Assessing milk borne bacterial contamination and possible strategies to reduce prevalence rates in dairy products by Integration and self regulation of quality management in Zimbabwe dairy value chain

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Dedication

I dedicate this work to my entire family especially my parents whose love and words of encouragement in my life has always given me the inspiration to give my best.

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Abbreviations

AGLABS	Agrianalysis Centre Private Limited
CAC	Command and Control
CDO	Chief Dairy Officer
CEO	Chief Executive Officer
CIP	Cleaning In Place
COMESA	Common Market for Eastern and Southern Africa
DDP	Dairy Development Programme
DLPD	Department of Livestock Production and Department
DO	Dairy Officer
DSU	Dairy Services Unit
DZPL	Dairibord Zimbabwe Private Limited
DZPL	Dairibord Zimbabwe Private Limited
EU	European Union
EU	European Union
HACCP	Hazard Analysis Critical Control Point
ICCS	Integrated Chain Control System
MAMID	Ministry of Agriculture Mechanization, Irrigation and Development
MIG	Milk Improvement Group
NADF	National Association of Dairy farmers
NADF	National Association of Dairy Farmers of Zimbabwe
NDC	National Dairy Cooperative
SHODFAZ	Small Holder Dairy Farmers Association of Zimbabwe
SIRDC	Southern Institute Development and Research Council
ZDPA	Zimbabwe Dairy Processors Association

Abstract

Zimbabwe has been experiencing a rapid decline in the volume of locally produced milk and milk products creating a shortage of locally produced milk products on the local market. Associated with the decline in milk production is also an increase in milk and milk products of poor quality which are finding their way onto the market for sale to consumers. This is despite the existence of regulatory control systems which are responsible for ensuring that only products meeting set standards on quality and safety are allowed to be offered for sale to the public. This study identifies critical control points in part of the Zimbabwe dairy chain. It identifies the status of the regulatory control systems in the dairy sector and explores the challenges involved in addressing milk quality problems. The sector's involvement in addressing quality problems, limitations and views are explored so as to finding approaches to improving quality control in the value chain. The study uses stakeholders' views to find the possibilities of integrated control systems as an approach to quality control in the local dairy sector.

The study interviewed 64 dairy farmers as part of a survey using a questionnaire with both open and closed questions. The farms visited were selected from dairy producing areas in the country according to a pre determined grouping into clusters using method of milking, milk delivery method and milk delivery interval in order to compare milk quality under different management systems which are assumed to be risk areas in the milk production chain. The most important variables for identifying sources of contamination were microbiological contaminants, chemical contaminants, physical contaminants, hygienic milking, dairy milking premises, cleaning and sanitizing, and dairy personnel skills.

Interviews were carried out using a check lists with open questions with key informants selected from stakeholders in the dairy sector. The selection of interviewees was guided by the research objective and information required to answer the research questions. In order to compare the views of actors in the chain on the idea of ICCS, descriptive statistics were used. Correlation between prevalence rates of contamination (using TBC counts) and method milk, delivery method and delivery intervals were calculated by Univariate analysis of variance. Descriptive statistics was used to show patterns of bacterial contamination. The input of the interviews from the case studies was processed by grouping, organizing and structuring the answers.

The study appears to suggest that milk contamination and deterioration during storage are the main causes of poor milk quality at farm dairies. Although equipment and facilities as well as the cleaning of dairy equipment and milking practice are unsatisfactory, the study could not prove that there were significant sources of contamination to milk in part of the local dairy chain. The information gathered from the study enabled the identification of possible areas for further development of hygiene education and guidance programs for stakeholders in the dairy sector. The outcomes of the study suggest that stakeholder perception favours an integrated quality control of dairy products. The study gave as its recommendation a suggested framework for integration of quality control.

Key words: critical control point, integrated chain control, milk, quality

CHAPTER ONE: INTRODUCTION

1.1 Background

The dairy sector in Zimbabwe has seen a sharp decline in milk production over the last decade with milk production figures falling by 65 % compared to production figures in the year 2000 (DSU, 2009). The current annual milk production figures are 60 % less than the annual national milk requirement. This in turn has seen the number of local dairy products available for domestic consumers becoming less creating an environment where demand is greater than supply. Judging by the way dairy products from unregistered operators are having regularly deliveries to some retail outlets, it would seem to suggest that local consumers have placed faith and responsibility in the existing regulating and monitoring systems such that they now assume that when products are placed in retail markets, the products will have been certified as being safe for consumption. A closer look at the test results of bacterial quality checks (Table 1.1) done on milk products by the regulatory institution responsible for monitoring the quality of dairy products indicate a general decline in product quality as well as a small number of operators whose products are being monitored.

Table 1.1 Processed dairy products tests summary-April 2010

No. of Processors	Product	Expected units	Samples tested	*TBC*	Yeast and Moulds	*Coliform*	E. Coli
***17**	Pasteurised milk	110	43	7	-	7	1
	Cultured milk	116	29	-	4	7	2
	Cream	30	2	0	0	0	0
	Butter	12	0	-	-	-	-
	Yoghurt	76	16	-	0	3	0
	Cheese	66	11	-	2	1	1
	Flavoured drinks	16	0	-	-	-	-
	UHT	8	6	-	-	-	-
	Ice- Cream	24	5	-	0	0	0
	Sterilised milk	8	4	0	-	-	-
	Total	**466**	**116**	**7**	**6**	**18**	**4**

*NB. * Figure is only for those who submitted samples out of a total of 42 small and large scale processors*
Source: DSU, 2010

Spoilage and contamination may occur in the milk chain as a result of poor hygiene, extended time of transportation and lack of suitable storage facilities. Poor hygiene has often been considered to be one of the most important reasons of spoilage of products (Bonfoh *et al.,* 2006). Quality control checks of milk and milk products as well as dairy facilities in the dairy subsector being implemented by government institutions are not being efficiently carried out by these institutions mainly due to financial constraints. This has resulted in unmonitored milk and milk products from the formal and informal sector being sold to unsuspecting consumers thereby exposing them to health risks. Around the world the trend has been to commercialize and privatize the delivery of these services so that they can be run in a financially self-sustainable way. One of the challenges in doing this is that some of the services are regulatory, however in practice it is very necessary for all the services to be offered in an integrated manner.

The testing of milk and milk products to ensure their quality is of a minimum standard is an expensive undertaking, and over time this has been carried out more and more through voluntary financial support from the dairy sector. Stakeholders and actors in the dairy sector should realize the need for a reliable quality control system that will result in only high quality and safe products on the domestic market. It is anticipated that if efforts are made to produce safe and good quality milk, it would not only protect public health, but also stimulate growth of dairy sector in Zimbabwe through the production of high quality products which can compete on regional and international markets.

1.2 Research problem

For some time stakeholders in the dairy sector have been of the opinion that in order to safeguard the reputation and viability of the sector, some system in addition to the traditional regulatory one needs to be in place. Traditionally food safety measures have been government regulated systems that require a great deal of inspection, policing and enforcement. The more operators there are the more difficult is to do this effectively, and cost tends to be at high levels that cannot be met by regulatory bodies thus enforcement becomes less effective. In such environments, especially where the consuming public is either unsophisticated or relatively ignorant regarding public health and food quality, unscrupulous operators tend to take “short cuts” in quality management, so put at risk both public health and the image of the sector (Gadaga, 2003).

A general analysis of activities in the dairy sector in Zimbabwe is showing a situation where there is an increase in activities within the formal and informal sectors which are being carried out without recognisance of existing laws governing the dairy sector. This situation if allowed to continue there is concern on the negative image that can be created should there be an outbreak of milk-borne diseases which is linked to local dairy products. Regulation of the dairy sector is mandated to Dairy Services Unit (DSU), which is a Unit under the department of Livestock Production and Development in the Ministry of Agriculture, Mechanization and Irrigation Development (MAMID). Dairy Services Unit’s responsibility is to provide regulatory and support services to the dairy sector by guiding and where provided for, directing, that the industry operates in accordance with the Dairy Act and its regulations so as to ensure that milk and milk products are wholesome and safe and produced cost effectively and in an environmentally sustainable manner. Bearing in mind that resources provided through official channels are totally inadequate for effective service delivery in terms of the Unit’s mandate or to achieve its objectives, Dairy Services Unit’s vision is to contribute to the viability of the dairy industry by working with stakeholders and business partners to ensure that milk and milk products meet or exceed the standards for safety and nutrition and that these products are available to meet dietary requirements. It is against this background that this study seeks to do an assessment of the risk at critical points in the dairy value chain and the possibilities to develop suitable strategies to control the risk to protect public health and safety with minimum but effective regulation.

1.3 Justification of study

Food safety is a key issue for consumers. The public expects safe food and believes that the governments in cooperation with scientific institutions can deliver it. Demand for safer food is increasing as consumers become better off, live longer, and better recognize the links involving diet and healthiness. An important motivation for governments to adopt quality control management systems is that it also reduces the costs of regulatory enforcement. Monitoring costs are increasingly recognized as constraining regulatory options (Laffont and Tirole, 1993). Dairy Services Unit (DSU) as the regulating authority, recognizes the need for a whole chain approach to food safety and a better understanding of where in the dairy chain the dairy food safety risks occur and therefore the research will

provide possible recommendations to the dairy sector on ways to *preserve the safety, nutritional value and other good qualities of "nature's most nearly perfect food".*

1.4 Research objective

The objective of this study was to identify the significant sources of contamination and critical points in the chain of locally produced raw milk and possible strategies to reduce prevalence rates by integration and self-regulation of quality management in the dairy value chain.

1.5 Main and sub research questions

Question 1: What are main possible sources of contamination in milk from production to delivery at processors?

i) What is current quality status of raw milk at farms?
ii) What is the status of production and transport management practices in relation to milk quality?
iii) What are the critical control points from production to delivery at processors?
iv) What is the current status of product quality control systems?

Question 2: What is the feasibility of introducing an integrated chain control system (ICCS)?

v) What are the views of the different actors and stakeholders on product quality and the idea of introducing ICCS?
vi) What are the main requirements for implementing successful ICCS?
vii) What constraints can be hindrances to the introduction and implementation of ICCS?

CHAPTER TWO: LITERATURE REVIEW

2.1 Concepts

2.1.1 Value chain concept

A value chain is a sequence of production processes which can be seen in the form of a vertical alliance from the provision of specific inputs for production to retailing and finally consumption (Richter, 2005). It analyses the links and information flows within the chain and reveals the strengths and weaknesses in the process. The value chain approach addresses factors that determine if a product meets market requirements with regard to quality, price, dependability, volume, design and speed of delivery. The dairy production chain is more than a supply chain. There is collaboration between actors in the chain. Milk production starts at the farm from where milk is handled by different but linked and coordinated actors with each actor owning the product and having a role in transforming it thus adding value to the product. There are chain supporters who are directly or indirectly involved with actors in the chain as a way of enhancing value addition.

2.1.2 Integrated chain control system concept

The integrated chain control system (ICCS) can be defined as a control system for food commodities, where industry is accountable for controlling their products and processes in agreement with the recognized standards and government is in charge of verifying the effectiveness of the control systems'' **(**McEachern and Mountjoy, 1999**).**

The ICCS will promote and provide the mechanisms to transfer inspection and control responsibilities from government to industry. Through the application of the principles of quality management, industry will inherit greater responsibilities in controlling their products and processes. As the food inspection programs evolve under the ICCS, industries will be required to be knowledgeable of the potential hazards associated with their products and processes and to develop and implement control measures to meet the established standards.

A well-informed and diligent industry will create an extra line of defence in the prevention of non-compliant food products. Controls will be proactive and preventative and the thinking will move from ``see a problem fix it'' to ``see a cause prevent it''. Government will maintain its responsibility in establishing the base line standards and guidelines for the development of industry controls. A second line of defence will be provided by government assessment (inspection, audit, verification and validation) of industries systems and outputs.

2.1.3 Definition of terms

Control (verb): to take all necessary actions to ensure and maintain compliance with established criteria.

Monitor: the act of conducting a planned sequence of observations or measurements of control parameters to assess whether a critical control point is under control

2.2 Dairying in Zimbabwe

The dairy subsector in Zimbabwe is in a state of decline creating a huge gap between supply and demand resulting in shortage of milk and dairy products on the market. Zimbabwe has turned from a net exporter of milk and dairy products to a net importer. The major problem faced by dairy farmers is lack of viability due to high cost of production that is not compensated by a viable producer price. The number of registered dairy farmers in 2009 was 225 a drop of 98 producers comparing with the year 2001 (Table 2.1).

Table 2.1National dairy data

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Nat intake (million-litres)	172	149	111	94	100	90	81	50	50
No. registered producers	323	283	280	279	278	279	278	271	225
Cows in milk	45290	38845	33667	23788	-	-	-	20000	20500
Dry cows	12198	11609	8942	6772	-	-	-	13000	13400
Productive cows	57488	50454	42609	30560	-	-	-	33000	33900

Source: DSU, 2009

2.3 Milk production

Black and white cattle are predominant, although a number of other breeds like the Ayrshire, Guernsey, Jersey and Red Dane exist in small numbers. Thirty five smallholder dairy organizations are in existence. Usually smallholder dairy producers start with whatever stock they have or buy crossbreeds and upgrade slowly. Productivity per cow has dropped from an average of 25 litres a day to the current 14 litres a day. The marketing and processing of milk has over the years been dominated by two processors; Dairibord Zimbabwe Private Limited (DZPL) and Nestle Zimbabwe but as a result of the deregulation of the industry, new companies are entering the industry. Currently there are 42 registered small scale and large scale processors in the country and these are operating at between 20-30% of their total capacity. Production is the starting point in the dairy industry and its performance determines the success of the processing and marketing industries. There are two main dairy sectors in Zimbabwe – the commercial and the smallholder sector. There are a lot of national and international organizations which have supported the local dairy sector e.g. European commission – Stabex Project. The aim was to develop the dairy sector so as to make possible to sell their dairy products at competitive price and improve milk quality.

2.3.1 Smallholder producers

The smallholder sector was developed in the mid 1980's. Their participation in the dairy industry has been curtailed by various factors that include lack of resources, access to dairy animals, lack of dairy production skills, and poor access to dairy production infrastructure. The smallholder farmers have been dropping out of the industry or downsizing due to economic hardships. Milk processing in the smallholder sector is rather limited. Small-scale milk collection and processing units owned by the farmers exist where the milk is processed into pasteurized and fermented milk products. The processed products are either sold locally or sent to urban areas for sale. However, farmers prefer selling their milk directly to consumers or milk vendors because they are paid promptly and the prices are usually higher than those offered at the milk collection centre. Estimates show that out of the total milk produced from this sector 5 to 10% enters the commercial market the rest is disposed of through direct sales to consumers, usually through milk vendors (DSU, 2009).

2.3.2 Large-scale commercial producers

According to DSU (2009), the bulk of the milking in this country still comes from large scale commercial farmers who account for 98% of the milk produced and marketed in the formal local market. The commercial sector has been the main player in the dairy industry. However, this sector has been shrinking since the beginning of the land reform programme. Some of the farms were subdivided into small units and some are no longer used for dairy production. The commercial farmers are better resourced and have the know-how for dairy production. A newer, and rapidly developing practise in the sector, is

that of direct bulk milk sales. Many farmers have cashed in on direct sales to the public who collect their raw milk in their own containers from their farms for sale in urban areas. Although it is illegal to sell or even give away raw milk in large urban areas of Zimbabwe, “special areas” or within their municipal boundaries (RGN, 1977), the lack of proper enforcement by responsible authorities is allowing this practice to continue unabated.

2.4 Food quality and food safety

Food quality, by definition, is a perception based on a value for money concept. It will without doubt be determined by the customer as one may ask a question whether food quality mean anything to people who do not have food and are starving. The definition will therefore always be in the eyes of the beholder. Food safety is a scientific practice based on the scientific evaluation of the risk of people getting sick from food. This is done by testing it for microbiological agents or toxins known for their effects on humans.
Milk and milk products are very nutritive for both humans and microorganisms, which means that these products are highly perishable and can be a threat to public health. This requires that processing is done in such a way as to limit the entry and subsequent growth of spoilage and disease causing organisms and that all products being sold for human consumption is traceable to a point of origin.

