ANALYSIS OF MILK-BORNE PUBLIC HEALTH RISKS IN MILK MARKETS IN KENYA.

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Abstract

The major role played by informal milk markets in Kenya and the benefits to those associated with it are now widely acknowledged. The benefits include higher prices for farmers, income generation for the market agents and convenient delivery and lower prices for poor consumers. However, in spite of these benefits, regulations governing informal marketing of milk continue to be unfavourable and do not reflect local realities of milk marketing, having been based on models derived from industrialised countries where virtually all milk destined for the market is pasteurised and packaged.

Results of risk assessment, including HACCP analysis, of milk quality and handling practices of informal milk market agents and consumers in central and southern Kenya show variable apparent prevalence of zoonotic health hazards in marketed milk, high bacterial counts especially in outlets associated with longer market chains. Notably, the ineffectiveness of current regulations was reflected in the lack of difference in the quality of milk sold by licensed and non-licensed traders. The study shows that health risks from the bacterial hazards identified are mitigated by the common consumer practice of boiling milk before consumption. The most important health risks were judged to be from two main sources: (i) anti-microbial residues found in up to 15% of milk samples tested and (ii) consumption of naturally fermented milk. Proposals for management of these health risks and the engagement of stakeholders and key players in the process to achieve more favourable policy environment policy are presented and discussed.

Introduction

Raw or traditional (often called "informal") milk markets account for nearly 90% of milk sales in Kenya. The market agents involved include farmer dairy co-operatives, small traders using bicycles and public or private transport, small retail outlets, such as dairy kiosks, and shops. Studies by the collaborative Ministry of Agriculture and Rural Development (MoARD)/Kenya Agricultural Research Institute (KARI) and International Livestock Research Institute (ILRI) Smallholder Dairy Project showed that convenient delivery and lower prices (reflecting lower handling and processing costs) are the principal benefits for

consumers (Omore et al., 1999; Ouma et al., 2000). Current milk handling and safety regulations in Kenya are derived from models in industrialised countries. These may not be appropriate for local market conditions where such regulations may unnecessarily inhibit efficient milk marketing. An important step in developing targeted policies more supportive of market participation of the majority is to conduct risk analysis (risk-assessment, -management and –communication) on milk-borne health risks under different production and marketing systems. This paper summarises the studies undertaken in central and southern Kenya aimed at assessing and managing the risks. Trade-offs between the risks and the efficient marketing of milk are considered and the process of engagement of stakeholders and key players to achieve the required change in policy are presented and discussed.

Materials and Methods

Risk assessment

Study sites were chosen in urban and rural locations that also represent contrasting levels of market access and types of dairy production systems. At the consumer-level the study was carried out in Nairobi and Nakuru districts representing both urban and rural populations. At the market-level the study was carried out in two sites representing a range from intensive peri-urban and high market access (IHMA) represented by Nairobi and Kiambu districts to more extensive production systems with medium market access (EMMA) represented by Nakuru and Narok districts. Data were randomly collected between January 1999 and January 2000. A total of 212 and 222 raw milk samples (fresh or boiled) were collected during the first (dry) and second (wet) season, respectively, from every household that consumed unpasteurized milk for laboratory assessments. Informal market agents that responded during the first (wet) and second (dry) seasons were 262 and 270, respectively. Data on milk handling practises by consumers and market agents; dairy product consumption and preferences were collected using questionnaires. Raw milk samples were collected from

each milk market agent at retail points and from each consuming household for laboratory assessments. In addition, 110 pasteurised milk samples were collected from retail outlets with and without chilling facilities and assessed as outlined above.

Total and coliform bacteria in the milk samples were counted using the Standard Plate Count method; brucellosis status was investigated using the Milk Ring Test (MRT) and the indirect enzyme linked immuno-sorbent assay (ELISA) (Nielsen et al., 1996)[1]; selective media and biochemical tests were used to isolate *E. coli* and *E. coli* 0157:H7; and, drug residues were screened using Charm AIM test kit (Charm Sciences Inc., USA) to detect β-lactams, tetracyclines, aminoglycosides, macrolides and sulphonamides at levels above maximum residue limits (MRLs) recommended by the European Union (EU (Table 1).

