ABSTRACT

SINDANI, WANANGWA GIFT. The Dairy Industry in Malawi- A Description of the Milk Bulking Groups in Malawi. (Under the direction of Dr. Jonathan Allen.)

The Malawi dairy industry consists primarily of cattle milk and is only a very small proportion of the live stock subsector and agricultural sector. Small holder farmers are organized into Milk Bulking Groups (MBGs) that gather milk from small holder farmers, store it in cooling tanks, and sell it to processors. There is anecdotal evidence that the milk produced by farmers and subsequently collected by milk processors is of low quality. In addition to the poor quality, milk production is low and the total milk supplied to processing plants only meets about 30% of their total production capacity (Imani, 2004). The objective of this research has been to describe the milk industry focusing in particular on the groups where bulking occurs to identify areas that need to be addressed in order to improve the quality and quantity of milk produced by farmers. Current practices were mapped to desired practices using questionnaires that were administered to farmers, representatives of the bulking centers and participants in a Focus Group Discussion (FGD) in which the MBG participated. The total bacteria count of raw milk, which is an indicator of the hygienic conditions under which milk is produced, was also analyzed. It was determined that in order to improve the quality and quantity of milk, the dairy industry needs to move away from use of low quality breeds, lack of extension workers, poor milk marketing that is characterized by low milk prices, lack or absence of insurance on dairy animals and bulked milk, and frequent electric power failures that affect cooling of milk. The overall bacteria count of raw milk was

found to be high, with a mean of $3.4x10^7$cfu/mL for milk collected from farmers and $4.7x10^7$ cfu/mL for milk collected from bulking centers. The total bacteria count for milk collected from farmers and bulking centers were not significantly different at the 0.05 level. High bacteria counts indicate that the quality of milk produced by farmers and subsequently collected by processors is of poor quality, which calls for better hygienic measures during production and handling of milk.

The Dairy Industry in Malawi-A Description of the Milk Bulking Groups in Malawi

by
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DEDICATION

Dedicated to my son, Stuart

BIOGRAPHY

Wanangwa Gift Sindani was born in Malawi on 7th November, 1975. He earned his bachelor's degree from The University of Malawi-The Polytechnic in Environmental Science and Technology in 2001. He entered the graduate school at North Carolina State University in the Department of Food, Nutrition and Bioprocessing Sciences in August 2009 and will complete his Masters of Science degree in food science in May 2012.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATION

CREMPA- Central Region Milk Producers Association

DAHLD- Department of Animal Health and Livestock Development

DANIDA- Danish International Development Agency

ESCOM- Electricity Supply Commission of Malawi

FDA- Food and Drug Administration

FDC- Focus Group Discussion

FAO- Food and Agriculture Organization

ISO- International Organisation for Standardization

MBG- Milk Bulking Groups

MBS- Malawi Bureau of Standards

MDFA- Mpoto Dairy Farmers Association

MDI- Malawi Dairy Industries

MMM- Malawi Milk Marketing

MPA- Milk Producers Association

MS- Malawi Standard

MSA- Milk Shed Areas

PCA- Plate Count Agar

pH- Power of Hydrogen

SHMPA- Shire Highlands Milk Producers Association

SWOT- Strengths, Weaknesses, Opportunities and Threats.

WHO- World Health Organization

THE DAIRY INDUSTRY IN MALAWI

1 INTRODUCTION

There is anecdotal evidence that milk produced by farmers and subsequently collected by milk processors in Malawi is of poor quality. The bacteriological level of raw milk is generally high and, as a result milk sours quickly (Imani, 2004, Land O`Lakes, 2003). In addition to the poor quality of milk, milk production is low mainly due to lack of good animal husbandry practices, long calving intervals, lack of good quality feed and insufficient veterinary and extension services and, as a result, there is inadequate milk supply to processing plants. The milk supplied to processing plants only meets about 30% of their total production capacity (Imani, 2004). Due to this, some processors have resorted to importing and using powdered milk to meet demand for liquid milk.

The purpose of this study was to describe the Milk Industry in Malawi at the milk bulking part of the process and focusing in particular on the groups where bulking occurs. In particular, our interest was to identify current practices and then compare to desired practices. For this purpose, we gathered data from the farmers of milk bulking groups to identify areas needed to be addressed in order to improve the quality and quantity of milk produced and therefore increase the amount of milk collected at bulking centers. A farmer for this study means any person with one or more milking cows who sells to the bulking center part or all of their milk production. An increase of milk quality and quantity is needed in

Malawi and it is related to economic growth, food safety and food security for the nation. The results and recommendations of the study will be made available for stakeholders and government.

In order to gather information of current and desired practices, we focused on the bulking groups that serve several farmers by collecting and maintaining the milk cold until it is collected by the processors. We used a data gathering tool as "SWOT". SWOT means strengths, weaknesses, opportunities and threats affecting the dairy industry in Malawi. We are confident that the information produced will highlight the need for knowledge on basic animal husbandry, milking and milk hygiene practices and reduction of milk losses at the point of milk production. Raw milk samples were also collected for total bacteria count to determine the bacteria quality of milk during the study.

The primary objective of this study is to determine current and desired practices and issues affecting the milk bulking group of dairy industry and to make recommendations on how to increase milk quality and quantity. In order to accomplish this primary objective we;

1. Conducted a SWOT analysis to gather data from farmers` on current and desired farm practices.
2. Conducted a focus group to map farmers` ideas to change current practices to desired practices.
3. Determined the bacteria count of raw milk.

2 LITERATURE REVIEW

2.1 Origin and Conception of Smallholder Dairying

Rural dairying in Malawi is an old practice with the Malawi Zebu *(Bos indicus)* cattle representing the majority of milking cows (Munthali, 2000). Most Malawians, especially in the North, have traditionally kept cattle for subsistence, prestige and a form of insurance against drought. Milk forms an integral part of the diet of people in the Northern part of Malawi, while the Central and Southern parts generally take it only with tea and coffee. Some farmers convert excess milk into butter, cheese and ghee.

European settlers introduced dairying (exotic breeds of cattle) in the early 1960`s in the Southern region of Malawi. According to The Codex Alimentarius Commission, 2004, a small holder dairy farm is a farm where the number of animals per farm or per herd usually doesn't exceed 10, milking machines are generally not used, milk is not chilled at the producers' level and/or where milk is generally transported in unrefrigerated cans. The time milk takes to be transported to milk bulking centres varies with distance from the farmers' premises to the bulking centers and also with farmers' practices as some keeps the morning's milk and deliver it together with the afternoon's milk. Intensive smallholder dairy farming commenced in 1969 due to growth of townships that led to the installation of processing plants in Blantyre in 1969, Lilongwe in 1973 and Mzuzu in 1974 through the Malawi Milk Marketing (MMM) Project to meet the growing demand of milk in these cities. At that time,

the government organized farmers into milk bulking groups (MBGs) that were run by a committee elected by the farmers themselves to operate collection and checking of milk. The quality checks that were conducted on milk included adulteration (addition of water to milk normally with the aim of increasing the quantity of milk) and sourness (acid test) which is an indicator of microbial growth on the milk. The three milk processing plants later transformed from being public entities to private. In 1985, the MMM project was reorganised and the Malawi Dairy Industry (MDI), a statutory corporation (that run on government subventions), took over the three plants and three dairy farms and was given the mandate to operate commercially. MDI served as a treasury fund, with the purpose of improving and multiplication of livestock for the production of milk and the manufacturing, processing and distribution of milk and its products. In 1997, the three processing plants and farms were privatized. As a result, Dairibord Malawi Limited in Blantyre, New Capital Dairy in Lilongwe, and Northern Dairies in Mzuzu took over the operations of the processing plants that were set up by the MMM. Since then, two private processors, Suncrest Creameries in Blantyre and Lilongwe Dairy in Lilongwe, have started their operations.

2.2 Dairy Industry Overview

The Malawi dairy industry, which is mainly cattle milk, consists of a very small proportion of the livestock sub-sector and agricultural sector. Milk from the informal sector is mainly produced from the Malawi Zebu cattle *(Bos indicus)* and is either home consumed or sold as

raw milk to local consumers. The formal sector has about 4,000 dairy farmers organised into MBGs with a dairy herd of approximately 15,000 cows. These cows are mainly Friesians and crossbreeds of Malawi Zebu producing about 6,500 tons of milk (Imani, 2004). The sector is reliant on smallholder farmers, with just a few large scale farms. There is also an informal sector that moves from house to house selling raw milk directly to consumers, who use it for home consumption. The milk produced by this sector is mainly produced from the Malawi Zebu, producing about 27,000 tons of milk per year according to DANIDA Report, 1997 as reported by Imani, 2004. The Malawi Food Security Bulletin (2009) reported a total of 35,594 dairy cattle in the formal and informal sectors. The trend of dairy cattle and milk production over the years is shown in table 1 below. The table shows that milk production is progressively increasing and this increase is attributed to crossbreeding of the Malawi Zebu (*Boss indicus*) with the exotic breeds.

Table 1: Milk production and dairy cattle numbers

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Number of dairy cattle	7,500	8,200	9,000	10,000	12,700	15,000	17,500	20,000	26,000	30,000
Milk produced (Metric tons/year)	8,500	9,300	11,000	13,000	15,000	18,000	20,000	24,500	30,000	35,000

Adapted fom; Goyder and Mang`anda (2009).

The feeding regime of dairy animals is characterised as pasture with complementary stall feeding. Dairy farmers with no land buy feed for their cattle or obtain roughage from communal land or simply let their animals graze and browse on residues after harvest. Supplementary feeding is becoming popular among dairy farmers, with bran as the most common supplement. However, the high price of dairy mash and other supplements is a factor that constrains farmers from using them.

