via Kenya Dairy Board and processed for final consumption (Wambugu.*et al*.,2011). However, there is lack of information, on the safety and hygiene assurance of the milk produced by the farmers regarding the use of drugs and unauthorized preservatives especially from the smallholders in Bomet, Nakuru and Nyeri Counties. The use of antibiotics and unauthorized preservatives (adulterants) such as hydrogen peroxide, neutralizersô benzoic acid, formalin and melamine is common in overpopulated countries to prolong shelf life hence meeting milk demand (Singh & Gandhi, 2015). Antibiotic residues and illegal preservatives such as formalin and hydrogen peroxide in milk have become a health concern because of the danger of potential carcinogens as classified by International Agency for Research (Singh & Gandhi, 2015). Besides this, development of antibiotic resistance has increased in animals and therefore subjecting human beings to the exposure of the same (Madougou *et al*., 2019). The administration of antibiotics imposes a withdrawal period, defined as the time required for the animal body to remove completely chemical residue from treatment outcome (Madougou *et al*., 2019). During this time, any use or consumption of milk is prohibited (Upadhyay *et al*., 2014). There is need to investigate the sources, use, levels and types of antibiotics and unauthorized preservatives in the milk produced in the Kenyan market. This survey was conducted to determine knowledge on the usage of antibiotics, preservatives, and general practices of handling milk by small hold milk producers in Bomet, Nakuru and Nyeri Counties.

3.2 Materials and Methods

3.2.1 Study area

This study was conducted in three Counties in Kenya, Nyeri, Bomet, and Nakuru from October 2019 to June 2020. Bomet is located at 0º 29' and 1º 03' South and longitudes 35º 05' and 35º 35' East and elevation of 1962 meters above sea level while Nakuru is located at latitude 0.23º North and 1.16º South and longitude of 35.41 º East or 35º 24ô coordinates and elevation of 1850 meters above sea level. Nyeri County lies between 36^{o}38ò and 37^{o}20ò East longitudinally and between latitude 0^{0} 38 elevation of 1460 meters. The mean annual rainfall for Nyeri ranges from 950 to 1500 mm, for Bomet is 1482 mm and for Nakuru is 895 mm with a bimodal pattern (KMD, 2020). The mean temperature for Nyeri, Bomet, and Nakuru is 15.2^{o}C, 18.2^{o}C and 17.5^{o}C respectively (KMD, 2020). These counties were chosen based on their divergent situations in dairy production and because they are among the highest milk producing areas in the Kenya (KDB, 2014). Moreover, these areas have cooperative societies and cooling centres where bulking of the milk sourced mainly from small scale farmers in the counties is done.

Figure 3. 1: A map showing study areas

3.2.2 Study population

From each county, smallholder farmers who were directly involved in milking and handling of milk and supplying milk to various cooperative societies were selected using systemic random sampling.

3.2.3 Sample size determination

The sample size was arrived at using the formula by Kadam, and Bhalerao. (2010):

$$N = \frac{Z^2 pq}{d^2}$$ é (Equation 1)

where N, is the minimum sample size, p is the proportion of the population (p=0.5), Z is the normal standard variation (1.96) at 95% confidence interval, q = (1-p) = 0.5 the fraction of the selected population expected not to have features under the study and d is the acceptable sampling error.

$$n = \frac{1.96^2 \times 0.5 \times 0.5}{(0.0405)^2} = 586$$

The actual sample size used was 586 and included traders that supply milk to different milk channels, managers of dairy processing plants and cooperative societies. The samples size was distributed as follows in the respective Counties: Nyeri 239, Bomet 207, and Nakuru140based on the intensity of dairy activities.

3.2.4 Sampling procedure

The study was carried out using a mixed method approach where farmers, traders and cooperative society staffs were interviewed. A simple random sampling method was adopted to obtain information on awareness level of the farmers and cooperative members on the residues within the milk products and to target chemicals and drugs used in treating farm animals. This study was conducted using a structured questionnaire that was used to interview farmers and processors. The target population was made up of farmers, attendants, and managers of dairy processing plants in the three Sub Counties. The survey was conducted through personal interviews of the individual farmers, traders that supply milk to cooperative societies and cooperative societyôs staff. Aspects such as socio-demographic characteristics of the milk producers, level of knowledge and handling techniques of antibiotics and preservatives, withdrawal period were also determined. For uniformity purposes the respondents were from centrally located areas through systematic random sampling. The central location was selected in each County and milk processors, traders, and farmers were identified and using the list from cooperatives.

3.2.5Data collection and Analysis

Data were collected with the help of questionnaires with various sections having questions related to milk handling practices and usage of antibiotics. Socioeconomic status of farmers was also assessed. Data was entered in computer Excel program and analysed using SPSS version 25. Comparison between farmers, traders and the cooperative societies was evaluated by Chi-square (G2) test. Descriptive statistics such as mean, frequencies and percentage were also used to describe the characteristics of the data.

3.3 Results

3.3.1 Socio-demographic characteristics of households

A total of 586 interviews were conducted across the three counties namely Nyeri, Nakuru and Bomet. These included farmers, managers of dairy processing plants, traders that supply milk to cooperative societies. Significantly, more than five in every ten (59.4%) respondents belonged to Protestant denomination and majority were from Nakuru. Majority (93.3%) of the respondents had at least attended school while only 6.7% had no education (Table 3.1). Nakuru County had the highest level of illiteracy while Bomet county had the most respondents (5.31%) who had attended university. There were few cases of divorce at an average (0.9%) among respondents with more than seven in every ten (79.95%) respondents being married and living with spouse. Majority of the divorce/separation cases (2.09%) were recorded in Nyeri County. Majority of married (87.14%) being in Nakuru County

Table 3. 1: Socio-demographic characteristics of households

Demographic characteristic		Percentage (% N) N=586		
		Nyeri (%) N=239	**Nakuru (%) N=140**	**Bomet (%) N=207**
Religion	Catholic	32.64	19.29	22.22
	Protestant	25.10	79.29	73.91
	Traditional African religion	0	0.01	0
Education	Illiterate	2.51	10.00	7.73
	Elementary school	34.31	41.42	35.75
	Middle school	42.68	35.71	33.81
	High school	16.74	7.86	17.39
	University	3.35	4.29	5.31
Marital status	Married	71.55	87.14	81.16
	Single	5.44	1.43	4.35
	Divorced/ separated	2.09	0.71	0
	Widow/ widower	20.92	10.00	14.49

3.3.2 Dairy animal health problems and their management

Farmers reported that their dairy animals were frequently infected by various diseases (Table 3.2). Averagely, 41% of the farmers reported East coast fever, Anaplasmosis (*Anaplasmosis trypanosomiasis*), and tick burdens as commonly encountered diseases, Bomet reported the highest percentage (59.9%), Nyeri had the least at (16.32%). About 19.4% of the farmers reported calf mortality, mastitis, foot problems, and intestinal worms as some of the diseases that were routinely managed. Nyeri County reported highest cases (26.78%) and Nakuru County the least (7.14%). Some of the notifiable diseases identified by about 14.8% of the farmers on average include lumpy skin disease, foot and mouth disease, black quarter and anthrax. Bomet reported highest cases (24.64%), and Nyeri least 5.44% in this Category. Seven in every ten farmers (70.0%) used acaricides as the main tick control measure while more than eight in every ten farmers (86.3%) could identify cows suffering from mastitis, however 83.8% of farmers indicated that mastitis was not a common problem. Farmer's level of education significantly (χ^2=13.627^a, $p<0.05$) influenced their capability to detect mastitis affected cows.

