



Project description MFQ thesis projects

**Understanding technological and managerial factors affecting
quality of dairy product in the supply chain in China**

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Executive Summary

Melamine-tainted infant formula scandal happened in 2008 had revealed severe safety problems existing in China's current dairy industry. This scandal has almost devastated the domestic dairy product industry, and consumers began to lose confidence in the safety of domestic dairy products. Raw milk is the primary source for all kind of dairy products. In other words, the safety and quality of raw milk has fundamentally determined the quality and productivity in the later-on processing plant.

In china, small-scale dairy farms (owing 2-4 cows) contribute to more than 70% of total raw milk production. However, the status of raw milk production in those household farms is in a critical condition. Village Milking centres (VMCs) serve as a bridge between small-scale farms and dairy processor by providing milking facilities. Due to lack of hygiene awareness and poor safety control in small-scale farms, raw milk is much more susceptible to all kinds of contamination. In view of food safety, microbial counts as quality indicator of raw milk and the possible impact of specific influence factors are of central importance.

Thus, the purpose of this research study is to analyze the factors that influence the microbial safety of raw milk in China through a techno-managerial approach. As a basis for this study, FSMS diagnose instruments developed by Luning and co-authors (2008 a,b,c) was used as an instrument to diagnose the food safety performance in on-farm and VMCs level.

To understand the details of the problems relating to the performance of their own specific system a systematic theoretical analysis was done in Chapter 2 using scientific literatures and information. It provides a clearer picture of the situation and a comprehensive understanding of the problems. According to the FSMS study and model analysis, a conceptual research model was developed, in Chapter 3, to specify the problems in China's raw milk production system. From the research model, indicators were identified and analyzed in detail. To investigate factors illustrated in the research model, practical research was carried out in the rural area of China. Questionnaires were prepared to gather more information from farmers and VMCs. Practical research was done by interviewing 8 VMCs and 30 farms which were selected as respondent. The result was discussed in Chapter 4. The results show that the points of improvement are lack of a standard operation guideline for milking and farming, lack of knowledge about hygiene performance from farmers and VMC worker and more importantly lack of an efficient inspection system. Chapter 5 focuses on developing improvement strategies for solving these weak points, from both technological and managerial aspects. Afterwards, a critical evaluation is made for those strategies with regards to applicability and capability to implementation. This thesis ends up with an evaluation of entire research process.

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Chapter 1 Introduction to the problem

1.1 background of the problem

The dairy product industry has been one of the fastest growing industries in China, with an annual growth rate of over 20%. The total retail market for dairy products increased in value to RMB28.3bn (US\$3.7bn) by 2007, having risen in value by 186% over 2001. In 2007, China's dairy product industry sustained rapid growth, with an annual output of 17.87 million tons, up 21.79% from 2006. By the end of 2007, the cow population reached 12.189 million herds, with 14% growth compared to 2006. The total milk output of 2007 reached 36.334 million tons, up 10% from 2006. The cow milk output stood at 35.252 million tons, ranking 3rd around the world, second only to the US and India.

However, severe problems are emerging out of surface of the fast growing appearance. In the autumn of 2008, the "melamine" scandal has almost devastated the domestic dairy product industry, and consumers began to lose confidence in the safety of domestic dairy products. The origin of the tragic incident of contamination is diluted milk in which the industrial chemical melamine has been added to mask protein count in quality tests.

The infant formula produced by Sanlu, China's largest producer of infant formula, was firstly tested to be contaminated by melamine. The following nationwide inspection of dairy products from more than 100 dairy food producer have revealed that the problem is much more widespread, with melamine found in samples of dairy food from more than 68 dairy producers, including two of China's largest producers, Sanyuan and Guangming. Other world brands, such as Fonterra and Nestle, were dragged into the effects of this scandal on their supply chains. The suspected contamination had spread beyond the mainland, with Japan, Singapore, and Hong Kong recalling Chinese-made dairy products, breads and candies made from these products. This tragedy highlighted the flaws of whole food supply chain in China, and the failure supervision of China's Quality Ministration and Inspection agency. The entire dairy food supply chain was seriously demolished and required to be reformed.

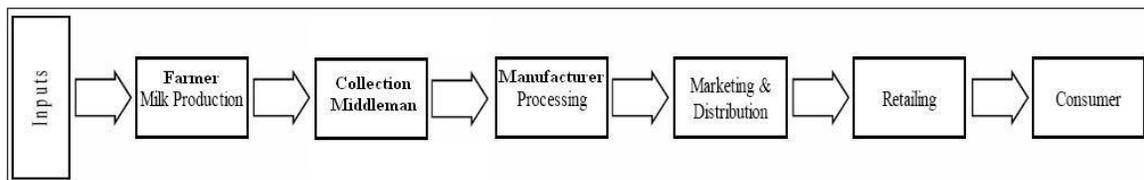


Figure 1. The generic dairy food supply chain.

The dairy-food supply chain embraces all participants from milk production through to consumer. Figure 1 maps a generic dairy-food supply chain, where milk is processed into drinking milk or milk products, marketed and distributed to the retail segment before being consumed by the end-user. In this dairy chain, quality of dairy product could be affected by both external and internal factors, for example, the microbial contamination can be induced in almost every process, including the milking in the farm, transportation of raw milk or final product, raw milk collection by middleman and manufacturing by producer. Temperature-time control is also a critical element that assure the quality of dairy product in whole supply. Therefore, controlling and management of very factors along the chain is the mean to meet the customers' quality demand.

1.2 Problem feeling

The melamine scandal revealed the severe milk quality and safety problem happening in China's milk supply chain. It is becoming more clear that melamine is not the only contaminants tested in the dairy products. Bacteria count in some of products were much higher than the acceptable level. The investigation of melamine scandal had also shown that there were more than one contamination source of melamine or other kinds of contaminant, like microorganism, along the supply chain, including animal feeding, dairy farmers, collection centers and manufacturers. In this sense, in order to ensure the safety and quality of dairy products, supply chain of milk must be tightly controlled in very single factor, from raw milk production to retailing of dairy productions. In developing country like China, various factors are combined to compromise the quality of milk product. Beside quality controlling on dairy supply chain, disfunctioning of regulatory systems on the level of government also plays a very important role in quality control system. Comparing two quality management system between EU and U.S., which is quality control along the supply chain versus quality regulatory and sterilization, the EU model is believed to be powerful and efficient for the dairy quality control, especially for the developing countries. A Food Safety Management System diagnostic instrument will be applied in this research to investigate factors and their contribution to the final dairy quality along the dairy supply chain according to China's actual situation. Aim of my research is to find ways to improve the dairy quality and safety control along the supply chain.

1.3 Problem definition

Small householders of dairy farm contribute to more than 70% of total raw milk production in China. The product quality of China's dairy industry is highly determined by the raw milk production performance of small scale farmers. In order to achieve and maintain high quality of final dairy products, control of raw milk production from small scale farms, therefore, is crucial. By means of raw milk quality control, demands of high quality of milk from consumers and high quality of raw milk from dairy processors could be satisfied. However, the status of raw milk production in household farms is in a critical condition. The raw milk produced by those small-scale farms is particularly susceptible for contaminations, for example microorganisms and chemical residues, as a result of poor quality control. Therefore, there is a need to assess FSMS (like HACCP, GDP) applied in those small-scale household farms.

Luning *et al* (2008 a, b, c) have proposed a diagnostic instrument that can be used to analyze the control and assurance of the FSMS system in order to identify the weaknesses and opportunities for improvement and/or implementation of new control and assurance measures and or techniques. These studies could be used to assess the situation of raw milk production in China and identify the critical factors that need to be considered to improve the food safety management system.

Therefore the problem definition for this research will be formulated as follow:

What are the critical factors that influence the performance of Food safety management system in China raw milk production from small-scale dairy farm and how to establish an efficient food safety management system that is suitable for the Chinese raw milk production situation?

1.4 Hypothesis

To improve the microbial safety performance of the food safety management system (FSMS) in China's dairy industry it is essential to have commitment from small scale dairy farm management

and VMC management to ensure the safety of raw milk. The fact that closely connected relation between small scale dairy farms and VMCs in China facilitates the implementation of a specific system for food safety management. The system is very largely influenced by farmers' and VMCs workers' knowledge and their compliance to food safety standard hygiene procedure.

1.5 Research objective & questions

The aim of this research is to study the current performance of the food safety management system in China's rural dairy industry and to analyze the factors that affecting the quality of dairy products throughout the whole chain, by which means that the existing weaknesses and opportunities for improvement of food safety management system will be identified. This research is focus on investigating the raw milk production. Factors that influence FSMS with respect to microbial and chemical safety of raw milk will be analyzed through a techno-managerial analysis. At the end, the opportunities to improve the performance of raw milk production in China would be derived.

According to the objective, several research questions will be formulated in the following:

1. What are the factors that influence the performance of the food safety management system with respect to microbial and chemical safety?
2. Which of those factors are mainly contributing to a good performance of food safety management system with regards to microbial & chemical safety in China's dairy industry?
3. What are the weaknesses that constraint the improvement of raw milk quality?
4. What are the alternative solutions that can be applied to overcome those weaknesses?

1.6 Research plan

The plan for this research is divided into four different phases which have various activities to be undertaken. These are the following phases with the plan of activities:

1. Appreciation phase:
This is a preliminary phase of the research in which problem feeling and an in-depth awareness on the problem will be undertaken. In order to be able to appreciate the problem, a techno-managerial analysis to the problem is conducted, the following activities are to be performed:
 - a. literature finding and exploration of other information and data in order to understand the problem;
 - b. finding for literatures and models that will support the problem feeling;
 - c. defining the problem statement;
 - d. formulation of hypothesis;
 - e. identification of research objective(s);
 - f. preparation of a research plan and research approaches.
2. Analysis phase:
In this stage of research, a thorough analysis of literatures, models and data will be carried out including:
 - a. more literature research and model analysis;
 - b. data gathering through survey, including questionnaires, interview with dairy farmers and farm visiting;
 - c. data analysis;
 - d. identification of bottlenecks
3. Assessment phase:
After research of literature and analysis of collected data, the bottlenecks would be indentified.

Alternative solutions will be proposed to bottlenecks. Criteria will also to be formulated to assess the effectiveness of different solutions.

4. Evaluation phase:

The developed solutions will have to be critically evaluated as to its effectiveness to solve bottlenecks. Finally, the whole research will be evaluated.

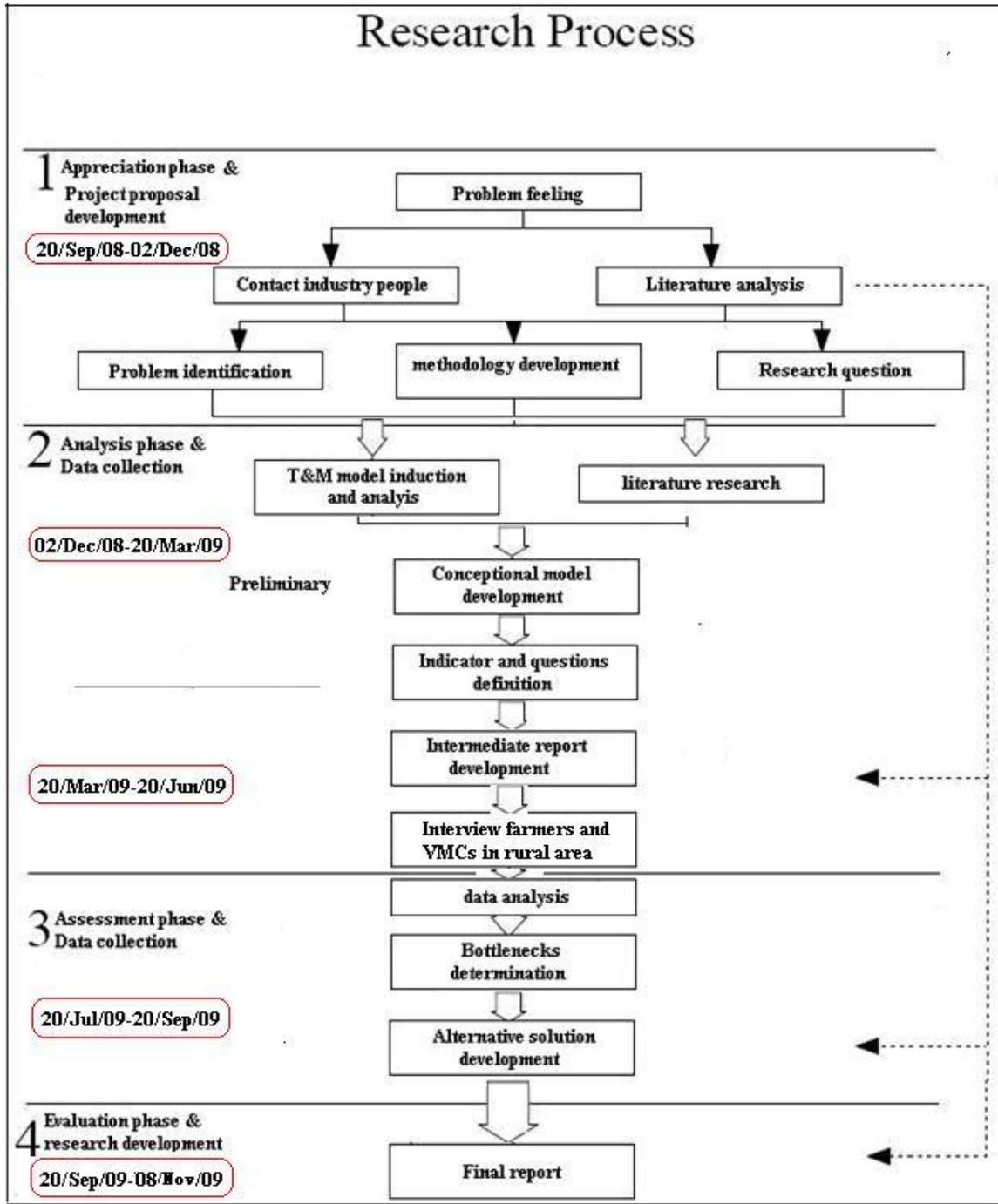


Figure 2. Thesis research plan.

In the next chapter, I will focus on the discussion of the different theories available to support the

problem feeling of this research study. In order to achieve a high food safety management system, personnel performance is one of the most critical factors that need to be managed, especially to the situation of China's dairy production system. In China, more than 70% of dairy farms are small-scale and are managed traditionally and microbial count is the most important problem facing dairy farmers. There is very less standard or regulation for dairy farmers on rising cows, therefore in very large extent that their performance determines the quality and safety of raw milk. Therefore, it is important that dairy farmer's knowledge will be increased about quality and safety of milk and dairy products. Training and guidance should be given to dairy farmers and VMCs workers who are responsible for milking, emphasized the need for hygienic practices at the farm and VMCs. Much of researches have been done that safety of dairy products can be enhanced by adopting proper management practices.

Chapter 2 Theory analysis

Considering the problem feeling, diagnosis and analysis the food safety system is an important aspect to evaluate the weaknesses and to find potential points for improvements of exiting system (Luning *et al.*, 2008a). To China, it is especially an efficient approach to fix or reconstruct the dairy supply chain. Thus, in this chapter literature findings and models (both technical and managerial) will be introduced in order to have a comprehensive understanding about the dairy quality problem in China. At the first of this chapter, the FSMS diagnostic instrument developed by Luning *et al* (2008, 2009) will be described. Based on this instrument, characteristics about raw milk quality will be described, including the compositional and hygienic quality. Hygienic quality will be detailed investigated considering that it is the major point to control for ensuring quality of raw milk. Hygienic quality will focus on the potential microbial and chemical contamination associated with raw milk production, transportation and storage. The possible monitoring and control strategies will also be introduced.

2.1 Food Safety Management System diagnostic instrument

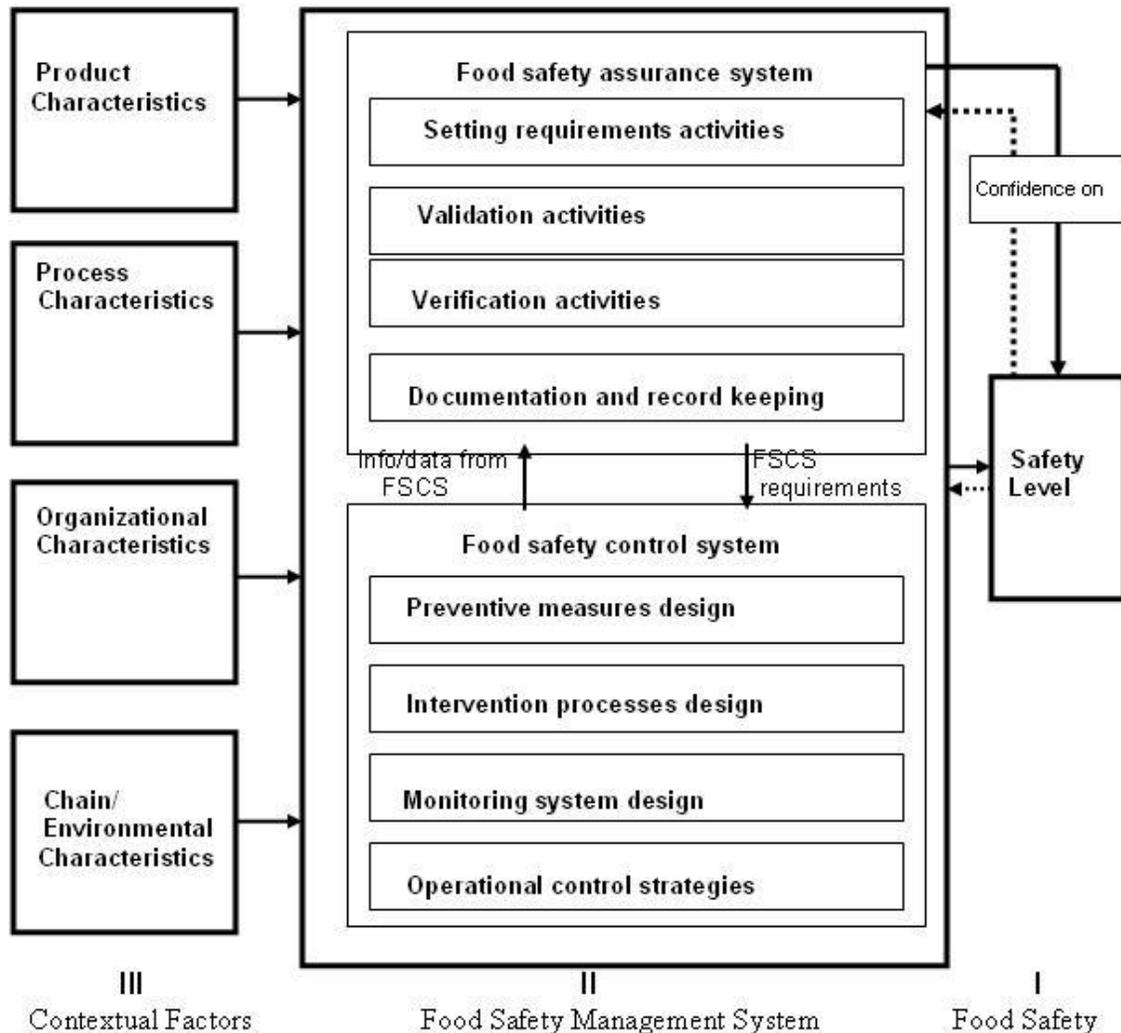


Figure 3. Conceptual model to measure effectiveness of Food safety management system (*developing*)

model from Luning and co-authors, 2008 a b c)

This diagnostic instrument is developed by Luning and co-authors (2008, 2009). This techno-managerial model explained that the level of food safety is highly dependent on the performance of a food safety management system (FSMS) implemented during food production and is being influenced by contextual factors. FSCS (Food Safety Control System) and assurance activities are relevant to the effectiveness of implementation of FSMS. This instrument is appropriate model to use to analyse the critical factors that influences performance of FSMS and this will be used as a basic model throughout the whole research. This model emphasized that its implementation is also influenced by contextual factors (product, process, organization and environmental characteristics). Thus, by understanding these factors it will help us realize the effective implementation of the system. Following the main point of the diagnostic instrument will be described, and detailed description can be found in the original article of the diagnostic instrument (Luning *et al.*, 2008 a, 2009).

2.1.1 Contextual factors

The contextual factors are classified into four characteristics which may negatively affect food safety. The four characteristics are:

- ***Product characteristics:*** These characteristics refer to the typical intrinsic characteristics of a product which influence its safety and quality. It depends on initial contaminations (microbial, chemical and physical), final product risk and type of packaging. It is assumed that the more vulnerable the product characteristics i.e. higher the initial contamination of microbial hazards such as from mastitis, the higher the demands on a FSMS for more control activities and assurance activities.
- ***Process characteristics:*** These characteristics are explained by the intervention that food safety and quality could be influenced by the process characteristics and operation characteristics like the milking equipment, facilities, and barn conditions. It assumes that the more influential to food safety they are, the more need for sophisticated FSMS.
- ***Organizational characteristics:*** Food safety are influenced by these characteristics in respect of creating conditions for decision making process by attracting, developing, and maintaining a quality work force, organizational structures and by information systems. For example, lack of technical workforce, lack of management commitment or absence of formalization etc. are all referred to organizational characteristics. The poor performance of organization would lead to poor decision making on food safety control activities, thereby influences the food safety of product.
- ***Environmental characteristics:*** These characteristics are referring to the interest and power relation, dependencies of a company or a farm. These factors influence the decision making ability directly. The assumption is that environmental characteristics, which create a higher dependency of the company or farm on its environment, make the company or farm more vulnerable to food safety problems, leading to higher demand for a sophisticated FSMS.

2.1.2 FSCS diagnostic instrument

To assess the effectiveness of the Food Safety Control System (FSCS) on food processing companies Luning, Bango, Rovira and Marcelis (2008a) have introduced a diagnostic instrument which is based on techno-managerial approach. The diagnostic instrument described the critical factors which influence the performance of the FSCS. The instrument is principally suitable for the analysis of systems aimed at controlling microbial safety. The diagnostic instrument consists in essence of two components. They are:

- 1) Comprehensive analysis: A list of crucial control activities aim at microbial food safety;

2) Assessment grids: Levels to assess to which extent these activities are implemented or executed.

There are three food safety control strategies distinguished for this instrument:

1. Preventive measures: These measures are aimed at creating circumstances that prevent/avoid the entry or growth of pathogens in the food production system.
2. Intervention Processes: These processes aim at inactivating or eliminating pathogens in order to reduce them to acceptable level, involving physical, chemical or biological interventions.
3. Monitoring systems: These systems provide information about the actual status of product or process conditions which enables process corrections, removal of non-performance products and system improvements in case of structural deviations.
4. Actual operation: The actual performance of preventive measure, intervention process and monitoring system are assessed into three different levels, low, medium and high based on assessment grids (Luning et al., 2007). It provides insight into how and at what level food safety is controlled.

Each of these up-mentioned three strategies contains both the technology-dependent activities and managerial activities, as they are both assumed to influence the performance of such systems (Luning and Marcelis, 2006, 2007). Elements of comprehensive checklist of crucial control activities are represented in Figure 4.

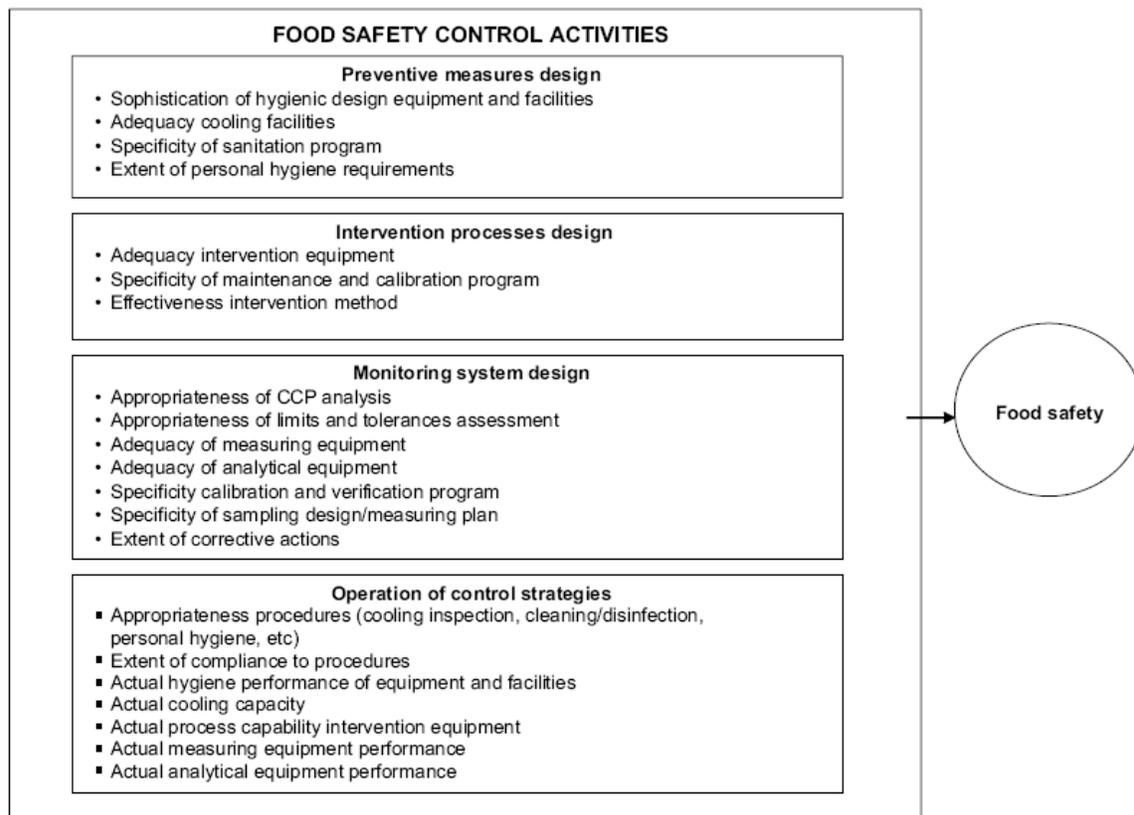


Figure 4. Food safety control activities (Luning et al, 2008a)

2.1.3 FSAS diagnostic instrument

As part of FSMS, the FSAS (Food Safety Assurance System) consists of four food safety assurance

activities in four different aspects and its corresponding assessment grids. By analyzing the organization using FSAS, it can provide opportunities for improvement and or implementation of new assurance and or techniques.

1. Defining system requirements - Translation of external requirements on assuring food safety into internal requirements on the FSCS, and the translation of data and information from the FSCS into concrete modification of the control system.
2. Validation process - Planning activity which judge the system in advance whether set measures are controlling the food safety.
3. Verification - Defined as checking if the control activities are operating in practice as designed.
4. Documentation and record keeping- Documentation is aimed at keeping knowledge and information, whereas record keeping is aimed at collecting data.

Assessment grids were developed in the instrument for each of the four assurance activities, and three levels of activities was described, namely low, medium and high. It provides insight in how food safety is assured and at what level aiming to assess the assurance system for possible improvements.

Relevancy: The diagnostic instrument is relevant model for that it can be used as a conceptual model in this study. It describes the contextual factors and strategies that influence the realization of a high level of food safety performance. Assessing of these factors using this instrument will able to understand the existing food safety situation of China's dairy industry. By using this instrument for situation analysis, it enables to find out the weaknesses and possible opportunities for improvements.

Validity: The diagnostic instrument has made detailed description on different aspects that may affect the performance of food safety. It provides a detailed checklist to assess the control and assurance activities in food production system. It has been validated by many case studies and proved its validity. Based on these, I believe that this instrument is a highly valid model for this research.

Reliability: This instrument can be considered as a reliable model as it was developed by credited researchers under a widely researched project the Pathogen Combat –EU food project. It is based on validated and published literature. This instrument has also been validated by some experts.

2.2 Characteristics of Raw milk

Before processed by dairy producer into all kinds of dairy products, the quality of raw milk must be maintained in high standard levels. Maintaining the high standards is important not only because it gives greater flexibility to the processor in term of holding milk prior to processing but most importantly because of the impact it ultimately has on product yield and quality. Quality of raw milk comprises of compositional quality and hygienic quality. Compositional quality of raw milk varies from breeding, animal feedings and environment etc. Some dairy processors have specific requirement for the compositional quality. Butter manufacturers, for example, are prone to raw milk with higher contained fat. Hygienic quality of raw milk is the prior consideration by dairy company or processor to ensure high quality of dairy production. Bacteria count or some other hygienic hazard contaminants must be constrained in an acceptable level to ensure the public health. Hygienic quality also influences greatly the composition of milk, leading degradation of fat, protein or lactose. The compositional quality, the hygienic quality and the level of contaminants present can all have an impact on the yield and quality, and hence financial return from products made from milk.

2.2.1 Compositional quality

The most obvious raw milk quality attribute to affect products is compositional quality. The simplest case is the production of butter. Butter has a legal minimum of 80% butterfat and legal maximum of 16% water content. Clearly a farmer producing milk of 3.0% fat would need to consign more liters of milk than one producing milk of 3.9% fat to produce the same amount of butter. The 3.9% fat contained raw milk would provide price advantages than the other one. Beside, the more dilute milk solids are more expensive to transport, store and concentrate and the yield of products are affected by the percentage of component in the starting material - the raw milk. The yield of specific products being manufactured is of utmost economic importance to the processor. For these reasons farmers are paid on compositional quality and it is important that extraneous water, which dilutes milk constituents, is strictly controlled. A typical nutritional composition of raw milk is shown in Figure 5.