2.3 Milk Bulking Groups and Milk Production

In Africa, milk production varies from milking a single cow to herds with several hundred cows milked by modern machines. Hand milking is the commonest method used and milk is either consumed raw or processed in traditional ways soon after milking (Dodd, 1986). In Malawi, smallholder farmers are organised into Milk Bulking Groups (MBGs), which are registered and organised by the Milk Producers Association (MPA). These MBG's operate as collection and checking centers. Producers bring milk to these collection points where it is tested for sourness using alcohol test and adulteration using a lactometer before it is being accepted. However, it should be noted that the main objective of MBGs is to gather milk from small holders, store (in cooling tanks), and sell it to the processors. Malawi experiences shortage of electricity and, due to this, the Electricity Supply Commission of Malawi (ESCOM), the sole supplier of electricity in Malawi, rations the supply of electricity to different parts of the country. On average, the blackouts are on daily basis with a minimum

of 2 hours per area per day. This makes it difficult to control the temperature of milk in the cooling tanks. As a result milk quality deteriorates and oftentimes the milk is rejected by the processors and is thrown away. When this happens, it is the smallholder farmer that suffers despite the fact that he might have delivered good quality milk to the bulking center. This wastage of milk is a cost to individual smallholder farmers and it affects dairying negatively. The evidence that the temperature of holding affects bacteria count of raw milk has been presented by a number of investigators (Marth and Frazier 1957, Van Demark and March 1957, Frayer 1930 and Frayer 1934). As a solution to electricity black outs, most of the bulking Centers have acquired diesel or petrol powered generators as back up. The problems faced though are that some generators do not have enough power rating to effectively cool the milk holding tanks. Producers are paid at the end of the month according to the volume of milk delivered to bulking group. Farmers bring milk to MBGs usually by pushbike or by foot and the milk processors pick it up by refrigerated trucks. Because of their nature, MBGs are also often used as focal points for contacting farmers to provide extension services and other related services.

Currently, there are around 5,000 smallholder farmers producing approximately 6,500 tons of milk annually in the formal sector. An average milk bulking group delivers around 528 liters of milk per day. Malawi is divided into three Milk Shed Areas (MSA), Blantyre, Lilongwe and Mzuzu. The Blantyre MSA has 2,700 farmers grouped under 21 MBGs registered under

the Shire Highlands Milk Producers Association (SHMPA). Around 80% of total milk production is produced in the Blantyre MSA. This is because the dairy industry is developed in the Southern Region and also because the Shire Highlands area, which is a high altitude zone, is said to be suitable for dairying, with good feed resources, favorable climate and relatively low disease challenge to dairy cattle. In addition to this, the milk collection network is also well developed in this area with convenient farmers` selling points. Smallholder farmers in the Lilongwe MSA are organized under Central Region Milk Producers Association (CREMPA) and those in Mzuzu MSA under the Mpoto Dairy Farmers Association (MDFA). Zimba et al., (2010) noted that individual farmers produce on average of about 7 liters a day and yet they have the potential of producing up to 40 liters per day. Key areas of investment at primary production level include: cattle breeding, feed growing and feed production, hay production through growing of Rhodes grass and stocking it for sale to farmers, manufacture of cooling tanks and collection equipment and service provision (Malawi Investment Promotion Agency, 2009). Small holder dairying at institutional level is affected by, among other things; lack of investment in farms supplying dairy cattle, inadequate training of farmers' extension agents, and inadequate training of animal scientists at all levels (Munthali, 2000). Constraints at the farm level include low literacy rate of farmers, lack of enterprise specialization, limited resources for investing in cows and pastures and shortage of labour at peak cropping period. There are a number of non-governmental organizations promoting the intensification of dairy production in Malawi. Their roles include but are not limited to research funding, dissemination of technologies to farmers,

capacity building and development. Some non-governmental organizations provide aid/loan to farmers inform of livestock using a pass on "the offspring" strategy where a cow is given to a beneficially who is then expected to give the first female offspring off the animal to another beneficially who is in turn expected to do the same.

2.4 Milk Processing

The beginning and growth of townships such as Blantyre and Zomba in the 1960`s created demand for milk for smallholder farmers. Government at the time realized the importance of milk as a nutritious food and it was also aware of the dangers that were associated with milk such as potential source of zoonotic diseases such as tuberculosis and undulant fever (Brucellosis). The government therefore organized marketing and handling facilities for hygienic processing of milk. With the assistance of the Food and Agriculture Organisation of the United Nations (FAO), a pilot plant was set up in Blantyre in 1971 to purchase fresh milk from producers, pasteurize it and sell it to urban dwellers (Munthali, 2000). Adherence to the quality standards was made more vigorous with the passing of the Malawi Milk Marketing Act, forbidding the sale of raw milk in areas where the new scheme was operating. At present, five dairy processing plants dominate the sector. These plants include the Dairibord Malawi Limited and Suncrest Creameries in Blantyre-Southern Region, the New Capital Dairy and Lilongwe Dairy in Lilongwe-Central region, and Northern Dairy Industries in Mzuzu in the Northern Region. These processors are to a large extent supplied by

smallholder farmers through the MBGs and to a lesser extent by the medium and large sized farms. Local supply of milk only meets around 60% of demand of the dairy processing industry (Imani, 2004). As a result, the industry is reliant upon imported milk to fulfill demand. It is reported that production capacity in total is around 126,000 litres daily and that the capacity utilization is currently around 26% due to shortage of raw milk. All processing plants are therefore heavily under-utilized as shown in Table 2. This, it is reported, is transmitted to consumers as it partly accounts for high consumption prices of dairy products and a large price spread between producer prices and consumer prices.

Table 2: Production capacity and utilization for major dairy processors

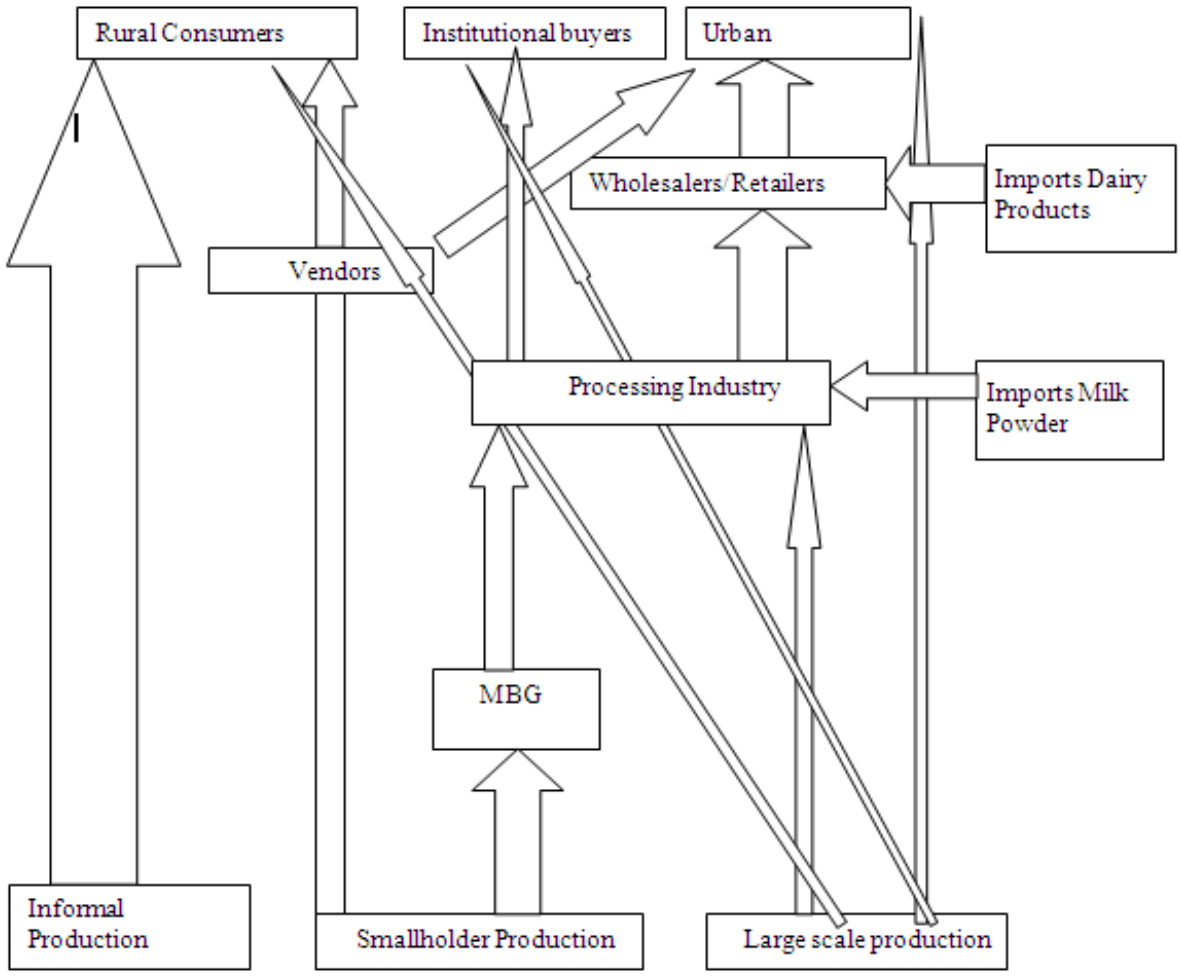
Dairy Processor Name	**Production Capacity (litres)**	**Production Utilization**
Dairibord Malawi Ltd	40,000	12,000-13,000
Suncrest Creameries Ltd	25,000	8,000-10,000
New Capital Dairy	32,000	3,000-4,000
Lilongwe Dairy	20,000	7,000
Northern Dairies	9,000	1,000
Total	**126,000**	**31,000-35,000**

Source: Adapted from Imani Development Consultants, 2004

The quality of milk received from the smallholder farmers is reported to be poor. The bacteriological level of raw milk is very high, and, as a result milk sours quickly. It is reported by Land O` Lakes (2003) and processors that the premises of many farmers are often unhygienic for milk production as are cows and milkers. Processing plants located in Southern Region import small amount of powdered milk as almost 90% of milk is produced in this area whereas plants in Lilongwe rely heavily on imports. The main products produced are pasteurised milk, flavoured and plain yoghurt, cream, butter and cheese. Apart from the five companies, some small processing units (Mafe Dairy, Mpamadzi Dairy, Mpalankhanga Dairy, Katete Dairy, Bvumbwe Smallholder Cooperation, Mweramkaka Dairy Cooperative, Mapanga Dairy and Nature`s Gift) are active around major cities, mainly producing pasteurised milk to sell to urban customers. Most of these small processing units have their own farms and are assured of having milk for their processing.