Table 3. 2: Frequent dairy animal health problems

Frequent health problems	Specific diseases	Nyeri(%) N=239	Nakuru(%) N=140	Bomet (%) N=207
Tick borne and other diseases	East coast fever, anaplasmosis, tick burdens	16.32	45.71	59.90
Notifiable diseases	Lumpy skin disease, foot and mouth disease, black quarter, anthrax	5.44	14.29	24.64
Reproductive health diseases	Infertility, abortions	4.18	1.43	2.90
Routine management-related and controllable diseases	Calf mortality, mastitis, foot problems, intestinal worms	26.78	7.14	24.15
Nutrition diseases and complications	Milk fever	2.51	3.57	1.45
General frequent infections	Respiratory, diarrhoea, pneumonia	17.57	10.71	9.66
Poisoning	Acaricide, snake bite	0	0	0

3.4.3 Antibiotics use and withdrawal period

The farmers reported several measures to control diseases in dairy animals with the main method being use of antehelmitics (Figure 3.2). Nakuru had the highest usage (76.43%) and Bomet the least (59.42%). More than half of the farmers (54.3%) followed the recommended withdrawal period of 2 days after treating the cows with antibiotics, vaccines and other drugs; they milked their animals after three days. Additionally, farmers waited for three days after deworming cows or after positive mastitis diagnosis. Farmer's level of education had a significant (χ^2 =15.438^a, p<0.05) effect on their decision on the length of the withdrawal period. Almost all farmers, (90.6%) reported that they followed product information or advice from veterinary doctors to decide on the withholding period. Most farmers (85.9%) on average did not know the type of antibiotics they used to treat their dairy animals. Bomet County reported (89.37%) highest number of farmers without knowledge of antibiotics being used and Nyeri reported (79.5%) being the least. The most commonly antibiotics used by the farmers are as shown in figure 3.3 More than half of the farmers (55.6%) reported that milk from a treated cow was discarded however, 22.7% of them used the milk to feed calves. The decision on the use of milk from treated animals was not significantly (χ^2 =12.093[a], $p>0.001$) associated with the farmer's level of education.

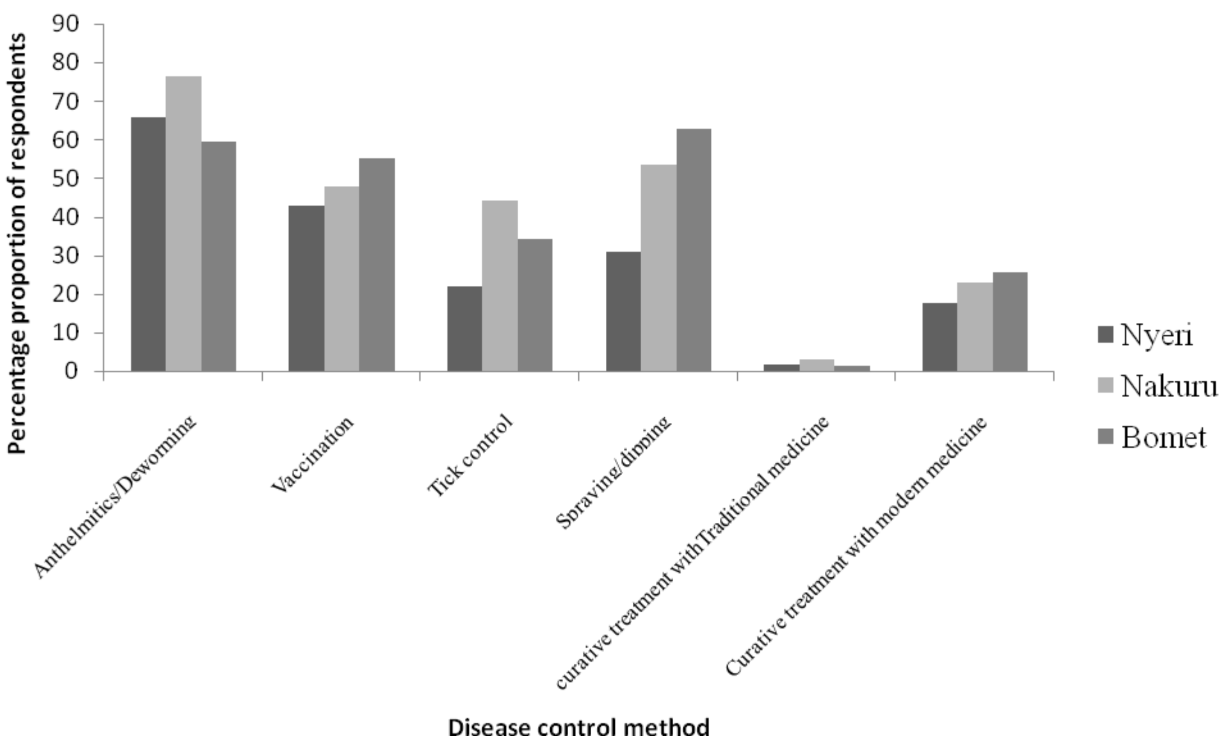

Figure 3. 2: Disease control methods

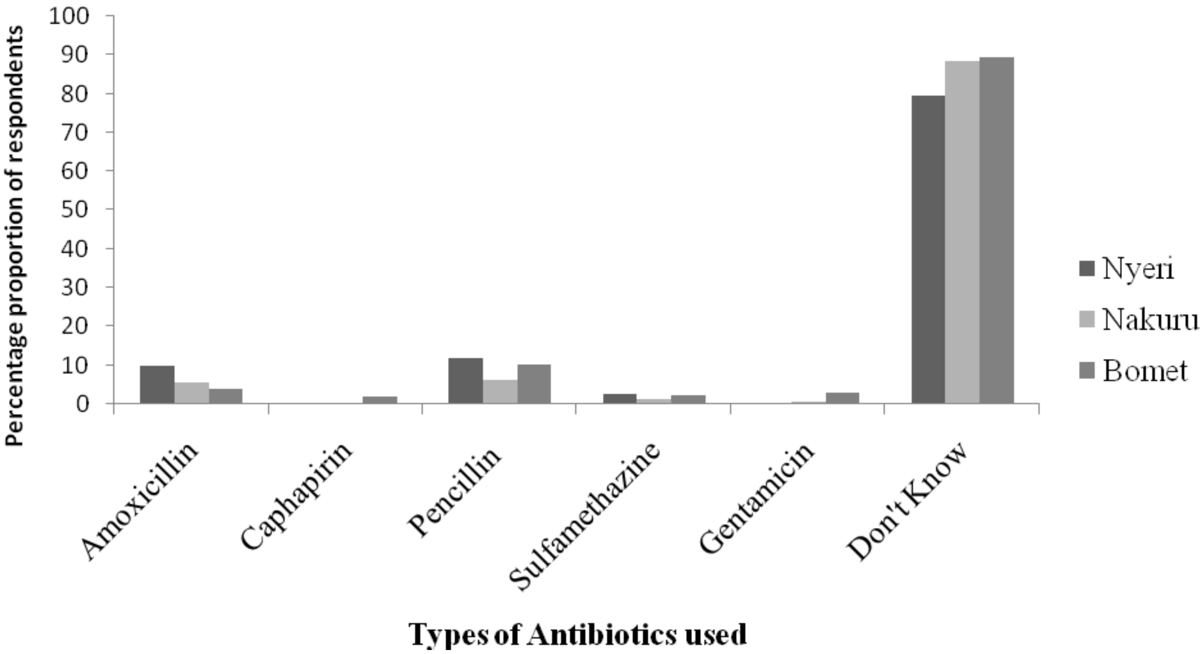

Figure 3. 3: Types of Antibiotics

3.4.4 Milk Hygiene management

Almost all (98.6%) farmers used manual method of milking and more than half of them (66.6%) milked using aluminum cans. Farmers practiced hygienic milking of cows by cleaning the teats (97.3%), however very few 2.2% wore gloves during milking. Additionally, more than eight in every ten farmers (84.0%) reported that they used pre-milking products such as disinfectants and barrier effect. Most farmers (82.4%) stored milk in closed containers awaiting collection. Refrigeration was a major challenge to almost all the farmers (96.4%) and most had no alternative cooling systems. Stripping udder of cows for inspection of mastitis was not a common practice (Table 3.3). Additionally, more than six in every ten farmers (66.0%) reported that they never disinfect teats of cows using teat dip.

