



SMALLHOLDER
DAIRY PROJECT

SDP Research and Development Report 3

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

A. Omore, T. Lore, S. Staal, J. Kutwa,
R. Ouma, S. Arimi and E. Kang'ethe



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The Smallholder Dairy Project

The Smallholder Dairy Project (SDP) carries out research and development activities to support sustainable improvements to the livelihoods of poor Kenyans through their participation in the dairy sub-sector. SDP is jointly implemented by the Ministry of Livestock and Fisheries Development (MoLFD), the Kenya Agricultural Research Institute (KARI) and the International Livestock Research Institute (ILRI). The project is led by the Ministry with primary funding from the UK Department for International Development (DFID). The three organisations work with many collaborators, including government and regulatory bodies, the private sector and civil society organisations.

Key areas of SDP research and development activities are:

- Analysis of factors constraining the competitiveness of smallholder dairy farmers, including farm constraints, markets and infrastructure, and information services.
- Analysis of policies and institutions affecting the dairy sub-sector, and provision of resulting information to support planning needs of stakeholders and policy-makers in the dairy sub-sector
- Analysis of social benefits of smallholder dairy production, including income, employment and child nutrition
- Participatory development of improved dairy farm technologies, such as improved fodder plants and feeding strategies
- Development of appropriate technologies and strategies for small scale milk and dairy product traders
- Development of extension and training materials to support smallholder farmers and small milk traders, and the development agencies serving them
- Spatial analysis of dairy systems for improved targeting of technology and investment

By combining the research capacity of KARI and ILRI with the experience and networks of the Ministry, SDP has been providing high-quality and wide-ranging research information to support smallholder dairy farmers, market agents, stakeholders and policy-makers since 1997.



MoLFD Ministry of Livestock and Fisheries
Development

KARI Kenya Agricultural Research Institute

ILRI International Livestock Research
Institute

DFID Department for International
Development – Kenya

DFID Department for
International
Development

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**SMALLHOLDER
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This collaborative research report is circulated prior to full peer review to stimulate discussion and comments. Based on that process, its contents may be revised.





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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 per cent), “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 litres¹.

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 (LPS²), 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 it⁴. 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 information⁷ 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

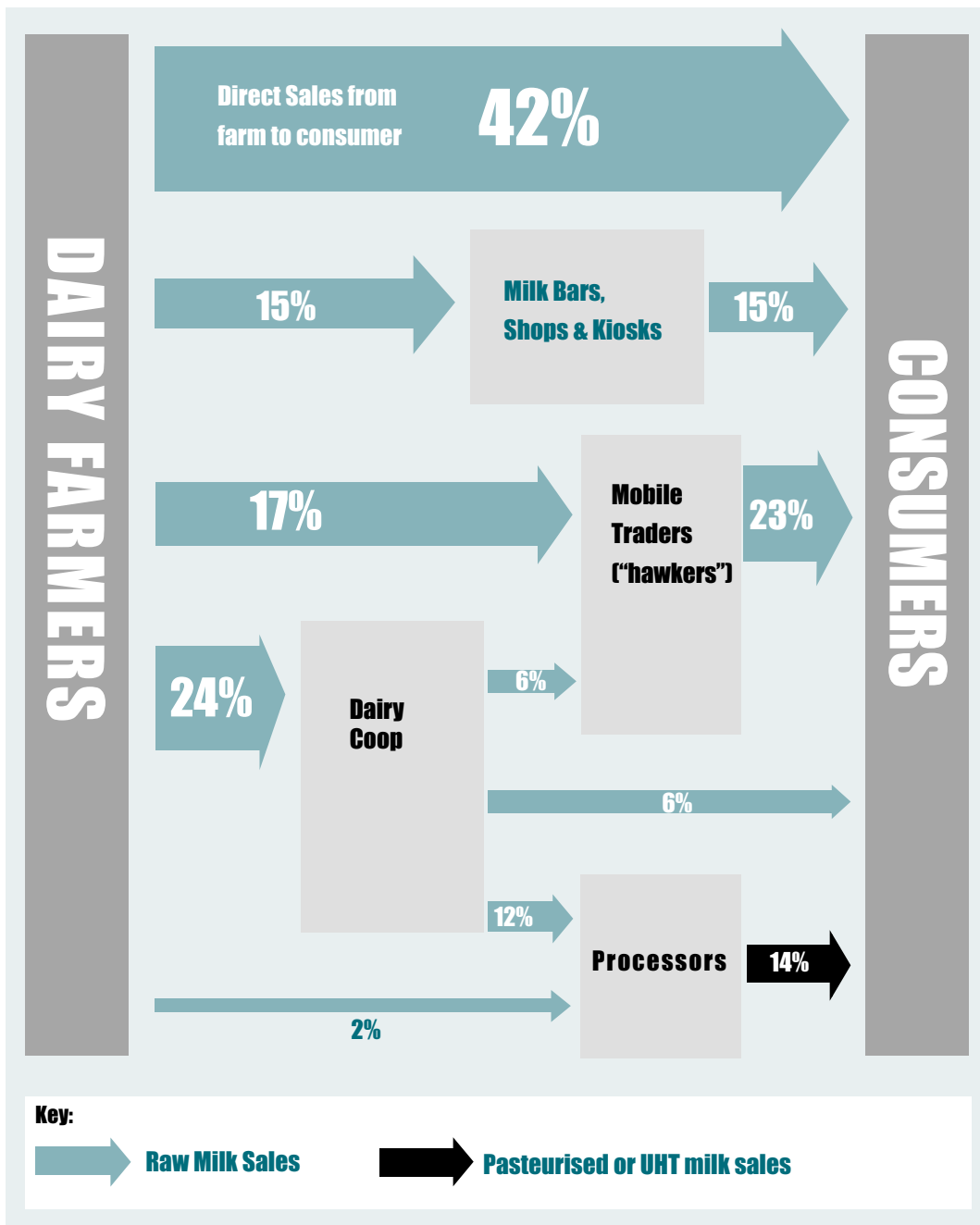
Details on the research methods and collection of data are given in Box 1.

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

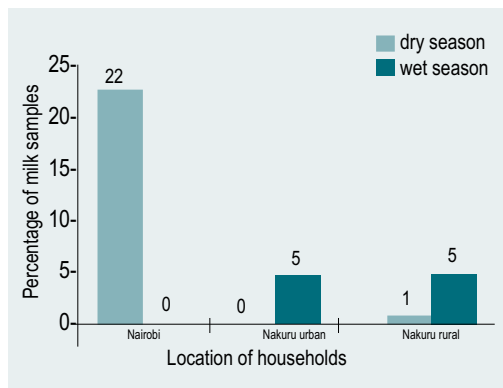


Figure 3. Kiambu and Nairobi market survey of adulteration of milk with water

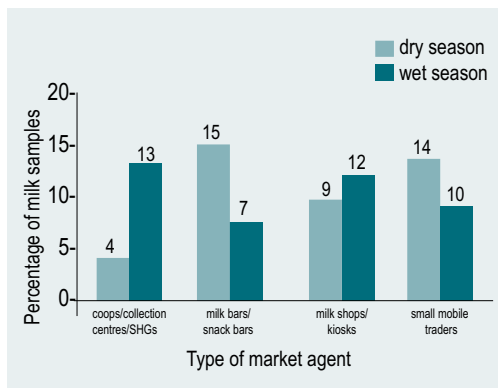
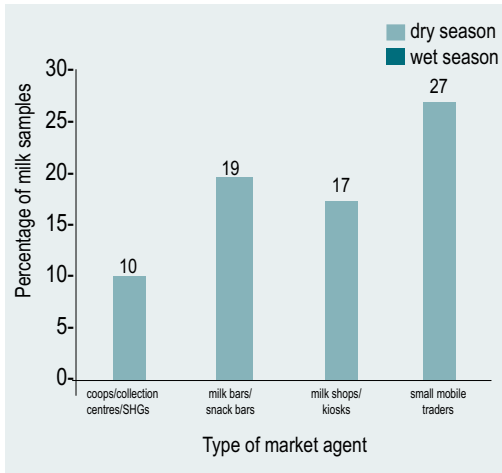


Figure 4. Nakuru and Narok market survey of adulteration of milk with water



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 time¹⁰ 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.