2.5 Milk Supply Chain

Total milk supplies comprise formal and informal milk production, plus imports of milk and milk products. Imports include all dairy products, such as milk liquid, powder, yoghurt, butter and cheese. Out of these products, the dairy industry only imports milk powder to use in its production processes while wholesalers and retailers directly import milk powder and other dairy products for direct sale to consumers. Most of the dairy imports come from South Africa, New Zealand, The Netherlands, Denmark and Zimbabwe.



Adapted from Imani Development Consultants (2004)

Figure 1: Milk Value- Chain

Figure 1 above shows that most of the milk does not enter the formal circuit at all. Farmers sell their milk for local consumption in villages, institutional buyers or vendors. Although it is not supposed to be allowed according to the Milk and Milk Products Act, vendors sell the

raw milk in town to urban consumers or to institutional buyers. Processors collect milk at the MBG and transport it to their processing facilities. The processed milk products are then sold to the wholesalers, retailers and institutional buyers. Large-scale processors sell their milk straight to processors or have their own processing plants. Smaller quantities are sold to institutional buyers such as hospitals and other organizations. Imported milk powder is reconstituted at the processors for use in their production processes while wholesalers import milk and its products for sale to the retailers who sell to the consumers throughout the country. Milk production estimates in Malawi is as given in Table 3.

Table 3: Milk Production Estimates

Source	**Total Quality (Tons)**	**%**	**Litres/Day equivalent**
Formal	6,500	13	17,808
Informal	27,000	50	73,972
Imports	20,000	37	54,794
Total	**53,500**	**100**	**146,754**

Source: Imani Development Consultants (2004)

2.6 Sanitary and Quality Standards

Malawi Milk and Milk Products Act of 1972, under chapter 67:05 of the laws of Malawi, provides for regulations to improve and control production, processing and marketing of milk and milk products. The act provides minimum specifications to which milk or milk products shall conform, whether as a condition of importation and exportation or sale within Malawi. It also prescribes the manner of handling, transportation, and storing of any milk or milk product intended for use or consumption by any person other than the producer. The Department of Animal Health and Livestock Development (DAHLD), under the Ministry of Agriculture, inspects premises where milk is produced, stored or processed. Each MBG is required to obtain a certificate of registration that specifies the premises with respect to which it is issued. The DAHLD inspects the applicants' premises before a certificate is issued. Individual smallholder farmers are also required to register with their respective MBGs. The DAHLD inspects the farms regularly, checking sanitary conditions and animal health. Milk and milk products, whether produced locally or imported, are subjected to quality tests by Malawi Bureau of Standards (MBS) under the MBS Act, 1972 (chapter 51:02). Under this Act, the MBS is given the mandate to promote quality assurance and standardization in Malawi. The MBS carries out routine inspections 3 to 4 times a year at the processors premises to determine if the establishments comply with the Food and Food Processing Units-Code of Hygienic Conditions (MS21). The MBS also collects samples of milk and its products for testing against the relevant Malawi Standards. The bureau formulates and implements standards that are international based and the following

regulations are related to milk production and processing in Malawi; Raw Cow's Milk-Specification (MS 73:1988), Pasteurised Cow's Milk-Specification (MS74:1988), Yoghurt-Specification (MS 191:1988), Dairy Creams for direct consumption:-Specification (MS 193:1988), Dairy Farming-Code of hygienic conditions for milking (MS 111:1988), Milk and Milk Products- Methods of sampling and analysis (MS 75:1988), Food and food processing units –Code of hygienic conditions (MS 21:2002) and Labelling of prepacked foods-general standard (MS 19:2001). Premises that comply with requirements of relevant Malawi Standards are issued with a Quality Mark and premises who fail to meet the minimum requirements may have their production suspended until critical areas are addressed. With respect to the imported products, the MBS has inspectors at border posts that inspect and monitor imported products. Usually a pre-shipment sample is sent to MBS by the supplier for testing before importation and once samples are approved, importation is allowed. The inspectors at border posts are responsible to check importation documents and visually inspect the products before allowing the shipment in. Samples are taken, where appropriate, for MBS quality testing. The City Assemblies are also involved in enforcement of sanitary regulation using the Hygiene Specifications set by the MBS on milk processors and milk selling points. Their inspectors focus on hygiene of premises, equipment and personnel. The premises that meet the minimum requirements are issued a Food License that allows them to process or sell milk.

2.7 Milk Marketing and Consumption

Milk is consumed whole or it is processed into other products. It is sold in mainly six categories; fluid milk, fermented milk, fresh cream, ice cream, cheese and butter (Kumwembe, 2000). Zimba et al., (2010) noted that currently the country has a processing capacity of 126, 000 liters of milk per day but only half of that volume is processed. Experts believe that scaling up the production and quality of milk would directly contribute, not only to nutritional and food security, but also significantly contribute to accelerating economic growth in the country. The current processed quantities are mainly consumed in the urban and peri-urban areas. Annual milk consumption in Malawi is the lowest in Africa at 5 litres per capita against the World Health Organisation (WHO) recommended intake of 200 liters.

Table 4: Milk Consumption per Capita in Malawi (kg)

Year	1990	1995	1996	1997	1998	1999	2000	2001	2002
Whole milk consumption	5.2	3.7	4.0	4.2	4.0	3.9	3.6	3.6	4.7

Source: FAO Database, 2005/2006

3 DEFINITION OF MILK

Milk is the natural food of the newborn mammal that must be well balanced and complete to serve as sole nourishment (Harding, 1999). Milk is a complex mixture of fats, proteins, carbohydrates, minerals and vitamins and other miscellaneous constituents dispersed in water (Robinson, 1985). It is secreted by mammals for the nourishment of young and the milk of all species is a complex biological fluid containing a wide variety of different constituents and it possesses unique physical characteristics (Robinson 1990, 1981). The availability of a variety of substrates that are available for fermentation such as lactose, fats and proteins makes it a suitable growth medium for many microorganisms (IDF, 1994). Eckles et al. (1982) defined milk as the normal secretion of the mammary glands of mammals secreted for the nourishment of their young. Milk Ordinance and Code recommended by the United States Public Health Services (1953) defines milk as the lacteal secretion, practically free from colostrums, obtained by the complete milking of one or more healthy animals, which contains not less than 8.25% milk solids non fat and not less than 3.25% milk fat. According MS 73:1988, raw milk is defined as that which is obtained from the producing animal without any additions thereto or subtraction there from, and has not been subjected to temperature –time combination which will give negative phosphatase test results, while processed milk is defined as the milk that gives negative phosphatase test results. Foley et al. (1974) stated that milk is a fluid secreted by female mammals to provide food for their offspring's from their birth until they are able to fend for themselves. Milk from seven species of domesticated animals (cows, buffalo, sheep, goat, horse, camel, and yak) has been

used to make traditional fermented milk products throughout the world (Kvoger et al. 1989). People from Africa use milk from cows, sheep, goats and camels. And out of these sources, cow's milk is the most widely produced and processed (FAO, 1990).

3.1 Importance of milk

Milk is a major component in human diet all over the world but, it also serves as a good medium for the growth of many microorganisms, especially pathogenic bacteria. Thus the quality of milk is considered essential to the health and welfare of a community. Cases of dairy illness continue to be of bacterial origin and pathogens that have been involved in the communicable diseases associated with the consumption of milk include *Salmonella, Listeria monocytogenes, Staphylococcus aureus, Campylobacter, Yersinia, Escherichia coli,* and *Clostridium botulinum* (Adesiyum et al., 1995; Hahn, 1996). The safety of dairy products with respect to food borne diseases is of great concern around the world. This is especially true in developing countries where production of milk and various milk products takes place under unsanitary conditions and poor production practices (Mogessie, 1990). Milk is the only food that provides a well balanced array of nutrients that include proteins, fats, carbohydrates, vitamins and minerals in forms that are palatable and highly digestible (Kordylas, 1991, Shah and Khan, 1982). Milk products contain quality proteins such as whey proteins that constitute about 18% of the protein content in milk and casein protein which is only found in milk and accounts for about 82% of total protein in milk (Jensen, 1995). Casein is used as a standard for evaluating proteins because it contains all the essential amino acids.

Proteins are needed in the body to build and repair tissues and to produce antibodies which circulate in blood and help to resist infection. Kon (1972) reported that proteins, calcium, potassium, phosphorous, vitamin A, riboflavin and thiamine are the most important nutrients that are provided by milk to humans. Milk is a low caloric food, hence it is a relatively expensive source of energy. Milk fat is also important in people's diet as it is readily digested and absorbed and is also necessary for calcium absorption. The body readily absorbs calcium that is found in milk; phosphorous plays a role in calcium absorption and utilization, while calcium and phosphorous are needed in proper ratios for bone formation (Walstra, 2002). Walstra also reported that milk is a significant source of riboflavin, vitamin D and vitamin A which helps to promote healthy skin and eyes. Milk and milk products have become a major part of human diet over many years; hence considerable attention has been paid to improving dairy production yield (Harding, 1999). Milk fat suddenly became undesirable after medical scientists claimed that saturated milk fat tends to raise blood cholesterol level that may contribute to heart disease (Harold, 2004). The dairy industry contributes significantly to social and economic growth of countries and its major contributions, in addition to food, include income, manure and social security.

