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Addressing the public health and quality concerns towards marketed milk in Kenya

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List of acronyms

BF	butterfat
CCP	Critical Control Point
cfu	colony-forming units
DFID	Department for International Development
ELISA	enzyme-linked immunosorbent assay
EMMA	extensive production system-medium market access
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GoK	Government of Kenya
HACCP	Hazard Analysis Critical Control Point
IHMA	intensive production system-high market access
ILRI	International Livestock Research Institute
KARI	Kenya Agricultural Research Institute
KCC	Kenya Cooperative Creameries
KDB	Kenya Dairy Board
KDPA	Kenya Dairy Processors Association
KEBS	Kenya Bureau of Standards
KEMRI	Kenya Medical Research Institute
LPS	Lactoperoxidase system
MoE	Ministry of Education
MoH	Ministry of Health
MoLFD	Ministry of Livestock and Fisheries Development
MRT	Milk Ring Test
NGO	Non-governmental Organization
PHC	Public Health Committee
PRA	Participatory Rural Appraisal
SDP	Smallholder Dairy (Research & Development) Project
SG	Specific gravity
SNF	solids-not-fat
TB	tuberculosis
TPC	total plate count
UoN	University of Nairobi
WHO	World Health Organization

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Executive Summary

The structure of Kenya's dairy industry

Current estimates show that about 86 per cent of all milk marketed in Kenya is sold raw either directly by producers to consumers or through the informal ("traditional or raw") milk market. These informal sales include direct sales to consumers (42 percent), "hawked" milk sold by mobile traders (23 per cent), milk bars, shops and kiosks (15 per cent) and co-operatives (six per cent). On average, each of these traders sells less than 120 litres of raw milk per day, enabling them to earn a daily income of about twice the national average. The formal or pasteurized milk market currently accounts for only 14 per cent of all milk sold.

While these proportions will vary somewhat year to year, it is widely accepted that most milk will continue to be sold without having first been pasteurized. When milk marketing was liberalized in 1992, and the urban milk sales monopoly was withdrawn from the Kenya Cooperative Creameries (KCC), the main milk processor till then, pasteurized milk quantity was slightly over 200 million litres. Currently, the 14 per cent of milk sold by the formal sector is equivalent to approximately 196 million litres[1].

[1] *Currently, 1.56 billion litres of milk is sold annually. This represents 55 per cent of total milk produced.*

These figures show that the amount of milk sold in the formal sector has not changed much over the years. This demonstrates that the common belief that the raw milk sector has displaced a significant market share for pasteurized milk is basically untrue, although the formal market has recovered since its low in the late 1990s.

Rationale for the study

Although small-scale traders efficiently link dairy producers and consumers, many are unlicensed due to concerns that the raw milk sold through the informal market poses public health risks. Because there has been no valid scientific evidence to support these concerns, this study was carried out to tackle the following research problems:

- lack of accurate information on milk-borne health risks;
- the need to identify practical steps to improve marketed milk quality; and,
- the need for a basis to define appropriate trade-offs between quality assurance on the one hand, and cost and restrictions on traders on the other.

Sampling

The study was carried out in 1999 and 2000 through the MoLFD/KARI/ILRI Smallholder Dairy Project (SDP). It assessed the quality of raw marketed milk, and quantified zoonotic hazards (animal diseases that can be transmitted to humans) and antibiotic residues in samples of pasteurized and raw milk. The principles of Hazard Analysis Critical Control Point (HACCP) were used as a tool and guideline to estimate the health risks associated with each milk-borne hazard, following which recommendations are given on how to reduce the identified risks.

The study involved about 1000 randomly selected households, milk market agents and retail outlets in Nakuru and Narok districts (representing areas of low human and cattle population densities with extensive dairy production systems), and in Nairobi and Kiambu districts (representing areas of high human and cattle population densities with intensive dairy production systems).

Assessment of milk quality and health hazards

Adulteration

Adulteration by adding water and other substances to milk can negatively affect its microbial quality, taste and market value. Overall, 4.7 per cent and 10.4 per cent of samples from consumer households and market agents, respectively, were found to be adulterated with water. Market agents in Nakuru and Narok had more milk samples with added water than their counterparts in Nairobi and Kiambu. However, there was no significant effect of type of market agent. Adding solids like flour to milk was widespread in Nakuru where up to 9 per cent of milk samples in the wet season had added solids. This level of adulteration is lower than the common public perception, which is often that most milk from traders is adulterated. This study has not found any evidence to support that perception.

Microbial quality of milk

Total bacteria counts in milk mainly reflect its storage temperature and time elapsed since milking. Coliform counts indicate the level of hygiene, since coliforms are microorganisms of faecal origin. According to the Kenya Bureau of Standards (KEBS), raw milk is judged as being of low quality if it contains more than 50,000 coliforms and 2 million total colony-forming units (cfu) per millilitre.

Most samples from short market chains and rural households met the KEBS quality specifications for raw milk. However, samples from long market chains and urban households did not. Similarly, over 60 per cent of processed milk samples did not meet the KEBS specifications for pasteurized milk (less than 30,000 cfu/ml for total bacteria counts and less than 10 cfu/ml for coliforms). Therefore, whether raw or pasteurized and packaged, most milk samples did not meet their respective standards for good milk in this carefully designed study. Whereas poor handling played a role, the lack of a means to preserve raw milk, such as a cold chain or use of Lactoperoxidase (LPS[2]), was the overriding factor contributing to high levels of bacterial growth.

Zoonoses

Zoonoses are diseases that can be passed from animals to humans. Common zoonotic agents commonly associated with consumption of raw milk from cattle that were assessed were: *Brucella abortus* (the cause of a flu-like illness known as brucellosis), *E. coli* O157:H7 (may cause bloody diarrhoea and acute kidney failure) and *Mycobacterium bovis* (a cause of TB).

