ASSESSMENT OF PHYSICO-CHEMICAL AND MICROBIOLOGICAL ASPECTS OF RAW MILK SOLD AT KHARTOUM STATE

By

Mona Mohamed Abd El Frag Ahmed

B.Sc. (Assuit), 1994

Faculty of Dairy Science

Assiut University, Egypt

Supervisor,

Prof. Abdel Moniem Mukhtar Abu Nikhaila

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DEPARTMENT OF DAIRY PRODUCTION

FACULTY OF ANIMAL PRODUCTION

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Dedication

To the pure sole of my father.
To my mother, husband, children,
brothers and sister with ever lasting love
I dedicate this work.

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All praise belongs to Allah who gave me the health, strength and patience to conduct this study.

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ABSTRACT

This study was conducted to evaluate the quality of milk offered for sale from various distribution channels in Khartoum State. Raw milk samples (108 samples) were collected from Khartoum (36 samples), Khartoum North (36 samples) and Omdurman areas (36 samples). From each area, samples were collected from three sources venders, groceries and collection centres.

All samples were subjected to physical and chemical evaluation as well as microbiological examination (Methylene blue test and coliform count). The samples were examined for adulteration by formalin and starch.

The results showed that the highest coliform count was found in groceries (182.68 MPN). The coliform count was higher in Omduran (149.2 MPN) compared to the other two towns (Khartoum and Khartoum North). The highest acidity index (0.201) was shown in Khartoum followed by salable milk in Omdurman (0.159) and the least acidity was recorded in Khartoum North (0.179).

The fat content in milk samples distributed through groceries maintained the highest level (4.2%) and which was significantly ($P < 0.05$) higher than vender's milk and centres. Adulteration by formalin was also evident, which attained a significantly ($P < 0.05$) higher index (1.25) compared to vender's milk (1.05) and centres milk (1.05), while adulteration by starch was not evident.

The results obtained in this study revealed that vender's raw milk was less hazardous to human health.

ملخص الأطروحة

أجريت هذه الدراسة لتقييم اللبن الذي يقدم للمستهلك في ولاية الخرطوم بقنوات التوزيع المختلفة.

تم تجميع 108 عينة من اللبن كالآتي: 36 عينة لبن من الخرطوم، 36 عينة من الخرطوم و36 عينة من منطقة أمدرمان من الباعة المتجولين، البقالات ومراكز توزيع اللبن، ثم تم اختبارها وتحليلها من حيث الصفات الفيزيائية والكيميائية للبن والاختبارات البكترولوجية من حيث العد الكلي لبكتريا القولون واختبار ازرق المثيلين، وغش اللبن بالفورمالين والنشا.

كانت النتيجة كما يلي:

* اعلي عد كلي لبكتريا القولون وجد في البقالات (182.68 MPN) وبالنسبة للمدن كانت امدرمان أعلي عد كلي من حيث الكلورفورم (149.2 MPN).

* أعلي نسبة حموضة (20%) كانت في الخرطوم تليها منطقة امدرمان (0.195%) وأقل نسبة حموضة كانت في الخرطوم بحري (0.179%).

* كانت نسبة الدهن عالية بالنسبة للبن المباع في البقالات (4.2%) وكانت أعلي من لبن الباعة ا لمتجولين ومراكز الألبان.

لمعرفة تأثير إضافة الفورمالين علي اللبن كانت النتائج كالآتي:

* أظهرت النتائج وجود غش بالفورمالين واعلي نسبة كانت بالنسبة للبقالات (1.25)، بينما اقل نسبة كانت عند الباعة المتجولين ومراكز التجميع (1.05).

* كما أظهرت الدراسة عدم وجود غش بالنشا في أي من عينات اللبن.

CHAPTER ONE
INTRODUCTION

Milk may be defined as the normal secretion of the mammary glands of mammals, and is often described as nature's most perfect food (Clarence, *et al*., 1951).

Chemically milk is described as an emulsion of fat in a watery solution of sugar and mineral salts and with protein in a colloidal suspension. The chemical breakdown of normal cow's milk is shown in Figure (1) (Chandan, 1997).

Milk supplies proteins of exceedingly high quality, in addition to liberal amount of calcium and is considered as an excellent source of vitamins necessary to health.

It is estimated that Sudan currently produces 7.1 million metric tons of milk annually. Most of the consumable milk in the country comes from cattle (75%); goats (18%) and (7%) from sheep (Sudan Dairy Sub-sector Dev. Project, 2003).

The raw salable milk in Khartoum State is produced by traditional as well as modern dairy farms. Three traditional dairy production systems exist in the study area, which include:-

1. Small-scale dairy farms attached to arable irrigated lands with traditional husbandry systems.
2. Backyard dairy units joined to owners' homes, the production of which is small.

3. Dakkas erected in open space at the fringes of towns or villages where operators maintain laws for fresh milk production (Saad *et al*., 1986).

Beside these traditional milk suppliers, there are some modern dairy units in Khartoum State, which supply consumers with pasteurized fresh milk, recombined milk and some dairy products.

The bulk of milk consumed in the study area comes from the traditional producers under poor hygienic conditions.

Because of the complex structure of milk, raw milk is a perishable food and is an ideal medium for bacterial growth. This nature renders the product very vulnerable and of short shelf life if hygienic measures are not adopted. In order to maintain the quality of milk, handling should be carried out under strict sanitary conditions.

In the Sudan, however, the handling and processing of milk constitute some of the weakest links and biggest drawbacks in the development of the dairy sub-sector. Not only is the physical infrastructure for collecting milk complicated by poor rural roads infrastructure. There are no established and strategically located milk collection facilities where milk from the farmers can be stored under appropriate conditions as it a waits collection by processing plants or traders. One more aspect added to milk handling problem is the prevailing hot climate of the country and with a lack of cooled transportation facilities, appreciable amount of milk is spoiled even while in transit. The dairy industry in the Sudan is faced with divergent problems including poor husbandry practices, poor handling of raw milk throughout the milking procedures and transportation. Factors such as bad roads, poor infrastructure, lack of cooling facilities, high ambient temperatures and long distances between production and marketing centres, all of which contribute to the dilemma of hygienic milk production.

The above problems are compounded by the relatively poor road network in most rural production centres.

The volume of spoiled milk due to poor handling and/or adulteration is hard to gauge under the prevailing distribution channels and figures in the literature ranged between 5 – 20%.

The present study was initiated to assess the physical, chemical and bacteriological qualities of raw salable milk in Khartoum State from three distribution cites in Khartoum, Khartoum North and Omdurman.

CHAPTER TWO

LITERATURE REVIEW

2. Milk:

Bovine milk may be defined as the liquid from the mammary glands of healthy and normally fed cows.

The composition of milk varies widely depending on a large number of factors including breed, season, stage of lactation, milking interval, health of the cow and level and type of feed. Several authors reported comparable values of milk chemical composition (Table 2.1).

Webb and Arndel (1974) has collected the compositional data for milk from 15 countries and many breeds. The fat content of milk is the most variable component. In certain breeds such as Jersy and

Gurnesy, the fat content may reach up to 8% or higher, while that from Friesian may be close to 3%.