3.2 Composition of milk

Milk is a complex mixture of fats, proteins, carbohydrates, minerals and vitamins and other miscellaneous constituents dispersed in water (Robinson, 1985). The composition of milk varies depending on a number of factors, mainly season, stage of lactation, milking interval,

health of the cow and level and type of feed (Martin, 1979). Foley et al. (1974) reported that the composition of cow's milk varies with individuality of the animal, herd management practices, climate and environmental conditions. The exotic breeds on average have milk composition of 87.3% water, 3.7% fats, 3.5% proteins, 12.8% total solids, 4.8% lactose, 9.1% solids non fat and 0.65% ash (Clarence et al. 1982 and Webb et al, 1980). Pearson (1976) reported 3.6% for fat, 3.29% protein, 4.8% lactose and 0.73% ash.

3.2.1 Milk Fat

Milk fat gives milk its characteristic smoothness, flavour, and colour, and it contains different fatty acids emulsified and dispersed in water in small globules. Elbarbery et al. (1983) reported that percentage fat declines gradually from the beginning of lactation up to 10 weeks and after that the fat percentage increase reaching the maximum value 5.3% at the end of lactation period.

3.2.2 Milk Protein

Milk contains about 3.5% proteins (Webb et al., 1980). Milk protein contains an amino acid composition that is important for growth and development of the young. Milk proteins contain all the 9 essential amino acids required by humans. Walstra (2002) reported that the major whey proteins in cow's milk are the β-lactoglobulins which are important proteins in the synthesis of lactose. There are two major categories of milk protein that are broadly defined by their chemical composition and physical properties. The casein family contains

phosphorus and will coagulate or precipitate at pH 4.6 while the serum (whey) proteins do not contain phosphorus and will remain in solution at pH 4.6. The principle of coagulation or curd formation at reduced pH is the basis for cheese curd making. In cow's milk, approximately 82% of milk protein is casein and the remaining is serum or whey proteins.

Enzymes are proteins that have biological functions. An enzyme has a specific site of action on its target molecule and works at optimal conditions of pH and temperature. Milk enzymes come from several sources; the native milk, airborne bacterial contamination or those from other contact surfaces, bacteria added intentionally for fermentation, or in somatic cells present in milk. It should be noted that enzymes in milk do not make major contributions in the digestion of milk in the human body. Digestion of milk in humans is accomplished by digestive enzymes produced by the stomach and small intestines. Lipases are digestive enzymes that degrade fats. The major lipase in milk is lipoprotein lipase and is associated with casein micelle. Pasteurization inactivates the lipase in milk and this in turn increases the shelf- life of milk. Proteases are enzymes that degrade proteins. The major protease in milk is plasmin. Some proteases are inactivated by heat and some are not. Protein degradation can sometimes be desirable as it provides desired texture to cheese during ripening while some degradation can be undesirable as it may lead to off flavours. Alkaline phosphatase is a heat sensitive enzyme in milk that is used as an indicator of pasteurization. Milk is properly pasteurized if alkaline phosphatase is inactivated.

3.2.3 Milk carbohydrates

The principle carbohydrate in milk is lactose (Filer and Reynold, 1996), which is a natural disaccharide consisting of one galactose molecule and one glucose unit. Filer and Reynold also reported that lactose accounts for about 50% of the solids-non-fat content of whole milk and about 30% of its calories. According to Holsinger (1988), milk contains approximately 4.9% carbohydrates that is predominately lactose with trace amounts of monosaccharides and oligosaccharides.

3.2.4 Milk vitamins

Vitamins have many roles in the body which include cofactors of metabolism, hormone precursors and antioxidants (Öste et al., 1997). Vitamins help the body use carbohydrates, proteins and fats. Milk contains the water and fat soluble vitamins. The water soluble vitamins include thiamine (vitamin B_1), riboflavin (vitamin B_2), niacin (vitamin B_3), Pantothenic acid (vitamin B_5), pyridoxine (vitamin B_6), cobalamin (vitamin B_3), vitamin C and folate. Milk is a good source of thiamine, riboflavin and vitamin B_{12}. Milk contains small amounts of niacin, pantothenic acid, vitamin B_6, vitamin C and folate and is therefore not considered a major source of these vitamins in the diet. The fat soluble vitamins that are contained in milk include vitamins A, D, E and K. The level of fat soluble vitamins in milk depends on fat content of the milk. Milk contains small amounts of vitamin E and K and is not considered a major source of these vitamins in the diet.

3.2.5 Milk Minerals

Milk is a good source of calcium, magnesium, phosphorus, potassium, selenium, and zinc. It also contains small amounts of copper, iron, manganese and sodium and is not considered a major source of these in the diet. Milk minerals have many uses in the body that include enzyme functions, bone formation, water balance, maintenance of the body and oxygen transport. Many minerals in milk are associated together in the form of salts such as calcium phosphate.

3.2.6 Milk water

The percentage of water in milk varies from 84.0-89.0, though occasionally an individual sample may exceed these limits (Clarence et al. 1982). This means that transporting milk from dairy farms to milk processing plants involves moving considerable amounts of water. Milk water holds in solution the soluble constituents of milk. Walstra (2002) reported that water content of milk is dependent on the synthesis of lactose and it ranges from low content in marine mammals to a high content in humans. He also reported that cow's milk contain 87% water.

3.3 Physical Properties of raw milk

The physical properties that are important to raw milk include pH, total solids and temperature.

3.3.1 Total Solids

Khalifa and Bayoumi (1966) reported that the total solids content of cows' milk varied slightly from one season to another ranging from 13.72% to 14.83%. Khalid Eltom and Joseph (1976) reported higher values of total solids in raw milk ranging from 12.13% to 15.39%.

3.4.2 Temperature

The evidence that temperature of holding affect bacteria count of raw milk has been presented by a number of investigators (Marth et al 1957, Van Demark et al 1957, Frayer 1930 and Frayer 1934). They all agree that it is essential to cool raw milk to 10°C or below soon after production to check on the growth of bacteria. Rapid cooling inhibits the metabolism lactic acid bacteria that causes milk to sour and inhibits the growth of bacteria.

3.3.3 pH

Raw cow's milk has a pH of 6.4 to 6.8, making it slightly acidic (Bowen et al, 2005). Microbial souring can be related to as slight a pH change and an early detection of pH change can provide useful information that can ensure thorough processing.

4 MILK PRODUCTION AND HYGIENE

Although the responsibility of ensuring that processed milk and milk products are safe for human consumption and use lies with the manufacturers, there is a continuum of effective

effort and controls needed by other parties, including milk producers, to ensure the safety and suitability of milk and its products. Milk should come from animals in good health, so that, considering the end use; it does not adversely affect the safety and suitability of end product (The Codex Alimentarius Commission, 2004). Areas, including premises used for the production of milk, should be designed, situated, maintained and used in a manner that minimizes the introduction of hazards into milk. In Africa, milk production varies from milking a single cow to herds with several hundred cows milked by modern machines. Hand milking is the commonest method used and milk is either consumed raw or processed in traditional ways soon after milking (Dodd, 1986). Milk is easily contaminated during milking, handling and transport (Panes and Parry, 1980, Kotnis, 1978 and Thomas et al., 1971). Milk is an ideal medium for most bacteria and that is the reason it spoils quickly. The microbial load of milk is a major factor in determining its quality. It indicates the hygienic level exercised during milking, that is, cleanliness of the milking utensils, condition of storage, manner of transport as well as the cleanliness of the udder and of the individual animal. As excellent and healthy as it is when fresh, milk is dangerous for the consumer if it is contaminated. Good hygienic practices should be applied throughout the food chain so that milk and milk products are safe and suitable for their intended use. The proper, clean handling of milk is of sanitarian interest, but it also serves the farmers` interest, because contaminated milk may not be distributed, and is also not suitable for producing good quality products. Regulations have been put in place by different nations and organizations to ensure microbiological, physical and chemical safety of milk.

4.1 Milk contamination

All foods have the potential to cause food borne illnesses, and milk and milk products are no exception. Dairy animals may carry human pathogens and such pathogens present in milk may increase the risk of causing food borne illness. Moreover, the milking procedure, subsequent pooling, and storage of milk carry the risks of further contamination from man or the environment or growth of inherent pathogens. Further, the composition of many milk products makes them good media for the growth of micro-organisms. Potential also exists for the contamination of milk with residues of veterinary drugs, pesticides and other chemical contaminants. Therefore, implementing the proper hygienic control in milk and milk products throughout the food chain is essential to ensure the safety and suitability of these foods for their intended use. Tanwani and Yadava (1983) categorized the organisms found in milk in the following groups: organisms excreted in milk which include *Streptococcus, Brucella, Mycobacterium, Salmonella, Listeria, Candida, Anthrax, Corynebacterium, Cryptococcus, Coxiella, Nocardia* and *Rabies virus*; organisms entering milk from outside environment, which include *Bacillus, Escherichia, Clostridium, Streptococcus, Salmonella, Corynebacterium, Pseudomonas, Acetobacter* and *Alcaligenes*; and organisms excreting toxins that include the following genera: *Staphylococcus, Salmonella, Escherichia, Clostridium, Bacillus* and *Streptococcus*. Microbial contamination of milk may take place in two broad ways; contamination from interior of the udder and contamination from exterior of the udder.

4.1.1 Contamination from interior of the udder

Carash (1944) reported that milk may become a medium of human infection in the following ways: a) the pathogenic organism may cause illness that is common to both cow and human. In such cases the pathogenic organisms get into milk directly from the animal and then infect consumers of raw milk. b) Infected person may contaminate the udder of a cow with pathogenic organisms. The organisms may develop and multiply and be given off in milk which may cause illness to consumers. O'Connor (1995) reported that the species of bacteria found in milk as it comes from the udder are limited to few genera. His findings indicated that majority of pathogenic bacteria found in milk is as a result of cross contamination from the milking environment including equipment.

