THE IMPACT OF DAIRY MANAGEMENT TRAINING OF SMALL SCALE DAIRY FARMERS ON MILK YIELD AND QUALITY IN MALAWI

By

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To my parents, Mr. & Mrs. Kazanga

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LIST OF ABBREVIATIONS

AI	Artificial Insemination
CBAM	Concerns-Based Adoption Model
CIDA	Canadian International Development Agency
CREMPA	Central Region Milk Producers Association
FAO	Food and Agriculture Organization
IDF	International Dairy Federation
MBG	Milk Bulking Group
MCDDP	Malawi Canada Dairy Development Project
MDFA	Mzuzu Dairy Farmers Association
MDI	Malawi Dairy Industries Corporation
MMM	Malawi Milk Marketing
MMPA	Malawi Milk Producers Association
NGO	Non-Governmental Organization
SHIMPA	Shire Highlands Milk Producers Association

Abstract of Thesis Presented to the Graduate School
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This study was conducted to assess the impact of dairy management training on milk yield and milk quality among small scale dairy farmers in Malawi. It was conducted against the background of failure by small scale dairy farmers in Malawi to realize the full potential of their dairy cows due to lack of dairy management skills. It was conducted in the Lilongwe and Mzuzu milk shed areas and six Milk Bulking Groups (MBGs) were selected using a purposive sampling method. Dairy farmers from three MBGs were trained in good dairy management practices that ranged from feeds and feeding, importance of water, milk handling, animal welfare, and farm hygiene to disease control, whereas farmers from the other three MBGs were not offered the training; they were treated as a control. The training was based on the Concern-Based Adoption Model (CBAM) that acknowledges that supporting people is critical for learning to bring change. Data was collected using a questionnaire for both the baseline (before training) and end-line survey (after training).

Results indicated that training had a positive impact on the behavioral change of small scale dairy farmers on availability of water (46%, 12% and 33.3%), availability of feed (40%, 43% and 26.6%), cleaning of utensils (100%), barn cleanliness (46.7%, 37.5% and 33.3%) and

the resultant increase in milk yields and reduced milk rejection (0%) by buyers in the trained MBGs. On the other hand, the untrained dairy farmers continued to practice unhygienic milk handling, which resulted in high milk rejection rate due to poor quality. At the same time the untrained dairy farmers continued to register low milk yields. The study results further showed that education level of dairy farmers had no impact on their behavioral change towards good dairy management practices. Similarly, the MBGs where farmers came from had no impact on their behavioral change.

In conclusion, the study findings indicate that training plays a crucial role in changing dairy famer's behavior towards good dairy management practices in Malawi. Emphasis ought to be placed on training in dairy management if milk yields and milk quality are to be enhanced.

CHAPTER 1
BACKGROUND

Introduction

Livestock make a significant contribution to the livelihoods of smallholder farmers in Malawi. Among livestock enterprises, dairy cattle have recently gained significant importance (Banda, 2011). For quite a long time, dairy farming has been a profitable part of livestock agriculture in Malawi. Many nondairy breeds have been used for milk production (Colleti, 1966). In Malawi, the dairy industry has grown rapidly over the past decade as evidenced by the increase in the number of farmers with interest in dairy production (Banda, 2011). Government and non-governmental organizations (NGOs) have put smallholder dairying as a priority in livestock production (Banda, 2011). There are several reasons why people keep dairy cattle; some will keep dairy cattle for direct economic returns on products such as milk, meat, hides, manure, whereas others keep dairy animals as an investment (Bonnier, 2004).

The dairy industry contributes a significant proportion of the Malawi's livestock sub-sector and agricultural sector. Currently the industry is still in its development phase and undergoing a rapid growth (Iman Development Consultants, 2004). The industry mainly hinges on smallholders with few large-scale farmers. Similar to neighboring countries like Zambia, the dairy industry in Malawi is composed of formal and informal sectors (Valeta, 2004). There are about 4,000 dairy farmers in the formal sector in Malawi, producing at around 6,500 tons of milk in a year (Iman Development Consultants, 2004). The informal sector, which sells its raw milk directly to consumers, is estimated to produce at around 27,000 tons a year, which is around 50 percent of the total milk supply of Malawi including imports (Chitika, 2008).

Livestock production in Malawi, especially dairying, is mainly integrated with crop farming. This livestock system is characterized as a low input-low output, with farmers keeping a

small herd of dairy animals for easy management of which approximately 60 percent are cows and the remainder young stock. The major opportunity for integrating crops with cows is the income from milk sales, which are significantly higher than other livestock products (Banda, 2011).

Small-scale dairy farmers in Malawi are organized in groups called milk-bulking groups (MBGs). These MBGs operate similar to cooperatives in the United States. Previously, the dairy industry had problems with milk marketing; hence the introduction of the smallholder farmers' MBG's (Kategile et al., 1992). The initiation of MBGs has resulted in the Malawi Government delegating some responsibilities to farmers through the MBGs. Functions such as the purchasing of raw milk from farmers, purchase of inputs (drugs, feeds and fertilizers in bulk) for resale to farmers have been transferred to the MBGs. This has created a need for high level leadership skills among farmers. The bulking groups have now formed milk shed-based associations. They are Shire Highlands Milk Producers Association (SHIMPA), Central Region Milk Producers Association (CREMPA) and the Mzuzu Dairy Farmers Association (MDFA), which have merged to form the Milk Producers Association (MPA). The association's objectives are to: develop leadership skills among dairy farmers; represent farmers at various levels; streamline solutions to field problems in dairying; provide communication channels for livestock extension; and secure better bargaining position with suppliers of inputs and milk processors (i.e. buyers) for prices. However, despite having an organized structure for the dairy associations in Malawi and a growing interest in dairying by farmers and other stakeholders, Malawi is still experiencing low milk yields due to lack of training in basic dairy practices.

Background to the Study

The dairy industry in Malawi is characterized by low milk yields, lack of dairy experts to offer extension services, high prevalence of mastitis (udder infection), low mineral

supplementation, insufficient supply of feeds and poorly adapted genetics for milk yield. As a result, there is a milk shortfall of 85,000 metric tons because annual domestic milk production is estimated at 35,000 metric tons while the demand is at 120,000 metric tons per annum (Goyder et al., 2009). Although the milk shortfall is partly met with milk imports from other countries such as South Africa, this state of affairs clearly causes food insecurity and economic loss to Malawi. There are several international non-governmental organizations (NGO) including Land O' Lakes, World Vision International, and Heifer International, that are currently supporting the improvement of dairy production in Malawi. Those NGOs have two main objectives: (1) to increase milk consumption especially for poor families (nutritional improvement) and (2) to increase returns from dairy farming (income generation and poverty alleviation) by increasing the number of dairy animals through donations through the pass-on system. A pass-on system is when a farmer will give a heifer calf to a new farmer when their donated animal gives birth, thus continuing to expand the population of dairy farmers. Additional support for smallholder dairying came from NGOs and Government-sponsored services in areas such as extension, artificial insemination (AI), disease control and agricultural research and the provision of loans to farmers to purchase cows, dairy equipment and fertilizers at the beginning of the dairy operation.

Despite these efforts by the development partners to improve overall milk production, Malawi continues to face challenges such as low milk yield per cow and high mortality rates. Processors indicate that the quality of milk is poor. The bacteriological levels of the raw milk are high and as a result, the milk sours quickly. Low milk quality is attributed to poor hygiene on the part of the cow, the person milking the cow, as well as the equipment being used to milk the cow (Imani Development Consultants, 2004). This development emanates from lack of basic

dairy management skills as the development partners have omitted the provision of husbandry training in their objectives. On the other hand, the Malawi government does not have adequate dairy experts to complement the development partners' efforts from the training perspective.

Commercial milk production in Malawi started as a result of an increasing demand for liquid milk in the southern region of the country, with Blantyre as the major commercial town in that region. The commercial farms marketed the milk directly to consumers. In 1979, the Malawi Government and the Canadian Government, through the Canadian International Development Agency (CIDA) approved a dairy development project: the Malawi Canada Dairy Development Project (MCDDP). Consequently, over a period of 5 years, a foundation stock of 400 Canadian Holstein-Friesian heifers were imported to the 5500 hectare Ndata Farm in the Southern region of Malawi and the 745 hectare Katete Dairy Farm in the central region. In 1988, the project was combined with Malawi Milk Marketing (MMM) to form the Malawi Dairy Industries Corporation (MDIC) a statutory organization involved in producing, processing, and marketing of milk and milk products (Chagunda, 2004).

Malawi, which is experiencing a growing interest in milk production and processing, has processing plants that still depend on imported commodities for recombination and reconstitution. For example, one of Malawi's dairy processing plants depends on milk powder imports to satisfy 75 percent of its demand (Kamwembe, undated). This suggests that there is a ready market for all the milk and milk products that can be produced by local farmers (Kamwembe, undated).

CISANET (2009) observes three main problems in marketing milk which, if overcome can improve the returns of dairy farmers. These problems are: (1) low production capacity, (2) low level of investment and (3) poor coordination of any system for milk marketing which is neither

well detailed nor responsive enough to avoid problems in the sector. For example, the production levels of milk in the bulking groups do not match with milk collection, showing that farmers' production of milk does not tally with what the processors can collect (CISANET, 2009). This problem has been cited as one of the factors that lead to milk souring in the cooling centers. The level of investment and investment management in the Malawi dairy industry has proved to be a challenge for some MBGs. Some do not want to take the risk of managing cooling tanks and the associated maintenance costs (CISANET, 2009). This results in a significant volume of raw milk being spoiled due to poor storage after harvest and collection.

A rapid growth in demand for milk and milk products presents great potential for the development of the dairy sector, and hence increased the need for processing to cater for the ever growing urban and suburban consumer preferences (Kamwembe, undated). With a growing demand for dairy products, Malawi is presented with a challenge and an opportunity for developing the dairy sector. There is a great need to develop the dairy sector both in the urban and rural areas. To promote general economic development, more emphasis should be put on enhancing rural dairy development with an objective to improve food security and to achieve sustainable agricultural development (Kamwembe, undated). Due to lack of basic dairy management skills by the farmers, hundreds of liters of milk are wasted at the farm level, at cooling facilities, and at milk processing plants (Zvomuya, 2007). This is a very disturbing development considering that the average milk yield per cow among small-scale dairy farmers is already quite low. The problem of low productivity is compounded by a lack of trained Dairy Extension agents to provide dairy farmers with requisite training in dairy management. In addition, small-scale dairy farmers experience low raw milk prices, unreliable raw milk collection by milk processors, lack of AI equipment, transportation issues for AI technicians, and

low competency of AI technicians (Banda, 2011). These challenges are further compounded by inadequate knowledge of animal husbandry by livestock extension workers (Banda, 2011). Banda (2011) contends that smallholder dairying in Malawi has the potential for enhancement through training farmers in proper dairy management skills. The use of model farmers to support dairy extension workers is an opportunity to complement extension workers with the help of regular follow-ups and refresher courses in place. Because of a lack of well-trained extension workers to equip farmers with skills in milking practices, animal nutrition and disease control, dairy farmers in Malawi do not realize the best out of their dairy animals.

Problem Statement

Dairy farmers in Malawi are unable to realize full potential from their dairy business due to lack of dairy management skills. The Department of Animal Health and Livestock Development, which falls under the Ministry of Agriculture and Irrigation, does not have the capacity to offer dairy management training because of a lack of dairy management experts and milk associations suffer from a similar lack of expertise. On the other hand, development partners that support Malawi's dairy industry have not emphasized dairy management training in their aid programs. As a result, the dairy industry faces problems of low milk yield per cow, high prevalence of mastitis, low mineral supplementation, insufficient feed supply and poor animal welfare. These limitations are barriers to Malawi in meeting its milk demand and result in an annual shortfall estimated at 85,000 metric tons (Goyder et al., 2009). Although the shortfall is partly being met with milk imports from other countries such as South Africa, the low domestic milk output is one of the causes of food insecurity and economic loss in Malawi.

Significance of the Study

The results of this study will help the Milk Producers Association (MPA) and its affiliates (CREMPA, MDFA and SHIMPA) as it will provide the much needed dairy management training

material for use by small scale dairy farmers and dairy extension agents. The dairy management skills that will be acquired following the use of this training material will effectively lead to the improvement of milk yield, milk quality, animal health and animal welfare.

Research Objectives

Main Objective

The overall objective of the research is to assess the impact of training small-scale dairy farmers to increase milk yields and improve milk quality, animal health and animal welfare by training them in proper dairy management.

Specific Objectives

In order to achieve the overall aim outlined above, the following specific objectives will be pursued:

- To investigate the availability of feed and water to dairy cows on small-scale dairy farms in Malawi
- To investigate the accessibility of feed and water by dairy cows on small-scale dairy farms in Malawi
- To identify and correct shortfalls in small-scale dairy farmers' milking practices in Malawi
- To asses and correct animal welfare shortfalls among small-scale dairy farmers in Malawi

CHAPTER 2
LITERATURE REVIEW

Adoption of Innovation

Rogers (2003) observes that getting an innovation adopted, even if it has great advantages, is in most cases difficult. Rogers (2003) defines diffusion of innovation as the process by which an innovation is communicated through certain channels over time among the members of a social system. There are four main elements in the diffusion of new ideas, practices or objects as follows: (1) an innovation (2) communication channels (3) time and (4) social system. Shahin (2004) reveals that one of the obstacles to fostering agricultural output in developing countries is the lack of effective extension education. Shahin (2004) observes that agricultural extension is a prerequisite to farmers' adoption of improved technology. He recommends that for effective application of improved farm technology in developing countries, good agricultural extension and advisory services need to be provided on a sustained basis. However, Shahin (2004), observes two barriers to technology adoption:- i) inability to adopt and ii) unwillingness to adopt.

There are factors that contribute the inability to adopt technology such as lack or scarcity of information; high costs of obtaining information; complexity of the system; technology expense; excessive labor requirements and planning; limited availability and accessibility of supporting resources; inadequate managerial skill; and lastly little or no control over the adoption decision. In contrast, Shahin (2004) gives unwillingness to adopt as another barrier to technology adoption. Shahin (2004) provides the following factors as attributes to the unwillingness to adopt:-information conflicts or inconsistency; poor applicability and relevance of information; conflicts between current production goals and the new technology; ignorance on the part of the farmer or promoter of the technology; inappropriate for the physical setting; increased risk of negative outcomes; and belief in traditional practices.

The adoption process tends to have five stages and they are as follows:

I. Awareness stage: The individual hears about the existence of the new idea for the first time but lacks information about it.

II. Interest stage: Out of curiosity and interest, the individual tries to gather more information about the idea.

III. Evaluation stage: The individual makes a mental judgment taking into consideration both the merits of the new idea and his existing situation and condition. Such an evaluation ends normally in a decision either to try the new idea on a small scale or to reject it.

IV. Trial Stage: Trial means implementation of the new idea or innovation on a small scale. For example the farmer who normally cultivates five hectares of particular crop might try to cultivate only one half hectare of a new variety of the crop.

V. Adoption stage: After the idea is examined, and its feasibility is tested, the farmer or the individual will try to implement such an idea on a full scale. Implementation on a full scale is conceptualized as adoption (Shahin, 2004).

An Innovation

Rodgers (2003) defines an innovation as an idea, practice or object that is perceived new by an individual or other unit of adoption. Damanpour (1991) concurs with Rodgers (2003) by defining innovation as any idea, practice, or object that the adopting individual or organization regards as new. Damanpour (1991) however, argues that newness of an idea, practice or objects, need not be limited to new knowledge. He contends that from such a perspective, the newness attached to an innovation remains a matter of perception and as such being first to adopt does not matter. He reasons that an innovation can be an idea, practice or object that one has heard of but has not yet made up his or her mind to reject or adopt. Shahin (2004), citing Dasgupta (1989) and

Rogers (1995) agrees with the above definition of innovation and further provides five characteristics of innovation as relative advantage, compatibility, complexity, trialability and observability. Rodgers (2003) concurs that characteristics of the innovations, as perceived by the individuals, will determine the rate of adoption. Innovations that are perceived by the adopting unit as having greater relative advantage, compatibility, trialability and observability with less complexity are adopted more rapidly than other innovations.