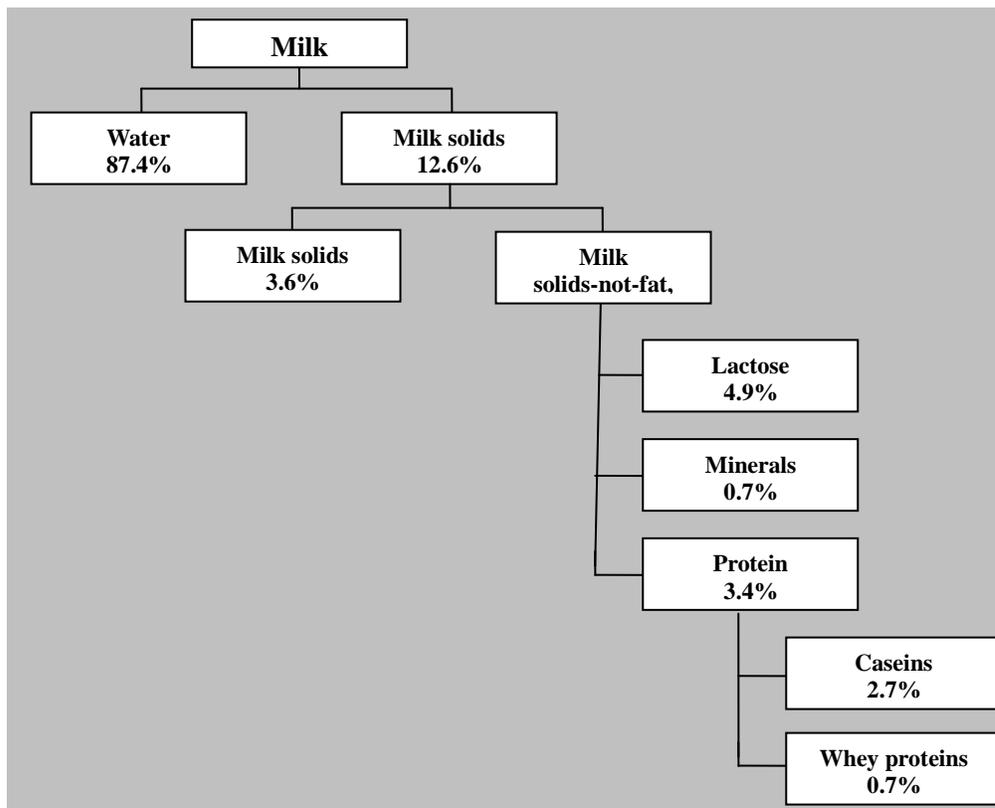


Figure 5. Nutritional composition of milk (Source: Ramesh C. Chandan, 2006)

Fat

In whole milk, the approximate 3% to 4% milk fat is mixture of lipid existing as microscopic globules suspended in the milk. The fat contributes about 48% of total calories in whole milk. Fat-soluble vitamins (A, D, E, and K) are normal components in milk fat. Milk fat contain most of the flavor components of milk, so when milk fat is decreased, there may be a concurrent reduction in flavor.

The type of milk fat produced by cows can be influenced by dietary changes. Milk fats containing a higher proportion of unsaturated fats have been produced by feeding cows with unsaturated fats encapsulated with protein with protects the fat from being saturated in the cows' rumen. Butyric acid, a characteristic fatty acid of milk fat, is absorbed in the stomach and small intestine and provides energy similar to carbohydrates (Salminen *et al.*, 1998). The fatty acids lower the pH for facilitating protein digestion. The flavor of milk fat is unique and it adds to mouth-feel of foods comprised of milk and dairy foods.

Protein

Milk contains approximately 3.3% protein. Protein accounts for about 38% of total SNF (solid-no-fat) and about 22% of the calories of whole milk. Proteins are the most valuable components of milk in terms of their importance in human nutrition and their influence on the properties of dairy products containing them. The major proteins of milk are casein and whey proteins in the ratio of 80 to 20.

The factors that affect the protein level in raw milk include genetics, stage of lactation, age of cows and environment. Of the variation of protein content, 55% is due to the heredity and 45% is due to the environment factors, such as feeding management. (R. Grant *et al.*, 2007). The content of protein is one of the most important factors to measure the quality of raw milk. It is, however, much more difficult to manipulate the protein content of milk than the fat content. Excess feed only results in a modest increase in protein level.

Carbohydrates

Lactose, the predominant carbohydrate in milk, is synthesized in the mammary gland. Approximately 4.8% of cow's milk is lactose. It accounts for approximately 54% of the SNF content in milk. Lactose, the milk sugar stimulates the absorption of calcium and magnesium. It has a relatively lower glycemic index as compared to glucose or sucrose, hence making it suitable for diabetics (Saxelin M *et al.*, 2003).

Vitamins and Minerals

Milk is a good source of vitamins. All vitamins essential in human nutrition are found in milk. Fat-soluble vitamins (A) are in the milk fat portion of milk, and water-soluble vitamins (C and B) are in the nonfat portion. The vitamin A in cow's milk varies significantly from cow's ration, whereas the water-soluble vitamin B and C are relatively constant in milk and are not greatly influenced by the vitamin content of the cow's ration (Taylor, 2003). Milk is also a rich source of calcium for the human diet. It contains high level of minerals, such as calcium, phosphorus and magnesium.

2.2.2 Hygienic quality

Milk production has inextricably linked to the environment and the latter depends largely on human activities. A large number of environmental contaminants are able to enter the cow as a residues of herbicides on feed stuffs or as antibiotics drugs given to the cow. These chemical agents would present in raw milk in a certain level and they possess a potential hazards to consumers especially to people that are allergic to them. Chemical contaminants also enter milk from equipment by after milking. Milk is an ideal balanced food for human, it is not surprising therefore that it also provides an ideal medium for growth of microorganism. These microorganisms, such as bacteria can enter milk by means of varies pathways, such as mastitis, improper milking process and handling, unhygienic milk processing and etc. Enzymes and biotoxins produced by microorganism can also induce degradation of protein and fat content in milk, causing destruction of compositional quality of milk. Some physical contaminants such as dirt, hair, and vermin can access to milk accidentally. The presence of all these three contaminants in milk are very important for consumers and it can be a matter of public health concerns as well as many of unknown diseases in human because milk and dairy products are so widely consumed by humans throughout the world.

Knowing which hazards are associated with dairy production enable not only to access the risk of hazards at the specific step along the dairy supply chain but, also help to identify the adoption of control and measure method. By doing so, the contamination risk can be lowered to an acceptable level to fulfill the quality and safety demand from consumer.

Table 1. Hazards of milk contamination in dairy supply chain.

Steps	Hazards	Risk factors
Farm	<ul style="list-style-type: none"> • Fecal Contamination : <i>E. coli</i>, <i>Salmonella</i>, <i>Clostridium</i> • Contamination by environmental germs : psychrotrophes flora (<i>Listeria</i>, <i>Pseudomonas</i>), Enterobacterias, yeast and fungus • Multiplication of bacteria on milking material • Contamination by pathogen bacteria : <i>Staphylococcus aureus</i>, <i>Streptococcus</i>, <i>Listeria</i>, <i>Mycobacterium tuberculosis</i>, <i>bovis</i>, <i>Brucella</i>, <i>E. coli</i> • Contamination by chemical residues • Lipolysis and raw milk turning rancid • Proteolysis : gelification of UHT milk, decreasing of cheese yield; appearance of sour components • Inhibition of the lactic fermentation : problems for milk processing 	<p>Transmission by the hands of the milkman Contamination by the animal at milking, by the tail and the splashes when the bucket is near the animals</p> <p>Milk in open air at milking time</p> <p>Inefficient cleaning and disinfecting of material and/or poor drying</p> <p>Healthy carrier animals: <i>Mycobacterium</i>, <i>Brucella</i>, Animals with mastitis: <i>Staphylococcus</i>, <i>E. coli</i>, Man : <i>Staphylococcus sp.</i>, <i>Streptococcus sp.</i> Environment : <i>Listeria sp.</i></p> <p>Non-respect of waiting time for veterinary medicine</p> <p>Frequent and brutal decanting</p> <p>Collecting milk with mastitis</p> <p>Collecting milk from animals treated with antibiotics</p>
Transport	<ul style="list-style-type: none"> • Growing of microbial flora • Contamination by material 	<p>Carrying time too long, at high temperature</p> <p>Cleaning and inefficient disinfecting of material and/or bad drying</p>
Collecting center	<ul style="list-style-type: none"> • Cross-contamination • Human contamination • Contamination by environmental germs • Development of psychrotrophic flora : synthesis of proteolytic thermostable enzymes • Development of coliform flora • Lipolysis 	<p>Cleaning and inefficient disinfecting of materials Absence or bad quality control of the milk before mixing</p> <p>Hand contacts with the milk at the time of sampling</p> <p>Use of contaminated water for cleaning the material</p> <p>Temperature of cooling tanks not regulated and too lengthy storage</p> <p>Absence of cooling</p> <p>Manual filling of the tanks from the top</p>
Dairy plant	<ul style="list-style-type: none"> • Cross contamination • Recontamination by environmental germs • Persistence of micro-organisms 	<p>Absence or bad quality control of the milk</p> <p>Non hermetically sealed packing Poor hygiene at packaging</p> <p>Absence of thermal treatment or insufficient treatment : no respect of time/temperature</p>
Consumers	<ul style="list-style-type: none"> • Food-borne disease : diarrheic syndrome, listeriosis, tuberculosis, brucellosis • Poor preservation of milk 	<p>Consumption of contaminated raw milk</p> <p>Poor quality (fragility of the components) High temperature and too lengthy preservation</p>

(Source: B. faye, G. Loiseau, 2002, from CIRAD)

Based on the summary of hazards associated with dairy production in Table 1, microbial hazards and chemical hazards are considered to be high risk to milk quality and safety. Along the dairy chain raw milk quality in on-farm level, collection centre level and transport level from farms to collection centre or dairy plant are considered to be critical, for that on those steps milk is more susceptible to microbial and chemical contaminants. These two hazards and raw milk control are subjected as reference guide to assess the food safety management system in my research.

Relevance: A summary of hazards associated with milk products shown in table 1 is considered as relevant, because it give me understanding about which hazards and which steps are critical in relation to health risk of the product concerned. Moreover this model also lists some factors that contribute to correlated hazards. It gives me idea of selecting appropriate control measures and intervention methods to be applied during the processing in order to realise the food safety.

Validity: The table gives me a detail information regards to which hazards are associated with the product concerned.

Reliability: The table is considered to be reliable because it is developed by CIRAD, which is a French agricultural research centre working for international development.

Microbial hazards

Milk is relatively free from bacteria when it leaves the healthy udders. While some contamination with bacteria from the milking environment and equipment is inevitable. According to Table 1, the most critical step managing the microbial hazards of dairy production is the raw milk quality control on-farm level. The total bacterial count of cooled raw milk, produced under good hygienic conditions, should be lower than 10,000 bacteria/ml. If the bacterial count of milk increased significantly, e.g. to over 3 million/ml this could lead to significant degradation of the fat, protein or lactose causing off-flavors and would significantly reduce the flexibility the processor has with respect to storage and use of milk. Both EU and PMO (Pasteurized Milk Organization) have regulation for the limit on bacteria level of raw milk (see Table 2). In order to achieve a high bacteriological quality at different level it is important to farmers to be aware of the sources of contamination and understand how to control them.

Table 2. Limits on bacterial levels in milk (cfu/ml)

	PMO	EU
<u>Raw milk for drinking</u>		
- bacteria	-	<20000
- S. aureus	-	<500
- Salmonella	-	0
- Coliforms	-	<100
<u>Pasteurized milk</u>		
- Bacteria	<20000	5000/50000
- Coliforms	<10	<5
<u>Raw milk for production</u>		
- bacteria	<100000	<100000
- S. aureus	-	<2000

Along the dairy supply chain from raw milk to final dairy production, varies of bacteria can enter the raw milk. According to bulk-tank milk analysis (Bhushan *et al.*, 2003), bacteria of environmental origin can be placed into four categories: (1) streptococci and streptococci-like organisms, (2) coagulase-negative staphylococci, (3) coliforms, and (4) gram-negative non-coliforms (see **Appendix 1**). Considering the characteristics of different bacteria, the sources of contamination vary. The important bacteria involved in contamination and their sources are listed in Table 3. The sources of bacteria contamination from Table 3 confirm the importance of raw milk control on-farm level. It suggests that good mastitis control, bacterial and cell count limits applying are necessary.

Table 3. Relative importance of sources for important bacteria in milk

Source	Bacteria				
	<i>S. aureus</i>	Listeria/Salmonella	<i>E. coli</i>	<i>M. bovis</i>	<i>M. paraTB</i>
Teats-skin colonization	+	-	-	-	-
Teats-fecal contamination	-	+	+++	-	++
Housing/food	-	+	+++	-	++
Milk handling-machine	+	-	++	-	-
Milk handling-tanks	-	-	++	-	-
Water supply	-	+	++	-	++
Intra mammary infection-milk	+++	(+)	+	+	+
Intra mammary infection-cells	+++	-	-	++	++
Post production	-	++	+++	-	-

(Source: J. Eric Hillerton and Elizabeth A. Berry, 2004)

Relevance: This table is relevant to this research; because it illustrates which factors influence the bacteria contamination of raw milk. These sources of bacteria are important to control for maintaining bacteriological quality.

Validity: The table is valid, because the table provides the information of sources of important bacteria affecting quality of raw milk.

Reliability: The table is considered to be reliable because it was published in Annual Meeting Proceedings in 2004 from NMC (National mastitis council).

Chemical hazards

Chemical contamination in milk comprises chemical hazards that may introduce during milk production, dairy processing or packaging. Veterinary drugs, heavy metals, radionuclides, mycotoxins and pesticides are chemical contaminants that can enter to animal feed and they have some residues in milk. A large number of environmental contaminants are able to enter the cow as a residues of herbicides on feed stuffs or as drugs given to the cow orally, by injection, or as intro mammary infusions for the treatment of mastitis (Jahed khaniki, 2007). Contaminants also enter milk from equipment after milking. The melamine contamination of Chinese infant formula was caused by addition of melamine into raw milk by some farmers or milk collection centers in order to increase the apparent protein content and pass the quality tests. Any of these compounds may persist at collection, preparation processes of dairy products and they are considered residues (Hubbert *et al.*, 1996). The potential to cause toxicological harm to consumers is one characteristic in common for all of chemical contamination (Tennant, 1997). Chemical contaminant in milk and dairy products may know to be contributory factors in several diseases such as cancer, heart disease and, of course, the kidney stones caused by melamine.

The sources of chemical contaminants in raw milk are to a large extent comparable to those of raw materials originating from plants (DeVries, 1997). The most of chemical contaminants in milk are veterinary drugs such as antimicrobials (antibiotics and sulfonamides), hormones, anthelmintic drugs, pesticides and etc. Food and Agriculture Organization (FAO) and World Health Organization (WHO) have established of Maximum residues Limits (MRLs) and Acceptable Daily Intake (ADI) of some veterinary residues in milk for consumer protection shown in Table 4.

Table 4. Residues of some veterinary drugs in cow's milk for human consumption.

Pesticides	ADI^a	Recommended MRLs^b (ml L⁻¹)	References
Antimicrobial agents:			
Ceftiofur	0-50	100	FAO/WHO (1998)
Sulfonamidine	0-50	25	FAO/WHO (1998)
Dihydrostreptomycin (Sreptomycin)	0-50	200	FAO/WHO (1998)
Chlortetracycline (Oxytetracycline)	0-3	100	FAO/WHO (1997)
Gentamycin	0-4	200	FAO/WHO (1995)
Benzyl penicillin	30	4	FAO/WHO (1995)
Insecticides:			
Cyfluthrin	0-20	40	FAO/WHO (1998)
Cypermethrin	0-50	50	FAO/WHO (1997)
Anthelmintic agents:			
Thiabendazole	0-100	100	FAO/WHO (1998)
Albendazole	0-50	100	FAO/WHO (1998)
Production acids:			
Bovine somatotropins	Not specified	Not specified	FAO/WHO (1993)

(Source: *Jahed khaniki, 2007*)

In U.S., the FDA is responsible for ensuring the safety of dairy product, and also for cosmetics, drugs, medical devices, radiological products, animal drugs used in raw milk production and treatment of food animals and for establishing maximum limits on such drugs that may be in the tissue of such animals (Tennant, 1997). EU has also regulations to MRLs for drugs, pesticides and other chemical agents that may be involved in dairy production (see **Appendix 2**). Antibiotic drugs are widely used by dairy farmers to treat infections in their dairy herds in China, and there is no regulation in place to restrict their use. Raw milk is collected from numerous small dairy farmers, testing for antibiotics is not a standard practice and it would be difficult to meet even if there is a standard.

2.3 Quality control of raw milk in the supply chain

2.3.1 Raw milk quality control in on-farm level

The demand for higher quality milk comes from retailers and major food service companies that supply milk and dairy products to the consumer. Consumer demand for a product that has consistent quality, good taste and a longer shelf life will ultimately benefit dairy producers by increasing consumption of this type of high quality products. In order to meet this demand, dairy producers should strive to produce the highest quality product possible. Producing a high quality product not only helps to maintain fluid milk consumption, but the incentive payments for meeting the various quality standards can be essential in improving or maintaining the profitability of a dairy operation. Therefore, it is important to understand what factors may interfere with milk quality in on-farm level for dairy farmers.

Variable factors are playing roles in microbial quality of raw milk in on-farm level. Figure 6 described the microbial introduction, growth, transmission, inactivation and removal in different parts of the

farm environment (e.g. feed, barn and milking parlor).

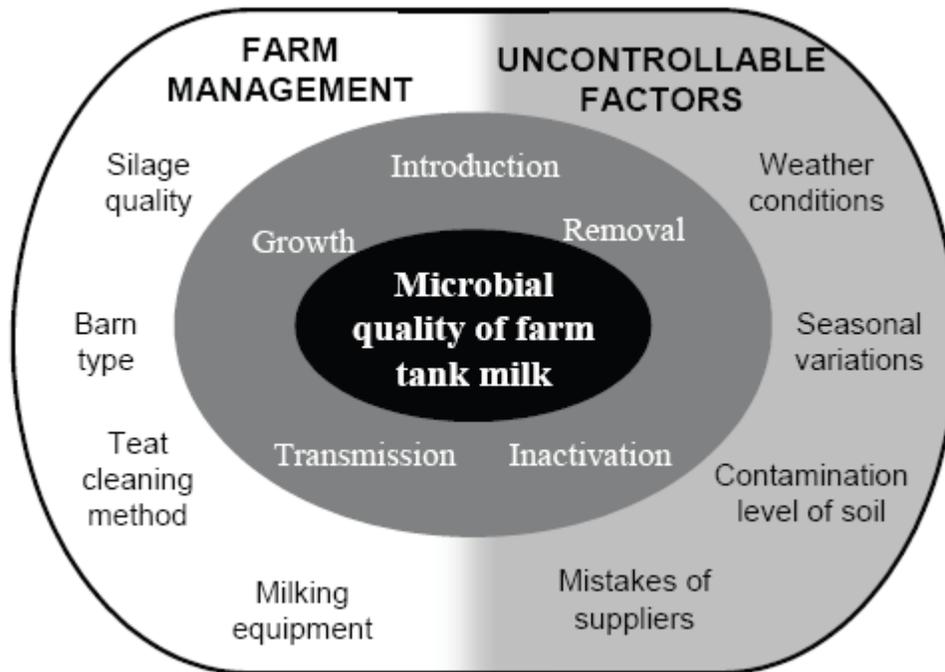


Figure 6. Control of microbial quality of farm tank milk (mentioned aspects of farm management and uncontrollable factors are examples and not all inclusive). (from Vissers and Driehuis, 2007)

Milk produced under careless conditions can contain in wide range of bacteria; pathogens (salmonell, listeria, etc.) from faecal contamination; pathogens from udder infection (streptococcal organisms) and milk-spoilage organisms which may be mesophilic, psychrotrophic or thermophilic. The major sources of contamination are the interior and exterior of the udder and the milking equipment (see Figure 7). The types of organism which will develop and predominate also depend on the storage time-temperature history of milk.

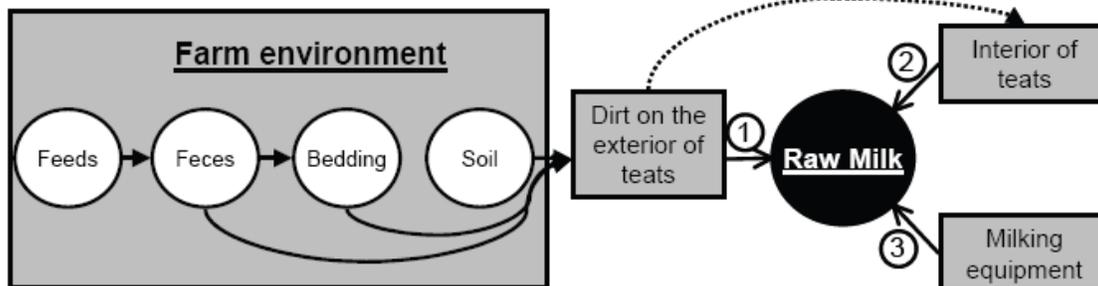


Figure 7. Routes for the contamination of raw milk with microorganisms (from Vissers and Driehuis, 2007)

In order to develop an effective strategy for controlling the contamination of raw milk by microorganisms and bacterial spores at farm level, it is essential to know the microbial sources and routes of contamination. Milk is nearly sterile when secreted into the alveoli of the udder (Tolle, 1980). Contamination by microorganisms occurs during and after milking processes. Microorganisms are transmitted to milk by means of three pathways: (1) via the exterior of the cow's teats, (2) via the interior of teats (in the case of mastitis) and (3) via surfaces of the milking equipment (see Figure 7). After the initial contamination, the concentration of bacteria can further increase due to microbial growth (Vissers and Driehuis, 2007). Aerial contamination is insignificant under normal production

conditions (Akam *et al.*, 1989, Stadhouders and Jørgensen, 1990, Te Giffel *et al.*, 1995).

Relevance: Since inspection and control both take place within the flower bulb trade, this is a relevant model, visualising the difference between the two of them.

Validity: This is a more general model, which can be applied to all kind of inspection and control activities. It doesn't give any specific norms whether to accept, reject or when to give feedback. This model can be linked to more detailed product related models

Reliability: Fox wrote this book for students of quality assurance as well as active practitioners. He cited a lot of authorities and used his own interpretation and experience within quality assurance management. Fox is a well-cited professor, who can be taken as reliable writer.

Contamination via the exterior of teats

The most common sources of microorganism in the farm environment are feed, feces, bedding material and soil. Bacteria, especially in the form of spores, from these sources are transferred to milk in a number of steps. Basically two overlapping routes or contamination pathways for bacterial spores can be distinguished. The first contamination pathway starts with feed. Spores in feed such as silages pass the gastrointestinal tract of cows unharmed and accumulate in feces. Feces and bedding material contaminate the cows' teats. Teat cleaning prior to milking only partly reduces attached dirt and spores (Vissers and Driehuis, 2007). During milking, feces, bedding material and spores on the surface of teats are transmitted to milk (Te Giffel *et al.*, 2002). The second contamination pathway starts with soil. Especially during grazing, soil can contaminate the exterior of teats and spores originating from soil are transmitted to raw milk during milking. For example, elevated *B. cereus* spore concentrations during the summer months have been associated with the transmission of soil to farm tank milk (Christiansson *et al.*, 1999 and Slaghuis *et al.*, 1997).

Contamination via the interior of teats

Contamination via the interior of teats is associated with mastitis. Mastitic cows can produce milk with very high bacterial counts. After mastitis pathogens entered the teat canal and infect tissue, the level of pathogens within the teat can increase significantly. During milking, the mastitis pathogens then will be transmitted to the milk. Milk from individual cows may contain millions of organisms per milliliter of milk. The level of contamination is so high that if allowed to go into the bulk vat the herd bulk supply can be elevated to over 100,000 bacteria/ml, which is far over the acceptable limit (F. Harding, 1995). The control of mastitis is therefore important with respect to the bacterial count of milk.

Contamination via surfaces of the milking equipment

Contamination of milk via the milking equipment occurs when microorganisms and milk residues adhered to surfaces of milking equipment are not cleaned completely during cleaning. It is often the major source of bacteria in milk. Visually clean surfaces, because of the high milk volume to plant surface area, should not contribute more than 1000 bacteria/ml of milk. However, surfaces ineffectively cleaned and sterilized or plant containing old milk residues will elevate the bulk milk count by at least 10,000/ml of bacteria (F. Harding, 1995). In the period between two milkings the concentration of adhered microorganisms may increase due to growth. In the Netherlands, the time between two milkings is approximately 10 to 14 h (Marc Vissers, 2007). During milking adhered microorganisms are released into passing milk and increase the microbial contamination. Especially cracked and decayed rubber parts are sensitive to accumulation of microorganisms (Akam *et al.*, 1989) Therefore, careful attention to milk production techniques and plant cleaning is essential to keep the bacterial count in a low or acceptable level.

2.3.2 Quality control of raw milk in milk Village Milking Centers (VMCs) level

The Village Milking Centers (VMCs) in China play a very important role in dairy supply chain. It functions as a bridge between the farming facilities that are the first step in milk supply chain and the dairy industry. There are 340,000 households that own and operate dairy farms with an average size of only 4.3 cows per household and most of them had other income sources (Lu, 2002). These small-scale farms contribute to around 70-80% of total milk production in China. The primary reasons to the importance of VMCs are small sizes, scarcity and low efficiency of the dairy farms. The large, specialized and high-tech farms are mostly state-owned farm established by government, which only contribute to less than 10% of total milk output. The small and mixed farms (ranged from 1-20 herds) contribute to 70-80% of total milk output in China (Schiere *et al.*, 2007).

The Village Milking Centers (VMCs) consists of milking machines, cleaning units, hygiene packages, bulk milk coolers and milk quality measure facilities. Local farmers in village bring their cows to the VMCs where the cows are milked. In this way milk is collected and efficiently cooled to ensure milk quality. VMCs are functioning more importantly in the supply chain in China because of the increasing consumption of dairy products and growing demand for quality milk (DeLaval homepage, 2004). The village is about 1-2 kilometers in diameter and there are approximately 300-1,000 cows raised by 100-300 households. The VMCs are built by the processing company or the individual investors. The farmers will raise their cow individually on their own properties, and bring their cows 2-3 times one day to the VMCs for milking. The first VMC was instituted about ten years ago, it has rapidly developed and there are currently more than 3,000 VMCs in China. The quality of milk is dramatically improved because the problem of adulteration is eliminated and the milking and handling of milk is controlled (Lu, 2002).

Maintaining a high standard of hygiene is one of the most efficient ways to achieve high quality raw milk during milking in VMCs. It is extremely important for workers to assure the best hygiene within production, from pre-milking preparation to post-milking cleaning and milking cooling.

Pre-milking preparation

Pre-milking udder preparation includes fore milking and teat cleaning, which has a direct mastitis-controlling effect because it reduces the number of pathogens. It also has an indirect mastitis-preventing effect because it minimizes the risk of teat congestion and oedema to an effective teat-cup position at the start of milking. The latter effect results in a shortened milking duration and improves the degree of udder evacuation.

Several investigations show the importance of practicing good pre-milking teat or udder preparation procedures. The teats should be dry before milking, for that wetting of the teats before milking followed by drying did provide low bacterial counts in the milk (Galton *et al.*, 1982). Washing of the whole udder should be avoided. If this is required, then it is critical teats are dried before attaching the milking machine. Cotton towels were found to be superior to paper towels for reducing bacterial and spore counts in milk (Rasmussen *et al.*, 1991). Cleaning for 20 seconds was shown to be 50% more efficient than cleaning for 6 seconds. One towel should be used per cow per milking. Cotton towels should be cleaned between milking sessions - preferably in a washing machine.

Milk inspection

The 89/362/ECC (EU) directive states: "Before milking of the individual cow, the milker must inspect the appearance of the milk. If any physical abnormality is detected, milk from the cow must be withheld from delivery". This requirement can easily be fulfilled in conventional milking and appropriately executed by using a foremilk cup. By inspection before milking, the risk of microbial contamination from mastitis can be largely avoided.

Milk extraction

Mechanical milk extraction should be conducted using machines that are designed, tested and serviced according to prevailing standards. These machines should also be used within accepted milking

routines. Machine settings like milking vacuum and pulsation characteristics should be applied in accordance with the manufacturer's recommendations. In general if this is followed, good udder health can be maintained. However if over-milking and inappropriate pre-milking preparation are conducted, or high frequencies of liner slip are not prevented, udder health can be negatively affected. The latter can occur directly through increasing the number of new infections, or indirectly by affecting teat condition.

Post-milking teat disinfecting

Research work carried out since the mid-seventies shows the feasibility of applying post milking teat disinfecting. Post milking teat dipping or spraying is widely used today. It is particularly effective in preventing environmental mastitis types. Frequency of mastitis created during the dry period is an increasing problem. Such infections may persist into lactation and cause clinical mastitis or elevated milk somatic cell counts. Dipping dry cow's teats using a special teat seal with a long lasting effect is an important tool for helping control such mastitis (Hogan *et al.*, 1989).

Cleaning of milking equipment

The milking equipment should be cleaned as soon as possible after milking. A rinse cycle should initially be executed, using tepid water. The purpose of this is to remove residuals from the milk and soil in advance of the cleaning cycle. Cleaning using detergents should be performed within sufficient time and with the cleaning solution at the highest possible temperature. It is important to have as much turbulence as possible for the cleaning solution during cleaning. Cleaning should be completed by flushing the milking system with clean water then draining it, or by flushing it with clean air. The milking system should be dry before the next milking.

Regular and efficient cleaning of the milking system is very important for hygiene raw milk production. Milking circuit is advisedly cleaned at least three times a day within as equal intervals as possible. Cleaning less than three times a day may cause increased bacterial counts in the milk. Efficient cleaning of the cooling tank is equally important. Cleaning with acid detergent may be required at frequent intervals, depending on the hardness of the water.

Cooling of milk

It is generally recommended that milk be cooled to a refrigerated temperature within a few hours after milking and stored at 4 °C or below. Primary cooling might be required to avoid the blend temperature of the milk in the bulk tank, exceeding a certain level. Cooling of milk shortly after extraction is also important for minimizing lipolytic activity.

With good milking routines and adequate milking equipment, the risk of new mastitis cases will be significantly lowered. 12 gold rules for milking are advised by DeLaval, a dairy company that has more than 120 year history in the dairy industry (see **Appendix 3**). It could provide a standard milking practice routine that can be applied to the VMCs in China.

2.3.3 Bacterial pathogen growth and inactivation

To understand how microbiological hazards grow and multiply, it is important to know the factors and limiting conditions for their growth. With this, we will be guided to control hazards and identify what appropriate inactivation processes are applicable to ensure safety of food. Model on Figure 8 will make us understand on what are the factors that influence growth of microorganisms in foods.