Food fails to comply with food safety requirements if:

- Rendered injurious to health
- It is unfit for human consumption
- It is contaminated (extraneous matter or otherwise)

Hygiene is paramount in production of safe food for consumers. Poor hygiene and sanitation will cost company money due to the following;

- Customers go elsewhere (low sales)
- Poor employee morale
- Unreported spoilage problems
- Increased returns of products
- Shorter shelf life
- Less profit and can invite threat of operation shutdown

2.4.1 Milk quality

Milk has an outstanding nutritional quality but is also an excellent medium for bacterial growth and an important source of bacterial infection when consumed without pasteurization. Pathogenic bacteria pose a serious threat to human health, and constitute about 90% of all dairy- related diseases (Ryser, 1998). To protect public health against milk-borne infections, there are regulations that require proper hygienic handling of milk and its pasteurization. However, such regulations are not usually adhered to in developing countries, making milk-borne health risk higher in developing countries. For local dairy products to be able to compete internationally, it is imperative that the dairy payment system in the country is based on quality and that it be effectively implemented. However, a major constraint in achieving a quality based milk payment system is the lack of information on how the local dairy products’ consumer perceives quality for the dairy products consumed and whether there is willingness to pay prices differentiated by quality.

2.4.2 Possible contaminants of raw milk

Literature shows that there are a variety of food pathogens that can be introduced into milk from cattle feed, the soil, milking machines, the udder and also from the skin of people. According to Vasavanda and Cousin (1992), some pathogens such as *Bacillus cereus* is able to produce spores which can survive pasteurization. With the exception of *Escherichia coli*, which has some toxin producing strains, the other food related pathogens identified in the milk samples hardly produce toxin, neither do they form spores. Thus

infections from these organisms through milk can be controlled fully through pasteurization. Faecal contamination is an important source of microbial contamination in milk and this may result from cow dung or originating from rodents. Addition of water and chemicals might reduce milk quality through the introduction of chemical and microbial health hazards. Health complications associated with consumption of inadequately pasteurized milk products include serious infections that are hard to treat with antibiotics. According to Gould (1994), this becomes clinically significant if organisms isolated from an assessed sample is resistant to conventional antibiotics, thus, can confer antibiotic resistance to the infected host while providing no alternative drug.

2.4.3 Effect of equipment of milk quality

Milk quality is greatly affected by handling methods applied during transportation and storage. The type of handling material is also affecting the quality of milk. Although both plastic and metal (aluminium) can be used as materials for milk handling equipment, plastic has adhesive properties which make it difficult to clean. Availability and cost are usually the limiting factor in regards to the use of recommended dairy equipment.

2.4.4 Quality of feed Supply

The dairy industry in the sub Saharan region of Africa is a major consumer of stock feeds as the climate does not favour grazing pastures. There is therefore the need for the industry to better understand the nature of the risks associated with stock feed consumption. These risks include physical, chemical and microbiological contamination of stock feeds that may result in unacceptable residues in milk.

3.4.3 Quality control in value chains

The dairy industry which is responsible for the production, processing and sale of its products is a vertically integrated industry with almost all parts of the value chain dependent on each other to ensure safe food. In order to move away from the system of end point testing, many dairy industries in mostly developed countries have introduced quality assurance programmes mainly at processing level as way of managing food safety through a risk based approach. This was mainly a demand driven response to consumers who are seeking safety assurances of products being sold to them. In developing countries food safety is a shared responsibility between all partners including, all levels of government (federal, provincial and municipal), industry and consumers (McEachern and Mountjoy, 1999). Internationally, emphasis is now being placed on shared responsibility for food safety between actors and stakeholders in food value chains. There is therefore need for implementation of quality assurance programmes by actors involved in input supplying, production, transportation and processing which will result in an integrated quality control of food safety risks across the whole value chain. Codex (Code of hygienic practice for milk and milk products) and the European Union (EU) have adopted this approach. According to an online publication by Dormon (2010), in Australia, while most States have State legislative requirements for on farm food safety programs, and the dairy regulatory authorities have agreed to ensure consistent implementation, there is no national legislative framework for a whole chain approach to dairy food safety. Food control strategies which characterize the principles of Hazard analysis critical control point (HACCP) and quality control systems will take a larger role in controlling industry products and processes. Industry will take an important role in developing the new strategies and the time frame for making the change.

3.4.4 Legislation and policies

McEachern and Mountjoy (1999) noted that policies on marketing of dairy products in developing countries have often relied on standards originating from developed countries where large-scale production systems, cold chain pathways, and milk pasteurization are key features. However, some of these standards may be inappropriate in developing

countries, owing to climate, poor infrastructure, and large distances. A review of current dairy industry policies and legislation is needed, with a view to creating greater consistency between related policies, and between policy and legislation in the industry. Appropriate regulations and the adequate enforcement help to ensure a milk supply of good hygienic quality, but good education and cooperation of everyone involved in the production, handling, processing and marketing of milk are essential to preserve the safety, nutritional value and other good qualities of “nature’s most nearly perfect food”.

2.5 Choice of efficient regulatory intervention

Government intervention can take many forms. This can be direct command and control (CAC) interventions and information-based interventions that provide incentives for private market solutions (Litan and Nordhaus, 1983). Direct interventions include CAC standards for performance, e.g. pathogen counts for products at some stage of the marketing channel (Hathaway, 1995). Such standards require monitoring of the product's quality, usually based on sampling and testing. In contrast, CAC processing standards achieve improved final product by directly specifying procedures to be followed in production. Examples of contamination control procedures include milk pasteurization, specific product washing solutions, or chill temperatures. These are sometimes specified as Good Manufacturing Practices (GMPs), such as those required under the food codes in many European countries. A third type of CAC approach is mandatory disclosure of information.

Litan and Ippolito (1984) further point out that in contrast to CAC, incentive-based approaches are designed to induce either producers or consumers to identify and practice cost-effective methods that achieve improved food safety. Such interventions might include providing information to consumers to allow them to evaluate and avoid a hazard, lowering the costs of information through subsidizing development of new pathogen tests, or facilitating private contracting through public certification of products that meet a minimum safety standard.

Setting performance standards and allowing choice of production methods and, over time, innovation to meet standards should allow greater efficiency in meeting a particular public health goal. Information-based approaches may not work simply because the main reason for the market failure is that information is very costly. Mandating the provision of information does not reduce its cost, and therefore may be a very expensive way to address the market failure in food safety. Litan and Ippolito (1984) argue that where quality information is costly or difficult to convey to consumers, and where there would be little informed demand for quality below a minimum standard, a CAC performance standard may be an appropriate choice. So if information interventions are impractical, then the choice is among CAC approaches. The difficulty for setting a CAC performance standard for microbial pathogens is again the high cost of testing for a hazard that often has a low incidence. Thus monitoring and enforcement of a performance standard can be costly.

2.5.1 HACCP based regulation

2.5.1.1 Critical control points

A critical control point (CCP) is “any point in the chain of food production from raw materials to finished product where the loss of control could result in unacceptable food safety risk” (Pierson and Corlett, 1992). Bryan (1992) cited in Bonfoh et al., (2006) defined a control point is as a point, in milk chain, at which control can be exercised to evaluate bacteriological spread by animal and different containers. Monitoring of CCPs is done best by using indicators that can be measured easily. This focus on measurable indicators provides a more cost-effective approach to control than product sampling and testing, which is more expensive and may not provide timely results. This is especially important

for food borne microbial pathogens, because their incidence is low and the costs of testing are high.

2.5.1.2 Hazard analysis critical control point (HACCP)

HACCP is widely recognized in the food industry as an effective approach to establishing good production, sanitation, and manufacturing practices that produce safe foods (Pierson and Corlett, 1992). HACCP is a concept which permits a systematic approach to identification and assessment of hazards and risks associated with the production, marketing and use of the food product, as well as provide preventative measures for their control. It is suggested that, if appropriately applied, HACCP is a more economically efficient approach to food safety regulation than CAC interventions. It is recognized by both private and public sectors as a tool for managing food safety and thus promoting the health of consumers. Besides HACCP providing a cost-effective way of monitoring quality control for private industry, it also may reduce the cost to a regulatory agency. The agency can test products, but the costs of testing are quite high when the probability that a hazard will get into the final product is relatively small. With a HACCP-based regulation, the regulatory agency can check records regularly to verify that a HACCP programme is functioning (Ababouch, 2000). Such records include verification of processes and the effectiveness of controls. According to Cato and Dos Santo (1998), the marginal costs of putting into operation HACCP may be higher in developing countries, where there is a limited amount of basic sanitation services available and technical assistance may be necessary because there are few trained HACCP.

2.5.1.3 Determining the impacts of HACCP regulation

An important question is whether HACCP is a more cost-effective approach to attaining enhanced food safety than other approaches. Studies on the economic impacts of HACCP which were done in the United States (MacDonald and Crutchfield, 1996) showed that the direct costs are likely to be surpassed by the implications of HACCP for long run industry structure. The huge investments and technical skills needed for implementation have economies of scale that favour larger firms than for small businesses. HACCP regulations could also create encouragement for better vertical coordination to control food safety throughout the value chain (Mazzocco, 1996).

2.6 Benefits of quality assurance systems in milk chain

In Zimbabwe like in other developing countries, regulatory resources are diminishing and traditional dairy hygiene regulatory controls have been shown to be in adequate. Quality assurance systems have a potential to identify conceivable and reasonably expected hazards thus preventing milk contamination and milk borne diseases. Of advantage would to be have systems that are applicable to the whole food chain which make it easy to audit and address problems e.g. HACCP. Identifying and monitoring CCPs is more cost effective than inspection and end product testing. From a chain perspective, such systems help to improve chain relationships by bringing chain actors to work together i.e. milk processor, dairy inspector and consumer.

2.7 Quality control in the Zimbabwe dairy sector

In Zimbabwe the dairy sector operates in accordance with standards prescribed under the Dairy Act [Chapter 18:08] and the dairy regulations RGN no. 886 of 1977. The Act lays down the basic principles while the regulations are more specific and generally provide the means of fulfilling the principles. Milk and milk products for sale can only be produced on dairy farms and processing plants specifically registered for this purpose. To be registered, the premises must meet the requirements for clean milk production and the sale of milk should be regularly tested to ensure that it meets the minimum legal standards. There are minimum standards laid down for all dairy products sold within Zimbabwe, and no product

may be offered for sale which does not comply with these standards. There are a number of likely health hazards which can result from consumption of contaminated milk.

Although there has been a general decline in milk production, the informal sector (marketing milk outside the formal sector) has been relatively stable. This has resulted in difficulties in monitoring the quality of milk in this sector giving rise to the risk of outbreak & spread of diseases e.g. tuberculosis (TB) and contagious abortion (CA), which can be spread to humans. However in the formal sector there exist to a limited extent quality control systems that ensure milk and milk products being produced for consumers is safe and wholesome. Quality checks on milk and milk products along the chain are carried out by the following government institutions; DSU, Ministry of health and child welfare, Food and Standards Board and Government Analysis Laboratory. Products which fail quality tests are confiscated and destroyed.

In the formal chain processors have put in place a payment system based on microbiological quality to encourage dairy hygiene on the farm. High quality milk production is encouraged by means of premium bonuses and poor quality milk is discouraged by deductions. Milk collection from the farms is done 2-3 times per week thus exposing the milk to the growth of bacteria therefore the need for quality tests.

2.7.1 Milk quality control at reception

The quality of dairy products is to a large extent dependant on the quality of raw milk used in their production. For this reason in many countries of the world payment for raw milk is linked to quality.

Milk is examined immediately before it is delivered to a collection centre and/or milk plant in order to determine whether it is of acceptable quality. If not, it is rejected in order to avoid endangering the quality of the plant's final product, such as liquid milk, butter or cheese. The examination of milk in order to determine its quality is normally based on a combination of both physical and chemical properties and this is done at the farm by trained road tanker drivers. The procedure involves checking the colour of the milk, smell or flavours (organoleptic tests) and measuring the temperature. A sample is also collected by the driver and put in a coolerman box with ice for further laboratory tests.

At the factory intake platform tests are carried out before the milk is offloaded. Platform tests are rapid tests on which acceptance or rejection of milk can be based. They are basically tests to be carried out on raw milk. Other tests are carried out in the laboratory and the basis for carrying out these tests is to check on milk keeping quality, milk cleanliness, milk composition and milk safety.

The organoleptic tests are based on smell, appearance and taste and thus permit rapid segregation of the poor milk if a skilled person with good senses of smell, sight and taste is used to carry them out. These tests are universally applied, and are to be complemented by the others, especially those for milk keeping quality.

Table 2.2 Legal standards of milk and milk products in Zimbabwe

Test	Product	Legal requirement
Butterfat	Raw and pasteurized milk	3 %
	Ice Cream	10 %
	Processed cheese	45 %
	Butter	80 %
Solids-not-fat	Raw milk	8.5%
Coliforms	Milk and milk products	Nil
Yeasts and moulds	Milk and milk products	Nil
Phosphatase	Pasteurized milk	<10g of p – nitro phenol/ ml
Moisture and water	Butter	16 %
	Cheese spread	60 %
	Low-fat cheese	67 %
	Processed cheese	45 %
	Dried milk	5 %
Total Bacterial Count	Raw milk	<500 000/ml
	Dried milk	<50 000/ml
	Sterilized	Nil
	Pasteurized	<20 000/ml
Freezing Point Depression	Raw milk	at least 0.530° Hortvet (H)
Triphenol Tetrazolium Chloride	Raw milk	Negative

Source: (RGN, 1977)

CHAPTER THREE: METHODOLOGY

3.1 Location of study

The study collected data from all dairy production areas in the country. Description of the study area in this section will therefore be on a national level.

3.1.1 Geography of Zimbabwe

The Republic of Zimbabwe is a landlocked country located in the southern part of the African continent, between the Zambezi and Limpopo rivers. It is bordered by South Africa to the south, Botswana to the southwest, Zambia to the northwest and Mozambique to the east and it has a tropical climate. The rainy season lasts from November to March followed by 8-9 months of warm and dry weather.

Zimbabwe has a total area of approximately 39 million hectares of which 11 million hectares is commercial farming land. Only the central plateau and the regions with altitudes above 1000 metres are suitable for dairy production. The country is divided into five natural ecological regions (Table 3.1).

Table 3.1 Natural ecological regions of Zimbabwe

Ecological Region	Rainfall	Dairy production system
Region I	>1 000 mm	Varies from intensive zero grazing, through irrigation pastures to dairy ranching with low feed inputs
Region II	750 – 1 000 mm	
Region III	650 – 800 mm	Most feeding is out of the bag, with some home mixing where irrigation is available.
Region IV	450 – 650 mm	Irrigation providing for pastures and crops for home mixing and the balance of feed is bought in.
Region V	<450 mm	

The distribution and location of dairy farms in the country was historically done in relation to processing factories which were mainly located in major urban cities. Before the industry was liberalized the only milk processor which was then known as Dairibord had processing factories in the following locations; two factories for Mashonaland provinces (Harare and Chitungwiza dairies), two factories in Midlands Province (Gweru and Kadoma dairies), one factory in Matebeleland (Bulawayo dairy) and two factories in Manicaland (Mutare and Chipinge dairies). Most dairy farms are located in Mashonaland East province because of its close proximity to Harare and also because of the climate and topography which are better suited for dairy as compared to other regions. Although Manicaland has a favourable climate for dairy (Table 3.1), the region is dominated by a mountainous landscape which is better suited for forestry plantations. The distance to factories of dairy farms in the country falls between 15 kilometres and 130 kilometres. Dairy farms are linked to urban areas by through a road network which includes both gravel and tarred roads. Gravel roads link the farms (not more than 15 kilometres) to the tarred national road network. All dairy farms are connected to the national electricity grid.

Table 3.2 Number of registered dairy farms by province-April 2010

Province	No. of Dairy Farms	Natural farming region
Manicaland	40	I and II
Mashonaland	105	II and III
Matabeleland	38	IV
Midlands	42	III and IV
Total	**225**	

3.2 Regulating institution organizational context

The Dairy Branch, which later became Dairy Services Unit, came into being when the first dairy officers were appointed in the early 1920s. Dairy Services Unit (DSU) was established in the early 1960s when the dairy Branch within the Department of Agriculture was incorporated into the Department of Research and Specialist Services (DR and SS). It has however been incorporated into the Department of Livestock Production and Development. The Head of Dairy Services Unit is a Chief Dairy Officer, responsible to the Director of Livestock Production and Development through the Deputy Director. In terms of the Dairy Act, the Chief Dairy Officer remains answerable to the Permanent Secretary in the Ministry of Agriculture, Mechanization and Irrigation Development.

In order to provide services to all parts of the country where there is milk production, DSU has offices with laboratories in four locations in the country. The central office is located in the capital city Harare and covers the northern, central and southern part of the country. The eastern part of the country is serviced by a regional office located in the city of Mutare. Located in the city of Gweru is the regional office servicing the Midlands region. The fourth office is the city of Bulawayo and this services the western part of the country. Most dairy farms and processing plants are located within a 100 km radius of the regional office with the exception of the central office which has some customers within a 130 km radius.