Kurwijila, (2006) asserts that to improve milk production, there is need for adoption of new skills in barn construction, milking procedures and disease control and detection. This shows that there are different but closely related innovations that collectively support the goal of improved milk quality and quantity. The approach of implementing more than one innovation is called a technology cluster (Rogers, 2003). This is used when one cannot determine an innovation boundary that is to say the innovations are closely interrelated (Rogers, 2003). Dairy management encompasses different aspects that lead to improved production and quality.

Communication Channels

Communicating a new idea for adoption requires a proper communication channel. The type of communication channel used depends on the innovation being introduced and the background of the individuals or unit of adoption of the innovation (Rogers, 2003). A communication channel is the means whereby messages get from one individual to another. There are three main types of communication channels: mass media, interactive (i.e. internet) and interpersonal (Rogers, 2003). Monge et al. (2008), assert that access to information about innovation is a key factor affecting the dynamics of the adoption process. They further indicate that farmers can access information through various sources and mechanisms such as visits from extension agents, participation in training activities and exposure to mass media.

The mass media approach is most effective in creating knowledge of innovations whereas interpersonal channels are more effective in informing and changing attitudes towards a new idea (Rogers, 2003). There is a need for persuasion for one to adopt an innovation. Interpersonal communication channel will provide an opportunity to persuade the individuals considering adoption of the innovation. Interpersonal communication channels involve a face-to-face exchange of information/ideas between two or more individuals (Rogers, 2003).

King and Rollins (1999) point out that many times, farmers' experiences and knowledge are expanded due to interactions with other farmers. They contend that farmers prefer their own experience and knowledge. As a result, improving communication networks among and between farmers can have significant impact on enhancing effectiveness of the adoption decision process.

Time

Time is another element of diffusion; this encompasses (1) the innovation-diffusion process, (2) innovativeness, and (3) the rate of adoption of an innovation (Rogers, 2003). An innovation-diffusion process is the process through which an individual or unit of adoption passes from first knowledge of innovation to rejection or adoption of the innovation. There are five steps that are expected to occur in a time-ordered sequence in the innovation-decision process, and these are; (1) knowledge of the innovation, (2) persuasion to try the innovation, (3) decision to adopt or reject the innovation, (4) implementation of the innovation and (5) confirmation of the decision made (Rogers, 2003).

An innovation is adopted at different times by the adopting unit; this is called the innovativeness of an individual. It refers to the degree to which an individual or unit of adoption is relatively earlier in adopting new ideas than the other members of the social system (Rogers, 2003). The adoption unit is classified into the adopter categories based on their innovativeness

and these adopter categories are; (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards (Rogers, 2003).

Shahin (2004) explains that adoption of new technology is not an instantaneous act, but it is a complex process that takes time. Norton and Frank (1987) share the same view that no matter how advantageous an innovation is, newer innovations are not adopted by all potential adopters immediately. Shahin (2004) adds that adoption is a mental process whereby an adopting unit ought to pass from first hearing of technology packages to form an attitude, either favorable or unfavorable, and then to a decision to adopt or reject up to the implementation decision.

Social System

Social system refers to the system within which the adoption unit is operating. In the social system, there are opinion leaders who act as models of the other members of the adoption unit. An opinion leader is an individual who is able to influence informally other individuals' attitudes (Rogers, 2003).

The social system also has its rules and regulations, which exert influence on the adoption decision of the members. This means that in a social system there are optional innovation decisions made by individual members, but these individual decisions are still influenced by the norms of the social system.

The pattern within which information of an innovation flows, is received and transmitted by individuals is related to their social system that is the network of their contacts and their status within the network. Development economists often take the view that social interaction determines, to a certain degree, the adoption of an innovation as it provides access to information, inputs, infrastructures and institutions (Monge et al., 2008).

Shahin (2004) states that the social system influences the adoption rate of an innovation, through its social and cultural norms. An innovation that is perceived not compatible with the

social system cultural norms and beliefs will not be adopted in that social system. There is great need to assess any innovation to see if it is in line with the norms, values and beliefs of the social system before the innovation is introduced in order to have effective adoption.

In the subsequent subsection, training will be discussed as it is directly linked to dairy farmers' ability to accept and put into practice new ideas and skills gained through training to enhance dairy productivity and milk quality. Winch (1995) criticizes the relative neglect of training by educators. Indeed, Winch (1995) recognizes that training is fundamental to many forms of human learning including early moral learning. Winch (1995) further observes that training takes different forms at different stages of human development.

Training

Noe (1986) defines training as a planned learning experience intended to bring about permanent change in an individual's knowledge, attitudes or skills. Knowledge, skills and competencies of all men and women have become the cornerstone of personal growth and employability, enterprise competitiveness, and society's economic and social sustainability (ILO, 1997). William and Thayer (1961) emphasize the role of training as a tool of management along with the other techniques which management has found necessary to use in order to achieve organizational goals. Kilpatrick (2000) contends that training events offer opportunities for interaction between participants and with expert trainers. This interaction assists in altering values and attitudes toward new practices. In the case of farmers, training enhances their ability and willingness to make successful changes to their management practices. A training program is therefore one of the several factors which influence participants to make changes in their practices. However, Koper (2005) contends that training needs to be done in an effective, efficient and attractive way and that there is no straightforward way of doing this. It differs from

training to training depending on the situation of the type of training and the participants. There is a great need to design a training program based on the specific audience so that it is effective.

There is abundant empirical evidence that shows that farmers get involved in diverse learning process either by experimenting in their own plots before full adoption, or by actively or passively taking advantage of the experiences and performance of the neighbors, friends and relatives who have experimented with the innovation (Monge et al., 2008). They acknowledge learning as another key source of information for farmers and one that is fundamental for promoting adoption under uncertain conditions because it helps to modify the perceived risk of innovation.

Concern-Based Adoption Model

The Concern-Based Adoption Model (CBAM; Figure 2-1) is a model for change in individuals. It acknowledges that learning brings change and that supporting people is critical for learning to bring change. CBAM facilitates change or adoption and provides diagnostic means of measuring implementation of an innovation in an organization. The model is very complex and involves interaction between the environment, the user system culture, resource system, change facilitator team, interventions, users and non-users and three diagnostic measures viz: innovation configuration, level of use and stages of concern.

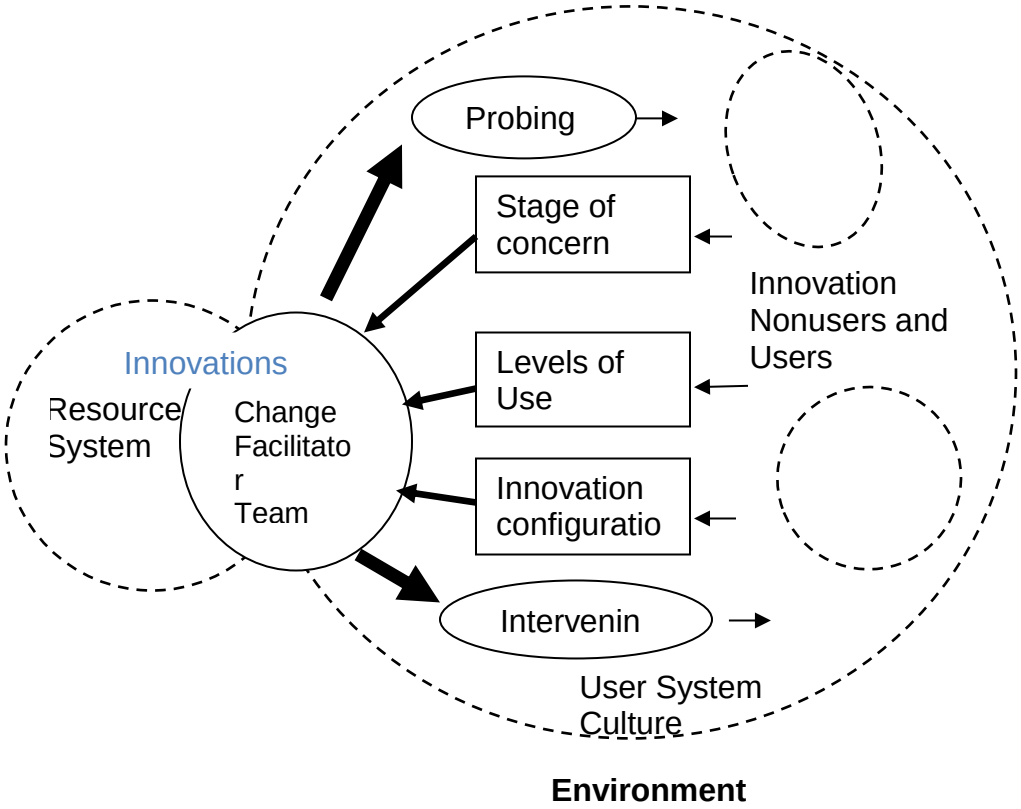


Figure 2-1. The Concerns-Based Adoption Model (CBAM)

Environment

The environment in this case would refer to all the external forces that affect the MBGs. The CBAM states clearly that external forces like feed price, transportation costs, disease out-break and other external forces that greatly affect the operation of the farm can change with time.

User System Culture

The CBAM views the adoption process as a user system composed of individuals. In this case, the MBG is the user system composed of small-scale dairy farmers. In combination, these small-scale dairy farmers represent the MBG and its function. Culture has an influence on individuals within the MBGs and their work. There are various interactions and combinations of individuals that occur within the MBG that affect decision-making among the members.

Resource System

The resource system in the CBAM is defined as any external source of resources. In the case of this study, the resource system includes; materials that were used for training, funds for training, support staff and facilities.

Change Facilitator Team

The change facilitator team in the CBAM provides leadership for the change. The change facilitator team acts as an agent to interact between the resource system and the user culture. The change facilitator team is composed of opinion leaders, extension agents, and experts or ordinary members. Anyone, regardless of position, has the position to play a role as a change facilitator. In terms of the MBG scenario, the change facilitator team is composed of an extension agent, trainer (who is from the resource system) and opinion leaders (from the MBG).

Interventions

Intervention refers to any action or event carried out by the change facilitator team that influence the individual's adoption process. Interventions in terms of the dairy management training ranged from classroom lectures to on farm training and demonstrations.

Mushroom interventions

During interventions there are new interventions that evolve at some point in the change process and these are referred to as "mushroom interventions". These new interventions are developed by individuals depending on their interpretation of actions and events. Mushroom interventions can either be good or bad; meaning that there is need for an expert to sort out good and bad interventions.

Diagnostic Instruments

The Innovation Configuration describes what the change should look like when it is properly implemented. This falls in line with the specific objectives of the program. The levels of

use looks at individual behaviors associated with change. It looks if the participants are really using the adoption and if so, how are they using it. On the stages of concern, it deals with feelings and perceptions of participants towards the innovation. This gives a progression of concerns which people move through as they implement an innovation.

Dairying

Dairy cattle are raised all over the world. Milking dairy cows can be very profitable, especially close to urban areas (Bonnier, 2004). However, management of dairy cattle is not as easy as taking care of goats and sheep. Sheep and goats are easier to feed and the economic risks are less. The biggest risk in dairy production in small-holder systems is loss of the animal, as a one cow represents a substantial investment that can be lost through careless management. The other risk is low productivity due to poor management, which can also lead to losses (Bonnier, 2004).

There are three dairy farming systems and they are classified as; grazing-system, grazing with supplementary feeding system and zero grazing system (Bonnier, 2004). These systems are defined according to the way the animal is fed (Bonnier, 2004). The system of farming is a very important aspect of dairying as it determines the possibilities and constraints in a system, as to how much labor to be deployed and the production potential of the farm.

In the case of the grazing system, animals are left on free range to find and harvest feed. In this system, the animals feed on natural or improved pastures. The grazing system is most ideal when one has enough land and but little time to devote to management of feed resources. For example, grazed animals can be easily released from a barn or holding area onto a pasture or paddock and browse to feed themselves. Consistent with lower inputs, this type of system has a fairly low level of production (Bonnier, 2004).

On grazing with supplementary feeding, the cows are left to feed in the paddock but with supplemental provision of fodder crops and/or concentrates. In most farms supplemental feeding is done when the animals are brought home from the pasture. The animals can be given the supplements when they are being milked, during the night or during rains. This system is prominent when supplements are not too expensive and the farmer has enough land (Bonnier, 2004).

A zero grazing system is the approach whereby animals are kept in stalls or a barn at all times. In this system, the supplements, forages and water are delivered to the animals in the barns. This system is more labor intensive but does not require as large a piece of land. The zero grazing system realizes the highest level of productivity but also requires the largest capital investment (Bonnier, 2004).

Dairy Management

Under good dairy farming practice, regardless if it is grazing, grazing with supplementary feeding or zero grazing, milk that is produced is of good quality and safe for consumers. This is achieved by milking animals that are healthy, practicing good milking hygiene, proper animal feeding, provision of adequate and clean water, animal welfare and good environment (FAO and IDF, 2011). These important dairy management practices are discussed in detail below.

Animal Health

The greatest question on animal health is '*how can one keep his/her cow healthy?*' The first step is by preventing entry of disease onto the farm. This can be achieved by having secure boundaries or fences to limit access of animals and people to the facility. Prevention of disease entry onto the farm can also be achieved by avoiding direct contact of visitors with the animals. Use of clean equipment from reliable sources and using effective disinfectants to clean and sanitize equipment, boots, and other facilities is very crucial in preventing disease entry into the

barn (SAI Platform Dairy Working Group, 2009). The other measure that can be put in place to prevent disease entry onto the farm is to have an effective herd health and disease management program. Some of the ways of achieving this control are by regularly checking for signs of disease and quick separation of animals with contagious diseases from herd mates and treatment when necessary.

Regular observation is important for health management of cattle. Observation of behavior can inform the herdsman that an animal is sick. For example, observation of the cow's attitude will help identify sickness, i.e. '*does the cow carry its head, ears, body and tail as usual?'*, if there is a change, it suggests that there is something wrong with the cow (Bonnier, 2004). Poor body condition is a commonly used sign of an unhealthy cow. Observing how well fleshed the animal is can tell one whether the cow is healthy or not. Eating and drinking behavior also helps in disease detection in cows, i.e. *'does the cow eat, drink and ruminate properly?'*, *'does it urinate and defecate as usual?'* alterations suggest a problem with digestion (Bonnier, 2004). With regard to mammary health, the use of California Mastitis Test (CMT) for regular surveillance of mammary infection is of great help to detect and limit the impact of clinical mastitis.

The use of all chemicals and veterinary medicines as prescribed to prevent occurrence of chemical residuals in the milk is another measure of good animal health management. All compounds should be used according to label directions and the withholding periods observed. Care should be used in storage of chemicals and medicines in a secure manner and expiration dates should be respected (SAI Platform Dairy Working Group, 2009). These practices limit the potential for drug or chemical residues in milk.

Milking Hygiene

The Food and Agriculture Organization (FAO; 2011) and the International Dairy Federation (IDF; 2011) state that milking is the most important single activity on the dairy farm. Both organizations contend that good milk is characterized by low bacterial content with no chemical or physical contamination. Good milking management ensures that there is no contamination during milking and that milking is done quickly and effectively while assuring the health of the cows and quality of the milk (FAO and IDF, 2011). Milking hygiene is described under the following headings; a) ensure milking routine does not injure cows or introduce contaminants in the milk, b) ensure milking is carried out under hygienic conditions and c) ensure milk is handled properly after milking (FAO and IDF, 2011).