Quantity of microorganisms in foods is always subject to permanent changes due to the kinetics' complexity of bacterial survival, growth and death (Untermann, 1998). As described in the model of Untermann (1998), bacterial kinetics' complexity is determined by various factors which can be differentiated into intrinsic, extrinsic and process factors. The spoilage of food is dependent on the

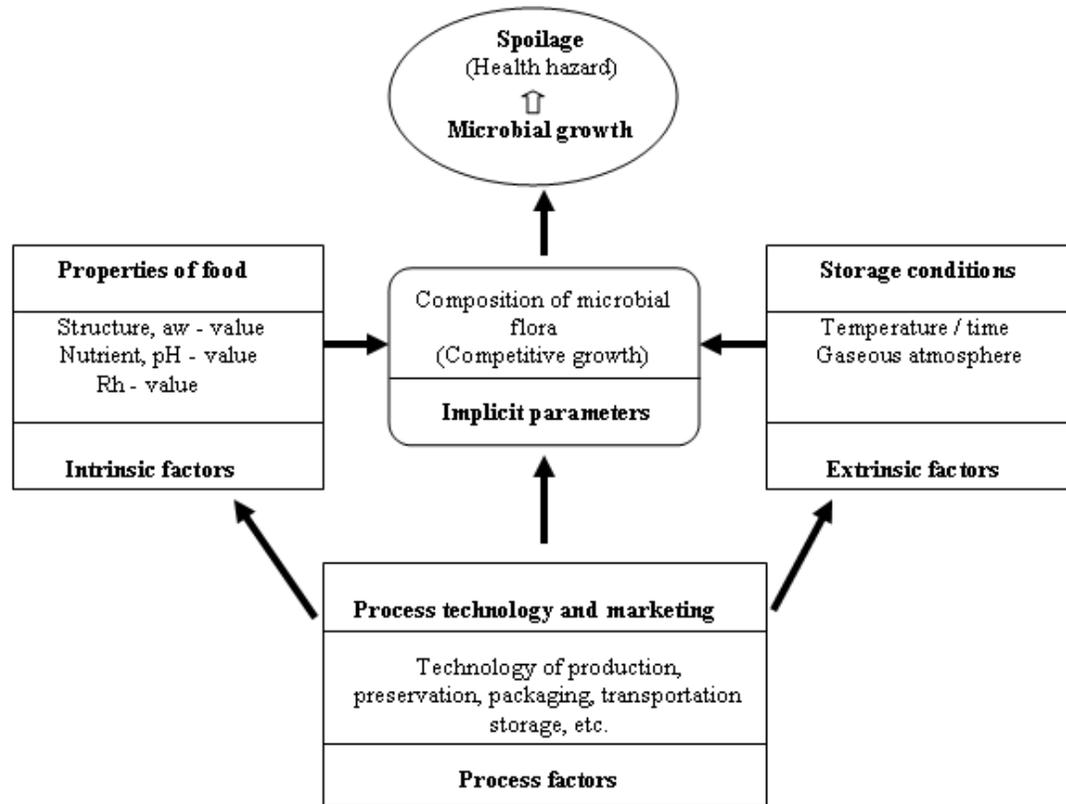


Figure 8. Influences on microbial growth in foods (Untermann, 1998)

growth of microorganisms which are influenced by the properties of food, storage conditions such as temperature and time, and the composition of microbial flora present in the food being processed. Consequently, the risk resulting from microorganisms concerning microbial safety varies depending on the composition of food, technology of production, processing and preparation procedures as well as on packaging and storage conditions (Untermann, 1998).

Knowing the different factors that affect growth, survival and death of microorganisms in foods, it is also important to know, what are the limiting conditions of microorganisms' growth in foods in order to complement the previous model as well as its controls and inactivation? To have a better understanding and guidance, **Appendix 4** summarizes these conditions that maybe helpful for the determination of control measures and inactivation. Given these factors, we are guided to undergo processes to control and inactivate hazards for the realization of food safety.

Relevance: Significantly, the table above summarizes to us the relevant hazards that are associated with fish and fishery products and therefore it is easier to identify measures and processes that will control, eliminate and inactivate them for a safe products. Interestingly, the model in Fig. 6 described the different factors that contribute to the growth of microorganisms in food that will result to unsafe product. As the problem feeling is concerned, we want to understand what are these factors that will affect implementation of FSMS in the realization of food safety? This model, answers one of the questions for the realization of food safety.

Validity: The model is valid because it gives a sufficient detailed description on the factors that affects safety of food and has been used by many literatures in research for understanding the realization of food safety.

Reliability: The model is considered reliable because it has been used by many authors as their reference and published in scientific journal.

2.4 Raw milk quality monitoring and measurement

Bacterial and somatic cell counts (SCC) are reference methods commonly used to evaluate raw milk quality (Costello *et al.*, 2003). Total bacterial count or TBC (often referred to as the standard plate count or SPC) indicates on-farm general hygienic conditions, herd health status, milking equipment sanitation and milk storage temperatures (Hayes *et al.*, 2001). Although most bacteria found in raw milk are nonpathogenic and are mostly destroyed by pasteurization, close monitoring of SPC is crucial to establish consumer confidence in the quality of milk produced and is of increasing interest to milk purchasers (Berry *et al.*, 2006). Successful milk quality assurance programs focus on producing of milk free of antibiotic residues and with low somatic cell and bacterial counts, resulting in better quality products with longer shelf life.

Dairy producers from some countries, like U.S., also receive premiums from their milk cooperative for producing milk with low somatic cell and bacterial counts (Jayarao *et al.*, 2004). Bacterial numbers in bulk milk will not typically increase from the contribution of non-pathogenic bacteria in the gland or teat duct in a healthy mammary gland. Normally, raw milk from healthy udders contains < 1,000 total bacteria per ml; and therefore do not have a significant contribution to the total numbers of microorganisms in the bulk milk, or to a potential increase in bacterial numbers during refrigerated storage (Murphy and Boor, 2006). It is unusual for mastitis to contribute to SPC but cows with mastitis can occasionally shed large numbers of microorganisms in milk; this is most commonly associated with subclinical infections caused by Streptococci (especially *Streptococcus agalactiae*). At the cow level, the influence of mastitis on the total bacteria count in milk mostly depends on pathogen type and stage of infection (Murphy and Boor, 2006). Occasionally, infected cows can shed more than 10,000,000 bacteria per ml (Bramley and McKinnon, 1990). At herd level, the effect of shedding on the bulk tank bacterial count depends on the size of the herd, number of mastitic cows, and ratio of mastitic to non-mastitic milk (Hayes *et al.*, 2001).

Thus, it is necessary to review the SCC and TBC and their correlated measurements that are involved raw milk quality control system. An overview of mastitis and milk quality tests was shown in **Appendix 5**.

2.4.1 Somatic Cell Count

Somatic cell count (SCC) is an internationally accepted measure of the quality and suitability of milk sold from the farm for human consumption. It is a measurement of the concentration of cells in milk that have originated from the cow itself (as distinct from invading bacterial cells). Mastitis is the most important source of increased SCC. Mastitis is an inflammatory reaction within cow's udder, commonly resulting from bacterial infection. Milk from infected cows is characterized by increased raw milk SCC. Almost all of the major and minor components in milk are affected by mastitis (Munro *et al.*, 1984). Thus, milk SCC is commonly used as an indicator of the incidence of subclinical mastitis in dairy cows (National Mastitis Council, 1996). Due to the inflammatory response during mastitis, secretion of milk components that are synthesized *de novo* is reduced and an influx of blood components into the milk occurs (Kitchen, 1981). These blood components include a variety of hydrolytic enzymes, which alter the milk composition through the breakdown of casein and milk fat (Grieve and Kitchen, 1985). Therefore, dairy company or processors may partly price the value of milk based on SCC.

The limit on the raw milk SCC is variable among countries. The EU limit is 400,000 cells/ml, which is comparable lower than the upper legal limit in U.S., the 750,000 cells/ml (as of January 1, 1997). However, in most EU countries the market usually demands a much lower level for a premium product with a common threshold around 200,000 cells/ml. Milk buyers pay a premium of 3-5% of milk price below the premium threshold, a neutral price above that threshold and then introduce price

reductions of 5-10% from a higher threshold, often 250,000 cells/ml, up to the regulatory level. Milk with a persistently high cell count is relatively worthless, even if some form of market can be found, with penalties of 30-60% of regular price and special collection costs often applied (J. Eric Hillerton and Elizabeth A. Berry, 2004). Achievement of an average SCC less than 200,000 cells/ml was reported in many countries (e.g. Germany, Netherlands, Sweden and Austria).

SCC in milk is comprised mostly of leukocytes that for the most part, enter the udder to destroy mastitis-causing bacteria and to repair damaged udder tissue (Shuster *et al.*, 1991). All milk samples will contain some somatic cells; however the count numbers will considerably increase when the udder is infected or there is trauma to the udder. Injured mammary tissue and a high number of somatic cells following an intra-mammary infection can clog the tiny milk ducts in the udder, which in turn results in lowered milk secretion and production. The SCC varies significantly among both infected and uninfected cows (Stiles *et al.*, 1984). Variation in SCC is also influenced by the stage of lactation, season of the year, and individual cow responses to infection (Harmon RJ, 1998). Considering these factors, the bulk-tank SCC should only be used as a guideline to indicate the overall udder health of a dairy herd.

A guideline (**Appendix 6**) recommended by National Mastitis Council (NMC) can be used for the determination and reporting of SCC, to ensure accurate representation of the milk shipped from a farm.

2.4.2 Total Bacteria Count

Raw milk is collected under different climates, by different handling practices, therefore its microbiological quality is variable, and the level of contaminations is reflected both in the number and types of microorganisms in the samples. One of the useful indicators that permit the monitoring of the sanitary conditions during the production, the collection and the handling of raw milks is the TBC, which is of interest for ensuring both quality and safety of raw milks (J.V. Chambers, 2002). The TBC is determined by the standard plate count (SPC), that estimates the aerobic bacterial populations (by the pour plate method); the viable bacteria are enumerated on Plate Count Agar (PCA) after serial dilution of the raw milk, following aerobic incubation for two or three days, at 32°C or 30°C respectively (International IDF standard 1991 and Health Protection Agency 2005).

SPC is the official regulatory standards for milk quality determination throughout the world. The SPC determines the total number of bacteria in a milk sample that can grow and form countable colony forming units on a Standard Methods Agar plate when 1 ml of milk is incubated aerobically at 32°C for 48 hours. Ideally, raw milk should contain less than 5,000 bacteria/ml. If sanitation in the cows, the milking procedures and the milking equipment is good, and cooling is adequate, then a SPC of 10,000 cfu/ml or less should be achievable. The maximum legal limit for SPC is 100,000 cfu/ml (International IDF standard, 1991). The SPC is a critical control point for milk quality and many milk purchasers have standards that are more rigorous than the official regulations. A SPC count of >10,000 cfu/ml usually indicates a bacterial contamination problem (Reinemann *et al.*, 1999), in this case a checklist is advised to do to estimate the possible error areas (Box 1).

Although SPC is an overall measure of milk quality, a single SPC value is not very useful diagnostically. A high SPC is an indication of a milk quality problem usually caused by errors in cooling milk or cleaning milking equipment. Rarely, a high bacterial count can be associated with subclinical mastitis (especially mastitis caused by *Streptococcus spp.*) (Hayes *et al.*, 2001). In order to identify specifically the problem, other kinds of tests are requested.

Another measure of milk quality is the Preliminary Incubation Count (PIC). In order to determine PIC, a sample of milk is incubated at 12.8 °C for 18 hours followed by the SPC procedure. Measurement of

Box 1. A checklist to estimate the microbial contamination problem

1. Improper cleaning of milking equipment after each milking or neglecting to sanitize equipment before the next milking.
2. Wash water temperature should start at 68-78°C and drain at above 50°C.
3. Using the wrong amount or type of detergent, acid or sanitizer.
4. Gaskets, teatcup liners, rubber parts and hoses need to be clean, free of cracks and deposits and replaced when needed.
5. Problems with debris buildup in receiver jars, sanitary traps, plate coolers and chillers.
6. Keep your animals out of the mud. Animals with excessive or long hair on their udders may need their udder hair clipped or singed.
7. Poor udder sanitation procedures or excessive water use to wash teats. Teats need to be clean, sanitized and dry before milking.
8. Check your bulk tank cooling system. Slow cooling bulk tank or temperature above 4°C. The bulk tank milk temperature should be less than 4.5°C within two hours of milking and kept below 7°C during milkings.
9. Mastitis infections due to *Streptococcus agalactiae* can lead to a large number of these bacteria being released in the milk. Several cows infected with Strep. Ag. can cause the bulk tank SPC to be elevated.

(Source: *Evaluating Milk Quality Using Standard Plate Counts and Preliminary Incubation Counts*, LSU AgCenter)

PIC is based on the theory that the normal microbial flora of the cow will not grow substantially when incubated at this combination of time and temperature, however other microorganisms present in milk due to poor sanitation, cooling and milking practices can grow to significant levels at these times and temperatures (Standard Methods for the Examination of Dairy Products, 1985). These microorganisms are called psychrotrophs or cold-loving bacteria. Psychrotrophic bacteria will continue to grow at temperatures below 7.2°C. These organisms and the enzymes, toxin they produce are associated with off-flavors, milk spoiling and short shelf-life. This has led some people to believe that PIC is the best measurement of raw milk keeping quality and sanitation practices on farms. Currently there is not a legal limit for PIC. A PIC of below 50,000 is acceptable, but a goal of 25,000 or less should be achievable. The same check list that was used for troubleshooting elevated SPC can be used for PIC.

PIC in relation to the SPC is another approach to determine the quality of the milk and good practices on the farm. If the PIC \geq 3 times the SPC, then there is a potential problem. For example a milk sample has a SPC of 10,000 and a PIC of 11,000, then no substantial increase occurred and the PIC would not imply poor cooling, milking or cleaning practices. If the PIC had been 30,000 or greater, this would imply that procedures on the farm should be checked. Another example would be the sample has a SPC of 100,000 and a PIC of 115,000. Although the PIC count is greater than 100,000, the sample provides no additional information, as no substantial growth occurred. In this case an SPC of 100,000 would be indicative of a bacterial problem by organisms that grow poorly at 12.8°C within 18 hours.

Another measure of milk quality that is sometimes used is the Coliform count. The source of coliform bacteria in bulk tank milk is the udders of cows or unsanitary milking practices. The coliform count is an indication of the effectiveness of cow preparation procedures during milking and the cleanliness of the cows' environment (Reinemann, *et al.*, 1999). Counts in raw milk should be less than 10 cfu/ml. Counts of 10/ml are achievable and desirable. A coliform count between 100 and 1000 usually indicates poor milking hygiene and a coliform count >1000 suggests that bacterial growth is occurring on milk handling equipment (Reinemann, *et al.*, 1999). The table below could be use to determine the sources of microbial contamination that are detected by selected testing.

Table 5. Trouble shooting to the sources of microbial contamination.

Procedure	Natural Flora	Mastitis	Dirty Cows	Dirty Equip.	Poor Cooling
SPC > 10,000	Not likely	Possible	Possible	Possible	Possible
SPC > 100,000	Not likely	Possible (rare)	Not likely	Possible*	Possible*
PIC High vs SPC	Not likely	Not likely	Possible	Possible*	Possible*
SPC High / No Increase in PIC	Not likely	Possible	Possible but not likely	Possible but not likely	Not likely but possible
Coliform Count High	Not likely	Possible (rare)	Possible	Possible	Not likely but possible

*A more likely possible cause

(Source: *Dairy Science Facts* – Cornell University 1998)

Relevance: Since inspection and control both take place within the flower bulb trade, this is a relevant model, visualising the difference between the two of them.

Validity: This is a more general model, which can be applied to all kind of inspection and control activities. It doesn't give any specific norms whether to accept, reject or when to give feedback. This model can be linked to more detailed product related models

Reliability: Fox wrote this book for students of quality assurance as well as active practitioners. He cited a lot of authorities and used his own interpretation and experience within quality assurance management. Fox is a well-cited professor, who can be taken as reliable writer.

Chapter 3 Development of Research Model

3.1 Research Model

Based on the techno-managerial models analysis and literature studies about the raw milk production in China, the FSMS diagnosis instrument was translated into an elaborated research model which is suitable to analyze the performance of FSMS in China. The research model was particularly developed according to current raw milk production in China.

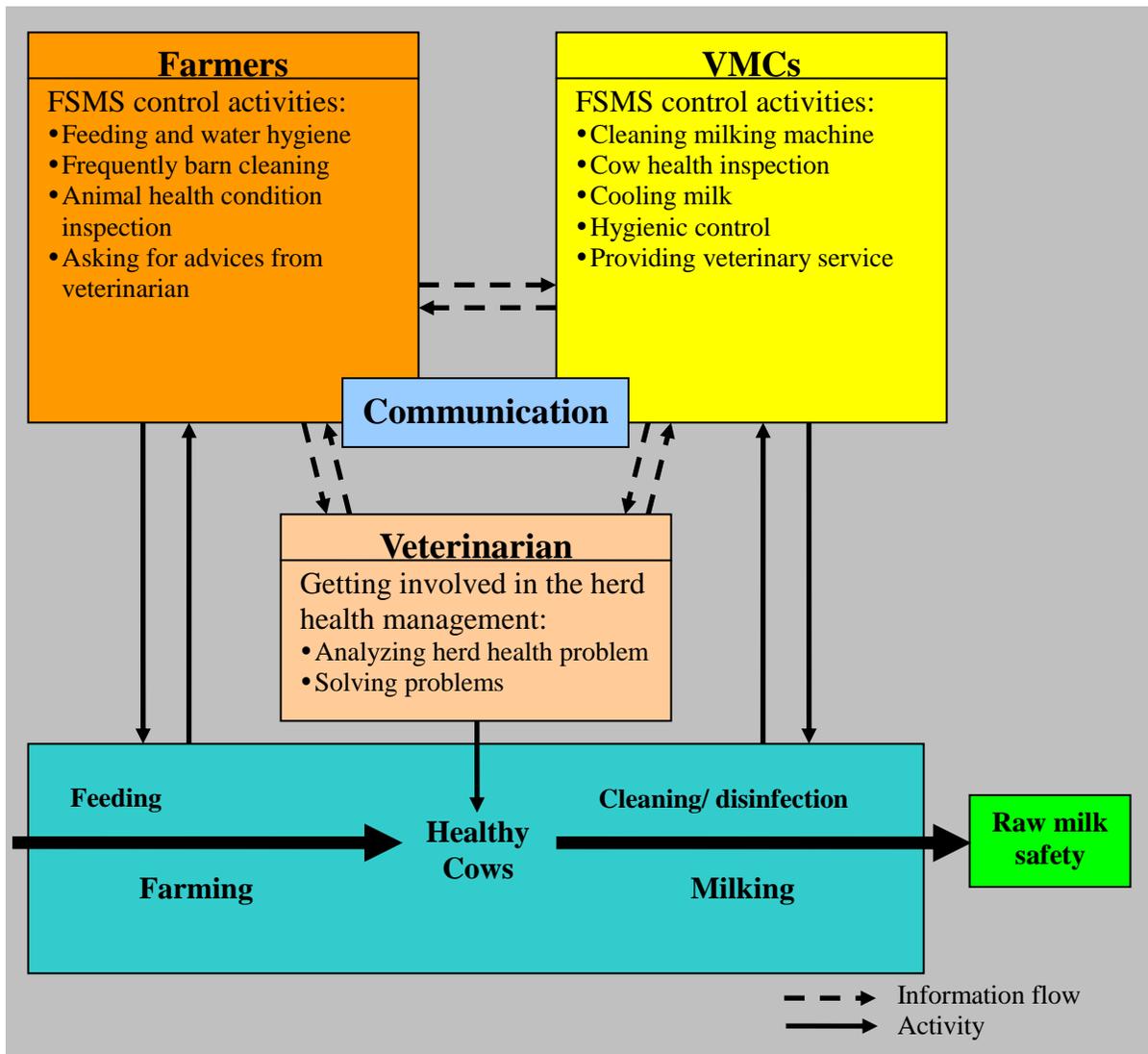


Figure 9. The conceptual research model designed for raw milk production in China.

The conceptual model illustrates different technological and managerial factors affecting the raw milk production in rural China throughout the supply chain. The factors are divided into four core elements: on-farm control, milking control on VMCs level and the involvement of veterinarian during farming management. The classification was primarily based on the different participants in the raw milk

production chain, and activities that are conducted in specific element. According to previous literature research activities in on-farm level are aimed at prevention of microorganism, chemical and physical contamination by means of hygiene animal farming. Milking process in VMCs worker would strive to ensure that milk is collected in a hygiene way and stored in right tank and temperature before sending it to dairy processors. In case of cow disease or milk quality related problems, veterinarian gets involved in the on-farm milk production processes. Veterinarian provides farmer product and service by consulting animal problem, and also may provide advice to farmer about on-farm operations. All of these factors are playing roles in the raw milk production chain and contributing for the raw milk safety.

The conceptual research model represents the relationship between these factors and all of these factors directly influence the safety control of raw milk. For each factor, detailed explanation will be developed in next section of this chapter.

3.2 Explanation of Research Model

Raw milk quality is a cornerstone for all dairy products. Dairy farmers together with VMCs take the responsibility to ensure that the safety and quality of their raw milk will satisfy the highest expectations of the food industry and consumers. On-farm practices should ensure that milk is produced by healthy animals under acceptable conditions for the animals and in balance with the local environment. VMCs, as the necessary bridge between small holder farmers and dairy processor, are obligate to enable cold chain in the period passing from the milking stage to the arrival at the dairy plant.

In order to achieve the high quality of raw milk production, the overarching principles applying to the on-farm herd management and on-VMC milking operation are:

- From farm to VMC, they should be subject to a combination of control measures. Together, these measures (good agricultural practice – GAP and good manufacturing practice – GMP, and more specifically good dairy practice – GDP) should meet the appropriate level of public health protection.
- Good hygienic practices should be applied throughout the farming and milking process in the chain so that raw milk is safe and suitable for their intended use.
- Wherever appropriate, hygienic practices for milk should be implemented following the Codex Recommended International Code of Practice – General Principles of Food Hygiene (FAO, 2004).
- GAP/GMP together should be effective (FAO, 2004).

The role of dairy farmers is to ensure that good agricultural, hygienic and animal husbandry practices are employed at the farm level. The focus should be on preventing a problem (including animal diseases) rather than solving it after it has occurred. According to Luning & Marcelis, 2006, 2007, the technology and managerial - dependent activities are both assumed to influence the performance of FSMS system (Luning & Marcelis, 2006, 2007). Based on the FSCA (see Figure 4) and literature analysis on the on-farm and VMC raw milk quality control, the Food Safety Management system was translated into FSMS control activities in dairy farm and VMC respectively (see Figure 9). According to literature study (Lu *et al.*, 2008), those activities are considered as the critical control points to be controlled in small scale dairy farm in China. The Good dairy farming practices and Milking practice should contribute to ensuring milk and milk products are safe and suitable for their intended use.

The veterinarians play a key role in ensuring that dairy cows are kept under hygienic conditions and in the early detection, surveillance and treatment of diseases, including conditions of public health significance (McKenzie, *et al.*, 2006). The veterinarians may also provide livestock producers with

information, advice and training on how to avoid, eliminate or control food safety hazards in primary production. Rural veterinarians are regularly in contact with farmers and are well placed to understand their priorities, so they are in a good position to provide awareness and training to farmers. All these can help to minimize the risk of adulterations of raw milk from microbial, chemicals, antibiotics contamination.

Farmer, VMC and veterinarian are the major actors involved in the raw milk production in China. High quality and safety raw milk can only be achieved through good performance of activities from each level. Furthermore, they are closely related to each other by their function in the raw milk production. Interactions among different stakeholders in this chain are widely conducted through communications. Communication is considered as an important element in building long-term relationship (Neeru Sharma Doctoral candidate et., al 1999). Meaningful communication between actors in a working partnership is also a necessary requirement of trust (Anderson and Narus ,1986). Interpersonal communication is a substantial part of the interaction process and can therefore be regarded as a processual element of relationships and information networks (Olkkonen *et al.*, 2000).

The up-mentioned four aspects are the four core elements, which include the critical factors affecting the raw milk safety and quality (see Figure 9). Each of core elements will be regarded as an indicator, from which the problem will be described in a simplified, but more focused ways. They reflect the technological and managerial factors and mechanisms that are assumed to contribute to safety of China's dairy industry. The indicators are addressed as:

1. *level of on-farm safety control activity;*
2. *level of on-VMCs safety control activity;*
3. *level of involvement of veterinarian toward raw milk production;*
4. *level of information sharing among farmers, VMCs and veterinarian;*

These measurable indicators will further be translated into research questions systematically, which are used to collect data and information to help to identify the bottlenecks and finally to improve the current dairy safety problem in China.

3.3 Level of on-farm safety control activity

3.3.1 Indicator analysis

As we discussed, raw milk quality is generally defined by its chemical components such as fat and protein, and more importantly its hygienic profile which is characterized by contamination level and specific distributions of microorganisms. The content of fat, protein and other chemical components in raw milk is a result of feeding practices (Demeyer and Doreau 1999), and can be greatly affected by contaminated microorganisms. The hygienic quality of milk affects its shelf-life (Ma *et al.*, 2000) and its eventual acceptability to consumers (Noordhuizen and Metz 2005). So the safety and quality of raw milk is highly correlated to udder health and pre-milking hygiene conditions, which are directly influenced by level of farmer's control activities.

Dairy farmers, as the primary producers in the dairy supply chain, must be given the opportunity to add value to their product by adopting methods of production that satisfy the demands of processors and customers. The role of dairy farmers is to ensure that good agricultural, hygienic and animal husbandry practices are employed at the farm level. The focus should be on preventing a problem (including animal diseases) rather than solving it after it has occurred.

In order to do so, individual dairy farmer needs a guide on how to achieve this goal at a practical

on-farm level. This guide should follow a proactive approach rather than reactive. Similar as Good Manufacturing Practice (GMP), Good Agricultural Practice (GAP) has become a recommended operating procedure applied to agriculture production in order to improve economic, social and environmental sustainability for agriculture (FAO, 2003). GAP offers means to stakeholders involved to reach certain objectives of food security, food quality, production efficiency, and environmental benefits in the medium and long term. GAP may be part of a management strategy for on-farm decision-making and assessing on-farm practices in order to improve output and efficiency (Noordhuizen *et al.*, 2008). As a component of GAP, Good Dairy Farm codes of practice (GDF) was defined specifically for on-farm dairy production and it should contribute to ensuring milk and milk products are safe and suitable for their intended use. GDF can be further divided into several specified codes of practice. In Figure 10, some different codes of practice under GDF have been listed.

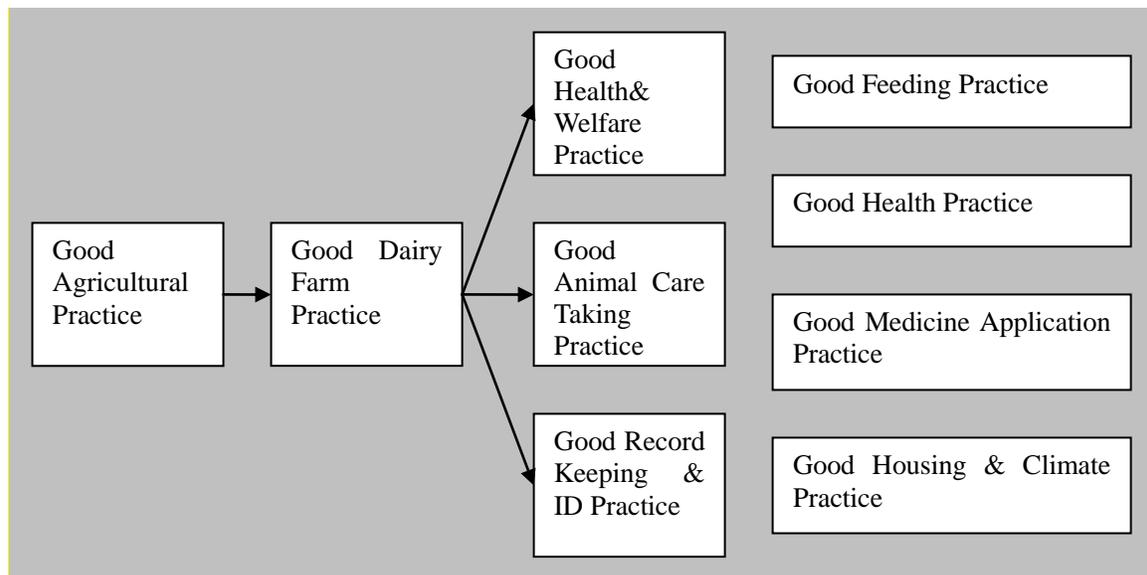


Figure 10. Overview of different codes of practice under the heading of Good Agricultural Practice (adapted after FAO, 2003).

The different codes of practice can be used to develop on-farm guidelines and operational working instructions. Choosing one or several suitable codes of practice will depend on the primary needs on a particular dairy farm. Considering the characters of small farming scale and low educational level of farmers in China, the whole package of codes of practice can not be complemented conveniently. In this situation, it is advisably to define practical guidelines selectively for particular on-farm activity based on actually condition in China.

The guiding objective for good dairy farming practice is that milk should be produced on-farm from healthy animals under generally accepted conditions. To achieve this, dairy farmers need to apply GAP in the following areas (FAO, 2004):

- animal health;
- animal feeding and water;
- animal welfare and
- environment.

Dairy farmers should also ensure that appropriate records are kept, especially those that enable adequate traceability of:

- the use of agricultural and veterinary chemicals;
- the purchase and use of animal feed and
- the unique identification of individual animals.

