

Bovine Mastitis in Fiji: Economic Implications and Management—A Review

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Abstract

Mastitis is a devastating disease condition in the dairy industry throughout the world and is caused due to the inflammation of the mammary gland. The etiological agents causing mastitis varies from one place to another depending on the animal breed, climate, and husbandry practices. However, the etiological agents causing mastitis include an extensive variety of gram-negative and gram-positive bacteria and fungi. Furthermore, the most common bacterial species responsible for causing mastitis include *Staphylococcus aureus*, *Streptococcus dysgalactiae*, *Streptococcus* (Strep.) *agalactiae*, Strep. *Uberis* and various Gram-negative bacteria. This review highlights the type of bacteriological etiology causing intramammary infection (IMI) is an essential part of effective mastitis control, prevention, and treatment. It also discusses the diagnostic tests used to test for mastitis in Fiji include Somatic cell count, California Mastitis Test (CMT), and bacteriological culturing. The development of Polymerase Chain Reaction (PCR) technology along with the version of real-time and multiplex PCR has improved the sensitivity and rapidity of mastitis diagnosis. The subclinical and clinical forms of mastitis can be treated with early detection of the signs of mastitis infection. Moreover, it is also essential to create awareness to the farmers about the cost, knowledge about mastitis and the loss it can cause.

Keywords: mastitis, diagnosis, CMT, somatic cell count, PCR, management.

1. Introduction

According to Kandemiri et al. (2013), mastitis is the inflammation of the mammary gland and all the components that make up the mammary tissues, as well as the connective tissue that surrounds it. The reaction of mammary glands to irritants influences the quantity and quality of milk. Mastitis can be categorized into subclinical and clinical mastitis. Subclinical mastitis does not create visible changes in the milk or the structure of the udder whereas in clinical mastitis abnormality of the udder and/or secretion is observed. For sub-clinical mastitis, since there is rarely any noticeable change in the milk or the udder, the farmer usually remains unaware of the existence of subclinical form in their animals, which if left medically unattended, results in clinical and chronic forms (Kumari et al., 2020). Cows with both subclinical and clinical mastitis will produce less milk, and the quality of the milk is compromised. Cattle mammary gland is protected by specific immune and innate responses but abnormal physiological and environmental factors tend to compromise this defense mechanism of the mammary gland (Reshi et al., 2015).

According to (Gröhn et al., 2004), there are various causes of mastitis in cows. Mastitis is caused by different types of pathogens. Some examples of mastitis-causing agents are *Mycoplasma* spp., *Streptococcus* (S.) *agalactiae*, *Staphylococcus aureus*, *Corynebacterium bovis*, streptococci (usually *S. dysgalactiae* and *S. uberis*), *Klebsiella* spp., *Escherichia coli*, *Enterobacter* spp., and *S. aureus* (Wald et al., 2019). Mastitis is caused by a variety of pathogens and pathogens that are most common which are found in the udder tissues which spreads from cow-to-cow and these pathogens are known as contagious pathogens and those that spread through animal bedding, soil, and manure are known as environmental pathogens (Halasa et al., 2007). Knowing the type of pathogen is an essential aspect of understanding the challenges faced in the herd and the measures that need to be taken to treat or reduce mastitis infection (Gröhn et al., 2004).

However, it is a difficult task to estimate the economic loss that results from mastitis due to the several levels of infection and various other factors (Janzen, 1970). The reduction in milk yield and quality causes a great economic loss for producers (Kandemiri et al., 2013). Various appropriate diagnostic techniques to test for

mastitis are being used in Fiji which provides an accurate, rapid, and confirmatory diagnosis. These tests are used based on the complexity of the disease and the economic loss it has caused over the years thus these tests provide the results faster so that actions are taken to minimized and stop the spread of mastitis at the earliest. The major and the easiest diagnostic test for mastitis in Fiji are the California Mastitis Test (CMT) and the somatic cell count test (Lakshmi, 2016). This review provides a framework for the economic effects and the economic factors that relate to the management of bovine mastitis in Fiji. This review will also discuss the test and the treatment that can be provided and the way forward to preventing the spread of mastitis in Fiji.

2. Discussion

2.1 Dairy Production in Fiji

Dairy farming is mostly concentrated in Fiji's Central division, which has the largest number of dairy farmers and has dominated the dairy industry since 1991 (Fiji National Agriculture Census Report, Department of Agriculture, Economic Planning and Statistic Division, 2009). The Central Division was home to roughly 70% of the total 1,126 commercial dairy farms. In the 2009 census, there were 22,551 dairy cattle registered, with 10,175 of them being milking cows. Since 1991, when there were 2,041 farms engaged in dairy production, the number of farms has decreased by nearly 45 percent.

According to the Fijian Government (2014), there are currently 256 dairy farmers registered under FCDCL from the Central division. The rural-based dairy farmers' geographical spread comprises 72 farmers in Tailevu province and 105 farmers in Naitasiri province. Ten farmers in Rewa delta, ten farmers at Navua flat, ten farmers in Tailevu south, and ten farmers in the Wainibuka region in Viti Levu (Moses, 2004).