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

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

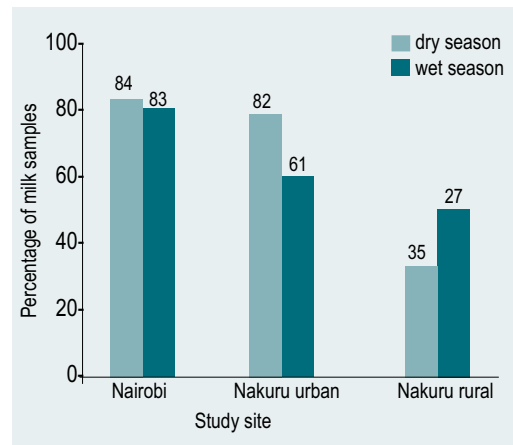
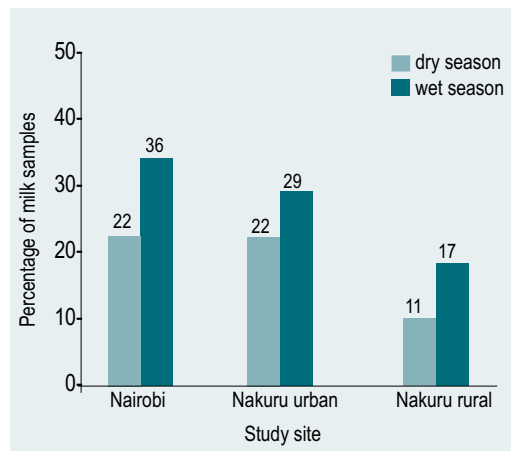


Figure 6. Consumer-level milk samples with coliform counts above 50,000 cfu per ml



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).

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

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

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

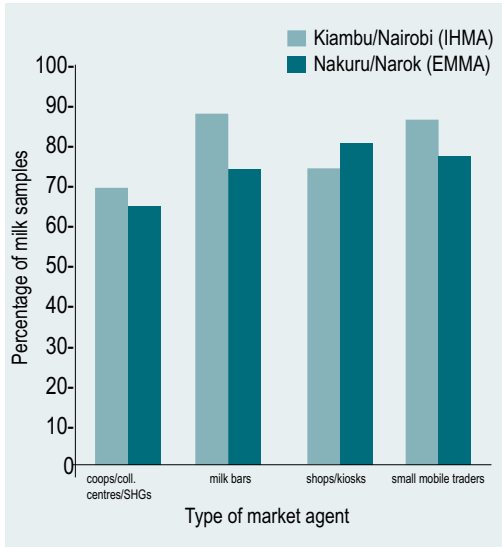


Figure 9. Wet season market-level samples with coliform counts above 50,000 cfu/ml

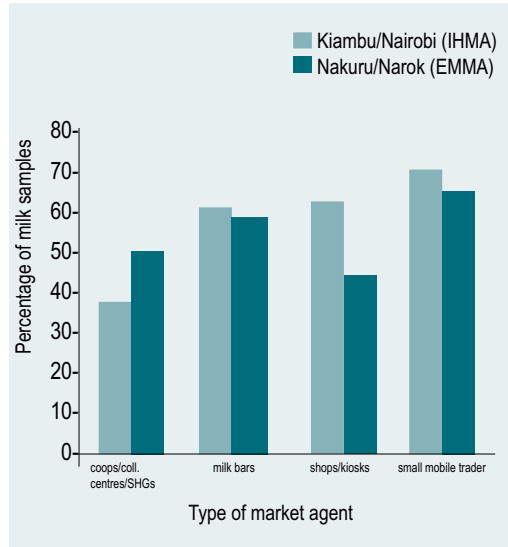


Figure 8. Dry season market-level milk samples with total counts above 2 million cfu/ml

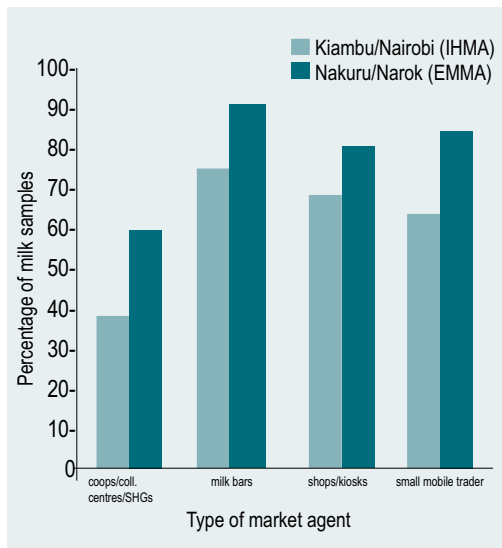
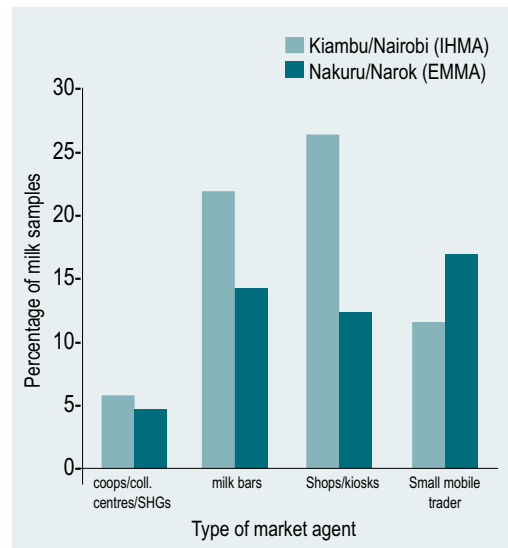


Figure 10. Dry season market-level samples with coliform counts above 50,000 cfu/ml



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

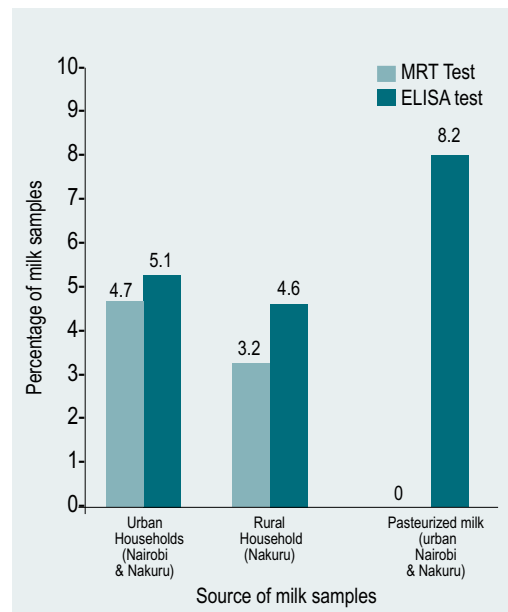
Brucella antibodies were detected in 3-5 per cent of raw milk samples from both rural and urban households in Nairobi and Nakuru (Figure 11). Two consumer households (out of 420) in Nakuru reported having a member diagnosed with brucellosis in the previous one year. However, the risk of *Brucella* can 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

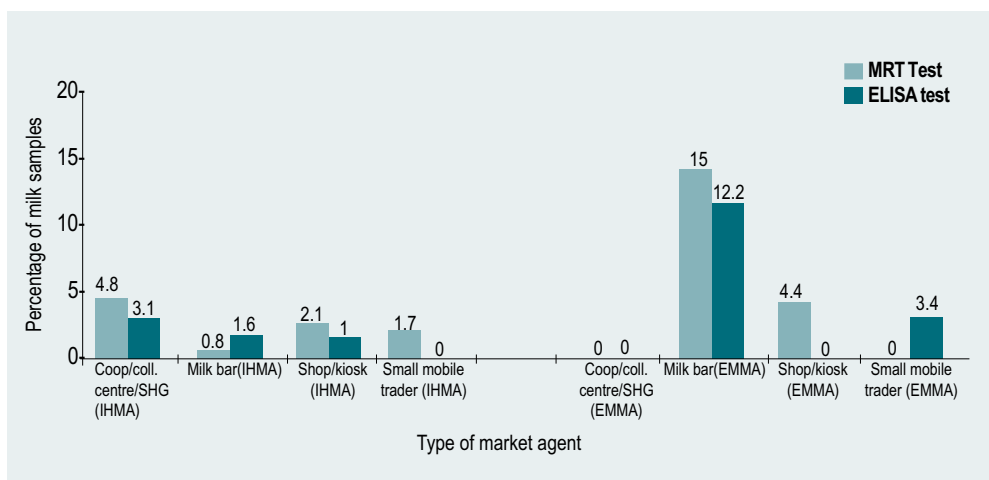
Generally, the prevalence of *Brucella* was variable across the different types of informal traders in Nairobi and Kiambu, ranging from 1-5 per cent of milk samples testing positive for *Brucella* antibodies. In Narok and Nakuru, 3-4 per cent of milk sold in kiosks and by hawkers contained *Brucella*.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