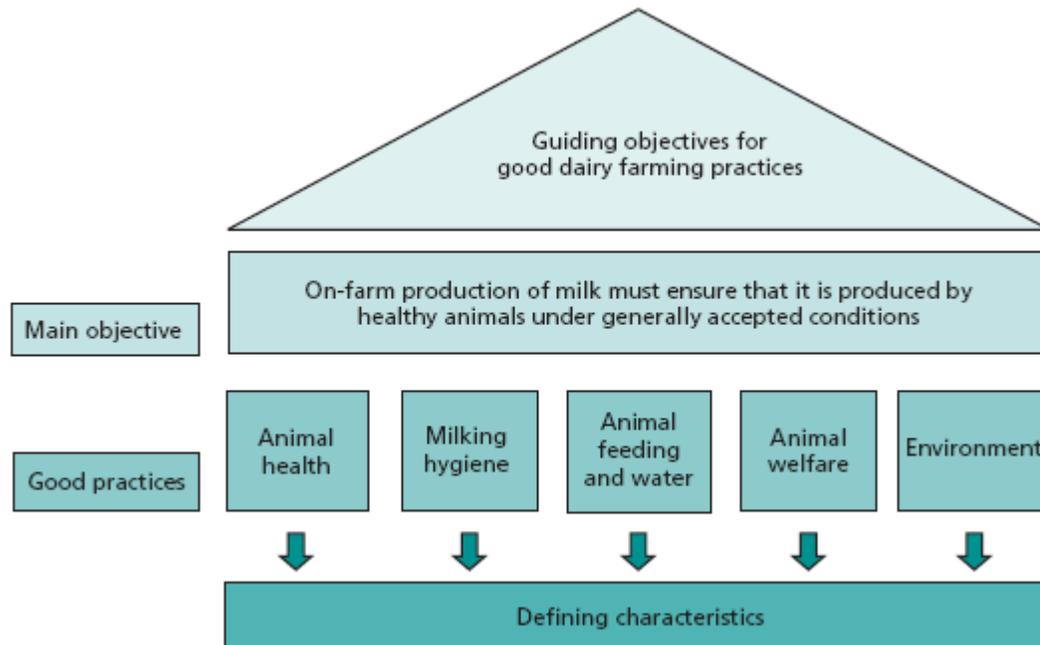


Figure 11. Overview of Good Dairy Farming Practices in on-farm level in the chain. (*adapted from FAO, 2004*)

According to FSMS diagnostic instrument (see Figure 11), the guidelines for on-farm activities should contain activities that are derived from both Food Safety Assurance System (FSAS) and Food Safety Control System (FSCS) in order to achieve an acceptable raw milk safety level. FSCS includes the design and operational activities of three different strategies (i.e. preventive measure, intervention processes and monitoring systems) aimed at keeping product and process conditions within acceptable safety limits. For each strategy, technology dependent activities have been considered because they are assumed to affect the performance of a FSCS.

When a suitable on-farm working guideline is available, the remaining consideration for farmers is capability of adherence to the guideline. It had shown that lack of food safety knowledge is considered as one of the major barriers in the effort to maintain safe food handling practices (Binkley & Ghiselli, 2005). According to a cognitive-behaviour barrier model to implement HACCP guideline (see Figure 12), developed by Azanza *et al.*, 2005, the major barriers are classified into categories: knowledge, attitude and behaviour. Although HACCP is not possible to implement in small-scale dairy farms, knowledge, attitude and behaviour are considered as main influencing factors to any FSMS.

Farmers' behaviour (actions taken) is as a result of knowledge acquisition and attitude development (Azanza *et al.*, 2005). Farmers' knowledge and attitude together determine how much they want to do to maintain good on-farm dairy activities on animal health, feeding and animal welfare.

Thus, three sub-indicators are defined to describe the indicator of FSMS on-farm control activities: presence of good dairy working instrument/guideline, knowledge and attitude of farmer. Different levels of each sub-indicator are formulated as:

Good dairy working instruction/guideline:

- Level 1. Farmers are provided with an understandable and well-illustrated dairy working instruction/guideline;
- Level 2. Farmers are provided with an incomprehensible instruction/guideline;
- Level 3. Farmers do not have any form of instruction/guideline;

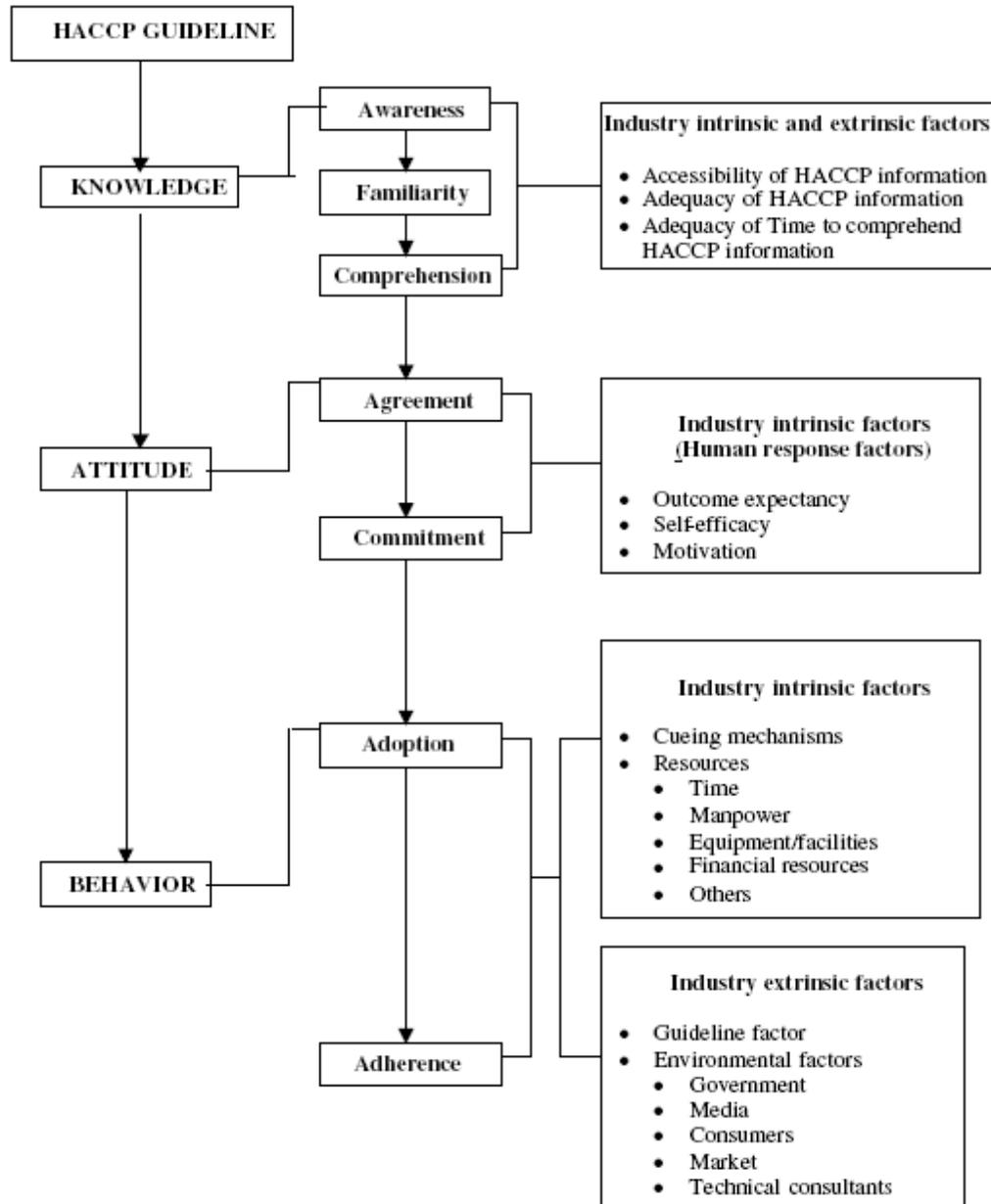


Figure 12. Cognitive and behaviour model to HACCP principle adherence. (Azanza *et al.*, 2005)

Good dairy farming practice knowledge:

Level 1. High level of knowledge: knowledge about animal feeding, welfare and animal health inspection, mastitis control, barn cleaning etc;

Level 2. Medium level of knowledge: knowledge about feeding, watering, barn cleaning;

Level 3. Low level of knowledge: knowledge about only few matters.

Attitude:

Level 1. High quality attitude: follow procedures most of the times, ask advice to a veterinarian most of the times, willing to improve raw milk quality;

Level 2. Medium quality attitude: follow procedures sometimes, ask advice to a veterinarian (sometimes), satisfied with raw milk quality level;

Level 3. Low quality attitude: no procedures (most of the times), ask advice to a veterinarian (very rarely), careless about raw milk quality.

3.3.2 Assumption

If small scale farmers are provided with a good dairy working instruction/guideline and they are knowledge sufficient and willing to improve raw milk quality, dairy cow health can be managed.

3.4 Level of on-VMCs safety control activity

3.4.1 Indicator analysis

VMCs have been playing very important role in China's dairy supply chain, it functions as a bridge between small-scale dairy farms and dairy processor. VMCs provide milking machines, cleaning units, hygiene packages, bulk milk coolers and milk quality measure facilities. The quality of milk is dramatically improved because the problem of adulteration is eliminated and the milking and handling of milk is controlled (Lu, 2002). Nevertheless, the melamine scandal happened in China revealed that VMCs are poorly managed, and hygienic condition and hygienic awareness in VMCs need to be improved.

Milking is the most important activity in VMCs. Consumers demand high standards of milk quality, so milking management aims to minimize microbial, chemical and physical contamination. Milking management covers all aspects of the process of obtaining milk from cows quickly and effectively, while assuring the health of the cows and the quality of the milk. Consistency in the day-to-day implementation of milking procedures is an important part of GDF for milking.

VMCs are obligated to make sure that raw milk is harvested and stored under hygienic conditions, and equipments used to harvest and store milk are well maintained. The suggested GDF practices for hygiene milking in VMCs should be focused on the followings (detailed in **Appendix 7**):

- Ensure milking routines do not injure cows or introduce contaminants in milk
- Ensure milking is carried out under hygienic conditions
- Ensure milk is handled properly after milking.

Standard milk collection centre need a number of equipments and activities to serve a complete function. It includes well-designed building for milking, milking machine, quality testing equipments, documentation etc. Beside milking machine, testing equipment is one of the most important facilities in VMC. Raw milk quality testing is capable of identifying the abnormal milk caused by microbial contamination or deliberate adulteration. Moreover, it provides essential information for establishment of a raw milk quality payment system. A list of recommended facility in VMC is shown in Box 2.

Facility

Level 1: VMCs have all recommended facilities, e.g. milking machine, all necessary testing equipments, documentation, cleaning and sterile solution, bulk tank etc.;

Level 2: VMCs have some facilities, e.g. milking machine, partly testing equipments, bulk tank;

Level 3: VMCs have only milking machine, bulk tank (some).

Standard milking procedure provides a working guideline for milker, in addition, it can eliminate the operating variation taking place among different workers. The standard procedures would help to ensure everyone performs each procedure the same way every time.

Standard milking procedure:

Level 1: VMCs have with an easy-to-follow standard milking procedure;

Level 2: VMCs have a complicated milking procedure;

Level 3: VMCs do not have a standard milking procedure.

Box 2. Detailed equipment list for milk collection centers.**Facility**

Ensure that the buildings are of adequate size and are designed and built to facilitate maintenance, cleaning and sanitary operations, prevent entry of insects and other animals, facilitate waste treatment and disposal, and prevent mix-ups and cross-contamination.

Equipment

- Milk receiving pump with filter
- Plate heat exchange with ice water generator or lactofrizers
- Food grade tube for milk receiving and manipulation
- Temperatures display and data recording
- Hot water -boiler

Laboratory

- Thermometers
- Alcohol probe
- Containers for tacking samples
- Mastitis probe
- Antibiotic and Inhibitor tests
- PH meter
- Refrigeration unit for milk samples storage

Cleaning solutions

- Acid solution
- Alkal
- Disinfection

Pest control

- traps for mouse, flay killer units

Documentation

- Plan for calibration
- Cleaning procedure and records

Maintains

- Plan for maintains
- Records for maintains
- Contract with external company

3.4.2 Assumption

If VMCs are provided with standard milk procedure and furnished with sufficient facilities, good quality and safety of raw milk can be easily achieved.

3.5 Level of involvement of veterinarian toward raw milk safety**3.5.1 Indicator analysis**

Production targets cannot always be achieved because of improper on-farm and VMCs activities. As previous analysis, healthy herd is one of the most important factors that attribute to quality and safety of raw milk. When it comes to advice in dairy farming, dairy herd health and safety management, the veterinarian is likely to be the first expert to be asked for advice. Providing advice gets the veterinarian involved into the on-farm management. The veterinarian's role is to help the farmer to limit the impact of factors caused by theirs activities and enhance or even maximize the quality and

productivity. So the most important objectives of dairy veterinary service are the continuous improvement of the efficiency and profitability of dairy production by the management of animal health. To achieve this, the veterinarian should:

- Provide the most economical method of diagnosis & treatment program tailored to each situation.
- Monitor animal health & production of the herd.
- Recommend specific disease control and prevention programs (vaccination, deworming, biosecurity ...)
- Plan & organize a herd health program
- Advise on nutrition, breeding & general management practices.

Veterinarians, however, display variant characteristics during their veterinary service for farmer. The strong and the weak points regarding cattle veterinarians have been collected in the field by Noordhuizen *et al.*, 2008, which is shown as following:

The strong points for cattle veterinarians were considered:

- His relationship with farmers is based on trust;
- Such a relationship is hard to break down;
- He has knowledge about health and disease;
- He has actual knowledge about reproductive affairs;
- He prevents a large proportion of disease losses;
- One can always reach him; he is always available;
- The veterinary training is highly esteemed;
- It is a protected, professional association, no loose persons.

The following weak points for cattle veterinarians were listed:

- His attitude is much too dominant in general, professionally in particular;
- He talks too much and listens too little (poor communication);
- He does not work according to structured protocols; his advice is not structured; he does not provide clear working instruction;
- He has limited knowledge about cattle nutrition and related issues;
- He has limited knowledge about managerial affairs;
- He has limited knowledge about dairy farm economics;
- He has little to no knowledge about entrepreneurship and organizational matters on the dairy farm;
- He has the public image of being too expensive (i.e. related to medicines);
- He tells his clients insufficiently about his fields of expertise or knowledge (no marketing knowledge);
- He does not indicate what he could contribute to the dairy farm;
- He is little pro-active and hence too much in waiting (next to the telephone);
- He does not offer on-site training to farm workers;
- There are too many personnel changes in the veterinary practice which may hamper the establishment of trustworthy relationships;
- He is (maybe) not willing to invest in discussions with the farmer; he shows little empathy.

The strong and the weak points featured by veterinarian has well-summarized the possible difficulties that farmers may counter in a cattle consultation.

The Calgary Cambridge Guide for medical consultation provides a framework for the planning and conducting of a medical consultation which may be valuable for veterinary consultation too (Figure 13). While the structure of this consultation process is evolving, also the relationship between clinician and client is built. Therefore while gathering information the basis of clinician-client interaction is

improved continuously and helps in further conducting the consultation. Using this framework in the course of a consultation in the herd health planning and Quality Risk Management requires only little adaptation (Noordhuizen *et al.*, 2008). The situation for veterinarian-farmers is very similar to clinician-client. They share the basic common elements for a medical consultation. Kurtz, 2006 has shown very clearly that gathering information, planning and eventually taking action on a problem is not only dependant on the structure of the whole process, but, to similar extent, also of the relationship between veterinarian and client.

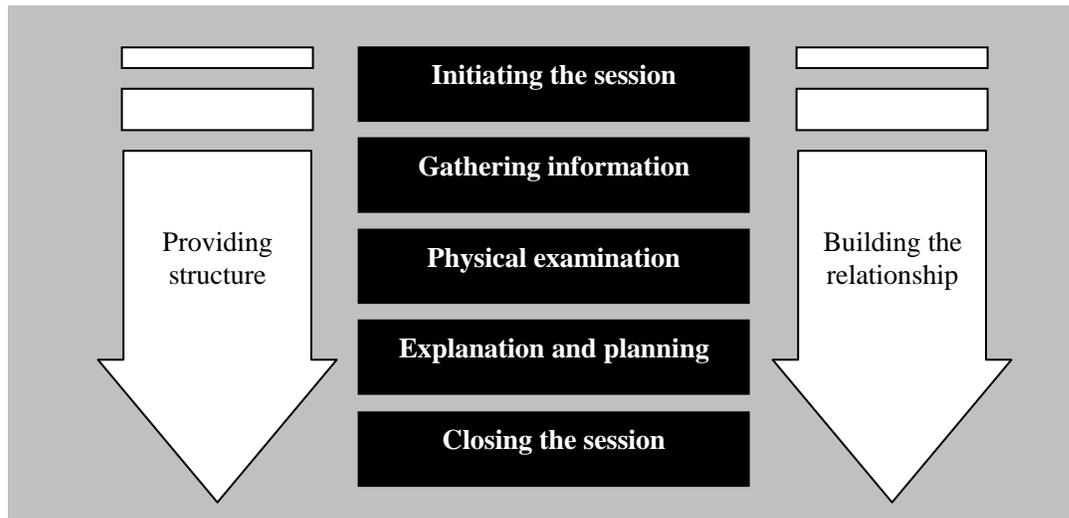


Figure 13. Framework for medical consultations and Calgary-Cambridge Guides (Kurtz, 2006)

The tasks occurring as continuous elements in a veterinary service are structuring the consultation and building the relationship (Kurtz, 2006). Proper structured consultation will provide a sufficient frame for a successful consultation. Relationship between veterinarian and farmers has been one of the most important factors determining the outcome of service. Poor veterinarian-farmer relationships not only limited the ability of veterinarians to work effectively, but also hindered attempts to improve the raw milk production.

An effective consultation requires a thorough history-taking process and analysis of the specific problem from individual farm. It is of complexity in the areas of herd health and safety control problems. Giving advice in areas of cattle farming is sometimes regarded as being unrewarding and complex. Dairy farmer needs veterinarian to solve the problem, but veterinarian on the other hand has to make decision whether he is going to get engaged or not. Decisions made will have a considerable impact on the processes on farm and, in addition, regularly involve costs for investments and other changes in management. This process therefore gets the veterinarian involved into the on-farm management. Consequently, the veterinarian might feel he is (partly) taking over the responsibility for the economic success of the farm, and also quality of farm's production.

In order to make such a decision, internal communication within the veterinary practice needs to be done. It includes things about the offers to farmer, the charging for these services and the time the consultation is likely to take. Veterinarian should take time to analyze the situation by asking and answering questions. A strength and weakness assessment (SWA) of the practice gives information about the products and services that can be best offered to farmer (Cannas de Silva *et al.*, 2006). Once internal processes are completed, the advisory process will be following. Veterinary consultation will finally generate service and products to client. A schematic overview of steps in establishing an advisory plan is illustrated in Figure 14.

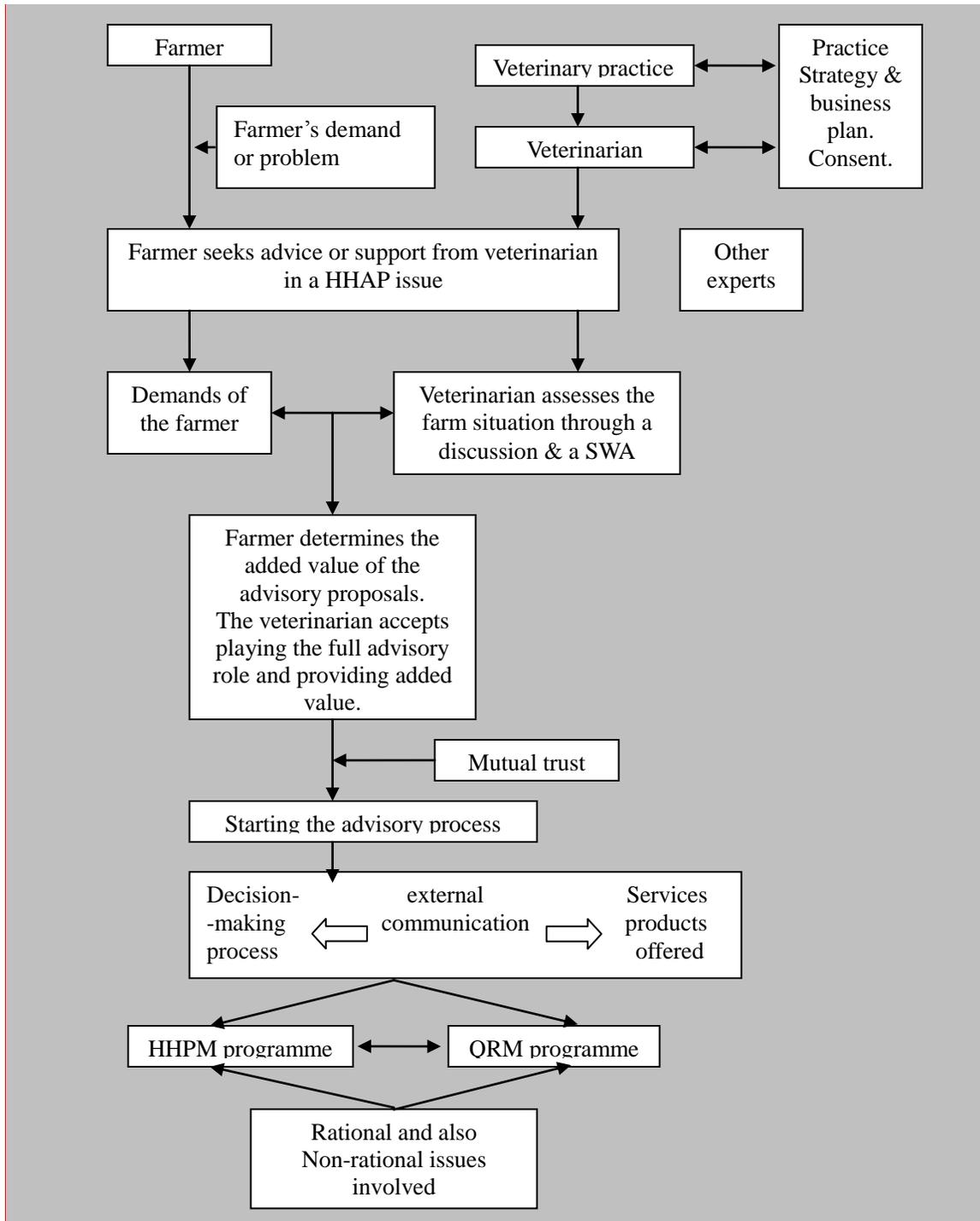


Figure 14. Schematic overview of subsequent steps in establishing an advisory plan, including aspects of internal and external communication. (Noordhuizen et al., 2008)

Various interactions between veterinarian and farmers happening in a veterinary consultation are shown sequentially in Figure 14. In a typical veterinary on-farm service, the consultation starts with farmer seeking help or advice from veterinarian. Subsequently information exchange with farmer explaining his/her problem and veterinarian asking for related information. It happens through interpersonal communication. The success of a practice may to a large extent be dependant on the communication skill of the veterinarian (Mills, 1998). Communication is also important in order to

reach an agreement for both parties. In this stage, trust is the foundation between them to have the agreement implemented (Morgan and Hunt, 1994). Farmer is now being explained and offered with services and products. Improvement points on the on-farm performance might also be advised. Taking action as the last step in the consultation can involve many different activities. This may be the purchase and use of a specific product, e.g. a vaccination. It can also imply changes in management, like feeding, cleaning routine.

Another determinant to the success of veterinary consultation is relationship between veterinarian and farmers. The relationship between veterinarian and his client, then dealing with each other, is not a consequence but rather the basis of a successful collaboration (Noordhuizen *et al.*, 2008). A large number of studies dealing with relationship management have been done. Dorsch *et al.* (1998) highlighted the relevance of trust, satisfaction, commitment, opportunism, customer satisfaction, and ethical profile. Naudé and Buttle (2000) proposed five attributes of relationship quality: trust, power, integration, mutual understanding of needs, and profit. Concerning the importance of farmer orientation and the satisfaction, Schulze *et al.*, 2006 defined relationship quality as a higher-order concept, composed of three different elements: satisfaction, trust and commitment (Figure 15).

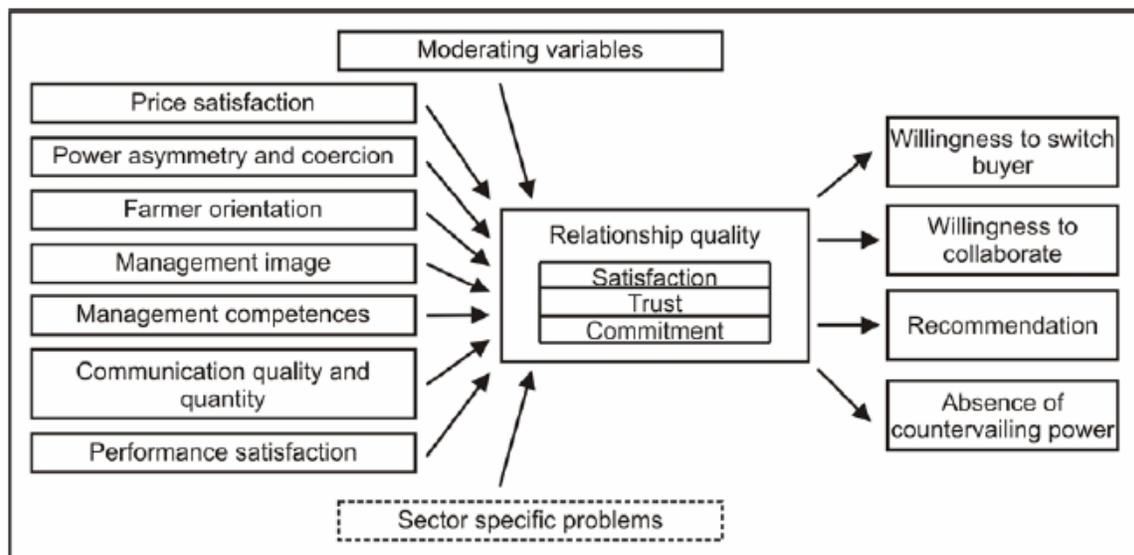


Figure 15. The crucial variable influencing the relationship quality (Schulze *et al.*, 2006)

Within this model, satisfaction, trust and commitment are the core elements influencing the veterinarian-farmer relationship. A basic element for nearly all relationship models is the outstanding importance of customer satisfaction or, in this case, farmer's satisfaction. Satisfaction reflects experience with a business partner as a necessary but not sufficient condition for an ongoing relationship (van Weele, 2002). Other elements of relationship quality are trust and commitment. Trust is defined as a willingness to rely on an exchange partner in whom one has confidence (Moorman *et al.*, 1993). It is a key construct in most models of long-term business as well as personal relationships (Morgan and Hunt, 1994). Commitment is an implicit or explicit pledge of relational continuity between exchange partners (Dwyer *et al.*, 1987). Commitment is seen as an outcome of trust and defined variously in the literature as the belief of a supplier that the relationship with a processor is so important that it warrants maximum effort to maintain it even if problems occur (Morgan and Hunt, 1994). To small scale dairy farmers in China, these three elements are more important beyond the contract and ethical obligation of a veterinarian.

Over past century, developed countries like Netherlands have progressively improved the animal health situation of their national herds through advances in veterinary science and the establishment of a sophisticated veterinary service infrastructure. It also has the capacity to translate research findings

into practical application and to implement area-wide disease control and herd health programs. Consequently, quality and safety of dairy products in those countries have been achieved and well maintained in a supreme level.

On the other hand, in developing countries like China the situation is quite different in several respects to that encountered in the developed world. Various factors have resulted that the animal health situation is hardly under control (Bedard *et al.*, 2004). Production and market regulation are either non-existent or practically not enforceable. The educational level of the great majority of livestock owners are very low. Small-scale farmer who contribute to more than 75% of total raw milk production in China are considerably poor.

In this case, to which extent the veterinary service can be applied to raw milk production, or in another words, to which level of involvement of veterinarian in on-farm level, has a critical influence on the safety level of raw milk. Four levels of involvement of veterinarian toward to raw milk safety are identified as:

Level 1: maximum involvement. Veterinarian have frequent interaction with farmers, advice are often provided by veterinarian and herd health problems are well-solved through veterinary service.

Level 2: medium involvement. Veterinarian get involved only if asked by farmers, most problems are solved by veterinarian.

Level 3: low involvement. Veterinarian have few interaction with farmers. Farmers call for veterinary service only when animal herd is really sick.

Level 4: no involvement. There is no veterinary service, farmers can hardly find a veterinarian to treat the unhealthy animal. Or veterinarian is available, but farmers seldom call for help.

3.5.2 Assumption

Maximum involvement of veterinarian would help farmer to solve the milk quality related problems, therefore ensure the raw milk safety on the primary milk production process.

3.6 Level of information sharing among farmers, VMC and veterinarian

3.6.1 Indicator analysis

Information distribution is basic to effective coordination in a supply chain. Many studies have emphasized that information sharing has great impacts on supply chain performance (Barrat, 2004, Lambert & Cooper, 2000). Sharing the information in the supply chain enables performers to make better decisions in their operation leading to better resource utilization and lower supply chain costs, more importantly to production safety.

In the raw milk production, dairy farmer together with milk collection centers (VMCs or MCCs) and veterinary play the determining roles on the raw milk safety performance. In previous sections, I have discussed the raw milk safety performance on different levels in detail, as well as the factors with respect to the raw milk production. Hence, information such as animal health condition in on-farm level, raw milk quality test in VMCs/MCCs level, mastitis or quality-related problem diagnosis in veterinarian level are crucial to be shared among different production participants.

Communication is the exchange and flow of information from sender to receiver. The Sender-Receiver model is the most basic way to illustrate the mechanism of communication. The goal of communication is the acceptance of the sender's message by the receiver (Luning, *et al.*, 2002). To achieve good information transmission communication requires that all participants understand

common information through transmission. Communication is a process of mutual interaction and never one-way only. Therefore, effective communication between farmer and veterinarian or VMCs/MCCs occurs only if the receiver understands the exact information that the sender intended to transmit.

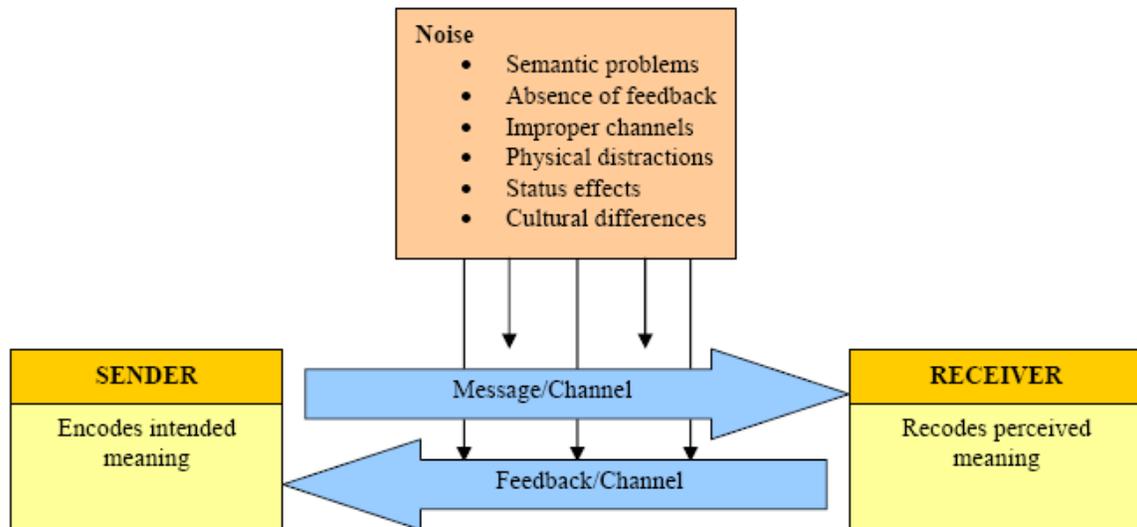


Figure 16. Communication process (Luning *et al.*, 2002)

The communication process starts with a sender sending a message or information to a receiver via a number of channels (Figure 16). With the feedback sender is able to tell whether the receiver understood the message that sender intended to inform. However, the receiver's interpretation almost never matched the sender's original intention for various reasons or Noises, referring anything that interferes with the message being communicated effectively.