Table 3. 3: Frequency of Hygienic practices by dairy farmers

Practice	Frequency of the dairy hygiene practice				
N=586	Always %	Most often %	Sometimes %	Rarely %	Never%
Cleaning of cow shed and cow dung disposal	43.5	11.9	12.6	10.8	21.2
Washing milking vessels with clean water	92.3	4.9	1.9	0.2	0.7
Washing hands with soap	81.7	3.1	3.2	1.9	10.1
Washing udder with clean warm water before milking	91.3	4.6	1.5	0.5	2.0
Fore stripping each quarter of udder to observe signs of mastitis	16.4	13.7	18.1	15.7	36.2
Applying milking jelly after milking	54.3	2.9	3.1	1.0	38.7
Disinfect teats with teat dip	9.7	3.2	9.0	11.9	66.0
Sieving milk after milking	98.1	0.3	0.3	0	1.2
Feeding spoilt feed to milking cows	10.2	1.7	4.3	3.6	80.2

3.4.5 Milk Rejection at Farm Level

Almost all farmers in the three Counties averagely (93.1%) stated that they did not experience milk rejection; however, the few who had their milk rejected indicated several causes of milk rejection (Figure 3.4). There was no significant ($\chi^2 = 0.729^a$, $p > 0.001$) association between the county of origin and milk rejection. Causes of milk rejection were not significantly ($\chi^2 = 20.0829^a$) associated with the farmers’ level of education.

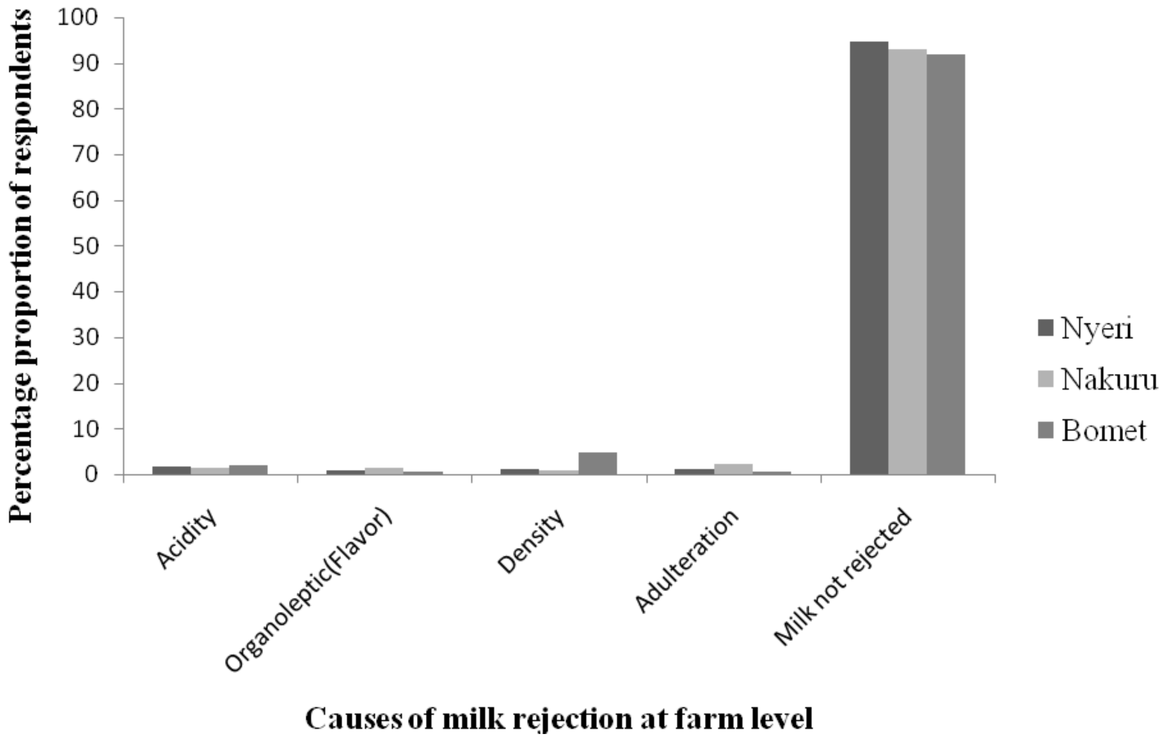

Figure 3.4: Causes of milk rejection at farm level

3.4 Discussion

The present study identified basic knowledge about usage of antibiotics among the farmers. The results show that majority of the respondents achieved some level of education which may have had an influence on implementation of good dairy management practices. According to Worku*et al*. (2018) education is an important entry point for empowerment of rural communities. The same thought is shared by Alhaji *et al*. (2019). According to the authors, education influences antibiotics misuse predisposing milk to residues following treatment of clinical mastitis. From the results of the present study, farmerûs level of education had significant effect on their decision on the length of the withdrawal period. Almost all farmers reported that they followed product information or advice from veterinary doctors to decide on the withdrawal period.

Studies have shown that there is a positive correlation between education and agricultural productivity (Oduro-ofori *et al*., 2014). According to Erick *et al*. (2014), a survey conducted to measure the relationship between farmerôs education and their agricultural efficiency found out that farmers with basic education are more productive and have improved decision making ability. This explains why many farmers with at least basic level of education followed the recommended withdrawal period of 2 days after treating their cows with antibiotics, vaccines and other drugs; they milked their animals after three days. Additionally, farmers waited for three days after deworming cows or after positive mastitis diagnosis. The general outcome of the present study shows that farmers have better ways of handling milk and practice milk hygiene however, there is need for improvement particularly in the type of containers used for storage and handling of milk

Farmers reported diseases such as East Coast Fever, *Anaplasmosis trypanosomiasis*, and tick burdens as commonly encountered tickborne problems. Some of the diseases that the farmers routinely managed were calf mortality, mastitis, foot problems, and intestinal worms. This finding supports those reported by (Kagira *et al*., 2010), Mutua *et al*., (2020) where various diseases such as lumpy skin disease, east coast fever, foot and mouth disease, and mastitis affected livestock production. East coast fever, foot and mouth disease, and mastitis were considered as diseases with greatest impact on livestock wellbeing. Mastitis remains a problem in dairy cattle contributing about 70% of losses (Mutua *et al*., 2020) especially in unhygienic milking conditions. Farmers reported several measures to control diseases in dairy animals with the main method being the use of anthelminthic, and antibiotics. Antibiotics are also widely used in treatment of sick animals and are administered through injections, orally, topically in the skin and by intra mammary and intrauterine infusions. When a lactating cow is treated, levels of antibiotics are usually detected in the milk (Khaniki, 2007).

Nearly all farmers used manual method of milking and more than half of them milked using aluminium cans. Majority of the farmers cleaned the teats, very few wore gloves during milking. Additionally, 84% of the farmers reported that they used pre-milking products such as disinfectants and barrier effects. The results are supported by the findings by Mahari (2016) where most of the respondents reported that they washed their hands and milk vessels before milking their cows, however, washing of udders was not reported in their findings. This may be due to the practice of allowing the calf to suckle before milking that will result in cleaning of the teats. The findings of the present study, however, contradict the finding reported by Onyango *et al*., (2021) where majority of farmers did not wash the udder and their hands before milking their livestock. This may cause microbial contamination of the milk. Milk handling is a concern because of the microbial contaminations occasioned by insufficient personnel knowledge and unhygienic equipment. This can lower milk quality and be of significant concern to public health.

Almost all farmers stated that they did not experience milk rejection, however, the few who had their milk rejected indicated acidity, bad flavour and adulteration as some of the causes of milk rejection. The results conform to those reported by Kyallo (2009) where out of four only one cooperative society had their milk rejected. According to Mahari, (2016) milk deterioration due to physical contaminants, detergents and antibiotics can also cause milk rejection. The presence of these contaminants in milk beyond the recommended levels is an indication that their withdrawal period was not adhered to therefore consumption of such milk can cause allergic reaction and public health concerns (Dinki & Balcha, 2013). For milk to be rejected, some tests such as alcohol, resazurin and lactometer tests are performed. However, most of the dairy co-operative societies use alcohol concentration in the range of 72% to 80% that is higher than that recommended by KEBS (68%). Increase in ethanol concentration increases sensitivity hence the chances of accepting milk of good keeping quality. A high acidity implies a high lactic acid content which, in turn could imply a high bacterial count (Knight-Jones *et al.*, 2016) or high solids content in milk. The milk components that are acidic and contribute to these normal acidity values are carbon dioxide, protein, phosphates and citrates. The higher the concentration of these components, the higher the acidity level observed. However, according to SNV, (2017) microorganisms may cause souring of the milk and hence rejection by the consumer or the milk collector.