4.1.2 Contamination from exterior of the udder

Swarthing (1959) reported that under normal practical circumstances, milk is contaminated with organisms from various sources such as dung, water, soil and the cow itself. Thomas et al. (1971) showed that sources of bacterial contamination of milk were the cow, milking environment, farm bulk and milk tanks and pipelines of milking plants. Mclarty (1981) reported a high recovery of bacteria from the teat of a cow with the majority of bacteria isolated being cocci (30%-40%) and aerobic spore formers 50%-60%). Kotnis (1978) reported that milk in the udder of normal healthy cow is usually sterile but it picks up a few organisms as it passes through the teat. Panes and Parry (1980) showed that milking equipment is responsible for high level of milk contamination. According to Dirar (1975),

tropical countries suffer from problems of keeping raw milk fresh for long periods of time due to high ambient temperature, absence of sanitary conditions for production of milk in the dairy farms, poor transportation facilities, and high bacteria counts of raw milk. The France, Center, National, DE coordination des etudes et Recherché Sur La Nutrition (1982) reported that poor quality milk may be due to: mixing of cooled milk with uncooled milk, high temperature of collection tanks, milk kept too long at the farm, inadequate cleaning of collection tanks and infrequent collection rounds. Kotnis (1978) reported that reducing contamination to minimum levels can be achieved by provision of buildings designed to facilitate hygiene, provision of clean water free from coliform organisms, cleaning of udder before milking, proper sterilization of milking equipment, rejection of foremilk, clean lines and good health and personal hygiene of workers. O'Connor (1995) reported that coliform bacteria and members of genus bacillus may enter milk from soil.

4.2 Total Bacteria count

The safety of dairy products with respect to food-borne diseases is of great concern around the world. This is especially true in developing countries where production of milk and various milk products takes place under unsanitary conditions and poor production practices (Mogessie, 1990). Microbial load of milk is a major factor in determining its quality. It indicates the hygienic level exercised during milking, that is, cleanliness of the milking utensils, condition of storage, manner of transport as well as the cleanliness of the udder of the animal (Spreer, 1998; Gandiya, 1999). Bacterial quality of raw milk is important for both

industry and consumers, since high bacteria counts on the farm contributes to poor keeping quality and inferior products (Law, 1979; White, 1993). Many of these microorganisms may come from the interior of the udder, exterior surfaces of the animal or the milk handling equipment and milk handling personnel (Ashenafi and Beyene, 1993). The number of bacteria depends on the cleanliness and health of animals and milkers, cleanliness and sanitation of milking utensils and the age and storage temperature of collected milk (Sartwell, 1977). According to MS 73:1988, raw milk samples at the farm and bulked raw milk at factory shall have a total viable count at 30°C of less than 10^5 per ml and O'Connor (1995) reported that milk produced under hygienic conditions from healthy animals should not contain more than 5 $x10^5$ bacteria/mL. FDA (1997) indicates that the total bacteria count of raw milk from producers should not exceed 3,000,000 cfu/mL while the bacteria road for pasteurized milk should not exceed 20,000 cfu/mL. Even though psychrotrophic bacteria at levels more than $1x10^6$ cfu/mL have been shown to cause quality problems in fluid milk, Titini et al. (1991) reported that milk of good quality may still have psychotropic bacteria in the range of $1x10^3$ to $1x10^9$ cfu/mL. According to the U.S. Department of Health Education and Welfare (1953), milk is graded as "A" when the plate count does not exceed $2x10^4$ cfu/mL; grade "B" when it is $2x10^4$ to $1x10^6$ cfu/mL and grade "C" when it is higher than $1x10^6$ cfu/mL. Grade A Milk is primarily used for direct sales and consumption, and Grade B Milk is used for indirect consumption such as in cheese making and other processing. Grade C Milk is the milk that is produced under few or no restrictions and the only use in which it may be used is that of cooking. Chandan and Hedrick (1979) reported that in order

to produce wholesome dairy products, milk must be of good quality when received at processing plants.

The objective of this study has been to describe the dairy industry in Malawi focusing in particular on the groups where bulking occurs and to identify areas that need to be addressed in order to improve the quality and quantity of milk produced by farmers. The total bacteria count of raw milk which is an indicator of the hygienic conditions under which milk is produced was also analysed.

5 MATERIALS AND METHODS

5.1 Study area

This study was conducted in the Blantyre Milk Shed Area (MSA) in four of its districts, namely Thyolo, Mulanje, Chiradzulu, and Mwanza. In the Blantyre MSA farmers are grouped under 21 Milk Bulking Groups (MBGs) registered under the Shire Highlands Milk Producers Association (SHMPA). Around 80% of total milk production in Malawi is produced in the Blantyre MSA. This is because the dairy industry is developed in this region and also because the Shire Highlands area, in which the Blantyre MSA is located, is said to be suitable for dairying, with good feed resources, favourable climate and relatively low disease challenge to dairy cattle. In addition to this, the milk collection network is also well developed in this area with convenient farmers` selling points. Ten bulking groups (out of the 21) and 100 farmers were selected, by employing purposeful sampling that involved an

intentional selection of informants with a wide range of variation which included age, education and distance from the bulking center. A farmer for this study means any person with one or more milking cows who sells to the bulking center part or all of his/her milk production.

5.2 Study design

This study involved qualitative and quantitative methods. Ritchie and Lewis (2003) described qualitative research as naturalistic and interpretive research approach concerned with understanding the meaning to which people attach actions, discussions, beliefs and values within their social world. They further argue that qualitative methods provide an understanding of the process that people use to make sense of and interpret the world around them. Qualitative researches are characterized by their flexibility. A flexible and interactive strategy is used which allows the discovery of unexpected and important findings. According to Bryman and Burger, (1994) and Hudelson, (1994), one of the most fundamental characteristic of qualitative research is to express commitment to view events, actions, norms, and values from the perspective of the people who are being studied. Bogdan and Biklen (1992) write that qualitative data are mainly collected through sustained contact with informants in settings where they normally spend their time.

Data were gathered from farmers of milk bulking groups' in order to identify current practices and a focus group was conducted to map farmers' ideas to change current practices

to desired practices. Two questionnaires were administered, one for the farmers and the other for the bulking center. Finally a SWOT analysis was carried out using information obtained from the farmers and the bulking centers. A SWOT analysis is a strategic planning method that is used to evaluate the strengths, weaknesses, opportunities and threats involved in a project by identifying the internal and external factors that are favourable to achieving the goal.

Bacteria quality of raw milk is important for both industry and consumers, since high bacteria counts on the farm contributes to poor keeping quality and inferior products (Law, 1979). The number of bacteria depends on the cleanliness and health of animals and milkers, cleanliness and sanitation of milking utensils and the age and storage temperature of collected milk (Sartwell, 1977). Forty eight (48) raw milk samples were collected for total bacteria count analysis to determine the quality of milk as produced by the farmers; 6 samples were collected from Bvumbwe, 3 from Thunga, 5 from Namahoya, 5 from Namitambo, 5 from Chisitu, 5 from Nachambu, 4 from Chonde, 5 from Mangunda, 5 from Mbulumbudzi and 5 from Midzemba. Thirty-nine samples were collected from farmers and 9 samples were collected from the cooling tanks of 9 bulking centers (one sample from each center) for total bacteria count analysis. A sample was not collected from Thunga Bulking Center because the collection vehicle had just collected the bulked milk by the time the researcher arrived. The samples were collected in clean and sterilized (by autoclave) bottles

and immediately transported in ice boxes to the Malawi Bureau of Standards Microbiology Laboratory for total bacteria content analysis.

5.3 Sampling

This study employed purposeful sampling which involved an intentional selection of informants with a wide range of variation which included age, education, and distance from the bulking centre. This type of sampling also ensures that core themes emerging from the study cut across a broad variety of persons who themselves have different experiences with smallholder dairying. Milk sampling was done by the researcher at the bulking centers during usual business times as the farmers brought milk to sell to their respective bulking centers.

5.4 Data collection

Questioning farmers was conducted in Chichewa, the national language in Malawi. The questionnaire for the milk bulking center was in English. The researcher, who is himself a trained inspector and quality auditor with knowledge of food safety and animal husbandry practices, administered all the questionnaires. The investigator tried to create a friendly environment with a warm hand shake to every participant, words such as: ` good to meet you and thank you for accepting to talk with me` were said to make participants feel appreciated and counted.

Focus Group Discussions (FGDs) represent a naturalistic method of data collection because it represents the kind of interaction people have in everyday life. FGDs help to increase depth

of inquiry and accentuate the range and diversity of views and experiences in a group discussion context. The focus group helped to explore and clarify informants' views that were less accessible through one to one interview. Ten participants, one from each of the participating groups, took part in the focus group. The participants were invited to the FGD 3 days in advance and the purpose for the focus group discussion was clearly explained. During the focus group discussion, the atmosphere was livelier. Participants greeted each other before they sat down for the discussions. This created a good feeling to get together among them; some of them may not have met before. The FGDs were recorded with permission from the participants and transcribed for analysis. A Ministry of Agriculture employee with experience with focus group discussions and animal husbandry practices was hired to help the researcher with translation to clarify certain issues. Analysis of data was done manually using principles of thematic content analysis. According to Green and Thorogood (2004), thematic content analysis involves analyzing the content of data in order to categorise emerging common themes.

5.5 Test for total bacteria count

The tests were conducted according to ISO 4833, Microbiology of food and animal feeding stuffs- Horizontal method for the enumeration of microorganisms- Colony-count technique at 30^{o}C.

5.5.1 Culture media

Mast plate count agar (PCA) - Mast Group Ltd., Merseyside, UK, was the media that was used to determine the standard plate count of bacteria. The media was prepared by suspending and swirling 20.5 g powder into 1 liter of distilled water and was autoclaved at 121^{o}C for 15 minutes and then cooled to approximately 45^{o}C for use in pour plates.

5.5.2 Dilutions and Incubation

One milliliter of well mixed raw milk sample was taken aseptically by means of a pipette and mixed well with 9 mL peptone water. After thoroughly mixing, ten-fold dilutions in 9 mL quantities were obtained; 1mL was then mixed with molten plate agar (45^{o}C) and allowed to solidify. Inoculated plates were then incubated at 30^{o}C for 48 hours.