Table 1. At the provincial, divisional, and national levels, the number of farms with dairy cattle and the number of dairy cattle by age

	Province	Farms with Dairy Cattle	Percent of Farms	Total Dairy Cattle	Percent of Dairy Cattle	Sub Total Females	Calves < 1 Year	Heifers 1-3 Years	Cows
Central	Naitasiri	506	64.2%	8773	43.1%	6347	1068	1455	3691
	Namosi	43	5.4%	281	1.4%	227	33	60	133
	Rewa	0	0.0%	0	0.0%	0	0	0	0
	Serua	43	5.5%	1981	9.7%	1686	349	321	1046
	Tailevu	196	24.9%	9340	45.8%	7215	977	1689	4530
	Total	789	70.1%	20374	90.4%	15475	2427	3524	9400
Western	Ba	19	16.7%	115	7.6%	32	10	12	10
	Nadroga	73	65.6%	1034	68.2%	687	187	169	330
	Ra	20	17.7%	367	24.2%	367	74	110	183
	Total	111	9.8%	1515	6.7%	1086	272	291	523
Northern	Bua	12	8.6%	12	2.5%	12	0	0	12
	Cakaudrove	25	17.5%	212	44.3%	201	65	51	84
	Macuata	105	73.9%	255	53.2%	149	11	50	88
	Total	141	12.6%	479	2.1%	362	76	108	185
Eastern	Kadavu	0	0.0%	0	0.0%	0	0	0	0
	Lau	21	24.6%	46	28.3%	22	0	4	18
	Lomaiviti	64	75.4%	117	71.7%	75	0	32	43
	Rotuma	0	0.0%	0	0.0%	0	0	0	0
	Total	85	7.5%	163	0.7%	97	0	36	61
Fiji	1126		22533		17020	2774	3953	10169	

Source: Fiji National Agriculture Census Report, Department of Agriculture, Economic Planning and Statistic Division (2009).

The main milk processing company is Rewa Co-operative Dairy Company (RCDC) which has changed its name to Fiji Co-operative Dairy Company Limited (FCDCL) in 2010 which operates in the Central Division of Viti Levu which is the main-land, and this is where most dairy farmers operate (Ministry of Agriculture, 2015). Between 2005 to 2008 it supplied milk to FCDCL was estimated that the total dairy milk suppliers were 260 and

only 80% of these suppliers (Fiji Islands Trade & Investment Bureau, 2009). According to (Mosese, 2004), there was 227 dairy registered farmers in Fiji. Two hundred and six farmers supplied milk to FCDCL as stated above, and the other 35 farmers supplied fresh milk, ghee, and cream directly to the consumers. Smallholder dairy farmers account for about 80% of dairy registered farmers since they had small farms. Forty-four percent of all the fresh milk that was supplied to FCDCL came from these small farm holder farmers.

The Department of Agriculture's Animal Health and Production Division estimated 9,630 milking cows in 2008, with an average of 37 milking cows per farm generating 5 litres per cow per day (Fiji Islands Trade & Investment Bureau, 2009) during the peak of diary yield, the milk production increases to 8-10 litres per cow (Figure 1). An annual review of the trend in milk production showed that between the years 1979 to 1998 the milk production had an increase of 4% per annum but despite this, there was a persistent decline in milk production by 5.6% annually from 1999 to 2001 (Mosese, 2004). The reduction in milk production could be attributed to political instability in the year 2000, which made most of the large farmers in the korovou/Tailevu area fearful. This political unrest was due to the coup that happened in 2000. It caused farmers to be reluctant to invest in their farms, some of the farmers suffered severe theft on their farms and the high cost of farm re-establishment. It also led to farmers losing their farms due to land tenure problems and rural to urban drift (Fiji National Agriculture Census Report, Department of Agriculture, Economic Planning and Statistic Division, 2009) It is also interpreted that the drought that hit Fiji in 1998 is the other possibility for the decline of milk in 1999 and the last attribute to the decline in milk production is the mastitis problem in cattle (Mosese, 2004).

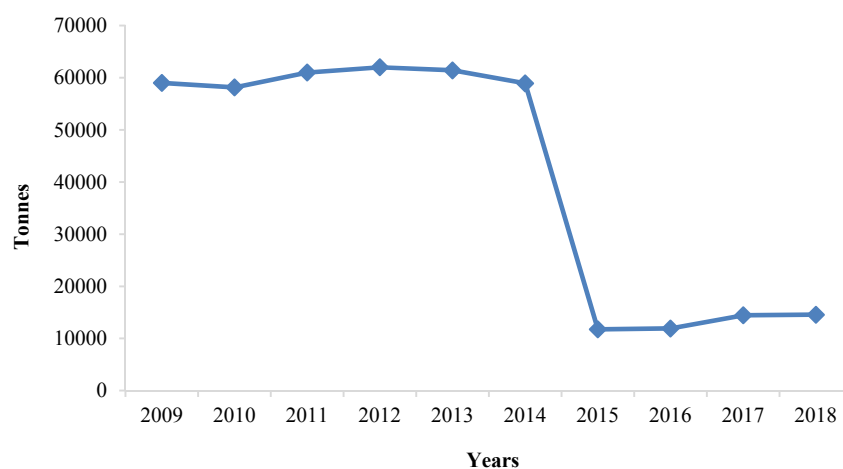


Figure 1. Quantity of Milk Production in Fiji from the year 2009 to 2018

Source: FAOSTAT (2020).