2.1 Composition of milk:

2.2 Total solids (TS):

Khalifa and Bayoumi (1966) reported that the total solids (TS) content of cow's milk in a dairy herd varied slightly from one season

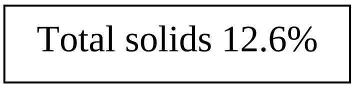
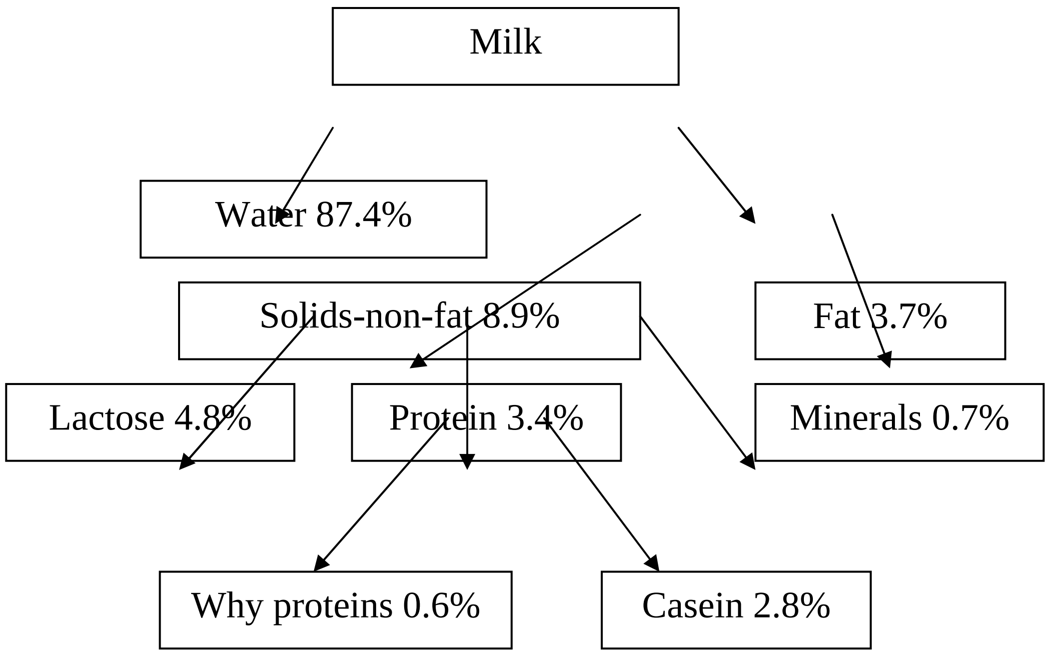


Figure (1); Major chemical components of raw milk (cow’s milk)



Source: Chandan (1997).

Table 2.1: Chemical composition of milk by different authors.

	Richmond [in Davis & Macdonald (1953)]	Davies [in Davis & Macdonald (1953)]	Person, D. (1976)	Webb *et al*. (1974)
Fat	3.75	3.67	3.61	3.5 – 2.7
Protein	3.20	3.42	3.29	3.5
Lactose	4.70	4.78	4.65	4.9
Ash	0.75	0.73	0.75	0.7

FAO Food and Nutritional paper 14/3, (1979).

of the year to the other ranging from 13.72 to 14.83%. Idris *et al*. (1975) reported comparable values of TS to those reported by Khalifa and Bayoumi (1966). On the other hand, Khalid and Joseph (1976) reported higher values of total solids (TS) content of cow's milk varying from 12.13 to15.39%.

2.3 Ash:

Clarence and Combs (1951) reported that milk ash contains potassium, sodium, calcium, magnesium, chlorine, phosphorous and sulfur in relatively large amounts. Beside other small amount of iron, copper, zinc, aluminum, manganese, cobalt and iodine, and traces of silicon, boron, titanium, vanadium, rubidium, lithium and strontium.

Khalid and Joseph (1976) reported that the ash content varies from 0.5 – 0.72%. Bauman (1988) reported that change in milk minerals can influence heat stability of milk proteins and protein coagulation in cheese making.

2.4 Moisture:

In average milk, about 87 pounds in each 100 pounds is water. This water is not different from ordinary water and serves to hold in solution the soluble constituents of milk. The percentage of water varies from 84.0 to 89.0% although, occasionally, an individual sample of authentic milk may exceed these limits. Any variation in the amount of other constituents is also reflected upon the water percentage (Clarence and Combs, 1951).

2.5 Lactose:

Ali (1973) found that lactose in cow's milk ranges from 4.83 – 4.90% while Idris *et al*. (1975) claimed different values of lactose ranging from 3.40 to 6.%. Khalifa and Bayoumi (1966) reported similar values. Philip (1984) reported that milk contains 4.8% lactose (the predominant carbohydrate). Lactose accounts for about 54% of the solids-not-fat of milk and contributes about 30% of the calories of the whole milk.

Clarence and Combs (1951) reported that lactose is found only in milk. It is a reducing disaccharide which, upon hydrolysis, yields one molecule of galactose and one molecule of glucose and it has the formula $C_{12}H_{22}O_{11}$.

2.6 Protein:

Philip (1984) reported that fluid milk contains approximately 3.5% protein, 80% of which is casein, the remainders are whey proteins (globulin and albumin). The casein and whey proteins effectively complement each other to give milk its high biological value.

Politiek (1957) reported that the protein level in milk is heritable with heritability estimates ranging from 0.70 to 0.75. He also reported that fat and protein content were to a high degree inherited independently of each other.

Stone *et al*. (1960) indicated that the steam distillation method can be used successfully to determine the protein content of milk. The average amount of steam distilled nitrogen expressed as precent of total nitrogen was 11.88%.

2.7 Fat:

Floyd and Kurtz (1974) reported that milk fat consists chiefly of triglycerides and free fatty acids, and Joseph (1989) reported that fat should no longer be described simply as saturated or polyunsaturated fat. It contains short, medium or long-chain saturated, mono-unsaturated, omega-3 or omega-t polyunsaturated trans-isomer fatty acids, and more. Khalid and Joseph (1976) reported that fat in the milk of Sudanese cattle is similar to those reported by Khaifa and Bayoumi (1966) which ranges from 3.40 to 5.9%.

2.8 Physical properties of raw milk:

2.8.1 pH:

Bates (1954) found that pH, or hydrogen ion exponent was introduced by Sorensen in 1909 as a convenient way of expressing small hydrogen ion normalities.

Murphy (1982) documented that widespread and longtime usage of pH has caused it to be considered mathematically equivalent to other biological variables. McDowall and McDowell (1937) showed that in general the pH is lower (down to pH 6.0) in colostrum. However, Prouty (1940) indicated that pH higher (up to 7.5) in cases of mastitis than in normal milk of mid-lactation.

Robert *et al.* (1974) reported that pH of cow's milk is commonly stated as falling between 6.5 and 6.7 with 6.6 the most usual value.

2.8.2 Acidity:

Gould (1945) declared the possibility that the breakdown of lactose to lactic acid and other acids was responsible for the increase in acidity.

Ibrahim (1973) reported that the titrable acidity of vendor's milk ranges between 0.18 – 0.20% as lactic acid.

International Dairy Federation (IDF) Bulletin (1983) reported that no significant relationship was found between the freezing point and acidity in fresh milk samples where acidity ranged from 0.12 to 0.18 g lactic acid/100 ml.

2.8.3 Specific gravity:

Robert *et al.* (1974) found that much of the older data is given as specific gravity of milk at 15.5^{o}C where the value for fresh whole mixed herd milk seldom lies outside the range of 1.030 to 1.035 and

1.032 is often quoted as an average value. The density of milk decreases as the temperature is raised.

Siegentholer and Chulthess (1977) highlighted that milk specific gravity is determined by its three major components: water, solids-non-fat and butterfat. Increased butterfat content decreases the spcific gravity of milk while increased solids-non-fat increases milk specific gravity.