Table 1. Detection levels of Charm-AIM-96 for representative drugs and European Union Maximum Residue Limits and acceptable daily intake (ADI)

Antimicrobial drug	Family	Minimum detectable range (μg/kg)	EU MRLs (μg/kg)	Codex MRLs (μg/kg)	Codex ADI[a]
Penicillin G	β-lactam	3-4	4	4	30 μg/day
Sulfamethazine	Sulphonamide	10-50	100	-	50 μg/kg body wt
Gentamicin	Aminoglycoside	30-100	100	-	20 μg/kg body wt
Oxytetracycline	Tetracycline	150-300	100	100	30 μg/kg body wt
Tylosin	Macrolide	40	50	-	-

[a] Acceptable daily intake
Source: Charm Sciences Inc, USA

In addition, between April and December 2000, a total of 159 suspect (acid-fast positive) sputum and three sub-mandibular biopsy aspirates from 134 patients in Narok District suspected to be suffering from tuberculosis were investigated through cultural and biochemical speciation of *Mycobacteriaceae* to assess risks of zoonotic tuberculosis. The principals of Hazard Analysis Critical Control Points (HACCP) process were considered and applied for each major hazard

[1] The ELISA test is more sensitive (96.5%) and specific (>99.5%)

Parallel economic and GIS analyses focused on market structure, conduct and performance including variation in risk due to seasonality, market margins and spatial factors influencing marketing behaviour and performance. Regression, principal component and clustering procedures involving milk quality and profit margin parameters were used to identify homogenous groups of market agents, pathways and trade-offs.

Risk management and engagement of stakeholders to communicate risk information

The outcome of the assessment of risks was used formulate recommendations for managing them. Various stakeholder meetings were held before, during and after the risk assessment studies to discuss what risks needed to be assessed and to communicate the risk information.

Results

Dairy product consumption patterns

Consumption is mainly of liquid milk. Raw fresh milk was purchased by 29% of households in Nairobi (average = 5.5 litres/hh/month) in comparison to 93% of households in both Nakuru urban (average = 22.5 litres/hh/month) and rural (average = 24.3 litres/hh/month). The total liquid milk equivalent of pasteurised milk and processed dairy products consumed in Nairobi, Nakuru urban and Nakuru rural were 15.6, 3.8 and 0.2 litres/hh/month, respectively. Pasteurised milk was purchased in Nairobi, Nakuru urban and Nakuru rural by 78%, 34% and 5% of sample households, respectively. Most consumers expressed a preference for raw over pasteurised milk. Interestingly and contrary to expectation, high-income consumers expressed the same preference for raw milk as do those with lower income, and often ended up buying more of it. All households in urban areas and 96% in Nakuru rural reported boiling milk prior to consumption, mainly as an ingredient in other foods, mostly tea (Table 2).

Assessment of milk quality

Descriptive statistics of milk quality indicators and comparisons with national standards are presented in Table 2. Overall, 4.7% and 10.4% of samples taken from consumer hh and market agents, respectively, had specific gravity below 1.026kg/litre and therefore suspected of adulteration by added water (Table 2). The overall mean for total solids (TS) in milk was 12.3%, not significantly different from the 12.7% normally taken as the average TS for bovine milk. Milk quality as judged by total bacterial counts was generally low with over 60% of samples collected from various locations excluding Nakuru rural, failing to meet standards set by the Kenya Bureau of Standards. The overall average TPC in milk was high at $39.8x10^6$ cfu/ml (range = $7.9x10^6$ cfu/ml for milk from farmer groups that mainly use short market chains to $79.4x10^6$ cfu/ml for milk from milk-bars using long market chains). Similarly, the overall average CPC was lowest in milk from farmer groups ($0.016x10^6$ cfu/ml) and highest among mobile traders, milk–bars and shops/kiosks ($0.005x10^6$ cfu/ml). Raw milk samples from consumer hh and retail outlets also reflected the same picture where samples from Nakuru rural (short market chain) had markedly lower bacterial counts than milk collected from consumers in urban areas (long market chain).