It is very important to milk a clean cow to avoid contaminating the milk with bacteria from the udder and the udder flanks. Removing long hair from the udder can help to keep the udder clean. Milk secreted into an uninfected cow's udder is sterile. This clean milk can get contaminated during milking due to the dirt on the udder and the flanks (Kurwijila, 2006). Provision of a clean housing area will limit exterior dirt on the animal and improve milk quality.

There is need to clean the teats and apply disinfectants before milking. If the udder is generally clean, then surface dirt or debris can simply be brushed away without use of water, but the teats should be dipped with a disinfectant. If the udder is dirty, then warm water can be used to wash the udder. Dry the cleaned teats and udder with a clean towel, using one clean towel per cow. It is of great importance to always milk a clean, dry udder to minimize milk contamination and transmission of mastitis due to udder contamination (Kurwijila, 2006). The process of cleaning and applying disinfectant to the udder will also help in stimulation of milk ejection in addition to preventing milk contamination (Johnson, 2000).

There are some important steps that need to be practiced on a daily basis for good quality milk production (Kurwijila, 2006). Some of the steps that need to be followed are:

I. Wash the udder with warm water and a clean towel before milking, this helps in reducing milk contamination and also stimulates milk ejection. If the udder is generally free of dirt then water is not necessary although physical removal of any dirt is recommended.

II. Remove the foremilk into a black strip cup, this helps to check for abnormalities in the milk like discoloration, clots or blood. Discard the foremilk.

III. Make sure you complete milking within 5 minutes from cleaning the udder, after 5 minutes, the stimulatory effect of release of oxytocin wanes.

IV. Dip teats in a post-milking disinfectant as this prevents infection of the udder.

V. After use, milking utensils must be cleaned with cold water first and then hot water with disinfectants (i.e. soap), rinsed and dried in the sun on a drying rack. Non-perfumed soap is preferred.

VI. Milkers must be healthy and not suffering from contagious diseases.

VII. Healthy cows should be milked first while cows suffering from mastitis should be milked last and milk from the infected quarter(s) should be discarded.

VIII. Milk should be cooled immediately after milking.

The other aspect on milking hygiene is discarding milk from sick or treated animals. Cows suffering from mastitis and on antibiotics should be milked last and their milk discarded (Kurwijila, 2006). This milk is unfit for human consumption (FAO and IDF, 2011).

With poor hygiene, the percentage of cows with mastitis is higher as compared with cows under good hygiene management. Mastitic milk has more whey protein, less casein and less water-soluble vitamins. It is also more alkaline, has a higher chloride content than the normal milk and it tastes salty. Milk from cows on antibiotic treatment should not be sold until the specified withdrawal period has elapsed. Most antibiotics circulate in the blood and are secreted in the milk for up to 72 hours whereas long acting antibiotics remain in the blood for extended periods.

Hygiene of the person milking the cow is very important when it comes to udder and milk contamination. The person doing the milking can be a source of bacteria that ends up contaminating the sterile milk being harvested. This is particularly a problem in areas where milking is done by hand, a practice prevalent in most developing countries like Malawi. The person milking the cow should not be suffering from any communicable disease or have open sores or abscesses on any of his or her uncovered body. Dipping hands in milk during milking, coughing or sneezing over milk or milk containers is to be avoided. There is also need to clean hands between milking of two cows to avoid transferring bacteria from one cows udder to another (Kurwijila, 2006).

In production of clean milk of good bacteriological quality, the cleanliness and sterility of milking utensils are the most important factors-even more so than cooling (Glegg, undated). Milking vessels must be cleaned every time after use. Proper cleaning of the utensils is of great importance. The proper cleaning of utensils starts with cold clean water to rinse the milking utensils. This eases the removal of milk residues on the surface of the vessels. Rinsing is followed by sanitization with boiled water with soap or just soap with and water. Non-perfumed soap is recommended for this exercise. After rinsing the soap from the vessel, the last step in

cleaning utensils is to dry them immediately, in the sun if possible. The utensils must always be stored upside down and off the ground when they are not in use (Kurwijila, 2006).

The other source of milk contamination is the use of inappropriate utensils. These are milking, storage or transportation equipment that cannot easily be cleaned or sanitized. These include use of jerry cans and buckets made of non-food grade plastic. Inappropriate equipment can harbor microbes in the cracks or crevices that develop as a result of its continuous usage. Metal containers such as aluminum and stainless steel cans are recommended under the code of hygiene practices.

Milk Storage After Milking

Milk will quickly become spoiled if it is stored for long period at high temperatures prevalent in tropical and subtropical countries. This is because of the presence of lactic acid bacteria and other contaminating microorganisms. It is very important to cool and store milk at temperatures between 2 and 4 ^{o}C as quickly as practically possible. During the first 2-3 hours after milking, the milk is protected from spoilage by the inherent natural antibacterial substances that inhibit the growth of spoilage bacteria. If the milk is not cooled for more than 2-3 hours, the natural antibacterial substances in the milk denature, allowing the bacteria in the milk to multiply rapidly, hence converting milk lactose into lactic acid and causing the milk to start souring. This means that high storage temperatures result in faster microbial growth and hence more rapid milk spoilage (Kurwijila, 2006).

There are simple means of cooling milk such that the antibacterial substances are not denatured to preserve the milk quality. These means of cooling include immersing the milk cans in ice blocks or cold water in a trough in cases where there is no domestic refrigerator. Cooling milk to less than 10 °C may prevent milk spoilage for up to 3 days. If milk is kept chilled at 4 °C

for more than 3 days, the cold-tolerant bacteria will multiply and produce lipase and protease enzymes that break down milk fat and proteins respectively (Kurwijila, 2006).

A good storage facility should be located away from the milking area. The storage area should be clean and easy to clean and clear of chemical substances or accumulated rubbish or any feedstuffs to avoid milk contamination. It should also have hand washing and drying facilities (FAO and IDF, 2011).

Feeding and Water

Bonnier (2004) advises that if milk production is the aim, special attention should be given to feeding. Dairy animals just like any other animals need to be fed properly to maintain health. The FAO and IDF guidelines (2011) are also emphatic on the need for dairy farmers to ensure that the nutritional needs of the animals are met. Bonnier (2004) reveals that feed contains energy, protein and water that are essential for animal growth, production and health. He also categorizes parts of feed as water and non-water-part, and defines the non-water portion as dry matter (DM). Bonnier (2004) further observes that the maintenance requirement for a typical indigenous cow weighing approximately 350 kg is 7 kg DM a day whereas a crossbreed weighing about 500 kg requires 10 kg DM a day. Thus, approximately 35 kg of grass at 20% DM, is required to provide the 7 kg of DM to meet the daily maintenance requirement for indigenous breeds. The water requirement for the indigenous breed is 45 liters (L) a day and 35kg of grass provides 28 L of water. In contrast, a crossbreed weighing 500 kg will require 50 kg of grass a day to provide 10kg of DM and will need an extra 20 L of water to meet the maintenance requirement (Bonnier, 2004). The amount of DM required by a milking cow is 2.53% of its body weight; this is more than the maintenance requirement. This means that a milking cow with a body weight of 350 kg will require 9 to 10.5 kg of DM and the one with the

body weight of 500 kg will require 12.5 to 15 kg of DM, along with additional fluid water to meet their needs (Bonnier, 2004).

Dairy feeds can further be divided into two groups; roughages and concentrates (Bonnier, 2004). There is need to always meet the nutrient requirements of the animal whether they are in milking, dry or in growing stage of their life cycle. Quality of roughages is of great importance as low quality feed has little protein and digestible energy compared with high quality roughages. Low quality roughages will normally fail to meet even the maintenance requirement for nutrients, and hence a need for supplementation is obvious (Bonnier, 2004).

The amount of water, additional to that from feed, a lactating cow needs depends on body size and milk yield, quantity of DM consumed, temperature and relative humidity of the environment, quality of the water and amount of water in the feed (Looper, 2007). There are five properties to consider when assessing water quality for both livestock and human consumption. These are organoleptic properties, physiochemical properties, and the presence of toxic compounds i.e. heavy metals, toxic minerals, excess minerals or compounds i.e. nitrate, sodium sulfates, and iron. The presence of bacteria and algae also need to be considered and avoided as much as possible. Organoleptic properties include odor and taste whereas physiochemical properties include pH, total dissolved solids, total oxygen and hardness. The most common water quality problems affecting livestock production include high concentrations of minerals, high nitrogen content, bacterial contamination, heavy growth of blue-green algae and accidental contamination by pesticides, petroleum or fertilizer products (Looper, 2007).

The amount of water is also of great importance to milk production as milk is directly made from water consumed. There is a positive correlation of 0.94 for water intake and milk

production and a positive correlation of 0.96 for water intake and DM consumed (Dado, 1997). Water intake increases significantly as environmental temperatures increase (Linn, 1997).

Animal Welfare

Welfare refers to the well-being of the animal in the context of the farmed environment. A cows well-being is of great importance to milk yield and health. A cow should be provided certain freedoms for their well-being. According to the FAO and IDF, there are five freedoms that a cow or any animal needs to be kept under: freedom of thirst, hunger and malnutrition, freedom from discomfort, freedom from pain, injury and disease, freedom from fear and freedom to engage in relatively normal patterns of animal behavior (FAO and IDF, 2011).

Metcalfe et al., (1992) and Rulquin and Caudal, (1992) suggest that cows make more milk when they are lying down as blood flow through the external pudic artery increases by around 24-28% when lying compared to when they are standing. Failure to achieve adequate rest due to poorly designed barns as is the case with many small-scale dairy farmers in Malawi can also increase lameness (Cook and Nordlund, 2004).

Cook and Nordlund (2004) emphasize the requirement for resting/lying as a threshold event for all cows, regardless of yield, by giving the required minimum period of 12 hours per day in a free stall environment. The following factors are some of the factors that challenge the cow's time budget and impact the time available for rest on a daily basis:

- Prolonged time spent milking
- Competition for stalls due to overstocking
- Excessive time spent in lock-ups
- Poor stall design
- Inadequate heat abatement

In order to understand the impact of poor cow comfort on dairy cow health and productivity an examination of potential impact of each of the challenges cited above is necessary.

Prolonged time spent milking. For increased milk yield, there is need for the cow to eat and adequately rest. There is a positive correlation between the time that a cow spends lying down and milk yield. If people milking cows are slow or inefficient, the milking process takes too long, thereby denying the cows enough time to rest. Similarly, the number of milkings each day will also tend to reduce the time for resting and milk yield. In some barn designs, the cows are required to move to milking parlors each time they are to be milked. This effectively contributes the reduction of resting time as time is wasted through such movements.

Competition for stalls due to overstocking. Friend et al., (1977) and Fregonesi et al., (2007) assert that overstocking decreases lying time and consequently milk yield. Stall design should be such that will meet the requirement of each cow to obtain at least 12 hours per day of rest. Designs that fail to provide for the movements of lying and rising, adequate resting space, and a comfortable surface will tend to reduce lying behavior to less than 10 hours per day.

Inadequate heat stress abatement. Thermal comfort and good air quality are crucial for the health and well-being of the dairy cow. In general, the dairy cow is far more tolerant of cold than of high ambient temperatures. Indeed in high temperatures, mature Holstein cattle seek shade and stand rather than lie down. The more time the cows spend standing because of high temperatures, the less the milk it will produce.

Environment

Milk production should be managed in balance with the local environment surrounding the farm (FAO and IDF, 2011). There is need to ensure that wastes are stored to minimize the risk of environmental pollution so as to prevent diseases and milk contamination. There are also variations in milk yield from farm to farm within Malawi, for example three large scale farms in the central and southern region reported different milk yields despite the similarities in the animals raised in these farms (Chagunda, 2000). A possible explanation for the variation in milk

yield on animals of the same breeds is the sizeable influence of environmental conditions, related to management and nutrition, on milk yield. Environmental influences may limit the expression of genetic potential of superior cows, hence restricting differences in yield due to genetic value among animals (Carabano et al. 1989).

CHAPTER 4
MATERIALS AND METHODS

Study Population and Setting

The study was conducted in the Lilongwe milk shed area, in central Malawi and the Mzuzu milk shed area in northern Malawi. The study targeted small scale dairy farmers in MBGs. MBGs fall under the auspices of CREMPA, SHIMPA and MDFA which are dairy farmers regional groupings and makeup the Malawi Milk Producers Association (MMPA). It specifically targeted small scale dairy farmers, and dairy extension workers from the targeted MBGs. The setting was ideal because Lilongwe and Mzuzu are among the districts with large numbers of dairy animals.

Sample Size and Sampling Method

Six MBGs were selected basing on their level of management and production: Machite and Likuni Milk bulking groups in the Lilongwe milk shed area were selected in central Malawi, whereas Lusangazi, Doloba, Sonda and Kabvuzi MBGs were selected in the Mzuzu milk shed area in Northern Malawi. 3 MBGs from the selected 6 MBGs were trained in good dairy management and these were Machite in the central region, and Lusangazi and Doloba in Northern Region. The remaining MBGs, Likuni, Sonda and Kabvuzi, were left untrained throughout the study period. All farmers from the trained MBGs (Machite, Lusangazi and Doloba) were trained in good dairy management for 3 days at their respective cooling centers. It was noted during the baseline survey that most farmers in these MBGs had Holstein-Friesian breed cattle. For this reason, a purposive sampling method was used in the study to come up with a sample of 15 farmers from each MBG from all the 6 MBGs, this gave a total sample of 90 dairy farmers. Only Holstein-Friesian farmers were selected for study to avoid breed effect on

the results. Farmers who had their cow in milking and of the same management levels were selected.

The study employed an exploratory research method (Churchill and Iacobucci, 2002). Farmers from MBGs were selected for the study. Three MBGs were trained in good dairy management skills and the farmers in remaining three MBGs were not trained. The trained MBGs were the treatments while the untrained MBGs were the controls in the study. Before commencement of the trainings a survey was carried out in all the MBGs. This was done to assess the current situation at that time in terms of milk yields, milk rejections at the cooling centers and general management practices in these MBGs.

Training in the selected MBGs commenced soon after the survey was carried out. Farmers were trained in good dairy management in their respective collection centers for 3 consecutive days followed by on farm trainings. Machite was the first MBG to be trained from 1 to 3 December 2011, followed by Lusangazi from 19 to 21 December 2011 and lastly Doloba from 5 to 7 January 2012. All the MBG members were encouraged to attend the training. The on farm training was for 2 days on selected farms within the MBG to demonstrate the good dairy practices. The classroom lectures in the MBG collection centers were conducted by the researcher (the researcher was the lead trainer) with the help of the local Government extension agents using the module “Basic Dairy Management Skills” that was developed for the study. Government extension agents and MBG personnel were used to advertise the training to ensure good attendance.

Extension agents from all the trained MBGs were first trained in Dairy Management skills before training the farmers. The extension agents were trained for two days using the same training module “Basic Dairy Management Skills’’.

After training the farmers a support and monitoring plan for 3 months was developed in each MBGs to make sure that the farmers are practicing the trained practices. Handouts and posters were developed and distributed to all the trained farmers to remind them of what they are supposed to do every day. The researchers/trainers and extension agent visits were also planned in a way that a farmer should be visited either by the researcher or the extension agent at least once a week. This was designed to make sure that the farmers are provided with support. Trainers or extension agents were there to guide where the farmers were missing it in terms of dairy management practices.

On completion of the study, another survey was carried to in both the trained and the untrained MBGs to assess if there has been any effect of the training provided. The study took 4 months.

Data Collection Method

The data collection method of this study was by interviews using a questionnaire. Data was collected directly by the interviewers. Six enumerators were specifically trained to collect data for this study. This approach facilitated accuracy and validity of data obtained from respondents.

A questionnaire was used as a data collection tool. Saunders (2000) defines a questionnaire as a general term to include all techniques of data collection in which each person is asked to respond to the same set of questions in a predetermined order.