Two consumer households (out of 420) in Nakuru reported having a member diagnosed with brucellosis in the previous one year. Almost all *Brucella*-positive samples at the market-level were from bulked milk from dairy cooperatives and milk bars in Nakuru and Narok districts. Nine (8 per cent) pasteurized milk samples were *Brucella*-positive, six of which were from one milk processor in Nakuru. The higher prevalence of *Br. abortus* antibodies in bulked milk reflects a potential higher health risk especially if the milk is consumed without prior boiling.

The prevalence of *E. coli* O157:H7 in raw milk was low. Only two out of 261 raw milk samples from consumer households tested positive for the organism (one sample was from Nairobi, the other from Nakuru). This prevalence translates to a potential risk of exposure to the pathogen of about three times each year, for a daily consumer of unboiled milk.

Mycobacterium bovis was not isolated from any of the samples obtained from suspect TB patients sampled. These results support the long-held official position that bovine TB is absent in Kenya. However, they need to be verified and periodically monitored in other areas, given frequent cross-border movement of livestock from neighbouring countries. If *M. bovis* were

[2] LPS is the internationally accepted Lactoperoxidase System of milk preservation, using a natural enzyme found in milk. It is approved by the Codex Alimentarius. For more information visit: www.fao.org/ag/aga/agap/lps/dairy/mpv/lactoperoxidase/sitemap.htm

present in Kenya, those at greatest risk of getting infected by the pathogen would be those pastoralist communities who traditionally drink raw milk. This group were however not the subject of this study.

Antimicrobial residues

Antimicrobial residues (antibiotics and other anti-bacterials) in milk can cause bacterial resistance to common antibiotics. These residues often arise when farmers fail to adhere to the specified milk withdrawal periods after antibiotic treatment of cows. Unconfirmed reports suggest that some unscrupulous traders add antibiotics to raw milk to increase its storage life.

Antibiotic residues were found in 9 per cent and 6 per cent of consumer- and market-level samples, respectively. This implies that someone who drinks milk daily is at risk of exposure to antibiotic drug residues about twice a month. Eight per cent of pasteurized milk samples contained antimicrobial residues. Since boiling or pasteurization will not destroy antibiotic residues, this hazard may pose a more serious long-term health risk than bacterial pathogens, if it leads to development of bacterial resistance.

Market risk factors

Within similar distances and time, small-scale traders sold milk of lower bacterial quality than their large-scale counterparts, such as dairy cooperatives. This was partly because the small-scale traders often handled milk in plastic jerry cans that were significantly associated with poorer hygiene as indicated by higher coliform counts. Interestingly, they preferred to use cheaper plastic containers mainly to reduce losses incurred when the containers get confiscated by regulators. Also, few small-scale traders were trained in hygienic milk handling. Lack of training was associated with poorer quality milk.

Where milk was sold directly from farms to retail outlets, small-scale traders travelled the longest distance (about 30 km) to the point of sale. If one or more intermediaries were involved, the time taken to transport milk to market increased by 1.5 hours on average. However, the use of intermediaries did not significantly affect milk quality.

Contrary to common public perception, there was hardly a case where chemical preservatives were added to milk to lengthen shelf life and prevent spoilage. Though not tested, only 2 per cent of traders indicated that they used hydrogen peroxide (one milk bar and one large-scale mobile trader)[3]. None of the agents sampled in this study said that they used hydrogen peroxide or antimicrobials. On average, 89 percent of all milk market agents indicated that they used hot water and soap / disinfectant to clean containers. This indicates a conscious effort by the most traders to improve hygiene and reduce spoilage of milk.

[3] Hydrogen peroxide readily breaks down into water and oxygen upon heating and therefore is undetectable in boiled milk. The resultant oxidation of milk proteins may however lead to undesirable off-flavours.

Boiling of raw milk before consumption

This study found that 100 percent of sampled urban households and 96 per cent of sampled rural households boiled milk, whether purchased raw or pasteurized, before drinking it[4]. This practice effectively destroys all milk-borne pathogens in raw milk. However, a small proportion of rural households (6 per cent) consumed home-made naturally fermented milk. These households may be at some risk. Because the milk is often fermented without first being boiled, there is a chance that the acidity developed in the sour milk may not totally eliminate all milk-borne pathogens.

Testing of training in milk quality control

The proportion of unacceptable milk samples reduced significantly after training, and this was particularly so for those traders who used plastic containers. Likewise, the use of sterilizable metal milk churns resulted in lower incidence of unacceptable milk samples as compared to the use of plastic containers. These positive results imply that training of informal sector milk traders combined with the use of more hygienic metal containers will significantly reduce the health risks associated with raw milk.

Policies and practices for the management of milk-borne health risks: conclusions & recommendations

Policy

The following factors need to be considered when devising policies related to milk quality:

- Dairy marketing policies in developing countries have often relied on standards derived from industrialized countries where large-scale production systems, cold-chain pathways and milk pasteurization are key features. However, some of these standards may be inappropriate in developing countries, owing to climate, poor infrastructure and large distances.
- In Kenya, as in most developing countries, consumers prefer unpasteurised milk and are often not willing to pay the extra costs associated with packaging and processing.[5]
- The almost universal practice of boiling milk destroys harmful disease pathogens and largely eliminates public health risks.

Considering such factors, the following policy directions might be appropriate:

1. Current dairy policy recognizes the sale of raw milk; regulations, however, often discourage it.[6] A review of current dairy

[4] Industrial pasteurisation of milk is at 72 degrees Centigrade for 15 seconds. Boiling attains a higher temperature and longer duration and so destroys all pathogens. Although boiling may affect milk flavour and nutritive value mainly due to loss of water-soluble vitamins B and C, it does not destroy fat-soluble vitamins A and D.
[5] See SDP Policy Brief 1, 'The Demand for Dairy Products in Kenya'.
[6] See SDP Policy Brief 6, 'The Policy Environment of Kenya's Dairy Sector'.

industry policies and legislation is needed, with a view to creating greater consistency between related policies, and between policy and legislation in the industry.