The existence of DSU regional offices contributed to the design of the sampling method as the regional officers were able to assist in data collection in order to get a representative sample of the whole sector. As one of its duties, DSU is mandated to keep a data base of the following information;

a) Names of registered farmers, their contact details, their locations and general farm information
b) Names of registered processors, their contact details, their locations and general operations information
c) Quality results of all tests done on raw milk and milk products produced by registered operators.
d) Milk production figures of dairy farms as well as milk intake figures of all processors in the sector.

Another key responsibility of the DSU which helped in data collection is that, the institution is required to identify possible areas of research on specific aspects of dairy production and processing, which are causing constraints or problems within the dairy sector. This responsibility was the basis on which the researcher was able to get assistance from Directors of the department in the form of fuel, transport as well as manpower for data collection. Stakeholders and actors in the sector are aware of the responsibility of DSU of collecting and keeping industry data such that the process of data collection and interviews were carried out with very high collaboration and participation by those contacted for the study.

Having described the background of the researcher's of his organization as well as its relationships with stakeholders in the dairy sector, the following sections describe the methodology that was used in carrying out this study.

3.3 Background of research method

The research was based on information collected by primary field data through field observation, discussions and personnel contact. In addition to this, secondary source of data such as books, internets sources, journals, publications was also checked with.

The sequence of events involved in carrying out this study will now be discussed. Before leaving for field work, the research made some literature review of the current status of the dairy sector in Zimbabwe using unpublished reports written by Dairy Services Unit and also by other stakeholders. These reports were requested from the relevant organisations and sent to the researcher by e-mail. Reference was also made to books and journals from the library and internet publications with information on control of food quality and safety with special focus on milk and its products. It is from this information that ideas on the sample design and contents of the questionnaire and checklist were derived.

Having come up with the list of key informant to be interviewed, the researcher sought contact details of the individuals from DSU which was then followed by contacting the people through e-mail and telephone to make appointments. The key informants were also given a brief description of the aim of the study in order for them to prepare for the discussions.

A detailed proposed itinerary for data collection was drafted and sent to the researcher's organisation so that arrangements could be made for fuel, transport and human resources requirement. This was done one and half weeks before departure for field work. The period for data collection was four weeks with some of the field work being conducted on weekends to compensate for time lost when the vehicle allocated needed to being used for other office duties in the organisation. The approach used by the researcher was to first carry out the survey which was then followed by interviews of key informants. This was done so that the informants would react to some of the issues that would have come up from the survey of the farmers.

3.4 Primary data collection

Survey questionnaires method and key informant interview was used to collect data.

3.4.1 Sampling design

Clusters of farmers were established according to method of milking, milk delivery method and milk collection frequency (Table 3.3). Altogether, 64 questionnaires were used for survey (34 for hand milking farmers and 30 for machine milking farmers) with clusters as indicated in Table 3.3.

Table 3.3 Clusters of survey

	Number in sample(N)								
Location (province)	Machine milking				Hand milking				Total as % of registered producers
	Bulk delivery		Can delivery		Bulk delivery		Can delivery		
	24-48 (hrs)	>48 (hrs)	24-48 (hrs)	>48 (hrs)	24-48 (hrs)	>48 (hrs)	24-48 (hrs)	>48 (hrs)	
Mashonaland	4	4	4	3	4	4	4	3	29
Manicaland	2	1	2	1	2	2	2	1	30
Matebeleland	2	2	2	1	2	2	1	1	34
Midlands	2	2	1	1	2	2	1	1	32
Total	10	8	7	5	10	10	8	6	30

The grouping that was used was specifically chosen in order to compare milk quality under different management systems which are risk areas in the milk production chain. In order to have a representative sample of the registered dairy farmers in the country, the clustering according to location took into consideration the total number of producers in the particular area. One smallholder milk collection centre was randomly selected in each province from which one producer was randomly selected on the basis of having been a consistent member for the past 5 years. Fewer smallholder producers were included in the survey as they account only for 5 % of the formal national milk produced. The study aimed at getting responses from at least 30 percent of the number of registered producers in the country so that views expressed by respondents could be interpreted as a true indication of views of producers in the dairy sector. The availability of regional dairy officers to take part in data collection allowed the sample designing to adopt and approach the sector at a national level. The location of dairy farms forms a uniform pattern where the farms are located close together in a particular area across the country thus allowing for the coverage of at least four or more farmers per day.

3.4.2 Survey

A structured questionnaire was developed and pre-testing of the questionnaires was carried out to make certain that all the questions were understandable to all the interviewees as well the data collectors in order to obtain quantifiable data which could be analysed. After the first day of the survey, the questionnaire was adjusted by adding rankings and scoring points on some of the questions so as to get meaningful data.

The survey questionnaires used in this study has both closed and open ended questions. This was done so that the questionnaire includes some open-ended questions which require written commentaries which would provide sufficient data on which to comment on rather than relying only on coded data which would become condensed into brief summaries when analyzed with statistics packages. Two sets of questionnaires were prepared and used for this study. One set for farmers who are hand milking and another for farmers who are machine milking. The questionnaire covered the following main farm risk areas: microbiological contaminants, chemical contaminants, physical contaminants, hygienic milking, water supply and quality, dairy milking premises, cleaning and sanitising, and dairy personnel skills.

Survey was carried out by the researcher with the assistance of regional dairy officers from DSU. Before carrying out the survey, the questionnaire was discussed together with the other Dairy officers to brief and inform them on the specific data which needed to be collected as well as giving basic techniques for effective data collection. Instructions for regional dairy officers in locations outside Harare were given over the phone.

On each particular day farms indicated on the itinerary were visited for the survey interviews. Upon arrival at the farm introductions were made to the farmer following which an inspection of the milking premises and discussions on management of milking operations were done whilst filling in the questionnaire. There was an important need for the research team to be very observant of situations and processes so as to cross check on validity of information which was being given. Information collected by visual observation was on condition of equipment, facilities, workers hygiene and milking practices and milk quality control. Information obtained through the questionnaire was on farmers views on milk quality and on idea of ICCS. In order to get the respondents to give accurate answers and avoid giving socially desirable answers, the researcher first stressed to them that this information was important as it would lead to the formulation of interventions aimed at improving the viability of the sector by addressing areas of high priority. On average 45 minutes were spent at each farm. On each day four farms were

visited. However the data collection team had to be very good at time management as some producers would see the visit as an opportunity to talk about all their problems.

3.4.3 Interviews

The researcher chose to carry out face to face interviews with key informants in Mashonaland provinces and opted for telephone interviews with those in other provinces because of the long distances to the regions in the country. The interviews were done using a check lists (Annex 1-5) with open questions and were characterized by probing and follow up questions depending on the type answer from the respondent. The questions for the check list were guided by the research objectives and had to provide answers to the sub questions. Below is a description of people interviewed and choice of respondents.

i) Chairman, National Association of Dairy Farmers of Zimbabwe (NADF)

The choice for the respondent was because the association represents the views of all dairy farmers in the country. Decisions made in the sector on issues related to farmers can only be successful with the full backing of the association thus the need to involve them in policy formulations. The interview addressed issues on how farmers can be involved in quality control and how they can be helped to produce high quality products. The discussion also looked at the role of the government and government institutions to help and provide farmers with a favourable environment for dairy production. The Chairman was asked to provide an overview of constraints being faced by members on quality management. The respondent was also probed on the association's view on giving farmers a responsibility on quality control and the requirements or approaches needed for the system to be successful.

ii) Chief Executive Officer, National Dairy Cooperative (NDC)

The interview was related to the current status of milk transportation operations in the sector. The interviewer was chosen because the organisation is the only transport company involved in milk transportation in the country. Although there exists individual farmers who are delivering their own milk with cans using their own vehicles, NDC is involved in transporting 95% of the milk delivered to processors. Milk transportation presents a risk of milk contamination in the movement of milk in the dairy value chain therefore the need ensure that it is involved in issues to address quality problems.

iii) Nutritionist , Agrifoods Private Limited

The researcher intended to interview the Quality Control Manager but because of the busy schedule of the informant, the feed company nutritionist was interviewed instead. Feed represents a source of contamination in the animal production chains. It was therefore against this background that the study sought to include this important input supplier the dairy value chain. Issues that were sought from the discussion were views of the feed industry on product quality and systems that have been introduced in their operations as well as what role they can play in promoting quality products for the dairy sector.

iv) Chief Dairy Officer (CDO), Dairy Services Unit

The head of the institution with the responsibility of regulating the dairy sector formed part of the key informant interviewed in this study. The contribution of the CDO was important as it from this organization that the researcher is part of and which is seeking to find possible approaches to addressing milk quality problems. The CDO as head of DSU is responsible for administering the Dairy Act and its regulations as well as providing technical back-up to the MAMID on dairy related issues, and advising on changes to dairy legislation in Zimbabwe.

v) Chairman, Zimbabwe Dairy Industry Trust (ZDIT)

ZDIT is the overall umbrella body for the dairy sector in the country. The trustees making up the ZDIT board are representatives of stakeholders in the sector including government which is represented by two members in the nine member board of the Trust. The responsibility of the organization is to make and implement decisions which promote milk production in the country. The researcher needed the input of the organization as it has the capacity to direct and coordinate programmes agreed by the sector as it is in charge of collecting and administering levies from all producers and processors in the dairy sector.

vi) Chairman, Dairy Processors Association of Zimbabwe

The representative of the association was chosen for interviewing as he would provide valuable information on the importance of milk and milk product quality problems at processing level as well as its implications for the image of the sector.

vii) Quality Control Manager, Dairibord Zimbabwe Private Limited (DZPL)

DZPL is the biggest of the processing companies in the country and has been in operation for a very long time. Before liberalization of the sector, DZPL used to be the only operating processor in the country and currently has six factories around the country out of the twelve which are there. Other processors each own one factory each. Of the total milk delivered to processors, DZPL accounts for 80 % of this delivery. Having considered the above information, the researcher saw it fit to make the key informant from this organization part of the respondents that would contribute valuable information on how the company has been dealing with quality issues over the years as well as its future plans.

viii) Deputy Director, Dairy Development Programme (DDP)

DDP is a government institution which is under the Agriculture and Rural Development Authority (ARDA), and is tasked with promoting smallholder dairying in the country. The institution employs Project officers who are working at each of the nineteen small holder dairy project centres in the country assisting farmers in animal production and milk processing. It is from DDP that information could be obtained on the current status of smallholder farmers, their challenges in terms of milk quality as well as actions being done to address the challenges. The Deputy Director was interviewed as the Director of the institution has been seconded to work at the Head office.

3.5 Secondary data sources

3.5.1 Literature review

The literature review formed the basis of my secondary data collection. Sources from which the researcher sought information were desk research. This included digital library of Wageningen University, various books, journals, annual and monthly reports from organisations and stakeholders in the dairy sector in Zimbabwe as well as policy documents. Desk research of information on the internet on the relevant subject was studied.

3.5.2 Milk test results database

Raw data which was used to show prevalence rates of contamination was collected from test results obtained from the database of laboratory analysis results of milk samples carried out in the microbiology laboratories of Dairy Services Unit, Department of Livestock Production and Development, Zimbabwe. For this study the researcher decided to use only total bacteria count (TBC) in the data analysis. The procedure leading up to this database is outlined below.

a) Collection of milk samples

Milk samples are collected by trained bulk tanker drivers at the farm from the bulk tank before the milk is loaded into the road tanker. The samples are collected under aseptic conditions in labelled sterilized vials and kept under cold temperatures (ice box at 0-4°C). The samples are brought to the nearest regional laboratory of Dairy Services Unit for microbiological analysis within 36 hours after samples are taken. On each milk sample, a microbiological examination is carried out for TBC, coliform counts, yeast and mould counts, freezing point and acidity.

Milk products are sampled from the processing plants by the respective processor and then delivered to the nearest regional laboratory under cold chain for analysis. Microbiological examinations are carried out for TBC, coliform counts, yeast and mould counts as well as other tests as specified according to the seventh schedule of dairy regulations (RGN, 1977).

b) Microbiological examinations

In order to determine standard plate counts, coliform counts and yeast and mould counts, the examinations are carried out in accordance with procedures outlined in the seventh schedule of dairy regulations (RGN, 1977). Results of the tests are entered into a recording book and then inputted into the computer database following which results are generated and sent to the producers.

The payment for milk based on hygiene quality is used by processors, because the processing of high quality milk is one of the conditions for the production of high quality products, and the use of TBCs is the most appropriate in the current circumstances. The grading system which applies on TBC payments is based on the average of two tests carried out per month (Table 3.4).

Table 3.4 Total bacterial count premiums

Band	Range	Premium
AA	<20,000	14%
A	<50,000	7%
B	50,001-150,000	3.5%
C	150,001-250,000	0%
D	250,001-375,000	-3.5%
E	375,001-500,000	-7%
F	>500,000	-14%

Milk products are examined and results are also inputted into their respective database and results processed and delivered to the customer. At the end of each month regional laboratories send their database to the central laboratory at Head office where these are consolidated into the national database.

Summary of data sources

Sub question	Information	Source
i.	Prevalence rates of contamination	Milk and product result database at DSU
ii.	Risk areas	Survey
iii.	Critical control point	Survey + interviews with NADF, ZDPA, DDP, Input supplier, NDC, processors
iv.	Actor views on quality	Survey + interviews with all key informants
v.	Views of actors on introducing ICCS	Survey + interviews with all key informants
vi.	PESTE for a successful ICCS	Interviews + literature review
vii.	Hindering forces for change	Survey + interviews with all key informants + literature review

3.6 Data analysis

Value chain mapping was used to help to illustrate and understand the process by which milk product goes through until it reaches the final customer. This approach was employed to get an insight into the actors' roles and relations as well as identify the bottlenecks the actors face and the opportunities within the dairy chain of improving milk quality. The survey data collected and the test results of milk and milk products from the database were coded and analysed using statistical package SPSS. In order to compare the views of actors in the chain on the idea of ICCS, descriptive statistics were used. Correlation between prevalence rates of contamination (using TBC counts) and factors such as method milk, delivery method and delivery intervals were calculated by Univariate analysis of variance. Descriptive statistics was used to show patterns of bacterial contamination. The input of the interviews from the case studies was processed by grouping, organizing and structuring the answers. As a way of constructing data from literature review the researcher used a qualitative content analysis. This was done through use of grouping arrangement where important ideas for the study were selected. This analysis was selected for use because the documents for use were many and differed but however accesses to them is easy and was not limited.

The current control measures were then analysed to determine their effectiveness and efficiency in preventing, eliminating or reducing the hazards to acceptable levels. In cases where the inspection system can be enhanced the study sought to provide recommendations for new control strategies. The control strategies identified the most effective point for control along the dairy chain from production to intake at processing; the control measures that are to be implemented; who is best suited to deliver the controls and how the controls be verified and who is best suited to verify the controls.

CHAPTER FOUR: RESULTS

4.1 Value chain map, Zimbabwe dairy sector

Through interviews and literature review, the study was able to map the value chain map of the dairy sector in Zimbabwe as shown in Figure 4.1 below. The value chain shows the current organization of the value chain and the different chain supporters who are directly or indirectly involved with actors in the chain as a way of enhancing value addition. They provide services which mainly further strengthen the linkages and relationships between the actors.

4.1.1 Status of quality control in the dairy sector

In discussions with the CDO about her views on the current dairy statutes she stated that,

> *"The current regulations although appropriate as a means of controlling quality and ensuring food safety, there are some sections which need to be updated in line with developments that have taken place in the country. The regulations are made specifically for a commercial set up without the consideration of the informal sector. This therefore makes control of quality difficult as the informal sector is left without monitoring" (CDO, DSU).*

Dairy Services Unit (DSU)

According to the client's service charter of DSU, the mandate of the organization is to ensure and improve milk and dairy product quality, both to safeguard public health and protect and increase the viability of dairying. This is done through the following:

- Providing regulatory and statutory services to the dairy industry from production to consumption.
- Inspecting and registering dairy production and processing premises (all milk production, collecting, processing and packaging plants).
- Conducting advisory services so as to enhance efficiency of statutory control and improve management in production and processing. Monitoring the quality of raw milk and ensuring that they meet the minimum standards.
- Testing and grading of processed dairy products.
- Proficiency testing of dairy personnel
- Monitoring the quality and appropriateness of equipment and chemicals used in the dairy industry.
- Contribute to development of smallholder dairying.