In this study, two questionnaires through the use of enumerators were submitted to respondents: one was submitted before training to assess the management levels of the farmers and record their milk yield and quality whereas the second questionnaire was submitted after training to evaluate the impact of the training. Each questionnaire had 44 questions with sections that covered: personal information of the respondent, animal nutrition and management, basic milking skills, milk marketing, housing, and disease management and control. The

questionnaires used in this study were a combination of open-ended and closed ended questions. Open-ended questions provided the researcher with the opportunity to probe where the interviewees have to build their answers (Saunders et al., 2000). The closed ended questions were more direct, precise, focused and hence less complex to respondents (Polite and Hungler, 1991). The questions were focused on investigating the day-to-day dairy practices and milk yields. The questionnaires had a section for the enumerators own assessment of the hygiene and availability of water and feed during the visit. Each MBG was assigned one enumerator.

Data Validity

The survey instruments were reviewed by a panel of experts and a pilot survey was done to assess the validity of the questions in the questionnaire. Data collection by the enumerators was closely monitored by the researcher for quality control purposes.

Out of the 45 farmers that were selected and took part in the baseline survey in the untrained MBGs, only 33 farmers were available during the end-line survey giving a 73% response rate. However there was a 100% response rate in the trained MBGs.

Data Analysis

The collected data was grouped, analyzed, interpreted and summarized with the help of the computer packages SAS version 9.0 and SPSS 16.0 to test how much effect training had on farmers' behavior. The SHEWHART procedure of SAS was used to generate box charts. The CATMOD procedure was used to test various binary variables against training to assess which variable is causing the change in farmers' dairy management practices. CATMOD procedure was used because the dependent variables were discrete variable with only two outcomes, mostly 'yes 'or 'no'. SPSS was used to generate the tables for all the descriptive statistics. Significance was tested at the 5% confidence level.

Ethical Considerations

Ethical considerations are important especially in research dealing with personal issues such as personal hygiene because they provide a basis for moral conduct in respect of human dignity, integrity and authority. To ensure that the subjects have ethical protection, subjects participated in the study voluntarily and there was an informed consent to participate in the study. The subjects had a full knowledge and understanding about the research project. All the data collected from subjects was kept very safe to ensure privacy and confidentiality. It was also communicated to the subjects that all questionnaires will be destroyed at the end of the study. The Institutional Review Board 02, of University of Florida approved the protocol used in this study.

CHAPTER 5
RESULTS AND DISCUSSION

Effects of Training on Mastitis Prevalence

Results presented in Table 5-1. show that there was a difference over time in the occurrence of mastitis in both the trained and the untrained MBGs. A key question was put to the farmers before training if they have ever experienced mastitis with their dairy cows regardless of when it was experienced. It was noted in the baseline survey that almost every farmer in all the MBGs had at least once experienced mastitis with his or her cow. During the end-line survey, the same question was put to the same farmers if they had experienced mastitis during the time between the baseline and end-line surveys. When the baseline and end-line survey results were compared, a significant change emerged in the occurrence of mastitis in all the MBGs with p-value of 0.0001. There was no effect of barn cleanliness on mastitis occurrence despite literature citing dirtiness of barns as a possible source of mastitis. Similarly, results of the study also indicated that the MBG where farmers came from had no effect on mastitis. The only variable that was tested to be significant on mastitis occurrence was the time that the baseline survey covered against time that was covered between baseline survey and end-line survey (three months). However the low levels of mastitis occurrence in both the trained and untrained farmers could be attributed to the short time the end-line survey covered. Perhaps if the study duration been longer, results on prevalence of mastitis could have been different from the ones presented in Table 5-1.

No mastitis occurrence was registered during the end-line survey in all the trained MBGs. However all the untrained MBGs registered mastitis cases with 25% occurrence in Kavuzi, 8.3% in Sonda and 14.3% in Likuni. This difference in the prevalence of mastitis between the trained

and untrained MBGs can be attributed to the behavioral change of dairy farmers that took place after undergoing training in barn cleanliness and hygiene practices.

Table 5-1. Occurrence of mastitis in all the MBGs before and after training. Farmers in the MBGs were either trained (n=3) or left untrained (n=3) with regard to good dairy management practices for 4 months.

MBG		Total	Experienced Mastitis	% Experienced	Not experienced Mastitis	% Not Experience
Machite[1]	Baseline	15	7	46.7	8	53.3
	End-line		0	0.0	15	100.0
Likuni[2]	Baseline	14	4	28.6	10	71.4
	End-line		2	14.3	12	85.7
Lusangazi[1]	Baseline	16	4	25.0	12	75.0
	End-line		0	0.0	16	100.0
Sonda[2]	Baseline	12	6	50.0	6	50.0
	End-line		1	8.3	11	91.7
Doloba[1]	Baseline	15	5	33.3	10	66.7
	End-line		0	0.0	15	100.0
Kavuzi[2]	Baseline	8	4	50.0	4	50.0
	End-line		2	25.0	6	75.0

The results also indicate that the change between baseline and end-line surveys in all the MBGs was highly significant (p-value 0.0001). It was observed that there was a decrease of mastitis occurrence in the trained MBGs of 46.7%, 25% and 33.3% in Machite, Lusangazi and Doloba respectively. The same trend was also observed in the untrained MBGs of Likuni, Sonda and Kabvuzi with a decrease of 14.3%, 41.7% and 25% respectively. This response may be explained by the short time that the study covered. The effect could also be attributed to the training that some dairy farmers had received in their MBGs. When all the possible variables are

[1] Trained MBG

[2] Not trained MBG

considered for this reduced occurrence of mastitis in the MBGs, it was only time between baseline and end-line survey that was noted to have a significant impact on mastitis occurrence.

Effects of Training on Barn Cleanliness

Results from the study (Table 5-2.) indicated that there was a positive change (barns were cleaner) in the trained MBGs after receiving training. There was a 46.7% increase in dairy farmers keeping their barns clean in Machite, 37.5% increase in Lusangazi and 33.3% increase in Doloba. However, it was noted that there was a decrease in the percentage of dairy farmers keeping their dairy barns clean in the untrained MBGs. This was attributed to lack of knowledge of having their dairy barns clean, and the impact of clean barns on cow productivity and health. The increased percentage in the number of dairy farmers keeping their dairy barns clean after receiving training on good dairy management is associated with the reported reduction in cases of mastitis in the trained MBGs as compared with the untrained MBGs.

Table 5-2. Effects of training on cleanliness of the barn in all MBGs. Farmers in the MBGs were either trained (n=3) or left untrained (n=3) with regard to good dairy management practices for 4 months.

MBG		Clean	% Clean	Not Clean	% Not Clean
Machite[3]	Baseline	5	33.3	10	66.7
	End-line	12	80.0	3	20.0
Likuni[4]	Baseline	10	71.4	4	28.6
	End-line	8	57.1	6	42.9
Lusangazi[3]	Baseline	8	50.0	8	50.0
	End-line	14	87.5	2	12.5
Sonda[4]	Baseline	7	58.3	5	41.7
	End-line	6	50.0	6	50.0
Doloba[3]	Baseline	9	60.0	6	40.0
	End-line	14	93.3	1	6.7
Kavuzi[4]	Baseline	6	75.0	2	25.0
	End-line	3	37.5	5	62.5

[3] Trained MBG

[4] Not trained MBG

Effect of Training on Milk Rejection at Cooling Centers (Quality)

Results presented in Table 5-3. indicate that there was no milk rejection at the cooling centers in the trained MBGs after the farmers had received training as opposed to the MBGs that did not receive training. There are two basic milk quality tests that take place at the cooling centers before the milk is accepted for sale. A lactometer is used to test for adulteration of milk and an alcohol test for sourness. This ensures that all the milk accepted at the cooling center is of good quality.

Table 5-3. Milk rejections at cooling centers in all the MBGs. Farmers in the MBGs were either trained (n=3) or left untrained (n=3) with regard to good dairy management practices for 4 months.

		Yes reason for rejection		% Yes	No	% No
		Milk adulteration	Milk souring			
Machite[5]	Baseline	3	10	86.7	2	13.3
	End-line	0	0	0.0	15	100
Likuni[6]	Baseline	5	6	78.6	3	21.4
	End-line	0	4	28.6	10	71.4
Lusangazi[5]	Baseline	5	8	81.3	3	18.8
	End-line	0	0	0.0	16	100
Sonda[6]	Baseline	0	11	91.7	1	8.3
	End-line	0	1	8.3	11	91.7
Doloba[5]	Baseline	6	6	80.0	3	20.0
	End-line	0	0	0.0	15	100
Kavuzi[6]	Baseline	2	5	87.5	1	12.5
	End-line	0	4	50.0	4	50

During the baseline survey (before training), a substantial number of dairy farmers had their milk rejected at least once at the cooling center. Two reasons were given for the rejection

[5] Trained MBG

[6] Not trained MBG

that is milk adulteration and souring of the milk. Although the overall rejection rate decreased in the untrained MBGs during the study, rejections still occurred at the end-line survey.

There was a 28% milk rejection in Likuni, 8.3% in Sonda and 50% in Kavuzi, and in all cases, the rejection was attributed to milk sourness at the end-line survey rather than adulteration. Milk becomes sour for different reasons; one of the reasons can be because of mastitis or bacterial infection of the udder. The other reason for milk souring could be damage due to failure to cool the milk soon after milking. Milk contamination is the other cause of milk souring as bacteria is introduced into the milk. Farmers in the trained MBGs were trained on milk hygiene, mastitis prevention and also the importance of keeping milking utensils clean. Thus, it is likely that the training had a positive impact to reduce mastitis occurrence and that in turn was associated with the 0% milk rejection in the trained MBGs relative to those that did not receive training, even though the untrained MBGs had a reduction in rejection over the course of the study.

The 0% rejection of milk in the trained MBGs could be a result of the training that the dairy farmers received as evidenced by continuous milk rejection in the untrained MBGs during the same period of time. Dairy farmers were trained in proper procedures of cleaning utensils to avoid milk contamination. Cleanliness of the barn is another factor for milk contamination and a cause of mastitis that results in milk rejection at cooling centers.

Effects of Training on Utensil Hygiene

The results in Table 5-4. indicate that there was a change in the way the dairy farmers cleaned their utensils after training. It is recommended under good dairy management that utensils be cleaned first with cold water followed by hot water to make sure that the utensil is cleaned effectively. There was no change on how the utensils were cleaned in the MBGs that were not trained and a 100% change was observed in the trained MBGs towards the

recommended cleaning procedure. These findings are supported by literature that milking utensils are a major source of milk contamination as they harbor bacteria. Knowing and understanding proper procedures for effective cleaning of milk utensils is crucial in reducing milk spoilage.

Table 5-4. Cleaning of utensils in all the MBGs. Farmers in the MBGs were either trained (n=3) or left untrained (n=3) with regard to good dairy management practices for 4 months.

MBG		wash with cold water then hot water	wash with cold water only	wash with hot water only	wash with hot/cold + soap
Machite[5]	Baseline	0	4	4	7
	End-line	15	0	0	0
Likuni[6]	Baseline	0	2	2	10
	End-line	0	2	2	10
Lusangazi[5]	Baseline	0	3	5	8
	End-line	16	0	0	0
Sonda[6]	Baseline	1	3	0	8
	End-line	1	3	0	8
Doloba[5]	Baseline	1	2	3	9
	End-line	15	0	0	0
Kavuzi[6]	Baseline	0	2	3	3
	End-line	0	2	3	3

Effects of Training on Availability of Water to the Dairy Cows

Following training, there was a positive percentage change in behavior towards water provision by farmers as compared with those who did not receive training. Specifically, there was a 46% increase in farmers having water available to their dairy cows in Machite, a 12% increase in Lusangazi and a 33.3% increase in Doloba. In contrast, a negative change in water provision was observed in the MBGs that were not trained. For example, there was a 14.5% decrease registered in Likuni, an 8.4% decrease in Sonda, and a 12.5% decrease in Kavuzi. From the

[5] Trained MBG

[6] Not trained MBG

above responses, it appears that training on the importance of water supply to lactating animals contributed to the improvement on water availability for dairy cows in the trained MBGs.

Table 5-5. Count of farmers who had and who did not have water available to their dairy cows in all the MBGs. Farmers in the MBGs were either trained (n=3) or left untrained (n=3) with regard to good dairy management practices for 4 months.

MBG		YES	%	NO	%
Machite[7]	Baseline	8	53.3	7	46.7
	End-line	15	100	0	0
Likuni[8]	Baseline	9	64.3	5	35.7
	End-line	7	50	7	50
Lusangazi[7]	Baseline	13	81.3	3	18.8
	End-line	15	93.8	1	6.3
Sonda[8]	Baseline	8	66.7	4	33.3
	End-line	7	58.3	5	41.7
Doloba[7]	Baseline	9	60	6	40
	End-line	14	93.3	1	6.7
Kavuzi[8]	Baseline	5	62.5	3	37.5
	End-line	4	50	4	50

For milk to be produced there is need for the dairy cow to have access to water as it is a major component of milk. Limiting water access will likely lead to less milk and poor animal performance and well-being. It is thus of extreme importance that the dairy cow should have ready access to water at all times to support the greatest milk yields. Table 5-5. presents the behavioral change of dairy farmers towards water availability in all the MBGs. The training used in the present study put a lot of emphasis on the need for water for milk production.

Education level, MBG, and training were all factors that could influence change, especially positive behavioral change by farmers. Thus, these factors were tested to see which variable could have an effect on the behavior of the farmers. It was hypothesized that individuals who

[7] Trained MBG

[8] Not trained MBG

went to school can manage their livestock better than those who had no schooling, and further that school experience increases the ability to accept and effectively make use of the training. Therefore the influence of education on the farmers' dairy management practices with regard to water availability to the cow was tested. In addition, the effect of education on the adoption of new practices by the small-scale dairy farmers in Malawi was tested directly. Finally, it was possible that locality of the farmer would affect responses. For this reason, it was necessary to test the effect of the MBG on the behavior of the dairy farmers towards water availability to the dairy cow. Apart from the education level and the MBGs farmers came from the fact that people can change behavior due to other unexpected factors, such as change in price of milk, was considered. For this reason, it was appropriate to determine the impact of such unexpected factors by having a control group that was not trained and determine if there would be any change in the absence of specific dairy management training. Therefore, baseline data was collected and compared end-line data for both the trained and untrained farmers. Lastly, the there was interest to test the influence of training on the behavioral change, as training is also believed to bring about change in individuals behavior.

The results indicate that education has no effect on the behavioral change of both the trained and untrained farmers towards water availability to the dairy cows with p-values of 0.93 and 0.44, respectively. That lack of significance indicates that, farmers were changing their behavior in the trained MBGs not because of their education level. Further, it was established that the MBGs where farmers came from had no effect on the behavioral change towards the provision of water to dairy cows implying that farmers behaved in the same manner despite coming from different MBGs.

Training was tested against change in farmers' behavior by comparing their behavioral change before receiving training (baseline) and after receiving training (end-line). Results indicate that the likelihood that training affected the behavior of the farmers in the trained MBGs towards provision of water to their dairy cows was highly significant *($p < 0.0016$)*. It was observed that there was a positive change in all the trained MBGs of 46.7%, 12.8% and 33.3% in Machite, Lusangazi and Doloba respectively. On the other hand, farmers from the untrained MBGs continued to practice bad behavior towards availability of water. A decrease in the number of farmers making sure that there is always water available to the cow in the barn of 14.3%, 8.4% and 12.5% was reported in Likuni, Sonda and Kabvuzi respectively. Thus, training had a significant effect on the farmer's behavioral change towards water provision to their dairy cows in the trained MBGs.