2.2 Factors Contributing to the Spread of Mastitis in Fiji

Mastitis is a disease related to cattle's milk glands. It is known as the highest disease of dairy cattle since it causes production loss and in certain cases even the death of cattle. Mastitis is commonly caused by bacterial infections that affect one or more quarters of the udder. As the cow's milk production increases the cow becomes more susceptible to being infected with mastitis and therefore good milk-producing cattle get more mastitis than the rest of the cattle in the herd (Stephen, 1998). When diagnosing the transmission pattern of pathogens causing mastitis in a herd, it is essential to do a herd-level diagnosis and it is also vital to identify the origin of the transmission, whether it is from lactation origin or dry period origin (Biggs, 2015). When good management is not practiced, mastitis tends to spread through the milking process from one infected cow to the other uninfected cows in the herd. Cows that have more than 60 days of the dry period have a greater chance of acquiring mastitis than those cattle with a shorter drying period (Stephen, 1998).

When one or several quarters are hard, hot, and painful and the milk from those quarters is watery and thin then a new mastitis infection is suspected. A thick white or yellow discharge that is clotted comes out of the teat when the cattle are milked with a new mastitis infection which can be due to secondary infection (Stephen, 1998). However, if the milk is squirted onto the side of a bucket or the floor and it shows few clots, then it is suspected to be old mastitis. After the squirting, the milk out, once the udder is left, it might contain hard lumps mainly

deep in the tissues. In the case of old mastitis, the discharge from the udder is thick greenish-yellow pus-like in appearance (Stephen, 1998).

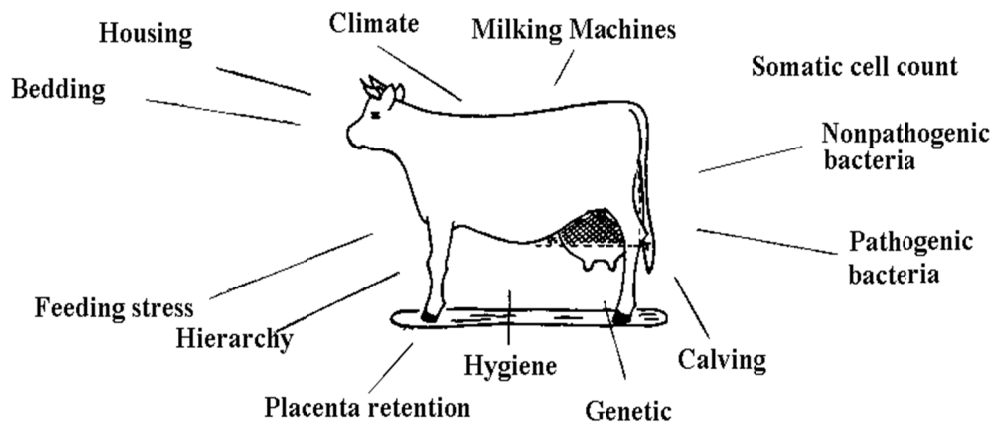


Figure 2. Factors influencing the incidence of mastitis

Source: Duval (1995).

Many factors contribute to the spread of mastitis in Fiji (Figure 2). Climate can have an indirect and direct influence on mastitis onset. One of the ways climates have an indirect influence on mastitis is that during the wet season the outside conditions are muddy therefore this type of environment can cause an increase in the number of mastitis-causing bacteria. As for housing, it also influences the chance of getting mastitis for example when cattle are outdoor, they have higher chances of getting mastitis and mastitis can easily be spread from one cow to another whereas indoor housing can also trigger mastitis when the stalls are small, the cows can get injured and contain mastitis. This can be avoided if the stalls are longer and wider as this can allow more space for movement and avoid injuries, particularly when lying down. Moreover, pasture leads to environmental mastitis in cows as much as housing system especially in dry cows (Balsom, 2010).

Mastitis spread through milking machines is a major problem and concern in Fiji. Proper milking technique and hygiene are important to avoid the bacteria, germ or mastitis spread from one teat to another or from one cow to another. It is important to milk the non-mastitis cow before the mastitis infected cow to avoid the spread from an infected cow to a non-infected cow. Therefore, it is advisable to milk the mastitis cow last. However, Bedding is another concerning issue in Fiji that contributes to the spread of mastitis. Due to humidity certain microbes can grow in the bedding of the cow. The cow spends an average of 14 hours out of 24 hours in contact with the bedding and this can increase the incidence of mastitis (Duval, 1995). Dairy cattle spend more time, lying on soft, well-bedded and dry surfaces than any other cattle (O'Connor et al., 2019). Multiple studies reported that bedding bacteria count (BBC) are mainly associated with a load of bacteria at the end of the teats and this causes a risk of IMI (Godden et al., 2019). Many cattle are kept without bedding have been shown to get highly infected with mastitis than those kept with bedding because apparently cow is more exposed to contagious mastitis when kept without beddings. Straw is said to be the most recommended type of bedding as there is a less rapid development of pathogenic microorganisms with a chopped straw rather than sawdust or newsprints.

Hygiene is also one of the important aspects to prevent the spread of many types of diseases and it also plays a crucial role in preventing the spread of mastitis as well. Bedding helps to prevent udder injuries, limits the udder encountering manure, and avoids it getting exposed to cold damp floors. Therefore, bedding can harbor microbes when dirty which is necessary to remove bedding and disinfect the stall at least once a month. The feed is important to all animals to maintain their health and to keep a strong immune system to fight diseases. Feed stress is another factor that contributes to mastitis spread. This is because a sudden change in feed can cause feed stress in cows. Once the cattle are stress this affects their immune system and suppresses it making animals more prone to infections and diseases like mastitis. It is advisable to change feeds slowly as stress can suppress the immune system making cattle 'more prone to diseases.