A model was developed by Schulz von Thun (1981) on interpersonal communication called 'The communication square' (Figure 17). This model describes four sites every message contains, content, appeal, self-revelation and relation between actors.

During a problem consultation in on-farm level, massive messages are sent from veterinarian to farmers. Through those message, veterinarian reveals his opinion and impression on the problem he is dealing with and the farm management. The farmer, who may not understand veterinarian's self-

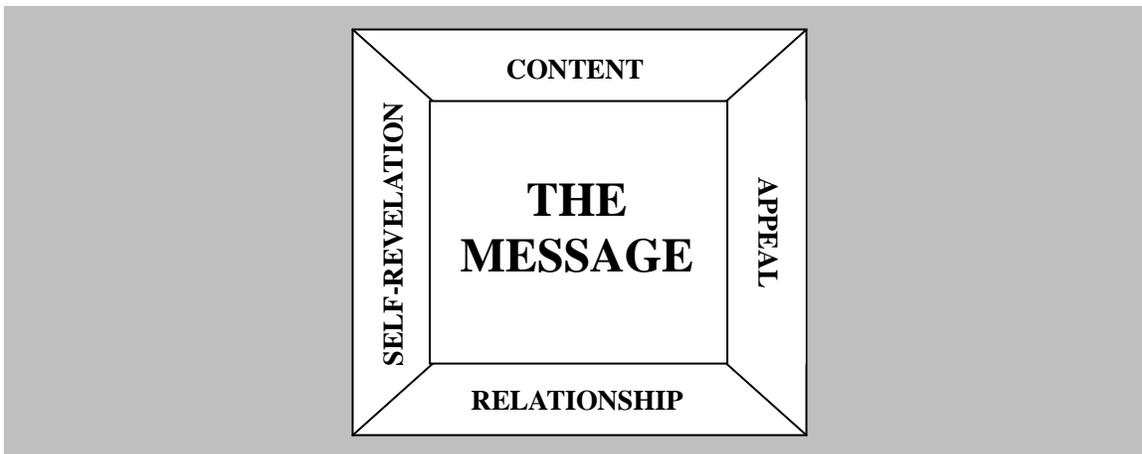


Figure 17. The Communication Square (adapted from Noordhuizen, 2008)

revelation, may interpret the problems and the messages in the different ways. The interpretation from each side of them depends on their educational level, experience and the actual situation they are handling. A relationship built between veterinarian and farmers also influence the interpretation of messages. A relationship dominated by mutual trust will improve the conversation and discussion, otherwise misunderstanding created can possibly lead the consultation into an unexpected result.

The relationship between persons involved may be the source of misunderstandings and largely conditions the result of the process. It is obviously that incongruence exists between veterinarian and farmers in some levels, thereby hindering the success of a consultation. Six main factors in a communication influence interaction between partners, they have been identified and listed by Argyle (1994):

- Amount of speech
- Emotional tone;
- Dominance;
- Role relation & definition of the situation'
- Intimacy;
- Tasks & topics

In this sense, this indicator can be divided into several aspects that influence the information sharing process among farmer, veterinarian and VMCs. For each of them, the indicating levels are identified:

Level of Information sharing:

- Level 1. High sharing of information: all relevant information is distributed;
- Level 2. Medium sharing of information;
- Level 3. Low sharing of information.

3.6.2 Assumption

If information related to milk quality can be shared among farmer, veterinarian and VMCs, it would enable a more convenient milk quality management in on-farm, VMCs level.

3.7 Research questions for interview

The indicators have been analyzed in previous sections of this chapter. Indicators have become more understandable by interpreting each of them with more literature study and scientific models. As a result, influencing factors to each indicator were identified accordingly. They are considered as critical issues to achieve the safety control (especially to microbial hazard) of raw milk under different indicators. Hence, how well or to what extent have those corresponding activities (see Figure 9, the research model) been performing by actors on the raw milk chain need to be examined.

To investigate the performance of activities related to raw milk safety in realistic situation, more information and data has to be collected. In order to do so, questions were deduced based on the indicator analysis and influencing factors. These questions were designed for gathering data from small scale dairy farmer, VMC, veterinarian. The answers to questions would enable to find the weak points existing in the raw milk production system in rural China.

Written question is not an option for information gathering in rural China. The low universal education level in rural China is the main restriction. Therefore, personal interview was conducted to farmers and VMC workers. Personal interview makes sure that each question would be explained clearly, avoiding misunderstanding.

A list of questions correlating to four indicators is listed in Table 6. It should be noted that these questions were developed only for primeval interview. More questions were engaged during my interview to farmer and VMC, and they were included in two more complete forms of questionnaires, shown in **Appendix 8** and **9**.

Table 6. Indicators and research questions

Indicator	Influencing factors	Questions
level of on-farm safety control activity	Good dairy working instruction/guideline; Knowledge; Attitude	<ol style="list-style-type: none"> 1. To design an appropriate working guideline for householder farmers, what is the basic practical guidance? 2. Do farmers have an advised working guideline? If yes, provided by whom? 3. Do farmers have sufficient knowledge to comply with the working guideline, if there was one? 4. Do farmers follow a dairy farming guideline? 5. Have farmers taken any kind of training about on-farming working? 6. What is farmers' attitude toward the GDFP.
level of on-VMCs safety control activity	Facility; Standard milking procedure; Knowledge; Attitude	<ol style="list-style-type: none"> 1. How many kinds of VMCs are functioning in China's rural dairy sector? 2. What are the regulations to run a VMC? 3. What else services do VMCs provide to farmers besides milking? 4. How many household farms are covered by each of VMC? What is the average herd number for one VMC? 5. What is the average educational level of staff working in VMCs? 6. Does VMC hold regular training for staff? 7. Do VMCs workers follow the standard milking guidance during the whole process? Is there a printed SOP or poster? 8. What kinds of test do VMCs do to determine the quality of milk? Does VMC have basic testing equipments which are needed for test? 9. How long does raw milk kept in VMCs before transported to next stop? 10. What kinds of recordings do VMCs need to control raw milk quality? 11. Do VMCs have recording system for milk quality control? 12. How is the relationship between VMCs and farmers? 13. Do farmers satisfy with the VMC's work? 14. Do farmers have more expectation to VMCs?
Level of involvement of veterinarian toward raw milk safety	Experience; Relationship	<ol style="list-style-type: none"> 1. In what condition do farmers ask for veterinary service? 2. Does veterinarian capable of giving advice on farming operation? 3. Do farmers satisfy with the veterinary service they have received? 4. How is the relationship between farmers and veterinarian?
level of information sharing among farmers VMCs and veterinarian	Communication; Information sharing	<ol style="list-style-type: none"> 1. What are the sources of information that farmer can request? 2. Do farmers have an information record about cow disease, drug & antibiotics treatment history etc? 3. What is the current information serving system in China? 4. Do farmers receive any training? Does the training help to improve the communication?

Chapter 4 Practical Research in Rural China

This chapter describes the practical research conducted in China's dairy farms. The work was designed to gather data with respect to performance of food safety management system during raw milk production in China. Considered as important influencing element, contextual factors illustrated in Food Safety Management System diagnostic instrument (Figure 3) was also addressed in realization environment. Subsequently, statistically analysis of raw data will provide a more understandable indication about the current production and living situation of small scale farms.

4.1 Research design and methods

The data collection was done by survey method. The educational level of farmers is considerably low. To avoid that misunderstanding of questions and find out as much information as possible about small-scale dairy farms and Village Milking Centres (VMCs), face to face interviews was conducted with farmers and VMCs worker or managers. Therefore two different questionnaires were designed for VMCs and farmers respectively (**Appendix 8, 9**). Questions were designed to be simply and apprehensible considering the education level of farmers and VMC worker. The questionnaires consist of alternative answers and extra space for comments of respondents.

Headlines for the questionnaire for farmer:

- Personal information
- Farm composition
- Household income
- Relation to VMC
- Feed/feedingCow health
- Recording

Headlines for the questionnaire for VMC:

- General VMC information
- Educational background
- Services and facilities at VMC
- Technical equipment in VMC
- Facility
- Cow health
- Milking procedure
- Payment system

In this study 10 VMCs, each from one village, were visited. Those VMCs was selected from provinces of Hebei and Tianjin, and 5 VMCs in each. In each village four farmers connecting to the VMC were interviewed and asked for information based on questionnaires. Totally 30 farmers were interviewed. Figure 18 presents a map of China indicating the places where the study and visits were performed.



Figure 18. Geographical location of visited VMCs and farmers (*adopted from <http://www.geographicguide.net/asia/china.htm>*)

4.2 Characteristics of Respondents

Respondents in this research are VMC and small-scale farmer. The profile of VMCs and Farmers are displayed in the Table 7 and Table 8 respectively.

Table 7. Characteristics of visited Village Milk Centres.

VMC	No. Staff	No. cow serviced	Operation years	Type	Location
V1	4	103	4	Private	Hebei
V2	3	120	3	Processor	Hebei
V3	6	around 300	6	Cooperative	Hebei
V4	4	207	2	Processor	Hebei
V5	5	195	4	Cooperative	Hebei

V6	3	90	3	Private	Tianjin
V7	4	140	3	Private	Tianjin
V8	6	129	5	Cooperative	Tianjin
V9	4	168	2	Private	Tianjin
V10	6	328	6	Processor	Tianjin

Table 8. Characteristics of interviewed small scale dairy farmers.

Farm	Milking VMC	No. Cow	Years of Dairy farm	Education
F1	V1	6	5	Middle school
F2		4	3	Middle school
F3		4	2	Elementary school
F4	V2	4	2	Middle school
F5		5	3	Elementary school
F6		2	2	No education
F7	V3	5	6	Middle school
F8		8	4	Middle school
F9		5	3	Elementary school
F10	V4	3	3	Elementary school
F11		4	3	Middle school
F12		2	2	Middle school
F13	V5	18	6	High school
F14		5	4	Middle school
F15		4	4	Elementary school
F16	V6	3	4	Elementary school
F17		5	3	Middle school
F18		1	3	Elementary school
F19	V7	3	5	Elementary school
F20		3	3	Middle school
F21		4	3	Middle school
F22	V8	9	3	High school
F23		3	4	Middle school
F24		5	4	Elementary school
F25	V9	3	3	Elementary school
F26		5	4	Middle school
F27		3	3	Middle school
F28	V10	6	5	Middle school
F29		3	2	Elementary school
F30		16	3	Collage

4.3 Results and discussions

4.3.1 Result and question summary to Indicator 1

Educational level

Dairy farmers were asked to report their highest level of education: 3.3% of dairy farmers were illiterate; 36.7% had completed elementary education; 50.0% had completed middle school education and 10.0% of dairy farmers had high school or college background. No interviewed farmer had

university education (Table 9). No farmer started the dairy business since the melamine scandal.

Farm composition

About 43.3% of farmers relied on the income from dairy cow, it was considered as their main business; whereas 56.7% of farmers had other kind of income sources, like crop production and temporary job in nearby cities. 80% of farmers had few chickens and pigs but only for household (Table 9).

Training received

60.0% of dairy farmers declared that they attended to some kinds of course of trainings which either held by dairy processor or provided by VMC. 40% said they had never been to any kind of training programs, simply because no one was held or given (Table 9).

Table 9. General information of farmers.

	No. of farmers	% of farmers
Education		
No education	1	3.3%
Elementary school	11	36.7%
Middle school	15	50.0%
High school/College	3	10.0%
University	0	0%
Dairy farming		
Main business	13	43.3%
Side business	17	56.7%
Farm composition		
Cow only	6	20.0%
Other animal like chicken, Pig	24	80.0%
Training received		
Yes	17	56.7%
No	13	43.3%
Dairy farming guideline		
Yes	7	23.3%
No	23	76.6%

Good dairy farming practice knowledge

Questions were arised to investigate whether an instruction or guideline for good dairy farming was present in dairy farms. 76.6% of dairy farm had not been provided with one instrument/guideline. On the basis of answers of respondents, the hygiene farming was introduced in some training courses.

To further assess farmers' knowledge about good dairy farming practice, questions were asked to farmers. Their GDFP knowledge was divided into three levels: weak, moderate, high levels. Findings showed that 80% dairy farmers had week knowledge about GDP, including cow health, feeding and welfare. 15.7% had Moderate GDP knowledge and only 4% had high level of knowledge toward quality milk (Table 10).

Table 10. Good Dairy Farming Practice knowledge level of farmers

	No. farmers		
	Low level	Moderate level	High level
Cow health	24	5	1
Feeding	20	7	3
Welfare	28	2	0
average	24 / 80%	4.7 / 15.7%	1.3 / 4%
Milking	4	21	5

It was observed that more than 80% of farmers milked their cows by themselves in VMCs. According to farmers, a briefly introduction and demonstration of milking procedure was given by VMCs. 73.3% of farmers declared that milking procedure was easy-to-follow process. The detailed milking practice will be discussed in next indicator.

Attitude

According to findings, more than 56.7% of farmers didn't care about the milk quality. 43.3% like to improve the milk quality from their cows. 30% of farmers wanted to know more about the farming practice, disease/illness of cows was interesting to them. Most of farmer (70%) were satisfied with their knowledge or did not want to improve their knowledge (Table 11).

Table 11. Good dairy farming practice knowledge level of farmers

Attitude	No. of farmers	% of farmers
Milk quality		
Care	13	43.3%
Doesn't matter	17	56.7%
Education		
Want more education	9	30.0%
Doesn't matter	21	70.0%

The model of raw milk production chain

In this study, all visited dairy farms can be concluded as in a dairy model of "Processor + VMC + Farm households". This model of raw milk production has been adopted by dairy processing enterprises since middle of 1990s in China. The milking station provides with mechanical milking machines linking to households who bring their dairy cows to the station for milking. Milk storage tank in VMC helps to maintain low temperature and inhibit bacteria growth before sent to processors. In most cases VMC is constructed in large dairy cow raising villages and towns.

According to the governance of milking stations can differ:

1. The dairy processor's milking station

In order to ensure milk supplies, some large dairy processors such as Mengniu, Yili and others, invest and construct milking stations near the processing plant or in large dairy cow raising villages and towns. The company then leases the stations to individuals and the purchased milk must be supplied to the processing enterprise.

2. The individual milking station

In some cases, private individuals construct milking stations. The milk collected by these stations can be sold to one dairy product processing enterprise, but also to some others.

3. The dairy product cooperative's milking station

Over the past decade, supported by government's policies, specialized cooperatives have developed rapidly, including those organized by dairy farmers. The cooperatives' milking stations collect milk from the members of the cooperative. Funds for construction come from the governmental project and some supplied by members of the cooperative.

The construction of milking stations directly benefits dairy cow raisers by not only reducing labour requirements but ensuring the availability of a stable market and technical training for dairy cow raisers. The dairy processors benefit from a stable source of high quality raw milk, limiting opportunities for milk adulteration. (Duan, 2007).

4.3.2 Result and question summary to Indicator 2

In this research, 4 were private owned VMCs, 3 were owned by cooperative, 3 by the dairy processor. The total number of households connected to the VMC ranged from 50 to 200. The total number of dairy cows connected to one centre ranged from 90 to 328 (Table 7). According to VMCs, there were big differences in the number of cows milking in VMCs before and after the melamine scandal. Cows milking in VMCs were 2/3 of the cow numbers used to be. The reasons for that were many farmers quitted from dairy business or decrease the number of cow after the striking of scandal. 70% of VMCs mentioned that they served milking service to farmers that were from neighboring villages

The educational level of employee working in VMCs were not detailed studied, however the highest educational background was high school. Most of employees had educated lower than high school.

Facility

Hygienic facilities in VMCs are the prerequisite for controlling the raw milk safety. During my visit of VMCs, variant milking machines were found, bucket milking machines, milking parlors etc. The average number of milking machines in the visited VMCs is 14. The water used in VMC for cleaning was from well. Heating facility was available for cleaning and disinfection in all VMCs. The findings of Visited VMCs have shown that 90% of VMCs were facilitated with cooling tanks. Bulk tank as well was used to transport the collected raw milk to processors. 90% of VMCs' floor was covered with concrete. 50% of VMC had sanitizing room (Table 12). 20% had computer that was used for recording.

Table 12. Information about facility in VMCs.

Facility	No. of VMC	% of VMC
Bulk milk cooling tank	9	90%
Sanitizing room	5	50%
Separate milking room	8	80%
Drainage system	6	60%
Heating facility	10	100%
Concrete floor	9	90%
Computer	2	20%

Raw milk quality testing equipment

It was found that 90% visited VMCs had thermometers. Half of VMCs were facilitated balance and more than half (60%) had alcohol burner. For most of equipment like mastitis probe, stove for constant temperature, pH meter, they could not be found in more than 60% of VMCs. Based on the findings, conclusion can be made that most of VMCs were short of quality testing equipment. As a result, the primary quality inspection in VMC was difficult to fulfill.

Table 13. Quality testing equipment in VMCs

Equipment	No. of VMC	% of VMC
Balance	6	60%
Incubation stove	0	0%
Thermometers	9	90%
density meter	4	40%
Mastitis probe	3	30%
pH paper	4	40%
pH meter	1	10%
Alcohol burner	6	60%
Antibiotic and Inhibitor tests	1	10%
Beakers etc	7	70%

Good milking practice in VMCs

Table 14. Good milking practice in VMCs

	No. of VMC	% of VMC
Wear gloves	3	30%
Mastitis test before milking	3	30%
Discard first few ml of milk	8	80%
Clean teat with sterilizing solution		
Before milking	6	60%
After milking	5	50%
Before and after	3	30%
One towel per cow	4	40%
Cleaning milking machine	7	70%
Milk cooling to 4°C	8	80%
Transport Frequency		
Twice per day	1	10%
Once per day	9	90%

Only 30% of VMCs indicated that they held frequent training sessions for their milkers. Some VMC workers claimed that they had never been trained for milking. In case of farmer milking themselves, 80% of farmers indicated that they were trained milkers only at first time of milking and 5% indicated that they were never trained. It is difficult to understand how VMC workers and farmers are expected to perform adequately because only 40% of VMCs had written milking operation procedure.

4.3.3 Result and Question Summary to Indicator 3

The food animal veterinary services in China are primarily delivered through governmental organizations as a public good. Veterinarians and animal health workers are employees of the Ministry of Agriculture (MOA). The delivery of veterinary services under the MOA is managed by the Animal Husbandry and Veterinary Department through operational institutions such as the National Animal Husbandry and Veterinary Service (NAHVS). The NAHVS operates programs through a network of 'centre' and 'stations' at national, provincial, municipal, county and township levels (Putt, 1997).

On-farm level delivery of animal health services is traditionally provided by the township animal husbandry station technical staff. They often lack of formal training but have responsibility for disease prevention, inspection, quarantine, regulatory veterinary medicine, treatment, and livestock improvement programs. These workers are assisted in their work by the more qualified technical staff at county or provincial level when necessary (Anon, 2001).

In last decade, the veterinary service system has been changing and now private veterinarians are becoming more prominent in close association with dairy farms. Private veterinarians usually work at the farm, village and township level. Some of them work for state farms and industrial farms, or are employed by dairy processors. The emergence of private veterinarians is usually associated with regions and sectors of the livestock industry that are market-driven and can profitably justify the value-added investment in the prevention of production related diseases, whereas, reportable or infectious diseases tend to be the preoccupation of the traditional government regulatory Veterinary Service. Some private animal health workers have veterinary degrees, but many of them do not have any formal veterinary education.

Total number of animal health veterinarian in China had been reported and estimated more than one million extension workers based in counties and townships throughout the country (Kouba, 2005). Among them, about 43,900 veterinarians worked in the network of public veterinary service around China, counting for 20.92% of all public veterinarians in the world. More than 50,000 private

veterinarians worked in farm, village and township level for animal health service (see **Appendix 10**).

As I discussed in Chapter 3, the success of a veterinary service depends on the educational level, communication skill and attitude of veterinarian, and also the relationship between veterinarian and farmer. In China, there are different levels of veterinarian working for veterinary service. Although most call themselves veterinarian, the education and training level vary from:

- graduated from 4-5 years university or college program
- 2-3 years high veterinary school animal husbandry/animal health training (vocational high school)
- Barefoot veterinarians (on the job training)

The first level of veterinarians normally go to higher levels in administration, education or research, and are therefore rarely directly involved in delivery of field services. The lower level consists of veterinary technician trained at vocational or technical schools for six months to two year periods, followed by a field assignment to deliver veterinary services. Most of barefoot veterinarians are doing unlicensed veterinary work in village level. The second level and barefoot veterinarians, who normally run small service station in village, are doing the most common veterinary service in China. Both of these two major types of veterinarian are featured with low educational level. However, their veterinary experience in rural area is more valuable than their educational level. Long period of working experience on veterinary would enable barefoot and vocational graduated veterinarians to be familiar with rural environment, to develop special communication skills with rural farmers, and more importantly the trust with farmers.

According to the survey, farmer asks for help from veterinarian in condition of ill cows. In most scenarios, antibiotics medicine or injection are provided to treat disease. They ask for a veterinary consultation when milk was rejected by VMCs for failed quality. 67% of interviewed farmers have confirmed their good relationship with veterinarian. 13% of farmers complained about hard to find a veterinarian. The reason was that there was not veterinarian in the same village, they had to, therefore, look for one in neighboring village. 40% were satisfied with veterinary service they received, and 53% complained that the health condition of their cows does not turn better after receiving the veterinary help.

4.3.4 Result and Question Summary to Indicator 4

The importance of information sharing within the supply chain have emphasized in numbers of studies in recent years (Barrat, 2004, Lau & Lee, 2000). Information sharing is a prerequisite for successful operation of the supply chain management (Mason-Jones & Towill, 1997). According to my research model, the supply chain of household raw milk production has involved the actors of dairy farmer, VMC and veterinarian. There is no doubt about the importance of information sharing, e.g. disease recording, veterinary treatment, improper farming practice, quality regulation from dairy processor and government, in this supply chain. Good information sharing can greatly reduce the costs, help for strategic planning on each actors. Information should be readily available to all actors in the supply chain.

In this study, dairy farmers were asked about their sources of information about awareness of milk quality. The most communication channels were with other farmers. Most farmers indicated that they acquired some dairy practice knowledge from other farmers in the same village. Veterinarian also played role to help farmers build proper farming practice. VMC, on the other hand, was not playing its role in the system. Dairy farmers went to VMC for milking twice every day, and it was surprising to find that VMC is not the most important knowledge acquiring channel for farmers (Table 15).

Table 15. Communication channel used by dairy farmer

Variables	No. Farmer	Ranking
Other farmers	19	1
VMC	14	2
Veterinarian	13	3
Dairy processor	6	4
Agriculture service station	5	5

Being a necessary linkage between dairy processor and household farmers, VMC is in a central position in the information flow. Milking practice proceeded in VMC has enabled them to obtain easily the primeval information about farmers, including the needs of farmers, the status of farms, overall raw milk quality and even the financial situation of farmers. These information together provides valuable data to manage and improve the raw milk production. In addition, VMC and dairy farmers were connected closely in geography. On the other hand, VMCs are able to transfer the information about dairy farms to processor as well as collected raw milk. Data about dairy farms can help processor to adjust its production and policy. Likewise VMCs can obtain information about policy and regulation about milk from processor.

However, the study showed that VMC were not contributing to the raw milk production enough as they should be. Information flow from farmer to farmer is normally very limited by its quality and quantity.

Additionally, only sharing of information will not lead to improvements, but also coordination of activities is crucial (Disney, Naim & Potter, 2004). Lack of trust between business partners is one of the main hindrances to collaboration in the supply chain context (Barrat, 2004; Ireland & Bruce, 2000). The relationship between farmers and VMC has been corrupted by unbalanced interest in the dairy market. The original driving force for dairy farmers to raise cows is its potential interest. However, in recent years, farmers can no longer make money by raising cows. Farmers' profit has been squeezed by VMC and processor (Lu, 2008). Trust barely existed between VMC and dairy farmers.

4.4 Point of improvement

Based on theory study and result discussion, the weak points or points of improvement will be deduced in this section. The concluded points of improvement are considered as the main obstacles facing raw milk quality and safety in rural area of China. Considering the contribution of small-scale farms to overall raw milk production, these weakness points are critical to the whole dairy industry production in China.

From the above discussion, it may be concluded that the present management condition of small dairy farms in rural area of Heibei and Tianjin in China is more or less traditional. There is a desperate need to introduce a more advanced farming system or modern dairy farming technology into those small dairy farms, help dairy farmers to improve their farming hygiene that finally achieve improved raw milk safety and quality.

The quality of milk is directly dependent upon the ability and motivation of dairy farmer to hire a series of advance good farming practices. Through performing the good dairy farming practices, farmers can, no doubt, improve the health condition of dairy cow by reducing exposure to environmental pathogens, which would make promising improvement to the quality and safety of raw milk production. So the questions are that whether farmers can have a GDFP guideline and, and even if they received one, are they capable to comprehend it?

According to farmer interview results, apparently more than 75% of dairy farmers did not have a

GDFP guideline, and some of them had never heard of GDFP guideline. Most dairy farmers did know that raw milk quality can be improved by employing certain farming practice, but had few clue how. They were in serious lack of knowledge about raw milk quality and the way reaching it. In this sense, providing a GDFP guideline may help farmer to establish good dairy farming habit in certain level. The guideline is supposed to be supplied by dairy processor who benefits from raw milk produced by those farmers. In respect of public health and safety, government is also obligated to provide one to guide farmers through the farming activities. VMC, the actor who connects to farmers the most, is partly responsible for adulterated milk could be rejected by processor.

A guideline may be easy to be provided, the more importantly the crucial part positioned on whether farmers are capable of understanding the GDFP comprehensively. Knowledge level of farmer is crucial to the success of adoption of GDFP in those small-scale dairy farms. It is important to increase farmers' knowledge about safety of raw milk, contamination sources, milking and, of course, about GDFP. Research result showed that the majority of dairy farmers had low educational levels. Likewise, the knowledge of VMC workers also needs to be improved. Good milk practice can eliminate the introduction and transmission of pathogens during milking. Quality test in VMCs is the primary quality inspection control. As I discussed previously numbers of testing methods should be conducted to test the abnormal raw milk. Therefore, knowledge about testing method, quality identification, and basics of measurement is the prerequisite being a technician.

The knowledge on up-mentioned subject is largely dependant on the educational level (Chizari, 2008). According to my research, in current dairy farming system, more than 80% of small dairy farmers' educational level was middle school and elementary school graduation. VMC workers also had considerably low level of education. Adoption of modern dairy farming technology can doubtless improve the raw milk quality, but it may also bring resulting from imperfect information and the possibility of committing errors (Lin, 1991). Education enhances one's ability to receive, decode, and understand information, Schultz (1964, 1975) have hypothesized that education may facilitate the diffusion of new technology. In other words, farmers with a relatively high level of education may have a higher probability of adopting the advanced GDF practice than those with relatively low education.

Attitude has been one of the most crucial factors for small dairy farmer to commit to the hygiene farming practice. The majority of farmers felt they could be farming more safely. They felt hardly responsible for improving the raw milk safety, although farming safely is one of the elements for safety raw milk. Most farmers showed good concern about health of their herds, but rarely about the animal welfare. Few farmers had experience of milk rejection by VMC for heard health problem. However in most scenarios there was neither raw milk testing nor payment variation for different quality of milk. Overall, small dairy farmers showed low attitude to improve their farming style.

On the other hand, most of visited VMCs had problems with hygienic milking operation. VMC managers in most of cases did not own any cows themselves, as a result they took less care of health condition of cows. The milk quality and safety is not the priority consideration to managers since they want to decrease the operation cost and to maximize their income as much as possible. For instance, VMC does not change rubber units of milking machine until machine were of failure of function, or they are asked to do so by the dairy processor. The incentive to improve the raw milk quality for VMCs was too low.

Lack of milk quality testing equipment was widespread according to my findings. Among 10 visited VMCs, approximately 20-30% of them were able do a series of basic raw milk quality test, including alcohol test, lactometer test, Gerber test etc. 20% of VMCs, both owned by private, had no testing at all. Among the 10 visited VMCs, SCC and TBC tests were hardly found. Without quality test, it is extremely difficult to inspect the collected raw milk. Possibility to identify the abnormal milk was nearly zero in stage of VMC. Hence, the only way to identify the sick cow was by naked eye before

milking, which requires certain knowledge about herd disease symptom. In this case, whole tank of raw milk is extremely vulnerable to be tainted with microorganism and somatic cell from sick cows. The only remaining possibility to inspect the safety of raw milk was in dairy plant before receiving milk from VMC. If raw milk was failed to pass the quality test conducted by dairy processor, whole tank of raw milk would be rejected. As a result farmers will not be paid because of lacking testing equipment in VMC.

To conclude, lack of knowledge and education, weak attitude to improve milk quality and shortage of quality testing equipment in VMC were the three basic weak points to be improved in rural raw milk production system. They are the underlying obstacles for improving the other remaining problems.

Chapter 5 Improvement Strategies

In this Chapter, possible improvement strategies are introduced based on the proposed weak points and quantitative analysis. An arrangement of sequential implementation of these improvement strategies will be outlined.