When the effect of other unexpected factors was tested against behavior change, it was noted from this research that there was no significant change between the baseline and the end-line of the untrained farmers *(p-value 0.32)*. This leads to the conclusion that there was no other variable other than training that had a significant change in the behavior towards good dairy management practices with regard to availability of water to their dairy cows.

Effect of Training on Availability of Feed to the Dairy Cows in the Barn

Results indicate that there was a positive percentage change in behavior towards feed provision in dairy farmers from the MBGs that underwent training as compared to dairy farmers from MBGs that received no training (Table 5-6.). The positive percentage change was observed in Machite, Lusangazi and Doloda with changes from 60% to100%, 50% to 93.8%, and 66.7% to 93.3% respectively. It was further noted that there was no behavioral percentage change towards provision of feed in farmers from untrained MBGs. In certain cases, the number of dairy farmers who did not provide dairy cows with feed increased during the study, as was the case in Likuni

and Kavuzi with the increase from 35.7% to 42.9%, and 37.5% to 50% respectively. Therefore, in the absence of training the feeding of cows was poorer over time.

Having identified the behavioral change in feed provision in farmers from the trained MBGs, it was important to test different variables to see which variables could affect the behavioral change towards feed availability, i.e. education level, the MBG where dairy farmers came from, and the training received. These variables were tested against availability of feed in the trained MBGs. The analysis indicates that there was no effect of education level and the MBGs from which dairy farmers came on the availability of feed. Crucially, this implied that dairy farmers' management, with regard to feed provision to dairy cows is independent from education level and where the farmers come from, or which group he or she belongs to. Training was thus the only variable that was tested to have a significant effect on the availability of feed

Table 5-6. Counts of dairy farmers who had and who did not have feed available to their dairy cows in all the MBGs. Farmers in the MBGs were either trained (n=3) or left untrained (n=3) with regard to good dairy management practices for 4 months.

MBG		YES	%	NO	%
Machite[9]	Baseline	9	60	6	40
	End-line	15	100	0	0
Likuni[10]	Baseline	9	64.3	5	35.7
	End-line	8	57.1	6	42.9
Lusangazi[9]	Baseline	8	50	8	50
	End-line	15	93.8	1	6.3
Sonda[10]	Baseline	8	66.7	4	33.3
	End-line	9	75	3	25
Doloba[9]	Baseline	10	66.7	5	33.3
	End-line	14	93.3	1	6.7
Kavuzi[10]	Baseline	5	62.5	3	37.5
	End-line	4	50	4	50

[9] Trained MBG

[10] Not trained MBG

with p-value of 0.0004 in the trained MBGs. Therefore, the dairy farmers change in behavior towards availability of feed to cows was improved with training.

Sometimes behavioral change can be a result of other motivators such as increase in milk price, cheap source of feed and other factors other than training itself. It was established, from this study, that other factors had no impact on the changes in the behavior of the dairy farmers towards practicing good dairy management with regard to feed availability as they all tested to be not significant. This enabled the researcher to deduce that the change in behavior towards feed provision to dairy cows was not due to any other factors other than training.

Feeds and feeding was one of the areas that the training covered. Farmers were taught the importance of feed for dairy animals. It is necessary for dairy farmers to know what to feed dairy cows, how much to feed, and at what interval. During lactation, there is an increased nutritional requirement in the cow to meet the needs for milk production, and fetal growth if the animal is pregnant, hence the need for knowledge of feeds and feeding. Whereas more feed is typically a positive with regard to milk production, feeding too much concentrate has negative effects, and thus there is a need for training in feeds and feeding. It was highly recommended during the training that dairy cows should have ready access to forage at any time they feel like eating, and that appropriate quantities of concentrate be available to supplement the forage. Because of the training, farmers were able to better understand their dairy cows requirements and hence the change in their management practices.

Effects of Training on Milk Yield

A cross tabulation was generated for all the MBGs to compare the milk yield frequencies and distribution in all the MBGs before some MBGs were trained in good dairy management. Results presented in Table 5-7. show that, there was no MBG that was producing more than 17 liters per cow. This was done to ensure that the MBGs were at the same level of milk yield

production before provision of training. Results from the cross tabulation indicated that there was no difference in the MBGs with regard to milk production level.

Table 5-7. Cross Tabulation of milk yields in all the MBGs before training. Farmers in the MBGs were either trained (n=3) or left untrained (n=3) with regard to good dairy management practices for 4 months.

Milk Yield (L/cow/day)	Machite[11]	Lusangazi[11]	Doloba[11]	Llikuni[12]	Sonda[12]	Kavuzi[12]
6	0	0	0	1	0	0
7	1	0	0	0	0	0
8	0	1	0	2	0	0
9	1	2	1	1	0	0
10	1	1	0	2	1	0
11	1	0	0	1	1	0
12	1	3	3	3	2	2
12.5	0	1	0	0	1	0
13	3	2	3	1	3	2
14	1	1	4	2	1	3
14.5	0	0	1	0	0	0
15	2	1	1	1	0	0
15.5	0	0	0	0	1	0
16	2	3	2	0	1	0
17	2	1	0	0	1	1

Following training, another cross tabulation was generated for all the MBGs to compare milk yield frequencies in all the MBGs. Results showed a highly significant change in milk yield in the MBGs that underwent training with p-value of <0.0001. Results presented in Figure 5-1. shows that there was no dairy cow that was producing below 11 liters in the trained MBGs with some dairy cows getting as high as 25 liters. There was no much change in the cows from the untrained MBGs, which had milk yields ranging from 8 liters to 18 liters.

Milk yield is a function of different factors ranging from genetics to management of dairy cows. Farmers were taught during the trainings that milk yield changes with time in lactation and

[11] Trained MBG

[12] Not trained MBG

that there is milk yield variation among dairy cows due to the difference in breed, lactation stage and parity and management practices. Milk yield also depends on type of feed fed to the dairy cow. Provision of feed supplements (concentrates) tends to increase milk yield. Farmers were also taught that there are different types of supplements with different nutritional compositions and that this makes milk yields differ among cows. The knowledge that the farmers got from the training helped them to better understand their business. It was stressed in the trainings that every dairy cow has a potential milk yield which dairy farmers must strive to achieve to maximize profits in their dairy business. For any dairy cow to attain its potential milk yield good dairy management should be practiced.

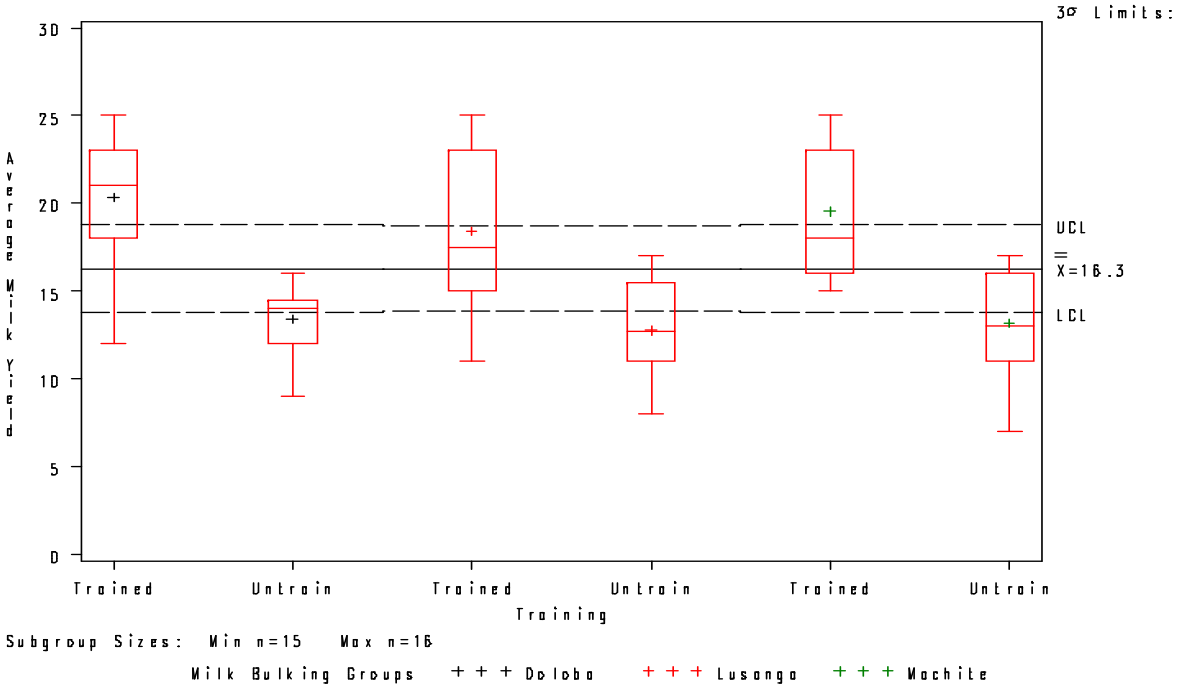


Figure 5-1. Comparison of milk yields in all the MBGs after training. Farmers in the MBGs were either trained (n=3) or left untrained (n=3) with regard to good dairy management practices for 4 months.

There was a small change in milk yields of the untrained dairy farmers. This change can be attributed to the breed of the dairy cow and the stage of lactation in which the cows were in their lactation. From these descriptive data, it is concluded that training resulted in significant change in milk yields between the trained and the untrained MBGs. Next, different variables were tested to determine which one(s) had a significant impact on the change on milk yield. Type of feed supplement, MBG, breed of the animal and training were the variables that were tested to explain the significant change in the milk yields. It was observed from the results that there was no impact on milk yield as a result of type of feed supplemented or the MBGs where the farmer came from. Breed of the dairy cows and training were determined to have an effect on the milk yield in the trained MBGs with p-values of 0.0001 for both variables.

Conclusion

The study has clearly demonstrated that it is possible to change dairy farmers' behavior towards good dairy management practices through provision of training. Most importantly, through training in dairy management practices, milk yields can increase and milk quality too can improve. The study has also revealed that disease prevalence, i.e. mastitis, in dairy cows can effectively be controlled with training in dairy management. Furthermore the study findings have revealed that milk loss through milk spoilage, adulteration and the resultant rejections by buyers, can drastically be reduced with training in dairy management.

It is evident from this study that training small-scale dairy farmers in dairy management can be a solution to the many economic and food insecurity problems Malawi has been going through in recent years. Small-scale dairy farmers, who are the major player in the dairy sector in Malawi, have failed to realize the fullest potential of their dairy cows due to lack of good dairy management skills. As a consequence of this, the hard earned foreign exchange is currently being

lost through the importation of milk and milk products from neighboring countries in order to cover the milk consumption deficit that has been created by poor dairy management practices.

Through this study, it is recommended that the “Basic Dairy Management Skills’’ module be adopted and used by dairy management extension agents in their pursuit to improve milk yields and quality in Malawi. However, further research ought to be conducted on the economic impact of the adoption of the new dairy management skills by the dairy farmers in Malawi as a result of using the “Basic Dairy Management Skills’’ module.

APPENDIX A
TRAINING MODULE

Course title: Basic Dairy Management Skills
Compiled by: D.T. Kazanga
Target Group (Direct): Dairy Farmers in Malawi

Prospectus

This module focuses on the basic milking skills for small scale dairy farmers in Malawi. It starts by highlighting the extent to which lack of basic milking skills have impacted on the performance of small scale dairy farmers and the dairy industry as a whole. Since the dairy industry is beset with so many problems that range from lack of technology, lack of trained dairy extension agents to lack of drugs, this module will serve as a reference material for dairy farmers or their servants, dairy training institutions and extension agents in their pursuit to reduce or eliminate milk spoilage through mastitis at farm level, in cooling facilities at the milk bulking group before collection by processors, milk processing plants and during transportation. It discusses quality control aspects starting from the farm i.e. management of the milking cows (use of teat dip), issues of sanitation with regard to cleanliness of the udders, equipment, cooling plant, transportation equipment, cooling of milk, and segregation of mastitis milk etc. It further discusses the milking husbandry practices by small scale farmers in Malawi for the purpose of exposing shortfalls/weaknesses in the Malawian milking management practices. Finally, it discusses the contribution of water and roughages to milk quality and the problem of mastitis in Malawi.

Rationale

In Malawi, hundreds of liters of milk are wasted at farm level, at cooling facilities and at milk processing plants largely due to lack of knowledge. A number of factors are attributed to milk spoilage some of which are unhygienic milking practices, inaccurate quality testing, poor milk cooling procedures, and incidences of mastitis, failure to segregate mastitis milk, inappropriate milk transportation and lack of preventive measures for milk spoilage. This is a very disturbing development considering that average milk yields per cow among small scale dairy farmers are already very low. The problem is compounded by lack of trained Dairy Extension agents in Malawi to provide dairy farmers with requisite training in dairy management. This state of affairs has necessitated the development and writing of this module which will serve as a reference material.

Efforts by Malawi's Development partners such as World Vision International, Heifer International, Land O'Lakes Plan International and others, who have all concentrated on increasing dairy cattle population through dairy cattle donations on a pass-on-basis, have ignored issues of milking skills training and nutrition management, will remain to be wasteful unless dairy farmers are equipped with milking skills.

The course therefore aims at equipping participants (dairy farmers) from various farmer associations with knowledge, skills and practices in basic milking management so that they can contribute towards reducing losses of milk.

Objectives

On completion of the module, participants should be able to:

- Articulate factors that contribute to qualitative losses in milk
- Determine/identify appropriate equipment for storing milk during transportation to a milk cooling facility.
- Demonstrate full understanding of the importance of cleaning cows and equipment before milking, use of teat dip to prevent mastitis
- Demonstrate full understanding of the need for segregation of mastitic milk.
- Determine appropriate local raw materials necessary to be used as roughages as a way of preventing mastitis. Some roughage can be a conduit for transmission of diseases.
- Demonstrate full understanding of the importance of good clean water in dairy management.

Module content

- Introduction to Small Scale Farmers Milking Practices in Malawi
- Factors that affect milk quality
- Preparations for milking
- Milking practices
- Milking equipment (milk testing equipment, reagents/chemicals for testing etc)
- Cleaning of equipment
- Cleanliness of the personnel involved in the milking activity
- Cooling of milk
- Segregation of mastitic cows and milk

- Water and roughages
- Housing

References

- FAO and IDF. 2011. *Guide to good dairy farming practice.* Animal Production and Health Guidelines. No. 8.Rome
- Johnson, A.P. 2000. *A Proper Milking Routine: The Key to Quality Milk*, Total Herd Management Service, Inc. Seymour, Wisconsin.
- Kurwijila, L.R. 2006. *Hygienic milk handling, processing and marketing: reference guide for training and certification of small-scale milk traders in Eastern Africa.* ILRI (International Livestock Research Institute), Nairobi, Kenya.

Mode of training

- Lecture with use of flipcharts/chalkboard/computer and projector
- Group work
- Visits to farmers' kraals, pasture and gardens

Mode of assessment

- Case studies and group discussions
- End of session questions and exercises

Training materials

- Flipcharts
- Closed rooms
- Exhibits

Module documentation

- Pamphlets
- Notes

Session 1

1.0 Factors that affect milk production

There are several factors that affect the amount of milk produced during the lactation period. In normal situations, milk production increases during the first six weeks of lactation and then peaks before gradually decreasing. These factors are either genetic, management. Below are five major factors that affect the cow's productivity;

1. Breed of the cow
2. Parity
3. Season of Calving
4. Geographic region
5. Management factors

1.1 Breed

There are different breeds of dairy animals around the world. The major dairy breeds are; *Ayrshire, Brown Swiss, Guernsey, Holstein-Friesian, Jersey and Milking Shorthorn.* In Malawi the commonly milked breeds are the Friesians, Jerseys and the local Malawi Zebu. The Friesians are the ones that give the highest milk yields followed by the Jersey and lastly the local breeds (Malawi Zebu). Malawi also has crossbreeds of the Malawi Zebu with either the Friesian or Jersey. The crossbreed produces quite a good amount of milk that is in between the Malawi Zebu and the Friesian or the Jersey. The advantages of the crossbreeds over exotic breeds are many when it comes to management factors i.e. resistance to diseases.