5.5.3 Counting of colonies

Counting of colonies was done using a mechanical colony counter, Stuart Colony Counter (SC6) manufactured by Bibby Scientific Limited, Stone, Stanffordshire, ST15 OSA, UK.

5.6 Statistical analyses

The quantitative data on total plate count was analysed using SAS Software (Cary NC). Specifically, we used ANOVA Tukeys Studentised Range and two way ANOVA.

6 RESULTS

A summary of information obtained on milk bulking centers related to milk bulking groups' size and milk collection practices is presented in **Table 5**. The quantity of milk supplied to the bulking center ranged from 600 liters to greater 4,000 liters a day. Most of the small holder farmers were supplying 10-15 liters of milk in a day. Capacity of cooling tanks for bulking centers ranged from 500 to 36,000 liters and 70% of the centers had adequate cooling tanks to accommodate milk from farmers. All bulking centers reported to have rejected milk from the farmer at one point or the other due to water adulteration and sourness.

Table 5: Completed Questionnaire analysis for milk bulking centers (see Key at bottom of Table)

Nr	Area	A	B	C	D	E	F	G	H	I	J	Average
1	Number of farmers	500	>300	>300	100 to 200	100 to 200	>300	100 to 200	100 to 200	100 to 200	200 to 300	300
2	Day's milk collection,litres	> 4000	2000 to 3000	3000 to 4000	< 2000	< 2000	2000 to 3000	< 2000	950	< 2000	600	2000-3000
3	Adequacy of tank capacity	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	70% adequate
4	Experienced problems with cooling tank	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100% experienced problems
5	Accessibility for milk collection by processors throughout the year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100%
6	Frequency of milk collection	Daily	Daily	Daily	Daily	Every 2 days	Daily	Daily	Every 2 days	Every 2 days	Every 3-4 days	60% collected daily
7	Farmers get reasonable pay	No	No	No	No	No	Yes	No	No	No	No	10% feel milk price is ok
8	Farmers sell milk through vending	No	Yes	No	Yes	No	No	Yes	Yes	No	Yes	50% indicate farmers sell through vending
9	Rejected milk from a farmer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100% rejected milk
10	Milk rejected by processor	Yes	No	Yes	Yes	Yes	No	No	No	No	No	40% had milk rejected by processors

The frequency of rejection (for 9 and 10) could not be established as some bulking groups lacked information on this.

Key:

A- Bvumbwe Bulking group	B- Thunga Bulking Group
C- Namahoya Bulking Group	D- Namitambo Bulking Group
E- Chisitu Buliking Group	F- Nachambo Bulking Group
G- Chonde Bulking Group	H- Mangunda Bulking Group
I-Mbulumbuzi Bulking Group	J-Midzemba Bulking Group

Data obtained indicate that all the milk bulking centers had experienced problems with their cooling tanks and electricity power failure was attributed to be the major cause of the problem (See table 5). Malawi experiences shortage of electricity and due to the fact that the Electricity Supply Commission of Malawi (ESCOM), the sole supplier of electricity in Malawi, rations the supply of electricity to different parts of the country. This makes it difficult to control the temperature of milk in the cooling tanks as a result milk quality deteriorates and oftentimes the milk is rejected by the processors. When this happens, it is the smallholder farmer that suffers despite the fact that he might have delivered his milk of good quality to the bulking center. The evidence that temperature of holding affect bacteria count of raw milk has been presented by a number of investigators (Marth and Frazier 1957, Van Demark et al 1957, Frayer 1930 and Frayer 1934). Forty percent of the bulking centers had their bulked milk rejected by the processors at one time or another. This study however did not try to establish the quantity of milk losses related to cooling tank problems. Fifty percent of the bulking centers indicated knowledge that their membership sells milk through vending.

The study also found out that processors collect milk on a daily basis in 60% of the bulking centers, every 2 days in 30% of the centers and every 3 to 4 days in 10% of the centers. It can be concluded that milk from 40% of the bulking centers, where milk is not collected on a daily basis, is bound to deteriorate and later be rejected by the processors due to frequent electricity rationing being experienced in the country. As a solution to electricity black outs, most of the bulking Centers have acquired diesel or petrol powered generators as back up. The problem faced though is that some generators do not have enough power rating to effectively cool the milk holding tanks. The study also found out that all the bulking centers are accessible to milk collection throughout the year despite the bad state of most roads during the rainy season. Individual processors trucks carry milk from 3 to 10 bulking centers on one trip. Mixing of milk from different bulking groups may also contribute to contamination of milk that is received at the processing plants thereby compromising the quality of processed milk and milk products.

Only 10% of the bulking centers feel farmers are being given reasonable pay for their milk by the milk processors. Most (93%) of the farmers are dissatisfied with the milk price per liter. Dissatisfaction on milk prices and lack of extension workers often times result in mismanagement of cattle by farmers, which often leads to lack of appreciation of dairy enterprises as a business.

Table 6 gives a summary of combined data on information obtained from farmers of all milk bulking groups related to animal husbandry practices and milk hygiene practices.

Table 6: Questionnaire analysis for farmers of bulking groups

Area	**Percentage**
Farmers with 1-3 cows	86.9
Farmers who supply 10-15 liters of milk per day	72.0
Farmers who indicated to have knowledge in milk hygiene & animal husbandry	88.0
Farmers who administer drugs on their own	0.4
Farmers who follow withdrawal period when advised	99.3
Farmers who keep records	82.3
Farmers who are satisfied with milk price	6.4
Farmers who also sell milk through vending	34.0
Farmers who had their milk rejected at one point	58.9

This study found out that 86.9 % of farmers own 1-3 cows on average and one cow produces an average of around 7 liters of milk in a day. It was noted that 34% of farmers sell milk through vending and 59% of farmers had their milk rejected by the bulking center at one point or the other. The study observed that the milk rejected by the bulking centers enters the milk supply chain through vending.

The study found out that 88% of farmers have been trained and have basic knowledge on animal husbandry and milk hygiene. This is because non-governmental organizations that are promoting small holder dairying give basic training to farmers before they can access their resources. Milk bulking centers also organize some training in good animal husbandry and milk hygiene practices to their membership. It was noted that most farmers are not able to put into practice some of the basics they got from the trainings due to poverty and low literacy level. For example, farmers demonstrated knowledge of the need for animals to be provided with good housing but most could not afford the resources that are required to provide for good housing for their animals. Farmers also indicated that their cows are not able to give larger quantities of milk due to poor feeding as approved feeds are expensive to get for most of the smallholder farmers. Farmers only hope that an improvement in the price of milk could help them provide better housing and better feeds for the animals which could in turn improve the quality and quantity of milk. This study found out that only 6.4% of farmers are satisfied with the present pricing of milk per liter. On herd health management, this study found out that 82% of smallholder farmers keep records for individual animals. Data obtained from farmers indicates that only veterinarians prescribe and administer drugs to sick animals. However, the focus group discussions revealed that most of the personnel farmers call veterinarians are not trained veterinarians but just trained to administer artificial insemination to animals on heat. The focus group also noted that farmers have experienced problems including death of cows due to the involvement of these untrained officers in prescribing and administering drugs. Almost all (99%) of the farmers indicated that they

follow withdrawal periods when advised by the veterinarians. However the focus group discussion noted that most of the farmers do not follow withdrawal period and that milk from such farmers enter the milk supply chain through vending fearing the risk of consumers developing resistance to antibiotics. Issues related to who prescribes and administers drugs and adherence to withdrawal period by farmers needs to be investigated and researched by authorities.

The data for bacterial quality of raw milk from farmers in Table 7 below indicate that bacteria counts of milk from farmers were generally high with a mean value of $3.4x10^7$cfu/mL

Table 7: Bacterial count of raw milk samples from farmers of bulking groups

Milk Bulking Group	**Number of samples**	**Bacterial Count cfu/mL**	**Standard error**
Bvumbwe	5	$7.3x10^6$	$\pm 2.6x10^6$
Thunga	3	$7.2x10^6$	$\pm 2.0x10^5$
Namahoya	4	$9.2x10^6$	$\pm 8.5x10^5$
Namitambo	4	$8.4x10^6$	$\pm 5.1x10^5$
Chitsitu	4	$5.7x10^7$	$\pm 3.5x10^7$
Nachambo	3	$5.2x10^7$	$\pm 4.8x10^7$
Chonde	4	$6.9x10^7$	$\pm 1.2x10^7$

Table 7: Continued

Milk Bulking Group	Number of samples	Bacterial Count cfu/mL	Standard error
Mangunda	4	$2.6x10^7$	$\pm 2.4x10^7$
Mbulumbudzi	4	$6.1x10^7$	$\pm 2.0x10^7$
Midzemba	4	$2.7x10^7$	$\pm 2.0x10^7$

Table 8 shows results for bacteria quality of milk from tanks of bulking centers. The data indicate that the bacteria count of bulked milk from the centers were generally high with a mean of $4.7x10^7$cfu/mL. None of the samples tested fell under grade B milk as all registered plate counts of higher than $1x10^6$ cfu/mL as milk is grouped as grade B when it contains between $2x10^4$ to $1x10^6$ cfu/mL.