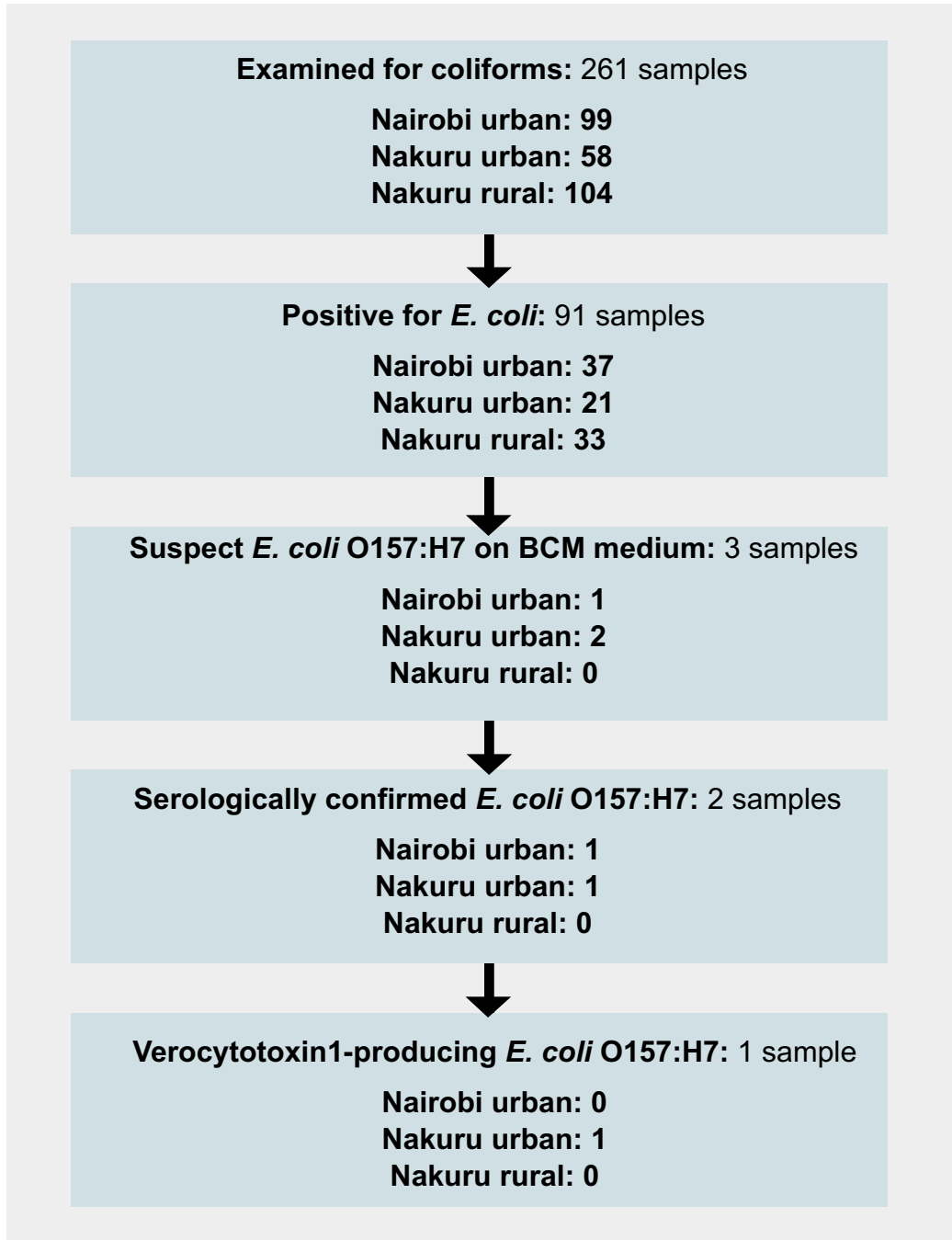
and faecal material of affected cows and humans. Milk can get contaminated with *E. coli* O157:H7 through contact with cow faeces or unhygienic handling.

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 verocytotoxin¹¹. 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.



Figure 13 The process of screening consumer-level raw milk samples for *E. coli* O157:H7



The prevalence of *E. coli* O157:H7 was low, being recovered from only two out of 261 samples (0.8 per cent). Although this recovery rate was low, it is noteworthy due to the severity of illness that *E. coli* O157:H7 can cause in form of permanent kidney damage. Still, the impact of *E. coli* O157:H7 in causing food-borne diseases in Kenya is not well known since few studies on the organism have been done locally. However, this study shows that consumers of unpasteurised or unboiled milk are at some risk of getting infected. The prevalence of 0.8 per cent implies that a person who daily drinks marketed milk that has not been adequately heat treated is at risk of being exposed to *E. coli* O157:H7 at least three times a year. Fortunately, this exposure would rarely translate into an infection. This is because of the widespread consumer practice of boiling milk—whether bought raw or pasteurized—before consumption. However, the fact that *E. coli* O157:H7 was isolated from milk samples in two towns that are far apart (150 km) may indicate that its occurrence is widespread.

Bovine tuberculosis

Although bovine TB has not been officially reported in Kenya¹², it has not been widely studied following comprehensive reviews in the 1960s by FAO/WHO/GoK experts (Myers and Steele, 1969) that ruled out the disease. The only sign that the situation could still be the same has been the lack of any reports of TB from passive reporting systems such as post-mortems in slaughterhouses and isolation of *Mycobacterium* from TB patients.

¹² The zoonosis is endemic in all neighbouring countries

Of the 37 samples from suspect TB patients that tested positive for *Mycobacterium*, none resulted in the isolation of *M. bovis*. Though these findings support the long-held official position that bovine TB is absent in Kenya, they need to be verified and periodically monitored in other areas, given the risk posed by frequent cross-border movement of livestock from neighbouring countries. Those at greatest risk of getting bovine TB would be pastoralist communities like the Maasai who traditionally consume raw milk and/or other raw animal food products.

Antimicrobial residues

Antimicrobial residues in milk are undesirable because of their negative health effects on people who are continually exposed to such risks. In particular, long-term exposure to antibiotic drug residues in milk can give rise to bacterial resistance by killing all but the most potent bacteria strains. This helps create ‘super bugs’ that are immune to common, less expensive antibiotics. Antibiotic residues in milk also inhibit the starter microorganisms involved in the processing of fermented milk products. These residues most often originate from farm-level practices when farmers fail to observe the specified milk withdrawal periods after antibiotic treatment of cows.

Results from consumer and market surveys

Milk samples were examined for residues of five common families of antimicrobials. Overall, 9 per cent and 6 per cent of consumer- and market-level milk samples, respectively, contained



antibiotic residues. This suggests that a person who drinks milk daily is at risk of consuming milk that contains antibiotic residues at least twice every month. On average, 15 per cent of milk samples from rural households had antibiotic residues. This was three times higher than the proportion of antibiotic-positive samples from urban households. At the market level, the proportion of milk samples with antibiotic residues decreased with increasing levels of milk bulking. Thus, milk bars and small mobile traders dealing in relatively small quantities of milk recorded more antibiotic-positive samples than dairy co-operatives that handled milk in bulk (Figure 14). This perhaps indicates dilution of the residues to levels below the detection thresholds of the test.

The higher proportion of rural consumer milk samples (milk from own farms) with antimicrobial residues indicates that the residues are more likely to originate at the farm than due to bad market practices. On the other hand, the relatively higher proportion of pasteurized milk samples with antimicrobial residues (8.2 per

cent) suggests that some antimicrobials may be added after the first milk sale transaction.

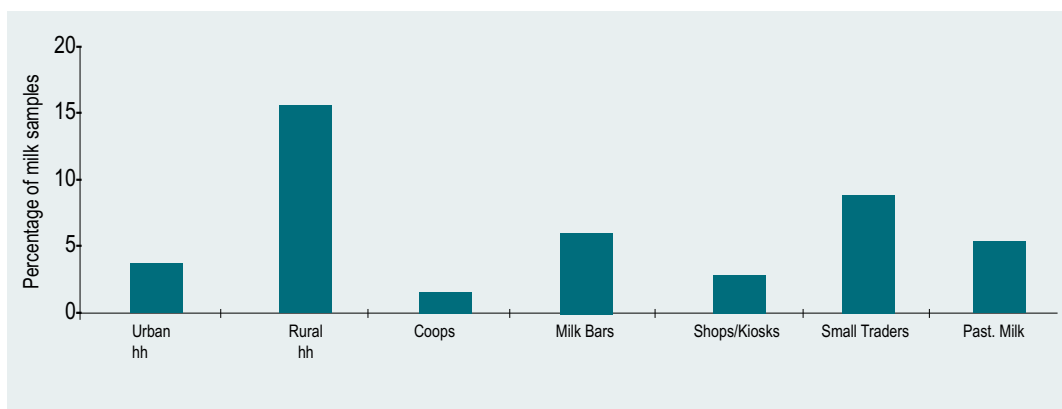
Since heat treatment does not eliminate antibiotic residues, they present a potential health risk in form of bacterial resistance and allergic reactions. The results indicate that an effective solution to the problem of antimicrobial residues in milk needs to be sought through a dual farmer-and-trader-training approach, and monitoring of antimicrobial residue levels along the milk supply chain.