1.2 Parity

Milk production increases with parity (lactation number). Cow's productivity is maximized in the fourth or fifth parity. By this time, as compared to the earlier lactations, there is increased development and size of the udder. The expected mature yield of a primiparous cow calving at 24 months (2 years) of age can be estimated by multiplying yield of first lactation by 1.3.

1.3 Season of calving

The effects of season of calving on milk yield are confounded by breed, stage of lactation and climatic condition. Cows calving in late autumn to spring produce more milk than cows calving in the summer. This is likely due to an interaction between daylight and ambient temperature.

1.4 Ambient temperature

The effect of the ambient temperature on milk yield is dependent upon the breed. Holsteins, Friesians and the other large breeds are less tolerant to high temperatures, whereas smaller breeds like the Jersey, the crossbreeds and the local Malawi Zebu, are much more tolerant to high temperatures. The optimum temperature for the Holstein/Friesian cow is about 10^0C.

Milk production declines when the environmental temperatures exceed 27^0C. This reduction in milk yield is largely explained by the reduced feed intake when the temperatures are high. High temperature will affect high producing cows more than low producers. This is particularly harmful during the peak of lactation. Advanced dairy management can manipulate the environmental temperature by using fans, sprinklers and other technologies to bring the temperature of the cows or the environment down. However this kind of management is expensive and cannot be afforded by the small scale farmers in Malawi and other developing countries whose production is not as high.

Session 2

2.0 Management factors

Of all the factors, this is the factor that is in the hands of the small scale farmers at little or no cost at all. By practicing good dairy management, high milk yields are achieved, good milk quality is produced and health animals are raised. Below are the management factors that affect milk production

2.1 Feed and Water supply

Implementing an adequate nutrition program improves milk production and reproductive performance. Nutrient requirements may not be the same for all animals depending on the breed, age and stage of lactation. A good nutrition program will take into consideration the quality and quantity of feed and water given to an animal in a particular physiological state. Nutrition plays an important role in milk production and in keeping the cow healthy. Any restriction in feed and water supply will result in a drop in milk production; the situation is most critical with water as the animal has no means of storing water in the body.

Different factors affect dry matter intake when forage is poorly digested, compared to feeding a ration containing more easily digested forage. Feeding poorly digestible forage increases the time necessary for ruminal digestion and fermentation, thus slowing the rate of passage through the digestive tract. This increases the heat produced and complicates the cow's physiological response to high ambient temperatures. In contrast, feeding forage that is easier to digest permits more rapid passage and lowers the heat produced in the rumen.

Concentrates, or grains, are usually low in calcium and high in phosphorous. However, high producing cows requiring large amounts of concentrates do not have sufficient time in the milking cubicle to consume all the necessary grain. Therefore, additional concentrates are usually fed at a different location.

Roughages (hay and silages) are usually the cheapest source of nutrients. Different types vary immensely in nutrient concentrations. Legumes (alfalfa) have high calcium, protein, and potassium, whereas grasses and corn silage have considerably lower amounts of these nutrients.

There is need to match concentrates to forage depending on the quality of the forage available at a particular time. Due to low production of forages specifically for cows, seasonal farming and lack of good storage of forage (i.e. silage), dairy cows in Malawi are mostly subjected to good quality forage on seasonal basis. There is need to match how much concentrate to give the cow when the forages are of poor quality, in most cases when the forage is dry and how much concentrates to give when the forage is of good quality, that's in most cases when it is fresh. Depending on the nutritional quality and digestibility of the forage, supplementation of concentrates will differ. Poor nutritive and poor digestible forage need more concentrate supplementation as compared to high nutritive and highly digestible forage to meet the lactating cow's nutrition requirements.

The amount of protein supplement (e.g. soybean meal, cotton seed, fish meal) and mineral supplement that must be added to a concentrate formulation depends on the type and amount of forage being fed. Trace mineralized salt, and vitamins A, D, and E are usually added to concentrates.

Forages are the most common type of feed used by small scale dairy farmers in Malawi. Forage can also be referred to crop residuals that we give to our cattle. Cereal grains, also known as concentrates, are the main contributors of starch to the diets and are very important in meeting

the energy needs of the dairy cow. In general, the concentrates are a good source of protein, energy and fiber. Corn is the main concentrate found in Malawi.

Corn bran is a by-product that most dairy farmers in Malawi feed to their animals. Using by-product is one way of reducing the high feed costs especially for the concentrates cost. If maize bran is given in excess it causes acidosis, which affects milk yield negatively. For this reason most farmers underfeed corn bran to their animals, and do not observe a significant increase in milk yield. Some of the by-products that farmers give their animals are wastes from industries like the brewery and other food factories. When giving such feed, farmers need to be more careful because the animal may have negative reaction to the feed. Grain supplementation should be done slowly and with proper follow up and not abrupt change from forage to grain.

Ensuring a good body score (body fat reserves) is essential for a cow to produce milk and also to keep her reproductive efficiency high. If a cow is too fat or thin, there are metabolic complications that are associated with the body score that will negatively affect productivity.

2.2 Milking Intervals

Milking interval refers to the time between two milkings. Cows are usually milked at equal intervals. Some milk the cows three times a day (8-h interval) while most farmers in Malawi milk their cows twice a day (12-h interval). Cows milked at unequal intervals produce less milk than those milked at equal intervals. This reduction due to milking interval is much more significant in the high producing cows than in low producing cows. Milk removal from the udder is very important for continuation of lactation. Incomplete milking for several consecutive days can permanently reduce milk yield for the entire lactation. Make sure you milk your cow within 6 minutes, after 6 minutes the stimulation effect of release of oxytocin wanes away.

2.3 Milking Frequency

Milking frequency refers to how many times in a day the cow is milked. The number of times a cow is milked per day has got an impact on the total milk yield per day. Cows that are milked twice a day have at least 40% more milk than cows milked once a day. Increasing milking frequency to three times a day increases milk yield by up to 20%. There are three attributes to the increase in milk yield due to milking frequency and these are:

I. Less intramammary pressure generated with frequent milk removal

II. Increased stimulation of hormone activity favorable of milk production

III. Less negative feedback on the secretory cells due to the decrease in factors not favorable to lactation

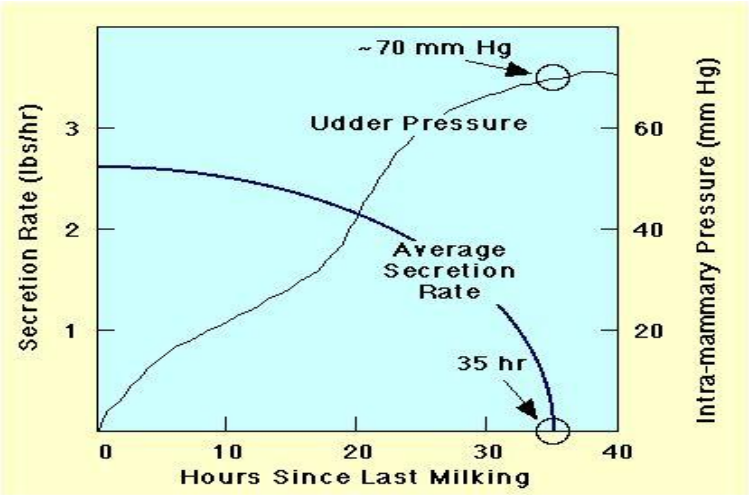
However, the three times milking frequency is not an ideal practice for the small scale farmers in Malawi as it has several problems associated with it. This practice may increase the incidence of mastitis as the cow gets milked frequently hence high chances of contamination. This practice is also not recommended for poorly managed cows or farmers with little resources as existing problems will be aggravated.

NOTE:

Rate of Milk secretion

Milk yield is mainly dependent on two factors: (1) the amount of secretory tissue and (2) the rate of milk secretion. The period following milk removal is characterized by low intra-mammary pressures, which facilitate the transport of newly synthesized milk into the alveolar lumen.

Secretion rate is affected by the accumulation of milk in the alveolar lumen. The accumulation of the milk in the lumen increases the intra-mammary pressure. Once the intra-mammary pressure reaches a certain level secretion rate declines. When the luminal pressure exceeds the force of secretion as the alveolar enlargement reaches its limit. It is presumed that the distention pressure of the lumen exceeds the strength of the secretory mechanism needed to push the newly formed milk out of the cell. As a result, the buildup of the formed milk in the cells retards the uptake of milk precursors by the chemical feedback mechanism and/or physical factors. The physical factors are a result of the distended alveoli partially displacing all other intra-mammary compartments, including the blood vessels. With restricted blood flow, less nutrients are available for milk production, less hormones are available to drive the mammary synthetic system, removal of waste products of synthesis is reduced and less oxytocin is available to stimulate the myoepithelial cells. The inhibition of milk secretion that accompanies increasing intra-mammary pressure is mainly caused by a chemical inhibitor rather than the increased pressure of the fluid itself.



(Adapted from: Schmidt, G.H., 1971, Biology of Lactation, W.H. Freeman and Co., p. 150).

Average secretion rate begins to decline after 10 hours since the last milking and secretion stops after 35 hours. The intra-mammary pressure is measured in the teat cistern using a teat cannula. This intra-mammary pressure estimate reflects total gland pressure from accumulation of milk and not directly the intra-alveolar pressure. The pressure measured in the teat cistern increases in three phases: (1) an initial rapid increase in the pressure caused by the movement of residual milk into the cistern from the alveoli and the small ducts, (2) lower phase can be an accumulation of newly synthesized milk that is released into the duct system from the alveolar lumens as they begin to accumulate milk and (3) an accelerated pressure increase that represents overfilling of the alveoli, ducts and gland cisterns.

Residual and Available milk

Residual milk can be defined as the amount of milk left in the udder after milking is completed. Residual milk is also called complementary milk. About 10-20% of total milk is left in the udder

as residual milk. The only way to get residual milk out is by giving the cow oxytocin and one minute later, milking the cow again.

Lactating heifers have less residual milk than older cows. The percentage of residual milk is lower for higher producing cows as compared to lower producing cows. It is reported that cows with higher percentage of residual milk usually have a lower persistency. The percentage of residual milk remains the same throughout a lactation, this means, residual milk decreases in proportion to milk yield as lactation progresses. Part of the residual milk can never be recovered by conventional milking procedures while another fraction can be collected if the amount of residual milk is large due to poor milking procedure. The portion of milk that can be collected is referred to as available milk. Available milk reflects how well the cow was stimulated for milking. There is need for a cow to be trained for milking and if the cow is not well trained for milking the amount of uncollected available milk will be great. It is very important to have the available milk removed completely so that the residual milk is reduced. Large amounts of residual milk reduce daily milk production, reduce lactation production and the cow will have fewer days in milk.

2.4 Disease

The main disease that affects milk yield of dairy cows is mastitis. Mastitis is the infection of the udder. This occurs when white blood cells are released into the mammary gland, usually in response to invasion of bacteria in the teat canal. Mastitis impairs the ability of secretory tissue to synthesize milk components and destroys the secretory tissue and consequently lowering milk yield. Milk secreting tissue, and various ducts throughout the mammary gland are damaged due to the toxins produced by the bacteria, hence a decrease in production persists even after disappearance of the clinical signs. Mastitis can also occur as a result of chemical, mechanical, or thermal injury.

Susceptibility to mastitis may be genetically determined to a certain degree, but environmental factors such as improper milking and unsanitary conditions are the most prevalent causes. The best approach to controlling mastitis is good management techniques. Most treatments involve infusing an antibiotic into the udder through the teat canal, but again, prevention of infection is the best approach.

Session 3

3.0 Other factors that affect cow productivity

There are also other factors (that in relation to the physical status of the cow) that affect the cow's productivity. These factors include:

I. Dry period

II. Age and body weight at calving

3.1 Dry period

The mammary gland of the dairy cow requires a nonlactating period prior to the next calving to optimize milk production in the following lactation. This period is called the dry period. The purpose of the dry period is to allow the cows udder an opportunity to regenerate secretory tissue. Dairy cows are usually dried-off for two months prior to the next calving. Generally, 40-60 days for drying-off is recommended.

The recommended procedure to dry off a cow is to withdraw all grain and reduce water supply several days before the start of the dry period. The withdrawal of grain and restricted water intake will cause a drastic decrease in milk production during this period. This is restricted intake is then followed by cessation of milking in the remaining 40-60 days before the expected date of parturition. After the milking is stopped, intramammary pressure increases, milk products accumulate in the gland, which leads to inhibition of milk secretion. If the cow is milked, there will be continuation of milk synthesis because the intramammary pressure is reduced and the pituitary hormones (oxytocin and prolactin) are released. If you milk half of the udder throughout the dry period while the other half is dry, then the milked half gives less milk in the subsequent lactation as compared to the unmilked half. Heat stress during the dry period has a negative effect on the milk yield in the following lactation. This can be avoided by providing shade to the cow, avoid muddy shades for disease prevention.

3.2 Age and body weight at calving

The amount of milk produced by the cow increases at a decreasing rate with advancing parity (age). As the cow matures, the mammary gland and the digestive system also grow larger. This means the capacity for milk production increases with age as the site of milk synthesis upgrades its capacity and the digestive system is also able to supply the nutrient requirement for the increased milk production from the feeds. A mature cow (i.e. 5 years old; third lactation) produces about 25% more milk than a 2-year-old heifer.

The other reason for increased milk production with age is due to the effects of recurring pregnancies and lactations. Recurring pregnancies and lactations can result in milk increases of 30% in the milk production from the first to the fifth lactation. Production data indicate that 20% of the increase in milk production in cow is due to increased body weight.

Large cows generally produce more milk than small cows, but it is not proportional to body weight. A cow which is twice as large as another usually produces only about 70% more milk. The variation is by 0.7 power of the body weight, which is an approximation of the surface area of the cow (metabolic body size).

Session 4

4.0 Factors Affecting Milk Composition

In cow milk, fat is the most variable component while minerals and lactose are the least variable. Milk protein to milk fat ratio ranges from 0.78 to 0.85 depending on breed type. Factors contributing to variations in milk composition include species, genetic variations within species, differences between individuals within a breed and differences in conditions affecting individuals.

4.1 Genetic Differences

Heritability is defined as the ratio of genetic variance to total phenotypic ratio. The concentrations (%) of the three major milk constituents are genetically controlled to a considerable extent. Heritability of fat, protein, and lactose contents average 0.58, 0.49, and 0.50, respectively, whereas that of milk yield averages 0.27. Some milk constituents are strongly correlated. There is a room to increase milk protein concentration (by genetic selection) without increasing fat concentration. Selection for high milk yield alone may reduce milk fat and protein percentages.

4.2 Stage of Lactation

4.2.1 Colostrum

Colostrum is the first mammary secretion after parturition. This is essential for the newborn calves' immune system. Colostrum differs greatly from normal milk in terms of composition. Bovine colostrum contains more minerals, protein and less lactose than milk. Fat concentration is usually higher in colostrum than in normal milk. Minerals such as Calcium, Mg, P, and Cl are high in colostrum as compared to normal milk, whereas K is low in colostrum. Iron is 10-17 times higher in colostrum than in normal milk. The high levels of Fe are needed for the rapid increase in hemoglobin in the red blood cells of the newborn calf. Colostrum contains 10 times as much vitamin A and 3 times as much vitamin D as milk. The most remarkable difference between colostrum and milk is the extremely high levels of immunoglobulin content of colostrum. Mammary secretion gradually changes from colostrum to normal milk within 3 days postpartum.

4.2.2 Normal Milk

Changes in composition that occur during the first few days continue but at a reduced rate for about 5 weeks of lactation. Fat and protein concentrations then rise gradually and may increase more sharply near the end of lactation. Lactose decreases while mineral concentration increases slightly during that period.