The somatic cell count is a good indicator of mastitis in cattle. Normal milk somatic cell count is generally 50,000 cells per ml and less than 200,000 cells per ml. A somatic cell count of more than 200,000 cells per ml

indicates cattle infected with mastitis. As a result, it is important to keep track of your somatic cell count in the dairy performance records. Calving is another concerning factor related to mastitis. Cows that nurse the calves 6-10 days following calving has shown less chance of getting mastitis whereas those cows that are separated from the calves soon after calving tend to keep calling the calves and develop stress and are more prone to mastitis. There are different types and breeds of cattle with different characteristics. Some cows tend to produce more milk than others. Cows that tend to produce more milk tend to get mastitis easily for example breeds such as Holstein Friesian (HF), Jersey crossbred, Jersey, or HF which are mainly present in Fiji rather than the indigenous cattle breeds (FAO, 2014; Moges et al., 2012).

When cows are in the loose housing system, they sometimes form a hierarchy system which is mostly seen in goats. This system leads to the least dominant cow being harassing or attacked and causes stress causing these types of cows to easily develop mastitis. There are chances that mastitis can also be spread due to placental retention. If mastitis is caused by *Actinomyces pyogenes*, then it is most likely caused by placental retention. Signs of mastitis due to placental retention are seen within 2 months of following calving and are associated with the uterus not being cleaned properly. In this case, the pathogen travels through the bloodstream to the mammary gland causing mastitis.

2.3 Management of Bovine Mastitis in Fiji

The phenomenon of mastitis is that mastitis is seen generally in higher-yielding cows in Fiji. Breeds that are most susceptible to getting infected by mastitis are Holstein Friesian, Jersey crossbred Jersey, or Holstein Friesian than the indigenous cattle breeds in Fiji (FAO, 2014; Moges et al., 2012). The occurrence of SCM rises in the increasing age, increase in parities, and the number of lactation periods (FAO, 2014). Furthermore. The growth and the multiplication of the mastitis-causing organisms depend on a specific humidity and temperature and due to this the occurrence of mastitis in cattle varies from season to season. The elevated temperature with incorrect ventilation and relative humidity helps various bacteria to multiply. Cattle exposure to high temperatures possibly increases stress levels in the animal and alters the immune functions (FAO, 2014).

There are different types of milking techniques used by dairy farmers which include the knuckling method, stripping method, full hand method, and machine milking. The use of faulty milking techniques such as the knuckling method of milking can cause serious harm to the tissue leading them to become more prone to mammary gland infections as this is one of the causes of mastitis in Fiji (Sudhan & Sharma, 2010). The predominant technique of milking was the stripping type of hand milking. This method inflicts microscopic traumas to the teat epithelium and is still used in certain parts of Fiji on small farms. It is also suspected in Fiji that the highest occurrence of mastitis is seen during the calf suckling period, and this can be due to the injury caused while dragging away the teat during suckling. It is observed that there is a higher occurrence of disease in cattle that are milked by folded thumb than in the cattle milked using the full hand method of milking. Fast milking is thought to be a detrimental factor contributing to mastitis development (FAO, 2014). According to numerous reports, the vacuum pressure inside the milking machine pipeline has a huge impact on SCM. The low or the high vacuum pressure directly affects the teat canal and the teat tissue which in turn leads to a decrease in natural protection of the udder and this becomes one of the predisposing factors associated with teat duct colonization by the environmental pathogens (FAO, 2014).

The primary source of environmental mastitis pathogens exposure is exposure to the manure, moisture, and mud present in the area or environment the animal lives in, which is seen in some farms in Fiji especially during rainy weather. A large amount of bedding is essential to keep the cows dry and comfortable especially in humid and cold weather conditions (Leso et al., 2020). Inorganic bedding materials such as sand is usually associated with lower bacterial concentration as compared to bedding materials that are organic such as chopped straw, shavings, and recycled manure (Farmer & Aug, 2010). Comfortable beddings lead to cows resting more comfortably and prevent long hours of standing time which later leads to lameness, and more cow comfort enhances the welfare of the cows (Aleri et al., 2012). Housing systems play a vital role in the welfare quality of dairy cows and a loose housing system is more beneficial when it comes to the behaviour of the cow, feeding and housing (Popescu et al., 2014). In all types of housing systems, the incredibly important risk factors to consider are dirty ground and bedding, poor ventilation, infected utensils, high stocking density, and high humidity. Since the animals are contained in one place, pathogens accumulate in the beddings and litters, increasing the teat challenge and causing mastitis, the housing system poses a high risk of mastitis. Mastitis is more common in herds kept in unsanitary stables and drainage systems, as well as in herds where mastitis-affected cows are not milked last. In coliform mastitis, this is quite common (Sudhan & Sharma, 2010). Several types of housing systems suit different climatic conditions. For tropical climate conditions such as Fiji, the open housing system is most suitable (Singh et al., 2020). In Fiji, proper management of the house is carried out. The farmers are taught by

FCDCL how to wash, clean, and disinfect the housing systems and the milking parlors and how often they need to change the bedding. Practicing milk hygiene during milking leads to the reduction of pathogenic species exposed, and they are prevented from surviving on the skin or in the immediate environment of the animals and reducing the spread of mastitis during the milking process (Sudhan & Sharma, 2010). Farmers in Fiji are taught how to use and clean the milking machine by FCDCL. Cows that are intensively managed pose a high risk of developing mastitis followed by semi-intensive cows and the extensively managed cows pose the least risk of developing mastitis (FAO, 2014). These measures are practiced by many farmers to prevent the spread of mastitis on their farms and increase production.