Overall prevalence of brucellosis at consumer-level as determined by both ELISA and MRT were 4.9% and 3.9%, respectively (Table 2). At the informal market level, ELISA and MRT classified 2.4% and 3.4%, respectively, as positive. Interestingly, brucellosis antibody detection by ELISA varied by milk source. Informally traded bulked raw milk from dairy co-operatives and milk bars had the highest proportion of ELISA and MRT positive samples. Nearly all these samples were from Narok District where extensively grazed pastoralist zebu herds predominate. The ELISA test classified nine (8.2%) of pasteurised milk samples as positive (Table 2).

Table 2. Summary descriptive statistics of milk quality indicators and proportion of households that boil milk before consumption

	Descriptive statistics		Proportion not meeting minimum standard / prevalence of zoonosis	Proportion of households that boil milk
	Mean	SD	%	%
Rural hh (N=218)				
Specific gravity (kg/lt)	1.03	0.00	3	-
Butter-fat (%)	4.19	1.18	19	-
Solids-not-fat (%)	9.04	0.57	11	-
Log_{10} total bacterial counts (%)	6.08	1.58	31	-
Log_{10} coliform bacterial counts (%)	2.89	1.40	13	-
Prev. of Brucellosis on ELISA (& MRT) (%)	-	-	5 (3)	-
Prev. of *E. coli* 157:H7 (%)	-	-	0	-
Prev. of antimicrobial residues (%)	-	-	15	-
Proportion of households that boil milk (%)	-	-	-	96
Urban hh (N=200)				
Specific gravity (kg/lt)	1.03	0.00	6	-
Butter-fat (%)	3.41	0.86	44	-
Solids-not-fat (%)	8.76	0.87	31	-
Log_{10} total bacterial counts (%)	7.87	1.88	77	-
Log_{10} coliform bacterial counts (%)	4.51	1.48	52	-
Prev. of Brucellosis on ELISA (& MRT) (%)	-	-	5 (5)	-
Prev. of *E. coli* 157:H7 (%)	-	-	0	-
Prev. of antimicrobial residues (%)	-	-	4	-
Proportion of households that boil milk	-	-	-	100
Market agents in IHMA[b] (N=167)				
Specific gravity (kg/lt)	1.03	0.00	9	-
Butter-fat (%)	3.77	0.84	26	-
Solids-not-fat (%)	8.48	0.49	34	-
Log_{10} total bacterial counts (%)	7.32	1.26	79	-
Log_{10} coliform bacterial counts (%)	4.80	1.09	57	-
Prev. of Brucellosis on ELISA (& MRT) (%)	-	-	3 (5)	-
Prev. of antimicrobial residues (%)	-	-	5	-
Market agents in EMMA[c] (N=295)				
Specific gravity (kg/lt)	1.03	0.00	11	-
Butter-fat (%)	3.71	1.00	28	-
Solids-not-fat (%)	8.60	0.51	31	-
Log_{10} total bacterial counts (%)	7.82	1.74	74	-
Log_{10} coliform bacterial counts (%)	4.69	1.25	52	-
Prev. of Brucellosis on ELISA (& MRT) (%)	-	-	2 (4)	-
Antimicrobial residues (%)	-	-	6	-

[a] The respective minimum standards are: Specific gravity=1.026kg/l; Butterfat=3.25% Solids-not-fat=8.5%; Total bacterial counts=2,000,000 cfu/ml; Coliform bacterial counts=50,000 cfu/ml.
[b] IHMA – Intensive high market access areas (Nairobi and Kiambu)
[c] EMMA – Extensive medium market access areas (Nakuru and Narok)

Of 264 milk samples tested for faecal coliforms, 22% and 1% contained *E. coli* and *E. coli* 0157:H7, respectively. This prevalence translates to a potential risk of exposure to the pathogen of about three times each year, for a daily consumer of non-heat treated milk. No *M. bovis* was found and the sampling strategy applied implies that one can be 95% confident that the maximum prevalence of bovine TB in the district is not greater than 2% (Koech, 2001).