Milk fat concentration increases continuously during the milking process. First drawn milk may contain only 1-2% fat, whereas, at the end of milking, fat concentration may be 5-10%. This is because of the tendency of the fat globules to cluster and be trapped in the alveoli. Thus after incomplete milking, milk fat content will be lower than normal. Residual milk (milk remains in the udder after milking) may contain up to 20% fat.

4.3 Seasonal Variations

Seasonal variations in milk composition are commonly observed with dairy cattle in temperate regions. Milk fat and solids-not-fat percentages are highest in winter and lowest in summer. Milk fat and protein percentages are lower by 0.2-0.4 points in summer than winter. Cows calving in the fall or winter produce more fat and solids-not-fat than cows calving in the spring and summer. Considerable variations in milk composition can also be observed in dairy cows managed on pasture.

4.4 Diseases

Infection of the udder (mastitis) greatly influences milk composition. Concentrations of fat, solids-not-fat, lactose, casein, β-lactogolbulin and α-lactalbumin are lowered and concentrations of serum albumin, immunoglobulins, sodium, and chloride are increased. In severe mastitis, the casein content may be below the normal limit of 78% of total protein and the chloride content may rise above the normal maximum level of 0.12%. Mastitis is also responsible for differences observed in milk composition from different quarters of the udder.

Session 5

5.0 Effects of Nutrition on Milk Composition

Of all milk components, milk fat is the most influenced by dietary manipulations. Most changes in milk composition due to dietary manipulation are related to changes in the ruminal acetate:propionate ratio. Several nutritional factors can influence milk composition. These include plane of nutrition, forage: concentrate ratio, forage quality (e.g. particle size), level and type of dietary fat.

5.1 Plane of nutrition

Underfeeding dairy cows reduces lactose concentration and increases fat concentration. Feeding an unbalanced ration (e.g. low energy:protein ratio) may reduce milk fat and protein percentages.

5.2 Forage:concentrate ratio

As the proportion of the concentrate in the ration increases above 50-60% of the ration, milk fat percentage tends to decline. This is mainly because of the lower ruminal production of acetate and butyrate (precursors of milk fatty acid synthesis in the mammary gland) associated with feeding high concentrate diets. The extent of milk fat depression is influenced by other feeding practices such as frequency of feeding and feeding system. Feeding cows less frequently results in a reduced ruminal acetate:propionate ratio especially if the concentrates are fed separately from the forage which in turn can result in reduced milk fat concentration. Forages have much to do with milk fat synthesis while concentrates will influence yield.

5.3 Forage particle size (forage processing)

Feeding finely chopped forages has a negative impact on milk fat concentration and may cause milk fat depression syndrome (drop of milk fat concentration below 3%). Cows fed finely chopped forages spend less time chewing and therefore will produce less saliva. Ruminal pH will drop as less salivary bicarbonate is produced to buffer the acid production in the rumen. As the ruminal pH drops below 6, the activity of the cellulolytic bacteria is reduced and so is the production of acetic and butyric acids, precursors of short chain fatty acid synthesis in the mammary gland.

5.4 Level of starch in the ration

As the level of starch in the ration increases, the level of acetate produced in the rumen is decreased while that of propionate is increased; this is due to the reduced pH in the rumen. This results in a reduction in milk fat concentration due to low acetate production in the rumen.

5.5 Dietary fat

The effect of supplemental fat on milk fat concentration depends on the type of supplemental fat. Feeding protected fat favors milk fat concentration. Polyunsaturated fat such as vegetable oil is susceptible to biohydrogenation in the rumen, and has a negative effect on milk fat concentration.

Milk fat differs from other sources of animal fat in that it contains significant amount of short chain fatty acids and relatively lower concentrations of long chain fatty acids. Half of the milk fat composition is derived directly from dietary long-chain fatty acids, adipose tissue and microbial synthesis. The other half is derived from de novo synthesis of short chain fatty acids, the precursors of which are acetate and butyrate. In general, milk fat composition is influenced by end products of ruminal fermentation as well as the supply of dietary long chain fatty acids to the mammary gland.

The extent to which dietary fat alters the fatty acid composition of milk fat is influenced by:

- Fatty acid composition of dietary fat

- The extent of hydrolysis and biohydrogenation of unsaturated fatty acids by ruminal microbes
- Effect of dietary fatty acids on de novo synthesis of short chain fatty acids by the mammary gland
- The extent of conversion of saturated fatty acids to mono-unsaturated fatty acids (mainly C18:0 to C18:1) as a result of intestinal and mammary gland desaturase activity.

Feeding oil seeds such as canola, sunflower or flaxseed has been found to reduce the concentrations of short (C4-C10) and medium chain (C16:0) fatty acids and increase the concentrations of C18:0 and C18:1 fatty acids. The inclusion rate of oils seeds in dairy rations is limited by the negative impact of polyunsaturated fatty acids on ruminal fiber digestion. In general, the maximum inclusion level oilseeds should result in 3-4 percent added dietary fat. At a higher inclusion of fat or if a greater change in the concentration of unsaturated fatty acids in milk is desired, some form of protection (e.g. heat treatment) should be applied to avoid negative effects on fiber digestion in the rumen.

Session 6

6.0 Factors that affect milk quality

High milk quality refers to milk that is free of dirt and other sediment, low in bacteria count, no chemical contamination, low somatic cell count, no adulteration and of good flavor. Milk will quickly become sour if it is stored for long period at high temperatures prevalent in tropical and subtropical countries. This is because the inherent lactic acid bacteria and contaminating microorganisms from storage vessels or environment break down the lactose to produce lactic acid in the milk. Accumulation of this lactic acid results in the milk becoming sour and coagulates, just as the case if you add sufficient lemon or vinegar to fresh milk. Milk containing too much lactic acid will coagulate when heated, even if it does not appear to be clotted. This acid is known as *developed acidity*. Milk with developed acidity cannot be sold on the market.

The levels of milk spoilage depends on the number of spoilage bacteria in the raw milk, and this number of spoilage bacteria depends on the level of hygiene during milking and the cleanliness of the utensils used for milking, storage and transporting the milk. Milk hygiene is very important to milk quality.

Milk is an excellent medium for bacteria, yeasts and molds that are the common contaminants for milk. Good hygienic practice will result in production of clean milk that is more preferable and acceptable on the market and has the following characteristics:

- No presence of non-milk matter (not dirty)
- Pleasant creamy smell and color
- Low bacterial count
- No obnoxious odors
- No presence of antibiotic, sanitizer or pesticide residues in the milk

Milk must be handled hygienically so that milk spoilage is minimized. There are several different sources from which milk can be contaminated by bacteria. These sources include:

- Udder and flanks
- Milker
- Milking equipment
- Vessels used for milk storage and transportation
- Disease (mastitis)

6.1 Producing clean milk

Good dairy management will practice hygienic milk handling practices that include using clean equipment, maintaining a clean barn and milking environment, observing good personal hygiene of the milker and preserving the quality of milk during storage and transportation to the cooling center.

6.1.1 Cow hygiene

6.1.1.1 Udder and flanks

It is very important to milk a clean cow to avoid contaminating the milk with bacteria from the udder and the flanks. Removing long hair from the udder can help to keep the udder clean. Milk secreted into an uninfected cow's udder is sterile. This clean milk can get contaminated during milking due to the uncleanliness of the udder and the flanks.

There is need to clean the teats with warm water or with disinfectants before milking. Disinfectant is preferred for this exercise. Dry the cleaned teat/udder with a clean towel, one per clean towel per cow. Always remember to milk a clean dry udder to minimize milk

contamination due to udder dirtiness. The process of cleaning and drying the cow will also help in the stimulation for milk ejection other than just preventing milk contamination.

6.1.2 Milker hygiene

Hygiene of the person milking the cow is very important when it comes to milk contamination. The person doing the milking can be a source of bacteria that ends up contaminating the sterile milk being produced. This is mostly a problem in areas where milking is by hand is prevalent, mostly in the developing countries like Malawi.

6.1.2.1 Cleaning hands before and between milking two cows

There is need for the person milking the cow to wash his/her hands and nails with clean warm water and soap before milk to prevent milk contamination from the milker's hands. There is also need to clean hands between milking of two cows to avoid cross-transferring bacteria from one cow's udder to another.

6.1.2.2 Clean clothes

There is need for the person milking the cow to wear clean clothes or shoes. Dirty clothes or shoes can be a source of bacteria that can contaminate the milk.

6.1.2.3 Avoid dipping hands in the milk during and after

The person doing the milking should always avoid dipping his/her hands in the milk during milking. There is a tendency to dip hands in the milking bucket during milking by some dairy farmer to use the milk as a lubricant in the milking process; this is to be avoided at all times.

6.1.2.4 Health of the milker

The person milking the cow should not be suffering from any communicable disease or have open sore or abscess on any of his/her uncovered body. Avoid coughing or sneezing over milk or milk containers.

6.1.3 Clean barn and milking environment

Cleanliness and design of the barn is very important for clean milk production. A dirty barn will promote the growth of bacteria with can either contaminate the milk during milking or can infect the udder. The floor of the barn must be durable and easy to clean, preferably made of concrete if funds are available. Milking should be done in a well- ventilated barn with adequate lighting.

6.1.4 Use of appropriate utensils

The major source of milk contamination is the use of inappropriate and/or unclean utensils. These are milking, storage or transportation equipment that cannot easily be cleaned or sanitized. These include use of jerry cans and buckets made of non-food grade plastic. The inappropriate equipment can harbor microbes in the cracks or crevices that develop as a result of its continuous usage. Metal containers such as aluminum and stainless steel cans are recommended under the code of hygiene practices.

6.1.5 Cleanliness of utensils

Milking vessels and equipment must be cleaned every time after use. Cold clean water should be used first to rinse the milking utensils; this will ease the removal of the milk residuals on the surface of the utensils. This should be followed by sanitization with boiled water or/and soap. Soap without perfume is preferred. Then dry the utensils as quickly as possible in the sun on a drying rack. Store the utensils upside down off the ground when they are not in use.

6.1.6 Milk storage and effects of temperature

Most small scale dairy farmers do not have cooling facilities. It is very important to cool milk and store it at the lowest temperature practically possible if the milk cannot be delivered to the cooling center within 2-3 hour after milking. This is practically important for evening milk for dairy farmers living miles away from the cooling center. During the 2-3 hours after milking the

milk is protected from spoilage by the inherent natural antibacterial substances that inhibit the growth of spoilage bacteria.

If the milk is not cooled for more than 2-3 hour, the natural antibacterial substances in the milk denatures, giving chance to the bacteria in the milk to multiply rapidly, hence converting milk lactose into lactic acid and causing the milk to start souring. High storage temperatures result in faster microbial growth and hence faster milk spoilage.

There are simple means of cooling so that the antibacterial substances are not denatured to preserve the milk quality. These means of cooling include immersing the milk cans in ice blocks or cold water in a trough in cases where there is no domestic refrigerator. Cooling milk to less than 10 °C may prevent milk spoilage for up to three days. If fresh milk (unpasteurized milk) is kept chilled at 4 °C for more than 3 days, the cold-tolerant bacteria will multiply and produce lipase and protease enzymes that break down milk fat and proteins respectively.

6.1.7 Transportation vessels

Vessels used in transporting milk to the cooling center must meet the specifications in the code of hygienic practices. Vessels made of copper or copper alloys should not be used for milk as copper oxidizes butterfat, resulting in off-flavors. Aluminum and stainless steel containers are ideal for milk transportation for the following reasons:

- Have smooth finishes free from open seams, cracks and rust
- Easy to clean and sanitize

6.2 Effects of adulteration

There is a tendency of adding water or other substance such as margarine, coconut milk, or cassava to the milk. This is done either to increase the volume or gravity of the milk. This is a problem in most developing countries. Adulteration is illegal because it alters the natural composition of milk and can introduce harmful bacteria and other dangerous substances in the milk.

6.3 Effects of antibiotics

Milk from cows on antibiotic treatment should not be sold until the specified withdrawal period has elapsed. Most antibiotics circulate in the blood and are secreted in the milk for up to 72 hours while the long acting antibiotic remains longer in the blood.

6.4 Effects of mastitis

With poor hygiene, the percentage of cows with mastitis is higher as compared with cows under good hygiene management. Mastitic milk has more whey protein, less casein and less water-soluble vitamins. It is also more alkaline, has a higher chloride content than the normal milk and it tastes salty. Cows suffering from mastitis should be milked last and their milk from mastitic quarters discarded.

6.5 Milking routine

There are some important steps that need to be practiced on a daily basis for good quality milk production. Some of the steps that need to be followed are;

(i) Washing the udder with warm water and a clean towel before milking, this helps in reducing milk contamination and also stimulates milk ejection

(ii) Remove the fore milk into a black strip cup, this helps to check for abnormalities in the milk like color or blood clots, discard the fore milk

(iii) Make sure you complete milking within 5 to 6 minutes from cleaning the udder, after 6 minutes, the stimulation effect of release of oxytocin wanes

(iv) Dip teats in a post dip disinfectants, this prevents infection of the udder

(v) After use, milking utensils must be cleaned with cold water first and then hot water with disinfectants (i.e. soap) and dried in the sun on a drying rack, non-perfumed soap is preferred

(vi) Milkers must be healthy and not suffering from contagious diseases

(vii) Only healthy cows should be milked, cows suffering from mastitis should be milked last and their milk should be discarded

(viii) Milk should be cooled immediately

Session 7

7.0 Housing

Dairy cow housing is one of the essential needs for a better performance of the cow. Good dairy housing will help to achieve high milk yields and high milk quality. Feed, water and environmental conditions and air are essential elements in the production of quality milk.

A good barn design should always take into consideration the following barn components:

- Feeding and water areas
- Resting areas
- Floor surfaces
- Ventilation
- Light
- Position of the barn (in reference to water movement)
- Size of the barn
- Milking area

The above components of dairy housing influences the cow's willingness and ability to consume large volumes of fresh, good quality feed and water very easily, comfortable and without risks of injuries.

7.1 Feed and water areas

A good dairy barn design should make water and feed availability to the cow more convenient. Limited accessibility to feed and water can limit the production and profit potential of a cow. Feeding areas should allow the caretaker to perform the tasks of feed delivery with minimal risks. The position of the feeders and the drinkers should be at a position where caretakers should also complete the tasks of observation, maintenance and cleaning easily.

Feed space design is also important for feed intake. A 24" feed platform design per animal is recommended. If it is 15" to 18", feed should always be available, meaning there is need for frequent refills of the feed in the feeders. The eating surface elevation should be 4" to 6" higher than cow's standing elevation.

7.2 Resting areas

A good housing should be designed in a way to encourage the cow to have a lot of hours lying-down than standing up or walking around. Good housing will have the resting areas on a good shelter with good beddings. A lot of resting hours will result in increased milk yield as there is not energy wastage by the activity of standing or walking.

There is great need to change the bedding of the resting area for production of good quality milk. Unchanged bedding will turn out to be microorganisms breeding ground which end up infecting the udder or get into the milk during milking. Therefore changing of the bedding once they seem dirty is a must to prevent mastitis and milk contamination.

There are different materials that are used as bedding in the resting areas. A good bedding material should be able to balance cow's comfort with cleanliness. It is important to provide a disease-free resting area. Sand is one of the recommended bedding materials that is able to balance cow's comfort with cleanliness. Cow's comfort on sand can be test by using "the knee test", while on the cleanliness, manure is easy to remove on the sand and sand does not promote

microbial grow. In areas where sand is a problem, other material like, wood shavings, sawdust, groundnut shavings, and straw can be used for bedding.

7.3 Floor surfaces

A good floor surface of a barn should be easy to clean, preferably made of concrete if funds are available. The floor should not be slippery; slippery surfaces put the cow in danger of injuries. The floor should be designed for easy cleaning and water drainage in case of the rain water.