2. The informal milk traders form a cost-effective link between dairy producers and consumers, and both formal and informal channels play important roles in meeting consumer needs; therefore realistic standards for both pathways need to be considered. Any rational development of raw milk markets will involve licensing of raw milk traders, to allow for monitoring of milk quality, along with a recognized system of training and accreditation. Milk cess revenue from such traders, along with fees for licensing and training, could finance such a system. This would have the aim of gradually "formalizing" their operations and improving the quality of milk they sell.

3. Consultative bodies such as the Dairy Public Health Committee, set up by stakeholders and convened by the KDB, provide an ideal mechanism for dialogue and a platform to agree on practical and detailed recommendations to address public health concerns, while maximizing efficiency in milk markets.

Milk consumption

4. Though potential public health hazards resulting from bacterial pathogens such as *Brucella* and *E. coli* O157:H7 were found in the milk sampled in this study, the common consumer practice of boiling milk prior to consumption eliminates all such health risks. Consumers should be encouraged to continue to ensure that all purchased milk is appropriately heated (boiled or pasteurized) before drinking it. This should be reinforced through appropriate media campaigns.

5. The small proportion of households (6 per cent) who consume home-made naturally fermented milk may be at some risk of certain zoonotic diseases. This is because natural fermentation may only reduce, but not eliminate milk-borne health risks. Studies should be undertaken on the survival of specific zoonoses in unheated soured milk, and how much of such milk is sold by market agents. Meanwhile, consumers of home-made naturally fermented milk are advised to boil milk before souring it using commercially available methods of souring. Raw milk retailers should also boil milk before fermenting it, and not sell milk that ferments naturally without prior heat treatment.

Milk bulking and marketing

6. Bulking of milk from many sources increases the risk of infection with milk-borne zoonoses. This is especially so among people who drink milk without boiling it. Thus, bulked milk such as that sold by dairy cooperatives should be sent for processing or screened for potential infections before being sold.

7. Most unlicensed milk "hawkers" used plastic jerry cans because of the risks of confiscation of containers used for unlicensed sale of milk. Unlike proper metal containers, plastic jerry cans are cheap thus pose less of a loss when confiscated. Because these plastic containers

were linked to poor milk quality, the lack of licensing may contribute to the continued poor quality of milk sold by informal traders. In order to improve milk quality, informal traders should be trained, certified and licensed to sell milk. This would gradually incorporate them into the formal milk market and allow for greater monitoring and control of their activities, which should include insistence on use of more hygienic/easily sterilizable metal or other food-grade containers. Also, the Code of Hygiene Practice should be specified for the different homogenous groups or cadres of milk traders due to the existing differences between them.

8. In most marketed milk samples, whether raw or pasteurized, total and coliform bacteria were present in numbers that exceeded the maximum acceptable limits specified by KEBS. These specifications are based on those operating in countries where milk flows entirely through a cold chain system and is always pasteurized before sale. This raises doubts on the efficiency of existing quality standards, as they are not based on local conditions. The KEBS quality specifications for marketed milk should be reviewed in the light of local conditions, which include tropical weather, lack of cold chains, widespread sale of raw milk and consumers' practice of boiling milk before consumption.

9. The testing of training of informal traders in hygienic milk handling and quality control showed that training can significantly improve the quality of raw milk. There is an urgent need to transfer practical milk hygiene technologies and institute simple and practical training courses in hygienic milk handling for raw milk traders, as recommended in 7) above. Pilot testing of appropriate mechanisms for such training should be the first step.

Milk production

10. Antimicrobial residues in marketed milk most likely originate at the farm level, although the findings do not rule out the possibility that some unscrupulous traders add antibiotic drugs to raw milk to increase its shelf life. Additional studies are needed to identify the specific farm-level causes of antibiotic residues in milk. This will help in developing appropriate extension materials for their safe use for dairy farmers. Milk traders should also be educated on the adverse effects of antibiotic residues in milk. Mandatory testing of antibiotic residues in milk should be carried out along the market chain, with penalties for offenders and incentives for improvement.

11. The quality of most raw milk samples had significantly declined by the time the traders received it for sale. Therefore, technologies to reduce bacterial growth before or at the first milk sale transaction point are needed in order to minimize milk losses through spoilage. Low-cost milk preservation technologies like cooling and the Lactoperoxidase System (LPS) need to be locally validated and encouraged as one way of reducing post-harvest losses of milk.

Background

This research report presents a scientific analysis of the public health hazards associated with milk sold in Kenya. It is based on a study carried out in 1999/2000 following concerns among some dairy industry stakeholders about milk-borne health risks. These concerns arose partly due a perceived increase in the sale of raw milk in urban areas following the liberalization of milk marketing in 1992.

The Smallholder Dairy Project (SDP) sponsored the study, which was funded by the Department for International Development (DFID) and jointly implemented by the Ministry of Livestock and Fisheries Development (MoLFD), Kenya Agricultural Research Institute (KARI) and the International Livestock Research Institute (ILRI). Scientists from the University of Nairobi's Department of Veterinary Public Health, Pharmacology and Toxicology and the Kenya Medical Research Institute (KEMRI) collaborated.

Before and during the study, SDP consulted with dairy industry stakeholders in the public and private sector to determine the research questions and activities that would adequately address the concerns expressed. Institutions that were consulted included the Kenya Dairy Board (KDB), the Kenya Dairy Processors Association (KDPA), the Kenya Bureau of Standards (KEBS), the Ministry of Health (MoH) and the MoLFD's Department of Veterinary Services.

Recommendations were presented to the same stakeholders at a workshop held on 14 February 2001 at KARI Headquarters in Nairobi. The stakeholders at that meeting formed a Dairy Public Health Committee that later on translated the recommendations into a work plan (see Annex II) for consideration for implementation by the Kenya Dairy Board and other responsible organisations.

This report is divided into an executive summary and a main section. The summary highlights the study's key findings, conclusions and recommendations. The main report gives more detailed information on the data collection methods and main outcomes of the research. It is hoped that the results and recommendations of the study will significantly contribute to the creation of a more favourable milk market environment for all stakeholders.