Good management practices can prevent the spread of mastitis and these management practices begin at the calf birth. Calves that are feeding on a cow that already has mastitis should not be allowed to suckle each other's udders. The calf is transmitted with the infection and the infection develops in the calf's udder from the first time or day the calf gets in contact with the milk. It is essential to keep the calf pen clean to avoid the spread of mastitis (Stephen, 1998). Cows that have mastitis should be milked last once all the non-infected cows are milked in the herd. The mastitis cattle milk should be tested by squirting the milk in a separate cup and not onto the floor as these kinds of milk are infectious. Once the cattle are treated, they are only used to suckle the foster calves for the rest of their lactation period. The milker should thoroughly wash their hands after finishing milking one cow and the beginning of milking another cow. This hygienic practice has helped prevent the transmission of mastitis from infected cattle to uninfected cattle in Fiji (Stephen, 1998). The farmers in Fiji are also taught how to test for mastitis using the California Mastitis Test. The FCDCL provides the reagents to the farmers, and they are given a guide to do the test and to determine the results to help them maintain and prevent mastitis on their farms. They are also made aware of using antiseptic teat dip or spray every time they milk the cows (Nacei, 2018). Pre-dip is often used with a dipper or cup and allowed to sit for 30 seconds. Sprayers may be used, but adequate protection, particularly on the teats farthest from the milker, is difficult to achieve (Christina & Isis, 2010). Shem et al., 2001 states that routine practices such as dry cow therapy and post and pre-milking under disinfection significantly decreases the general prevalence of mastitis. It is essential to test for CMT in dairy cows that are ready for the drying period and if they test positive, it is essential to first treat with intramammary long-term antibiotics and then dried (Zigo et al., 2021). Zigo et al. (2021) also states that treatment of all the quarters of the cow at drying off period (blanket dry cow therapy) is a crucial component of a broader plan for mastitis control, and this is because dry cow therapy cures both existing infections that may be caused by contagious pathogens and prevent the development of new infections mainly caused by environmental pathogens.

2.4 Economic Implications

Mastitis in cattle's causes a reduction of productivity of milk (Ibrahim, 2017) which increases the number of clinical treatments in cattle's, which later leads to the culling of cattle at an early age. Consequently, culling cattle's due to mastitis imposes heavy loss to the milk producers in the dairy industry. Most of the time the additional economic loss caused by mastitis has been due to the labour investment, cost of stock replacement, feed management, antiseptic techniques, the use of antibiotics, laboratory tests, and veterinary services (Ibrahim, 2017).

According to per quarter, most of the estimates show a 30% depletion in productivity and per cow lactation shows a 15% decrease in production due to mastitis (Ibrahim, 2017). When the cattle are affected by subclinical mastitis (SCM), the milk yield decreases (Ibrahim, 2017). Reduced milk production caused by mastitis constituted the major cost component of the economic loss (Nielsen, 2009). Heifers with intramammary infection generally indicate the presence of the pathogen in heifers. These are the heifers that generally continue to cause a consequential amount of financial loss. The per-acute form of mastitis can also cause death in cattle's reduction in milk production, and loss of cattle stock due to culling. The bacterial contamination in milk due to mastitis from affected cattle renders the milk unsuitable for human consumption as it causes food poisoning and can spread diseases to humans (Ibrahim, 2017). Economic losses emanating because of the following indices:

2.4.1 Milk Yield Loss

According to FAO (2014), the decrease in the production of milk is substantially due to the physical damage to the parenchyma of the mammary gland in the affected gland or cattle. For assessing the injury to the secretory tissues in the mammary glands of cattle's that can be caused by mastitis pathogens a histological analysis is carried out. The inflammation in the mammary gland causes lower food intake, a decrease in appetite, and a decrease in movement due to pain which later leads to a negative impact on the production of milk by cattle.

Estimating milk yield loss is difficult as milk yield is generally influenced by many characteristics of a cow such as the stage of lactation, the type of cow, the udder morphological characteristics, the grade of inflammation, milk yield before mastitis, the type of mastitis-causing organisms, early or late diagnosis of mastitis, type of treatment, season, feeding practices, and reoccurrence of mastitis (FAO, 2014). Some of the mastitis-causing agents have been shown to have a greater impact on milk production than the others. Such mastitis in cattle is caused by *S. aureus* normally results in persistent but moderate infection unlike mastitis caused by coliform bacteria. Generally, the greater the inflammation is the less the milk yields (Halasa et al., 2007).

Generally, the production loss due to subclinical and clinical mastitis is two important variables between the test-day record and the Somatic Cell Count (SCC) (Halasa et al., 2007). The production of the milk fails to improve after the complete recovery of cattle from subclinical mastitis, even after antibiotic therapy. The non-appearance of an increase in milk yield in treated cattle suggests that the milk-secreting tissues did not recover or return to normal after the treatment, which can be due to fibrosis and involution of udder tissue resulting in the loss of secretory epithelium (FAO, 2014).

2.4.2 Discarded Milk

During the treatment of clinical mastitis cases in cattle, the milk is discarded during the treatment days and waiting time. In general, the milk must be discarded for 6 days which includes 3 days for treatment and 3 days for the withholding period (FAO, 2014).