2.9 Bacteriological aspects of raw milk:

2.9.1 Methylene blue test:

Jackson (1936) reported that milk drawn from the udder aseptically reduces methylene blue, indicating that its potential is more negative than that of the methylene blue system.

Robert *et al.* (1974) claimed that neither cysteine nor glutathione in the quantities present in milk is apparently able to reduce methylene blue. After an extensive study of different bacterial tests, Wilson *et al*. (1969) recommended the methylene blue reduction test, with inversion of the tubes every 30 min., as the most accurate method of determining milk quality.

Ellenberger *et al*. (1927) also found the methylene blue test as the most accurate measurement of keeping quality.

2.9.2 Coliform test:

Hartley *et al.* (1968) reported that although coliforms constitute a specific group of bacteria in milk, the count is generally used as a routine test to indicate the general care taken in production and processing.

Parr (1969) reported that all aerobic and facultative anaerobic, Gram-negative, non-spore forming rods are capable of fermenting lactose with the production of acid and gas at 3 – 35^{o}C within 48 hr on solid or in liquid media.

McCrady and Langerin (1932) demonstrated that the importance of coliform in milk was recognized as early as 1920, when coli-aerogens determination was first officially suggested in the Report of the Committee of Milk Supply published by the American Public Health Association. However, quality control laboratories were slow in adopting the practice.

Johns (1958) reported that the coliform bacteria in raw milk are rarely assessed in North America except for “Certified” milk. He mentioned that several persons in Europe regard it as the best indicator for clean milking conditions, particularly where farm bulk tanks are used.

2.10 Milk handling and processing:

Joseph (1963) reported that personnel involved in the production and handling of milk may contribute to the microflora of milk. Raw milk available for consumption may serve as a vehicle for the transmission of several diseases, especially enteric and respiratory types. Also he indicated that the level of microbial population in milk would be dependent largely on the extent to which the efforts of personnel will contribute to clean cows in a clean milking environment and to the use of clean milk handling equipment and methods.

FAO Reports (2002) indicated that the handling and processing of milk constitute one of the weakest links and biggest draw-back in the development of the dairy subsector in Sudan. There is no physical infrastructure for the collection, proper storage and distribution of milk; farmers are not well organized for milk collection, proper storage and distribution of milk.

There are no good relationships between producers and milk plant operators; the processing plants are being set by inefficient operations and gross under. Capacity utilization; and some plants' equipment is old and needs modernization and replacement. Milk handling and processing is therefore an area that needs urgent attention if the Sudanese dairy sub-sector is to move forward.

Mohamadi (1988) reported that milk sold by milk venders in Khartoum area is usually produced and transported under bad hygienic conditions.

2.11 Sources of contamination:

2.11.1 Interior of the udder:

Paul Carash and Brooklyn (1944) reported that milk may become a medium of human infection in several ways.

1. The pathogenic organisms may be a cause of illness common to both cow and man. In such cases the bacteria get into the milk directly from the animal and then infect the consumers of the raw milk.
2. The organisms may get into the udder of the cow from an infected person, develop and then be given off in the milk.

O'Conore (1995) reported that the species of bacteria found in milk as it comes from the udder are limited to few genera. The micrococci are generally present in the greatest proportion followed by streptococci and rods.

2.11.2 Exterior of the udder:

Swartling (1959) claimed that under normal practical conditions contamination of milk can result from different sources including dung, water, soil, the cow itself, the milkers and milking facilities.

Paul Carash and Brooklyn (1944) reported that the milk may become the contaminated through outside sources because of careless handling at some point between production and ultimate use.

Richard (1958) documented that udder skin and milking machines contribute equally to the microbial count of milk. However, milking machines gave markedly high contamination with psychrotrophs, penicillin resisted psychrotrophs, coliforms and heat resistant bacteria. O'Conore (1995) reported that coliform bacteria and members of the genus bacillus may enter the milk from soil.

Thomas *et al.* (1971) indicated that cow's milking environment, pipeline milking plants and farm bulk milk tanks comprised a bacterial contamination.

2.12 Bacteria of importance in milk:

Tanwani and Yadara (1983) categorized the organisms found in milk into three groups.

2.12.1 Organisms excreted in milk:

Streptococcus, Staphylococcus, Brucella, Mycobacterium, Salmonella, Listeria, Candida, Anthrax Bacillus, Corynebacterium, Cryptococcus, Coxiella, Nocardia and rabies virus.

2.12.2 Organisms entering milk from outside:

Bacillus, Escherichia, Lactobacillus, Clostridium, Streptococcus, Salmonella, Corynebacterium, Pseudomonas, Acetabacter and *Alcaligenes.*

2.12.3 Organisms excreting toxins including the following genera:

Staphylococcus, Escherichia, Clostridium, Bacillus and *Streptococcus*. Bacterial types associated with milk are presented in Table (2.2).

Table 2.2: Bacteria types commonly associated with milk.

Bacteria	Effect on milk
Pseudomonas	Spoilage
Burcella	Pathogenic
Enterobacteriaceae	Pathogenic and spoilage
Staphylococcus aureus	Pathgoenic
S. agalactiae	Pathogenic
S. thermophilus	Acid production
L. lactis	Acid production

L. lactis-diacelylactis	Flavour production
L. cremoris	Acid production
Leuconsotoc lactis	Acid production
Bacillus cereus	Spoilage
L. lactis	Acid production
L. bulgaricus	Acid production
L. acidophilus	Acid production
Propainibacterium	Acid production
Mycobacterium tuberculosis	Pathogenic

(International Livestock Research Institute, Ethiopia, 1995).

2.13 Family: Enterobacteriaceae:

The family enterobacteriaceae includes 12 genera: *Escherichia, Edwardsiella Citrobacter, Salmonella, Shigella, Klebsiella, Entero-bacter, Hafnia Serratia, Proteus, Yersinea, Erwina.*

The bacteria of this family have common genetic bonds and have undergone considerable evolution during a long period of time.

They are non-spore formers, Gram-negative and are facultatively anaerobes (Pyatkin and Krivoshein, 1987).

2.13.1 Salmonella:

Marth (1969) indicated that the importance of salmonella as human pathogens has been recognized for over 100 years. These bacteria recently received attention in the dairy industry after the recovery, salmonella from nonfat dry milk in 1966.

Foley and Menzies (1944) reported that if infected carriers of salmonella handle milk or other dairy products, the bacteria can be passed on to the consumer.

2.13.2 Klebsiella:

The members of the genus Klebsiella are facultatively anaerobes, which grow readily on common nutrient media at pH 7.2 and at a temperature of 35 – 37^{o}C and include bacteria capable of producing capsules when present in the host's body or on nutrient media. The organisms ferment carbohydrates, producing both acid and gas or, sometimes, only acid. Milk is not always curdled (Pyatkin and Krivoshein, 1987).

2.13.3 Escherichia:

Griffin and Stwart (1940) reported that Escherichia were normal inhabitants in faces but not in other sources (milk, water, soil and grains).

Brandol *et al.* (1978) reported that coliform bacteria can exist in large numbers in milk or cheese, and these may include Enteropathogenic *Escherichia coli* serotypes. Marier *et al.* (1973) suggested that the prevalence of *Escherichia coli* in milk and milk products is of worldwide interest as a result of its implication in several food poisoning outbreaks.

Taylor (1969) emphasized that *Esherichia coli* was a more delicate indicator than the fecal streptococci for water supplies.