Introduction

Quality standards and regulations for hygienic milk handling are put in place to protect consumers from milk-borne hazards. These standards and regulations, which have largely been borrowed from Western models, restrict milk handling to cold chain pathways and pasteurization. Whereas these quality standards have been successfully implemented in western countries, they have largely failed in most of the developing world where raw milk sales predominate. Kenya is one of those countries where current regulations and some officials insist that pasteurization should be compulsory for all marketed milk. This is despite the fact that only 14 per cent of all milk sold in Kenya is pasteurized (Figure 1) and the rest sold raw through the informal market (Omore *et al*., 1999).

Although the raw milk market continues to dominate, current restrictions against the sale of raw milk prevent most traders from scaling up their businesses. There are indications that promoting the informal milk market would increase the benefits to farmers, market agents and consumers. These benefits include higher incomes, job creation and competitive prices. However, there has been much public debate, but without quantified information, that encouraging the sale of raw milk by small-scale traders poses public health risks.

This study was therefore designed to produce valid evidence-based information to inform this debate and propose needed interventions. In this regard, the two main research problems addressed were the lack of accurate information on milk-borne health risks, and the need to define practical steps to achieve the best possible milk quality. Answers to these problems were important in addressing the need to define the trade-offs that Kenya's dairy industry should go for, in terms of quality assurance on the one hand, and cost and restrictions on traders on the other. The research problems were addressed under specific topics of risk assessment and risk management.

Research questions

Questions in risk assessment

- Are milk-borne hazards present in informally marketed milk and at what levels?

- Do the hazards pose significant health risks in terms of chances and levels of occurrence?
- What are the risk factors involved?

Questions in risk management

- Can public health be safeguarded while ensuring that the liberalized dairy market operates efficiently?
- What technical and policy options can be applied to the informal dairy sector to ensure the safety of consumers?

To assess risk, the study evaluated the risks factors of the main public health hazards associated with raw milk market pathways, namely:

- milk-borne zoonoses: brucellosis, bovine TB and *E. coli* O157:H7;
- high counts of total and coliform bacteria;
- antimicrobial and antibiotic drug residues; and
- adulteration

To manage risk, the study

- analyses the compromises that must be made to assure consumer safety while also supporting the efficient operation of the informal milk market; and
- recommends practical ways of reducing the risks and protecting public health without discouraging informal milk markets. The recommendations are a basis for communicating the risk information[7] to stakeholders and consumers.

The principles of Hazard Analysis Critical Control Point (HACCP)[8] system were used as a tool and guideline to assess and manage the risks noted above. HACCP involves five main steps:

- identifying risks in the food chain;
- determining critical control points (CCPs) to reduce or eliminate the identified risks;
- determining critical limits (CL) for ensuring food safety;
- developing systems for monitoring the interventions to improve food safety; and
- implementing procedures to verify that the safety management system is effective.

The first two steps are reported here, based on risk analyses at consumer- and market-levels, and recommendations made on the latter three.