Avoid muddy or dusty floors. Muddy floors are difficult to clean and can be a good source of udder infections while the dusty floors have also the health risks to both the cow and the caretaker. We also want the cow to have a confident footing.

7.4 Ventilation

Good barn construction is designed in a way to allow good air circulation. Due lack of electricity or any other source of power by the small scale dairy farmers in Malawi, the barns are designed in a way to that they must rely on natural ventilation. There is need for adequate air floor or exchange in the barn to minimize the favorable conditions for microbial multiplication and cooling the cow as the cows produces a lot of heat as it digests.

Poorly ventilated barns will result in the increased chances of structural members deteriorating faster than in those with good ventilation because inadequate air exchange allows water vapor to condense on the interior surface making the lifespan of the building shorter. This also provides the two main requirements for bacterial growth available in the barn, which are moisture and high temperature. Evidence of inadequate ventilation also includes the presence of foul odors in the barn.

7.5 Light

There is need for efficient lighting in the barn, a good barn design will make sure that the barn has good natural light available. This is good for the cow milk production, caretaker's and cow's sight for easy activities in the barn i.e. movement. It is recommended to have 16 hours of light and 8 hours of dark for an increased milk yield. This is a problem in area where electricity is not available.

7.6 Position of The barn

The position of the barn is very important when it comes to the rainy season. Barn that are positioned in the low land tend to have floods in the barn.

7.7 Size of the barn

The size of the barn should not be too big to encourage cow movement and at the same time should not be too small to overpopulate the cows in a small barn.

7.8 Milking area

Design of the milking area is also important for dairy production operation. The milking area should be designed in a way to keep the animal the animal is fixed not to move or kick the milking bucket. The design of the milking area should also include a feeder.

Practical exercise in hand milking and mastitis control

Objectives

The objectives of this one-hour practical exercise is to enable participants to:

- Learn how to milk a cow hygienically
- Test for and identify cows with clinical and sub-clinical mastitis

Materials required

- Five to ten lactating cows – at least one with known sub-clinical mastitis
- Appropriate milking buckets
- Clean towels (one per cow)
- One strip cup (black cup)
- Two or three CMT paddles
- Warm water
- Udder disinfectant (milk salve)
- Soap (un perfumed)
- Record form/book

Activity procedure

- Pour clean warm water into a bucket or if sodium hypochlorite is available add adequate amount to cold water until the water has a distinct smell of chlorine
- Take one of the milking cows into the milking cubicle
- Wash the udder with the warm or the chlorinated water
- Dry the udder with the clean towel
- Squeeze a few strips of milk onto the black surface of the strip cup. Examine the milk for any abnormalities like clots or blood stains. Presence of clots or blood stain indicates that the cow is suffering from mastitis. If there are no clots or blood stain in the milk, proceed to the next step
- Take a CMT paddle and squeeze a few squirts of the milk from each quarter of the udder into each compartment, labeled A, B, C and D or 1, 2, 3 and 4
- Add CMT reagent
- Record your observations on the provided form
- Take a clean, dry bucket and start milking by squeezing and releasing the teats (demonstrated by an experienced milker)

- Make sure you complete milking within 5-6 minutes
- After finish milking, apply udder disinfectant
- Make sure that animal is not laying-down before complete closure of the teats. This can be achieved by giving concentrates to the cow after milking
- Cool the milk as soon as possible

Mastitis test record form

Cow No./name	**Lactation No.**	**Month in Lactation**	**CMT test results**			
			Q1	**Q2**	**Q3**	**Q4**

Key for CMT mastitis test

- Negative

+ Slightly positive
++ Positive
+++ Very positive

APPENDIX B
QUESTIONNAIRE

THE IMPACT OF DAIRY MANAGEMENT TRAINING OF SMALL SCALE DAIRY FARMERS ON MILK YIELD AND QUALITY IN MALAWI

Introduction

I am a student at the University of Florida in the United States pursuing a MSc Degree course in Dairy Management. As part of my studies I am required to do a project as a partial fulfillment of the requirements for the Master of Science degree in Animal Science.

The information to be obtained in this questionnaire will be confidential and will contribute to the body of knowledge about the effect of Dairy Management Training Skills on the quality and yield of milk in Malawi.

Date of Interview_____
Name of Enumerator _____
Questionnaire Number_____
Study Type_____

PERSONAL INFORMATION

Name of Respondent_____

District_____

Village_____

Milk Bulking Group (MBG) _____

Sex	Age	Education	Marital Status
☐ Male ☐ Female	☐ 18-23 ☐ 24-30 ☐ 31-35 ☐ 36-40 ☐ 41-above	☐Primary ☐Secondary ☐ Tertiary ☐ None	☐ Single ☐ Married ☐ Divorced ☐ Separated ☐ Widowed

(A) Animal Nutrition management

(1) How many Dairy cows do you have?

☐ Not more than two

☐ More than two

(2) What is the breed of your dairy cows?

☐ Local Zebu

☐ Pure exotic dairy breeds (Holstein, Friesian)

☐ Cross breeds

(3) What is the average milk yield of your dairy cow per day?

(4) How much milk does your family consume weekly?

☐0-5 liters

☐ 6-10 liters

☐ More than 10 liters

(5) Do you grow your own pasture?

☐ Yes

☐ No ⟶skip to question 5

(6) What type of forage do you grow?

Name of forage	**How much is grown (acres)**

(7) Do you feed your dairy cows any feed supplements?

☐ Yes

☐ No ⟶skip to question 8

(8) If yes to the above question, describe what you

Feed _____

When _____

How often _____

(9) Do you give your dairy cows any mineral supplement?

☐ Yes

☐ No ⟶skip to question 9

(10) If yes to the above question, describe what you

Feed _____

When _____

How often _____

(11) Describe any training that you have received in feeds and feeding since you started dairy farming?

_____

_____

_____

_____

(12) Are there any Dairy extension educators within your Milk Bulking Group?

☐ Yes ⟶Skip to question 12

☐ No

(13) If there are no dairy extension agents in your Milk Bulking Group, who provides you with advice related to dairy management?

_____

_____

(14) What do you believe you need in order to be able to increase production?

☐ Training in animal husbandry

☐ Good dairy cow breeds

☐ Dairy feeds

☐ Money

☐ Other(s) _____

_____

(15) Does the fee structure of an MBG limit your interest in joining the MBG?

☐ Yes

☐ No

(16) What benefits would you expect to get if training in dairy management was offered to you?

_____

_____

_____

For Enumerator: Please comment on

(a) Was there water available to animal at the time of your visit?

☐ Yes
☐ No ⟶ Skip to (d)

(b) If yes to the above question, how was the quantity?

☐ A lot
☐ Enough
☐ Not enough

(c) How was the quality of the water?

☐ Clean

☐ Dirty

(d) Was there any feed available to the animal at the time of your visit?

☐ Yes
☐ No ⟶ Skip to question 15

(e) If yes, what type of feed was available?

_____

_____

(f) How was the quantity?

☐ A lot

☐ Enough

☐ Not enough

B. Basic Milking Skills

(17) What kind of utensils if any, do you use when milking your cows?

☐ Plastic bucket
☐ Aluminum mental containers

(18) Could you please describe what you have to do to care for your milking equipment?

_____
_____
_____

Please Note How often _____

(19) Have you or any member of your MBG ever received any basic training in milking cows?

☐ Yes
☐ No ⟶ Skip to question 19

(20) If yes to the above question, can you please describe the training you received?

_____
_____

_____
_____
_____

(21) Have you used teat dip?

☐ Never heard of
☐ Never used but aware of its existence
☐ Frequently (almost every day)
☐ Occasionally (once in a while)
☐ Always

For Enumerator: Please comment on

(a) Are the milking utensils clean at the time of your visit?

☐ Yes
☐ No

C. MARKETING

(22) Has your milk ever been rejected at milk collection center?

☐ Yes
☐ No ⟶ Skip to question 22

(23) If yes to the above question, what was the main reason?

☐ Milk adulteration
☐ Milk souring

(24) Do you feel that the Milk Bulking Group is adequately meeting your needs with regards to?

Milk Quality	Milk Quantity	Milk Marketing
☐ Strongly disagree	☐ Strongly disagree	☐ Strongly disagree
☐ Disagree	☐ Disagree	☐ Disagree
☐ Neutral	☐ Strongly agree	☐ Strongly agree
☐ Agree	☐ Agree	☐ Agree
☐ Strongly agree	☐ Strongly agree	☐ Strongly agree

(25) How are quality measures being followed at your Milk Collection Centre?

_____
_____
_____

(26) Is the milk marketing system rewarding quality?

☐ Strongly disagree
☐ Disagree
☐ Neutral
☐ Agree
☐ Strongly agree

(27) How are the milk prices determined?

_____

(28) Does your milk reach the Market (milk collection center) in good condition?

☐ Strongly disagree
☐ Disagree
☐ Neutral
☐ Agree
☐ Strongly agree

(29) If it does not reach the market in good condition, why is that the case?

_____
_____

(30) What would you think should happen to reduce milk spoilage before it reaches the milk collection center?

_____
_____

(31) Do you think basic training milking management would reduce milk spoilage/rejection at the milk collection center?

☐ Strongly disagree
☐ Disagree
☐ Neutral
☐ Agree
☐ Strongly agree

(32) What do you think of the current milk marketing system in relationship to the growth of the dairy industry in Malawi?

_____
_____
_____
_____

D. HOUSING

(33) How do you clean the animal's house/barn?

_____
_____

(34) How often do you clean it?

_____

(35) Where do you dispose the manure?

☐ In the crop field
☐ Pit latrine
☐ Anywhere

For Enumerator: Please comment on

(a) The roofing of the house/barn

☐ Good (provides good shade and does not leak)
☐ Adequate

☐ Bad

(b) Your own assessment on the cleanliness of the house/barn

☐ Clean
☐ Not clean

(c) Animals space in the house/barn

☐ Good
☐ Not good

E. DISEASES

(36) Could you describe what mastitis is? (if no, skip to question 40)

_____
_____
_____

(37) If yes to the above question, have you ever experienced it/have you experienced it since the first visit?

_____
_____

(38) Are you able to identify by yourself that your animal has mastitis?

☐ Strongly disagree
☐ Disagree
☐ Neutral
☐ Agree
☐ Strongly agree

(39) Do you know any cause(s) of Mastitis?

☐ Yes
☐ No

(40) If yes to the above question, how do you prevent mastitis?

_____
_____

(41) How do you treat mastitis?

_____
_____
_____

(42) Do you still milk the sick animal(s)?

☐ Yes
☐ No

(43) If yes to the above question, can you please describe how you milk these sick animal(s)

_____
_____
_____

(44) What do you do with the mastitic milk?

_____
_____
_____

APPENDIX C
INFORMED CONSENT FOR THE NON-TRAINED FARMERS

Protocol Title: Small scale dairy management in Malawi.
Purpose of the research study: To observe small scale farmers' dairy management on milk yield and quality in Malawi.

What you will be asked to do in the study:
You will first be asked to participate in a dairy management survey. You will also be visited at least once a month for 5 months for information of your farm activities like milk yield, diseases, vaccination, artificial insemination and others. At the end of the program, you will also be asked to participate in another management survey.

Time required:
1 hour per month for 5 months.

Risks and Benefits:
There is no potential risk that is identified by the program. Potential benefits to the participants include knowing their position in dairy production at the end of the program.

Compensation:
There will be no compensation.

Confidentiality:
Your name will not be used in any report. No circumstance will need to disclose your identity. Your name will be assigned a code number and the list connecting your name and the code number will only be accessible by me and my supervisor. On completion of the study, the list connecting the number codes with the names will be destroyed.

Voluntary participation:
There is no penalty for not participating in this study. Your participation is completely voluntary.

Right to withdraw from the study:
You have the right to withdraw from the study at any time without consequences.

Whom to contact if you have questions about the study:
Donald Kazanga, Ndatani Investment, Box 1928, Lilongwe, Malawi. Phone: (265) 1 920 650. Cell: (265) 999 304 354
G. E. Dahl, PhD, Department of Animal Sciences, Box 110910, University of Florida, Gainesville, FL. 32611-0190. Phone: (352) 392 1981; ext. 221 Cell: (352) 275 8162

Whom to contact about your rights as a research participant in the study:
IRB02 Office, Box 112250, University of Florida, Gainesville, FL 32611-2250; phone 392-0433.

Agreement:

I have read the procedure described above. I voluntarily agree to participate in the procedure and I have received a copy of this description.

Participant: _____Date: _____

Principal Investigator: _____ Date: _____

APPENDIX D
INFORMED CONSENT FOR THE TRAINED FARMERS

Protocol Title: Impact of training small scale dairy producers in Malawi.
Purpose of the research study: To assess the impact of training in good dairy management on milk yield and quality in Malawi.

What you will be asked to do in the study:
Before attending the training in good dairy management, you will be asked to participate in a dairy management survey. After being trained in good dairy management, you will be asked to follow the stipulated guidelines of hygienic milking. You will also be asked to keep records of your farm activities like milk yield, diseases, vaccination, artificial insemination and others. You will also be asked to improve your animal's barn to approach that of an ideal barn. You will also be asked to make sure that there is always feed and water available for the animals all the time. At the end of the program, you will also be asked to participate in another management survey.

Time required:
Training for 3 hours for 5 days (2 days for lectures and 3 days for demonstration)
1 hour per month for follow up for 5 months.

Risks and Benefits:
There is no potential risk that is identified by the program. There are a number of potential benefits to the participants which include: learning new dairy management skills, improving milk yield and quality and also change in attitude and behavior.

Compensation:
There will be no compensation, but soft drinks and snacks will be provided to the participants during the 2 days of lectures.

Confidentiality:
Your name will not be used in any report. No circumstance will need to disclose your identity. Your name will be assigned a code number and the list connecting your name and the code number will only be accessible by me and my supervisor. On completion of the study, the list connecting the number codes with the names will be destroyed.

Voluntary participation:
There is no penalty for not participating in this study. Your participation is completely voluntary.

Right to withdraw from the study:
You have the right to withdraw from the study at any time without consequences.

Whom to contact if you have questions about the study:
Donald Kazanga, Ndatani Investment, Box 1928, Lilongwe, Malawi. Phone: (265) 1 920 650. Cell: (265) 999 304 354
G. E. Dahl, PhD, Department of Animal Sciences, Box 110910, University of Florida, Gainesville, FL. 32611-0190. Phone: (352) 392 1981; ext. 221 Cell: (352) 275 8162

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IRB02 Office, Box 112250, University of Florida, Gainesville, FL 32611-2250; phone 392-0433.

Agreement:

I have read the procedure described above. I voluntarily agree to participate in the procedure and I have received a copy of this description.

Participant: _____Date: _____

Principal Investigator: _____Date: _____

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BIOGRAPHICAL SKETCH

Donald Tatha Kazanga was born in Zomba district, southern region of Malawi. His home village is Mbera, Traditional Authority Kaphuka in Dedza district, in the central region of Malawi. He is a fourth born in a family of five with two brothers and two sisters. He grew up with his parents. He attended his primary education in different schools in all the three regions of Malawi. He did his secondary education at William Murray Secondary School in Lilongwe district. Thereafter, he was selected to Bunda College where he graduated with a Bachelor of Science degree in Agribusiness Management in the year 2008. Upon graduation, he joined his father in managing a family business. In 2010, Donald got a scholarship to pursue a master's degree in animal sciences at the University of Florida in the U.S. with financial support from United States Agency for International Development (USAID) under the supervision of Dr. Geoffrey Dahl, who was the current Chair of the Department of Animal Sciences. Donald's focus has been on dairy management. Donald is the first Malawi to get this scholarship from while working for a private institution as all the other beneficiaries of this scholarship have come from Government Departments.