2.13.4 Coliforms:

Wilson *et al*. (1969) reported that a considerable proportion of coliform organisms in raw milk is not of the true coli type but belongs to intermediate *Aerogenescloacae* types. They said that the true coliform organisms found in milk appear to come directly from animal faces or directly from unsterilized milk utensils in which bacterial multiplication has occurred. Rolands (1939) reviewed several articles on the udder as a source of coliform bacteria. He reported that, in a few instances, coliform infection of the udder was accompanied by a disease condition or abnormality in secretion. Injuries to the teats or quarters were, in some instances, responsible for the presence of coliform organisms in milk.

American Public Health Association (1960) stated that if milk is kept at 4.4^{o}C or below and proper sanitary procedures are used, the resultant milk should be of good quality and should contain less than 100 coliforms per ml.

Sudanese Standards an Metrology Organization (2004) declared that the Aerobic plate count of the Sudanese raw milk standard is 10^5/ml.

Idris *et al*. (1975) tested 113 samples of milk collected from vendors in the three towns (Khartoum, Khartoum North and Omdurman) for coliform test. Of the samples tested 64.65% resulted in coliform counts ranging from 3 x 15^5 to 3 X 10^6 cfu/ml. This result indicates faecal contamination of milk. Idris (1975) reported that bacterial load of vendor's milk is unsatisfactory when compared to the maximum allowable level in developed countries. By American standards, certified raw milk should not have a coliform count of more than 10 cfu/ml.

Hussein (2001) found that the coliform count of raw milk was high in Khartoum North ($\log_{10}$ 3.071 $\pm$ 0.689 cfu/ml) followed by Khartoum ($\log_{10}$ 3.071 $\pm$ 0.749 cfu/ml) and Omdurman ($1og_{10}$ 3.051 $\pm$ 1.01 cfu/ml).

2.14 Definition of adulteration:

Awan (1979) stated that, "an article may be said to be adulterated if its nature, substance or quality is not what is usually expected from the description of article".

Sieghenthaler and Schulthess (1977) reported that different methods used by some milk producers and vendors for gaining more profit from the amount of milk they have, reduce the milk value. The Food and Drugs Act, 1938 British specified that milk must be sold as it comes from the cow. When milk falls below the legal standards for fat or milk solids-non-fat, the onus of proving that the milk has not been adulterated rest on the vendor.

2.14.1 Methods of adulteration:

According to Foley *et al*. (1999) adulteration of milk supplies may be deliberate addition of water, preservatives and neutralizers or it may arise from faulty methods of milk production particularly in the use of sterilizers and in the methods of rinsing milking equipment.

Other methods of adulteration likely to be resorted to are the addition of skim milk or the extraction of some fat by skimming.

2.14.2 Adulteration of milk with water:

According to Siegenthaler and Schulthess (1977) addition of water is the simplest way for increasing milk quantity. In addition to the economic part of the problem, watering milk may also cause public health hazards since the available water added may be grossly contaminated. In countries applying the pricing system, milk with high amount of water receives low price.

2.14.3 Adulteration of milk with preservatives:

Frazier (1967) reported that milk is such a delicately flavored easily changes type of food where vigorous preservative methods can not be used without changing it in an undesirable manner.

Foley *et al*. (1999) claimed that the most likely preservatives to be found in milk are formaldehyde, boric cid and hydrogen peroxide.

2.14.4 Adulteration of milk with antibiotics:

Marth (1969) considered problems which were created by contamination of milk and milk products with antibiotics and claimed that the level of antibiotic in milk inhibits most starter cultures. Martin (1959) designed a survey of penicillin contamination in raw milks produced in Elkhart country, India. He found 11 out of 105 samples tested to contain penicillin.

2.14.5 Adulteration with starch:

Siegenthaler and Schulthess (1977) reported that starch or even plaster powder is sometimes added to give milk a higher viscosity and improve its colour.

In India, milk samples were collected from established dairies, local gowalas, local shops, milk collection centres and pasteurized milk booths. No adulteration with starch was detected (Mishra, *et al*., 1977).

CHAPTER THREE

MATERIALS AND METHODS

3. Sites and collection procedures:

To obtain representative samples of raw milk offered for sale in Khartoum State, three stereotyped distribution channels were chosen from each of the three towns in Khartoum State. A total of 108 raw milk samples were collected, such that 36 milk samples were secured from each of the three towns (Table 3.1).

The sites for collection in each town included:

i. Milk vendors (usually involve donkey or donkey carts-transported milk).

ii. Groceries

iii. Distribution centres (involve pick-up trucks).

Raw milk samples were collected in either labeled sterile bottles or in plastic bags. To keep the temperature at about 4^{o}C the containers (bottle or bags) were surrounded with ice till they arrive to laboratory where they were kept in a refrigerator pending analysis which usually carried out the next day.

Attempts were made, where possible, to gather further information on location of farms, breeds used and other management particulars associated with the milk produced in the farms.

Table 3.1: Collection channels, producer localities and number of samples of raw milk in Khartoum State

Collection channel	Locality	No. of samples
Venders	Azhari	1
	Om-badda	5
	El-Hashmab	1
	El-Abassia	1
	Banat	1
	Bet-Elmal	2
	El Moradda	1
	Al-Saffia	2
	El Sababy	2
	Azhari-St.	1

	El-Haj Youssif	1
	El-Shabbia	3
	El-Samrab	1
	Shambat	2
	Burry	4
	Hay El-Zohour	1
	El-Amarat	3
	El-Riad	4
Groceries	Azhari	1
	El-Thawra	2
	Om-Badda	5
	El-Fitihab	3
	El-Masalma	1
	El-Mazad	4
	El-Sambrab	1
	El-Danagla	3
	Shambat	1
	El-Saffia	1
	El-Hag Yousif	2
	El Mogran	1
	El-Saggana – Abu Hamama	2
	El-Amarat	2
	Mojahdeen	1

	El-Said Abd Rhman St.	1
	Burry	1
	El-Manshya	1
	El-Sahaffa	3

Table 2: Contd.

Collection channel	Locality	No. of samples
Centres	Azhari	1
	Ombadda	2
	El-Ardda	1
	El-Abbassia	1
	El-Galaa	1
	Bit-El Mal	2
	Wad Nobawi	1
	El-Thawra	2
	Hay-El Said El Makkey	1
	Shambat	2
	El-Haj Yousif	3
	El Samrab	1
	El Sababby	2
	El Danaglla	2
	El Mazad	2
	Burry	2

	El-Lamb-Nassir	2
	El-Lambab-Bahr Abid	1
	El-Amarat	5
	El-Riad	2
Total		108

3.1 Physiochemical anlysis of milk

3.2 pH:

The pH of the milk was determined as described by Newlander *et al.* (1964) with a pH metre (model Hanna/Instruments, Bench meters, HIS 521).

Procedure:

a) The pH meter was first connected to the power cord, switched on and left for about 15 minutes to warm up.

b) The temperature of the pH meter was adjusted to 20^{o}C, and the needle switched to the neutral position.

c) The electrodes were rinsed with distilled water and wiped with a clean dry cloth then immersed in buffer solution (pH) and the standardization control adjusted until the meter needle indicated exact pH of buffer.

d) About 10 grams of milk samples were placed in a beaker, and the pH of the milk was measured by transferring the electrodes from the buffer solution and immersed into the milk solution.

e) The` value was determined twice for each sample and the average value was then computed. The electrodes were rinsed properly between samples.

3.3 Acidity:

The acidity of milk samples was determined according to Pearson (1976).