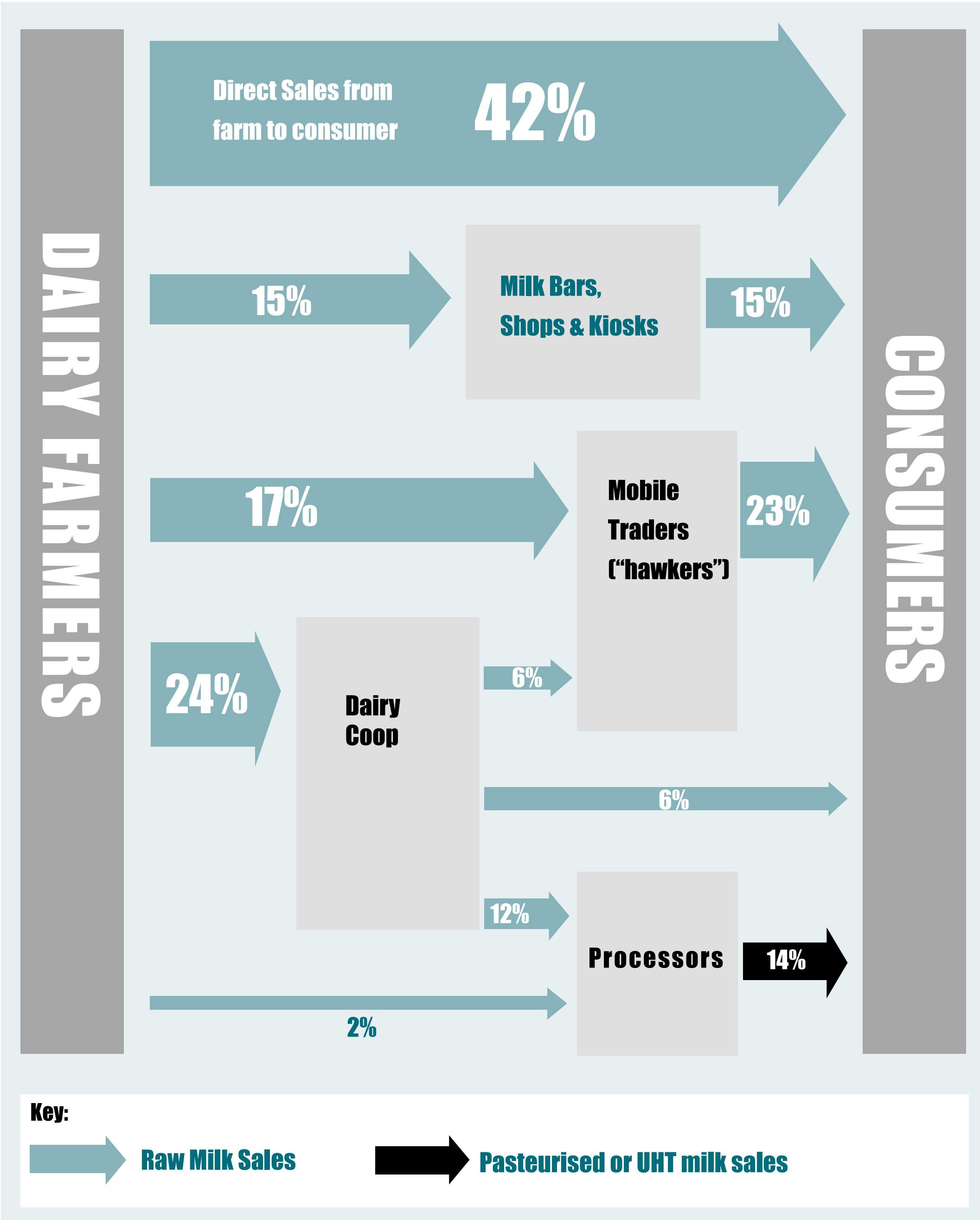
Research methodology

Details on the research methods and collection of data are given in Box 1.

[7] Risk communication is a critical part in risk analysis that involves productive interactions between policy makers and stakeholders on the one hand and scientists on the other

[8] HACCP is a risk analysis tool and system of process control aimed at ensuring food safety. Originally designed in the early 1960s to ensure safe foods for astronauts, HACCP is now widely applied along the food chain from farm to table to identify and prevent microbial, chemical and physical hazards in food from harming consumers by a) correcting deviations as soon as they are detected and b) preventing their occurrence. A guidebook by USDA (1997) gives a useful and detailed description.

Figure 1. Flow of marketed milk from dairy farmers to consumers in Kenya (Adapted from Omore *et al.,* 1999)



Note:
1.4 Billion litres of milk marketed annually represents 55% of on-farm production. The remaining 45% is either fed to calves or consumed on farm

Box 1. How the data were collected

Milk samples for the consumer and market surveys were collected during wet and dry seasons between January 1999 and February 2000.

Consumer survey

- Three sites: Nairobi city, Nakuru town and rural areas near Nakuru
- 210 households were sampled in each site
- 433 milk samples taken from households that bought unpasteurized milk

Market-level survey

- Two sites: Nairobi and Kiambu (urban), and Nakuru and Narok (rural)
- 10 divisions sampled in urban site and six divisions in rural site
- 532 informal milk market samples from cooperatives, self-help groups, milk bars, hawkers and shops/ kiosks
- 145 pasteurized milk samples collected from supermarkets and kiosks in Nairobi and Nakuru

Raw milk samples were analysed in the laboratory for

- adulteration (added water and solids) according to KEBS specifications
- counts of total and coliform bacteria according to KEBS specifications
- antibodies of *Brucella abortus* by Milk Ring Test (MRT) and enzyme-linked immunosorbent assay (ELISA)
- antibiotic drug residues according to EU specifications

Pasteurized milk samples analysed on "sell-by" date for counts of total and coliform bacteria
(See flow diagram in Annex 1 for summary of laboratory analyses)

Risk assessment of bovine TB

- One site: Narok district; chosen because of high chances of exposure to *M. bovis* due to extensive cattle grazing and consumption of raw milk by local Maasai pastoralists.
- 162 sputum and aspirate samples were collected from 134 suspect TB patients at the local health clinics.
- Samples collected between April and December 2000

Identification of market risk factors and CCPs

- Indicators of microbial milk quality were combined with market factors to identify groups of traders and trade-offs between quality and profitability in milk marketing.
- HACCP, multiple regression and multivariate analyses were used to identify CCPs and determine which health hazards were associated with specific trader groups, market pathways and consumer outlets.

Results of laboratory testing of milk samples

Assessment of quality of raw milk

Adulteration

Adulterating milk with water lowers its specific gravity (SG)[9] towards that of water. On the other hand, adding solids such as flour or sugar and removing the butterfat (BF) increases its SG. Such interference may introduce chemical and microbial health hazards into the milk, besides affecting its nutritional and processing quality, palatability, and market value. The SG depends on the solids content of the milk; the respective SGs of fat, solids-not-fat (SNF) and water are 0.93, 1.6 and 1.0.

Overall, 4.7 per cent and 10.4 per cent of milk samples from *consumer households* and *market agents*, respectively, were adulterated with water. Adulteration varied widely with study site and season but no significant variances were noted among the different types of market agents.

From the *consumer survey*, the highest proportion of adulterated milk samples (22 per cent) was observed in Nairobi during the dry season. This was markedly higher than the proportion of

[9] *The specific gravity of normal whole milk measured at 20°C ranges between 1.026 - 1.032. It is a ratio of the weight of milk to the weight of an equal volume of water.*

adulterated samples from urban and rural Nakuru during the same season where only a negligible fraction of samples had added water (Figure 2). The reverse was observed in the wet season, where more samples in Nakuru had added water compared to Nairobi, which recorded no incidences of water adulteration in the milk samples tested. It is likely that milk sold to consumers in Nairobi is adulterated with water during the dry season so that traders can increase volumes and get better prices when milk supply is low and prices high. This was especially true for milk samples obtained from kiosks.

Among milk samples from *market agents* (Figure 3 and 4), added water was detected in 7-13 per cent of milk from Kiambu and Nairobi in the wet season. Almost similar proportions (4-15 per cent) were recorded in the dry season, but there was no noticeable trend between types of market agents. In contrast, cases of milk adulteration in Nakuru and Narok showed marked seasonal variation, from none in the wet season to 10-27 per cent of samples in the dry season. Generally, adulteration seems to occur across seasons in Kiambu and Nairobi, but is only associated with the dry season in Nakuru and Narok. These proportions indicate a large variation in added water by season and area and may be attributed to relative changes in milk supply and price.

Overall, 5.9 per cent and 1.0 per cent of milk samples from consumer households and market agents, respectively, were adulterated by adding solids. However, the incidence was highly variable, ranging from 0 per cent to 15 per cent and with no obvious pattern.