Table 8: Bacterial count of raw milk samples from bulking centers

Milk Bulking Group	Bacterial Count cfu/mL
Bvumbwe	$8.3x10^6$
Namahoya	$7.8x10^6$
Namitambo	$7.9x10^6$
Chitsitu	$8.6x10^7$
Nachambo	$7.7x10^7$
Chonde	$2.2x10^7$

Table 8: Continued

Milk Bulking Group	**Bacterial Count cfu/mL**
Mangunda	$4.2x10^7$
Mbulumbudzi	$8.2x10^7$
Midzemba	$9.0x10^7$

The total bacteria count for raw milk obtained in this study is generally high compared to the acceptable level of $<1x10^5$ bacteria count per mL (O'Connor, 1995, MS 73:1988). Microbial load of milk is a major factor in determining its quality. It indicates the hygienic level exercised during milking, that is, cleanliness of the milking utensils, condition of storage, manner of transport as well as the cleanliness of the udder of the animal (Spreer, 1998; Gandiya, 1999). Bacteria quality of raw milk is important for both industry and consumers, since high bacteria counts on the farm contributes to poor keeping quality and inferior products (Law, 1979, White, 1993). In general, lack of implementation of knowledge about clean milk production (milk hygiene) and lack of resources, for example, use of unclean sources of water because clean water is a scarce resource in developing countries like Malawi, would be some of the factors that contribute to poor hygiene quality of milk produced in the study area. It should also be noted that Malawi is within the tropics and therefore experiences high prevailing temperatures. Taking this in mind, the time it takes for the milk to be transported from the farmer to the bulking center is important in connection with quality of milk as received at the bulking center. The data analysis in Appendix 1

indicates that bacterial count from raw milk from farmers was not statistically different from bulked raw milk. This indicates that low quality milk that is collected by processors from bulking centers originates from the farmers in this state and that the process of bulking may not contribute much to high bacterial load.

Appendix 2 below shows comparison of bacterial loads among milk of farmers from the ten milk bulking centers using Tukey's Studentized Range Test Method. The data indicates that bacterial loads from milk samples of farmers of the bulking groups were not significantly different at the 0.05 level. This indicates some similarity in the manner milk is being produced by farmers of the groups.

The focus group discussion identified the following, shown in table 9, in order of importance, as current practices and their desired practices including the paths of transforming the current practices into desired practices with the aim of improving dairy farming in Malawi.

Table 9: Current and desired practices as identified and discussed during the focus group

Serial Number	Current Practice	Path to change current to desired	Desired Practice
1	***Milk Marketing*** -Low milk prices per liter that do not compare well with price of cow feed and labour involved. The average price of milk per liter at the time of study was K56.00/l which is about$ 0.3/l -Prices prepared by the milk processors	***Milk Marketing*** Farmers to have a board that will work with government and milk processors to come up with milk prices.	***Milk Marketing*** -Improved milk prices -Prices prepared by farmers, government and processors together
2	***Dairy feed*** -Low quality feed which leads to low milk yield -High prices of feeds compared to milk price -Poor feed production technology	***Dairy Feed*** Government to monitor quality of feeds produced by feed manufacturers. Improved feed production technologies through government research which should be imparted to farmers through extension agents.	***Dairy feed*** -High quality feed which will translate to high milk yield. -Reasonable prices of feed which should compare well with milk price -Improved feed production
3	***Dairy animals*** -Low supply of dairy animals -Low quality breeds in terms of milk production -Insufficient veterinary and artificial insemination services	***Dairy animals*** -Government to invest in farms supplying dairy cattle and breed and supply animals of high quality (High milk production) - Government to secure and make available semen of high quality	***Dairy animals*** -Adequate supply of dairy animals of high quality (High milk production) -Sufficient/adequate veterinary and artificial insemination services

Table 9: Continued

Serial Number	Current Practice	Path to change current to desired	Desired Practice
4	***Agriculture Extension Services*** -Few/no veterinary and agriculture extension workers -Limited knowledge of good animal husbandry practices among the small holder farmers -Lack of professional advice to small holder farmers	***Agriculture Extension Services*** -Government to train adequate veterinary and agriculture extension workers	***Agriculture Extension Services*** -Adequate veterinary and agriculture extension workers -Small holder farmers knowledgeable of good animal husbandry practices and milk hygiene -Readily available professional advice to small holder farmers
5	***Hygiene/animal husbandry practices*** -Lack of knowledge in hand milking, feeding and feed mixing (hay and silage making), heat detection and milk hygiene. -Poor animal housing -Use of unclean equipment in milking and milk transportation to bulking groups -Use of unclean sources of water for cleaning equipment and teats A simplified code of hygiene not available for smallholder farmers use taking into account low literacy rate of most farmers	***Hygiene/animal husbandry practices*** -Government and other stakeholders to formulate tailor made trainings in good husbandry practices and milk hygiene for smallholder farmers -Government and other stakeholders to provide clean sources of water to all areas. -Water from unclean sources to be boiled before use. -Government to simplify and translate code of hygiene and other codes into local languages due to low literacy rate among smallholder farmers.	***Hygiene/animal husbandry practices*** -Farmers trainings in hand milking, feed making and feed conservation, heat detection and milk hygiene. -Improved animal housing -Improved handling of milk during production and transportation -Use of clean sources of water for cleaning of equipment and teats -A simplified code of hygiene should be available to small holder farmers.

Table 9: Continued

Serial Number	Current Practice	Path to change current to desired	Desired Practice
6	***Insurance*** -Animal insurance in place though few farmers insure their animals. This often leads to close down of dairying due to loss of animals which are usually expensive for the smallholder farmer -No insurance on bulked milk	***Insurance*** -Stakeholders, including bulking groups, to sensitize and encourage farmers to insure their animals. -Government and other stakeholders to look into possibility of insuring bulked milk. It was noted that there is none in place at the moment	***Insurance*** -Compulsory animal insurance -Insurance on bulked milk which may help farmers not to lose on milk supplied to bulking center in case of deterioration due to power failure or delayed collection by processors.
7	***Electric power for cooling tanks*** -Frequent power failure leading to deterioration of bulked milk at centers -Low power ratings for stand by generators	***Electric power for cooling tanks*** -Government and other stakeholders should help bulking groups in acquiring generators with adequate power ratings as they are expensive.	***Electric power for cooling tanks*** -Power all day -Generators with adequate power ratings in case of electric power failure.
8	***Drug Administration*** -Untrained personnel involved which have lead to death of animals in most cases -Lack of Veterinary officers/technicians (extension workers)	***Drug Administration*** -Government to train adequate veterinary and agriculture extension workers	***Drug Administration*** Trained personnel to be involved in drug prescription and administration Adequate extension workers for the small holder farmers

Source: Our Focus Group Discussion 25/03/2011

Table 10 shows a SWOT analysis of the dairy industry based on information as given by farmers, bulking centers and focus group discussion. A SWOT analysis is a strategic planning method used to evaluate the strengths, weaknesses, opportunities and threats involved in a project aimed at identifying internal and external factors that are favourable and unfavourable to achieving the objective.

Table 10: SWOT analysis of the dairy industry

STRENGTHS	WEAKNESSES
• A community of farmers that is committed to dairy production and eager to improve. • A society with a tradition in dairy farming and a number of organizations and institutions related to dairy industry. • Low labour costs. • Donor projects in research and production on technical and social economic aspects. • Production of milk by smallholders is progressively increasing year on year.	• Poor infrastructure, especially roads, supply of clean water, electricity and communication. • Most of the milk is produced by smallholder farmers who own 1-3 cows. • An efficient operating of communal milk collection centers was not yet available. • Farmers have poor access to short to medium term credit. • Poor quality of dairy input and service (feed, semen, and extension services). • Farmers are poorly organized, resulting in limited bargaining power. • Seasonality in production due to weather conditions. • Limited or no opportunities for on-farm 'value addition'. • Lack of trained personnel • Quality control at production level is variable.

;

Table 10: Continued

STRENGTHS	WEAKNESSES
	• Low average yield per cow. • Low supply of income to individuals (low buying power)
OPPORTUNITIES	**THREATS**
• Growing local consumers through growth of population. • Government and donors recognize the importance of the dairy sector and give active support. • Much potential to increase milk production per animal through management and (cross) breeding. • Political stability. • Availability of quality standards (regulations).	• Strong competition on regional and international markets. • Natural disasters (outbreak of diseases and drought).

7 DISCUSSIONS

This study identified use of poor breeds and feed, low milk price, lack of extension workers and poor infrastructure (electricity, cooling tanks, and clean water) as areas that need to be improved in order to increase production of milk in Malawi. This finding agrees with the observation made by Munthali (2000), who noted that smallholder dairying at institutional level is affected by among other things inadequate training of farmers extension agents, limited resources for investing in cows and pasture, lack of enterprise specialization and low literacy rate. Thus key areas of investment at primary production level include: cattle breeding, feed growing and feed production, and manufacturing of cooling tanks and collection equipment.

The study also found out that around 72% of farmers deliver 10-15 liters of milk a day to the bulking centers. This finding is similar to Zimba et al (2010), who noted that individual farmers produce on average 7 liters of milk a day and yet have the potential of producing 40 liters per day. This highlights the opportunity that has to be capitalized in order to increase the quantity of milk produced by farmers thereby increasing local supply of milk to processors which is currently around 60% (Imani, 2004).

We found out that milk produced by smallholder farmers that is subsequently collected by processors contain high plate count (with a mean of $3.4x10^7$ cfu/mL and $4.7x10^7$ cfu/mL for milk collected from farmers and bulking centers, respectively). The bacterial load is a major factor and it indicates the hygienic level exercised during milking, cleanliness of utensils, condition of storage and manner of transportation. The time milk takes from production and

its transportation to the bulking center is also important to microbial quality of milk. Marth et al (1957), Van Demark et al (1957), Frayer (1930), and Frayer (1934) agree that it is essential to cool raw milk to 10^{o}C or below soon after production to check the growth of bacteria. With the prevailing high temperatures in Malawi, it will be important to determine the minimum time the milk can stay outside the plant as it will be important to both the farmer and processing company for maximum profit. Foley (1999) reported that high bacteria count is expected under tropical conditions which enhance growth and multiplication of bacteria. Dirar (1975) stated that under tropical conditions, many factors such as high temperature, absence of sanitary conditions for production of milk in the dairy farms and unavailability of cooling during handling and transportation of milk affect the quality of milk.

Constraints to implementation of standards at production and processing levels include; lack of capital to implement standards, inadequate qualified personnel at controlling agencies such as MBS and DAHLD, luck of funding at the Ministry of Agriculture to carry out more regular checks at farm and MBG level and luck of extension workers which relate to luck of advice to farmers on how to improve quantity and quality of milk produced.