Milk sample (10 mls) was measured into a glass beaker and 3 drops of phenolphthalein indicator (colourless) were then added. This was titrated against N_9 sodium hydroxide until a faint pink colour lasting for not less than 30 seconds was obtained. The titration figure was divided by 10 to give the acidity of the sample expressed as percentage lactic acid.

Formula:

1 ml of N_9 lactic acid. 1 ml of N_9 NaOH =

= 0.01 g lactic acid

= 0.01 X y lactic acid

0.01 Y in 10 ml i.e.%= 0.1 7

where y is the titration figure.

3.4 Specific gravity:

The specific gravity of milk was determined as described by Pearson (1976).

The specific gravity of milk was measured by a lactometer, a certain amount of milk was poured into a measuring cylinder. The milk temperature was read using a thermometer and the temperature was recorded. The lactometer was then immersed in cylinder and the reading was taken. The specific gravity of milk was then computed from the following:

$$Sp.\ G = 1 \pm \frac{C.L.R.}{1000}$$

Specific gravity   Where Sp.G=

Correct lactometer reading   =   C.L.R.

3.5 Moisture:

The moisture of milk sample was determined according to Pearson (1976).

A metal dish with close-fitting lids was dried in an oven and cooled in a desiccator. Two gram of milk sample were placed into the dish and dried in the oven (100 – 105^{o}C) for 2 hours with the lid alongside. The lid was placed on the dish and transferred to the desiccator, the sample was weighed when the dish had completely cooled.

The moisture percent of the sample was calculated according to the following:

$$\text{Moisture (\%)} = \frac{(B - C) \times 100}{A}$$

Sample weight in grams   Where A=

Weight of dish $\pm$ sample prior to drying   B=

Weight of dish $\pm$ sample after drying   C=

3.6 Ash:

The ash was determined according to Pearson (1976). A porcelain dish dried in an oven, cooled in a desiccator and then weighed. Three gram of milk sample were placed into the dish and burned in furnace (550 – 600^{o}C) until free from carbon (residue appears grayish-white) (about 2 hr.). It was transferred to the desiccator to cool-down. The dish and sample was then re-weighted when the dish had completely cooled. The ash percent of the sample were calculated according to the following:

$$\text{Ash (\%)} = \frac{(B - C) \times 100}{A}$$

Sample weight in grams Where A=

Weight of dish and contents after drying B=

Weight of empty dish. C=

3.7 Lactose:

Lactose content was determined according to Lane and Eynon.

Ten mllitres of Fehling's Solution (Fehling A. Cupric sulphate pentaphydrate) Fehling B (Sodium potassium tartrate tetrahydrate) were pipetted into a glass flask. Fifteen ml of the lactose solution, was run into the flask. The cold mixture was then heated to boiling, for 10 – 15 seconds, till a change in colour was secured. Following this stage 3 to 4 drops of methylene blue indicator were added and addition of the lactose sugar solution continued at intervals of about 10 seconds, until the colour of the indicator was completely discharged and the boiling reaction liquid resumed the bright orange appearance, due to cuprous oxide, which it had been before the addition of the indictor.

The concentration of reduced lactose was found by reference to appropriate table in lactose table.

3.8 Protein:

Kjeldahl reference method was used as described by A.O.A.C. (1984).

Digestion:

Two grams of the sample were transferred to a kjeldahl digestion flask. Catalyst mixture (96% anhydrous sodium sulphate, 3.5% copper sulphate and 0.5% selenium dioxide) and 3 ml of concentrated sulphuric acid were added to the digestion flask. It was heated strongly until the liquid had become clear.

Distillation:

The digested sample of milk and fifteen ml of NaOH (40%) were added to kjeldahl distillation apparatus. Ten ml of boric acid (2%) and screamed methyl red indiccator were added to a receiving flask. The distillation was continued until the distillate in the receiving flask was 75 ml.

Titration:

The distillate was titrated against HCl (0.1 N) until a faint pink colour lasting was obtained

Calculation:

$$\text{Protein (\%)} = \frac{\text{T.F X N (HCl) X 0.014 (m.L of N) X 6.38}}{\text{Weight of sample}}$$

Titrition figure Where: TF =

Normality of (HCl) N(HCl)=

Equivalent of nitrogen (mL of N)=

3.9 Fat:

The fat content was determined using Gerber Method described by Davis (1959). Milk sample (10.94 ml) was added to 10 ml of suphuric acid (density of 1.815 gm/ml at 20°C) in a Gerber tube. Then 1 ml of amyl alcohol (0.815 mg/mL) was added. The mixture was then centrifuged at 110 revolutions per minute (rpm) for 5 minutes, removed from the centrifuge and placed downward in a water bath at 65°C for at least 3 minutes.

The water level was maintained above the top of the fat column in the butyrometers. The fat column was adjusted by bringing the lower end of the fat column to the graduation mark. The difference between the reading gave the percentage of fat in the milk sample. The butyrometers were placed in the water bath for another 3 minutes and then the reading of the percentage of fat was taken again.

3.10 Microbiological examination:

3.10.1 Methylene blue reduction test:

One ml methylene blue was added to 10 ml raw milk in a test tube and left for 3 hr at 36.5°C. Following that the level of decolorisation of the methylene blue was judged (reduction of the methylene blue).

3.10.2 Coliform bacteria test:

Sterilization of equipment and media:

The flasks, test tubes and pipettes were sterilized by hot air oven at 160^{o}C for 60 min. The media were prepared as prescribed by the manufacturer and sterilized in an autoclave at 121^{o}C for 15 minutes.

Solid media ingredients:

Macconkey broth, (Scharlau microbiology).

20,000 gm	Peptone
10,000 gm	Lactose
5,000 gm	Bile salts
5,000 gm	Sodium chloride
0.075 gm	Neutral red
1000 ml	Distille water

pH 7.4 ±

Liquid media ingredients

Peptone water:

The medium was prepared by dissolving 10 gm peptone and 5 gm sodium chloride in one litre of distilled water. The pH was adjusted to 7.4 before sterilization. The medium was distributed in 9 ml amounts in clean test tubes and sterilized.

Coliform test:

A representative sample of raw milk (1 ml) was transferred for three consecutive dilutions to each of three tubes of Macconkey broth. The tubes were incubated for 24 $\pm$ 2 hours at 35^{o} $\pm$ $1^{o}C$. The gas production was examined in the inverted Durham tube. All tubes showing gas were recorded and calculated as the presumptive most probable number of the coliform bacteria per ml.

3.11 Adulteration procedures:

3.11.1 Formalin:

Formalin was determined as follows: 2 ml of milk were added into test tube. Sulphric acid (90% containing a trace of ferric chloride $FeCl_3$ 0.1) was then added gently down the wall of the test tube. In the presence of formaldehyde (formalin) a violet zone forms at the junction of the layers.

3.11.2 Starch:

One ml of milk was poured in a test tube and the same amount of iodine was added, changing of colour to blue indicated the addition of starch.

Statistical analysis:

The factorial design was adopted in the data analysis.

CHAPTER FOUR

RESULTS

The proximate analysis of the collected milk samples offered for sale in the three towns is presented in Table (4.1). The results indicated that both physical and chemical component of the salable milk were almost similar between the three towns under study. The acidity of milk however showed variability. The milk in Khartoum showed the highest acidity index (0.201) ($P< 0.05$) followed by salable milk in Omdurman (0.195) and the least acidity was recorded in Khartoum North (0.179).

The Specific grravity of milk samples in the three towns ranged between 1.029 – 1028. The protein content of milk in the three towns was 3.794, 4.028 and 4.047, in Omdurman, Khartoum North and Khartoum respectively. The fat content also showed a slight variation among the samples from the three towns. The highest fat value was recorded in the samples from Omdurman (4.085), followed by Khartoum North (4.000) and the least fat value was obtained from the samples from Khartoum (3.697).