3.4.1 Conclusions

From the results, there is need for farmers to be educated on safe handling of milk and on the use of antibiotics to ensure food safety since some of the farming practices may contribute to contamination. Farmersô hygienic handling of milk from production was noble and this is due to their good knowledge of hygienic practices and knowledge of the risks associated with milk hygiene practices.

3.4.2 Recommendations

The study recommends:

i. Farmers should be educated on safe use of antibiotics and practices to ensure food safety among milk consumers

ii. Deployment of Veterinary Officers to guide, assist and train farmers on dairy diseases management and on available types of antibiotics and their usage.

CHAPTER FOUR

PREVALENCE OF ANTIBIOTIC RESIDUES IN MILK SUPPLIED BY SMALLHOLDERS TO PROCESSORS IN NYERI, BOMET AND NAKURU COUNTIES, KENYA

Abstract

In animal production, antibiotics are broadly used for the treatment of various diseases. However, a portion of the drugs may persist in animal products for a period of time causing serious health concerns to humans as the end-product users. This study assessed the presence and the levels of antibiotic residues in milk sold to processors in Nakuru, Bomet, and Nyeri counties of Kenya. A total of 108 milk samples comprising raw milk purchased and sampled from farmers were analyzed for the presence of Beta-lactum Tetracycline and sulphonamides residues using rapid tests in the field and high-performance liquid chromatography (HPLC) for quantification in the laboratory. The antibiotics residues were detected in milk from all the counties albeit in different concentrations. However, there was no significant difference (pÒ0.05) among the three counties. The most commonly detected antibiotic was oxytetracycline while the common beta-lactam detected was ampicillin in all three sites. Sulphonamides detected were dapsone, sulfachlorpyridazine, sulfadiazine, sulfadimethoxine, sulfadoxine, sulfamerazine, sulfamethoxazole, sulfamethoxypyridazine, sulfamonomethoxine, sulfapyridine, sulfisoxazole, and sulfithiazole at different concentrations. Of the samples collected 60 (55.6%) tested positive for at least one antibiotic residue. The mean concentrations for oxytetracycline were 0.017mg/l in Bomet, 0.016mg/l in Nakuru and, 0.015mg/l in Nyeri, which are within the WHO recommended maximum level for oxytetracycline.

Results from this study confirm the presence of antibiotic residues in raw milk collected from selected farmers and sold to processors and this can be attributed to lack of observation of the withdrawal period. The occurrences of such residues pose health risks to consumers hence the need for proper monitoring and control in the supply chain.

4.1 Introduction

The dairy industry in Africa is not as robust as in other parts of the world due to poverty and unfavourable climatic conditions (Alary *et al*., 2007). The highest milk-producing countries in the continent are South Africa, Kenya, Egypt, and Sudan out of which South Africa boasts of the highest milk production per cow. Kenyaøs dairy sector contributes to 14% of agricultural GDP and 6-8% of the countryøs GDP (Odero-Waitituh, 2017). Milk production in Kenya is mainly by small-scale farmers who produce about 80% of the countryøs total milk production (Tegemeo Institute of Agricultural Policy and Development, 2021) The widespread adoption of dairy cattle in the country is attributed to several factors: conducive government policies, a good tropical climate suitable for dairy farming, and the existence of communities that traditionally kept cattle as a source of milk.

The dairy industry remains dynamic and plays major roles in the nutrition and economic aspects of many actors ranging from milk producers, hawkers, consumers, and processors hence its safety and quality will determine good health, stability, and a prosperous economy (Douphrate *et al*., 2013). However, milk production depends on human activities which in one way or the other interfere with the ecological system or natural compounds in milk. The use of chemicals to control pests and diseases in plants and animals has negative effects on the health of both humans and animals (Tudi *et al*., 2021). These chemicals may find their way through animal feeds or as drugs given orally, through injection, or as intramammary gland infusions to control mastitis in dairy herds. The regular use of antibiotics in clinical practice results in the occurrence of antibiotic residues in various animal products (Chowdhury *et al*., 2015).

In Kenya, some of the common diseases are mastitis, milk fever, ketosis, bloat acidosis, and sore hooves-laminitis (Maitho & Kinyua, 2015). These diseases are often infectious; hence, the use of antibiotics in their treatment. According to (De Briyne *et al*., 2014), oxytetracycline is the most used antibiotic in dairy animals. Globally, tetracyclines are used more than any other class of antibiotics (Marth, 1961), however, other antibiotics such as fluoroquinolones, beta-lactams, and cephalosporins are also in use. The use of antibiotic drugs and unauthorized preservatives (adulterants) like hydrogen peroxide, neutralizersô benzoic acid, formalin, and melamine is common in developing countries to prolong shelf life hence meeting milk demand (Singh & Gandhi, 2015). Researchers have noted that there has been an increased use of antibiotics globally over the past decade, a situation that is attributed to increased awareness among small-scale farmers(Benavides *et al*., 2021). There is a growing concern about human antibiotic resistance which is likely to be brought about by the consumption of antibiotics in dairy products such as milk and meat (Paphitou, 2013). The inappropriate use of antibiotics coupled with existence of drug residues in milk cuts across all parts of Kenya and has not conclusively been confirmed. Therefore, there is a need to investigate the sources, use, levels, and types of antibiotics and unauthorized preservatives in milk produced in Kenya.

4.2Materials and Methods

4.2.1 Study area

This study was conducted in three counties in Kenya: Nyeri, Bomet, and Nakuru (Figure 4.1). Bomet is located at 0º 29' and 1º 03' South and longitudes 35º 05' and 35º 35' East and elevation of 1962 meters above sea level while Nakuru is located at latitude 0.23º North and 1.16º South and longitude of 35.41 º East or 35º 24ô coordinates and elevation of 1850 meters above sea level. Nyeri lies between 36°38ò and 37°20ò East longitudinally and between latitude 00 38 elevations of 1460 meters. The mean annual rainfall for Nyeri ranges from 950 to 1500 mm, for Bomet is 1482 mm and for Nakuru is 895 mm with a bimodal pattern (MoALF. 2016). The mean temperature for Nyeri is 15.2°C, for Bomet is 18.2°C and for Nakuru is 17.5°C (MoALF. 2016). These areas have been chosen because they are among the high milk-producing areas in the country (KDB, 2014). Moreover, these areas have well-established cooperatives societies and cooling centers where bulking of the milk is done.

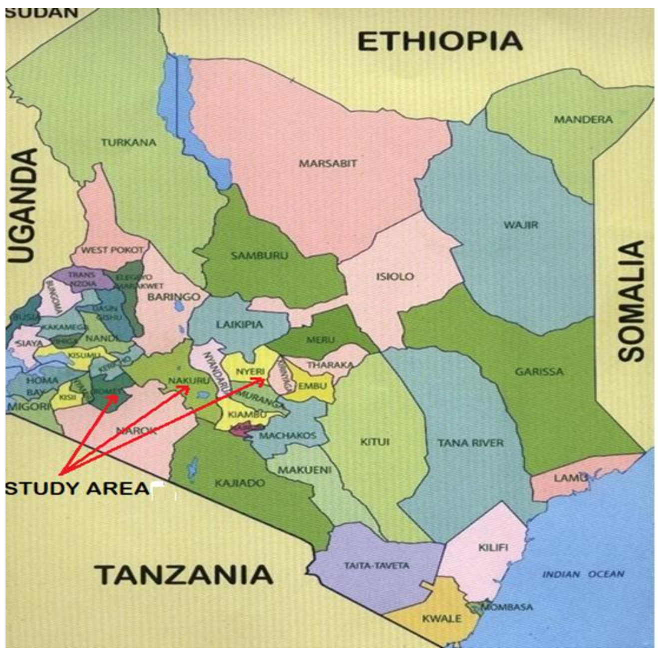

Figure 4.1: Map of the study areas

4.2.2 Sample size determination

The sample size was arrived at using the formula by Kadam, and Bhalerao. (2010):

$$n = \frac{Z^2pq}{d^2}$$ é (Equation 1)

Where N, is the minimum sample size, p is the proportion of the population (p=0.5), Z is the normal standard variation (1.96) at 95% confidence interval, q = (1-p) = 0.5 the fraction of the selected population expected not to have features under the study and d is the acceptable sampling error.

$$n= \frac{1.96^2 \times 0.5 \times 0.5}{(0.0405)^2} = 586$$

The actual sample size used was 586 and included traders that supply milk to different milk channels, managers of dairy processing plants and cooperative societies. The samples size was distributed as follows Counties: Nyeri 239, Bomet 207, and Nakuru, 140 based on the intensity of dairy activities.