Assessment of quality of pasteurized milk

The microbiological quality of pasteurized and packaged milk was assessed alongside that of raw marketed milk 1) to compare both types of milk according to respective standards, and 2) in response to complaints by some dairy industry stakeholders about high rates of spoilage of pasteurized milk.

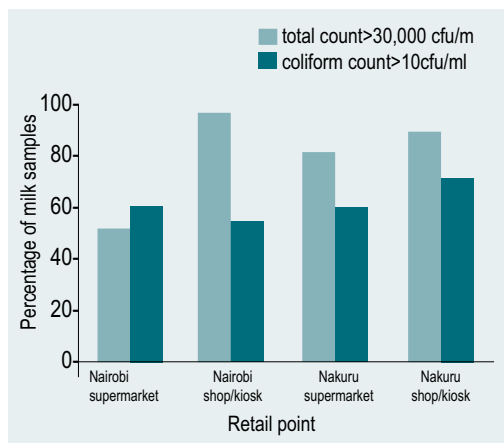
Over half of pasteurized milk samples failed to meet the KEBS quality requirements for

Figure 14. Proportions of consumer- and market-level samples containing antibiotic residues



processed milk (Figure 15). The KEBS maximum allowable levels for total and coliform bacteria in pasteurized milk are 30,000 and 10 cfu per ml, respectively.

Figure 15. Pasteurized milk samples with microbial counts above KEBS limits



In Nairobi, 82 per cent and 59 per cent of milk samples had unacceptably high numbers of total and coliform bacteria, respectively. A similar trend was observed in Nakuru, where 89 per cent and 70 per cent of samples had total and coliform counts, respectively, that were above KEBS specifications. In addition, a substantial number of samples recorded total counts above 1 million cfu per ml.

In both Nairobi and Nakuru, over 90 per cent of milk samples from shops and kiosks had unacceptable total bacteria counts. This was significantly greater than proportions of similarly sub-standard milk from supermarkets in Nairobi (52 per cent) and Nakuru (81 per cent). The lower incidence of high bacteria counts in pasteurized milk in Nairobi supermarkets may be attributed to the use of chilling facilities,

which are largely absent in most shops and kiosks. About 60 per cent of pasteurized milk from outlets in Nairobi and Nakuru had unacceptable coliform counts, but samples from supermarkets did not consistently have lower coliform counts compared to retail outlets without chilling facilities.

These results show that by the time pasteurized and packaged milk reaches its “sell-by” date, the number of total bacteria in the milk will be quite high. The main factors contributing to this are a high initial bacterial load in raw milk, the lack of chilling facilities in kiosks and unhygienic handling of milk after processing. KEBS standards only assure quality immediately after pasteurization and assume that the milk is chilled at all retail points.

The cross-cutting failure of both pasteurized and raw marketed milk samples to meet their respective KEBS specifications for microbial quality indicates that these standards may be unsuited to prevailing local conditions, which include the widespread absence of cold chains in both formal and informal market pathways, poor road networks, predominant sale of raw milk and the common consumer practice of boiling milk before consumption.

It is noteworthy that chilling of pasteurized milk at supermarkets did not markedly reduce average coliform counts compared to pasteurized milk purchased from kiosks. This indicates that a CCP for pasteurized milk may exist during transportation from processing plants to retail points, or that storage temperatures are not kept low enough at retail outlets, even those with chilling facilities.



Identification of risk factors and critical control points



Market risk factors that influence milk quality

Milk marketing pathways

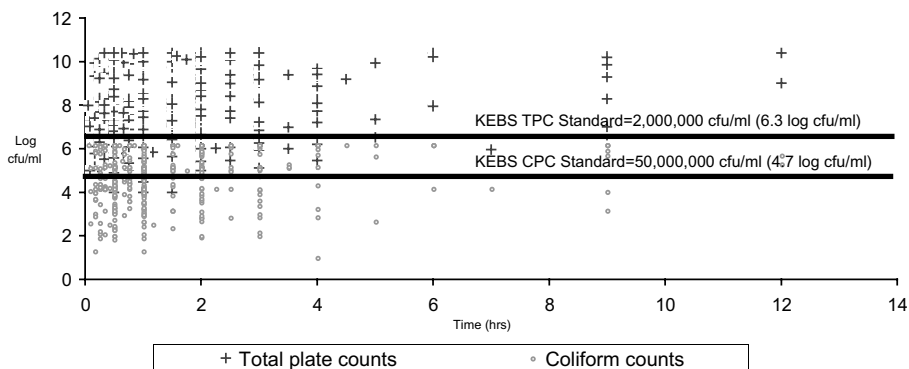
Two main types of marketing pathways were identified according to how the traders got their raw milk:

- direct sourcing from the farm without intermediaries (70.8 per cent), and
- pathways with one or more intermediaries (29.2 per cent)

Majority of small mobile traders handled less 120 litres/day and travelled an average of 30 kilometres to the retail outlets. Milk sold in milk bars was transported over the longest distance to market (35 kilometres). Although milk that was sold through one or more intermediaries was transported over longer distances than that sourced directly from the farm, no significant difference in milk microbial quality was noted between the two pathways. Thus, the risks associated with use of intermediaries in marketing of raw milk are considered to be insignificant.

Figure 16 indicates the bacterial counts in milk after time of milk collection. It will be noted that even 1-2 hours after milk was collected, more than half of the milk samples had total and



Figure 16. Bacterial counts vs. time since milk collection by market agents

coliform bacteria counts that exceeded KEBS specifications. Again, this suggests that the standards, which are based on those in countries where milk is marketed through cold chain systems, are not appropriate to local milk marketing conditions. Thus, judging the quality of informally-sold raw milk according to the current KEBS specifications may in fact unfairly penalize otherwise “good” quality milk.

Milk handling methods

The methods used in handling of raw milk varied across the different scales of business. Most of the small-scale milk hawkers handled milk in plastic jerry cans unlike the larger dairy co-operatives that preferred to use metal churns. Eighty-nine per cent of hawkers and only 10 per cent of co-ops used plastic containers. On the other hand, 6 per cent of hawkers and 86 per cent of co-ops used metal containers. The use of plastic containers was associated with high coliform counts in raw milk. This is likely due to the fact that plastic containers are difficult to clean and sterilize.

Regarding the methods used by informal traders to clean milk containers, majority (89 percent) used hot water and soap/disinfectant. This indicates a conscious awareness among the traders of the need to reduce milk spoilage and ensure cleanliness during milk handling. This positive mindset needs to be reinforced by training and use of improved handling practices, such as sterilizable metal milk containers.

Refrigeration or chilling of milk was used by 47 per cent of market agents, and most of these were milk bar traders. Boiling of milk as a method of preservation was practised by 19 per cent of traders, the majority being shop and kiosk traders. Though boiling was mainly done to lengthen shelf life, it had an added advantage of killing pathogens in milk, thereby eliminating these microbial risks. On average, 28 per cent of all traders, mainly co-ops and hawkers, sold milk without preserving it in any way. Notably, hardly any chemical preservatives were recorded as being added to milk to lengthen storage life. Only 2 per cent of traders (one milk bar and one large-scale mobile trader) said that



they used hydrogen peroxide and none indicated using lactoperoxidase or antimicrobials.

Level of training and experience of traders

Overall, only 12 per cent of milk handlers were trained in milk handling and quality control but this was wide-ranging, from only 4 per cent of mobile traders to 43 per cent of dairy cooperative workers. The lack of training in milk quality may be a contributing factor to unhygienic milk handling by the informal sector traders. Small-scale milk traders had been in business for an average of 2.5 years, a substantially shorter time than farmer groups (average 21 years). This may indicate a high turnover in the milk market business or an expanding market with several recent entrants. These factors need to be considered alongside any efforts undertaken to improve milk hygiene among these groups of traders.

Major constraints cited by milk traders

Harassment by regulatory authorities was the most commonly cited constraint by half the traders. Milk spoilage, seasonality in supply, high competition and transportation problems due to poor roads were the other major constraints cited. Though mobile traders—who are mainly unlicensed—faced more harassment, there was no significant difference in milk quality (based on coliform counts) between the quality of the milk they sold and that of licensed traders who had fixed premises. This raises questions on the validity of the official regulations governing licensing of milk traders;

currently traders must have fixed premises in order to qualify for a milk handling licence from the KDB. However, licensing can still play an important role in improving the quality of milk sold in the informal sector if it is put in place as a means to promote training and certification of informal milk traders. In this way, licensing forms an operating framework where the activities of the informal milk sector can be effectively monitored and evaluated from time to time.