Table 4.1: Physio-chemical analysis of salable milk in the three towns.

	Physio-chemical composition of milk				
	Sp.G	Moist. (%)	Ash (%)	Lactose (%)	Protein (%)
Omdurman	1.029^{a}	87.211^{a}	0.610^{a}	4.328^{a}	3.794^{a}
Khartoum North	1.028^{a}	87.044^{a}	0.618^{a}	4.308^{a}	4.028^{a}
Khartoum	1.028^{a}	87.342^{a}	0.618^{a}	4.289^{a}	4.047^{a}

In this table and subsequent Tables means bearing similar superscripts are not significantly different ($P > 0.05$)

TS (%)	Fat (%)	Acidity (%)	pH
12.783^{a}	4.085^{a}	0.195^{a}	6.606^{a}
12.969^{a}	4.000^{a}	0.179^{b}	6.667^{a}
12.656^{a}	3.697^{a}	0.201^{a}	6.572^{a}

The total solids (Ts) content of milk in the three towns was almost similar with the highest record in Khartoum North (12.969) followed by Omdurman (12.783) and with least value in Khartoum (12.656).

The quality of salable milk based on Methylene Blue Test (MBT), coliform count and adulteration by formalin is highlighted in Table (4.2). The figures showed that coliform count was significantly high ($P< 0.05$) in milk obtained from Omdurman (149.2). The lowest cliform count (35.32) was recorded in the milk samples from Khartoum North and which was significantly ($P< 0.05$) less than the coliform count in Khartoum City (96.84). On the other hand the MBT was almost similar in the samples from the three towns. The values were 1.111, 1.000 and 1.083 in Omdurman, Khartoum North and Khartoum respectively.

In Table (4.3) the physico chemical analysis of the salable milk as affected by the three distribution channels is portrayed. The data indicated similarity in most of the studied parameters except the fat content. The fat content in milk samples distributed through groceries maintained the highest level (4.27%) and which was significantly ($P < 0.05$) higher than vender milk and centres.

Table 4.2: Hygiene characteristics of salable milk in the three towns.

City	Parameters tested in milk		
	Methylene blue	Coliform (MPN)	Formalin
Omdurman	1.111	149.20[a]	1.167
Khartoum North	1.000	35.32[b]	1.111
Khartoum	1.083	96.84[c]	1.083

Table 4.3: Physico-chemial analysis of salable milk as affected by distribution channel.

	Physio-chemical composition of milk							
	SPG	Moist.	Ash	Lactose	Protein	TS	Acidity	pH
Venders	1.028^{s}	87.344^{a}	0.600^{a}	4.356^{a}	3.992^{a}	12.650^{a}	0.190^{a}	6.636^{a}
Groceries	1.029^{a}	87.044^{a}	0.634^{a}	4.228^{a}	3.836^{a}	12.953^{a}	0.198^{a}	6.617^{a}
Collection centre	1.028^{a}	87.208^{A}	0.613^{a}	4.342^{a}	4.042^{a}	12.806^{a}	0.187^{a}	6.592^{a}

In this table and subsequent Tables means bearing it similar superscripts are not significantly different (P>

	Fat	3.722^{a}	4.272^{b}	3.788^{a}

The Protein content was highest in milk distributed through the centres (4.042) as compared to vender's milk (3.992) and groceries milk (3.836). The lactose content of milk from the three distribution channels ranged between 4.356% and in vender's milk to 4.222% in groceries milk and centres milk with an intermediate value of 4.342%.

The data describing the effect of the three distribution channels on milk quality in terms of MBT, coliform MPN and Formalin adulteration is displayed in Table (4.4). The results postulated that the least contaminated milk judged by MBT was that distributed through the centres, which recorded a significantly ($P< 0.05$) less value than the other two channels. The most contaminated milk seemed to be that distributed by the groceries (1.14). Similarly when the coliform MPN was considered it was also evident that milk distributed through groceries showed the highest count of MPN, indicating more contamination. The coliform MPN in groceriesmilk was 182.68 ml which was significantly ($P< 0.05$) higher than the coliform MPN in the other two distribution channels. The least contaminated milk was also found to be distributed by the centres MPN (25.95). The vender's

Table 4.4: Hygiene characteristics of salable milk as affected by distribution channel.

Distribution channel	Methylene blue	Coliform (MPN)	Formalin
Venders	1.056^{b}	72.69^{b}/ml	1.056^{b}
Groceries	1.139^{a}	182.683^{a}/ml	1.250^{a}
Distribution centres	1.000^{b}	25.948^{c}/ml	1.056^{b}

milk secured an intermediate position with a count of MPN (72.69). Adulteration of milk by formalin was also evident in the grocerie's milk, which attained a significantly (P< 0.05) higher index (1.25) compared to vender's milk (1.05) and centres milk (1.05).

The data pertinent to the interactive variations in fat and protein of the salable milk in the three towns distributed through the three channels is presented in Table (4.5).

The results indicated significant (P< 0.05) variations in protein and fat channels in the three towns. A significant variation was found in protein in milk offered for sale in venders milk in Omdurman town (1.1) and that distributed by groceries in Khartoum North (22). Similarly venders milk in Omdurman town varied in protein from vender milk in Khartoum town (3:1). Groceries milk in Omdurman (1.2) differed from centres milk in the same city (1.3). The fat percent of the salable milk together with the coliform count followed the same pattern of protein (Tables 4.5 and 4.6).

To investigate the effects of within city and between distribution channels on the quality of salable milk, the data in (4.5)

Table 4.5: Protein, fat variation in the three towns and within the three distribution channels.

Code	Protein	Code	Fat

11	22	-.583	11	130	.771
11	31	-.667	11	31	1.225
12	13.	-.450	12	13^{*}	1.246
12	22	-.792	12	23^{*}	.708
12	31	-.875	12	31	1.700
12	33	-.550	13	11^{o}	-.771
13	12	-.450	13	12^{*}	-1.246
13	32	-.458	13	32^{*}	-.721
21	22	-.625	21	31	1.067
21	31	.708	22	31	1.067
22	11	.583	23	12*	-.708
22	12	-.792	23	31	.992
22	21	-.625	31	11	-1.225
22	32	.800	31	12	-1.700
23	31	.475	31	21	-1.067
31	11	.667	31	22	-1.067
31	12	.875	31	23^{o}	-.992
31	21	.708	31	32	-1.175
31	32	.883	31	33^{o}	-1.042
32	13	.458	32	13*	.721
32	22	.800	32	31	1.175
32	31	-.883	33	31^{o}	1.042
32	33	-.558			

33	12	.550			
33	32	.558			

Town: 1. Omdurman 2. Khartoum North 3. Khartoum

Dis. Channels 1. Vender 2. Grocery 3. Centre

* The first figure in the code denotes town, the second denotes

types of outlet.

Table 4.6: Coliform variations in the three towns and within the three distribution channels.

Code		Coliform value
11	12	-363.47
12	11	363.47
12	13	361.23
12	21	324.48
12	22	374.35
12	23	367.52
12	31	266.27
12	32	249.90
12	33	365.62

13	12	-361.23
21	12	-324.48
22	12	-374.35
23	12	-367.52
31	12	-266.27
32	12	-249.90
33	12	-365.62

Town: 1. Omdurman 2. Khartoum North 3. Khartoum

Dis. Channels 1. Vender 2. Grocery 3. Centre

Table 4.7: Overall average and within city differences in protein, fat and coliform.