Milk bacteriological quality

According to KEBS, raw milk is considered low quality if it contains more than 50,000 coliform and 2 million total colony-forming units per millilitre (cfu/ml). Raw milk from the udder of a healthy cow contains very few microorganisms and will generally have less than 1000 total bacteria per millilitre. However, soon after milking, the milk may be contaminated from the environment where milking is done and the

Figure 2. Consumer survey of adulteration of milk with water

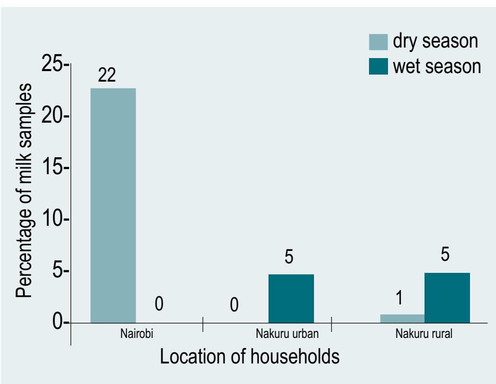


Figure 3. Kiambu and Nairobi market survey of adulteration of milk with water

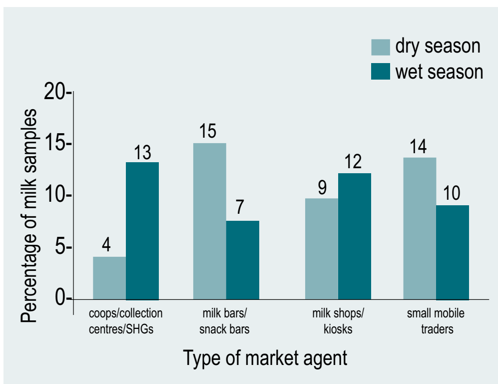
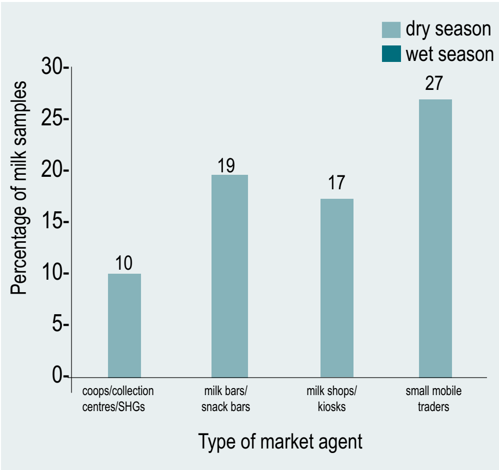


Figure 4. Nakuru and Narok market survey of adulteration of milk with water



handling equipment. The hygiene of the milk handler also influences milk quality. The presence of coliform bacteria in raw milk is an indicator of poor hygiene in milk handling since these bacteria are of faecal origin.

Temperature of storage and time since milking are also important in determining milk quality, as these influence the rate at which the bacteria will increase in number. At tropical temperatures, a bacterial cell with a typical generation time[10] of 20 minutes will multiply within seven hours to 2 million cells, the threshold set by KEBS for total bacteria counts in raw milk. However, if the milk temperature were lowered to below 10 degrees Centigrade, the same cell would multiply to only 32 cells within the same time (FAO, 1979). With higher initial bacterial load, the time taken to reach these thresholds reduces considerably.

Results from consumer households

Households in urban Nairobi and Nakuru had higher proportions (61-84 per cent) of milk samples with unacceptable total bacteria and coliform counts compared to milk samples from rural Nakuru (27-35 per cent). These results are

Figure 5. Consumer-level milk samples with total bacteria counts above 2 million cfu per ml

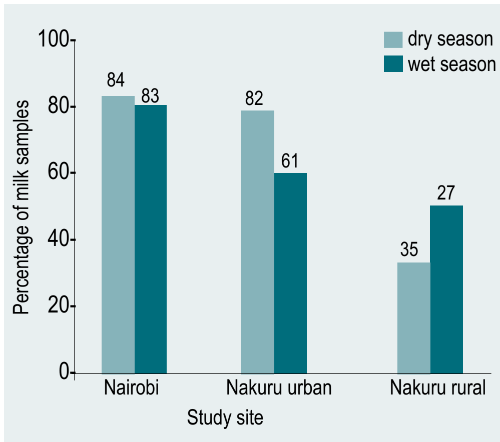
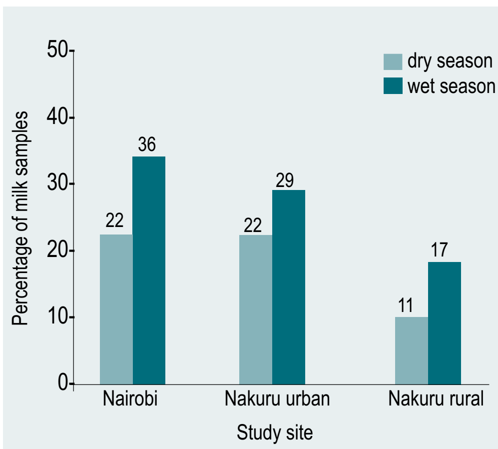


Figure 6. Consumer-level milk samples with coliform counts above 50,000 cfu per ml



[10] *The time taken for a microbial population to double in number.*

presented in Figures 5 and 6. However, it was striking that as high as 35 per cent of milk samples from Nakuru rural (very short and direct market chain) did not meet KEBS standards for total bacteria counts. This observation suggests that these standards may not be suited to the prevailing local conditions of milk marketing, specifically the lack of cold chains.

It was noted that many urban households bought milk from stationary or mobile milk traders while some were supplied directly by farmers. Milk sold by traders was often transported in plastic containers and handled by several intermediaries. Most households and sale points for informal milk did not have cooling facilities to preserve milk. It is thus likely that the use of non-food grade milk containers and the lack of cold chains contribute to the failure of the sampled raw milk samples to meet the KEBS quality specifications.