Through chain mapping the role of DSU in the dairy production value chain was identified as providing quality control and grading of milk and milk products. The organization contributes to value addition of dairy products through training and proficiency testing of dairy personnel. Being an organization responsible for implementing dairy legislation, it is therefore of most important that the existing regulations are up to date with regional and international developments. The CDO was asked on the institution's requirements for it to carry out its duties and how it was relating with other stakeholders in the sector and the following is the response given,

> *"In order to successfully provide optimal services to its customers DSU needs to have adequate financial resources, material resources and a committed human resources team. The organization also requires well-coordinated relationships with the public and private sector as well as other national and international organizations. An enabling external environment supported by government policies will promote and strengthen DSU's role in the value chain. However currently the institution faces challenges in getting adequate resources as it relies on government funding which is limited" (CDO, DSU)*

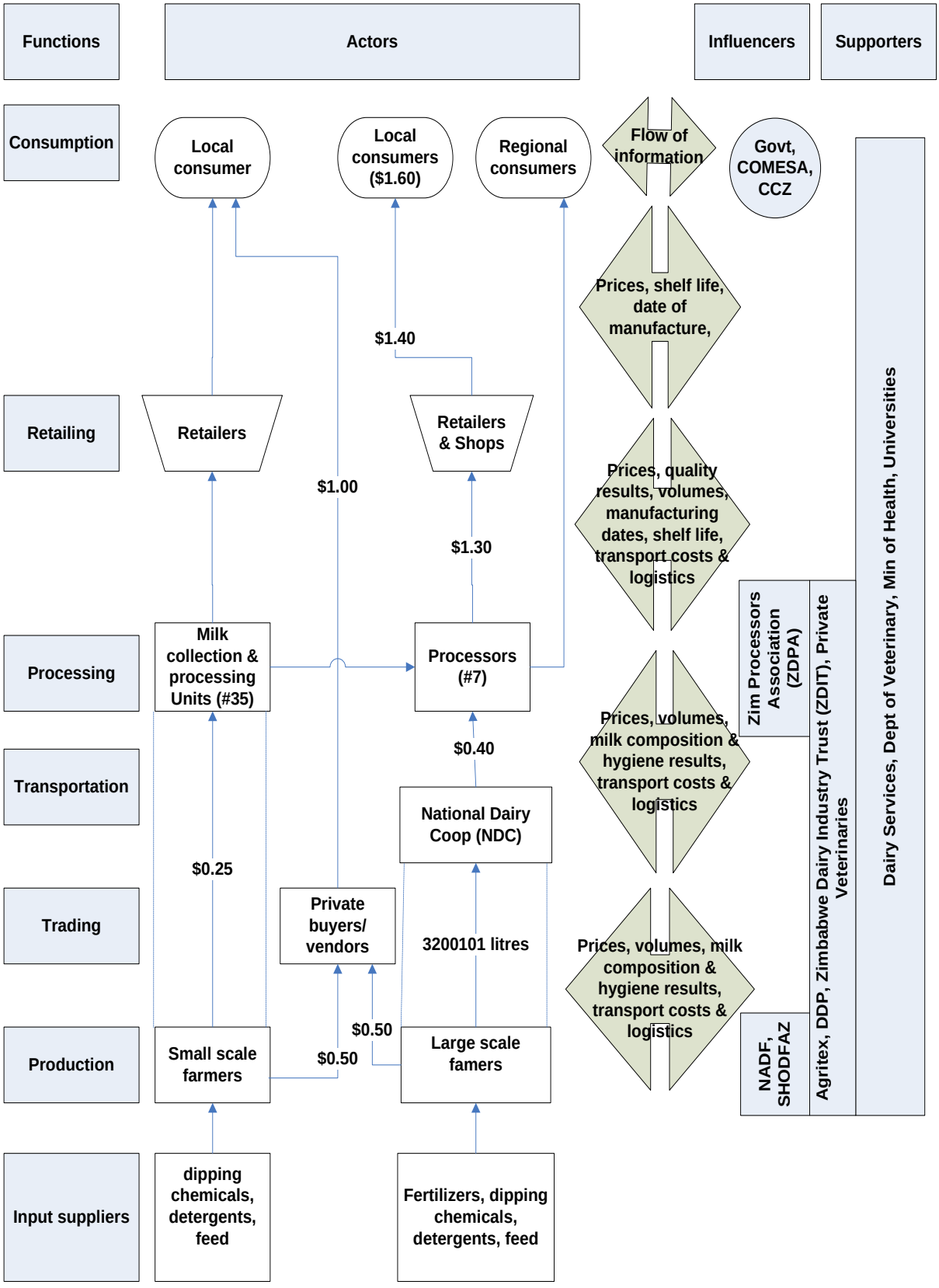

Figure 4.1 Dairy sector chain map, Zimbabwe

Table 4.1 SWOT analysis of the dairy regulatory controls in Zimbabwe

Strengths	**Opportunities**
• Existing laws on standards for the dairy sector • Existing institutions with offices whose locations allow for accessibility to most areas of the country	• Availability of cost effective food safety assurance systems which can be adopted
Weakness	**Threats**
• Few samples submitted for testing • Limited resources for regulatory institutions • Ineffective controls	• Milk contamination and outbreak of milk borne diseases

4.1.2 Prevalence rate of contamination of raw milk at farm level

The distribution of TBC found in raw milk from dairy farms is shown in Figure 4.2. As can been seen from Table 4.2 there were only 1.5% (n=1) with TBC <20.000/ml (grade AA). This despite the fact that in this grade a 14% premium is offered (Table 3.4). Most of the farms are in grade C and below which suggest the existence of risk areas at farm level.

Table 4.2 Descriptive frequencies for TBC for dairy farms

TBC count per ml	Frequency	Percent	Valid Percent	Cumulative Percent
<20.000	1	1.5	1.6	1.6
<50.000	3	4.6	4.7	6.3
50.001-150.00	8	12.3	12.5	18.8
150.001-250.000	6	9.2	9.4	28.1
250.001-375.000	17	26.2	26.6	54.7
375.000-500.000	12	18.5	18.8	73.4
>500.000	17	26.2	26.6	100.0
Total	64	100.0	100.0	

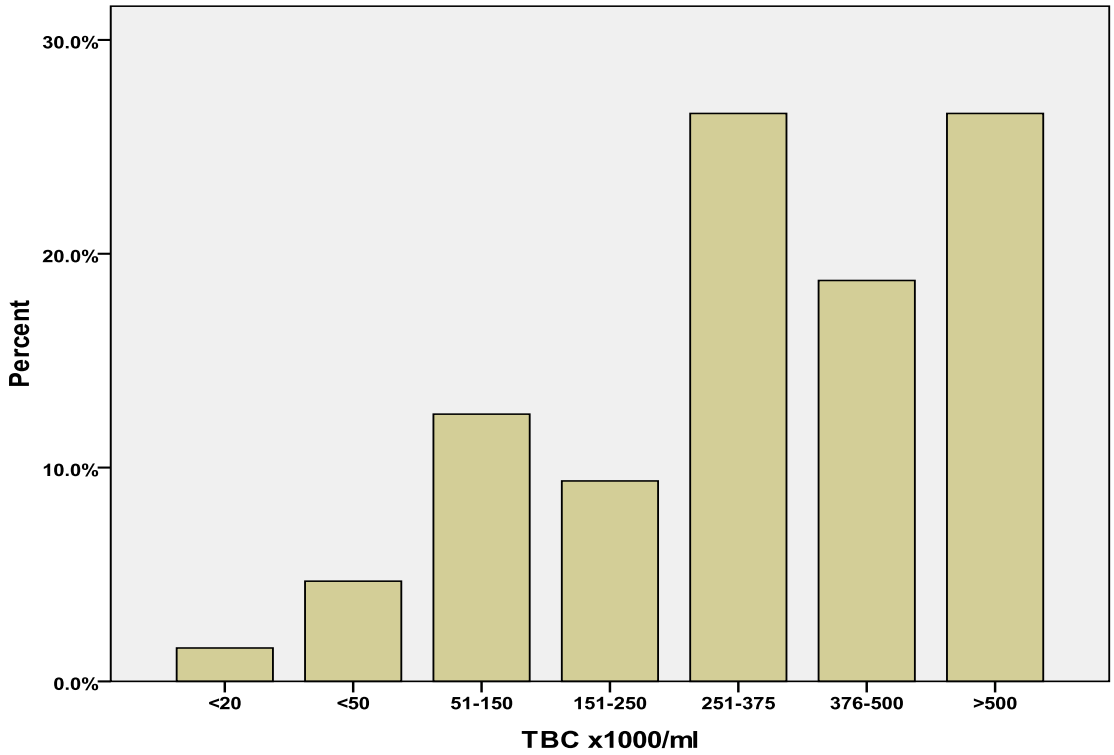

Figure 4.2 Distribution of TBC in raw milk at dairy farms

4.2 Hygiene practices

Most of employees (80%) involved in handling milk in the dairy have clean (74%) protective clothing which they use during milking. A smaller number was observed to be working without appropriate attire. However the majority of the protective clothing (80%) requires replacement as it is either worn out or torn. Although there are bathing facilities on all dairies visited, a very large percentage of dairy workers (70%) are not as required by the regulations taking full body washes before engaging in milking or any duties inside the dairy. It is expected that personal hygiene of dairy personnel and hygiene practice in milking handling influences the level of bacteria in milk. The total number of dairies with hand washing with soap was only 18 % which indicates a great risk of potential contamination from the skin. It was observed that clean hands were used to roll sleeves of overalls and used for milking without disinfection an indication that contamination of milk could result.

Table 4.3 Summary of some hygiene practices on dairy farms

		(%)	Yes (%)	No (%)
Protective clothing	Available		80	20
	Clean		74	26
Condition of clothing	Good	20		
	Fair	52		
	Bad	28		
Bathing before milking			30	70
Hand washing basin with soap			18	82

4.3 Effect of dairy facilities and equipment

On dairy farms with milking machines, 10 % were having their machines tested every 6 months whilst approximately 47 % of the respondents had testing at between 6 and 12 months (Table 4.5). Recommended testing frequency of milking machines should be at

least once every 6 months of which most dairy farmers are not meeting this requirement. The condition of machine rubbers (63.5% below good) is also an indication of the neglect in checking milking machine facilities by farmers (Table 4.5). The expectation is that all drainage systems should be functioning effectively due to the very high risks of contamination which can result from effluent and waste from the dairies. However results from the study indicate that 30 % of the dairies do not have proper functioning drainage systems where at some dairies it was observed that effluent was accumulating just a few metres from the premises. Contributing to the poor system of drainage is the condition of the floors in the milking parlours which are having cracks and pot holes as shown by the results where 38% of the floors can be classified as being good or better.

Table 4.4 Status of dairy facilities and equipment

		%	Cumulative %
Machine testing	0-6months	10	10
	6-12months	46.7	56.7
	12-18months	23.3	80
	>18months	20	100
Condition of liners/ buckets	Very good	10.9	10.9
	Good	25.6	36.5
	Fair	36.7	73.2
	Bad	15.8	89.0
	Very bad	11.0	100
Conditions of floors in milking parlour	Very good	9.2	9.2
	Good	28.7	37.9
	Fair	36.4	74.3
	Bad	24.1	98.4
	Very bad	1.6	1000
Proper functioning drainage system of dairy	Yes	69.8	69.8
	No	30.2	100

The condition of buildings at the factories visited is generally good. At Harare dairy which is the biggest factory for DZPL at which the researcher visited, it was observed that major renovations of the premises were in progress. The Quality assurance manager at the factory said,

> *"This was necessitated by the need to ensure that the facilities are in line with technological developments in the dairy industry and would result in efficient and hygienic production processes which is capable of producing high quality standards" (DZPL Quality control manager).*

The dairy regulations (RGN, 1977) specify the type of facilities which are required for dairy operators as a way of lowering prevalence rates of contamination. An example is that plastic containers are not allowed to be used for conveyance of milk. Plastic containers are difficult to clean thoroughly but during visual observation at some dairies visited, these could be seen in some being used to transport milk to processors.

4.3.1 Effect of cleaning programme

The use of detergents varied between the different dairy farms. Detergents were used by 78 % of the farmers in the survey but it was revealed out that sanitizers were not commonly used on dairy farms with only 23 % farmers using them (Table 4.6). There was almost an equal distribution on the number of farmers using sanitizers during milking especially during change of animals. According to Dodd and Phipps (1994), rinsing, cleaning using detergent and disinfections soon after use reduces contamination of milk.

Table 4.5 Usage of cleaning chemicals in cleaning

Activity	Yes (%)	No (%)
Using detergent	78	22
Using detergent and sanitizer	23	77
Using sanitizer on equipment during milking	42	58
Using proper cleaning chemicals	64	36
Using hot water for cleaning	100	0

It is thought that the use of detergents and quality water in cleaning equipment affects the microbiological quality of milk as it could be expected to remove milk residues, including microorganisms. Although the majority of the farms had heating equipment for boiling water, there was no means of verification of the temperature of the water before use. Disinfection through use of chemicals or hot water heated to a temperature above 60^{o}C would most reduce levels of contamination (Gran *et al.,* 2002).

4.3.2 Staff competency

Discussions with farmers and other stakeholders revealed that the sector was experiencing a high turnover of staff leaving inexperienced staff to carry out milk operations at all levels along the chain. The Deputy Director of DDP speaking on the status of smallholder farmers remarked that,

> *"Milk quality in smallholder dairy farming had been improving but at a slow pace. This is attributed to limited skills among the farmers involved. This has led to improper milk management practices especially in areas where hygiene is concerned" (Deputy Director, DDP).*

4.4 Pre and post milking procedure

Before milking, the udder requires cleaning and drying. From the study it was revealed that 4 % cleaned udders with disinfectant before milking, 19 % of all the respondents used water and dried the teats with absorbent paper, and 69 % used a cloth for drying after washing with water whilst the remainder used water but did not dry the teats (Table 4.7). The number of respondents who reported to be using teat dip was very high (95%). This could as a result that the information was based on oral evidence as it was not possible to observe the activity being done due to the busy schedule of the research team. The effects of teat dipping after milking according to Dodd and Phipps (1994) is that it lowers the level of microbial organisms in milk as well as helping the healing of skin injuries.

Table 4.6 Pre and post milking treatment of udders

Activity		Number (%)
Cleaning treatment	With disinfectant	4
	Water and disposable paper towels	19
	Water plus re-used cloths	69
	Water only	8
Use of teat dip after milking	Yes	95
	No	5

4.5 Management of milk storage and transportation

The result of the effect of delivery interval on milk quality showed that there is a significant positive correlation between delivery period and Total bacterial counts (r = 0.323) as shown in Table 4.3. In the same way no significant negative correlations were established for the effect of delivery method and method of milking on Total bacterial counts (r = -0.323).

Table 4.7 Tests of Between-Subjects Effects

Dependent Variable: TBC

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	51.387[a]	7	7.341	3.816	.002
Method of milking (MM)	.875	1	.875	.455	.503
Delivery method (DM)	.141	1	.141	.073	.787
Delivery interval (DI)	30.806	1	30.806	16.014	.000
MM* DM	5.345	1	5.345	2.779	.101
MM *DI	1.100	1	1.100	.572	.453
DM* DI	5.302	1	5.302	2.756	.102
MM *DM *DI	1.687	1	1.687	.877	.353
Error	107.723	56	1.924		
Total	1871.000	64			
Corrected Total	159.109	63			

a. R Squared = .323 (Adjusted R Squared = .238)

The Total bacteria count was numerically considerably higher in hand milking deliveries done more than 48 hours after milking (Figure 4.3) than deliveries done in less than 24 hours in hand milking deliveries but the difference was not significant.