4.2.3Sampling procedure

The study was carried out using a mixed method approach where farmers, traders and cooperative society staffs were interviewed. A simple random sampling method was adopted to obtain information on awareness level of the farmers and cooperative members on the residues within the milk products and to target chemicals and drugs used in treating farm animals. This study was conducted using a structured questionnaire that was used to interview farmers and processors. The target population was made up of farmersô co-operative members and managers of dairy processing plants in the three Counties. The survey was conducted through personal interviews of the individual farmers, traders that supply milk to cooperative societies and cooperative societyôs staff. Aspects such as socio-demographic characteristics of milk producers, level of knowledge and handling techniques of antibiotics and preservatives, withdrawal period were also determined. The central locations were selected in each county and milk processors, traders, and farmers were identified using a list from cooperatives.

4.2.4Collection of milk samples

Out of 586 farmers interviewed during the baseline survey, using the formula by Kadam, and Bhalerao(2010) where normal standard variation (1.96) at 95% confidence interval, q = (1-p) = 0.5 and d as the acceptable sampling error (0.00889), 108 farmers were randomly selected for sampling. Milk samples (n 108; 50 mL per sample) were obtained from the three different Counties through individual farmers supplying milk to the processors in Bomet, Nyeri and Nakuru Counties over a period of one month. Samples were collected randomly in labelled sterile bottles early in the morning between 5:00am to 8:00am in the three counties at the cooperatives from individual farmers before bulking. Necessary information such as date of sampling, area, and the time at which the samples were obtained was recorded. All of the samples were subjected to a rapid test using Betalactum tetracycline and Sulphonamides (BTS) antibiotic strip test kits developed by National Dairy Research Institute (ICAR-NDRI), Karnal, India.Paper strip was dipped in milk samples. Results were interpreted depending on colour: Colour blue indicated absence of antibiotics while faded blue colour indicated the presence of antibiotics. Samples that tested positive were immediately kept in cool boxes for transportation to the laboratory for refrigeration at 4^{o}C for further analysis to identify various antibiotic groups and to evaluate the levels of contaminations and if the samples exceeded the maximum residue limits set by CODEX. The milk samples were stored at -20^{o}C for HPLC analysis and quantification. Milk samples were used for analysis of antibiotics and drug and preservatives residues.

4.2.5Analysis of antibiotic residues from milk samples

4.2.5.1 Rapid screening test for milk samples (Tritest BTS Test Kit (β-Lactams, Sulfonamides and Tetracyclines)

Rapid screening test of milk samples through immunochromatography-assay (lateral flow dipstick/lateral test) were done according to (Naik *et al.,* 2017).The tests were performed using fast antibiotic residues screening kits which utilized high affinity antigen antibodies attraction against (ϐ-Lactams, Sulfonamides and Tetracyclines**)** which identified these potential hazardous compounds in milk samples. The kits were stored at 2°C and left for an hour at room temperature before use. Milk samples were prepared in clean sterile wells and were fully in liquid form without any deposition and agglomeration from raw milk. About 200µl of clear milk samples were added into the micro wells and allowed to mix with reagent to form a pink mixture for rapid screening. The assays were done in 108 micro wells and results recorded after absorption of milk sample on the kit strip. The strip had four lines, Control, Tetracycline, Beta-lactams and Sulfonamides as supplied by the manufacturer. Positive or negative results were recorded by comparison of color shades of the lines on the strip with the control line shade after absorption of milk sample through the strip. A color shade of similar intensity as control line or lighter indicated a positive test of antibiotics. One strip was used per milk sample and discarded after observations.

4.2.4.2 Analysis of antibiotics in milk sampled from different counties using HPLC

The milk samples were analyzed following the multi-residue method described by Mamani *et al.* (2009) for antibiotic determination in milk using Shimadu HPLC-Japan. The equipment was fitted with UV-vis detector. Milk samples were extracted, purified, and evaporated. About 5ml of the sample was mixed with Trichloroacetatic acid (25%, 2.5 ml) and centrifuged for 10 seconds with vortex. EDTA buffer solution of 10ml. 0.1 M Na-EDTA, 0.1 M citric acid, 0.2 M

Na_2HPO_4, pH 4) was added and the sample vortexed for 10 seconds, ultra-sonicated for 10 minutes and centrifuged at 4000 rpm at 10°C. Samples were cooled before centrifugation in a freezer at 4^{o}C for 6 minutes to avoid disintegration of thermally unstable compounds. The resultant supernatant was centrifuged to separate the fat layer. The milk samples were then purified with oasis HLB solid-phase extraction cartridges which were activated with 5ml methanol, 10ml acetonitrile and 5 ml of EDTA buffer. The cartridges were washed with 10 mL of 5% methanol in EDTA and then dried in a vacuum for 5 minutes. The preservatives were eluted with 5 ml of methanol then the eluent was dried in a nitrogen flow in a warm water bath at 40 to 50°C). The resultant residue was dissolved in acetonitrile of the mobile phase (200 εl), vortexed and then water (300 εl) was added (Ahlberg *et al.*, 2016).

4.2.6Data analysis

All the statisticaldata collected were subjected to analysis of variance using the SPSS version 25 software and treatments means were compared by using Duncanꞌs new multiple range test at 0.05 percent.

4.3 Results

4.3.1 Levels of antibiotics in milk samples collected from Bomet, Nakuru and Nyeri counties

The results obtained from the evaluation of the presence of antibiotics in milk samples are presented below (Table 4.1). According to the results, 60 samples (55.6%) out of 108 samples were positive for antibiotic residues (Table 4.1). In Nyeri, all the samples were found to contain antibiotics residues while in Bomet and Nakuru 10 (27.8%) and 14 (38.9%) of the samples tested positive for antibiotics residues respectively. Various antibioticcompounds such epitetracyline, oxytetracycline, and tetracycline were identified in various concentrations in Bomet, Nakuru and Nyeri. In Bomet(Table 4.2) there was significant difference (PÒ0.05) between the concentrations of antibiotic compounds found in milk samples collected from different sources and taken to the collection centres showed high presence of antibiotics. Oxytetracycline, was identified as the highly concentrated antibiotic compound in all the sites.There was no significant difference among the sites in the levels of antibiotics found.

Table 4. 1: Antibiotic residue contamination in difference milk samples from various sites in Bomet, Nakuru and Nyeri.