Trait	Item	Overall average difference	Average within cities		
			Omdurman	Khartoum North	Khartoum
Protein	Between G. & V.	0.7415	0.450	0.625	0.883
	Between G. & C.	0.504	0.450	-	0.558
	Between C. & V.	0.475	-	-	-
Fat	Between G. & V.	1.314	-	1.175	1.75
	Between G. & C.	0.890	1.246	-	-

	Between C. & V.	0.935	0.771	1.042	1.042
Coliform	Between G. & V.	318.1	363.47	-	-
	Between G. & C.	364.8	-	-	-
	Between C. & V.	-	-	-	-

Table (4.7) shows the overall average differences between types of outlets for the different traits. It also indicates the differences between these outlets within each of the three cities.

and (4.6) was extrapolated in Table (4.7). The overall average difference in protein content between Groceries and venders was 0.7415, while the within city average differences in Omdurman, Khartoum North and Khartoum were 0.450, 0.625 and 0.883

respectively indicating that the differences between groceries and vendors in protein content of salable milk in Omdurman and Khartoum North were small. However, the differences between the two outlets in Khartoum is twice the difference in Omdurman. Similarly the differences between the overall average difference between groceries and centres on one hand and the within city average of Omdurman indicates that differences between the various outlets in Omdurman are minimal while in Khartoum they are maximal..

Concerning the fat % of milk the results revealed that the difference in fat content of milk offered for sale in groceries and venders in Khartoum North was lower than the overall average difference (1.175, 1.314) indicating a problem of adulteration or otherwise in Khartoum North groceries. The results also indicated such a problem in the salable milk in centres and venders in Omdurman town and none in the other two cities.

The overall average differences of coliform counts between groceries and vender was 318.1 while that in Omdurman city was 363.47 indicating low hygienic levels of milk handling in Omdurman.

The results also highlighted that sanitary measures in milk handling were poor in the three cities, but was more pronounced in Omdurman.

4.1 Effect of interaction between towns and distribution channels on salable milk characteristics:

The impact imposed on some milk characteristics by town and distribution channel interactions is demonstrated in Table (4.8). The data in the table revealed that the interaction between town and distribution channels seemed to have no significant effect on the studied characteristic. The SPG of the salable milk in the three towns was maintained between the range of 1.027 to 1.03 which coincides with the SPG of normal milk. The ash content also fell within the normal milk contents of minerals (0.58 – 0.64). Moisture content and pH were also found to be within the known range indicating no effect of interactions.

The data in Tale (4.9) showed that the fat content in all samples studied were within the range of fat content in normal cow's milk (3.5 – 5.96).

Table 4.9: Some milk parameters as affected by distribution channel.

Distribution channel	Protein			Fat			Lactose			T.S		
	1	2	3	1	2	3	1	2	3	1	2	3
Vender	3.783^{a} ±0.158	3.742^{a} ±0.158	4.450^{a} ±0.158	4.183^{a} ±0.244	4.025^{a} ±0.244	2.958^{a} ±0.244	4.317^{a} ±0.084	4.417^{a} ±0.084	4.333^{a} ±0.084	12.833^{a} ±0.25	12.792^{a} ±0.250	12.325^{a} ±0.250
Grocery	3.575^{a} ±0.158	4.367^{a} ±0.58	3.567^{a} ±0.158	4.658^{a} ±0.244	4.025^{a} ±0.244	4.133^{a} ±0.244	4.250^{a} ±0.084	4.250^{a} ±0.084	4.208^{a} ±0.084	13.633^{a} ±0.250	13.283^{a} ±0.250	12.542^{a} ±0.250
Centre	4.025^{a} ±0.158	3.975^{a} ±0.158	4.125^{a} ±0.158	3.413^{a} ±0.244	3.950^{a} ±0.244	4.000^{a} ±0.244	4.442^{a} ±0.084	4.258^{a} ±0.084	4.325^{a} ±0.084	12.483^{a} ±0.250	12.833^{a} ±0.250	13.100^{a} ±0.250

Table 4.10: Some milk parameters as affected by distribution channel.

Distribution channel	Coliform (MPN)			Acidity			Methyblu		
	1	2	3	1	2	3	1	2	3
Vender	27.300 [a] ±67.408	66.283 [a] ±67.408	124.500 [a] ±67.408	0.189 [a] ±0.011	0.178 [a] ±0.011	0.202 [a] ±0.011	1.083 [a] ±0.07	1.000 [a] ±.070	1.083 [a] ±.070
Grocery	390.767 [a] ±67.408	16.417 [a] ±67.408	140.867 [a] ±67.408	0.202 [a] ±.011	0.180 [a] ±0.011	0.211 [a] ±0.011	1.25 [a] ±.070	1.000 [a] ±.070	1.167 [a] ±.070
Centre	28.533 [a] ±67.408	23.25 [a] ±67.408	25.150 [a] ±67.408	0.195 [a] ±0.011	0.178 [a] ±0.011	0.189 [a] ±0.011	1.000 [a] ±0.07	1.000 [a] ±0.07	1.000 [a] ±0.070

The protein content of milk samples tested showed also normal protein values known in cow's milk. Some milk samples however, especially from (collection centres) and in the three towns showed a slightly elevated protein value when compared to the protein content of normal cow's milk which has a value of 3.4%. The lactose content on the other hand was a slightly lower than the normal value of 4.8%. The range of lactose content in the studied samples fell within 4.208 – 4.442%. The total solid (T.S) content was within the normal range for cow's milk.

As described previously in Table (4.2), the coliform counts for the three towns and the three distribution channels are presented in Table (4.10). The figures indicated a wide array of the MPN of coliforms as an indication of milk contamination. The highest coliform count was demonstrated by groceries milk while the least counts were obtained from milk samples distributed by milk centres. The acidity of the investigated milk samples expressed as percent lactic acid (Table 4.10) fell within the range of 0.178 – 0.211. The lower limit coincides with the normal acidity of cow's milk, while the upper limit indicates contamination.

Table 4.8: Some milk parameters as affected by distribution channel.

Distribution channel	Sp.G			pH			Moisture			Ash		
	1	2	3	1	2	3	1	2	3	1	2	3
Vender	1.029^{a} ±0.01	1.028^{a} ±.001	1.027^{a} ±.001	6.700^{a} ±0.083	6.733^{a} ±0.083	6.475^{a} ±0.083	87.158^{a} ±.255	87.200^{a} ±255	87.675^{a} ±.255	0.583^{a} ± 0.046	0.596^{a} ±0.046	0.62^{a} ±0.046
Grocery	1.030^{a} ±.001	1.029^{a} ±.001	1.029^{a} ±.001	6.558^{a} ±0.083	6.600^{a} ±0.083	6.692^{a} ±0.083	86.958^{a} ±255	86.717^{a} ±255	87.458^{a} ±.255	0.650^{a} ±0.046	0.618^{a} ±0.046	0.633^{a} ±0.046
Centre	1.030^{a} ±.001	1.028^{a} ±.001	1.0027 ^{a} ±.001	6.558^{a} ±0.083	6.667^{a} ±0.083	6.550^{a} ±.255	87.517^{a} ±2.55	87.217^{a} ±.255	86.892^{a} ±.255	0.590^{a} ±0.046	0.642^{a} ±0.046	0.600^{a} ±0.046

salable milk with either formalin or starch, the data in Table (4.11) documented noticeable adulteration of milk offered for sale in the groceries in the three towns, while adulteration by starch was not evident.