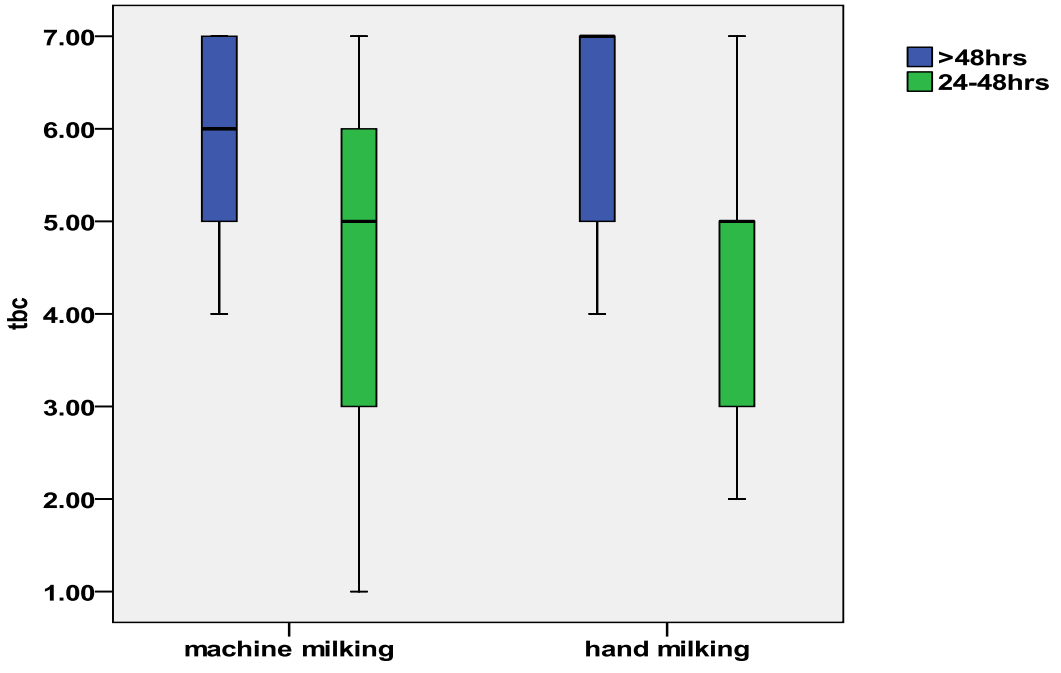

Figure 4.3 Box plot showing subject effects

Distance to the milk collection centres plays a role in quality of milk delivered in smallholder dairy farming. However this survey was not able to reveal that. According to the centre supervisor at one milk collection centre visited,

"Farmers sometimes travel distances of up to 10 km by either bicycle or by animal drawn carts with most roads being poorly maintained. This results in milk getting to the centres after very long periods and in hot weather conditions leading to deterioration of milk quality" (Supervisor, small holder milk collection centre)

Although NDC places a great value on the importance of milk quality, the company says there exists some challenges that have impacted on provision of service to its clients. In the following extract with the CEO of NDC he highlights the problems faced by the transporting company,

"The main challenge has been the difficulties faced in trying to replace some of the aged and worn fleet and equipment for milk storage. A large number (80 %) of our fleet needs replacement as it is constantly breaking down. Because of its old age it has become expensive to maintain and repair these vehicles. As the number of reliable bulk tanker trucks available is limited, the organisation has employed a strategy of reducing the frequency of collection of milk from farms on some routes where volumes are not high. Taking from the total collections done by our trucks, 85 % of the collections are done 48 hours or more from the last collection" (CEO, NDC).

Summary of limiting factors affecting service provision to clients by NDC

Factor	**Level of influence**
Road condition	High
condition of vehicles	Very high
distribution of your clients	Not at all
Viability	Moderate
untrained drivers on milk handling	Less likely

The following information on road tankers was obtained from operations manuals and procedure of NDC. In cleaning of the tankers, the company uses both manual and Cleaning in Place (CIP) method. Before milk is collected from the farm, the driver who is also the official sampler carries basic sensory tests to check on the quality of milk. Bulk tanks at farms are fitted with a temperature gauge which is checked at collection to make sure milk is at the required storage temperature of between 3-4^{o}C. CIP is used to clean the interior of the tanks whilst the outside is done manually. Cleaning is done by the factory where the milk is delivered as it is requirement of the dairy regulations for processors to have a CIP system for cleaning tankers at their factories. When a tanker arrives at the factory, it is first cleaned on the exterior before offloading the milk. After it finishes offloading the milk, the tanker goes for a thorough cleaning of both interior and exterior. Twice a month, swabs are randomly carried out by DSU to check on the effectiveness of cleaning. All road tanker drivers have to be trained and proficiency tested on milk sampling techniques before they are allowed to go for milk collection.

Information obtained from the processing plants visited indicates a similar procedure for milk reception. Platform tests are done at milk reception which include sensory, lactic acid test, etc all which are prescribed under the dairy regulations. The tests are mainly done to check on milk freshness. Milk found to have failed platform tests requires conformation of an independent person who according to the rejection procedure is a dairy officer from DSU. Rejection of milk is done if it fails the lactic acid test reading falls below 0.19. The factory has a choice either accepting the milk or rejecting it for which it is supposed to be disposed after having put a dye in it.

The researcher however observed that milk reception facilities at most factories have now included incorporated a section for milk delivered in cans. However the design which is used exposes milk to contamination from birds, rodents and wind when the cans are being emptied.

Summary of observations on quality issues at processing plants visited

Raw material handling	Packaging material	- Store room well protected from rodents - Stored in sterile packaging - Once opened packaging used and not returned for storage
	Ingredients	- Stored in sterile conditions - Microbial examination done before use
Monitoring and traceability	Temperature control	Temperature charts available on walls and up to date
	Production records	Production records kept and up to date
Quality assurance	HACCP	Being implemented

4.6 Critical control points from production to processing

From information gathered during the survey as well as observations made during data collection, the researcher was able to combine this with information from literature to come up a list of CCPs from production to the point of milk reception at the processing plants.

Table 4.8 Identified critical control points in the dairy value chain (Field study, 2010 and Codex Alimentarius, 2001)

Step	Hazards	Preventative measures	CCP	Critical limits
Design quality and hygienic design of equipment	i. Microbial contamination ii. Bacterial growth	- A good design from approved equipment dealers -Inspection, maintenance and replacement of equipment	Design quality	TBC level below 150,000
Cleaning and disinfection	i. Microbial contamination ii. Bacterial growth iii. Cleaning residues of chemicals	-Hygienic quality of design -Effective cleaning and disinfection procedure -Supervision programmes	Duration, temperature and application of rinses	As per specifications of the chemicals
Storage of raw milk at farm	i. Cleaning residues ii. Antibiotics iii. Mastitis milk iv. Microbial contamination v. Bacterial growth vi. Environmental contaminants	-Hygienic equipment and methods -Cooling to below 4^{o}C within 4 hrs -Storage time and temperature limits -Transport planning to limit storage at the farm	Inspection by tanker driver before loading	-Maximum storage time of 48 hrs from first milking -Temperature at below 6^{o}C -No flavour deviation -No visual deviation
Transfer of milk to tanker/ Cans	Cleaning residues Bacterial contamination	-Tanker/ Can cleaning after every milk collection		
Transport to processing plant	Bacterial growth	-Short transportation time -Transportation very early in the morning (Cans)		
Unloading at milk reception at processing plant	Physical contamination	-Protection from dust, rodents and birds -Hygienic handling of unloading hoses	Platform tests	-Temperature over 10^{o}C refusal -Lactic acid above 0.19 reject -No deviation of flavour and test

4.7 Value put on milk quality by stakeholders in the chain

Discussions with different respondents and informants on this topic showed a common idea existing among stakeholders on importance of quality. Table 4.6 shows that only two responses were selected by all people interviewed. Consumer satisfaction was ranked on the top of the drivers for maintaining quality products when comparing means of the other variables (Table 4.6).

Summary of value put on quality by stakeholders

Item	Ranking in order of importance
Importance of quality	Very important Somewhat important
Drivers for ensuring and maintaining high quality milk	consumer satisfaction sector reputation self satisfaction legal obligation

However a look at the levels of TBC in raw milk from the survey (Figure 4.2) tells a different story were most of the milk is falling in grade D. This can be explained by the fact that farmers are not satisfied with the current milk price as indicated by their responses as when asked about their views to the milk price (Figure 4.4).

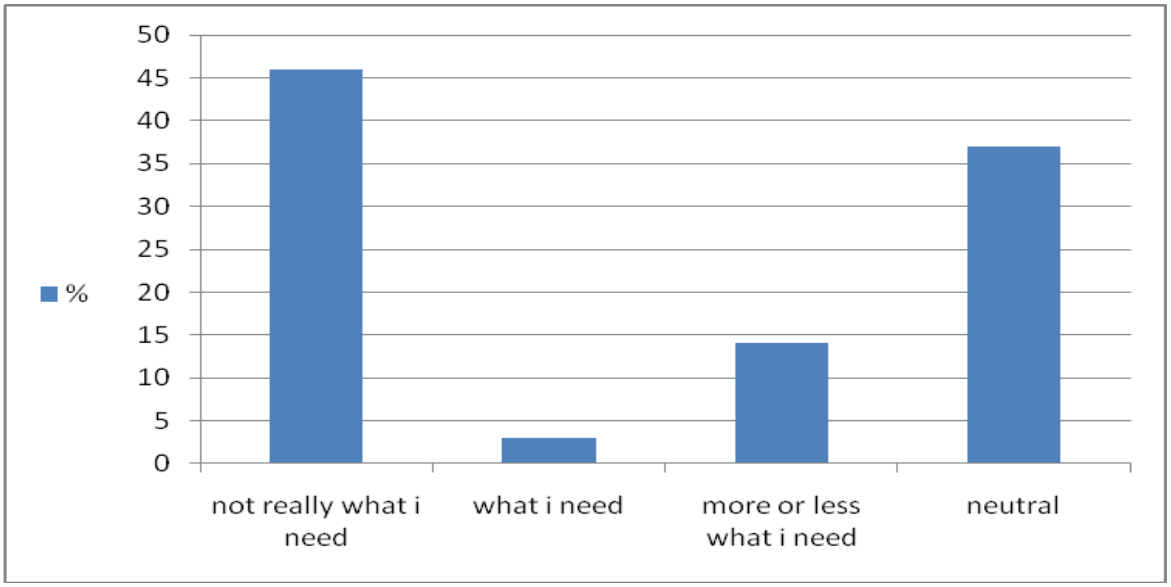

Figure 4.4 Farmers views on current milk producer price

In giving answering the question on the value put on milk quality by stakeholders, CDO at DSU provided the following answer,

> *"Standards for milk and milk products were at one time among the best in the region; however over the past 10 years the quality of local products has continued to deteriorate. Actors in dairy value chain have neglected their responsibility of ensuring that products produced are of high quality and safe for human consumption. A small number of chain actors are taking part in quality improvement programmes. The majority of actors seem to be focused on increasing production with very little consideration to quality" (CDO, DSU).*

This was interpreted by the dairy farmers association (NADF) as being a result of viability problems linked to the economy of the country of which the effects are have been faced over the past 10 years. He further went on to say that, "*Operating costs were so high that farmers were operating on survival mode"*. This resulted in producers doing short cuts in their management of the dairies. The most notable effect was that farmers were opting to use cheap cleaning chemicals in their cleaning routines thus affecting quality of products.

ZDPA conquered with other stakeholders that product quality was very important as a company is judged by the quality of its products or services by consumers. As the representative of the processors put it, *"In a world of competition, the only way to stay above the rest is to have a product that is of high quality which is consistent."* The association bemoaned the situation in the sector where same actors were taking advantage of the shortage of dairy products to shift from focusing on quality to profit making without consideration for the consumers. The chairman pointed out that this could backfire to those involved when the situation normalizes as current milk production statistics are showing a recovery of the sector. Once consumers have a bad perception of products of a company, it becomes difficult to erase this perception.

The expert interviewed from feed supply side pointed out that with the land reform programme some farms have since been subdivided and some of the resulting farms are too small to grow enough feed for dairy herds. The dairy sector is one of the major consumers of stock feeds in the country. However feed costs are very high and represent 70% of the total cost of production of dairy farmers. Because of the high prices being paid by farmers in purchasing feed, expectations are that feed companies play their role in ensuring that products available are of high quality. According to the expert, most commercial feed companies in the country have directed a considerable amount of effort to ensure that products from their companies are meeting consumer expectations.

Summary of constraints faced by dairy farmers in addressing quality

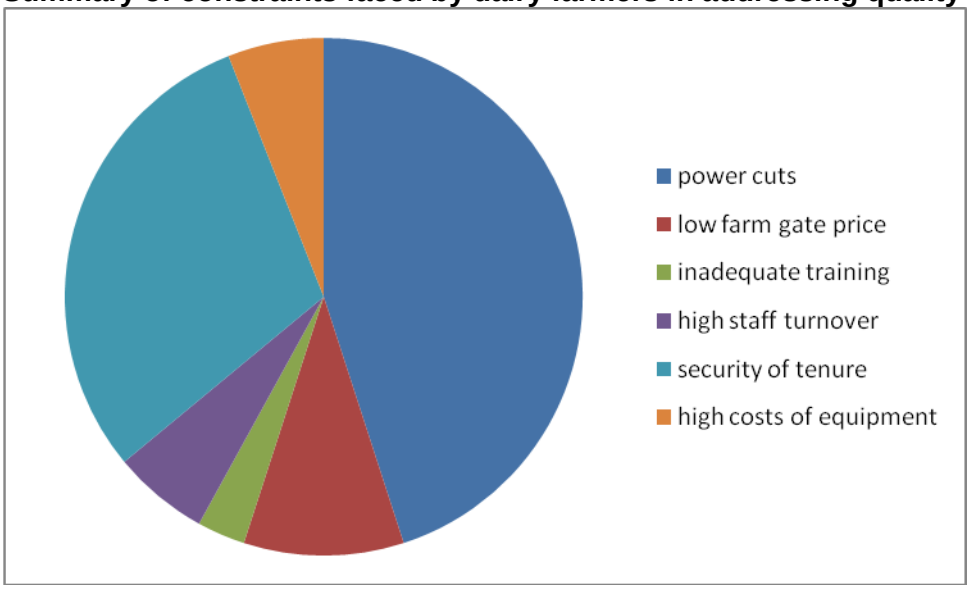

Figure 4.5 Constraints of dairy farmers

4.7.1 Extension and technical support

Farmers views on the level of extension and technical support received are shown in Table 4.9. The decline in technical assistance can be explained by the high staff turnover which being experienced by service institutions in the sector. For the smallholder farmers,

DDP occasionally carries out training courses on clean milk production for the smallholder farmers with assistance from relevant resource persons from stakeholders within the sector. In normal circumstances there should be a project officer from DDP at each milk collection centre who is assisting farmers in carrying out proper milk production practices. However, the association like other organizations in the country is facing a high staff turnover as its employees are leaving for greener pastures on the job market.

Table 4.9 Rating of technical service received

Response	Frequency	Percent	Cumulative Percent
none at all	7	10.9	10.9
very little	22	34.4	45.3
not less but not enough	28	43.8	89.1
Much	4	6.3	95.3
very much	3	4.7	100.0
Total	64	100.0	

One example of vertical integration within the chain is presented by the case of one of the processors DZPL. The processor is working with its suppliers in addressing constraints being experienced in producing quality milk. This is being done through a newly formed Milk Supply department which carries out trainings and advisory services to producers delivering milk to the processor. The department organises and carries out clean milk production trainings together with DSU, Agrianalysis centre and NADF. DZPL has put in place incentives aimed at encouraging dairy farmers to increase production of high quality milk. Producers contracted to DZPL have their milk payment based on the Quality payment scheme. This has been in the form of quality premiums which are paid for producing above minimum standards. There are also penalties applied to poor quality milk. The processor is of the opinion that dairy farmers should also be assisted by government extension workers in forage production and management. Government should also assist in facilitating importation of dairy equipment by lowering duties as the majority of equipment on farms is old and needs replacement.

4.7.2 Stakeholder views of idea of ICCS

DSU sees the idea of implementation of integrated chain control management for the local dairy sector as a positive and worthwhile approach. As the CDO put it,

> *"With the continued decline in financial support from coming from government, the institution stakeholders should put a combined effort and with adequate policies and legislation put in place by government as well as enough publicity, this approach could be a possible solution to control of product quality and ensuring food safety. However, food quality and safety control is a critical issue which cannot be left completely to the private sector, but requires a combined effort between public and private sector working in partnership" (CDO, DSU).*

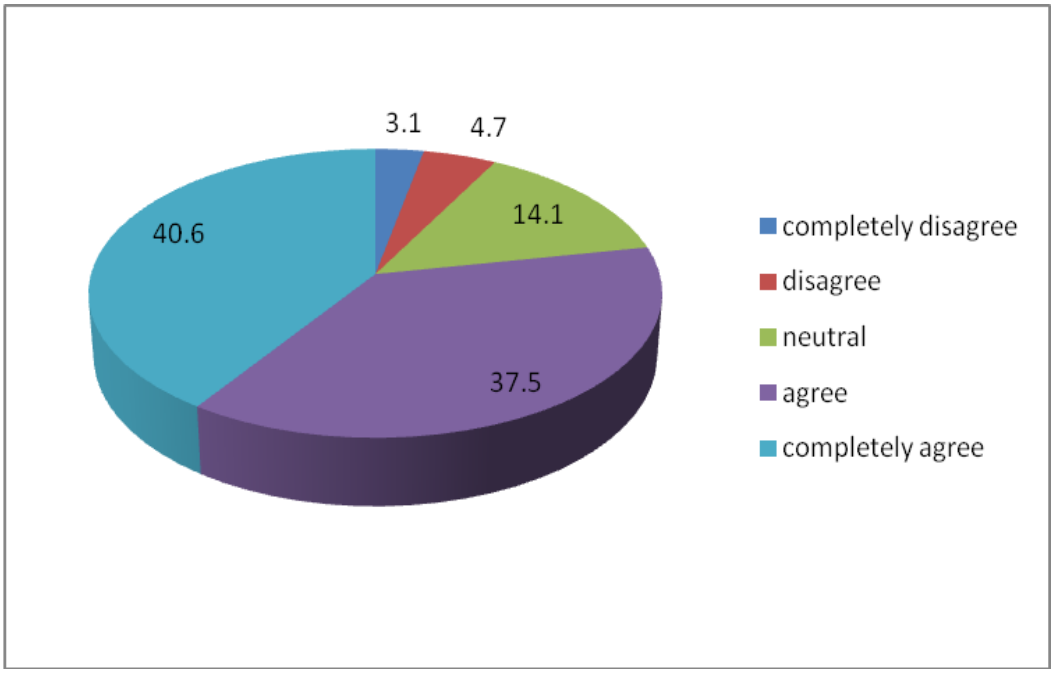

Figure 4.6 Farmers opinion on idea of ICCS

Summary of the opinions of stakeholders on idea of ICCS

	Completely agree	Agree	Neutral	disagree	Completely disagree
Producers		☺			
Transporter	☺				
Processors	☺				
Feed company		☺			
ZDIT	☺				
DDP		☺			
NADF	☺				
ZDPA	☺				
NDC		☺			
DSU		☺			

With regards to an integrated quality control system, the NADF chairman speaking on behalf of the association pointed out that, "*This is a welcome idea which they were willing to support."* This was also in concurrence with the views from the survey done on dairy farmers were 92 % respondents indicated that they did not object to the idea of an ICCS (Figure 4.6).