County	Sample Size (n)	Positive samples (n)	Positive samples (%)
Bomet	36	10	27.8
Nakuru	36	14	38.9
Nyeri	36	36	100.0

Table 4. 2: Average levels of antibiotics in milk samples collected from Bomet, Nakuru and Nyeri counties

Compound	**Concentration (mg/litre)**		
	Bomet(n=14)	**Nakuru (n=10)**	**Nyeri (n=36)**
Epitetracyline	0.004±0.009 ^{a}	0.003±0.007 ^{a}	0.004±0.008 a
Oxytetracycline	0.017±0.009^{b}	0.016±0.006 ^{b}	0.015±0.008 ^{b}
Tetracycline	0.003±0.007 ^{a}	0.013±0.021 ^{ab}	0.005±0.010 a

Values (means± standard deviation) with different letters along the column are statistically different (Tukey's test, PÒ0.05)Tetracyclines Ò100 εg/kg

4.3.2 Occurrence of Beta-lactams residues in milk

The milk samples tested positive for beta lactam antibiotic residues (Table 4.3). Some of the beta lactams detected were penicillin G, penicillin V, ampicillin and amoxicillin and Oxacillin.Amoxicillin, Ampicillin, Cloxacillin, Penicillin G, and Penicillin V were detected in samples collected from all the sites. However, Oxacillin was not detected in all the samples. In Bomet, Nakuru and Nyeri Counties, high levels of ampicillin was detected ranging from 0.046 ï 0.086 mg/l. However, there was no significant differences (PÒ0.05) among the sites in the compounds detected in the milk samples

Table 4. 3: Average levels of Beta-lactams in milk samples collected from Bomet, Nakuru and Nyeri counties

Compound	Concentration (mg/litre)		
	Bomet (n=10)	**Nakuru (n=14)**	**Nyeri (n=36)**
Amoxicillin	0.003±0.0 ^{a}	0.003±0.001 ^{a}	0.002±0.001^{a}
Ampicillin	0.046±0.070 ^{ab}	0.086±0.084^{b}	0.047±0.060 ^{ab}
Cloxacillin	ND	ND	ND
Oxacillin	ND	0.000±0.001 ^{a}	ND
Penicillin G	0.044±0.052 ^{ab}	0.028±0.034 ^{a}	0.047±0.066 ^{ab}
Penicillin V	0.006±0.004 ^{a}	0.007±0.004 ^{a}	0.007±0.004 ^{a}

Values (means± standard deviation) with different letters along the column are statisticallydifferent (Tukey's test, PÒ0.05)

4.3.3 Sulphonamides levels

All the samples collected tested positive for salphonamides except for Bomet where Sulfadiazine, Sulfadimethhoxine and Sulfapyridine were not detected (Table 4.4). They contained dapsone, Sulfachlorpyridazine, sulfadiazine, Sulfadimethhoxine, Sulfadoxine, Sulfamerazine, Sulfamethoxazole, Sulfamethoxypyridazine, Sulfamonomethoxine, Sulfapyridine, Sulfisoxazole, Sulfithiazole and the concentration ranged from 0.002mg/l to 0.076mg/l. The mean concentrations of the antibiotic contaminants were not significantly different between counties and between the salphonamides. The highest mean concentration was recorded for Sulfamethoxazole in Bomet and Sulfisoxazole in Nyeri and Nakuru.

Table 4. 4: Average Levels of Sulphonamides in milk samples collected from Bomet, Nakuru and Nyeri counties

	Concentration (mg/litre)		
Compound	**Bomet (n=14)**	**Nakuru (n=10)**	**Nyeri (n=36)**
Dapsone	0.014±0.012 [a]	0.017±0.019 [a]	0.020±0.062 [a]
Sulfachlorpyridazine	0.008±0.010 [a]	0.014±0.013 [a]	0.017±0.024 [a]
Sulfadiazine	ND	0.003±0.007 [a]	0.185±1.135 [a]
Sulfadimethhoxine	ND	0.016±0.054 [a]	0.008±0.035 [a]
Sulfadoxine	0.040±0.018 [a]	0.034±0.017 [a]	0.037±0.019 [a]
Sulfamerazine	0.002±0.006 [a]	0.002±0.006 [a]	0.002±0.005 [a]
Sulfamethoxazole	0.035±0.043 [a]	0.029±0.034 [a]	0.023±0.029 [a]
Sulfamethoxypyridazine	0.017±0.016 [a]	0.035±0.044 [a]	0.025±0.014 [a]
Sulfamonomethoxine	0.002±0.005 [a]	0.213±0.755 [a]	0.015±0.044 [a]
Sulfapyridine	ND	0.001±0.004 [a]	0.000±0.002 [a]
Sulfisoxazole	0.139±0.211 [a]	0.062±0.039 [a]	0.076±0.064 [a]
Sulfithiazole	0.027±0.022 [a]	0.033±0.013 [a]	0.030±0.014 [a]

Values (means± standard deviation) with different letters along the column are statistically different (Tukey's test, PÒ0.05). ND ï not detected. Sulfonamides Ò100ε g/kg

4.4Discussion

The results from the present study confirm the presence of various antibiotics such as Penicillin, tetracyclines, sulphonamides in milk samples collected from Nyeri, Bomet and Nakuru. The results are supported by outcomes from cross sectional studies of residues in milk in different parts of Kenya where presence of Penicillins, tetracyclines, sulphonamides, and aminoglycosides antibiotics in marketed milks samples were reported. (Ahlberg *et al*., 2016; Sachi *et al*, 2019). In similar manner, the present study confirms the results reported by the studies. In Kenya, in 2004 Shitandi and Sternesjö (2004) reported 14.9% of milk samples to have been contaminated by penicillin while in 2010 Ahlberg*et al*., (2016) reported a further increase of over 24% of antibiotic residues milk at the farm. The outcome suggests an increase in milk contamination with antibiotics residues a fact that has been observed since 1978 when penicillin residues were reported to be just 1% (Kangêthe *et al*., 2005). In Nigeria, over 60% of milk samples tested positive for antibiotic residues in milk and milk products (Olatoye *et al*., 2016). High levels of tetracyclines have been reported in milk and milk products from Algeria (Layada *et al*., 2016) while Chowdhury *et al*. (2015) reported way above recommended levels of antibiotic residues in Bangladesh milk. The use of antibiotics in livestock production has been reported to generate drug residues in animal products causing adverse health effects on consumers. After the drugs are administered to an animal, most of the drugs are metabolized for detoxification, however, after excretion, a portion of the drugs may persist in milk, eggs, and meat for a certain period of time as residues(Sachi *et al*., 2019). The residues of antibiotics present toxicological health risks to humans and may trigger resistance of antibiotics to human (Orwa *et al*., 2017).

Testing of milk samples for antibiotic residues showed positive results for beta lactam antibiotics Amoxicillin, Ampiicllin, Cloxacillin, Penicillin G, and Penicillin V in samples collected from all the sites. However, Oxacillin was not detected in all the samples. In Bomet, Nakuru and Nyeri counties, high levels of ampicillin was detected ranging from 0.046 to 0.086 mg/l. These results concur with the findings by Movassagh and Karami (2010) in Iran and Lejaniya*et al*., (2017) in India who reported detection of several beta lactam antibiotics in milk. In the current study, all samples collected from the three sites were confirmed to be contaminated with different levels of beta lactum. The same results were reported by Movassagh & Karami (2011) in Turkey where

44% of 204 raw milk tested positive for beta lactam antibiotic residues. Since ϐ lactam antibiotics are dominantly and widely used in treatment of bacterial diseases in cattle, it was easy to confirm the availability of the beta lactam antibiotics (Fejzic *et al*., 2014). These samples either contained residues above MRL or slightly below.

The results of the present study indicate different concentration levels of sulphonamides such as Dapsone, Sulfachlorpyridazine, Sulfadiazine, Sulfadimethhoxine, SulfadoxineSulfamerazine, Sulfamethoxazole, Sulfamethoxypyridazine, SulfamonomethoxineSulfapyridine, Sulfisoxazole, Sulfithiazole. The results concur with those reported by Chung *et al*., (2009); Takeda and Akiyama (1992) where the authors found sulfadiazine, sulphadimidine sulfamethoxazole, sulfamerazine, sulfadimethoxine, sulphasalazine, sulfisoxazole and silver sulfadiazine as the most common sulphanomides. The prevalence of sulphanomides in Kenya has been reported to be at 21% and is way above the maximum residue level (Shitandi & Sternesjö, 2004). In Kenya in 2010, 2.5% samples tested positive for sulphonamides (Ahlberg *et al*., 2016). According to Orwa*et al*., (2017) the occurrence of antibiotics residues in milk is due to noncompliance with the withdrawal period, excessive usage of drugs, contamination of animal feeds with those of treated animals, or the use of unlicensed antibiotics (Nisha, 2008) while other researchers have attributed this common occurrence to lack of education and training in drug administration and use among the small scale farmers (Shitandi & Sternesjö, 2004). When milk and other animal products with high levels of sulfamethazine residues are ingested by humans there is occurrence of immunopathological effects, transfer of bacterial resistance to humans, hypersensitivity and carcinogenicity (Orwa *et al*., 2017).