Risk factors identified at consumer households

Shops and kiosks sold milk that had the highest average total and coliform bacteria counts. Adulteration was also found to be more likely associated with milk sold at kiosks (collected from co-operatives). However, adulteration of milk varied depending on the season, with more cases being noted during the dry season when milk supply is low and prices are higher.

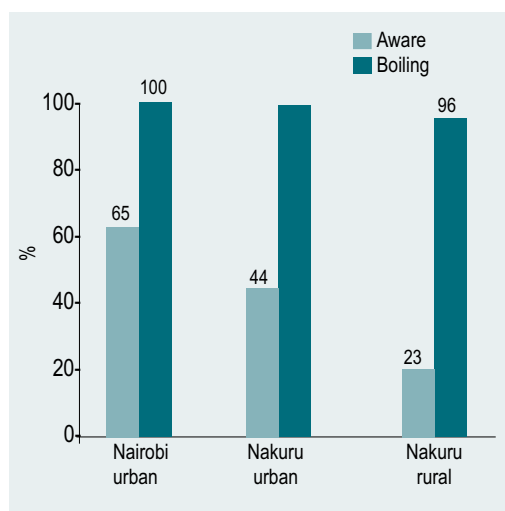
More consumers in Nairobi (65 per cent) were aware of the public health risks associated with raw milk consumption compared to Nakuru rural (23 per cent) and Nakuru urban (44 per cent). All sampled urban households and 96 per cent of sampled households in Nakuru rural reported boiling milk (alone or in tea) before consumption (Figure 17). About 6 per cent of sampled rural households, mostly from Nakuru rural, consumed home-made fermented milk (often unboiled before fermentation) in the previous one month before each seasonal survey.

Boiling of raw milk attains a higher temperature



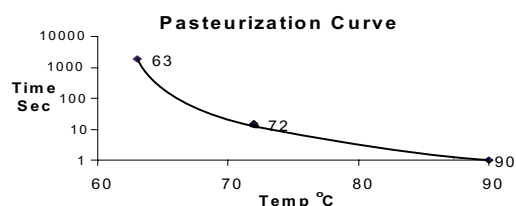
than pasteurization and therefore effectively destroys all pathogens in milk¹³ (Figure 18). Given the widespread consumer practice of boiling milk before consumption, the public health risks from bacterial pathogens were determined to be very low. This practice should be encouraged, especially in rural/pastoral areas, where a small proportion of households reported consuming milk that had been naturally fermented without prior heat treatment.

Figure 17. Proportions of households in urban and rural areas that are aware of milk-borne risks and boil milk



The risks of consuming naturally fermented milk need to be studied further. This practice was reported by 6 per cent of rural households. Such milk is often not boiled before fermentation, which, despite increasing the acidity of milk, may not kill all pathogens present in raw milk.

Figure 18. The time-temperature combinations for pasteurisation



Thus, such fermented milk could be a source of milk-borne infection. The survival of these and other pathogens in unboiled fermented milk also needs further investigation.

It is noteworthy that all the respondents reporting a household member diagnosed with brucellosis were from rural Nakuru, where some unboiled and/or home-made fermented milk was consumed. This study also shows that bulking of raw milk by large-scale raw milk market agents can increase the risks of infection with *Brucella* or any other zoonotic agent, particularly if the milk is not boiled before consumption. Likewise, failure to achieve the pasteurization conditions may result in survival of some milk-borne pathogens.

Critical Control Points

Critical control points (CCPs) are specific links in the food chain where identified potential public health risks can be reduced or eliminated in order to protect the health of consumers. The CCPs can therefore be used as target points for

¹³ Pasteurization involves heating milk to 72 degrees Centigrade for 15 seconds to destroy pathogens. The pasteurization curve (Figure 18) gives the highest temperature required to kill all pathogens as 89 degrees Centigrade for one second. Boiling attains a higher temperature and longer time and thus destroys all pathogens.



interventions aimed at minimizing risks. Using the principles of HACCP, the following health risks were analysed: high total and coliform

bacteria counts, milk adulteration, *Brucella* antibodies and antimicrobial residues. The results are summarized in Table 2.

Table 2. Critical Control Points in informal milk market channels

Health risk	Critical Control Point	Seasonal variation
High total bacteria counts	Farm-to-shops/kiosks pathway Farm-to-milk bar pathway in Kiambu/Nairobi (IHMA) Use of plastic containers in Nakuru/Narok (EMMA) Small-scale milk traders	Increase during wet season
High coliform bacteria counts	Farm-to-coop pathway in Nakuru/Narok (EMMA) Farm-to-shops/kiosks pathway in Kiambu/Nairobi (IHMA) Use of plastic containers Non-cooling of milk Small-scale milk traders	Decrease during wet season
Adulteration with solids	Cooperative-to-shops/kiosks pathway	More during wet season
<i>Brucella abortus</i>	Farm-to-milk bar pathway in Narok	
Antimicrobial residues	Farm-to-mobile trader pathway*	

** It is likely that these residues originated at the farm since no mobile traders used antimicrobials to preserve milk, and milk sourced directly from rural farms had relatively high levels of antibiotic residues.*



Testing of training of informal sector traders on hygienic milk handling and quality control



Rationale for the testing of training informal milk traders

The results of the market-level survey indicated that only 12 per cent of all raw milk handlers reported receiving any form of training in hygienic milk handling and quality control, although this was wide-ranging, from 4 per cent of mobile milk traders to 43 per cent of dairy co-op workers.

These findings pointed to a need to test training of informal milk traders on hygienic milk handling operations, such as the use of sterilizable aluminium milk churns as opposed to the commonly used non-food grade plastic containers. It was anticipated that training would result in improved quality of milk sold by small-scale traders.

Training methodology

A pilot study was carried out in Murang'a, Nakuru and Thika districts to test the potential gains that could be achieved through training and certification of informal milk traders. All three districts have vibrant small-scale informal milk market systems that emerged following the liberalization of milk marketing in 1992.



The informal milk market in Nakuru district is characterized mainly by bicycle traders who collect milk from the rural milk-producing areas and cycle long distances over poor roads to markets in urban Nakuru. Conversely, most milk traders in Murang'a and Thika use public transport (*matatu*) to ferry milk to market. Most of the small-scale traders in Murang'a are women and few have received formal training in milk hygiene. Thika traders often face problems of milk spoilage and adulteration by some unscrupulous farmers. These unique features characterizing informal milk trade in the three districts offered the opportunity to

- 1) develop an appropriate milk container suitable for carriage on a bicycle,
- 2) examine the impact of training and use of improved milk containers on raw milk quality, and
- 3) train small-scale traders on simple methods of testing the quality of raw milk before purchasing it from farmers.

Two approaches were used to collect information and train the milk traders: a series of participatory rural appraisals (PRAs) and a structured questionnaire. The objective of the PRAs was to use a group-based process to arrive at viable, applicable improvements to milk handling practices. This was done by getting information on the milk handling methods used by the traders and their reasons for using those methods. The information was then used to collaboratively develop an appropriate milk container that would contribute to improved milk quality. The questionnaire was used to obtain more detailed information on milk

procurement, handling and sale; and the impact of training and use of improved milk containers on milk quality and business operations.

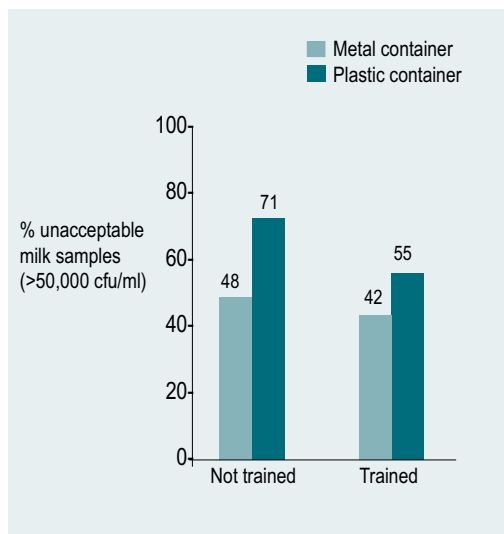
About 80 milk traders from all three districts were involved in the training exercise, which was carried out in two phases between April and December 2002. Traders were trained on general milk hygiene, factors leading to milk spoilage and simple tests that can be used to examine the quality of raw milk before purchase, namely organoleptic, alcohol, and clot-on-boiling tests. They were also trained on how to use lactometers to measure the specific gravity of milk and thus establish whether or not milk has been adulterated by addition of water or solids, or removal of cream. The second training phase was held three months after the first phase in order to test for significant changes in milk quality attributable to training in improved milk handling techniques. The use of newly designed metal milk cans of appropriate size and shape was also examined to test for their effect on raw milk quality. The quality criteria used were KEBS microbiological quality thresholds for coliform counts in raw milk, i.e. 50,000 cfu/ml.