According to the ZDPA chairman,

> *"The sector should move in line with international and regional developments where quality assurance programmes have become a requirement of food production systems. However, at the same time, the sector is aware of the need for regulation and the function it plays, as well as the need for the sector to assume responsibility for the safety and reliability of the products it makes." (Chairman, ZDPA)*

The Deputy Director of DDP said the institution was in support of initiatives by the sector in addressing quality problems and would fully cooperate as long as the approaches taken would be taking into consideration the specific needs of smallholder farmers.

The chairman of ZDIT expressed the organization's willingness to support any initiatives that would be of benefit to the sector as a whole. This would ensure that levies being paid by the sector are ploughed back into the sector in order to uplift the standards of production and product quality. The idea of an integrated quality control system was in line with previous initiatives where a subcommittee had been formed by ZDIT to look into how best to address the problems of milk quality in the country. The subcommittee named Milk Improvement Group (MIG) had done some proposals which however were not fully completed due to the committee members having left and during which time the country was economical problems which made it difficult for making any long term plans.

However NDC fully supports the idea of an integrated chain control system which it sees as a way in which stakeholders in the sector work together to try to solve their problems instead of waiting for someone to always be chasing them into doing the right thing whereas it should be a common culture amoung all in the sector to always do the right thing. With a favourable operating environment, a sense of belonging by actors and good consumer education, the CEO saw no reason why this approach would fail.

CHAPTER FIVE: DISCUSSION

This chapter will discuss risk areas in the milk chain from production to delivery at processors. It aims to reveal the implications of these areas as well as challenges involved in addressing milk quality problems. The sector's involvement in addressing quality problems, limitations and views are explored so as to finding approaches to improving quality control in the value chain.

5.1 Contamination prevalence rate of raw milk at farm level

The current study shows that a high percentage of dairy farms are having high levels of TBC counts indicating the importance of identifying risk areas within the dairy chain. The sector must take responsibility and work together to address challenges of milk quality as poor milk quality exposes the consumers to a high risk of milk borne disease. The microbiological content of raw milk affects quality, shelf life and safety of the processed milk and other dairy products (Gunasekera *et al*., 2000). Other researches done have shown that high total bacteria count is related to several pathogenic micro-organisms (*Staphylococcus aureus, Escherichia Coli*, Coliforms) and the eating of processed milk from milk with high bacteria counts results in a great health hazard for consumers, together with the danger of an intake of toxins that make the milk inappropriate for human consumption (Millogo, 2009). The poor results of milk quality at farm level point out how the control system's ineffectiveness which is supported by a statement from one of people interviewed who stated that the sector was focusing on production with little consideration to quality. The reduced milk volume being produced in the country has resulted in an environment where the demand is greater than supply which has seen some people trying to maximise on this shortage with less consideration to legal requirements. This is further supported by Ryser (1998) who noted that regulations are not usually adhered to in developing countries. The results are also in agreement with observations by Gadaga (2003) who was of the view that in environments where the consuming public is either unsophisticated or ignorant regarding public health, unscrupulous operators tend to take short cuts in quality management so put at risk public health. There is therefore evidence of poor quality control within the value chain.

5.2 Effect of hygiene practices on milk contamination

Because of the shortage of milk on the local market, side marketing by producers seems to have increased thus it has been easy for farmers to dispose their milk without worry of being penalized for quality as is the case when they deliver to processing companies. The high levels of bacteria counts on most farms is most likely caused by contamination either by the milkers, hands of milkers, the surroundings at the milking place on the farms or unclean storage equipment with established bacteria colonies.

In the study it was observed that most protective clothing needs replacement. Proper clean clothes should be worn when handling milk as dirty clothes are a source of contamination. Milk handlers are not showering before engaging in their activities in the dairy. When milkers fail to observe certain minimum standards of cleanliness, contamination of the milk is likely to occur from bacteria either from their skin surfaces or clothes. Some pathogens such as *Bacillus cereus* which is able to produce spores which can survive pasteurization can be introduced from cattle feed; soil and also the skin of people (Vasavanda and Cousin, 1992). Discussions with farm employees to find out reasons for not taking a bath at the dairy indicated that this was mainly due to ignorance as well as lack of supervision. The workers are not able to see the importance of taking the bath at the dairy. Due to contact with the environment a person can be a carrier of bacteria when moving from one area to the other.

5.3 Effect of dairy facilities and equipment

The influence of the condition of milking premises on milk quality is highlighted by Latorre *et al.,* (2009) who showed that lack of sanitation around the milking area during milking was found leading to contamination of milk. Furthermore, under tropical conditions like Zimbabwe, the high temperature enhances the growth and reproduction of bacteria. The condition of dairy facilities and equipment is at low levels which the farmers themselves acknowledge but are doing little to address the problem.

The design of dairy facilities should be done with hygiene in mind. It is therefore that the design takes into consideration issues such as water supplies, waste disposal facilities and facilities for cleaning and sanitizing equipment. However observations made during the study indicate that most farm dairies facilities' drainage for waste disposal is not functioning properly. Effluent from dairies could be seen to have accumulated very close to the milking parlour which promotes breeding grounds for flies which are sources of contamination during milking. Some of the floors are having cracks and pores such that they are having stagnant water which can also harbour bacteria. It was also observed that quite a number of bulk tanks are without functional dial thermometers. In this case farmers are required to have a hand held thermometer to take the temperature. However only a few farmers are having the thermometers and when asked how they were able to know if the tank was having the correct temperature, one dairy employee said, "*if we hear the stir operated by the automatic timer switching on and off, then the milk is having the correct temperature"*. At farms with immersion coolers an almost similar answer was given whereby it was assumed that if the water in the immersion tank was showing some ice, then it automatically meant the milk was having the correct storage temperature. According to Gadaga (2003), it is possible to reduce to a minimum the risk of contamination by having and using correct facilities and equipment.

The chairman of NADF said that he was aware of the effect of poor facilities and equipment has on milk quality and that this had been a burning issue during NADF executive and production meetings. The association although it fully supports efforts aimed at addressing quality problems, it was of the view that the operating environment was mainly to blame as business in the sector was operating in uncertainty. Operators were reluctant to make big investments in premises and machinery which are now old and outdated and are seen as a main contributor of poor product quality. It was in the view of the farmer association that government addresses all issues with regards to land tenure so that operators are operating in a favourable environment as dairy production is a long term enterprise that requires committing resources in the long term.

5.3.1 Effect of cleaning programme

The cleaning method during milking, cleaning of dairy equipment and hygiene in the handling of milk after milking requires attention to avoid contamination of milk and poor hygiene of raw milk produced at dairy farms. The carrying out of hygienic practices at the time of milking is one of the first and the most essential step in clean milk production. Although this study could not show the influence of cleaning programme on contamination, however the results of some previous studies cited by Milligo *et al.,* (2009) done along the dairy chain in Zimbabwe, Ghana and in Uganda showed that cleaning programme has an influence on contamination.

Cleaning is very important in achieving food hygiene. Its main purpose is to remove microorganisms from contact with foodstuff that can cause spoilage and poisoning. Bacteria require food and moisture and ideal temperature for growth. For bacteria to move from one area to the other, it needs a "carrier" to achieve that (Harrigan and Park, 1991). Interrupting this conveyance by utilizing a good cleaning programme that includes the use

of proper cleaning chemicals is a way in which the continuous spread of bacteria can be accomplished.

The survey made interesting observations that farmers with low TBC count levels had in place programmes for addressing milking hygiene. This agrees with a similar survey conducted in 1997 by the EGD on small holder dairy farms in Zimbabwe where it was discovered that farms with a total bacteria cell count of <20,000 cells/ml milk were more often ready to take the required steps to put into practice improved milking hygiene than farms with >100,000 cells/ml milk produced at their farms.

5.3.2 Staff competency

Dairy is highly skilled operations when compared to other farm operations like cropping or beef production. It therefore requires skilled personnel to manage and run its operations. Training is long time process which is also costly. Having unskilled employees can result in losses to the business through reduced output or production of poor quality products. The dairy sector in Zimbabwe has lost quite a number of its skilled people as they move to greener pastures. Support institutions, actor associations and private organisations in the sector need to put in place a training programme that will assist in the training of personnel in the sector. NADF recalled that there used to such a programme which involved technical people from stakeholder organisations that was involved in a clean milk training programme which was sponsored by processors which seeing that the economic situation has improved can be revived.

5.4 Pre-milking procedure

Faecal contamination from cow dung and contamination by environmental germs and bacteria presents a risk as these pathogens can be introduced into milk during milking. This shows the importance of udder cleaning and treatment before and after milking. An effective way would be to use a disinfectant in cleaning the udder. This ideal practice is not common on dairy farms as shown in this study where only 4 % of the farmers in the survey are using disinfectant in cleaning. The most common practice of using water and cloths does not completely remove the risk of contamination as cloths used cannot be guaranteed 100 % clean when they are washed for re-use.

5.5 Management of milk storage and transportation

The major discovery in the this study was that the hygienic quality of the milk, shown as total bacteria count was lower for the more period of storage at the farm which suggests good milk quality when the delivery interval is low. The anti-microbial activity of raw milk usually inhibits bacteria growth for the first hours after milking (Milligo *et al.,* 2009). Preliminary bacteria count, temperature and time of storage are the main factors that determine bacteria growth.

The high levels in total bacteria count at farm tank milk can be explained by contamination by manure or dust, milkers and established bacteria in the storage containers, which can double in number at optimal pH and when the temperature is above 25^{o}C (Harding, 1999). The constant power cuts experienced in the country affect the ability of bulk tanks to keep milk at the ideal storage temperatures (3-4^{o}C).

5.6 Critical control points from production to processing

The definition of a critical control point (CCP) by Bryan (1992) provided a guideline for the identification of CCPs in the dairy chain in this study. A CCP in milk chain was defined as a point at which control can be exercised to evaluate bacteriological spread by animal and different carriers. CCPs for raw milk in the chain where determined using a decision tree (Figure 5.1).

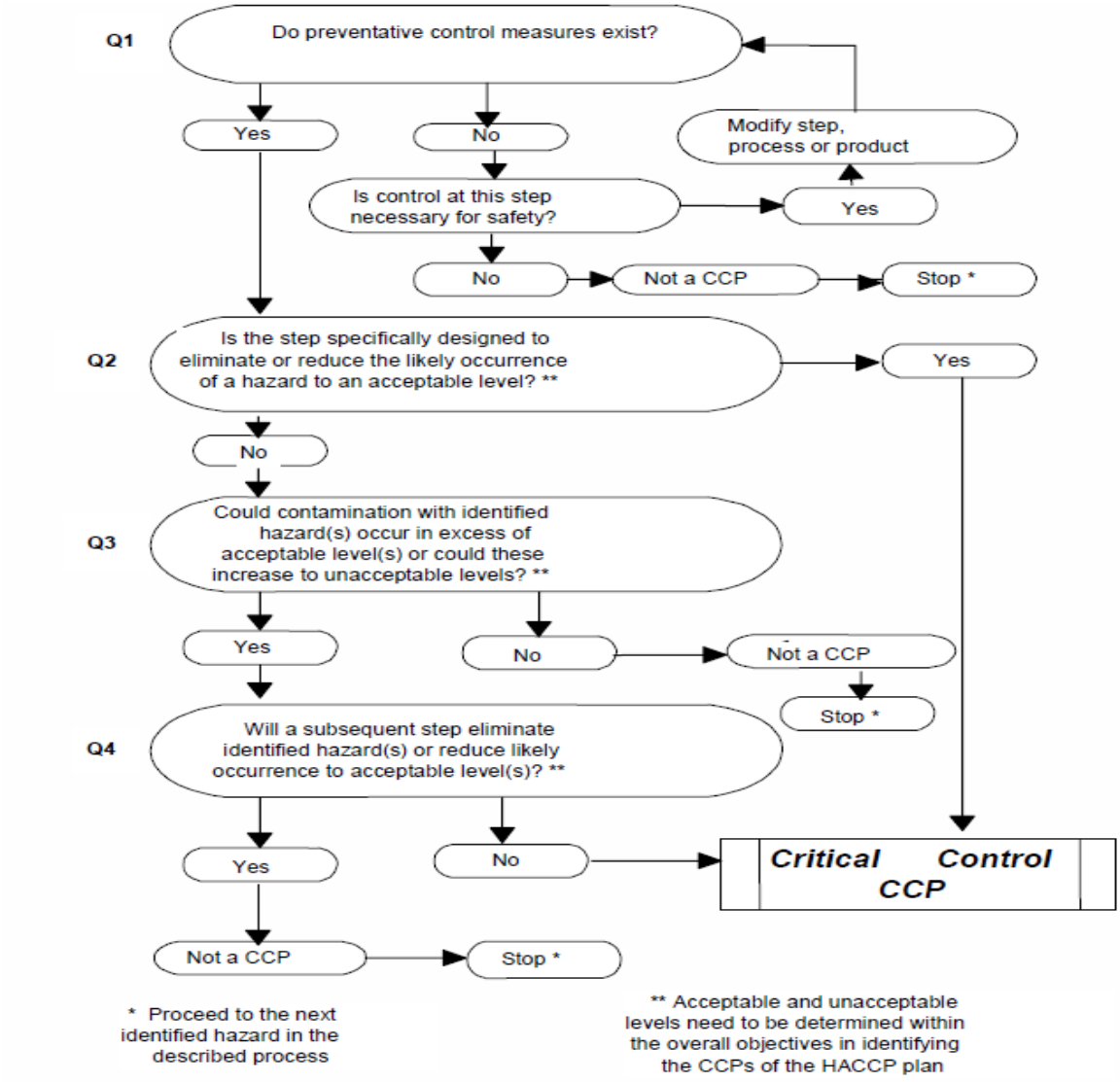

Figure 5.1 Decision tree to determination of CCPs for raw milk
Adapted from: Codex Alimentarius, 2001

The study only identified CCPs from production to raw milk delivery at processing plants. Preventative measures were also included in the analysis of risk areas in this part of the chain.

5.7 Value of milk quality in the chain

Although stakeholders rank the importance of quality high, the low levels of quality which are evidenced by practices and results from this study are showing a different story. Reports from DSU on milk product quality also confirm the poor levels of quality within the sector. DSU attributes the poor quality of products to the limited adoption of quality assurance programmes by actors in the chain. Routine inspections of dairy operators show that only one processor has a fully functional quality control programme meeting international standards. Other processors are still in the process of having their programmes accredited. Depleted and out dated equipment, machinery as well as building

structures which are poorly maintained is a cause for concern for the institution as this seems to be at a large scale in the sector.

Although it is the mandate of DSU to ensure that products produced for the market are of high quality and safe, the institution acknowledges that it must be a combined effort by all involved who also need to share the responsibility in order for the sector to prosper. In view of this, the institution has engaged stakeholders in the sector to find approaches to addressing quality problems.

One example of initiatives done so far is the coming together of DSU laboratory section with a private laboratory, Feedlab Services to form Agrianalysis centre (Aglabs) which aims to be a one stop testing lab for farmers. This public private sector partnership will provide farmers especially dairy farmers with a facility where they can have their milk, feed, soil and water tested under one roof and be provided with consultancy services on issues aimed at improving their businesses. The level of participation of actors and stakeholder from the sector in formulating possible solutions to addressing quality of product has somehow been half-hearted. Although actors are agreeing to the existence of the problem, when it comes to implementing agreed action plans there seems to be some hesitation.

a) Stakeholder views on quality

The discussions with stakeholders in the sector found out that most operators are blaming their slow responsiveness to addressing quality to external factors which they say they have no control over. However the Chairman of ZDIT in his opinion said that because operating businesses involves risks, it is therefore imperative that people should be willing to take the risks rather than making excuses for not following laid down procedures.