According to the European Union and Codex Alimentarious regulation for maximum residue limits, sulfonamides should not exceed 100εg/kg, while tetracyclines should not exceed 100 εg/kg (Commission regulation (EU), 2010). These levels also fall below the European Union Commission Regulation (EU) 2010 of antibiotic residues in raw milk. Some of the samples had antibiotics above the limit of detection. This indicates that even higher levels than the read value might have been present. This study concludes that antibiotics are commonly used to treat bacterial diseases in cattle management and these results in antibiotic residues in milk products such as milk. This is mainly due to lack of observation of the withdrawal period by the farmers.

4.4.1 Conclusion

The study confirmed the presence of antibiotic residues in raw milk collected from selected farmers in Bomet, Nyeri and Nakuru counties and sold to processors. The presence of these antibioticsin milk pose health risks to consumers hence the need for proper monitoring and control in the supply chain.

4.4.2 Recommendation

- There is need for farmers to be educated on safe use and of antibiotics to ensure food safety since most of the farmers lacked awareness on the type of antibiotics being administered during treatments
- The study recommends sensitization of milk actors on the knowledge and usage of the antibiotics in the control of diseases in in dairy industry.
- The entire milk supply chain should be regularly capacity built to ensure good antibiotic handling practices.

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CHAPTER FIVE

GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 General Discussion

The present study in Nyeri, Bomet and Nakuru counties of Kenya evaluated knowledge about usage of antibiotics among the farmers. The results show that majority of the respondents achieved some level of education which may have had an influence on implementation of good dairy management practices. According to Worku*et al*. (2018) education is an important entry point for empowerment of rural communities. The same thought is shared by Alhaji *et al*. (2019). According to these authors, education influences antibiotics misuse predisposing milk to residues following treatment of clinical mastitis. From the results of the present study, farmerọs level of education had significant effect on their decision on the length of the withdrawal period and identification of dairy diseases. According to Erick *et al*. (2014), a survey conducted to measure the relationship between farmerọs education and their agricultural efficiency found out that farmers with basic education are more productive and have improved decision making ability. Nearly all farmers used manual method of milking and more than half of them milked using aluminum cans. Majority of the farmers cleaned the teats, very few wore gloves during milking. Additionally, 84% of the farmers reported that they used pre-milking products such as disinfectants and barrier effects. The results are supported by the findings by Mahari (2016) where most of the respondents reported that they washed their hands and milk vessels before milking their cows, however, washing of udders was not reported in their findings. According to past studies, residues of drugs in milk are a public health concern all over the world. Cross sectional studies of residues in milk in different parts of Kenya indicate presence of Penicillins, tetracyclines, sulphonamides, and aminoglycosides antibiotics in marketed milks samples

(Ahlberg *et al*., 2016; Sachi *et al*, 2019). In similar manner, the present study confirms the results reported by these studies. For instance, results confirm the presence of various antibiotics such as Pencillins, tetracyclines, sulphonamides in milk samples collected from Nyeri, Bomet and Nakuru. In Kenya in 2004, Shitandi and Sternesjö (2004) reported 14.9% of milk samples to have been contaminated by penicillin while in 2010 Ahlberg*et al*. (2016) reported a further increase of over 24% of antibiotic residues in milk at the farm. The outcome suggests an increase in milk contamination with antibiotics residues, a fact that has been observed since 1978 when the prevalence of penicillin residues in farmersô milk was reported to be just 1% (Kangœthe *et al*., 2005). The residues of antibiotics present toxicological health risks to humans and may trigger resistance to antibiotics in human population (Orwa *et al*., 2017).

Testing of milk samples for antibiotic residues showed positive samples for beta lactam antibiotics Amoxicillin, Ampiicllin, Cloxacillin, Penicillin G, and Penicillin V in samples collected from all the sites. However, Oxacillin was not detected in all the samples. In Bomet, Nakuru and Nyeri Counties, high levels of ampicillin were detected ranging from 0.046 to 0.086 mg/l. These results concur with the findings by Movassagh and Karami (2010) and Lejaniya*et al*., (2017) who reported detection of several beta lactam antibiotics in milk. The results of the present study indicate different concentration levels of sulphonamides such as Dapsone, Sulfachlorpyridazine, Sulfadiazine, Sulfadimethhoxine, SulfadoxineSulfamerazine, Sulfamethoxazole, Sulfamethoxypyridazine, SulfamonomethoxineSulfapyridine, Sulfisoxazole, Sulfithiazole. The results concur with those reported by Chung *et al*., (2009). The prevalence of sulphanomides in Kenya has been reported to be at 21% way above the maximum residue level (Shitandi & Sternesjö, 2004). In Kenya in 2010, 2.5% samples tested positive for sulphonamides (Ahlberg *et al*., 2016). According to Orwa*et al*., (2017) the occurrence of antibiotics residues in milk is due to noncompliance with the withdrawal period, excessive usage of drugs, contamination of animal feeds with those of treated animals, or the use of unlicensed antibiotics (Nisha, 2008) while other researchers have attributed this common occurrence to lack of education and training in drug administration and use among the small scale farmers (Shitandi & Sternesjö, 2004).

According to the European Union and Codex Alimentariouscommission regulation for maximum residue limits, sulfonamides should not exceed 100εg/kg, while tetracyclines should not exceed 100 εg/kg (Commission regulation (EU), 2010). The levels found in this study also fall below the European Union Commission Regulation (EU) 2010 of antibiotic residues in raw milk. Antibiotics are commonly used to treat bacterial diseases in cattle management and these results in antibiotic residues in milk products. This is mainly due to lack of observation of the withdrawal period by farmers in dairy industry.

5.2 Conclusions

From the results, there is need for farmers to be educated on safe use and of antibiotics to ensure food safety since a majority of the farmers lacked awareness on the type of antibiotics being administered during treatments. Farmersô hygienic handling of milk from production is good and this is due to their good knowledge of hygienic practices and knowledge of the risks associated with milk. The use of antibiotics by farmers in all three counties (Bomet, Nyeri and Nakuru) as means of bacterial diseases management in cattle results in the presence of antibiotic residues in raw milk which was attributed to lack of farmers observing a drug withdrawal period. The milk with antibiotic residues is bought off by processors and thus ends up as a consumable product for unsuspecting consumers posing a risk to their health. The farmers and processes would make a great contribution towards the reduction of occurrence of antibiotics in milk through proper monitoring and control in the supply chain by proper training and enhanced milk inspection at the collection centres.

5.3 Recommendations

The study recommends that:

i. Veterinary Officers should train farmers in Nyeri, Bomet and Nakuru on available types of antibiotics and their usage.

ii. Policy and decision makers should come up with proper measures, monitoring and surveillance practices to help farmers follow the guidelines on usage of antibiotics

iii. Animal health attendants should be deployed to guide and assist farmers on dairy diseases management.

iv. The entire milk supply chain should be regularly monitored by Public Health Officers to ensure good antibiotic handling practices.

v. Public Health Officers should educate consumers and alert them on the possibility of presence of antibiotic residues in raw and processed milk.