8 CONCLUSIONS

The study showed that milk from small holder farmers contains high plate counts, which are an indicator of poor hygiene. The focus group discussion identified 8 current practices that need to be changed if quality and quantity of milk produced by smallholder farmers in Malawi is to be improved. The practices identified are as follows;

1. Current low price per liter of K56.00/l ($0.3/l) should be improved to compare well with price of feed and labour involved in dairy farming and for this to be achieved it was felt that farmers need to have a board that should work with government and milk processors in the process of setting milk price, unlike the current situation where prices are set by milk processors only,

2. Low quality of animal feed that leads to low milk yield where it was agreed that relevant government authorities should implement quality assurance programs and regulations to ensure that dairy feed is produced to the required quality,

3. Inadequate supply of dairy animals that are also of poor quality and it was felt that government needs to facilitate adequate supply of dairy animals of high quality, through research and other interventions, that will lead to high milk yield per animal,

4. The current situation lacks extension workers who are critical in dissemination of new technologies to farmers which might include knowledge of milk hygiene and good animal husbandry practices,

5. Improved farmers knowledge in milk hygiene and basic animal husbandry practices including hand milking, feed making and feed conservation, milk hygiene, animal housing and herd health management.

6. There is also need for animal insurance to be compulsory as this will ensure farmers continue with dairy farming in case of death of their animals. Introduction of insurance on bulked milk should also be looked into as it will help farmers not to lose out in case of deterioration of milk at the bulking center that often leads to processors rejecting the milk,

7. Each bulking group to have a stand-by generator with sufficient power rating in case of fluctuations in electricity supply that in most cases lead to deterioration of milk at the bulking centers.

8. Only trained personnel to be involved in drug prescription and administration and this will only be possible through training of adequate veterinary workers.

Change of these practices, it was believed, could bring confidence into smallholder farmers and hence they could appreciate smallholder dairying as a business. This will in turn improve quality of milk and quantity of milk as farmers will be working towards producing more milk of high quality in order to receive more money.

9 RECOMMENDATIONS

It is recommended that;

a) Farmers should have a board that should work with government and milk processors to come up with milk prices.

b) The hygiene at farmers' production facilities needs to be organized and periodic inspections carried out to determine the effectiveness of the hygiene measures put in place.

c) Bulking centers should explore means (e.g. through loans either from government or other stakeholders in dairying) of providing permanent electricity supply in terms of standby generators of enough power rating.

d) Civic education is recommended to farmers to sensitize them on the need to follow withdrawal period after use of antibiotics in cows.

e) The official authorities should implement quality assurance programs for regular monitoring of dairy feed production to ensure that dairy feed produced meets required specification.

This research project has highlighted several areas which are themselves areas of further studies and inquiry;

a) The quantity of milk lost due to fluctuation in electricity supply at bulking centers that often leads to deterioration of milk and later rejection of this milk by processors needs to be investigated.

b) It will be important to measure quantitatively levels of adherence to withdrawal period by smallholder farmers after use of antibiotics in dairy cattle as consumption of such milk is associated with the development of resistance to antibiotics in consumers

c) The time a farmer takes between milking and delivering the milk to bulking centre for cooling need to be investigated as it is critical to keeping quality of the milk.

d) The economical loss due to poor organization of smallholder dairying needs also to be researched upon.

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APPENDICES

Appendix 1: Statistical comparison between farmers' milk (A) and Bulked Milk (B) using T-test

Variable	Group	N	Lower CL Mean	Mean	Upper CL Mean	Lower CL Std Dev	Std Dev	Upper CL Std Dev	Std Err	Minimum	Maximum
Milk_sample	A	10	1.47E+07	3.37E+07	5.27E+07	1.83E+07	2.66E+07	4.85E+07	8.40E+06	7.23E+06	7.41E+07
Milk_sample	B	9	1.89E+07	4.70E+07	7.51E+07	2.47E+07	3.66E+07	7.01E+07	1.22E+07	7.80E+06	9.00E+07
Milk_sample	Diff (1-2)		-4.40E+07	-1.33E+07	1.74E+07	2.38E+07	3.17E+07	4.75E+07	1.46E+07		

T-Tests					
Variable	Method	Variances	DF	t Value	Pr > |t|
Milk_sample	Pooled	Equal	17	-0.91	0.373
Milk_sample	Satterthwaite	Unequal	14.5	-0.9	0.3832

Equality of Variances					
Variable	Method	Num DF	Den DF	F Value	Pr > F
Milk_sample	Folded F	8	9	1.9	0.3587

Appendix 2: Tukeys Studentized Range test for milk samples from farmers

Dependent Variable: Milk_sample

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	2.47E+16	2.75E+15	1.95	0.0846
Error	29	4.09E+16	1.41E+15		
Corrected Total	38	6.57E+16			

R-Square	Coeff Var	Root MSE	Milk_sample Mean
0.37647	109.4485	37577323	34333333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Group	9	2.47E+16	2.75E+15	1.95	0.0846

The ANOVA Procedure

Tukey's Studentized Range (HSD) Test for Milk_sample
Note: That this test controls the Type I experimentwise error rate

Alpha	0.05
Error Degrees of Freedom	29
Error Mean Square	1.41E+15
Critical Value of Studentized Range	4.83663

Comparisons significant at the 0.05 level are indicated by *.**

Group Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
F - I	11325000	-79548724	1.02E+08	
F - G	16275000	-74598724	1.07E+08	
F – E	17075000	-73798724	1.08E+08	
F – J	46575000	-44298724	1.37E+08	
F – H	48325000	-42548724	1.39E+08	

Appendix 2: Continued

Comparisons significant at the 0.05 level are indicated by ***.				
Group	**Difference**	**Simultaneous 95% Confidence**		
Comparison	**Between**	**Limits**		
	Means			
I – F	-11325000	-102198724	79548724	
I – G	4950000	-85923724	95823724	
I – E	5750000	-85123724	96623724	
I – J	35250000	-55623724	1.26E+08	
I – H	37000000	-53873724	1.28E+08	
I – C	53550000	-44604840	1.52E+08	
I – D	54325000	-36548724	1.45E+08	
I – A	55450000	-30760384	1.42E+08	
I – B	55516667	-42638173	1.54E+08	
G – F	-16275000	-107148724	74598724	
G – I	-4950000	-95823724	85923724	
G – E	800000	-90073724	91673724	
G – J	30300000	-60573724	1.21E+08	
G – H	32050000	-58823724	1.23E+08	
G – C	48600000	-49554840	1.47E+08	
G – D	49375000	-41498724	1.4E+08	
G – A	50500000	-35710384	1.37E+08	
G – B	50566667	-47588173	1.49E+08	
E – F	-17075000	-107948724	73798724	
E – I	-5750000	-96623724	85123724	
E – G	-800000	-91673724	90073724	
E – J	29500000	-61373724	1.2E+08	
E – H	31250000	-59623724	1.22E+08	
E – C	47800000	-50354840	1.46E+08	
E – D	48575000	-42298724	1.39E+08	

Appendix 2: Continued

Comparisons significant at the 0.05 level are indicated by ***.				
Group	**Difference**	**Simultaneous 95% Confidence**		
Comparison	**Between**	**Limits**		
	Means			
E - A	49700000	-36510384	1.36E+08	
E - B	49766667	-48388173	1.48E+08	
J - F	-46575000	-137448724	44298724	
J - I	-35250000	-126123724	55623724	
J - G	-30300000	-121173724	60573724	
J - E	-29500000	-120373724	61373724	
J - H	1750000	-89123724	92623724	
J - C	18300000	-79854840	1.16E+08	
J - D	19075000	-71798724	1.1E+08	
J - A	20200000	-66010384	1.06E+08	
J - B	20266667	-77888173	1.18E+08	
H - F	-48325000	-139198724	42548724	
H - I	-37000000	-127873724	53873724	
H - G	-32050000	-122923724	58823724	
H - E	-31250000	-122123724	59623724	
H - J	-1750000	-92623724	89123724	
H - C	16550000	-81604840	1.15E+08	
H - D	17325000	-73548724	1.08E+08	
H - A	18450000	-67760384	1.05E+08	
H - B	18516667	-79638173	1.17E+08	
C - F	-64875000	-163029840	33279840	
C - I	-53550000	-151704840	44604840	
C - G	-48600000	-146754840	49554840	
C - E	-47800000	-145954840	50354840	
C - J	-18300000	-116454840	79854840	
C - H	-16550000	-114704840	81604840	
C - D	775000	-97379840	98929840	
C - A	1900000	-91953978	95753978	
C - B	1966667	-102965271	1.07E+08	

Appendix 2: Continued

Comparisons significant at the 0.05 level are indicated by ***.				
Group	**Difference**	**Simultaneous 95% Confidence**		
Comparison	**Between**	**Limits**		
	Means			
D - F	-65650000	-156523724	25223724	
D - I	-54325000	-145198724	36548724	
D - G	-49375000	-140248724	41498724	
D - E	-48575000	-139448724	42298724	
D - J	-19075000	-109948724	71798724	
D - H	-17325000	-108198724	73548724	
D - C	-775000	-98929840	97379840	
D - A	1125000	-85085384	87335384	
D - B	1191667	-96963173	99346507	
A - F	-66775000	-152985384	19435384	
A - I	-55450000	-141660384	30760384	
A - G	-50500000	-136710384	35710384	
A - E	-49700000	-135910384	36510384	
A - J	-20200000	-106410384	66010384	
A - H	-18450000	-104660384	67760384	
A - C	-1900000	-95753978	91953978	
A - D	-1125000	-87335384	85085384	
A - B	66667	-93787312	93920645	
B - F	-66841667	-164996507	31313173	
B - I	-55516667	-153671507	42638173	
B - G	-50566667	-148721507	47588173	
B - E	-49766667	-147921507	48388173	
B - J	-20266667	-118421507	77888173	
B - H	-18516667	-116671507	79638173	
B - C	-1966667	-106898604	1.03E+08	
B - D	-1191667	-99346507	96963173	
B - A	-66667	-93920645	93787312	