One of the respondents had the view that the poor quality of products on the local market could be blamed on the public which is largely ignorant of food safety or even of what good quality dairy products are. This is evident as milk is being sold all over the country in the most unhygienic conditions imaginable. Dairy products are appearing on supermarket shelves form unregistered operators. The respondent further stated that it was time that the sector took its social responsibility of ensuring safe and quality products for the general public as well as maintaining the reputation of the sector instead of relying on law enforcement.

Although feed companies are putting an effort to ensure provision of quality feed products, there has been however an increased supply of unregistered operators who are selling some feeds which are of inferior quality. Some unscrupulous individuals are repacking homemade feeds into bags of well established companies which they latter sell to the farmers.

5.7.1 Extension and technical support

Results from the study (Table 4.9) suggest that farmers are not satisfied with the level of technical and extension service they are receiving from technical institutions with 90 % of the respondents scoring it as not being enough or less. This is mainly a result of the high staff turnover experienced in the sector. However institutions tasked with provision of extension services as well as other private organisations are drawing up plans in order to address the gap which is now having an effect on quality of production practices by players in the sector as shown by the study. DDP which is tasked with provision of technical service to smallholder farmers is looking at ways of getting sponsorship from international organization who it has worked with in the past in order to provide a better service to smallholders. At present there is an EU funded programme for smallholder farmers assisting in rehabilitating and improving facilities at smallholder milk collection

centres and this is expected to go a long way in efforts to address quality problems in the smallholder dairy sector.

According to the CDO, farmers need to be directed at training farmers in different technologies that shall include modern and hygienic milking techniques, hygienic way of handling of milk, simple transformation techniques especially in areas not easily accessible. Training shall also touch on proper feeding of dairy cows for the production of milk with standard ingredients. As a way of assisting farmers to have access to affordable and high quality products one of the feed companies, Agrifoods, has put in place a scheme where farmers provide the raw materials and then the company does the feed formulations and processing into stock feeds at an agreed price.

5.7.2 Stakeholder views of idea of ICCS

The idea of introducing ICCS got a very high degree of support from stakeholders and this can be explained by the fact that the players in the sector are now looking ahead in the future where the local sector will face competition from regional products as a result of regional trade integration. The removal of trade barriers within the region by trading blocs such as COMESA requires that local products become competitive with regards to quality.

DSU although agreeing to the difficult conditions, in which dairy farmers and other stakeholders in the sector were operating in, pointed out that it was not ethnic for them to deliver to unsuspecting consumers products of poor quality which pose a health risk to the nation.

The technicalities of implementing this approach require people who would be fully committed to have the programme running. It was ZDIT's view that DSU and its officers could be tasked to spearhead this initiative as it was more inclined to their duties and also would be working towards having the necessary legal changes to accommodate the quality control system.

5.8 PEST analysis of operating environment of the dairy sector

In order to get an understanding of the external factors which are acting on the dairy sector and which could play a role in the success or failure of the intended goal, the researcher used the PEST tool to carry out this analysis. The following discussion tries to explore the way in which the external factors influence the value chain development initiative from the sector.

Political / legal

Monthly regulatory reports by DSB indicate a big number of dairy premises which are not meeting the minimum standards of the dairy regulations. Reasons given are that dairy operators do not have secure land tenure therefore are unwilling to invest on infrastructure on the premises. The intended quality control system requires support of being made legally binding for those affected. This therefore implies that government drafts new legislation to consolidate and update the existing dairy statutes. To quote the CDO,

> "*Legislation does not exist for a purpose of its own. Legislation exists to pursue another goal like public interest, orderly marketing, health requirements and quality standards. Legislation can only be drafted once the need therefore has been identified by the industry. Therefore the initiative for the streamlining and consolidation of legislation and the institutions administering such legislation will have to come from the sector. The client's wish is the lawyer's command" (CDO, DSU)*

From the above quotation, it is clear that once the dairy sector speaks with one voice on the need for a new quality control system, there would be no reason for government not to

work with dairy sector in drafting and updating dairy legislation so as to allow more efficient quality control systems which are now being used in regional and international food chains. This is supported by McEachern and Mountjoy (1999) who highlighted the need to review some of the dairy standards in developing countries with the view of creating consistency between related policies and legislation.

Economic
The economy of the country is a mixed economy where State and private sector both have roles in economy. It is the responsibility of the State to provide public goods and services such as infrastructure. Before January 2009, the country had hyper inflation which negatively affected operations in most sectors. The dairy sector lost valuable technical people who migrated to other countries due to the harsh economic conditions. The high cost of equipment replacement resulted in an increase in dairy products which were not meeting minimum quality standards as could be seen in the product quality reports from DSU. Although the economy of the country is recovering, government is still not in a position to source and provide national energy requirements. As way of managing available resources, the power authority carries out load shedding across the country. Dairy farmers need electricity for running machines and for cooling milk. Power interruptions affect the cooling of milk and this in turn affects the keeping quality of raw milk and dairy products.

Socio-cultural
Consumption patterns of dairy products by consumers have shifted from local to foreign products which are cheaper and are assumed to be of better quality. Demand for milk and milk products is very high in the country because people have been made to believe on the nutritive benefits of consuming dairy products. This provides a reason for actors in the value chain to improve on product quality by working together and try to find approaches to addressing milk quality problems.

Technological
The country has seen an improvement in communication technology following the liberalization of the sector. New telecommunication companies are now offering services such mobile phones and internet thus providing for an efficient and effective means of communicating for actors, supporters and stakeholders in the chain. However the country still remains heavily dependent on imports for most of its technological developments which contributes to the high cost associated with replacement of outdated equipment in industries. Results from the study indicated that farmers rate the level of technical assistance provided to them as being low (Table 4.9). Dairy production requires various technical expertises for example in dairy hygiene. Success stories of agricultural development programmes in various countries identify farmer education as one of the main reasons for the realised success. Extension services have been offered mainly by government institutions and private organisations. However extension services have declined due to high staff turnover and poor resources.

5.8.1 Requirements for successful ICCS

a) Technical manpower for monitoring system
Discussions with ZDIT indicated that it would be willing provide financial support in carrying out the work. This according to the chairman would also help to retain skilled staff as they would be remunerated for the work by the sector.

b) Administration of system
ZDIT would want government to have an overall role as food safety is a very important responsibility of most governments, therefore a better option would be to have DSU as the

monitoring authority. Other stakeholders were also in agreement as this would take the advantage of the private public sector partnership which now exists through Aglabs. DSU would still retain it regulatory role as it would now be required to audit the quality assurance programmes in the sector. The Australian system would be a good reference to learn and adopt for the local dairy sector. In their system, the State Dairy Food Safety Authorities is responsible for licensing farm operators thus allowing the farms to operate. A conditional requirement is on the licence is the compulsory prerequisite in most States for dairy farmers to have and implement an approved, accredited food safety program (Sutherland, 2004). The on farm food safety programs are then approved and accredited by the State Dairy Food Safety Authorities. State Authority approved auditors will then be responsible for undertaking an ongoing verification of the implementation of the systems. Appropriate management strategies which include full traceability should be put in place by dairy producers to manage safety risks from inputs.

c) Physical facilities and resources

Existing institutions, DSU and Aglabs should be able to provide the requirements of offices space, vehicles, office equipment and furniture. However additional resources would be required in the form of vehicles, office equipment to further strengthen these two organisations.

d) Production and operating procedures for stakeholders (codes of conduct)

For the scheme to be a success there was need for guidelines drafted to which everyone would be bound by and this supported by legal structures. According to the discussions with the CDO, the process of updating Acts and regulations starts with the industry presenting required changes to the Permanent Secretary of the line Ministry, again going through the relevant departments (in this case DSU and DLPD). The Ministry then studies the changes and finally handles the legalities of making the changes.

e) Quality assurance programmes to be in place

Stakeholders in the chain should be given a period in which they are to put in place quality assurance systems for their operations.

f) Minimum standards for products

The sector should agree on minimum standards for products which will be used in the system. The currently developed harmonized standards for COMESA are a good reference which the sector can adopt so that the sector is in line with regional developments. Approved and applied certification standards will be a tool to get to quality milk collection and transportation starting from the farm through to the processing plant.

g) Training syllabuses for proficiency testing of employees

According to the CDO syllabuses exist in the dairy regulations (RGN, 1977) for proficiency testing of dairy personnel. However, these need to be updated in line with international developments in the dairy industry. Technical people in the dairy sector as well as regional and international experts can be consulted and be involved in drafting the syllabuses.

h) Consumer education or generic advertising

The success of the system will depended on the support given by the consuming public as to whether they will be willing to pay for quality. There is therefore need for mass media campaigns so that the public develops the culture of consuming only certified products. One of the processors visited was very enthusiastic on the idea of ICCS mentioning that those who would be excelling in production of quality products should be given awards as a way of encouraging others to copy and follow their achievements.

i) Favourable environment where strong actor linkages and relationships exist within the sector

The existence of strong actor relationship in the sector is likely going to be an advantage in getting everyone to work together for a common purpose. These linkages will facilitate both quality and quantity assurance and will contribute to the growth of each of the players.

The interview with the Chief executive officer of NDC yielded the following information:

- Government should ensure that the producers are assured of security of tenure
- Government should formulate policies which are favourable and aimed revitalizing the dairy sector

5.8.2 Constraints to introduction and implementation of ICC

The dairy sector as whole has no control of what happens to its environment and so in order to be able to cope with this it will have to adopt new ways of functioning as a way of strengthening chain development. However change is a dynamic process which consists of two forces: one pushing in the direction of change and the other pulling in the opposite direction. There is therefore need for the sector to increase the strength of the forces pushing for change so as to succeed in planned changes. To illustrate this, the Lewin's force field analysis Model will be used (Figure 5.2).

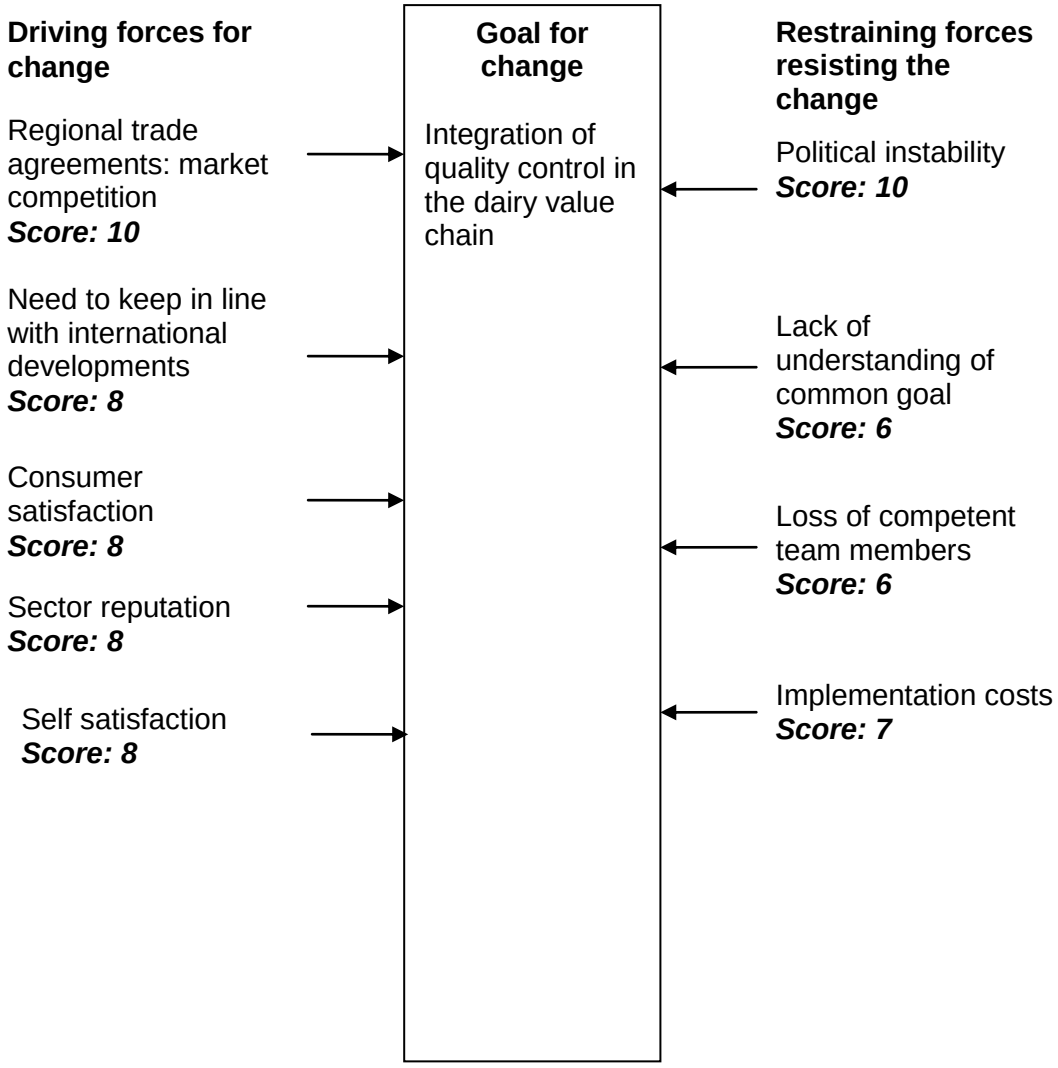

Figure 5.2 Lewin's force field analysis for changes in quality control system

From the analysis (Figure 5.2) it can be seen that the chances of success in implementing the goal of introducing an integrated quality control system are very high.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The study appears to suggest that milk contamination and deterioration during storage are the main causes of poor milk quality at farm dairies. There is therefore need to focus on approaches that address milk storage and transportation problems. Although equipment and facilities as well as the cleaning of dairy equipment and milking practice are unsatisfactory, the study could not prove that there were significant sources of contamination to milk in part of the local dairy chain. The information gathered from the study enabled the identification of possible areas for further development of hygiene education and guidance programs for stakeholders in the dairy sector. Stakeholders in the sector are fully aware of the importance of producing quality products and agree to the need for an integrated chain control system as a possible approach which can be adopted by the sector. Technical expertise is limited in the country thus the system would need to rely on hiring international experts to help in training and implementing the system which would require reliable funding for the initial set up. It can therefore be concluded that only if the sector secures a financial partner to work with, then the chain control system is feasible.

6.2 Recommendations

Basing on findings from this study, recommendations are therefore going to be made to the dairy sector. The dairy sector through ZDIT should set up committees to draft standards of hygienic codes of practices for stakeholders in the value chain. DSU as the institution responsible for regulation of the sector should spearhead the setting up of a legal framework incorporating approved and certified codes of practices for actors in the chain. All strategies to be employed in introducing the quality control programme should be implemented through awareness creation and training.

Although there is noticeable progress, however a special attention needs to be given to whole milk chain as main component in dairy sector e.g. giving awards for best quality products, milk quality management at processing unit, improving raw milk quality.

Training for dairy farms

The dairy sector needs to organise through MIG trainings for farmers and their farm workers who are involved in handling milk in milk hygiene and the physical characteristics of raw milk. The trainings should focus on the following topics;

- Pre milking procedures i.e. importance of washing milkers' hands before milking, washing and drying of the udder, teat dipping
- Recommended dairy equipment
- Cleaning procedures for dairy utensils used for storing and transporting milk
- Milk storage requirements and conditions

From the drawn conclusions it can be seen that the dairy sector should assume as its objective, the introduction of a sustainable operating quality control system that will ensure the quality and safety of dairy products available to consumers, thereby safeguarding and supporting the viability of the sector. This should clearly separate quality driven, responsible and committed operators form unscrupulous operators trying to make a quick profit. Through promotion and education of consumers by the dairy sector working together with relevant government institutions and other public health organizations, this should empower the general public to get value for their money. ZDIT should sponsor visits by experts from the region to provide technical support in designing and implementation of quality control assurance programmes.