5.1 Improvement strategies for identified weak points

In chapter 4, three weak points have been identified to be the basic obstructions for raw milk quality improvement in China, which are:

- Lack of knowledge and education
- Weak attitude to improve milk quality
- Shortage of quality testing equipment in VMC

These three points are thought to be the prerequisite for any other improvements. In order to improve them, six improvement strategies are introduced based on literature research:

1. **Training:** Numerous studies have found that food safety training would impact positively the food handler's knowledge on food safety (Finch *et al.*, 2005; Meer and Misner, 2000), and on microbial count in milk and milk samples of dairy farmers (Rodrigues *et al.*, 2005).
2. **Promotion of quality-based raw milk payment system:** Quality-based payment system can positively influence the actions of the farmer and VMC. An incentive is provided for the farmer to focus on feeding, animal welfare and health practices, and at the same time for VMCs to improve hygienic activities in milking process.
3. **Building up Standard Operating Procedure in VMC:** Well-written standard operating procedures (SOPs) provide direction, improve communication, reduce training time, and improve work consistency (Stup, 2001). Working by SOPs can ensure VMC staff work together toward a common goal, which creates a very positive sense of teamwork.
4. **Establishment of a sophisticate recording system:** Establishment of simple, accurate, understandable and easy-to-keep recording systems can help to reach substantial improvements in milk production (Chagunda *et al.* 2006).
5. **Standardization of VMC:** Standardization of VMC can eliminate the failure functioning caused by ineligible and illegal VMCs. It facilitates the raw milk quality control in process of milking and transporting.
6. **Shifting farming model to "Processor + Dairy cow raising area + farm households":** The new model has been proven to be more suitable and functional on quality control in current raw milk production system. Hence, the old farming model of "Processor + VMC + dispersed dairy farms" should be replaced.

5.1.1 Training

The goal of every dairy farm and VMC should be continually improve the quality of the milk. It is clear that the quality and safety of raw milk can be enhanced by adopting a number of GDFP (good dairy farming practice) in on-farm level. Standard milking operation and good performance in VMC (e.g. bulk tank management, maintenance of milking machine and testing equipment etc) can minimize the risk of microbial contamination and transmission. Therefore, dairy farmers need to learn

about milking, managing dairy farms and quality of milk and milk production (Toro *et al.*, 2004), likewise VMC employees should have more knowledge about milking operation, raw milk quality testing.

Many studies (Finch *et al.*, 2005; Meer and Misner, 2000) have found that food safety training have a positive impact on food handlers' knowledge on food safety. Rodrigues *et al.*, 2005 found that training had positive effect on microbial count in milk and milk samples of dairy farmers. Enhancing knowledge can change behaviours and practices (Jenkins-McLean *et al.*, 2004).

Training and education programs held by extension agents can be considered to improve the knowledge level of farmer and VMC employee. Agricultural extension is a vital component in the agricultural development of a nation. An effective extension system provides a two-way communication channels between dairy farmers and formal research bodies and extension provides an avenue for dairy farmers to access information about the latest research findings (Toro *et al.*, 2004). Extension agents and dairy professionals often act as educator to encourage clients to implement new technologies (Rodrigues, 2005). Extension and agricultural professionals helps farmers achieve goals more rapidly.

Training and education programs should be considered to all aspects of quality and production, as well as providing information and knowledge on quality associated with raw milk to dairy farmer and VMC worker. The low educational level of farmers and VMC workers must be paid attention. Therefore, extension educators and dairy professionals must develop and deliver educational programs on the basis of dairy farmer's needs (Chizari *et al.*, 2008). Extension workers must encourage farmers to participate in extension programmes and use of GDFP for improving dairy production.

A training program has the following layout:

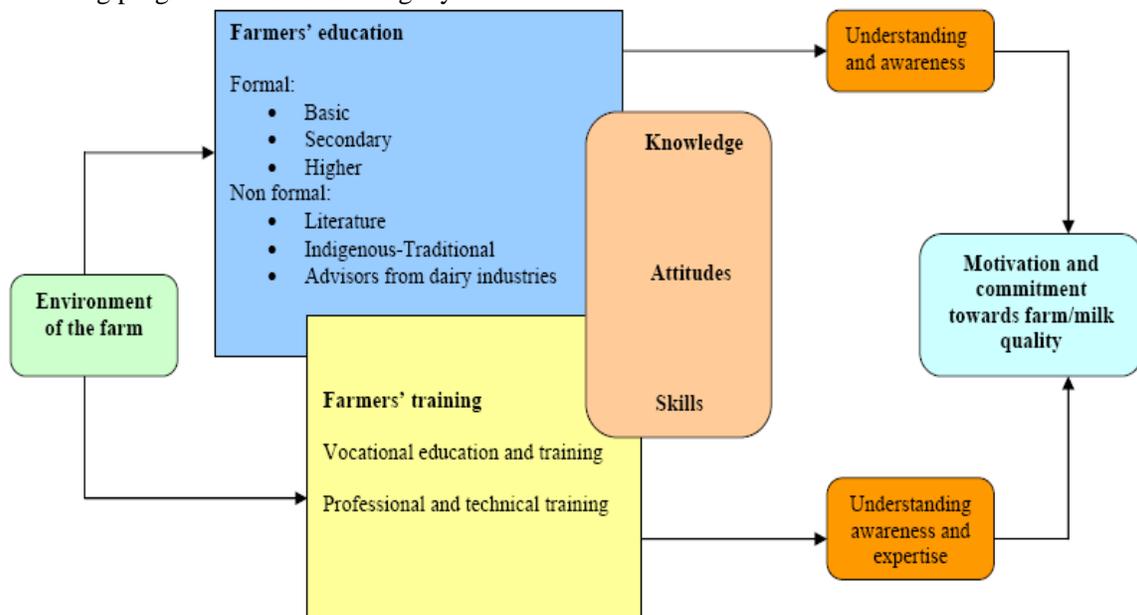


Figure 19. Education and training of the farmer (adapted from Johnson, 1980)

Training programs for farmers should focus on a lot of different subjects in order to increase the level of prevention in the farm and improve the knowledge of farmers:

- Learn to work in a specific way (more systematic);
- Learn to follow protocols;
- Learn how to use useful tools in the herds which will improve the monitoring of the herd management;

- Improve the ability to diagnose diseases in the herd increase prevention;
- Improve disease control through proper feeding and selection of animals;
- Learn the importance of raw milk safety and quality;

Training should also be conducted at the VMCs level for permanent and temporary employees. The goal is to increase the hygiene level at VMC and to maintain the quality of the milk until distribution to the dairy processors. A similar training and education programs in Figure 19 can be used in VMC. Beside the extension agents, specific training programs about standard milking operation and raw milk quality testing should be provided within VMC. During the training, demonstration was performed on Box 3.

Box 3. Training items for VMC workers

1. Proper sampling and labeling the samples of the milk for chemical and microbiological analysis, refrigerator storage at 0-4oC and transport of the samples at a temperature of 0-4oC in sterile and well closed containers;
2. Control of the temperature during intake of the milk from the farmers;
3. Selection of proper cleaning chemicals for cleaning and disinfection of the premises, equipment for storage the milk and other assisting utensils;
4. Introduction of procedures for cleaning and disinfection of the premises and equipment at the collecting center;
5. Introducing methylene blue test as orientation control of the microbiological quality of the milk: preparation of 0, 1% solution of methylene blue, testing of the milk, evaluation of the results from testing and classification of the milk according the test;
6. Preparation of the alcohol test for determining the freshness of the milk: preparation of 68-70% solution of ethyl alcohol, testing of the milk and proper evaluation of the results form the test;
7. Usage of Lacto scan for determination of the chemical parameter of the milk, proper evaluation of the results and procedure for cleaning the instrument;
8. Usage of pH meter: calibration of the instrument, testing the milk, evaluation of the results and cleaning of the probe of the instrument;
9. Preparation of the titration method with the solution of NaOH for determining the acidity of the milk: preparation of the solution NaOH, testing the milk and evaluation of the results form the test.

For rural veterinarians, lack of knowledge about the etiology, diagnosis, and control of mastitis is widespread. To play a good role in the dairy production in rural area it is necessary to have well-qualified (well-trained, experienced) veterinarians. Well-trained veterinarian means that veterinarians should gain good initial training, including good theory and practice, as undergraduates. They are capable of continuing for a better professional education. Continuing education is now mandatory for veterinarians in China. Annual training for veterinarian is held at local level in most areas. The training includes veterinary knowledge, technical skills and profession ethic. Veterinarian should be able to provide better advice to improve dairy farm performance after training. It is important to increase their access to dairy related information about available products and how to use them, good veterinary practices, good Dairy Production Practices, economics of dairy farms, legislation on milk quality.

5.1.2 Promotion of quality-based raw milk payment system

The idea of quality-based payment system is simple – dairy processors pay for what they receive – therefore encourage VMCs and farmers to supply high quality and safety raw milk. Farmers and VMCs are together in control of the quality and quantity, but in different levels of animal farming and milking respectively. In analysis section, it has been studied that farmers are responsible for cow

health, animal feeding and water animal welfare and rising environment; VMCs are engaged of milking process. Combining different practices determines the quality, quantity and composition of raw milk, which are measured by the index of SCC (Somatic Cell Count), TBC (Total Bacteria Count), and fat, protein content of raw milk.

As we already know, high levels of bacteria and somatic cells cause disagreeable taste in dairy products and reduce storage life. The quality of the raw milk supply can be influenced via the payment system. Premiums and deductions based on e.g. bacteria content, somatic cell count, freezing point depression (added water) and antibiotic residue create the incentive to upgrade the quality of raw milk.

Thereby the payment system influences the actions of the farmer, because negligence with hygiene, adulteration of raw milk by adding water, failure to discard raw milk from mastitic cows or cows on antibiotics, will cost the farmer money. In worst cases the milk will be rejected entirely, no payment will be made. On the other hand, farmers supplying superior quality raw milk will be rewarded by an extra payment.

By paying for the individual components, an incentive is provided for the farmer to focus on feeding, animal welfare and health practices, and at the same time for VMCs to improve hygienic activities in milking process. By incorporating SCC and TBC in the payment system, they are encouraged to do their best to provide high quality raw milk. Variant determinants of raw milk price and rejection limits are given in Table 16.

Table 16. Possible determinants of raw milk price and rejection limits.

Increased price factors	Reduced price factors	Rejection criteria
High Fat & Protein	Low Fat & Protein	Added Water
Low Bacteria Content	Moderate Bacteria Content	Too High Bacteria Content
Low Somatic Cell Count	Moderate Somatic Cell Count	High Somatic Cell Count
Good Taste	Acceptable Taste	Bad Taste
Fresh	Stale	Inhibitory Substance/Antibiotics
Cool	Too high temperature	Harmful Contaminants

(adopted from Denmark, 2005P/N 1025189, Issue 3 GB)

The incentives provided by a quality-based payment system can directly influences the quality, quantity and composition of the raw milk supply. A study by IDF (International Dairy Federation) in 1995 has proved that 82% of the countries participating in the study had reached their objectives through payment systems (IDF, 1995).

After the tainted milk scandal, Chinese central government had emphasized the importance of raw milk payment system in the milk quality control, and encouraged local government to approach a quality-based payment system according to the local condition. In this system, dairy processors play the crucial roles to determine the efficiency of the system. Each processor is free to determine the price of raw milk which mostly is based on a value given to fat and protein.

Table 17. Quality premium and deduction standard according to bacteria quality in Danish payment system.

Bacteria Quality Grading		
	Class limits CFU/ml	Recommended price adjustment DKK/kg milk (2004)
Class 1 extra	< 30,000	+ 1%
Class 1 B	< 50,000	0
Class 2	< 200,000	-4%
Class 3	> 200,000	-10%

Table 18. Quality premium and deduction standard according to somatic cell quality in Danish payment system.

Somatic Cell Quality Grading		
	Class limits cells/ml	Recommended price adjustment DKK/kg milk
Class 1 S	< 200,000	2%
Class 1 extra	< 300,000	1%
Class 1	< 400,000	0
Class 2	< 600,000	-4%
Class 3	> 600,000	-10%

(adopted from Denmark, 2005P/N 1025189, Issue 3 GB)

An example of raw milk payment system in Denmark is given to illustrate how the premiums and deduction is implemented. The Danish payment system outlines the minimum prices to be paid and the maximum deductions to be made, as well as a minimum sampling frequency and parameters tested. The price of raw milk is determined from fat and protein contents in the raw milk. A deduction or a premium is given in accordance to the quality classification by bacteria quality and somatic cell quality (Figure 17, Figure 18).

Box 4. Calculation of raw milk price based on a quality payment system in Denmark

Recommended value in 2004:

Fat:	DKK 21.94/kg of fat
Protein:	DKK 37.30/ kg of protein
Milk treatment costs:	DKK 0.12/kg milk

Base price example:

$$4.20 \% \text{ fat: } 0.0420 \times 21.94 = + 0.92$$

$$3.40 \% \text{ protein: } 0.0340 \times 37.30 = + 1.27$$

$$\text{Milk treatment costs: } - 0.12$$

$$\text{Base price of this milk: } \text{DKK} + 2.07/\text{kg}$$

Good case of milk price examples:

Fat 4.30%, protein 3.60%, CFU 15,000, SCC 190,000

Base price:

$$(21.94 \times 0.043) + (37.3 \times 0.036) - 0.12 = +2.17$$

$$\text{Bacteria grading: Class 1 extra } + 1\%$$

$$\text{Somatic cell grading: Class 1 Super } + 2\%$$

$$\text{Price of this milk: } \text{DKK} +2.23/\text{kg}$$

Bad case of milk price example:

Fat 3.95%, protein 3.10%, CFU 150,000, SCC 760,000

Base Price:

$$(21.94 \times 0.0395) + (37.3 \times 0.031) - 0.12 = +1.90$$

$$\text{Bacteria grading: Class 2 } - 4\%$$

$$\text{Somatic cell grading: Class 3 } - 10\%$$

$$\text{Price milk of this milk: } \text{DKK} 1.64/\text{kg}$$

(Based on P/N 1025189, Issue 3 GB, Nov. 2005, www.foss.dk)

According to composition and the quality classification of raw milk, price of raw milk supplied by farmers can be calculated as shown in Box 4.

Implementation of the quality-based payment system is established on quality tests. To grade the quality of milk a sample of milk received from the individual farmer must be taken and be submitted to the following tests:

- Bacteriological test every week
- Cell count and inhibitory substances determinations at least once every 4 weeks.
- Determination of added water at least once every 12 weeks.

5.1.3 Building up Standard Operating Procedure in VMC

A successful VMC business requires all involved employee to contribute their experience, knowledge, and ideas to constant improvement of VMCs future and, more importantly, milk quality. The “12 golden roles for milking” (see **Appendix 3**) establishes a comprehensive and useful milking guideline for VMC workers. However it does not provide a detailed operating procedure by which workers can easily follow. Well-written standard operating procedures (SOPs) provide direction, improve communication, reduce training time, and improve work consistency (Stup, 2001). Working by SOPs can ensure VMC staff work together toward a common goal, which creates a very positive sense of teamwork.

Producing a high-quality milk product at a profit depends on the consistent operation of all systems within the dairy. Successes of dairy farmer and VMCs depend on how well these systems work together to produce large volumes of high-quality milk to sell. Management systems are made up of work procedures. For example, milking proceeded in VMC consists of more than just cleaning and attaching milking machine unit to them. VMC workers must prepare the milking equipment system before milking started, which usually involves sanitizing and changing the configuration from wash mode to milking mode. After all cows are milked, milking equipment must be changed back to wash mode and system cleaned. Each of these three activities—sanitizing and preparing to milk, milking, and cleanup—are examples of procedures that when put together make up the milking management system. Finally, steps are designed as smaller actions that forms a procedure when put together.

Building SOP for on-farm activities on the other hand, e.g. animal feeding system, animal health care and welfare system and a waste management system (see Figure 11), are much more complicated scenarios. There are excessive works that need to be done in farm, which requires a series of SOPs in each of the systems. Household dairy farm can not afford SOPs in regards of time, cost and other factors involved in small scale farms.

Table 19. Standard and Operating Procedure format Choice and Criteria

Many decisions?	More than 10 steps?	Best SOP format
No	No	Simple Steps
No	Yes	Hierarchical or Graphic
Yes	No	Flowchart
Yes	Yes	Flowchart

(adopted from Price et al., 2001)

A number of different ways to organize and format a SOPs are available for managers - Simple steps, Hierarchical steps or Graphic procedures, and flowchart. The choice of specific format to be adopted is dependant on two factors (Table 19). First, how many decisions will the user need to make during the procedure? Second, how many steps and sub-steps are in the procedure?

The goal is to create a document that is easy for the reader to understand and helpful for the work at hand. So a SOP should be designed sophisticatedly for workers to follow.

- Routine procedures that are short and require few decisions can be written using the simple steps format.
- Long procedures consisting of more than ten steps, with few decisions, should be written in hierarchical steps format or in a graphic format.
- Procedures that require many decisions should be written in the form of a flowchart.

A milking procedure is very repetitive and requires few decisions. In addition, low educational level of workers in VMCs is widespread, and no more than five people work in small VMCs (<100 cows) including the manager. Farmers and VMC employees had low educational background. Considering these circumstances, the milking procedure needs to be designed as simple, short and highly understandable. According to Table 18, the simple step format is advised for VMCs that target on small-scale dairy farms. A simple set of steps like those in Figure 20 is sufficient, which provides a basic standard operating procedure for prepping cows, attaching milking units, and post-dipping in a double-12 parlor. In this case, The SOP in Figure 20 does not contain much detail. A thorough training program would be necessary to make sure that milkers either farmer or VMC worker understand how to perform each step in the procedure. The small steps are where variation among different workers takes place if procedures are not standardized. Managers can use standard operating procedures to help ensure everyone performs each procedure the same way every time.

SOP #1, Basic Milking Procedure

1. Dry-wipe dirt and debris from the first cow's udder.
2. Predip all four teats with the dip cup.
3. Strip two squirts of milk from each teat and observe for abnormal milk. If any abnormal milk is found, refer to Parlor SOP #2, "**Cows with Abnormal Milk.**"
4. Repeat steps 1, 2, and 3 with the second and third cows on the same side.
5. Return to the first cow and thoroughly wipe with a clean towel.
6. Attach unit to first cow and adjust.
7. Repeat steps 5 and 6 with the second and third cows in the side.
8. Begin at step 1 with the fourth cow on the side and repeat procedure with each group of 3 cows until all 12 units are attached.
9. When all units have detached, postdip all cows and release.

Figure 20 Example of "SIMPLE STEPS" operating procedure format. (Source: adopted from *Stup, 2001*)

Step 3 in Figure 20 refers to another SOP, called "Cows with Abnormal Milk". Raw milk needs to be tested to assure the quality. This SOP is likely to require many decisions to determine what is wrong with the milk, if a sample should be taken, whether the cow should be treated, etc. Procedures that require many decisions should be presented as a flowchart.

Flowcharts are simply a graphic way to present the steps of a decision-making process. Normal milking procedures are quite straightforward and repetitive, while deciding what to do with a cow with abnormal milk is not. Many different factors such as mastitis or an injury may cause the abnormal milk. A flowchart provides an easy-to-follow mechanism for guiding a worker through a series of logical decisions and the steps that should be taken as a result. Figure 21 is a flowchart depicting how milkers should deal with cows showing abnormal milk. Symbols are useful to indicate the specific activities in flowcharts.

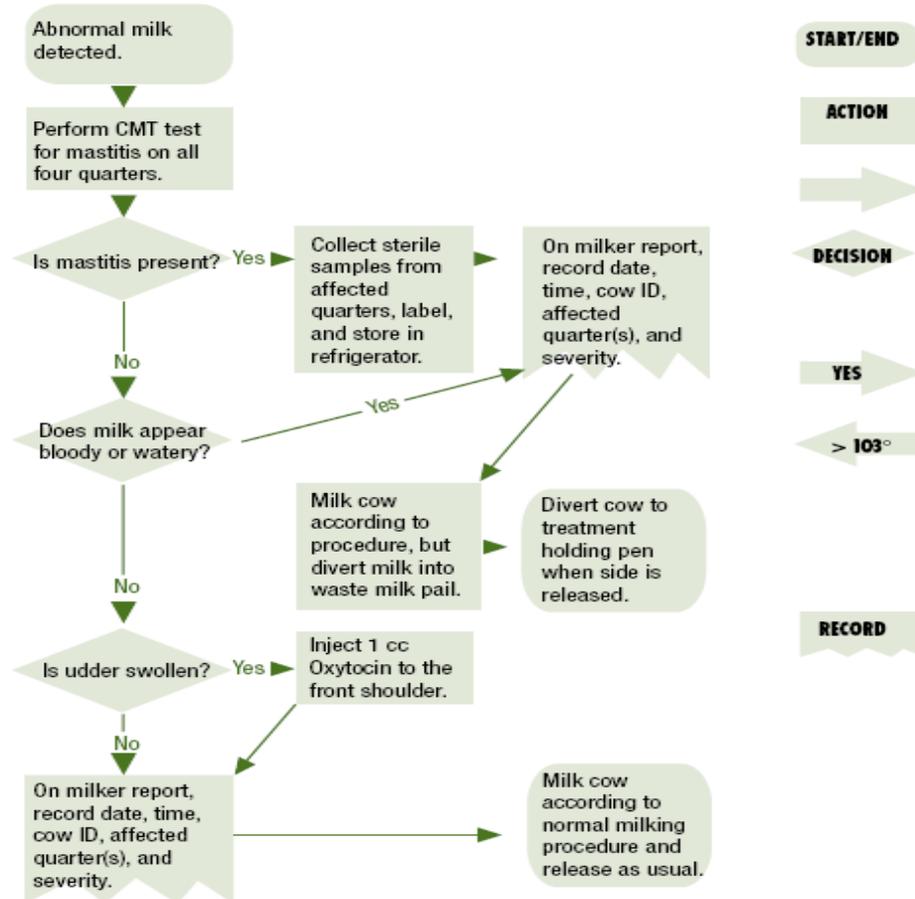


Figure 21. Flow chart operating procedure format: Cows with Abnormal Milk (*adopted from Price et al., 2001*)

After choosing the proper SOP format, there are a few elements of information that should be included into every SOP. A formal SOP should include a clear and descriptive title; the name of the author responsible for the SOP; and the date on which the SOP or revision becomes effective (Stup, 2001). In addition, some SOPs should include lists of materials or tools needed to complete the milking job e.g. milk test equipment etc.

5.1.4 Establishment of a sophisticated recording system

Galal (1998) defines animal recording as an activity that involves the measurement of various indicators of animal performance and the use of that information in the decision making process. In modern dairy farming, successful management relies on good record keeping and on information that can be derived from it. Farm records are used routinely for daily management and to solve problems. A quantitative knowledge about a farm provides the basis for understanding where the dairy has been, where it is today and where it is going (Jelan and Dahan 1998). Establishment of simple, accurate, understandable and easy-to-keep recording systems can help to reach substantial improvements in milk production (Chagunda *et al.* 2006). Recording of animal performance is of enormous value for management decision-making for both individual farmer and for the industry or country as a whole. Animal recording for animal management involves monitoring of each animal's performance and use of that information in normal, day-to-day farm management (Galal 1998). This represents the integration of performance data into the farm management process and permits more effective

decision-making at farm level on an on-going basis. Furthermore, milk records can be used as a diagnostic tool and for detecting different kinds of health and reproduction issues in the herd.

According to my research, record keeping is an activity that is almost completely neglected by the small scale farmers. It has been indicated that most smallholder farmers having very small herds (around 2 cows) have significant difficulties in recording adoption (Bachman, 1998). With increasing herd size, recording participation in dairy farm with 3-5 cows increased. However, recording for individual animals might be a lot of work such that farmers might see the exercise as cumbersome. The only record that the interviewed farmers are likely to keep is the receipt issued by VMCs for selling milk.

The level of education, training, and experience of small scale farmers have been obstacles to record keeping, and all these three characteristics are individual-based. In current situation, it is difficult to improve the record keeping in the farmer level. Comparably higher educational level of veterinarians and VMC technicians can facilitate the improvement of recording system. Therefore, the record keeping system should be built on the base of multipurpose objectives. In this system, for the purpose of herd health management, herd treatment record keeping needs to be relied on veterinarian instead of on farmers. On the other hand, VMCs are compulsory to keep the record about all kinds of quality test, reproduction, milk yield from farmers. In addition, recordings about special services events supplied by VMC provide valuable information on improvement of VMC management. Meanwhile, farmers need to record the feedings information and major events happened in farm.

5.1.5 Standardization of VMC

Implementation of sufficient milk quality test forms the primary raw milk quality inspection in the dairy chain. The methods used for milk testing are usually related to the payment system. This research has found that most of VMCs had poor situation of facility and management. Only 40% of VMC were furnished with basic quality testing facilities like density meter, pH meter, fat content testing equipment etc. This result is 10% higher than previous finding by Zhong *et al.*, 2009. Li found that, for most of VMCs, there was not specific hygienic design for layout of VMCs plant (Li, 2008). As a result, it is not surprised that VMC had difficulties meeting the quality standards.

Hence, dairy processors together with government must take effort building standard VMC. A standardized VMC is required to be designed, constructed and managed with the goal of providing an excellent environment for the cow and worker. The milking system and its operation must assure continuous production and storage of high quality milk. Cows are brought to VMC by farmer, and milked worker and returned to farmer without infection or hurt in VMC. Milking machine and testing equipment must also be washed, sanitized and stored in an appropriate manner in VMC. A well-designed milking center allows the animals, milk and wastewater to be handled effectively and efficiently. Design and construction of the milk center must also consider other activities that could happen in VMC, for example the location of telephone, office, rest rooms, bulk tank location.

The authority must establish corresponding regulations to standardize VMC. The standardization should consider aspects of milking plant design and construction, VMC management, VMC working procedure, milking operation, quality testing and milk transportation (Shangguan, 2008).

1. Milking plant design and construction

Several factors need to be considered during constructing a VMC (Table 20). A standard herringbone milking centre is illustrated in **Appendix 10**.

Table 20. Considerations when building a VMC/MCC

Factors	Considerations
Location	<ul style="list-style-type: none"> • serving area <2.5km; • no competing VMC within 5km; • no dumping ground around; • convenient transportation
Scale	<p>Medium size</p> <ul style="list-style-type: none"> • milking capacity: 3~5ton; • milking parlor: >24; • bulk cooling tank: >5 ton. <p>Small size</p> <ul style="list-style-type: none"> • serving herd: >50 or 1 ton milk; • milking parlor: >10; • bulk cooling tank: >3 ton.
Plant layout	<ul style="list-style-type: none"> • milking room, storage room, water room, office, sterilizing room, testing room etc.; • drainage system, concrete floors etc.
Milking machine	<ul style="list-style-type: none"> • prior: recorder milking machine • next: bucket milking machine
Testing equipment	<ul style="list-style-type: none"> • see Box 2

2. Milking operation

See 5.2.3

3. Raw milk quality testing operation

Raw milk testing in VMC provides the basis quality inspection. The methods used for milk testing are usually related to the payment system. Below a description is given of a few very simple milk testing procedures which are suitable for sector of small-scale milk production in developing countries. There are many other tests, often more complicated and more expensive, and they are not realistic to implement in rural area in current condition. The testing methods below focus on raw milk reception tests that can be carried out at VMCs or other kinds of milk collection centers in rural area. Milk testing for quality can be divided into testing for hygiene and for composition. Some examples of tests, in order of cost and simplicity are described below:

1). taste, smell, visual observation and temperature

Use:	screening, organoleptic tests
Advantages:	quick, cheap, easy
Disadvantages:	experience needed
Alternatives:	other equipment tests

This approach should always be considered as the first screening of the milk, since it is cheap, quick and does not require any equipment. These tests are also called 'organoleptic tests'. It is also reliable if the person carrying out the tests is experienced. The tester smells the milk, observes the appearance, tastes if necessary, checks the can for cleanliness, looks for sediment and filters the milk to check its cleanliness. If doubts arise after the examination about the quality of the milk, other tests can be done to determine the quality.

2). lactometer test or density meter

Use:	test for payment or screening; determine added
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	water, level of solids or removal of fat.
Advantages:	quick, cheap
Disadvantages:	can be inaccurate, influenced by temperature and fat.
Alternatives:	freezing point test, rapid AMA

A lactometer is the equipment that is used to measure the density of milk, and any deviation from the normal range would indicate that the milk has been adulterated. The test is based on the fact that the density of whole milk ranges from 1.026 to 1.032 g/ml (Draaiyer, 2009). Adding water to milk lowers its density, while addition of solids increases the density of milk. Hence, whether raw milk has been adulterated with added water or solids can be determined by reading the lactometer.

It is better to combine the lactometer reading with the fat test. If the results of the fat test are low and the density is high (e.g. 1.035), then the milk might have been skimmed. If the results of the fat test are low and the density is low (e.g. 1.027), then water might have been added to the milk. You can use the lactometer reading together with the fat percentage to estimate the Solids-Non-Fat (SNF) content of the milk. According to the food standards in many countries, the minimum acceptable SNF content and density for whole milk is 8.5% and 1.026 g/ml, respectively (Draaiyer, 2009).

3). clot-on-boiling

Use:	test for screening, rapid testing of increased acidity.
Advantages:	simple, quick, cheap, definitive result (milk either coagulates or not)
Disadvantages:	slightly sour milk is not detected.
Alternatives:	alcohol test, acidity test, other hygiene tests

The acidity of milk that gives a positive test is generally above 0.22% (as lactic acid) or has an abnormally high percentage of protein like colostrum milk. Such milk cannot stand the heat treatment in processing and is therefore not suitable for distributing as liquid milk or for processing. Such milk must therefore be rejected.

The clot-on-boiling test is simple, quick and cheap. If raw milk is sour or abnormal (colostrum or mastitis milk), milk clotting will happen when milk is heated for up to 4 minutes in boiling water or in a flame. This test is not very sensitive to slightly sour milk and an alternative is the alcohol test.

4). alcohol test

Use:	test for screening, rapid assessment of acidity
Advantages:	quick, cheap.
Alternatives:	Clot on boiling test, Acidity test

Proteins in milk that has become sour (i.e. because of lactic acid formation) will coagulate when mixed with alcohol. Alcohol test can be easily done by mixing equal amounts (2 ml) of milk and a 68% ethanol solution (Draaiyer, 2009). Milk that contains more than 0.21% acid or if milk is abnormal (colostrum or mastitis milk) the milk will not pass the alcohol test.

5). pH test

Use:	test for screening
Advantages:	simple, cheap
Disadvantages:	regular calibration
Alternatives:	rapid AMA tests

A rough estimate of pH may be obtained using paper strips impregnated with an indicator. Paper strip

treated with bromocresol purple and bromothymol blue can be used as screening tests for milk. Bromocresol purple indicator strips change from yellow to purple between pH 5.2 and 6.0, while bromothymol blue indicator papers change from straw yellow to blue-green between pH 6.0 and 6.9.

pH meter provides a more accurate pH measurement. A pH meter depends on the potential difference between two electrodes when they are in contact with a test sample. One electrode called a reference electrode (a glass electrode) independent of the pH of the milk is connected to an electrode whose potential is proportional to the pH of the milk (a calomel electrode). The pH of the milk depends on the hydrogen ion concentration in the milk. A pH meter measures the current produced by the difference in potential between the two electrodes.