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APPENDICES

Appendix One: Questionnaire

Africa-Milk Task 1.2. Baseline Farm Survey

QUESTIONNAIRE REFERENCES

1. Household code	
2. Country	
3. Date of survey (DD/MM/YYYY)	___________ / _________________ / _________________
4. Enumerator name	
5. Time: starting interview	
6. Time: ending interview	

SECTION A. HOUSEHOLD AND DEMOGRAPHIC DATA

A.1. Provide the following details about the household head

Full name of the respondent				
First name of the respondent				
County/district of the respondent				
Village of the respondent				
Household GPS coordinates	**Latitude**		**Longitude**	
Ethnic affiliation of the respondent				
Religion of the respondent (codes)				
Level of education of the respondent (codes)				
Marital status of the respondent (codes)				

Religion codes:	Level of education codes:	Marital status codes:
1 = Catholic	1 = Illiterate	1 = Married/living together
2 = Muslim	2 = Elementary school	2 = Single
3 = Hindu	3 = Middle School	3 = Divorced

4 = Protestant	4 = High school	4 = Widow(er)
5 = Traditional African Religion	5 = University	
6 = Atheist	6 = Koranic school	
7 = Other(specify)]	7 = Other	

A.2. Give details of all household members (including the household head) living permanently on the compound and their primary dairy activity on the farm

BE SURE THAT ALL CHILDREN AND INFANTS ARE INCLUDED:

Name (first name only)	**Age (yrs)**	**Sex (1= Male 2= Female)**	**Highest education level in years**	**Primary occupation**	**Primary dairy activity on the farm (codes)**
1 (Head of HH)					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

dairy activities codes:	4 = Milking	8 = All activities related to cattle
1 = Grazing and watering cattle	5 = Marketing milk	9 = No dairy activity
2 = Cattle feeding	6 = Other livestock activities	10 = Other (specify)
3 = Activities related to fodder	7 = Food or cash crops activities	

SECTION B. LIVESTOCK INVENTORY & MANAGMENT

B.1. Livestock Inventory

1.1. Indicate the **heads of cattle** kept on the farm in 2018 including those kept but not owned:

Breeds (codes)	Animal type (codes)	Owned and kept on the farm (number)	Owned but kept out of the farm (number)		Kept on farm but not owned (number)

Animal types codes:	3 = Immature males (< 3 yrs)	6 = Pre-weaning males
1 = Bulls (>3 yrs.)	4 = Cows (calved at least once)	7 = Pre-weaning females
2 = Castrated adult males (oxen>3 yrs)	5 = Heifers	

Breed codes (Kenya):	Breed codes (Burkina & Senegal):		Breed codes (Madagascar):
1 = Holstein-Friesian (pure)	1 = Local zebu pure		1 =
2 = Holstein-Friesian (cross)	2 = Local dairy zebu (Azawak, Goudali) pure		2 =
3 = Ayrshire (pure)	3 = Local zebu crossed with local dairy zebu (Azawak, Goudali		3 =
4 = Ayrshire (cross)	4 = Local zebu crossed with exotic dairy breed (Holstein, Montbeliarde, Gyr, Girolando, Jersiaise, etc.)		4 =
5 = Jersey (pure)	5 = Exotic dairy breed pure (Holstein, Montbeliarde, Gyr, Girolando, Jersiaise, etc.)		5 =
6 = Jersey (cross)			6 =
7 = Guernsey (pure)			
8 = Guernsey (cross)			
9 = Sahiwal			

10 = Boran 11 = Local zebu 12=Fleckvieh			

Health management

B.2. What are the **most frequent animal health problems** that have been affecting your dairy cows?

Animal health problems	Rank most frequent=1 and least =8	Frequency (Codes)	Occurrence in 2018 (1 = yes ; 2 =No ; 3 = don't know)	Number of cows affected	Outcomes (Codes)
1 = Tick borne and other insect borne-diseases (e.g. East Coast fever, Anaplasmosis, Trypanosomosis, Tick burdens)					
2 = Notifiable diseases (e.g. Lumpy skin diseases, Foot & Mouth, Black quarter, Anthrax)					
3 = Reproductive health diseases (e.g. Infertility, abortions)					
4 = Routine management-related and controllable diseases (e.g. Calf mortality, Mastitis, Foot problems, Intestinal worms)					
5 = Nutrition diseases and complications (e.g. Milk fever)					
6 = General frequent infections(e.g. Respiratory/ Pneumonia, Diarrhea)					
7 = Poisoning (e.g. Acaricide, snake					
8 = Other (Specify)_______________					

9 = Other (Specify)________________					
	Frequency codes: 1 = Frequent 2 = Rare 3 = Never 4 = Donât know		Outcomes codes: 1 = Died 2 = Survived 3 = Slaughtered		

Milk hygiene management

5.5 aWhich kind of milking cans do you use during milking? (1= Aluminium bucket; 2=Plastic bucket)

5.5. What **type of milking** do you do (most common)? [___] = manual (hand) [___] = mechanic (tick)

5.6. Do you **clean teats before milking**? [___] = YES [___] = NO (tick)

5.7. Do you **wear gloves during milking**? [___] = YES [___] = NO (tick)

5.8. Do you **use pre-milking products**? [___] = YES [___] = NO (tick)

5.9. If **yes**, what is the **nature of the product**? [___] = disinfectant [___] = barrier effect (lubricant) [___] = both

5.10. Do you **use post-milking products**? [___] = YES [___] = NO (tick)

5.11. If **yes,** what is the **nature of the product**? [___] = disinfectant [___] = barrier effect (lubricant) [___] = both

5.12. Fill in the table the information on MILK REJECTION at the individual point of collection

Cause of rejection	Number of times rejected in 2018	Quantity rejected (litres)	Where is the rejected milk taken to?
Acidity			
Organoleptic (flavor)			
Density			
Adulteration by hydrogen pexide and formalin			

5.2 Milk rejection by processor

		causes of milk rejection					
Type of supplier	Information on causes and amount of milk rejected	Mastatis and Acidity	Organoleptic (flavor)	Density	Bacterial load	Antibiotic residues	Others
Individual farmer	Average number of times rejected						
	Quantity rejected (litres)						
	Proportion of rejection (%)						
	Where is the rejected milk taken to? (1=Pour ; 2= return to supplier ; 3=Other)						
	Cost of disposing off of rejected milk						
Cooperative society	Average number of times rejected						
	Quantity rejected (litres)						
	Proportion of rejection (%)						
	Where is the rejected milk taken to? (1=Pour ; 2= return to supplier ; 3=Other)						
Self-help group	Average number of times rejected						
	Quantity rejected (litres)						
	Proportion of rejection (%)						
	Where is the rejected milk taken to? (1=Pour ; 2= return to supplier ; 3=Other)						
Brokers	Average number of times rejected						
	Quantity rejected (litres)						
	Proportion of rejection (%)						
	Where is the rejected milk taken to? (1=Pour ; 2= return to supplier ; 3=Other)						
Other	Average number of times rejected						

	Quantity rejected (litres)						
	Proportion of rejection (%)						
	Where is the rejected milk taken to? (1=Pour ; 2= return to supplier ; 3=Other)						

5.4 Which are some of illegal [practices that are done by farmers and milk collectors

No.	Illegal practices by farmers (see codes below) Rank stating with the most important	Illegal practices by milk collectors (see codes below) Rank starting with the most important
1		
2		
3		
4		
	Illegal practices codes: 1= Milk adulteration 2= Failure to adhere to withdrawal period after treating the cow 3=Addition of hydrogen peroxide 4=Other (s) specify	Illegal practices codes: 1= Milk adulteration 2=Addition of hydrogen peroxide 3=Other (s) specify

Appendix two: Analysis of variance for the antibiotic residues in milk

	Source	DF	Sum of squares	Mean squares	F	Pr> F
Sulphonamides	Model	35	1.726	0.049	0.603	0.967
	Error	679	55.493	0.082		
	Corrected Total	714	57.219			
Tetracyclines	Model	8	0.006	0.001	7.502	**<0.0001**
	Error	170	0.016	0.000		
	Corrected Total	178	0.022			
Beta-lactams	Model	16	0.199	0.012	9.343	**<0.0001**
	Error	343	0.457	0.001		
	Corrected Total	359	0.657			

Appendix three: Turnitin Report

Turnitin Originality Report

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ASSESSMENT OF ANTIBIOTICS RESIDUES IN MILK SUPPLIED BY SMALLHOLDER FARMERS TO PROCESSORS IN KENYA: A CASE OF BOMET, NAKURU AND NYERI COUNTIES By Omullo Tobias Aduda

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