Training results and discussion

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 (Figure 19). These positive results imply that training of informal sector milk traders combined with the use of more hygienic metal containers will significantly



Figure 19. Proportion of unacceptable milk samples (coliform counts over 50,000 cfu/ml) sold by trained and untrained traders



reduce the health risks associated with raw milk of poor bacteriological quality, and in so doing, provide consumers with a higher degree of product quality assurance.

Among the Nakuru-based bicycle traders, the use of the metal churns was beneficial to their business operations, in form of less spillage of milk during transportation, reduced cases of milk spoilage (since the cans are easy to clean and sterilize) and fewer incidences of harassment by public health officials. Additionally, many traders reported that their customers preferred to buy milk that was

handled in the more appealing aluminium containers as opposed to plastic jerry cans.

Prior to the training sessions, most traders had little or no knowledge of objective tests that can be used to assess raw milk quality. They mostly relied on organoleptic (sight and smell) assessment and other informal tests, which though useful, may not always effectively detect adulteration of milk¹⁴. After training, many traders appreciated the need to use more objective milk quality tests and consequently, the use of lactometers increased significantly with many traders buying their own after SDP availed them at a subsidized cost. Those who could afford to buy ethanol for the alcohol test preferred to use this test instead of the clot-on-boiling test because of its higher sensitivity in detecting milk that has started souring. The traders also used the quality tests during storage and before sale of milk, to monitor the effectiveness of the storage methods and ensure that only good quality milk was sold to consumers.

These outcomes indicate that training of informal sector traders can lead to improved milk quality and business operations. However, in order for the impact of training to be fully effective, it must be accompanied by a system of licensing and certification of traders in order to properly monitor and evaluate their operations.

¹⁴ Many traders reported using an informal "match stick" test to check for added water in milk. A match stick head is dipped in the milk then struck. Failure of the match to light immediately means the milk has been adulterated with water.



Risk of exposure to milk-borne pathogens from soured milk sold in Nairobi milk bars



Background

In the market-level survey, 25 per cent of milk traders recorded unsold leftover milk of about 7 per cent of the previous day's sales. This leftover milk was either consumed by the family or fermented and sold as soured milk. Milk bars are a key outlet for these soured milk products. Because the milk is often left to sour naturally without being boiled, there are chances that some milk-borne pathogens—which would otherwise have been killed by boiling the milk—may survive the acidity developed in the soured product and pose a health risk to consumers.

Thus, a study was undertaken to quantify the risks of exposure to milk-borne pathogens from soured milk sold in milk bars within Nairobi. The specific aims of the study were to determine 1) the extent of sales of raw milk, 2) the extent of sales of non-heat treated sour milk and 3) the extent to which consumers of soured milk bought from milk bars in Nairobi are exposed to milk-borne pathogens.



Methodology

The study was undertaken between November and December 2003. Survey data were collected from randomly selected milk bars in five divisions in Nairobi (Githurai, Kangemi, Kawangware, Kibera and Riruta). The divisions were chosen based on their high human population densities and the common sale of raw and sour milk in milk bars. Milk samples were collected only from those milk bars selling naturally soured milk.

A questionnaire was used to get information on how the milk bar owners procured and sold their milk, the fate of leftover unsold milk and the methods used to ferment leftover milk. The pH (degree of acidity) of the sour milk samples was measured; the lower the pH value, the more acidic the milk. The duration of souring was also recorded.

The established thresholds of pH 4.2 and souring time of 66 hours were used to assess the risks of consumers being exposed to milk-borne pathogens in naturally soured milk. For the purposes of this study, soured milk samples of interest were those whose fermentation conditions did not meet the set thresholds, that is, samples of sour milk with pH above 4.2 (less acidic) and those that were fermented for less than 66 hours.

Results and discussion

A total of 47 milk bars were surveyed, 38 (81 per cent) of which sold soured milk. Mostly, the fresh milk was left to ferment naturally without the use of commercial cultures, though in some cases a portion of previously fermented milk was

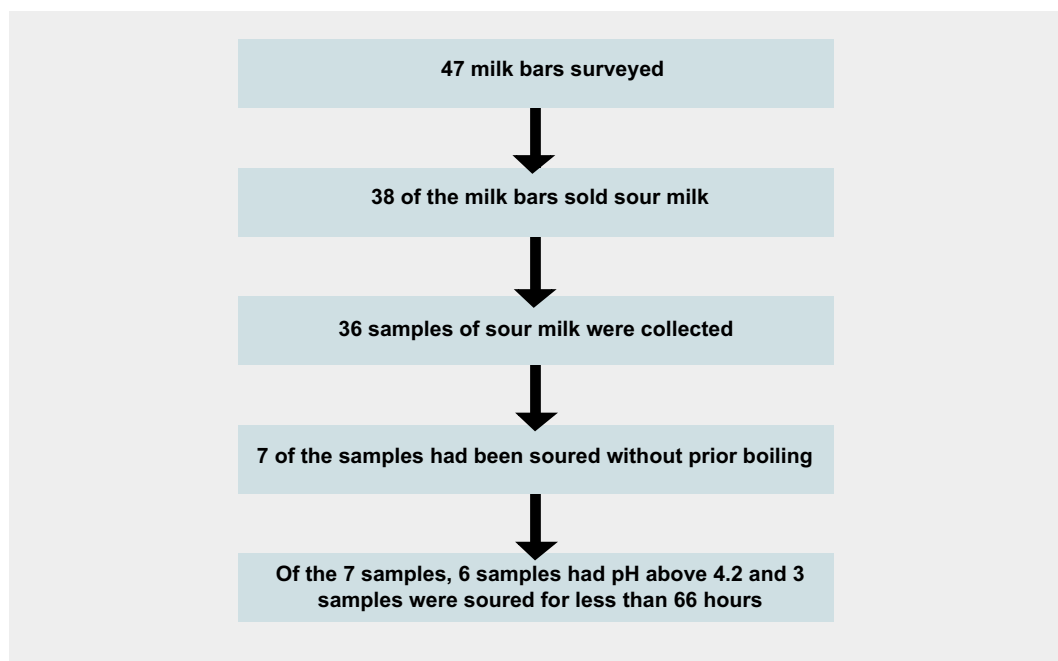
added to a batch of fresh milk to initiate the souring process. Soured milk samples were obtained from 36 of the 38 milk bars selling sour milk at the time of the survey. The average pH of the sour milk was 4.3. Most of the sour milk samples were fermented for 18-48 hours but generally the fermentation time was wide-ranging across all milk bars, from 2 to 168 hours.

Of the 36 soured milk samples, seven (19 per cent) were not boiled before souring, thus presenting a possible pathogen risk. Figure 20 illustrates the process used to screen samples of soured milk for potential risks of exposure to milk-borne pathogens.

Of the seven non-boiled and soured milk samples, six did not meet the pH threshold of 4.2 and three were soured for less than 66 hours, suggesting a prevalence of 8.3-16.7 per cent of soured milk samples that were not rendered safe by any practice (Table 3). This translates to a potential risk of exposure to milk-borne pathogens of 30-61 times a year for a person who daily drinks soured milk bought from milk bars in Nairobi. However, the actual health risks from bacterial contamination are judged to be low because of the common practice—by 81 per cent of sampled milk bars—of boiling milk before souring it. This practice should be encouraged.

Regarding the awareness of milk bar personnel on the health risks associated with raw milk, 93 per cent of them were aware of these risks and knew that boiling and hygienic handling of milk can greatly reduce health risks to consumers. Indeed, over 90 per cent of the sampled milk bar personnel said that they boiled milk before consumption or sale. Only 2 per cent of milk



Figure 20. Screening of naturally soured milk samples for risks of exposure to milk-borne pathogens**Table 3. Proportions of the 36 soured milk samples that pose pathogen risks**

Risk factor	Number	Percentage
Soured without boiling	7	19.4
Soured without boiling and pH more than 4.2	6	16.7
Soured without boiling for less than 66 hours	3	8.3

bar owners cited pasteurization as a method of making raw milk safe. This level of awareness on milk safety needs to be reinforced through appropriate education efforts aimed at both milk bar traders and consumers. It is further recommended that all milk bar personnel be advised to subject raw milk to effective heat treatment—boiling or pasteurization—before souring and selling to consumers.



Conclusions



This study was undertaken to arrive at valid, scientific evidence on the health risks associated with milk sold in Kenya. This information is useful to consumers as it allows them to balance the risks and potential benefits and make informed choices on which milk products to buy, and what steps they can take to minimize the identified risks.

In addition, the study has shown that the informal milk sector does indeed play an important role in milk marketing in Kenya by linking producers and consumers in a timely and efficient manner. Thus, constructive policies are needed to support improvements in milk marketing sectors. Those policies should aim at safeguarding public health without impeding the efficient marketing of milk.