6). Gerber test for fat

Use:	test for grading or payment system
Advantages:	relatively simple to use
Disadvantages:	equipment needed
Alternatives:	Babcock test, rapid automatic milk analyzer (AMA)

The fat content of milk is one of the most important factors in determining the price paid for milk supplied by farmers. Also, in order to calculate the correct amount of feed ration for high yielding dairy cows, it is important to know the butterfat content and yield of the milk produced. Furthermore, the butterfat content in the milk of individual animals must be known in many breeding programs. The butterfat test is also done on milk and milk products in order to make accurate adjustments of the butterfat percentage in standardized milk and milk products

The traditional standard reference method for fat analysis is based on either weight or volumetric determination. There are many analytical methods for the determination of the fat content of milk, the Gerber test is widely used all over the world. It is a volumetric method in which fat is separated from milk by centrifugal force. Sulphuric acid is used to dissolve the protein that forms the membrane around the fat (fat globules) and amyl alcohol is added to improve the separation of fat from other solids (detail procedure, see Draaiyer *et al.*, 2009).

4. milk transportation

- Considerations
- bulk tank transport;
 - $T < 6^{\circ}\text{C}$ during transportation;
 - transporting to processor within 12 hours;
 - filling forms of transportation record.

5.1.6 Shifting farming model to “Processor + Dairy cow raising area + farm households”

In this model the dairy cow raising area regroups dispersed dairy farmers in a designated area. The infrastructure in this area is constructed by dairy processors, combined with villages and township government. Usually, a dairy cow raising small area can hold approximately 200-300 cows, and sometime reaching 500-1000 cows (Chen *et al.*, 2008). The barns for cow and other facilities are uniformly designed and constructed, and the household farmers manage their own dairy cows. Except that, the activities of milking, disease control and other supportive activities are normally contracted to administrative and managerial departments within the region. The cow raising zone is facilitated technical assistance and supervision while the separation between production and residential areas benefits disease control and possible infection between man and animals.

In this model, it is possible for farmers to form association or cooperative that can represent the smallholders in the dairy sector in China. The dispersed small dairy cow raising households lack the negotiating and bargaining power necessary to benefit from marketing arrangements with dairy processing enterprises and feed marketing enterprises (Chen *et al.*, 2008). Chinese government had also recognized the potential importance of farmer cooperatives and gave strong support to the establishment of cooperative societies. For instance, the Chinese government issued the Law of Farmer Specialized Cooperative Society in 2007, thus providing legally based organizational guarantees for farmer cooperative organizations. Some local governments are exploring and supporting dairy operators to set up “Dairy Industry Cooperatives”.

Advantage of this model to small household farmers and dairy processors:

To farmers:

1. better inspection of raw milk production
2. advanced milking device and milking technique
3. provide supporting services for raw milk production. The service includes breeding, feeding, health caring, technique
4. decrease the cost of cow rising
5. connects substantially the farmer and raw milk production to dairy processor.
6. community can be managed more efficiently as a whole group.

To dairy processors:

1. one of the efficient ways to expand business on a low budget. It enables dairy processor to build up numbers of larger-scale raw milk producing bases (farms), and provides stable, high quality raw milk supply.
2. simplifies the procedure of raw milk collection. The reduced procedure precludes the adulteration of foreign materials, like melamine, water and other forms of contaminants, by few unethical farmers.
3. facilitates dairy processor to adopt and implement the HACCP in raw milk quality control.
4. enables dairy processor to reinforce the targeted services that are needed for farmer and raw milk production.

5.2 Discussion

In china, small-scale dairy farms contribute to more than 70% of total raw milk production. Controlling the quality and safety of raw milk produced from those household farms is significantly important for the entire dairy industry. On the other hand, VMCs is playing a necessary role functioning as a bridge between hundreds of thousands of small dairy farmers with dairy processors in current raw milk production system. Consequently, dairy safety performance in on-farm level and on-VMC level together determine the raw milk quality to what extent can be possibly maintained.

Through my research in rural area of Heibei and Tianjin, three dominating weak points have been defined to be the basic obstructions underlying the raw milk production system. Lack of knowledge and education is widespread among dairy farmers and VMC worker. They were both found having relative weak attitude to improve milk quality in their dairying work. VMC, in particular, was in serious problem of shortage of quality testing equipment.

In order to improve these weak points, six improvement strategies have been proposed based on literature study and realistic situation in China. Each of them has been designed specifically focusing on certain point(s). The characteristics of strategies have determined that they can not be implemented simultaneously but need to be arranged in special progression. Implementation of six strategies should be classified into four stages, and in each stage certain strategies are executed to maximize their

functioning efficiency. The progression of strategies implementation is outlined in Figure 22.

Stage 1: Training + Raw milk quality testing equipment

Stage 2: Promotion of quality-based raw milk payment system

Stage 3: Building up Standard Operating Procedure in VMC + Standardization of VMC +recording system

Stage 4: Shifting farming model to “Processor + Dairy cow raising area + farm households”

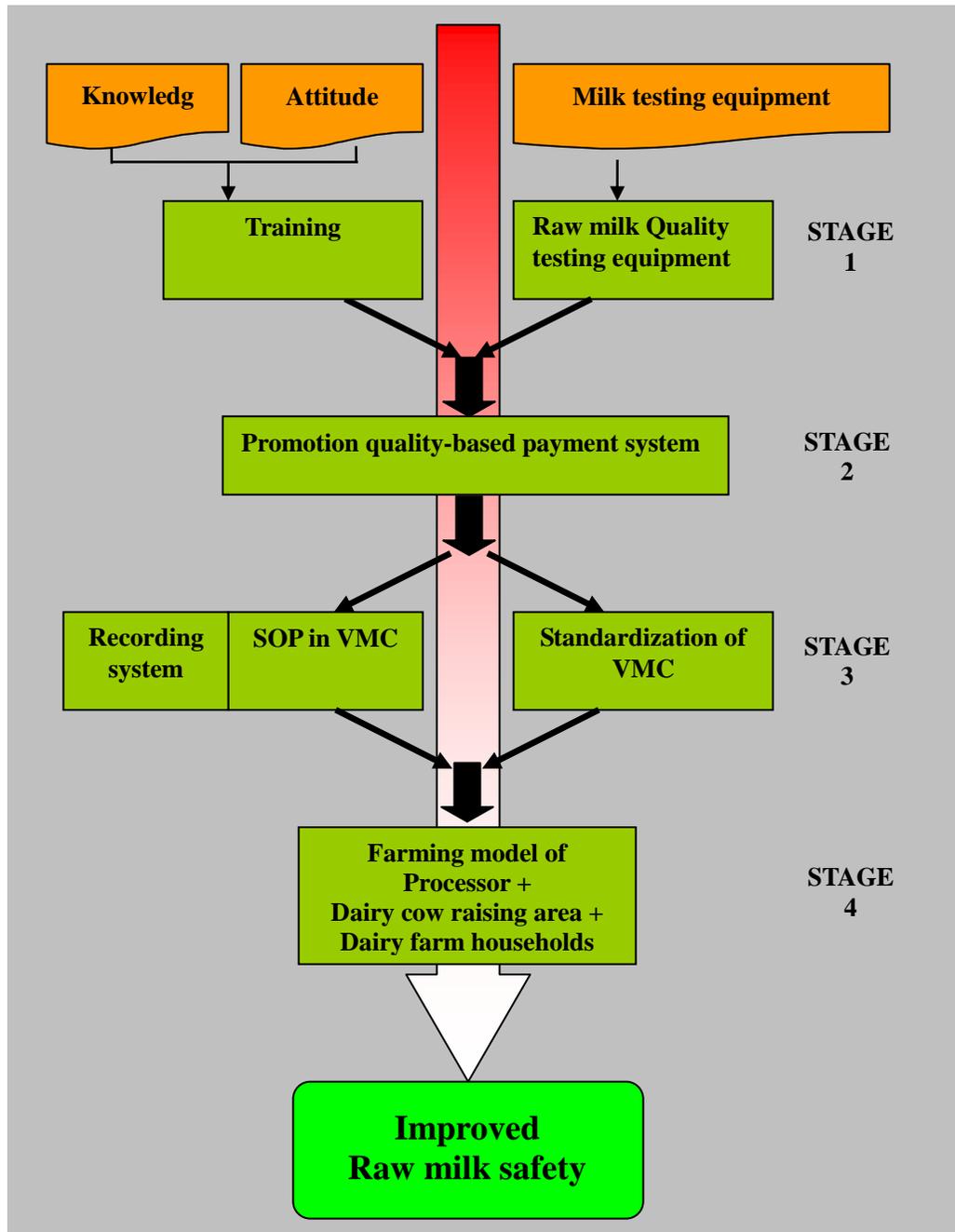


Figure 22. Progression of strategy implementation.

As outlined in Figure 22, training and raw milk quality equipment is firstly introduced in to dairy farm and VMC simultaneously. In the primary stage, the food safety training would improve the milk safety

related knowledge of farmer and VMC worker. Good Dairy Farming Practice will be, more specifically, introduced to dairy farmers. In VMC level, VMCs need to be furnished with raw milk quality testing equipments, and VMC employees will be trained with corresponding testing knowledge. Completion of stage 1 enables farmers and VMC employees to gain sufficient knowledge and attitude for the implementation of rest strategies. Hence, stage 1 is a cornerstone for the whole strategies implementation.

In stage 2, a raw milk quality-based payment system will be established. To do so, dairy processor ought to play a central role, meanwhile the payment system need to be encouraged and supported by the local government. The payment system stimulates VMC to hire a series of actions to improve the raw milk quality collecting form dairy farmers. VMC may force or persuade dairy farmers to improve the farming hygienic activities in order to raise healthy cow. Farmers would receive more money for good quality of raw milk. As a result, payment system may provoke a positive chain reaction in the raw milk production system. At the end of this stage, an incentive is created to farmers for focusing on feeding, animal welfare and health practices, and to VMCs for improving milking process and milk storage.

Stage 3 focuses on standardization of VMC. Illegal VMC will be cracked down and standard VMC will be built to standardize the market. The standardization comprises of facility, certificate, and equipments. Only eligible VMC is allowed to access to the market. Standard Operation procedure including milking and testing process will be built up to provide direction, improve communication, reduce training time, and improve work consistency. In the same stage, a sophisticated recording system will also be attempted to introduce. It involves all actors in the raw milk production chain, farmer, VMC and veterinarian. Having been introduced with sufficient knowledge and elevated attitude, recording system can be relatively established.

With previous three stages completed, I would say that the last step is to abandon the old farming model and manage to adopt the more successful one - “Processor + Dairy cow raising area + farm households”. More and more studies have proved that the old farming model caused serious milk quality problem in last few year, and “Processor + Dairy cow raising area + farm households” may provide more opportunity to improve the raw milk safety (Li, 2008; Zhong *et al.*, 2009).

Along the progression of stages, the identified weak points will be improved to in depth. As a result, the raw milk safety will be, at the same time, improved stage by stage. With all stages completed and all strategies implemented, quality and safety of raw milk will certainly be improve to another mountainous level.

Chapter 6 Evaluation

In this final chapter, different phases throughout my thesis research will be evaluated. At the beginning of this research, four phases were planned for my thesis: appreciation, analysis, assessment and evaluation phases. The evaluation will focus on the works that been done during previous phases, which include literature analysis, research model adoption, personal experiences during my field research in rural China. The initially proposed hypothesis will also be evaluated according to outcome of research. At the end, recommendations for the future study will be given.

6.1 Evaluation of Appreciation phase

The appreciation phase started with an attempt of understanding the cause of melamine-tainted infant formula scandal. To uncover the cause behind this striking disaster, extensive literature study was done. From the literature, I realized that the melamine contamination in milk was not just an isolated accidental phenomenon. It appeared that there were increasing number of food poisoning cases, increasing number of detentions of exports of food branded with “made in China”. The brand of “made in China” has been staining with word of “low quality, poor safety”. For that reason, I made resolution of digging out the real problem underlying the melamine scandal.

Although this melamine scandal is determined as chemical contamination in milk, literature research kept reminding me that, beside the chemical contamination, the microbial contamination should be concerned even more extensively. The characteristics of milk product has determined that bacteria is always the priority of concerning issue in its supply chain. With all kinds of investigation on this disappointment went through, truth had been revealed as that the sources of contamination was in raw milk supply chain: dairy farmer and milk collection centres.

In the appreciation phase of this research, the situation of raw milk production system in China was studied, including the two main actors involving in raw milk production. After literature search and exploration of information/data corresponding to the situation was conducted in order to identify the problems. The deduced problem feeling provided me with general direction of research. To gain support on the identified problem, scientific models and literatures were deeply studied to appreciate the factors affecting the performance of raw milk production. Consequently, hypothesis was formulated and several general questions were promoted to lead my research into the next phase: Analysis phase.

6.2 Evaluation of Analysis phase

The goal of this research is to investigate the factors that influence the quality and safety of raw milk in China. Thus, based on different scientific literatures, a model was employed in this research to diagnose the problems existing in raw milk production: the Food Safety Management System diagnostic instrument developed by Luning *et al.*, (2008a,b,c). This instrument was sub-divided into three categories namely: contextual factors, food safety management system and the food safety. Through the profound theory analysis of researched scientific literatures, each category was investigated on rural raw milk supply chain. It had been approved to be useful in this study to analyze the factors toward raw milk quality and safety. Based on the FSMS diagnostic instrument, a conceptual research model that specifies all elements in realistic factors.

I have paid attention to search literature on technological and managerial part about the characteristics

of dairy farm and milking centre, especially small-scale dairy farm and village milking centres. They had supported and helped to specify the factors illustrated in FSMS diagnostic instrument. The chosen tech-managerial models helped to understand the complete activities of the implementation of specific system. Literatures and models were evaluated in respects of relevance, and reliability, validity.

More importantly, in this phase my own conceptual research model was developed. The FSMS diagnosis instrument was translated into an elaborated research model which is more suitable to analyze the performance of food safety system in China. This research model is the central model in my research. It illustrated different technological and managerial factors affecting the raw milk production in rural China throughout the supply chain. The factors are divided into four core elements: on-farm control, milking control on VMCs level, involvement of veterinarian during farming management and the information flow among three actors.

This conceptual model provides indications of detailed control activities in different levels, with which raw milk safety and quality can be improved. To which extent these activities are performed by farmers and VMCs determines how much the quality of raw milk can be reached. To investigate the performance condition in rural area in China, questions were asked for collecting more information.

6.3 Evaluation of Method used for data collection

The questionnaire for the VMC was sent out to collect information. The result, however, was not as good as it had been expected. Only few of papers were filled in and not complete. Part of reasons is that workers in VMC were unable to understand the questions from questionnaire. Therefore VMC and farmers had to be visited and interviewed in order to collect sufficient information.

The process of interviewing was time-consuming, and the quality of data often is dependent on the aptitude of the interviewer. The face to face interview was a big challenge to accomplish. It was a new experience to me, and I was not familiar to the rural situation and country life. However, the most difficult part of this interview was that it was carried out after the melamine scandal. It was a critical period for the whole dairy industry, and the topic was sensitive to VMCs and farmers. Therefore both farmers and VMCs were very cautious on the subject of melamine contamination and safety issues. Small scale dairy farmers were highly relied on VMCs for milking and selling raw milk, so some of them were not comfortable talking about subject like the relationship with VMC. They always tried to avoid the VMC-related subjects. In the sense, how reliable the data are remains to be determined.

Difficulty on question understanding was expected before interview. Questions from questionnaire were specially designed for easy understanding to farmers, nevertheless the real situation was beyond my expectation. Some of the questions in the questionnaires had to be changed during the study to make them more understandable to farmers, beside that very detailed explanation about questions must to be given.

6.4 Evaluation of Assessment Phase

Instead of developing the alternative solutions, improvement strategies were elaborated for China's dairy industry. These improvement strategies are focusing on the raw milk quality produced from small-scale dairy farms that account for more than 70% of total raw milk production in China. The complexity of China's dairy supply chain, poverty in rural area, low educational level, "vague, incomplete, and weak" (Lubman, 2008), lack of effective food laws and regulations have constraint the healthy development of dairy industry. Multiple factors have determined that it is extremely

difficult to find out an efficient solution(s) to solve the current predicament and crisis. For that reasons, improvement strategies to those established critical weaknesses of the complication were built up. Individual of them alone is not capable to give the solution, but most of the bottlenecks need to be addressed to improve the dairy quality basically.

Proposed improvement strategies were based on scientific literatures and considered with reliability and validity to the current situation in China. More important than choosing the best solution(s), improvement strategies, in this case, were classified according to their urgency of implementation, naming long-term strategy and short-term strategy. According to the urgency of the existing weaknesses, specific, efficient adjustment can be done accordingly to approach a better quality dairy industry.

6.5 Evaluation of Hypothesis

In the appreciation phase of this research, hypothesis to the appreciated problem was formulated and carried through the whole research. At this stage, the hypothesis will be evaluated based on the result of this study.

At the start of this research, it was hypothesized that to improve the to improve the microbial safety performance of the food safety management system in China's dairy industry it is essential to have commitment from small scale dairy farm management and VMC management to ensure the safety of raw milk. The fact that close connection between small scale dairy farms and VMCs in China facilitates the implementation of a specific system for food safety management. The system is very largely influenced by farmers' and VMCs workers' knowledge and their compliance to food safety standard hygiene procedure.

Results of my study has demonstrated that hypothesis has been partly convinced. Analysis of small scale dairy farms and VMCs in rural China revealed that, in order to improve the quality and safety of raw milk, the knowledge and attitude of farmers and VMC workers need to be improved; standard operation procedures for VMCs worker and GDFP guideline for farmers must be provided. A "Processor + VMC + Farm household" model had indeed helped to improve the raw milk quality. However, more and more problems had been emerging and finally provoked the melamine scandal. Therefore, the "Processor + VMC + Farm household" model needs to be abolished, meanwhile new evolving raw milk production models like "Processor + Dairy cow raising area + Farm household" would be worth a try.

6.6 Recommendations

In this section appropriate recommendation for the this field of studies will be performed for the further research.

1. This study concentrated on analysis of raw milk production in respects of small scale dairy farmers and Village Milking centres. To get a overview of whole dairy structure and to make comparison, visit of medium and large dairy farms is recommended.
2. In order to elevate the precision of practical result statistically, more farms and VMCs should be visited and interviewed.
3. It would be nice to include the current status of food safety legislation and its enforcement in China.

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Appendix

Appendix 1. Bacteria isolated from bulk-tank milk.

Group of bacteria	Species ^a
Staphylococci	
Contagious	<i>Staphylococcus aureus</i>
Environmental (coagulase-negative staphylococci)	<i>Staphylococcus caprae</i> , <i>Staphylococcus chromogenes</i> , <i>Staphylococcus cohnii</i> , <i>Staphylococcus epidermidis</i> , <i>Staphylococcus hominis</i> , <i>Staphylococcus hyicus</i> , <i>Staphylococcus intermedius</i> , <i>Staphylococcus lentus</i> , <i>Staphylococcus simulans</i> , <i>Staphylococcus warneri</i> , <i>Staphylococcus xylosus</i>
Streptococci and streptococci-like organisms	
Contagious	<i>Streptococcus agalactiae</i>
Environmental	<i>Streptococcus mutans</i> , <i>Streptococcus salivarius</i> , <i>Streptococcus alactolyticus</i> , <i>Streptococcus bovis</i> , <i>Streptococcus equinus</i> , <i>Streptococcus uberis</i> , <i>Enterococcus faecalis</i> , <i>Enterococcus faecium</i> , <i>Enterococcus saachrolyticus</i> , <i>Enterococcus avium</i> , <i>Enterococcus durans</i> , <i>Enterococcus hirae</i> , <i>Enterococcus malodoratus</i> , <i>Streptococcus dysgalactiae</i> , <i>Streptococcus equi</i> , <i>Streptococcus equisimilis</i> , <i>Streptococcus zooepidemicus</i> , <i>Streptococcus downei</i> , <i>Streptococcus acidominimus</i> , <i>Streptococcus thermophilus</i>
Coliforms	<i>Citrobacter</i> spp, <i>Enterobacter</i> spp, <i>Escherichia coli</i> , <i>Klebsiella</i> spp
Gram-negative noncoliform bacteria	<i>Acinetobacter</i> , <i>Hafnia</i> , <i>Moraxella</i> , <i>Pseudomonas</i> , <i>Serratia</i>

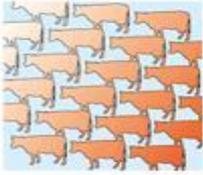
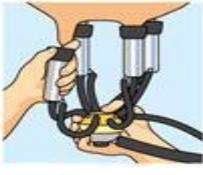
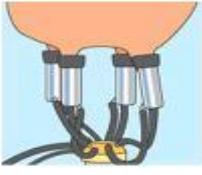
^a Species indicated in bold are associated with subclinical and clinical mastitis.
(Source: Bhushan et al., 2003)

Appendix 2. MRLs of some veterinary drugs in milk according to EU regulations

Drugs	Concentration ($\mu\text{g kg}^{-1}$)
Benzylpenicillin	4
Tetracycline	100-200
Oxytetracycline	100
Chlortetracycline	100
Trimethoprim	50
Ceftiofur	100
Streptomycin	200-1000
Oxfendazole	10
Sulphonamides	100

(Source: Jahed khaniki, 2007)

Appendix 3. 12 gold rules for milking

Before milking			
<p>1. Monitor udder health regularly</p>  <ul style="list-style-type: none"> - Review regularly all udder health and milk quality information provided by the dairy plant, official testing organizations, veterinary clinics and on farm testing using the DeLaval cell counter (DCC) or the California Mastitis Test (CMT). - Develop benchmarks for each cow and herd to assist in monitoring changes that may occur. 	<p>2. Milking order</p>  <ul style="list-style-type: none"> - Regardless of housing system or herd size, milk first calf heifers, fresh cows next and then the main herd. - Milk sick cows last and then wash and sanitize the milking system. 	<p>3. Foremilk cows</p>  <ul style="list-style-type: none"> - Remove 2-3 squirts of foremilk and examine it. In tie stall and parlour facilities use a strip cup. Wash off the parlor floor before the next group of cows enters. - Foremilking provides a powerful signal to initiate milk let-down and it provides an opportunity to detect and prevent abnormal milk from entering the tank. 	<p>4. Clean teats and teat ends</p>  <ul style="list-style-type: none"> - Mastitis control and producing high quality milk requires that cows have clean, dry teats when units are attached. Clean each teat and teat end using approved materials. Wipe each teat dry using single service paper or cloth towels, one per cow. If cloth towels are used be certain to effectively launder and dry them before reusing.
<p>Never start the milking procedure with cleaning of teats! The result is that germs growing in the teat canal can be moved further up into the udder. Always start with foremilk before cleaning of teats!</p>			
During milking			
<p>5. Check Milking System</p>  <ul style="list-style-type: none"> - Select a vacuum level and pulsation system appropriate for the dairy farm and have it installed according to DeLaval specifications. - Always check the vacuum level at the start of each milking. 	<p>6. Attach milking cluster at appropriate time</p>  <ul style="list-style-type: none"> - Within 60-90 seconds of all teat preparation procedures, milking units need to be attached. - Minimize air entries during cluster attachment. - Adjust milking cluster so that it is properly balanced front to back, side to side with no twisting. 	<p>7. Avoid overmilking</p>  <ul style="list-style-type: none"> - Overmilking is considered a primary cause of teat end hyperkeratosis. When the udder has been emptied satisfactorily, the milking unit needs to be removed. This can be detected by manual observation or, for systems with ACR's, allowing flow sensors to detect low flow and direct the automatic removal of the cluster. Flow controlled milking systems provide a visual indication when low flow has been attained. 	<p>8. Ensure proper removal of cluster</p>  <ul style="list-style-type: none"> - When milking is completed vacuum to the cluster can be shut-off manually or automatically. Allow claw vacuum to decline completely before removing the unit. DO NOT squeeze the udder and pull down on milking units as this may lead to air entry around the liner mouthpiece, this has been implicated in new cases of mastitis.

After milking

9. Sanitize teats after each milking



- As soon as possible after the unit is removed sanitize each teat with an approved post milking teat dip or spray. This is the single most effective procedure to prevent the cow to cow spread of contagious mastitis organisms.

10. Clean milking equipment immediately after milking



- Clean off the external surfaces of the milking system.
- After each use, either manually or automatically rinse and clean all system components using appropriate products at the proper temperature. Allow the system to drain dry.
- Where required, sanitize the system prior to the next milking using approved sanitizers at the proper dilution.

11. Properly cool milk



- Check cooling temperatures to be certain the proper temperatures are being reached during and after each milking.
- Proper refrigeration temperatures greatly slow or stop the growth of most bacteria.

12. Monitor milk quality, milking equipment, and milking performance data regularly



- Review all milk quality, milk composition, and milking center performance information regularly and compare it to historical data.
- Replace liners and rubber goods according to recommendations. Old rubber goods become cracked and porous and this influences milking performance and increases the risk of soil and bacterial build-ups. Such problems may lead to increased milking times and higher bacteria counts.
- Have the total milking system serviced regularly according to the DeLaval's recommendations.

Appendix 4: Summary of limiting conditions, time and temperature controls for growth of microbiological hazards and its inactivation

Pathogens	Conditions		
	Limiting conditions for pathogen growth	Time/Temperature guidance for controlling pathogens growth and toxin formation in seafoods	Inactivation temperatures
Clostridium botulinum Type E, non-proteolytic B and F	Min. Aw (using salt) = 0.97 Min. pH = 5 Max. pH = 9 Max % water phase salt = 5 Min. Temp. = 37.9 °F 3.3 °C	Product Max Temperature Cumulative	Internal Product Temp. process °F
		Exposure Time	Lethal rate ¹ Time for 6D
		37.9-41°F(3.3-5 °C) 7 days 42-50°F(6-10 °C) >2 days	min. 185 194 201 205 0.193 1.000 2.510 3.980 51.8 10.0 4.0 2.5

	<p>Max. Temp. = 113 °F</p> <p>45 °C</p> <p>O₂ requirement = anaerobe**</p>	<p>51-70°F(11-21 °C)</p> <p>11 days</p> <p>> 70 °F(> 21 °C)</p> <p>6 hours</p>	<p>208</p> <p>210</p> <p>212</p> <p>6.310</p> <p>7.940</p> <p>10.000</p>	<p>1.6</p> <p>1.3</p> <p>1.0</p>
Pathogenic strain of E. coliform	<p>Min.Aw (using salt) = 0.95</p> <p>Min. pH = 4</p> <p>Max. pH = 9</p> <p>Max % water phase salt = 6.5</p> <p>Min. Temp. = 43.7 °F</p> <p>6.5 °C</p> <p>Max. Temp. = 120.9 °F</p> <p>49.4 °C</p> <p>O₂ requirement = facultative***</p> <p>anaerobe</p>	<p>Product</p> <p>Max Temperature Cumulative</p> <p>Exposure Time</p> <p>44.6-50°F(7-10 °C)</p> <p>14 days</p> <p>51-70°F(11-21 °C)</p> <p>6 hours</p> <p>> 70 °F(> 21 °C)</p> <p>3 hours</p>		
Listeria Monocytogenes	<p>Min.Aw (using salt) = 0.92</p> <p>Min. pH = 4.4</p> <p>Max. pH = 9.4</p> <p>Max % water phase salt = 10</p> <p>Min. Temp. = 31.3 °F</p> <p>-0.4 °C</p> <p>Max. Temp. = 113 °F</p> <p>45 °C</p> <p>O₂ requirement = facultative***</p> <p>anaerobe</p>	<p>Product</p> <p>Max Temperature Cumulative</p> <p>Exposure Time</p> <p>31.3-41°F(-0.4-5 °C)</p> <p>7 days</p> <p>42-50°F(6-10 °C)</p> <p>2 days</p> <p>51-70°F(11-21 °C)</p> <p>12 hours*</p> <p>> 70 °F(> 21 °C)</p> <p>3 hours</p>	<p>Internal Product process °F min.</p> <p>Lethal rate¹</p> <p>Time for 6D</p> <p>145</p> <p>151</p> <p>156</p> <p>165</p> <p>174</p> <p>180</p> <p>185</p> <p>0.117</p> <p>0.293</p> <p>0.736</p> <p>3.415</p> <p>15.849</p> <p>39.810</p> <p>100.000</p>	<p>17.0</p> <p>6.8</p> <p>2.7</p> <p>0.6</p> <p>0.1</p> <p>0.05</p> <p>0.02</p>
Salmonella Spp.	<p>Min.Aw (using salt) = 0.94</p> <p>Min. pH = 3.7</p> <p>Max. pH = 9.5</p> <p>Max % water phase salt = 8</p> <p>Min. Temp. = 41.4 °F</p> <p>5.2 °C</p> <p>Max. Temp. = 115.2 °F</p> <p>46.2 °C</p> <p>O₂ requirement = facultative***</p> <p>anaerobe</p>	<p>Product</p> <p>Max Temperature Cumulative</p> <p>Exposure Time</p> <p>41.4-50°F(5.2-10 °C)</p> <p>14 days</p> <p>51-70°F(11-21 °C)</p> <p>6 hours</p> <p>> 70 °F(> 21 °C)</p> <p>3 hours</p>		
Shigella Spp.	<p>Min.Aw (using salt) = 0.96</p> <p>Min. pH = 4.8</p> <p>Max. pH = 9.3</p> <p>Max % water phase salt = 5.2</p> <p>Min. Temp. = 43.0 °F</p> <p>6.1 °C</p> <p>Max. Temp. = 116.8 °F</p> <p>47.1 °C</p> <p>O₂ requirement =</p>	<p>Product</p> <p>Max Temperature Cumulative</p> <p>Exposure Time</p> <p>43.0-50°F(6.1-10 °C)</p> <p>14 days*</p> <p>51-70°F(11-21 °C)</p> <p>12 hours*</p> <p>> 70 °F(> 21 °C)</p> <p>3 hours*</p>		

	facultative ^{***} anaerobe		
Staphylococcus aureus growth	Min.Aw (using salt) = 0.83 Min. pH = 4.0 Max. pH = 10 Max % water phase salt = 20 Min. Temp. = 44.6 °F 7.0 °C Max. Temp. = 122.0 °F 50.0 °C O ₂ requirement = facultative ^{***} anaerobe	Product Max Temperature Cumulative Exposure Time 44.6-50°F(7-10 °C) 14 days 51-70°F(11-21 °C) 12 hours* > 70 °F(> 21 °C) 3 hours	
Staphylococcus aureus toxin	Min.Aw (using salt) = 0.85 Min. pH = 4.0 Max. pH = 9.8 Max % water phase salt = 10 Min. Temp. = 50.0 °F 10.0 °C Max. Temp. = 118.0 °F 48.0 °C O ₂ requirement = facultative ^{***} anaerobe	Product Max Temperature Cumulative Exposure Time 44.6-50°F(7-10 °C) 14 days 51-70°F(11-21 °C) 12 hours* > 70 °F(> 21 °C) 3 hours	
Vibrio parahaemolyticus	Min.Aw (using salt) = 0.94 Min. pH = 4.8 Max. pH = 11 Max % water phase salt = 10 Min. Temp. = 41.0 °F 5.0 °C Max. Temp. = 113.5 °F 45.3 °C O ₂ requirement = facultative ^{**} anaerobe	Product Max Temperature Cumulative Exposure Time 41.0-50°F(5.0-10 °C) 21 days 51-70°F(11-21 °C) 6 hours* > 70 °F(> 21 °C) 2 hours*	
Vibrio vulnificus	Min.Aw (using salt) = 0.96 Min. pH = 5.0 Max. pH = 10 Max % water phase salt = 5 Min. Temp. = 46.4 °F 8.0 °C Max. Temp. = 109.4 °F 43.0 °C O ₂ requirement = facultative ^{**} anaerobe	Product Max Temperature Cumulative Exposure Time 46.4-50°F(8-10 °C) 21 days 51-70°F(11-21 °C) 6 hours > 70 °F(> 21 °C) 2hours	

* = additional data needed

** = requires the absence of oxygen

*** = grows either with or without oxygen

1 = lethal rates and process times may not be sufficient for the destruction of nonproteolytic *C. botulinum* in Dungeness crabmeat, because of the potential that substances that may be naturally present, such as lysozyme, may enable the pathogen to more easily recover from heat damage (USFDA, 2001b).