Table 4.11: Adulteration of milk in distribution channels.

Distribution channel	**Formalin**			Starch		
	1	2	3	1	2	3
Vender	1.167 [a] ±0.093	1.000 [a] ±0.093	1.000 [a] ±0.93	1.000 [a] ±.000	1.000 [a] ±.000	1.000 [a] ±.000
Grocery	1.250 [a] ±0.093	1.250 [a] ±0.093	1.250 [a] ± 0.093	1.000 [a] ±.000	1.000 [a] ±.000	1.000 [a] ±.000
Centre	1.083 [a] ±0.093	1.083 [a] ±0.093	1.000 [a] ±0.093	1.000 [a] ±.000	1.000 [a] ±.000	1.000 [a] ±.000

CHAPTER FIVE

DISCUSSION

The results as shown in Table (4.1) are in agreement with the known physical and chemical cow's milk as declared by Shandan (1997) (flow chart). Slight changes were noticed in the chemical composition of the salable milk in the three towns and through the three distribution channels. The differences were however so small and did not attain a statistical significant. Previous reports by Khalifa and Bayoumi (1966) and Idris et al. (1975) postulated slightly different result of TS which may be attributed to seasonal variation.

The results of fat, protein, lactose and ash analysis are similar to those reports by Richmond and Davis (1958), Pearson (1976) and Web *et al*. (1974) (Table 2.1).

Also these results indicated that the fat % was significantly higher in the milk offered for sale through groceries when compared with that sold through venders or marketing centres. This may be attributed to the fact that grocery milk is usually not disposed off readily and takes longer time to be distributed compared to the other two channels. This lag of time may allow the butter fat layer to rise to the upper portion and when the samples were collected from the groceries, no attempt of shaking the milk to break the fat layer was practiced.

The results on the titrable acidity of salable milk obtained in this study revealed a slight elevated levels. This result comply with previous findings reported by Gould (1945) and Ibrahim (1973) who declared that the acidity of venders milk ranges between 0.18 – 0.2% lactic acid. The relatively high acidity reported here may be attributed to lack of cooling facilities during transportation and distribution of raw milk in the Sudan. Moreover the poor roads and long distances traveled by the milk from production areas to consumers added more to the dilemma and facilitated rapid multiplication of acid, where growing micoorganisms results in changing of lactose to lactic acid and other acids, which is responsible for the rise in acidity.

Mainly coliforn in milk is one of the best indices for judging sanitation. In the present study the highest coliform count witnessed in the salable milk of Omdurman city and which was significantly higher than the counts in both Khartoum and Khartoum North. This may be attributed to the fact that most of the salable milk in Omdurman comes from Khartoum North farms. The milk being milked under poor sanitary measures and transported for long distances under poor hygienic environment, with lack of cooling facilities intensified the bacterial contamination. This result complies with previous findings of Idris *et al*. (1975) who tested 113 samples of milk collected from vender, in the three towns, for coliform. They concluded that 66.65% of the samples were infected with coliform ranging from 3 X 10^5 to 3 X 10^6 bacteria/mL. Idris *et al*. (1975) also documented that bacterial load of venders milk is unsatisfactory when compared to the maximum allowable level in developed countries.

The least coliform count was obtained in milk collected from Khartoum North (35.317 MPN). The milk offered for sale in this town comes from the nearby farms and so the milk is subjected to the hazards leading to contamination. Despite this the coliform (MPN) (Table 4.4) in the salable milk in the three towns may be considered as highly contaminated when compared with standard adopted in developed countries. The American Public Health Association considers that if milk is kept at 4.4^{o}C or below and proper sanitary procedures are used, the resultant milk should be of good quality and it should contain less than 100 coliform/ml. Moreover by American standards certified raw milk should not have a coliform count of more than 10 bacteria/ml. Also the Sudanese standards certified raw milk should not have an aerobic plate count more than 10^5/ml. The adoption of coliform count as a measure testing milk contamination was recognized as early as 1920. McCardy and Largerin (1932) highlighted the importance of colifirm test in milk. Idris *et al*. (1975)

mentioned that several persons in Europe regard coliform test as the best indicator of clean milking conditions, particularly where farm bulk tanks are used.

The coliform tests regarding the distribution channels confirmed that the highest count being obtained in milk collected from groceries (182.632 MPN). Although no obvious reason for this can be thought of the high MPN may be attributed to the long storage of the groceries milk one to two days longer than the other channels. Moreover the repeated electricity cuts and power failures may add to the poor storage conditions and so more contamination. Wilson (1969) postulated that most of the coliform contamination arise from poor storage conditions.

The lowest coliform count was obtained from samples collected from distribution centres. Usually the distribution centres dispose their milk readily and so the milk does not stay longer and so the chances for contamination are less. Similarly venders milk was of low coliform count compared to groceries milk. Usually venders have regular customers and so the quantity of milk distributed is limited and venders will care more for handling their milk so as not to loose their customers Idris *et al.* (1975). The sources of contamination of coliform of the three channels need further investigations.

The Methylene blue test as a measure of milk keeping quality was also endevoured in this study. The results documented that the MBT highest value was found in milk samples distributed by groceries. The same justifications presented previously can hold here, since both coliform count and Methylene blue test are indicators of the quality of milk. Both Wilson (1969) and Ellenberger *et al.* (1927)

confirmed that Methylene blue test is considered as the most accurate measurement of keeping qualities of milk.

Principles governing the quality control of raw milk and milk products are lacking in the Sudan. This lack of specifications for identity and quality are conducive to milk adulteration and neglegance of sanitary standards by milk distributors.

The British Food and Drugs Act (1938) specified that milk must be sold as it comes from the cow. When milk falls below the legal standards for fat or milk solids-non-fat, the onus of proving that the milk has not been adulterated rests on the vender.

In this investigation tests for adulteration by formalin and/or starch were attempted. The results indicated that adulteration was practiced in some of the salable milk, especially in milk disributed through groceries. No obvious reasons could be detected, but one assumption may be visualized that groceries milk was the lowest in quality compared to other distribution channels, consequently groceries are more subjected to financial losses and so they may resent to adulteration to compensate their losses. Sceglhaler and Schulthess (1977) reported that different methods used by some milk producers and distributors for gaining more profit from the amount of milk, they have.

The results of this study indicated significant variations in the protein and fat contents of milk distributed through the three distribution channels under study. The variation exceeded the overall average content of protein and fat in Omdurman and Khartoum North towns indicating the involvement of factors, which can not be visualized in both cities. The result also supports the previous data on the poor quality of the salable milk distributed through groceries as compared to the other two distribution channels. Adulteration too was recorded in some of the groceries milk. The hygiene level of salable milk in Omdurman town was the poorest among the studied towns. Previous justifications offered here may also be applied for this piece of this result.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion:

The results of this investigation revealed the poor sanitary measures associated with milking handling, transporting and disposal of milk offered for sale in the capital.

Recommendation:

1. The level of hygiene should be raised at the different steps in producing raw milk.
   - Attention should be paid at the level of the milking parlous and milk utensils.
   - Milkers awareness of producing clean milk should be boosted. They themselves should be healthy and free of diseases and undesirable habits performed during milking.
   - Cooling facilities should be provide during transportation.
2. Foundation of legislation and locally imposed laws should be adopted to guarantee supply of milk of high quality i.e. quality control measures, to control adulteration and other practices that reduce the quality value of milk and endangous the health of consumers.
3. The study also recommends adoption of quality control measures and implementation of extension service to raise the

level awareness of farmers, retailers and consumers towards, hygienic milk producing.