An important health risk that heat treatment of milk cannot eliminate is anti-microbial residues in milk. Antibiotic or anti-bacterial residues exceeding acceptable EU maximum residue limits were detected in 9.4% and 5.7% of consumer- and market-level samples, respectively. The proportion of samples from consumer households in rural areas with antibiotic residues was nearly four times those from urban areas (Table 2). Among informal market level samples, the proportion testing positive for residues decreased with increasing levels of bulking with milk bars and small mobile traders having a significantly ($P<0.05$) higher proportion of samples with anti-microbials compared to samples from dairy co-operatives (Figure 1).

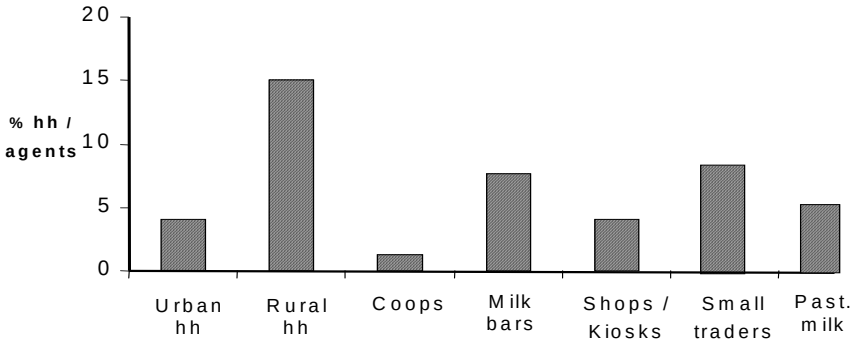

Figure 1. Proportions of milk samples with drug residues above EU maximum residue limits (MRLs)

The overall drug residue prevalence levels indicate that that a consumer who takes milk daily – as most Kenyans do - is at risk of consuming milk with drug residues at least twice every month. Table 1 shows it would be very easy to go beyond the acceptable daily intake (ADI) for the various drugs.

Handling practices by market agents

Methods of milk handling were markedly different between types and scales of business. The use of plastic containers used was recorded because most are not food-grade quality and are not easy to clean properly. Smaller market agents used more plastic containers (up to 89% for mobile agents) than larger scale market agents such as dairy cooperatives that used plastic containers in only 10% of cases, the rest being mainly aluminium metal churns. Smaller agents reported that they used the cheaper plastic containers, because health inspectors often confiscated their equipment. On average, 28% of milk from all traders was not treated for preservation in any way, 47% was refrigerated/chilled and 19% was boiled. Notably, hardly any chemical preservatives were recorded as being used by small-scale market agents to lengthen shelf-life. Only 5% of small traders indicated that they used various non-recommended chemicals to preserve milk and reduce spoilage: 2% used hydrogen peroxide and 3% used other unspecified chemicals to preserve milk. However, the addition of hydrogen peroxide is commonly reported among larger bulk milk suppliers who were not the focus of this study. Efforts are needed to reverse this practice by introducing the recommended lacto-peroxidase system (LPS) for milk preservation (FAO, 2002) in circumstances where cooling by refrigeration is not possible. Overall, only 12% of milk handlers had received any form of training in milk handling and quality control with a wide range amongst different cadres from only 4% of mobile traders to 43% of dairy cooperative staff. Small traders had been in business for a short period of only 2.5 yrs (SD=2.9), many times less than farmer groups (mean=24yrs). 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 in any milk hygiene improvement efforts.

Homogenous groups of market agents

Cluster analysis combined with principal component analysis was conducted on variables for quality, scale, margins, etc. The five clusters are mainly separated on the basis of factors associated with scale of business, milk quality, type of intermediary and profit margins (Table 3). Small traders were found to be statistically grouped together irrespective of licensing, and milk quality is not a major problem of small traders compared to other groups. A critical control point was identified among a small group that sells very small quantities of milk and is also associated with low milk quality, low profit margins and long duration between milk collection and re-sale. None in this group had received any training in milk quality control. However, the majority of small traders were largely neutral with regard to milk quality. Currently, milk traders must have fixed premises before they can qualify for trade licenses. However, the fact that the majority of smaller, mobile, unlicensed traders show no significant difference in milk quality from licensed fixed vendors suggests that there is no justification for this requirement.