Appendix 5. Mastitis and milk quality tests

Test	Abbrev.	Measurement	Tests Conducted By
Somatic Cell Count	SCC	White blood cells in milk	Regulatory, Coop/Plant, DHI, Vets, Independent/University
Individual Cow Somatic Cell Counting Program	Cow-SCC	SCC in individual cows at monthly intervals	DHI, Independent
Bulk Tank Somatic Count	BTSCC	SCC of bulk tank milk	Regulatory, Coop/Plant, Vets, Cell Independent/University
Direct Microscopic Somatic Cell Count	DMSCC	Standard method for determining SCC of a milk sample	Regulatory, Coop/Plant, Independent/University
Wisconsin Mastitis Test	WMT	Indirect measure of SCC in a milk sample (antiquated)	Coop/Plant, Vets, Independent/University
California Mastitis Test	CMT	Cow side test for SCC in milk	Vets, Producers
Standard Plate Count	SPC	Total number of bacteria in a milk sample	Regulatory, Coop/Plant, Independent/University
Preliminary Incubation	PI	Number of psychotrophic (cold loving) bacteria in a milk sample	Coop/Plant, Independent/University
Bulk Tank Milk Cultures	BTMC	Estimates total number and type of bacteria in a milk sample	Vets, Coop/Plant, Independent/University
Cow/Quarter Cultures	—	Infection status of cows/quarters and pathogen type	Vets, Independent/University, Coop/Plant

Appendix 5. (B) Information derived from mastitis and milk quality tests.

Test	Importance of Information	Disadvantages
BTSCC	1. Indicator of herd mastitis prevalence.	1. No indication of which cows/quarters are infected. 2. No indication of pathogens involved. 3. Poor monitor of environmental mastitis.
SPC	1. A monitor of milking equipment sanitation, milking time hygiene, and efficiency of milk cooling.	1. No indication of bacterial types. 2. No indication of specific source of contamination.
PI	1. Indication of bacterial contamination from environmental sources. 2. Low values necessary for quality bonus payments.	1. No indication of causative agents. 2. No indication of the specific environmental source.
Individual Cow SCC	1. Monitor of subclinical mastitis in a cow. 2. Can be used to assess subclinical mastitis in a herd 3. Informed management decisions (culling). 4. Assess monetary losses associated with subclinical mastitis.	1. No indication of causative agents. 2. Poor monitor of environmental mastitis. 3. Poor indicator of clinical mastitis.
CMT	1. Inexpensive, rapid, and subjective evaluation of quarter SCC at cow side.	1. Interpretation is difficult. 2. Relative numbers of pathogens are poorly related to infection prevalence. 3. The source of organisms other than contagious pathogens is not indicated.
BTMC	1. Estimates SPC. 2. Detects presence of specific pathogen types. 3. Indicates primary bacterial contaminants. 4. Can be used to evaluate milking time hygiene.	1. Interpretation is difficult. 2. Relative numbers of pathogens are poorly related to infection prevalence. 3. The source of organisms other than contagious pathogens is not indicated.
Cow/Quarter Cultures	1. Only method that determines infection status of a cow/quarter. 2. Identifies specific causative agents in clinical and subclinical mastitis.	1. Costly. 2. Requires special training to collect and analyze samples.

(Source: *Milk Quality Evaluation Tools for Dairy Farmers*, J. W. Schroeder, 1997)

Appendix 6. Guideline for accurate sampling and reporting of bulk milk cell counts

National Mastitis Council

Guidelines For Accurate Sampling and Reporting of Bulk Milk Cell Counts

The bulk tank somatic cell count (BTSCC) is an internationally accepted measure of the quality and suitability of milk sold from the farm for human consumption. It is used by regulatory agencies to permit or exclude milk from interstate or international trade. Dairy cooperatives and processors may partly price the value of milk based on BTSCC. The National Mastitis Council (NMC) recommends that the following guidelines be used for the determination and reporting of BTSCC, to ensure accurate representation of the milk shipped from a farm.

1. Bulk tank milk samples must be collected, identified, handled and tested by personnel and protocols certified by the regulatory agencies of jurisdiction to ensure the accuracy of the BTSCC.
2. Bulk tank milk must be sampled so that all cows contributing milk to the bulk tank are represented proportionally according to the amount of milk contributed.
 - (a) If a bulk tank contains all of the milk from all cows being milked in one day (or complete multiples thereof), then one sample of that bulk milk is sufficient. However, if the pick-up only takes a portion of the milk that is produced in a given day, then the volume of each portion must be known and a sample taken.
 - (b) If there are multiple pick-ups during the day or multiple bulk tanks are used to hold milk from all of the farm's cows, then each tank should be sampled each time milk is removed.
 - (c) If each pick-up represents the supply from more than one day but not a whole number of days, then the tank should be sampled when it contains the output for one or more complete days.
3. The BTSCC to be reported for any day or any multiple-day period (up to 7 days) should be the weighted arithmetic mean of the BTSCC from all samples taken for that period.

Examples:

- A) One collection per day: use the BTSCC determined for the appropriately collected sample
- B) Two or more collections per day, or more than one tank:

$$BTSCC = \frac{\sum_1^n (SCC \times vol)}{Vol}$$

n = number of loads or tanks/day

SCC = somatic cell count of the individual sample

vol = amount of milk in the individual load or tank

Vol = total volume of all loads or tanks

4. The BTSCC for a month should be reported from at least one complete day or a daily arithmetic average for a multiple-day period reported during each month.

(continued)

5. In some instances, e.g. with certain United States milk buyers or companies involved in international trade with the European Union etc., milk suitability is determined by the geometric mean of the BTSCC. In these cases, a rolling geometric mean of the BTSCC for the last three months should be used.
6. The three-month geometric mean is a monthly rolling value calculated from all individual daily averages collected from the previous three complete months.

$$\text{The BTSCC}_{\text{GM}} = \text{antilog } 1/n \sum_1^n \log .X_i$$

X = each individual BTSCC, daily values as defined in #3 above

n = number of samples taken in each three-month period; usually 3 if monthly counts are made or 13 when weekly counts are made.

The calculation is made by summing the logarithm to base 10, of each daily BTSCC, taking the mean, and obtaining the antilog.

NOTE: The geometric mean will be lower than the arithmetic mean. The geometric mean has a lower variance thereby reducing the significance of individual values, which are perhaps related to sampling or measurement errors.

This document was developed by the National Mastitis Council Milk Quality Monitoring Committee and approved by the National Mastitis Council Board of Directors, February 2002.

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Appendix 7. Detailed GDF practice guideline

12.1 For animal health:

Objective ->Animals that produce milk need to be healthy and an effective health care program should be in place.

Good agricultural practice (GAP)	Suggested measures to achieve GAP	Objective/Control measure
1.1 Prevent entry of disease onto the farm	1.1.1 Only buy animals of known disease status and control their introduction onto the farm 1.1.2 Ensure cattle transport on and off the farm does not introduce disease 1.1.3 Have secure boundaries/fencing 1.1.4 If possible, limit access of people and wildlife to the farm 1.1.5 Have a vermin control programme in place 1.1.6 Only use clean equipment from a known source	<ul style="list-style-type: none"> - Keep animals healthy - Comply with national/regional animal movement and disease controls
1.2 Have an effective herd health management programme in place	1.2.1 Use an identification system that allows all animals to be identified individually from birth to death 1.2.2 Develop an effective herd health management programme focused on prevention that meets the farm's needs as well as regional and national requirements 1.2.3 Regularly check animals for signs of disease 1.2.4 Sick animals should be attended to quickly and in an appropriate way 1.2.5 Keep sick animals isolated and separate milk from sick animals and animals under treatment 1.2.6 Keep written records of all treatments and identify treated animals appropriately 1.2.7 Manage animal diseases that can affect public health (zoonoses)	<ul style="list-style-type: none"> - Detect animal diseases early - Prevent spread of disease among animals - Prevent transmission of zoonoses - Ensure traceability
1.3 Use all chemicals and veterinary medicines as prescribed	1.3.1 Use chemicals according to directions, calculate dosages carefully and observe appropriate withholding periods 1.3.2 Only use veterinary medicines as prescribed by veterinarians and observe specified withholding periods 1.3.3 Store chemicals and veterinary medicines securely and dispose of them responsibly	<ul style="list-style-type: none"> - Prevent occurrence of chemical residues in milk
1.4 Train people appropriately	1.4.1 Have procedures in place for detecting and handling sick animals and veterinary chemicals 1.4.2 Make sure all people are sufficiently trained to carry out their tasks 1.4.3 Choose competent sources for advice and interventions	<ul style="list-style-type: none"> - Follow correct procedures

12.2 For milking hygiene

Good agricultural practice (GAP)	Suggested measures to achieve GAP	Objectives/Control measures
2.1 Ensure milking routines do not injure cows or introduce contamination to milk	2.1.1 Uniquely identify individual animals 2.1.2 Ensure appropriate udder preparation for milking 2.1.3 Ensure consistent milking techniques 2.1.4 Separate milk from sick or treated animals 2.1.5 Ensure milking equipment is correctly installed and maintained 2.1.6 Ensure a sufficient supply of clean water	- Use suitable and well maintained equipment for milking and milk storage
2.2 Ensure milking is carried out under hygienic conditions	2.2.1 Ensure housing environment is clean at all times 2.2.2 Ensure milking area is kept clean 2.2.3 Ensure the VMC workers follow basic hygiene rules	- Harvest milk under hygienic conditions
2.3 Ensure milk is handled properly after milking	2.3.1 Ensure milk is cooled in the specified time 2.3.2 Ensure milk storage area is clean and tidy 2.3.3 Ensure milk storage equipment is adequate to hold milk at the specified temperature 2.3.4 Ensure unobstructed access for bulk milk	- Refrigerate and store milk under hygienic conditions

12.3 For Animal feeding and water:

Objective: Animals need to be fed and watered with products of suitable quality and safety.

Good agricultural practice (GAP)	Examples of suggested measures to achieve GAP	Objectives/Control measures
3.1. Ensure animal feed and water are of adequate quality	3.1.1 Ensure the nutritional needs of animals are met 3.1.2 Ensure good quality water supplies are provided, regularly checked and maintained 3.1.3 Use different equipment for handling chemicals and feed stuffs 3.1.4 Ensure chemicals are used appropriately on pastures and forage crops 3.1.5 Only use approved chemicals for treatment of animal feeds or components of animal feeds and observe withholding periods	- Keeping animals healthy with good quality feed - Preserve water supplies and animal feed materials from chemical contamination - Avoid chemical contamination due to farming practices
3.2. Control storage conditions of feed	3.2.1 Separate feeds intended for different species 3.2.2 Ensure appropriate storage conditions to avoid feed contamination 3.2.3 Reject mouldy feed	- No microbiological or toxin contamination or unintended use of prohibited feed ingredients or veterinary preparations - Keeping animals healthy with good quality feed

3.3. Ensure the traceability of feedstuffs bought off the farm	3.3.1 All suppliers of animal feeds should have an approved quality assurance programme in place 3.3.2 Maintain records of all feed or feed ingredients received on the farm (specified bills or delivery notes on order)	- Quality assurance programme of feed supplier
--	--	--

12.4 For Animal welfare:

Objective: Animals should be kept according to the following principles:

- Freedom from thirst, hunger and malnutrition
- Freedom from discomfort
- Freedom from pain, injury and disease
- Freedom from fear
- Freedom to engage in relatively normal patterns of animal behaviour

Good agricultural practice (GAP)	Suggested measures to achieve GAP	Objectives/Control measures
4.1 Ensure animals are free from thirst, hunger and malnutrition	4.1.1 Provide sufficient feed (forage and/or fodder) and water every day. 4.1.2 Adjust stocking rates and/or supplementary feeding to ensure adequate water, feed and fodder supply 4.1.3 Protect animals from toxic plants and other harmful substances 4.1.4 Provide water supplies of good quality that are regularly checked and maintained	- Healthy, productive animals - Appropriate feeding and watering of animals
4.2 Ensure animals are free from discomfort	4.2.1 Design and construct buildings to be free of obstructions and hazards 4.2.2 Where relevant, provide adequate space allowances and clean bedding 4.2.3 Protect animals from adverse weather conditions and the consequences thereof 4.2.4 Provide housed animals with adequate ventilation 4.2.5 Provide non-slippery floors	- Protection of animals against extreme climate conditions - Provide a safe environment
4.3 Ensure animals are free from pain, injury and disease	4.3.1 Have an effective herd health management programme in place and inspect animals regularly 4.3.2 Protect against lameness 4.3.3 Lactating animals should be milked regularly 4.3.4 Do not use procedures and practices that cause unnecessary pain 4.3.5 Follow appropriate calving and weaning practices 4.3.6 Have appropriate procedures for marketing calves 4.3.7 When animals have to be killed on-farm, avoid unnecessary pain 4.3.8 Avoid poor milking routines as they may injure cattle	- Justified and humane actions - Good sanitary conditions
4.4 Ensure animals are free from fear	4.4.1 Provide competent animal husbandry skills and appropriate training	- Absence of ill-treatment - Security of animals

		and farmer
4.5 Ensure animals can engage in relatively normal patterns of animal behavior	4.5.1 Have herd management and husbandry procedures that do not unnecessarily compromise social activity	- Freedom of movement - Preserve gregarious behavior and other behaviors, such as preferred sleeping position

12.5 For Environment:

Objective: Milk production should be managed in balance with the local environment surrounding the farm.

Good agricultural practice (GAP)	Suggested measures to achieve GAP	Objectives/Control Measures
5.1 Have an appropriate waste management system.	5.1.1 Ensure wastes are stored to minimize the risk of environmental pollution 5.1.2 Manage pastures to avoid effluent runoff by spreading farm manures in accordance with local condition	- Limit the potential impact of dairy farming practices on the environment.
5.2 Ensure dairy farming practices do not have an adverse impact on the local environment	5.2.1 Contain dairy runoff on-farm 5.2.2 Use chemicals (fertilizers, agricultural and veterinary chemicals, pesticides, etc) appropriately to avoid contamination of the local environment 5.2.3 Ensure overall appearance of the dairying operation is appropriate for a facility in which high quality food is harvested	- Presenting a positive image of milk production practices.
5.1 Have an appropriate waste management system.	5.1.1 Ensure wastes are stored to minimize the risk of environmental pollution 5.1.2 Manage pastures to avoid effluent runoff by spreading farm manures in accordance with local conditions	- Limit the potential impact of dairy farming practices on the environment.

Appendix 8. Questionnaire for farmers

Farm code:	Date:
<p>Survey</p> <p>Question 1 and 2: Personal information</p> <p>Question 3: Farm composition</p> <p>Question 4: Household income</p> <p>Question 5: Relation to VMC</p> <p>Question 6: Feed/feeding</p> <p>Question 7: Cow health</p> <p>Question 8: Recording</p>	

1. Working experience

How long have you been working with dairy cows?

- 1) Less than 5 years

- 2) 5-10 years
- 3) 10-20 years
- 4) More than 20 years

2. Educational background

Kind of education

- 1) No education
- 2) Elementary school
- 3) Middle school
- 4) High school/Collage
- 5) University

3. Farm composition

3.1 Farm enterprise

- 1) Dairy cows
- 2) Other animals: _____
- 3) Pasture: yes/no

3.2 Do you have other income sources: yes/no

3.3 Number of cows in household: _____

3.4 How much time do you spend with your dairy cow/cows: _____ (hour/day)

3.5 Who owns the cows?

- 1) You and your family
- 2) The VMC
- 3) The dairy processors
- 4) Other: _____

4. Household income

4.1 Major sources of income (rank the three most important)

- 1) Milk production
- 2) Other animals
- 3) Cash crop
- 4) Other: _____

4.2 What are your main tasks within the household? (Rank the three most important)

- 1) Bring dairy cows to VMC
- 2) Animal care
- 3) Crop production
- 4) Child care
- 5) Cooking
- 6) Herd management
- 7) Other: _____

4.3 How often do you get paid from the VMC?

- 1) Once a week
- 2) Every second week
- 3) Once a month
- 4) Other: _____

4.4 Are there any seasonal differences in how much you are paid per litre of milk?

- 1) No
- 2) Yes.

5. Relation to VMC

5.1 Did you join the VMC from the very beginning?

- 1) Yes
- 2) No

5.2 What was the main reason why you signed up at the VMC?

- 1) Economical
- 2) Safe and more regular income
- 3) Dairy processor decision
- 4) Cooperative/community decision
- 5) Political decision
- 6) Other _____

5.3 What kind of services at VMC do you use except for milking facilities? (Rank the three most important)

- 1) Training/education
- 2) Feed (education, purchase)
- 3) Breeding (AI, education, etc.)
- 4) Communication (phone, internet)
- 5) Seed (for crop production)
- 6) Veterinarian
- 7) Place for meeting
- 8) Other _____

5.4 How do you regard the services provided at VMC?

- 1 Unsatisfied
- 2
- 3
- 4
- 5 Very satisfied

5.5 Have your expectations to VMC been met?

- 1 Not at all
- 2
- 3
- 4
- 5 Totally

5.6 Any other services at VMC you would like to see in the developing further? (Rank the three most important)

- 1) Training/education
- 2) Feed (education, purchase)
- 3) Breeding (AI, education, etc.)
- 4) Communication (phone, internet)
- 5) Seed (for crop production)
- 6) Veterinarian
- 7) Other _____

5.7 What kind of changes have been achieved since joining VMC?

- 1) More money per litre of milk
- 2) More milk produced
- 3) Healthier cows
- 4) Less work
- 5) Safer more regular income
- 6) Improved standard of living
- 7) Improved knowledge about dairy/management
- 8) Other _____

5.8 Have you participated in any courses at VMC?

- 1) No
- 2) Yes Which?

5.9 Do you want to participate in courses at the VMC?

- 1) No
- 2) Yes Which?

6. Feed/feeding

6.1 What kind of feed do you give your cow/cows?

- A) Roughage
 - 1) Straw
 - 2) Hay
 - 3) Silage
 - 4) Pasture
 - 5) Green chop

- 6) Other: _____
- B) Concentrates
- 1) Grain corn
 - 2) Soybean
 - 3) Cereal/Grain
 - 4) Cotton seed
 - 5) Ready mix
 - 6) Minerals
 - 7) Other: _____
- 6.2 Are there any seasonal differences in how the cows are fed?\
- 1) No
 - 2) Yes. What kind of differences?
-
- 6.3 Water supply
- 1) Free access of fresh water most of the day
 - 2) Once a day
 - 3) Twice a day
 - 4) Other _____
- 7. Cow health**
- 7.1 Different kind of health problem (Rank the three most important)
- 1) Mastitis
 - 2) Injured udder
 - 3) Stomach disturbances
 - 4) Leg and hoof problem
 - 5) Under fed/Starving
 - 6) Worms
 - 7) Lice, flea etc
 - 8) Ticks
 - 9) Decreased fertility
 - 10) Pneumonia
 - 11) Other problems
- 7.2 How do you know whether cow has health problem?
- 1) Find by myself
 - 2) Told by VMC
 - 3) From someone else
- 7.3 Who do you ask for help if cow needs to have medical treatment?
- 1) Veterinarian
 - 2) VMC
 - 3) By myself
 - 4) No treatment
- 7.4 Does cow health improve after treatment?
- 1) Find by myself
 - 2) Told by VMC
- 8. Recording**
- 8.1 Do you record events happened with your cows?
- 1) No
 - 2) Yes
- 8.2 What kinds of records do you have?
- 1) Disease history record
 - 2) Cow treatment record
 - 3) VMC payment record
 - 4) Feedings record
 - 5) Others _____
- 8.3 Do you record for every cow?
- 1) No
 - 2) Yes
- 8.4 Do you think that record can improve milk safety?

- 1) No
- 2) Yes
- 3) No idea

Appendix 9. Questionnaire for VMCs

VMC code:	Date:
<p>Survey</p> <p>Question 1: General VMC information</p> <p>Question 2: Educational background</p> <p>Question 3: Services and facilities at VMC</p> <p>Question 4: Technical equipment in VMC</p> <p>Question 5: Facility</p> <p>Question 6: Cow health</p> <p>Question 7: Milking procedure</p> <p>Question 8: Payment system</p>	

1. General VMC information

1.1 Form of VMC ownership:

- 1) Private investor
- 2) Cooperative
- 3) Dairy processor
- 4) Other _____

1.2 Number of person in household _____

1.3 Total number of households _____

1.4 Total no. of milking dairy cows connected to the VMC _____

1.5 No. of farmers with:

- 1-3 cows _____
- 4-6 cows _____
- 7-10 cows _____
- ≥10 cows _____

2. Educational background

2.1 Average educational level of VMC worker

- 1) No education
- 2) Elementary school
- 3) Middle school
- 4) High school/collage
- 5) University
- 6) Other: _____

2.2 Educational level of VMC manager

- 1) No education
- 2) Elementary school
- 3) Middle school
- 4) High school/collage
- 5) University
- 6) Other: _____

3. Services and facilities at VMCs

3.1 Services provided at VMC:

- 1) Veterinary Services
- 2) Animal medical supply
- 3) Breed (AI/ training)
- 4) Feed (supply/ training)

- 5) Herd Management
- 3.2 Any other services at the VMC you would like to introduce and/or developed further?
 - 1) Training/education
 - 2) Feed (education, purchase)
 - 3) Breeding (AI, education, etc.)
 - 4) Communication (phone, internet)
 - 5) Seed (for crop production)
 - 6) Veterinarian
 - 7) Other: _____
- 3.3 What changes do you think have been the result for the farmer after they joined the VMC system? (Rank the three most important) Kind of education
 - 1) More milk produced
 - 2) Higher price per litre of milk
 - 3) Healthier cows
 - 4) Change in workload and working condition
 - 5) Safer and more regular income
 - 6) Better milk quality
 - 7) Improved standard of living
 - 8) Improved knowledge of dairy/management
 - 9) Other: _____
- 3.4 Does VMC organize courses at the VMC for the farmers?
 - 1) No
 - 2) Yes, What are the course/courses about?
 - 1) Herd management
 - 2) Technical facilities
 - 3) Breeding
 - 4) Feeding
 - 5) Other: _____
- 3.5 What services are mostly used/asked for by farmers?

- 3.6 Have you taken any training in VMC?
 - 1) No
 - 2) Yes, What was it about?
 - 1) Management
 - 2) Technical maintenance procedure for equipment
 - 3) Breeding
 - 4) Milking
 - 5) Milk quality testing
 - 6) Other: _____
- 4. Technical equipment in VMC**
 - 4.1 Type of milking machines _____
 - 4.2 washing facilities _____
 - 4.3 Proper working cooling tank? _____
- Quality testing equipment**
 - 4.4 What kind of testing equipment does VMC have?
 - 1) Lactometer
 - 2) Thermometer
 - 3) Alcohol burner
 - 4) pH meter
 - 5) Antibiotic test
 - 6) Mastitis probe
 - 7) Containers like beaker, tube etc.
 - 8) Others _____
- 5. Facility**
 - 5.1 Is the building designed specially as milking station
 - 1) No

- 2) Yes
- 5.2 Any addition or/and change of original building? _____
-
- 5.3 Does VMC have quality testing room?
- 1) No
- 2) Yes
- 5.4 Does VMC have good drainage system in milking room?
- 1) No
- 2) Yes
- 5.5 Does VMC have backup power source in case of power cut?
- 1) No
- 2) Yes
- 5.6 Computer available
- 1) Yes
- 2) No
- 5.7 Overall description of VMC facility
-
-

6. Cow health

- 6.1 Pleas fill in treated and untreated number of cases of health problems (average during the last year)

Health problem	No. of case	Proportion treated at VMC
Mastitis		
Injured udder		
Digestion problems		
Leg/hoof problem		
Worms		
Lice, fleas		
Ticks		

- 6.2 Possibility to treat with antibiotics without consulting a veterinary if needed?
- 1) No
- 2) Yes
- 6.3 How do the routines look like when you notice different health problems in the dairy herd? (When is treatment used? When not?)
-
-

7. Milking procedure

- 7.1 Does VMC have written standard milking procedure?
- 1) Yes
- 2) No
- 7.2 Do VMC worker comply with the standard procedure every time milking?
- 1) Every time
- 2) Often
- 3) Some time
- 4) Rarely
- 7.3 Does VMC understand each step of milking procedure?
- 1) Yes
- 2) No
- 7.4 Does milker clean the teats before and after milking?
- 1) Before milking
- 2) After milking
- 3) Before and after milking
- 7.5 Does milker discard first few ml of milk?
- 1) Yes
- 2) No
- 7.6 Is VMC capable to store the raw milk under 4°C?

- 1) Yes
- 2) No

8. Payment system

8.1 Under what conditions do you get paid?

Depending on milk quality

Depending on milk yield

Independent

Other: _____

8.2 Does the VMC have any quality payment system to farmer?

1) Quality payment that include bacteria, inhibitor and somatic cell count

2) Payment based on milk density and acidity

3) Payment based on fat content using simple fat testing equipment

4) Payment based on fat, protein, lactose and total solids

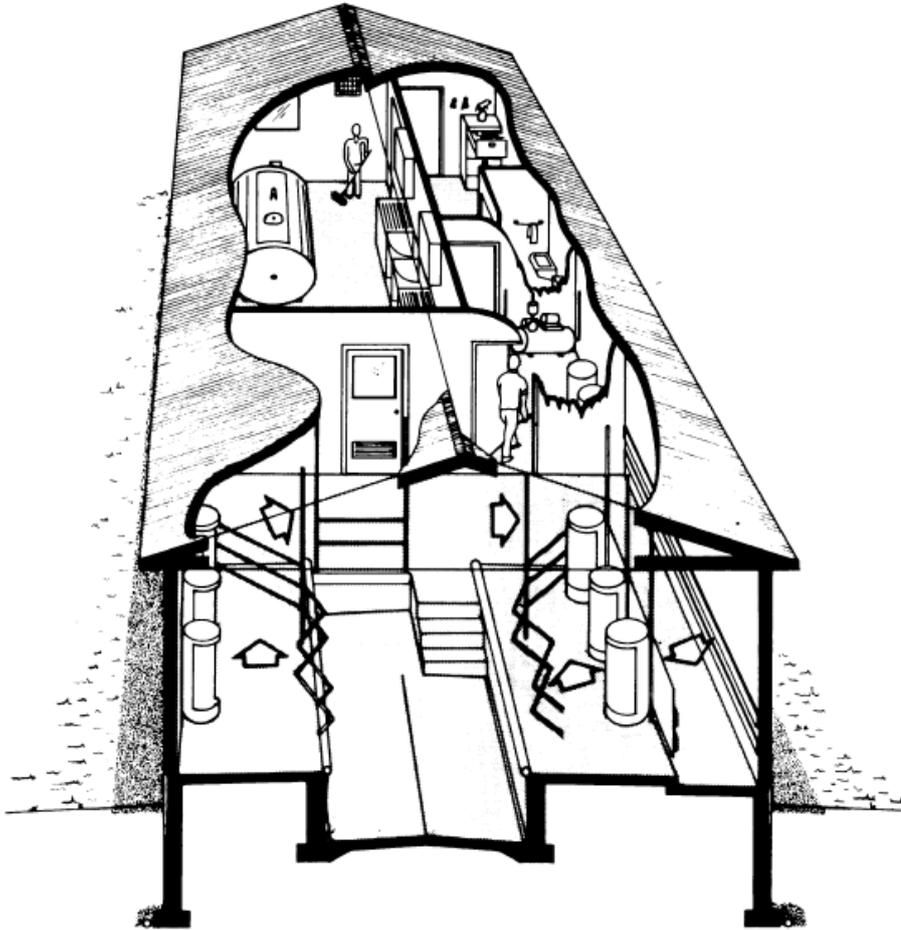
5) Other: _____

Appendix 10. List of the countries with major number of public service veterinarians as reported in 2003

Order	Country	Number	% of all public vet. in world	Ratio public/total	Ratio public/private
1	China	43,900	20.92	0.3859	0.8767
2	India	31,495	15.01	0.8266	15.9468
3	Egypt	19,750	9.41	0.4759	1.5800
4	Japan	8,106	3.85	0.2638	0.4804
5	Ukraine	6,967	3.32	0.5453	4.3763
6	Italy	5,648	2.69	0.3179	0.5888
7	Cuba	5,363	2.56	0.8099	
8	Kazakhstan	3,737	1.78	0.4109	0.6976
9	Brazil	2,867	1.37	0.0540	0.0636
10	USA	2,782	1.33	0.0479	0.0618

(Source: Kouba V.: *Public Service Veterinarians Worldwide: a Quantitative Analysis*. Acta Vet. Brno 2005, 74: 455-461.)

Appendix 11. Herringbone milking centre.



(Source: Canada plan service, plan 2051. www.cps.gov.on.ca/english/dc2000/dc2501.htm)