2.4.3 Treatment Cost

There are 2 main elements of treatment costs which include the cost of drugs and the veterinarian fees (FAO, 2014). For the treatment of infected cattle, drugs are a necessity, and the drug costs vary depending on the type of drugs used such as penicillin, oxytetracycline, etc. Apart from just delivering drugs to the farmers, the veterinarians must spend time on the diagnosis of mastitis cases. Veterinary services are generally mandatory for clinical mastitis cases, and these are generally very costly (Halasa et al., 2007).

2.4.4 Labour Cost

The labour cost analysis is difficult. From farm to farm the opportunity cost of the labour differs. If the labour is from an outside source, then calculating the labour cost for the time taken to prevent mastitis is easy and simple. If the farmer does the labour work, then it is essential to note that the farmer will spend less time on other farm management work due to mastitis thus the opportunity cost is the reduction in the income due to disregarding the other tasks (Halasa et al., 2007).

2.4.5 Premature Culling and Replacement

Culling the cattle is the farmers' decision. Normally when the farmer decides on a replacement of the cow then culling is a suitable decision. Culling can be categorized as voluntary culling or involuntary culling (Dallago et al., 2021). Mastitis-affected cows are generally the ones culled from the farm and the replacement of premature cattle's due to mastitis is one of the substantial areas of economic loss (Halasa et al., 2007) and this is known as involuntary culling where the farmer has no choice but to cull the animal (Dallago et al., 2021). There are also returns from the culled cattle in terms of meat. The direct costs are the costs of buying or rearing the replacement stock. The indirect cost is the reduced efficiency of milk yield by the replacement stock (Halasa et al., 2007).

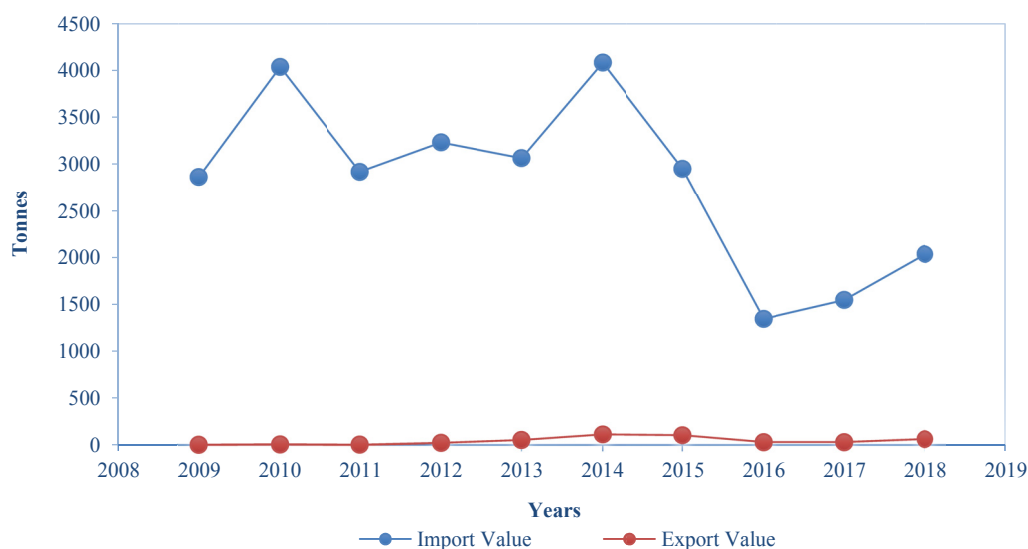


Figure 3. Milk Export and Import records for Fiji from the year 2009 to 2018

Source: FAO (2014).

2.5 Government Interventions

The Fijian Government had come up with plans and strategies to help the local dairy farmers. The government-funded the Demand Driven Approach (DDA) program which ensured that the illegal dairy supplier complies with the Dairy Act which leads to more farms being registered. 252 dairy farms were registered in Fiji in 2009 compared to 2008, there were only 236 dairy farms registered which indicates a 7% increase in the registered dairy supplier. All 236 farms supplied their milk to FCDCL (Cokanasiga, 2009).

The dairy farmers who are the smallholders have gained an extraordinarily strong foothold in the dairy industry and have successively increased their total milk production contribution from 2008 to 2009 which was from 49% to 53%, a 4% increase. The establishment of the Dairy Industry Support (DIS) project in Fiji has subsequently boosted the maintenance and development of farm infrastructure in the dairy sector (Cokanasiga, 2009). The Fijian Government is committed to assist the dairy farmer by subsidizing drugs, fencing materials, and providing free services such as advice, consultancy, and extension services through the aid of the Ministry of Agriculture and FCDCL (Fiji National Agriculture Census Report, Department of Agriculture, Economic Planning and Statistic Division, 2009).

According to (Cokanasiga, 2009), the Fijian Government has continuously assisted the dairy farmers through the Dairy Capital Development Programme in improving the herd, supplying genetically improved bulls, artificial breeding programs, pasture improvement by providing grass and legume seeds, more veterinary services provided, general farm extension services, training of farmers and improvement in dairy infrastructures such as milking, and calf shed repairing and roads for farm access. The government provides funds for rehabilitation programs for the industry which involves, importation of breeding bulls, semen for AI, improvement of the KRS Dairy unit and Waidradra Bull Station, upgrading of dairy access roads, and the setting up of a small milk chilling centre.