Distances travelled by farmers or market agents to consumers in rural Nakuru were shorter than in urban Nakuru while some respondents, mainly in rural areas, were also milk producers themselves. These variations contributed to the large range in bacteria counts, ranging from very low counts in milk from rural Nakuru to high counts in milk from urban centres (Table 1).

Table 1 Average numbers of bacteria in milk samples from consumer households

Site	Total counts (cfu/ml)	Coliform counts (cfu/ml)
Nairobi	316 million	50,000
Urban Nakuru	20 million	20,000
Rural Nakuru	1.3 million	1,000

According to KEBS, thresholds for good quality raw milk are 2 million cfu/ml total and 50,000 cfu/ml coliform counts, respectively

Results from samples from market agents

The average total bacteria count in milk from farmer groups was 7.9 million cfu/ml; this was much lower than the overall average of 39.8 million cfu/ml. Similarly, coliform counts in milk from farmer groups (15,000 cfu/ml) were much lower than the overall average (50,000 cfu/ml).

Among market agents at both rural and urban sites, bacterial counts increased as the milk moved up the market chain. Milk bars, shops/kiosks and small mobile traders sold markedly higher proportions of milk with unacceptably high bacterial counts as compared to cooperatives and collection centres (Figures 7 to 10). This may reflect prolonged storage of milk at high temperatures before the market agents receive it. However, seasonal differences in microbial quality of milk at the market level were not definite.

The overall picture at both the consumer and market levels is that bacterial counts increase (and subsequently, milk quality decreases) as milk passes through increasing numbers of intermediaries. The high proportions of raw milk samples that did not achieve KEBS requirements for total bacterial counts suggest that prolonged milk storage and lack of a cold chain between milking and sale may be major factors contributing to low milk quality. This effect of the lack of a cold chain also applies to most outlets for processed milk without chilling

Figure 7. Wet season market-level milk samples with total counts above 2 million cfu/ml

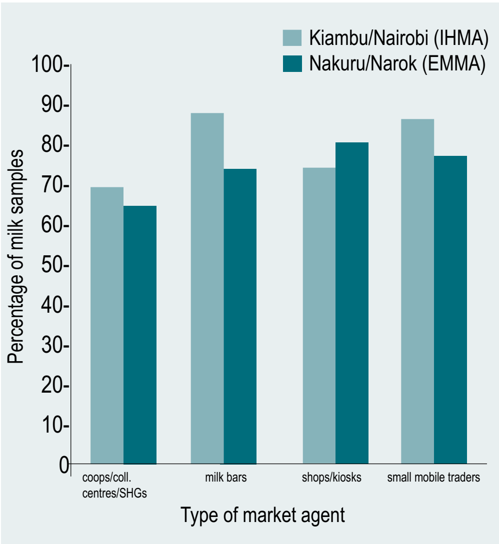


Figure 8. Dry season market-level milk samples with total counts above 2 million cfu/ml

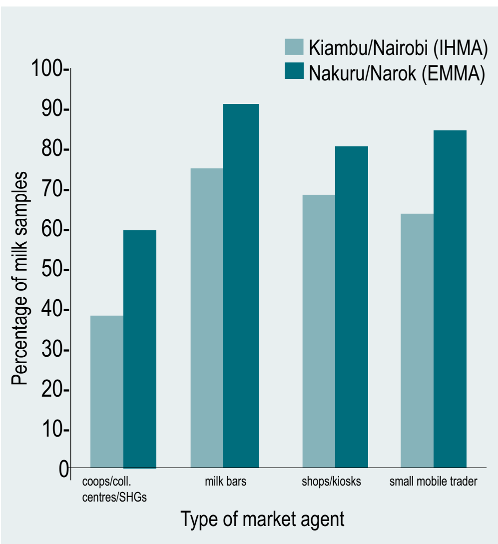


Figure 9. Wet season market-level samples with coliform counts above 50,000 cfu/ml

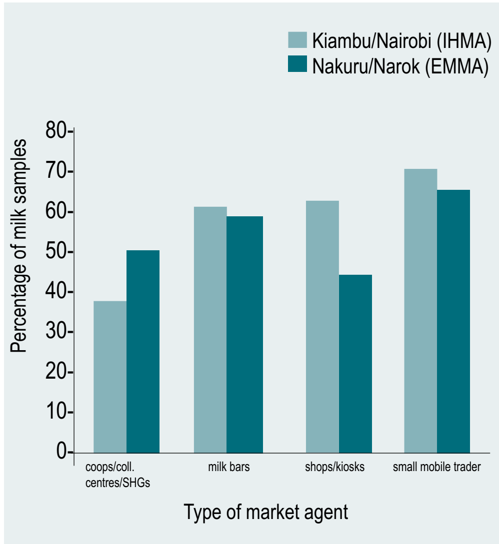
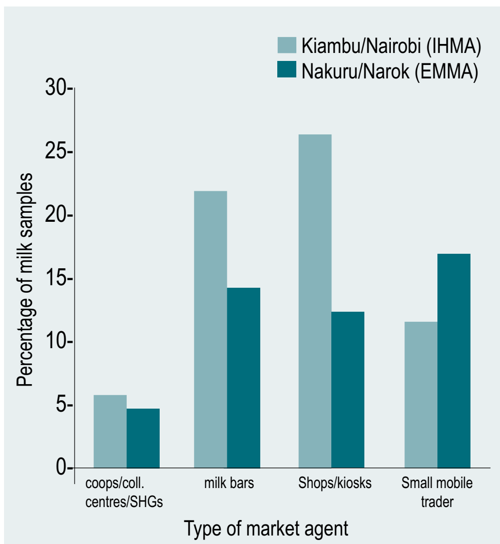


Figure 10. Dry season market-level samples with coliform counts above 50,000 cfu/ml



facilities (see Section on "Assessment of quality of pasteurized milk").

Zoonotic health hazards

Brucellosis

Brucellosis is a type of flu-like fever caused by *Brucella abortus*. Since *Brucella* is associated with raw milk, the risk of brucellosis is a major reason for advocacy of heat treatment of milk (pasteurization or boiling) before consumption.