Suggested framework for ICCS in the local dairy sector

First and foremost it is essential for those involved in dairying to have a clear understanding of the underlying need for the dairy sector to be quality driven and thus assume responsibility for achieving food safety and good quality. The coming onto the local scene of an international organization, Land O'Lakes Inc International Development provides stakeholders in the dairy sector an opportunity to formulate strategies aimed at addressing quality and safety of milk and dairy products which fails in line with one of the key areas of Land O'Lakes. The organization has food systems and food safety as one of its five key practice areas. This is achieved through working with agriculture sectors in developing countries in strengthening the business and technical capacity of stakeholders throughout the agricultural value chain. Land O'Lakes also works with the food industry to upgrade quality assurance systems and food product specifications to meet market requirements (Land O'Lakes Inc, 2010)

Methodology

ZDIT should set up committees which will be tasked on behalf of the sector to produce reports which will be agreed upon and adopted in setting the system. The committees should be set up to work in the following areas;

- Expected administration of the system
- Training needs of monitoring authority staff
- Expected facilities
- Production and operating procedures for stakeholders (codes of conduct)
- Quality assurance programmes to be in place
- Minimum standards for products
- Consumer education or generic advertising
- Training syllabuses for proficiency testing of employees

From information gathered in desk research as well as information obtained from the field work carried out during this study, the researcher recommends for the committees, the following as a way of setting up this system. The recommendations are made basing on reference made to the Macedonian seal of quality system (Land O'Lakes Inc, 2003).

Monitoring authority

Dairy Services Unit as an independent regulatory authority to monitor the system. This will include an on-site verification to check on implementation of approved safety assurance systems (Ababouch, 2000). Operators meeting quality requirements are to be awarded a quality stamp or logo to put on their products. Through consumer education and generic advertising, consumers should be made to understand that they should purchase only products bearing the logo or stamp.

Economic sustainability of system

The cost of the system will be met through charges made by Dairy Services for its services or for the sale of each logo. This will allow DSU to become a partner in the quality management system rather than a policeman. There is also possibility of funding by the international organization Land O'Lakes Inc which has made its intention known to the sector of its willingness to support in upgrading quality assurance systems

Components of the system

1) Registration of operators

Registration should be dependent on the facilities, equipment, system and services to be used in production or processing. For dairy farmers this would cover premises, equipment the agreed code of conduct. The need to cover these areas has been highlighted by findings from this study which showed the need for improvement. For dairy processors this

would also cover the quality assurance and manufacturing processes being followed. This study also revealed that employee skills form an important contribution in production of quality products. It is in this view that an additional criteria maybe the competency of employees. With reference to re-registration, it may be possible to exempt from re-inspection, those who have exceptionally clean records. However they would need to pay an administration fee for renewal of their certificates.

2) Product testing

Testing of end product will be the monitoring tool. Every product line will be sampled in line with agreed procedures. A product status or grade will be established from results of tests over an agreed time e.g. six months (rolling mean) whereby new results replace the oldest. Each month the processor is given a certificate showing the current status. Logos will be colour coded to indicate the grade of the product. If the quality of the product deteriorates, the processor has sufficient warning and is without delay able to take steps to resolve the situation either through help from other stakeholders which includes consultants or the monitoring authority.

3) Awards

Sector awards should be given as a way of encouraging others to improve their operations as well as make aware the consuming public about existing local products which have gained high quality status.

4) Advisory services and technical training

Discussion and observations during this study showed that basic hygiene practices are not being employed by those involved in handling milk and milk products. This demonstrates the need for intensive training programmes targeting the following shortcoming areas identified by the study which are;

- Workers hygiene
- Cleaning procedures for machinery and equipment
- Pre milking practices

Stakeholder associations (NADF, ZDPA, DDP etc) and other private organizations should form strategic partnerships with government institutions in order to have a fast message delivery to intended beneficiaries e.g. farmers. This will allow for the strengthening of linkages of participants in the dairy sector. DSU will be required to carry out proficiency examination of trained individuals and reinforce the training with provision of certificates.

Addressing energy shortages

In the coming years solutions to addressing the erratic power supplies which is affecting milk storage are unlikely to come soon from the state authority responsible for provision of electricity to the country. The dairy sector therefore needs to look at its own initiatives which will allow for operations to continue without disruptions. One option would be the use of renewable energy such as solar power which is abundant in the region. Stakeholder associations should on behalf of its members engage local and international organizations involved in promotion of environmental sustainability through the use of clean sources of energy. The Southern Institute Development and Research Council (SIRDC) is one local research organization which the sector can work with as it is involved in developing technologies which are adapted for the local situation. An example provided by Total (2010) is in South Africa where KwaZulu Energy Company has equipped isolated households with power. Photovoltaic panels can be used for lighting, power for appliances, refrigeration, telecommunications, water pumping and supply, and sanitation.

6.3 Limitations of the study

The milking time employed at dairy farms limited the study as it was difficult to visit all the dairies during the period milking in order to get valuable data through visual observation. For dairy farms visited when milking was not taking place, the researcher had to rely on verbal information on practices which are carried out such as teat dipping, cleaning of udders among other variables in the research. This had the implication of being given socially desirable answers. Although the researcher had a planned itinerary for data collection, this had to constantly change during the course of data collection as the vehicles allocated for the field work are pool vehicles which sometimes needed to be used for urgent business in the department. This therefore meant that the researcher had to work on weekends so as to cover all intended visits. This time was used to do desk research in which information was collected from departmental reports and minutes of meetings held between stakeholders in the sector. In order to carry out an in depth study, the researcher did not include in the field study the part of the chain from processing to consumption with information used mainly based on literature review. It was therefore not possible to get information on how local consumers perceive quality for dairy products consumed and whether there is willingness to pay prices differentiated by quality and also the views of retailers could not be captured. This therefore gives an opportunity for further research centred on consumers and retailers in the dairy sector value chain.

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Annex 1 Questionnaire for Producers

Type of milking	Hand	☐	Machine	☐
Delivery method	Can	☐	Bulk	☐
Delivery interval	24-48hrs	☐	>48hrs	☐

1. How often do you have your milking machine tested?
   a) 0-6mths b) 6-12mths c) 12-18mths d) <18mths

2. What is the condition of rubber liners? (N.B hand milking i.e. Cans)
   a) excellent b) good c) fair d) bad d) very bad

3. What is the condition of floors in the dairy premises;
   a) excellent b) good c) fair d) bad d) very bad

4. Do you sanitize liners during milking between cows? (N.B hand milking i.e. Cans)
   a) yes b) no

5. Do you use a sanitizer to clean your equipment after milking/use?
   a) Yes b) No

6. Do you use a detergent to clean your equipment after milking/use?
   a) Yes b) No

7. Do you use a detergent and sanitizer to clean your equipment after milking/use?
   a) Yes b) No

8. Do you always use hot water (>100^{o}C) in your cleaning? Source of water_____
   a) Yes b) No

9. What is the status of protective clothing in terms of;

Availability	a) available	b) not available	
Condition	a) good	b) fair	c) bad
Cleanliness	a) clean	b) dirty	

Storage and use a) kept and used only at dairy
b) Used only at dairy and kept at home
c) Multipurpose use

10. Do you have wash facilities for workers? a) yes b) no

11. Do workers wash before milking at the dairy?: a) Yes
    c) No

12. Do you have toilet facilities for worker?: a) yes b) no
    i) Hand washing basin with soap a) yes b) no

13. Is there proper functioning drainage system at in the dairy?:
    a) yes b) no

14. Do you clean udders before milking?
    i) with disinfectant a) yes b) no
    ii) with water and disposable paper towel a) yes b) no
    iii) with water and re-used cloths a) yes b) no

iv) with water only and no drying a) yes b) no

15. Do you perform pretesting for mastitis before milking? a) yes b) no

16. Do you use teat dip on cows after milking a) yes b) no

17. What is the temperature at which your milk is stored?: _____

18. What equipment is used to verify the temperature?_____

19. What do you see as contributing to contamination in your dairy?
(On a scale 1-5; where 1=least & 5 = most)
    a) workers hygiene 1 2 3 4 5
    b) milk parlour condition 1 2 3 4 5
    c) condition of milk machine and equipment 1 2 3 4 5
    d) storage temperatures 1 2 3 4 5
    e) cleaning procedures 1 2 3 4 5
    f) lack of knowledge of workers 1 2 3 4 5
    g) other (list)_____

20. How do you rate the importance of milk quality?
    a) Extremely important
    b) Very important
    c) Somewhat important
    d) Neither unimportant or nor important
    e) Somewhat unimportant
    f) Very unimportant
    g) Extremely unimportant

21. What are drivers for producing high quality milk?
(On a scale 1-5; where 1=least & 5 = most)
    a) Premiums 1 2 3 4 5
    b) consumer satisfaction 1 2 3 4 5
    c) legal obligation 1 2 3 4 5
    d) self satisfaction 1 2 3 4 5
    e) sector reputation 1 2 3 4 5
    f) other_____

22. what is your opinion on the producer price being paid
    a) exactly what I need b) what I need c) more or less what I need
    d) Neutral e) not really what I need f) not at all what I need

23. What is your weighted average TBC grade for the last 6 months_____

24. Give a mark for the technical service you get from other stakeholders in the sector in addressing quality problems
None at all 1 2 3 4 5 very much

25. What is your opinion on current legal standards on quality?
    a) appropriate totally disagree 1 2 3 4 5 completely agree
        explain_____
    b) outdated totally disagree 1 2 3 4 5 completely agree
        explain_____
    c) too strict totally disagree 1 2 3 4 5 completely agree
        explain_____

26. What do you think needs to be done by the sector to ensure production of quality products?

27. What role can you play in ensuring production of quality products?

28. What do you think on the option of ICCS as a way to ensure quality of dairy products? totally disagree 1 2 3 4 5 completely agree
    explain_____

29. What do you view as the three most important assumptions necessary for success of ICCS?

Annex 2 Check list for Transporter

1. What is the ideal and the current vehicle fleet versus number of clients serviced?
2. What cleaning method is employed for your milk transport fleet?
    a) CCP b) manual
3. Who is responsible for cleaning of tankers?
    a) Processor b) transporter
4. What cleaning procedure is employed when tanker arrives at factory?
    a) Cleaning before offloading b) no cleaning before offloading
5. What is the frequency of cleaning of tankers?
6. What is the maximum time a vehicle is allowed to stay on the road after breakdown?
7. How often do you carry out swabs on the vehicles?
8. What is the condition of your vehicles
9. What training is given to drivers/ samplers?
10. What procedure is used for monitoring temperature of milk from collection to delivery?
11. What do you see as limiting the provision of proper service?
    a) road condition
    b) condition of vehicles
    c) distribution of your clients
    d) viability
    e) untrained drivers on milk handling

12. What value do you put on milk quality?
    a) Extremely important
    b) Very important
    c) Somewhat important
    d) Neither unimportant or nor important
    e) Somewhat unimportant
    f) Very unimportant
    g) Extremely unimportant

13. What are drivers for producing high quality milk?
    (On a scale 1-5; where 1=least & 5 = most)
    a) Premiums 1 2 3 4 5
    b) consumer satisfaction 1 2 3 4 5
    c) legal obligation 1 2 3 4 5
    d) self satisfaction 1 2 3 4 5
    e) sector reputation 1 2 3 4 5
    f) other_____

14. What measures have been taken by your organization to address constraints in milk handling?

15. What is your opinion on current legal standards on quality?
    a) appropriate totally disagree 1 2 3 4 5 completely agree
    explain_____
    b) outdated totally disagree 1 2 3 4 5 completely agree
    explain_____
    c) too strict totally disagree 1 2 3 4 5 completely agree
    explain_____

16. What do you think needs to be done by the sector to ensure production of quality products?

17. What role can you play in ensuring production of quality products?

18. What do you think on the option of ICCS as a way to ensure quality of dairy products? totally disagree 1 2 3 4 5 completely agree
    explain_____

19. What do you view as the three most important assumptions necessary for success of ICCS?

Annex 3 Check list for Processors

1. What platform tests are done at milk reception?
2. What is the rejection process for milk of poor quality?
3. What is the condition of milk reception facilities?
4. What is general condition of the factory building?

5. How is the milk reception protected from contamination;
    a) birds
    b) rodents
    c) wind and dust

6. Protective clothing:
    a) availability
    b) Condition
    c) Cleanliness
    d) Storage and use:

7. Do you have wash facilities for workers?:
    a) Is there provision for hot and cold water
    b) How frequent do workers wash:

8. How often do workers undergo for medical checkups?

9. Do you have toilet facilities for worker:
    a) Hand washing basin?
    b) With soap?

10. What is the handling procedure for raw materials at the factory?
    a) Packaging material
    b) ingredients:

11. What is the level of record keeping for monitoring?
    i. temperature:
    ii. product traceability
    iii. production records

12. What value do you put on milk quality?
    a) Extremely important
    b) Very important
    c) Somewhat important
    d) Neither unimportant or nor important
    e) Somewhat unimportant
    f) Very unimportant
    g) Extremely unimportant

13. What are drivers for producing high quality milk?
    (On a scale 1-5; where 1=least & 5 = most)
    a) Premiums 1 2 3 4 5
    b) consumer satisfaction 1 2 3 4 5
    c) legal obligation 1 2 3 4 5
    d) self satisfaction 1 2 3 4 5
    e) sector reputation 1 2 3 4 5
    f) other_____

20. What is your opinion on current legal standards on quality?
    a) appropriate totally disagree 1 2 3 4 5 completely agree
       explain_____
    b) outdated totally disagree 1 2 3 4 5 completely agree
       explain_____
    c) too strict totally disagree 1 2 3 4 5 completely agree
       explain_____

14. Which international food safety procedures have been implemented?
    a) HACCP
    b) Other

15. What is being done by your company to assist producers improve on milk quality?
    a) advisory services
    b) trainings
    c) other

16. What other actors or stakeholders are you working with to address milk quality and safety issues? (name, activity).

17. What assistance do think should be provided by other actors and stakeholders? (by whom, type of assistance)?

18. What do you think needs to be done by the sector to ensure production of quality products?

19. What role can you play in ensuring production of quality products?

20. What do you think on the option of ICCS as a way to ensure quality of dairy products? totally disagree 1 2 3 4 5 completely agree
    explain_____

21. What do you view as the three most important assumptions necessary for success of ICCS?

Annex 4 Check list for feed company

1. What is your opinion on current legal standards on feed quality
    a) appropriate totally disagree 1 2 3 4 5 completely agree
    explain_____
    b) outdated totally disagree 1 2 3 4 5 completely agree
    explain_____
    c) too strict totally disagree 1 2 3 4 5 completely agree
    explain_____
2. What are the drivers for producing quality feed at your company?
    (On a scale 1-5; where 1=least & 5 = most)
    a) consumer satisfaction 1 2 3 4 5
    b) legal obligation 1 2 3 4 5
    c) self satisfaction 1 2 3 4 5
    d) sector reputation 1 2 3 4 5
    e) other_____
3. what is your opinion on the current feed prices
    a) exactly what you need b) what you need c) more or less what you need
    d) Neutral e) not really what you need f) not at all what you need
4. What do you see as the main causes of poor quality feed products?
5. What is being done by your institution to address product quality issues?
6. What do you think needs to be done by the feed manufacturing sector to ensure production of quality products?
7. What has been the level of participation of actors and stakeholder from the sector in formulating possible solutions to addressing quality of products?
    (On a scale 1-5; where 1=least & 5 = most)
    1 2 3 4 5
    Explain what you see as the main reasons for the above:

8. Give your opinion and views on the role that feed companies as input suppliers in the local dairy food chain can take in an integrated quality control management system.

Annex 5 Check list for Dairy regulatory institution

1. What is your opinion on current legal standards on quality?
    a) appropriate totally disagree 1 2 3 4 5 completely agree
    explain_____
    b) outdated totally disagree 1 2 3 4 5 completely agree
    explain_____
    c) too strict totally disagree 1 2 3 4 5 completely agree
    explain_____

    Explain:
1. What are your views on actor responsibility in maintaining high quality standards
    a) very high responsibility
    b) adequate responsibilities
    c) less responsibilities
    d) no responsibility

    Explain:
2. What do you see as the main causes of poor quality for dairy products?
3. What is being done by your institution to address quality issues?
4. What has been the level of participation of actors and stakeholder from the sector in formulating possible solutions to addressing quality of products?
    (On a scale 1-5; where 1=least & 5 = most)
    1 2 3 4 5
    Explain what you see as the main reasons for the above:
21. What do you think on the option of ICCS as a way to ensure quality of dairy products? totally disagree 1 2 3 4 5 completely agree
    explain_____

Annex 6 List of interviewees

Organisation	Person Interviewed	Actor level
Agrifoods Private Limited	Nutritionist	Input Supply
National Association of Dairy Farmers of Zimbabwe	Chairperson	Dairy farmer association
Dairy Development Programme	Deputy Director	Smallholder dairy farmers development organisation
National Dairy Cooperative	Chief Executive Officer	Transportation
Zimbabwe Dairy Processors Association	Chairperson	Processors association
Dairibord Zimbabwe Private Limited	Quality Control Manager	Processor
Kefalos Cheese	Production Manager	Processor
Zimbabwe Dairy Industry Trust	Chairperson	Trust for the dairy sector
Dairy Services Unit	Chief Dairy Officer	Government regulatory institution