The key conclusions of the study are summarized as follows:

Milk production

Residues of antimicrobials in raw milk are likely to originate at the farm rather than from market-level malpractice. This is because raw milk from many rural farms had high levels of antibiotic residues. However, the study does not rule out the possibility of unscrupulous milk traders adding antibiotics to raw milk to prolong its storage life. Thus, a closer look at this potential hazard is needed, given that boiling or pasteurization of milk will not destroy antimicrobial residues.



Milk bulking and marketing

Bulking of milk from different sources increases the risk of exposure to milk-borne zoonoses, particularly among people who drink unboiled milk. Thus, market agents handling bulked milk (such as dairy cooperatives) should ensure the milk is adequately processed before sale.

Lack of formal training, use of plastic containers and the absence of cold chains are the main factors that contribute to the low quality of raw milk sold by small-scale informal milk traders and hawkers. However, training in milk hygiene and quality testing, combined with the use of more hygienic metal containers can significantly improve the quality of milk sold by informal small-scale traders.

The study found that there was no significant quality difference between milk sold by licensed and unlicensed traders, whether or not they had fixed premises. Thus, the current KDB requirement that traders have fixed premises before they can be licensed seems to be unjustified. Thus, licensing should be implemented as the means towards improving milk quality and not merely as an end in itself. However, licensing alone is not likely to have much impact and would need to be accompanied by a formal system of training and certification of informal traders.

Milk consumption

Risks of being exposed to milk-borne pathogens are minimal, since the incidence of *Brucella* and pathogenic *E. coli* in raw and processed milk was low and almost all consumers boil milk before

they drink it, thus effectively eliminating any bacterial pathogens that may be present.

The small proportion of rural households who drink naturally fermented milk could be at some risk of certain zoonoses, particularly if the milk is not boiled before souring. This is because some zoonotic agents present in the raw milk may survive the acidity developed during spontaneous fermentation.

Milk quality assessment

The failure of most milk samples, whether raw or pasteurized, to adhere to KEBS specifications for microbial quality suggests that the standards are not relevant to local milk marketing conditions. Because these standards have been borrowed from countries where all milk flows through cold chains and is always pasteurized before sale, there is a need to develop local milk quality standards that specifically address the prevailing conditions under which milk is sold in Kenya. These include the widespread lack of cold chains, tropical weather conditions, poor road networks and the almost universal consumer practice of boiling milk before consumption.



Summary of recommendations of the dairy public health committee



A nine-member Public Health Committee (PHC) convened by the KDB and MoLFD identified key recommendations on the management of milk-borne public health risks in Kenya. The PHC representatives were drawn from the KDPA, MoLFD, KDB, KEBS, MoH, and SDP. The PHC was appointed at the end of a stakeholders' workshop held on 14 February 2001 at KARI Headquarters to review research findings on milk-borne health risks. The stakeholders' workshop discussed various recommendations arising from the research study. These recommendations were revised and finalized by the PHC on 26-27 March 2002.

The terms of reference for the PHC were to:

- finalise recommendations (interventions, plans of action, institutional roles for implementation and financing) agreed at the workshop;
- ensure institutional ownership and consensus on issues raised with regard to ensuring good milk quality in a liberalised market;
- oversee the proposed testing of interventions to improve milk quality;



- set up appropriate reporting mechanism to stakeholder/key-player institutions; and
- convene a follow-up key-player/stakeholders' meeting to report progress.

Details of the revised recommendations are in Annex 2, but they are summarized below, indicating the key roles of some dairy industry stakeholders:

Consumer education

Consumers need to be educated on the risks of drinking raw milk and the need to ensure that milk is adequately heated (boiled or pasteurized) before drinking it. Since boiling of milk was noted as an almost universal practice among Kenyan consumers, the practice needs to be reinforced by appropriate media campaigns. Consumers also need to be educated on the potential risks of drinking fermented milk that was not heated before souring.

Retailers

Small-scale retailers of raw milk, particularly traders in kiosks and milk bars, should be made aware of the need to ensure that milk is boiled or pasteurized before being sold. However, customers who prefer to buy raw milk should boil it before drinking.

Researchers

More studies are needed on the survival of milk-borne pathogens in naturally fermented milk and the extent of sale of such milk in informal milk market outlets. Regarding farm-level milk handling, the specific farm practices that lead to

unacceptable levels of antibiotic residues in milk need to be examined in order to arrive at effective training solutions for dairy farmers. The use of LPS to preserve raw milk also needs to be tested under field conditions as one of the technology-based interventions aimed at reducing bacterial spoilage of milk.

Policy stakeholders and legislators

A system of licensing and training/certification of informal sector traders is needed to improve the quality of milk sold and monitor the operations of the raw milk sector. Additionally, the regulations governing the quality of marketed milk need urgent review to keep pace with the current conditions of milk marketing in Kenya. There is also need to harmonize the policies and laws affecting the dairy industry.

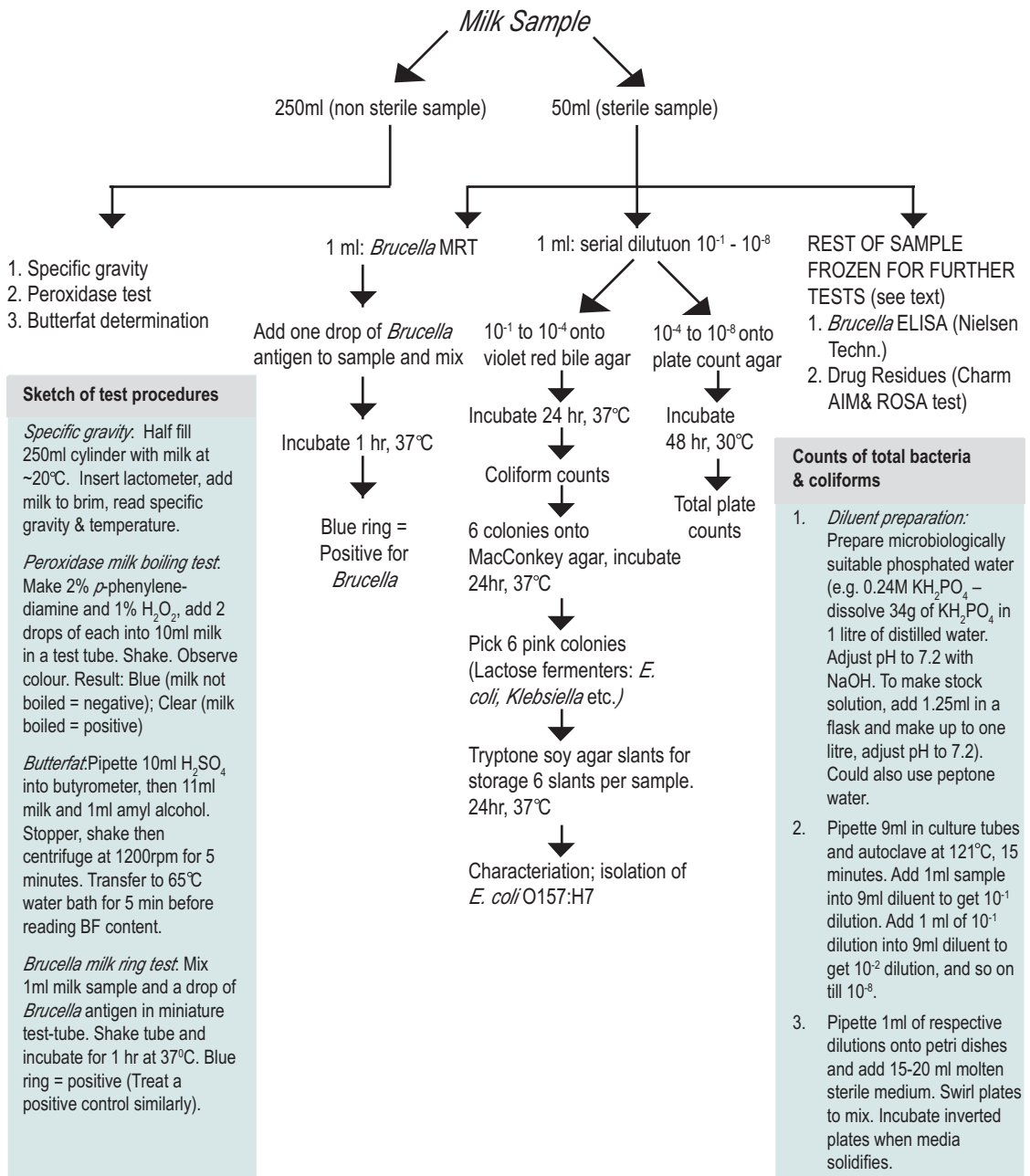


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Annex 1. Flow diagram summarising laboratory analysis