Table 3. Associations among principal components and clusters: Summary of means of new variables and major clusters with significant frequencies

Cluster	Freq	Means							Relative Scale of Business (Litres sold/day)
		Large scale/ experience	Low milk quality	Coop intermediary	High margin	Mobile intermediary	No Bulking	Long time since collection	
1	**22**	**-0.31**	**0.29**	-0.19	**-1.47**	**0.29**	0.23	**0.48**	Small (44)
2	**158**	**-0.25**	0.06	0.16	-0.19	0.06	0.21	0.03	Small (126)
3	**120**	**-0.37**	-0.01	-0.19	**0.58**	-0.18	-0.17	0.08	Small (108)
4	**25**	**2.74**	**-0.29**	-0.22	0.11	-0.10	**-0.64**	0.07	Large (5,536)
7	**22**	**0.89**	**-0.36**	**0.39**	-0.21	**0.35**	-0.16	-0.03	Medium (367)

NB. Significant clusters and mean values in respective axes are bolded

Outcome of engagement of stakeholders to communicate risk information

The process of communicating the risk information has been largely productive with some positive changes in mindsets among many stakeholders from the public and private sectors. A wide spectrum these stakeholders were gathered in early 2001 to consider the trade-offs that are required to optimize milk quality and they adopted a wide range of recommendations to manage the health risks. The stakeholders at the same time mandated the Kenya Dairy Board and the MoARD to appoint a committee to oversee the beginning of the implementation of the recommendations.

The new information generated has already contributed to the changing policy environment regarding raw milk marketing in Kenya. Both the drafts of the new Dairy Development Policy (DDP) and revised Dairy Bill, presented for discussion by stakeholders at a meeting convened by the MoARD in late 2001, explicitly recognize the predominance of the raw milk trade and provide institutional guidelines supportive of the small-scale production and marketing of milk.

Discussion

The key findings were: 1) consumers generally prefer whole raw milk, even those who can afford pasteurized milk; 2) more than half of samples exceed bacterial count and coliform count standards, but nearly all consumers boil milk before consumption, eliminating any bacterial threat to health (except for naturally fermented milk); 3) anti-microbial residues were found in many samples, and since they are not destroyed by pasteurisation, they may pose the major long-term public health threat in milk; 4) small mobile vendors use poor quality containers, mainly due to policies that exclude them from applying for licensing; 5) the quality of milk delivered by the small mobile traders does not differ significantly from

those with fixed premises and licenses; and, 6) training can significantly improve the quality of marketed raw milk .

The Kenyan policy to attempt to implement strict international milk quality standards is clearly not working, and further, attempts to police small mobile traders may actually reduce milk quality, by forcing them to use cheap containers due to frequent confiscation. A fundamental factor in determining trade-offs between milk safety and economics in traditional and emerging dairy markets is how to ensure that consumers are being supplied by milk that is "safe" by the standards considered appropriate by them. Public contribution here should be through education to allow informed choices. This would allow the battle between formal and informal milk markets to be fought on the basis of quality and price and not on perceived health risks, which are in any case significantly reduced or eliminated by the common practice of boiling milk before consumption. Given that these informal markets will continue to be dominant in the foreseeable future, a policy of training and certification of small traders, allowing them to operate legally, is likely to result in both higher milk quality and better service to consumer preferences. That approach is also likely to provide opportunity for them (as individuals or groups) to scale-up their activities to sale of added-value milk products.

Besides the achievements so far in engaging stakeholders, the final success in creating a more favourable environment for all milk traders would be measured by revisions in legislation and change in institutions that govern milk marketing. Fortunately, the changes have already been recognized as desirable by the new DDP. However, some of the desired changes will take some time because they require parliamentary approval (e.g., reconstitution of the Kenya Dairy Board to equitably represent all stakeholders). To enhance the process of institutional change, demonstration of the desired alternative options for improving milk quality (e.g.,

training and certification of currently unlicensed small market agents) should be the next step.

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