The government runs research stations and the Vet Laboratory facilities which provide free services to the dairy farmers for the benefit of the whole industry. The government also assists FCDCL in providing funds to cover the overhead costs of running Naluwai and Waidalice Milk Chilling Centres. Through the government, Fiji Development Bank (F.D.B.) continues to serve the farmers with borrowed capital and supplementary loans for the continued development and upgrading of the dairy industry and through the government, FAO is also providing a lot of funding and consultancy work for the development of the industry. FCDCL provides free advisory service and training to the farmers (Fiji National Agriculture Census Report, Department of Agriculture, Economic Planning and Statistic Division, 2009).

This government intervention does not have sufficient data since 2009 nor the current census report since the last Fiji National Agriculture Census was conducted in 2009 therefore, the progress report of the assistance provided to the dairy farmers through the Dairy Capital Development Programme has not been known.

2.6 Diagnosis and Treatment of Bovine Mastitis

2.6.1 Diagnostic Methods Used to Detect Mastitis in Fiji

In SCM some of the changes can be distinguished in the milk such as elevated levels of plasma protein, changes in the ion concentration, a decrease in the synthesis capacity of mammary epithelium. Therefore, changes can also be seen in the intracellular components of milk because of the local cell destruction, and an increase in the somatic cell count (Kandemiri et al., 2013). The changes in the passage of the albumin of blood to milk are the first pathological changes observed in cattle infected with mastitis. Bicarbonate and Sodium chloride passage is also elevated with relative changes in the milk's pH (Kandemiri et al., 2013).

2.6.2 California Mastitis Test (CMT)

The CMT is an inexpensive, simple, and rapid screening test for mastitis. This test is based on the quantity of cellular nuclear protein present in the sample of milk (Lakshmi, 2016) and (Ibrahim, 2017). The inflammatory cell type is the predominant cell type present in milk since the inflammatory cell is related to mastitis infection. The CMT reflects the SCC levels in the milk accurately which is a reliable indicator of the severity of the disease (Lakshmi, 2016). When the CMT reagents are mixed with the milk, the CMT reagent disrupts or dissolves the nuclear cells and outer cell wall of any leucocyte which mainly contains the primary fat. The DNA released from the nuclei will form gel or string together as a stringy mass. The amount of gel formation increases linearly as the number of leucocytes increases (Lakshmi, 2016). This test is adapted by FCDCL in Fiji and most of the farmers are advised on how to do this test and how they can determine the result (Table 2). FCDCL also provides the reagents to the farmers to run the test on their farms.

Table 2. CMT score to predict the somatic cell count of milk

CMT Score	Average somatic count (cells per millilitre)	Description of reaction
N (negative)	100,000	No thickening, homogenous.
T (Trace)	300,000	Slight thickening, Reaction disappears in 10 seconds
1	900,000	Distinct thickening, no gel formation
2	2,700,000	Thickens immediately, begins to gel, levels in the bottom of the cup
3	8,100,000	A gel is formed, surface elevates, with a central peak above the mass

Source: Lakshmi (2016).

2.6.3 Somatic Cell Count (SCC)

Measuring the number of somatic cells is the most frequent practice to identify cattle with SCM. SCC evaluates the number of leukocytes and other cells per millilitre of milk. An uninfected mammary gland contains less than 200,000 cells/ml of SCC. SCC acts as an indirect indicator of the udder health status in dairy cattle (Lakshmi, 2016). Somatic cell (SC) is a normal milk constituent, and it becomes a problem when it becomes excessive than the normal range in the milk (Ibrahim, 2017). In a healthy udder majority of SCC comprises macrophages (66-88 percent) followed by neutrophils (1-11 percent), lymphocytes (10-27 percent), and epithelial cells (0-7 percent) (Lakshmi, 2016). The increase in SCC is associated with a decrease in milk quality and this is due to an influx of phagocytic cells, especially neutrophils. During mastitis infection neutrophils about 70-80% form, the essential part of milk SC, and an early influx of neutrophils in the milk lead to early detection of infection (Lakshmi, 2016). The neutrophil count in a healthy udder quarter of a cattle should be less than 100 000 cells ml. A level >200 000 cells per ml indicate infection (Ibrahim, 2017). The SCC is generally done in the Fiji Veterinary Pathology Laboratory when the farmers submit the samples for testing. Kelly et al. (2009) state that houses that are confined show higher SCC plate count than intensively managed houses with rotational grazing management.

2.6.4 Bacteriological Culturing (BC)

The Bacteriological culturing can be done at the herd and as well as the cattle and quarter level, each with its specific goals. Bacteriological culturing is commonly used as a diagnostic tool to solve mastitis problems in cattle (Lakshmi, 2016). The knowledge about the state of infection of the mammary gland is extremely helpful in preventing the transmission of pathogens by diagnosing the reservoir at an early stage of transmission. BC

results generally provide herd-based information that can be used in optimizing the treatments for future mastitis cases (Lakshmi, 2016). This test is rarely conducted in Fiji but is performed when the need arises or if it is requested by the farmers at the Fiji Veterinary Pathology Laboratory.

2.7 Treatment of Mastitis in the Dairy Herd in Fiji

2.7.1 Antibiotic Treatment for Mastitis in Dairy

The first line of treatment for mastitis-affected cows that have only mild complications in a single quarter is intramammary antibiotics. Systemic antibiotics are used when a cow has more than one quarter affected by mastitis and when there are marked changes in the udder or when the cattle are ill. Combine therapy of intramammary antibiotics with a systemic antibiotic can increase bacteriological cure rates but should only be used when advised by a veterinarian. Intramammary antibiotics are given by the classic mastitis tube whereas systemic antibiotics are given by subcutaneous or intramuscular route. Although commonly antibiotics are used to treat mastitis, it is essential to limit this therapy as farm use of antimicrobials play an important role in the development of antimicrobial resistance (Ruegg, 2017).