Results of consumer survey

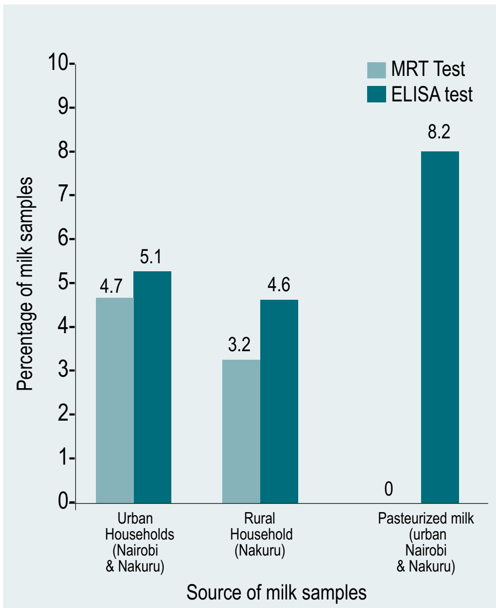
Brucella antibodies were detected in 3-5 per cent of raw milk samples from both rural and urban households in Nairobi and Nakuru (Figure 11). Two consumer households (out of 420) in Nakuru reported having a member diagnosed with brucellosis in the previous one year. However, the risk of *Brucella* can be eliminated if milk is boiled before consumption. This should be encouraged as a standard consumer practice.

Nine (8.2 per cent) pasteurized milk samples were positive for *Brucella* by the ELISA test. Of these, six samples were from one milk processor in Nakuru. Since pasteurization destroys *Brucella*, the isolation of *Brucella* antibodies from samples of processed milk suggests poor hygienic handling of milk after processing. Thus, even the formal milk processors need to reinforce hygienic post-pasteurization handling of milk and good manufacturing practice in order to safeguard the health of those consumers who may not subject pasteurized milk to further heat treatment before consumption.

Results of market-level survey

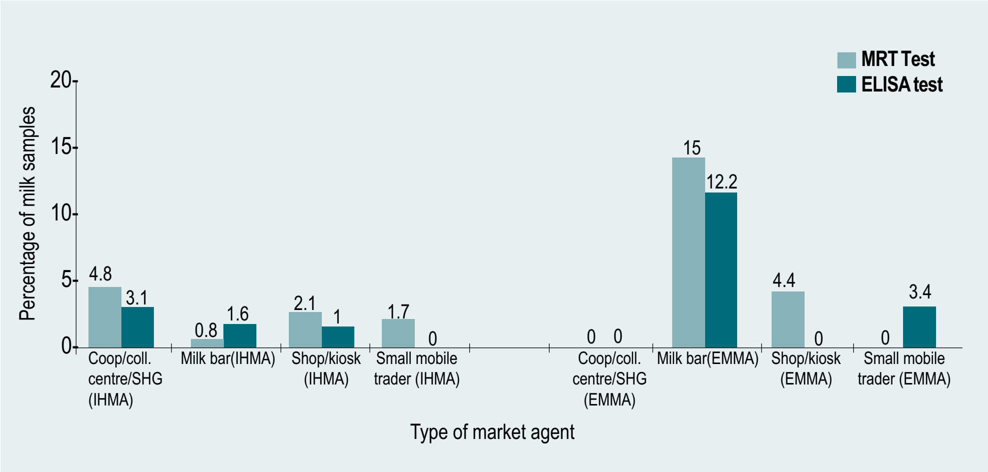
Generally, the prevalence of *Brucella* was variable across the different types of informal traders in Nairobi and Kiambu, ranging from 1-5 per cent of milk samples testing positive for *Brucella* antibodies. In Narok and Nakuru, 3-4 per cent of milk sold in kiosks and by hawkers contained *Brucella*. Almost all the *Brucella*-positive samples were from bulked milk from dairy cooperatives

Figure 11. Household and pasteurized milk samples containing *Brucella abortus* antibodies



in IHMA sites and milk bars in EMMA sites. The highest proportion (12-15 per cent) of *Brucella*-positive milk samples was from milk bars in Narok, where extensively grazed Zebu herds are common. The higher prevalence of *Br. abortus* antibodies in bulked milk points to a potential health risk, particularly if milk is consumed without first being boiled.

Figure 12. Informal market-level milk samples containing *Brucella abortus* antibodies



These results generally agree with findings from previous studies in cattle that indicated higher prevalence of brucellosis in extensively grazed cattle than in smaller stall-fed herds. Kagumba and Nandokha (1978) reported a prevalence of 10 per cent bovine brucellosis in extensive production systems in Nakuru, while Kadohira *et al.* (1997) reported a 2 per cent apparent prevalence of bovine brucellosis in smallholder farms in Kiambu. Human brucellosis is also more common where extensive cattle production systems exist. Muriuki *et al.* (1997) found that as high as 21 per cent of human flu-like cases reported in health facilities in Narok were diagnosed as brucellosis.

E. coli O157:H7

E. coli O157:H7 is a newly recognized strain of *E. coli* that causes bloody diarrhoea and acute kidney failure. The organism is found in the gut and faecal material of affected cows and humans. Milk can get contaminated with *E. coli* O157:H7 through contact with cow faeces or unhygienic handling.

A total of 261 consumer-level raw milk samples from Nairobi and Nakuru were screened for *E. coli* O157:H7 (Figure 13). Only three suspect isolates were recovered from three different milk samples out of the 91 samples that tested positive for *E. coli*. Two of the suspect isolates (one from Nairobi and one from urban Nakuru) were serologically confirmed to be *E. coli* O157:H7. The Nakuru isolate produced verocytotoxin1[11]. The third suspect isolate–which could not be serotyped (only O157:H7 specific antiserum was used) and did not produce verocytotoxin–was from urban Nakuru. *E. coli* O157:H7 was not isolated from any of the 33 *E. coli*-positive samples from rural Nakuru.

[11] *Verocytotoxin is the poison produced by E. coli O157:H7 that causes foodborne illness.*