Annex 2a. Plan of action by the dairy public health committee on the management of milk-borne health risks in Kenya

Issue	Recommendations/ Interventions	Plan of action	Responsibility for implementation & financing ^a	First Step	Remarks
1. Elimination of infections from zoonoses and faecal coliforms in raw milk.	Consumers: Ensure milk is heat treated (boiled or pasteurized) before consumption	Media campaigns through leaflets, billboards etc	<u>KDB</u> , <u>KEBS</u> , <u>MoH</u>	Consult media company on strategy by end 5/02	Build on leaflet and media campaign by SDP
	Raw milk retailers: Boil or pasteurize milk	Education and training of market agents	As in issue No. 4: <u>SDP</u> , <u>MoLFD/SDP</u> , <u>KDB</u>	As in issue No. 4: <u>SDP</u> to finalise field testing and training of trainers by 3/03	
	Influence long-term change in practices	Lobby to include information in school education curriculum	<u>KDB</u> , <u>MOE</u>		
2. Consumption of naturally fermented raw milk as a potential source of zoonoses.	More information needed on survival of zoonoses in fermented milk, fermentation practices by market agents and the extent of sale of raw fermented milk	Conduct further study	<u>KDB</u> , <u>MoLFD/SDP</u> , other research bodies	Commission study by <u>KDB</u> : Letter to request for design of study by end 5/02	This is a critical issue amongst market agents who often sell un-boiled raw fermented milk
	Consumers: Boil raw milk before fermentation (using commercially available methods of souring) and ensure purchased fermented milk has been boiled beforehand	Media campaigns	<u>KDB</u> , <u>KEBS</u> , <u>MOH</u>	As in issue No. 1: Consult media company on strategy by end 5/02	Build on leaflet and media campaign by SDP
	Raw milk retailers: Boil milk before fermentation. Throw away milk that naturally ferments before boiling.	Comply with <u>KDB</u> recommendations for milk fermentation	<u>KDB</u>	Reduce information on fermentation procedures to a leaflet by end 5/02	

^aLead institution underlined



Issue	Recommendations/ Interventions	Plan of action	Responsibility for implementation & financing ^a	First Step	Remarks
3. Bulkied raw milk increases the risk of infection with milk-borne zoonoses	Consumers: Pass message on increased level of risk from bulkied milk and emphasize the need for using heat treated milk	Media campaigns	As in issue No. 1: <u>KDB</u> , <u>KEBS</u>	As in issue No. 1: Consult media company on strategy by end 5/02	Build on leaflet and media campaign by SDP
	Raw milk retailers: Should emphasise the need to boil milk before retailing	Training of market agents	As in issue No. 4: <u>MoLFD/SDP</u> , <u>KDB</u>	As in issue No. 4: SDP to finalise field testing and training of trainers by 3/03	Coops to be encouraged to buy kits for testing
	Transfer/extend appropriate tests to separate milk that must go for processing (esp. coops)	Encourage testing of milk for common zoonoses (e.g., brucellosis), Transfer appropriate tests. Education and training.	<u>KDB</u> , <u>KEBS</u> , Coops and other groups that bulk milk	<u>KDB</u> to acquire capacity to conduct random tests by end 8/02	
4 a) Mobile milk traders are not licensed, lack training and therefore do not sell quality milk	Define specific codes for different groups	Specify hygiene codes of practice for different homogenous groups, including appropriate milk handling equipment.	<u>KEBS</u> , <u>KDB</u> , <u>MoLFD</u> , <u>Moh</u> , <u>NGOs</u>	<u>KEBS</u> to circulate current Hygiene Code of Practice to <u>PHC</u> by mid-4/02 and <u>KDB</u> to initiate steps to repackaging Code by end 6/02	Code to be sent to <u>PHC</u> as soon as possible. Small traders play a very important role and cannot be excluded from the licensed milk trade
	Train and license raw milk traders	Train traders on milk hygiene before licensing	<u>MoLFD/SDP</u> , <u>KDB</u>	As in issue No. 1: SDP to finalise field testing and training of trainers by 3/03	
4 b) Raw milk sales not allowed in urban areas	Take steps to allow raw milk sales everywhere	Verify interpretation of existing Act Cap 336 to see if raw milk sale is "banned"	<u>Dairy PHC Members</u>	<u>KDB</u> to circulate 1972 and 1984 revisions of Act by mid-4/02. <u>PHC</u> to discuss Act and its interpretation by end 6/02	Repackaging of Code to be initiated immediately after its launching

^aLead institution underlined

Issue	Recommendations/ Interventions	Plan of action	Responsibility for implementation & financing ^a	First Step	Remarks
5. Lack of awareness of existing standards and that they can be revised at any time	Create awareness amongst stakeholders	More media campaigns in addition to current radio programmes. More education & training of stakeholders	<u>KEBS</u> , Stakeholders	KEBS to circulate existing milk hygiene standards and process to follow for revisions by end-4/02	KEBS rep noted that any stakeholder can initiate the process of revising standards
	6. Low quality of milk in the market	Mount training and awareness campaigns on the need to observe good hygiene from farm-to-table Encourage quality control by promoting testing at collection points and self certification	<u>MoLFD/SDP</u> , KDB, KDPA <u>KDB</u> , KDPA, NGOs, Coops, Small traders associations	MoLFD to review current leaflets and devise mechanisms for their further distribution by end-7/02 KDB to hold meeting with KDPA by end-6/ 02	Build on milk hygiene leaflet and media campaign by SDP Borrow leaf from elsewhere
7 a) High prevalence of antibiotic residues in milk	Testing to be made mandatory along the milk market chain Institute penalties for offenders plus give incentives for improvement	Training of farmers on dangers of drug residues. KDB to meet with processors and agro-vets to begin to pass message Enforce existing Act	<u>KDB</u>	KDB to hold meeting with KDPA by end-6/ 02 KDB to initiate random checks by end-9/02	Learn 'how' from other countries
	Use KEBS Act disallowing drugs residues in foods or enact additional legislation if required	Enforce existing Act	<u>KDB</u> , KEBS	KDB to use Act or take steps to enact additional legislation if necessary by 3/03	Aim for zero tolerance for drug residues in milk.
	Incorporate issue in training of milk market agents More info required on farm-level practices that result in residues in milk	Train traders on adverse effects of drug residues and to pass same message to farmers Conduct farm-level study	<u>MoLFD/SDP</u> , KDB <u>KDB</u> , MoLFD/SDP, other research bodies	SDP to finalise field testing by 3/03 KDB to commission study. First step is to request SDP to design study by mid 5/02	Approach KDPA to fund study. Explore opportunities for collaboration with other interested parties

^aLead institution underlined

Issue	Recommendations/ Interventions	Plan of action	Responsibility for implementation & financing ^a	First Step	Remarks
7 b) Presence of hydrogen peroxide and other chemical residues in milk.	Create more awareness on adverse effects amongst traders Encourage testing along the milk market chain	Do a brief on adverse health effects of H ₂ O ₂ residues in milk Conduct tests	<u>KDB</u>	KDB to hold meeting with KDPA by end-6/02 KDB to initiate random checks by end-6/02	Brief on adverse effects of H ₂ O ₂ to be supplied by MoLFD (Mary) by 6/02
8. Rapid bacterial degradation of milk.	Train farmers to cool milk using practical technologies	Document and encourage use of practical technologies for cooling Test use of LPS	<u>KDB</u>	KDB to describe alternative technologies by end 6/02	
	Investigate role of LPS		<u>MoLFD/SDP</u> , KDB, KEBS	Testing of LPS: SDP to give report by 3/03	There is need for Kenya to be represented at relevant Codex meetings such as the one that will consider changes in guidelines governing the use of LPS

^aLead institution underlined



Annex 2b: Members of the dairy public health committee

Name	Institution	Address
J.P. Cheruiyot (Chairman)	Ministry of Livestock and Fisheries Development	P.O. Box 34188 Nairobi
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M. Mwambia (Secretary)	Ministry of Livestock and Fisheries Development	P.O. Box 34188 Nairobi
C.K. Tom (Secretary)	Kenya Bureau of Standards	P.O. Box 54974 Nairobi
A. Omore (Secretary/Facilitator)	Smallholder Dairy Project	P.O. Box 30709 Nairobi
H.G. Muriuki	Ministry of Livestock and Fisheries Development	P.O. Box 30028 Nairobi
J.K. Waihenya	Ministry of Cooperative Development and Marketing	P.O. Box 40811 Nairobi
Z. Nelima	Kenya Dairy Processors Association (Official from Brookside Dairy)	P.O. Box 236 Ruiru
K. Kilei	Ministry of Health	P.O. Box 30016 Nairobi
N. Hooton (Observer)	Smallholder Dairy Project	P.O. Box 30709 Nairobi