2.7.2 Non-steroidal (NSAID's)

Certain drugs help to reduce the pain and inflammation associated with mastitis for example the aspirin-like drugs. These types of drugs have proven to be immensely useful with mastitis which is a severe case. Cattle that are treated with NSAIDs and intramammary antibiotics have shown to have better cure rates, lower cell counts, and better fertility than those cows treated alone with antibiotics. The efficiency of NSAIDs in alleviating pain and clinical signs linked with mastitis is stronger than glucocorticoids and that is why NSAIDs can be considered as drugs of choice for the treatment of mastitis (Mainau et al., 2014).

2.8 Causes of Treatment Failure in Fiji

There can be a time when there is treatment failure when dealing with mastitis affected cattle. Here are the 4 reasons why the treatment does not result in cattle returning to normal. Firstly, it can be due to the administration of wrong antibiotics, this action leads to a mastitis-causing organism not being killed by the choice of treatment. Secondly, not enough antibiotics were administered for long period at the site of infection; although some of the bacteria are killed the treatment does not kill all bacteria thus the cattle return to being infected after the end of treatment. Reinfection can be another reason for cattle to return to mastitis again. Reinfection can be misdiagnosed at times, and this is when the cow is treated successfully but returns or gets infected again. Lastly, treating the wrong cow. It is essential to identify the mastitis-affected cow and mark them as persistent damage to the udder that can prevent the antibiotic from encountering the bacteria in sufficient concentration.

3. Way Forward

Kivaria (2006), states that the major concern associated with mastitis is that the herd attendants and the farmers need to improve their knowledge level, their attitude, and motivation towards udder health. The first goal for animal health is to create awareness associated with the cost and seriousness of the disease. FAO (2014), states that a lack of awareness and knowledge is undoubtedly the major risk factor that contributes to IMI. Awareness and knowledge about mastitis will influence the farmers' decision and perception about mastitis which can later lead to better preventive and treatment regimens such as dry cow therapy, ventilation, hygiene, post-milking teat disinfection, housing, beddings, and milking techniques. Semina et al. (2020) state that during the dry-off period in cows, administration of "Amber-splenivitis" aids in enhancing both local and general protection of the mammary gland thus providing prevention of morbidity in lactating cows is in the postpartum period. Limitations of the use of antimicrobial therapy are encouraged to reduce the effects of antimicrobial drug resistance but the use of antibiotics to treat cows affected with certain pathogens is a vital tool for mastitis control (Ruegg, 2017). Despite a decade of research, no "truly effective" vaccine is commercially available for mastitis. The utmost exciting progress regarding the field of mastitis vaccination is the development of a subunit vaccine known as the plasminogen activator pau A against Str. *Uberis* (Reshi et al., 2015).

The awareness of economic loss can be calculated by the cost due to mastitis therefore it can increase awareness and lead to an increase in dairy farmers being motivated in considering improving the udder health on their farms (Sharifi et al., 2014). According to (FAO, 2014), there are several approaches to estimate the loss in milk production due to mastitis and some of the approaches are comparing the performance of the uninfected quarter with the performance of the infected quarter on the opposite one. Generally, it is observed that the contralateral quarters of the udder produced approximately the same amount of milk if they are uninfected. There is scientific evidence that the mastitis-free quarters may compensate for the quarters with mastitis by increasing milk production. Other approaches can be differentiating and comparing the state's previous lactation with the present

lactation state of the same cattle. Comparing the production of uninfected cattle with infected cattle. This technique is also known as the between-cow comparison model. This technique can be affected by some of the non-mastitis heightened factors such as age, lactation number, breed, etc. and the cows should be closely matched for these factors.

The Ministry of Agriculture (2015) implicates that some of them were to increase production in dairy farms affected with mastitis by selecting production and breeding stock carefully. This will lead to a good breed, large and spacious udder, free from diseases, good conception, medium teats, and docile animals. Some other ways stated by the Ministry of Agriculture (2015) are the use of good management practices, keeping production records for cows, safeguard the animals from diseases, provide adequate water supply, and proper feeding that is feeding cows a balanced diet according to their maintenance and production needs.

The Fiji dairy production is low therefore there is a need to elevate the productivity of the cow, land productivity using integrated measures, and to increase the farmer's productivity. Cattle productivity can be enhanced by improving the breeds and the dairy herd upgrade. The farmers who are the smallholders need to be encouraged to adopt the intensive concept related to dairy for milk production. The land productivity can be improved by better drainage on the farms, pasture development, proper utilization of land resources, and controlling the movement of cattle of the pasture to ensure better productivity and to maintain high milk production. The calf sheds, night paddocks for keeping the cattle, and the stockyard structure should be improved by the farmers to help prevent the spread of mastitis (Mosese, 2004).

4. Conclusion

This review indicates that mastitis is a serious disease in cattle's and the highest disease as well not just in Fiji but also around the world. Mastitis in cattle has caused major economic loss through decreased production and culling of young cattle. The IMI has caused reduced milk yield and the quantity and quality of milk produced are affected. This had a huge economic impact on the dairy industry.

Furthermore, Cattle can get infected with mastitis through the environment or from an infected animal. Finally, it can be said that good hygiene, proper shed management, and creating awareness about mastitis can help prevent the spread of the infection and make treatment easier and faster.

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