ILRI
International Livestock Research Institute

Market mechanisms and efficiency in urban dairy products markets in Ghana and Tanzania

Market mechanisms and efficiency in urban dairy products markets in Ghana and Tanzania

Amos Omore, Steve J Staal, Francis Wanyoike, Emmanuel LK Osafo, Lusato Kurwijila, David Barton, Ntegua Mdoe, Gyiele Nurah and George Aning

ILRI   International Livestock Research Institute

Kwame Nkrumah University of Science and Technology (Ghana)

Sokoine University of Agriculture (Tanzania)

Animal Research Institute (Ghana)

NRi   Natural Resources International (UK)

DFID   Department for International Development

Authors' affiliations

Amos Omore, Steve J Staal, Francis Wanyoike: International Livestock Research Institute, Nairobi, Kenya

Emmanuel LK Osafo, Gyiele Nurah: Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

David Barton: Natural Resources International Limited, Kent, UK

Lusato Kurwijila, Ntegua Mdoe: Sokoine University of Agriculture, Morogoro, Tanzania

George Aning: Animal Research Institute, Accra, Ghana

Omore A, Staal SJ, Wanyoike F, Osafo ELK, Kurwijila L, Barton D, Mdoe N, Nurah G and Aning G. 2009. *Market mechanisms and efficiency in urban dairy products markets in Ghana and Tanzania.* ILRI Research Report 19. ILRI (International Livestock Research Institute), Nairobi, Kenya. 56 pp.

Contents

List of Figures

List of Tables

Acknowledgements

Executive summary

Market-oriented smallholder dairying is a promising avenue to alleviate poverty in rural areas. However, its development is constrained by inefficient mechanisms for marketing milk. This report has identified efficient and viable market mechanisms and processes which deliver safe, consumer-preferred dairy products at low cost, and which provide higher and more reliable returns to resource-poor smallholder dairy producers. These mechanisms and processes will help improve the welfare of smallholder dairy producers, small-scale processors and market agents, and consumers. This study quantified actual public health risks and economic performance in indigenous dairy product markets and identified relationships with those and market agent practices and government policies. Indigenous dairy markets have not been examined in this way before. The technology developed and promoted in this study worked towards the project goal by improving the quality of dairy products for consumers and increasing opportunities for livelihoods for small-scale market agents. It addresses the United Kingdom Department for International Development-Livestock Production Programme (DFID-LPP) purpose of 'Energy-efficient and socio-economically acceptable handling, processing and distribution technologies identified and promoted'.

Activities and outputs

The project investigated three major areas of indigenous milk and dairy markets in the target countries (Ghana and Tanzania): 1) marketing, profits and economic efficiency; 2) threats to public health from milk products; and 3) processing of indigenous milk products.

Marketing and efficiency

In Ghana and Tanzania, several hundred milk/dairy market agents were surveyed in key urban areas and their peri-urban milk sheds. In Ghana this included the Accra and Kumasi areas, while in Tanzania this comprised Dar es Salaam, including a wide area of the coast, and Mwanza. In both countries, the survey respondents represented a wide variety of milk market agents including small-scale local vendors, wholesalers or milk assemblers, milk hawkers, retailers with fixed premises, commercial cheese makers, local indigenous cheese (*wagashi*) makers (Ghana), cooperatives, and dairy farmers. Most of these were women in both countries, and about three-quarters were either proprietors or family members of proprietors. Many were very small-scale operators, handling less than 30 litres of milk a day.

Raw milk is the primary product sold in most areas, although in some parts of Tanzania (Mwanza) fermented milk is important, and *wagashi* is important for some communities in Ghana. The markets studied displayed a wide variety of interactions between market agents and market channels. In the simplest example, milk producers sold raw milk directly to consumers with no other intermediaries. At the other extreme, three intermediaries could play a role between farmer and consumer, including rural assembler, larger-scale urban assembler and small-scale fixed retailer or hawker. This was particularly true when market chains were long, bringing milk from distant areas. The market agents were studied for profitability, market margins, policy-related constraints and handling/hygiene practices. Quality control measures were rarely used, although in Mwanza there was significant use of lactometers. Milk preservation was found mainly in Tanzania, with refrigeration used by many retailers; some market agents boiled the milk. A key finding was that proper metal milk containers were rarely used; plastic buckets and jerry cans were preferred, except among retailers in some cases.

Returns were highest to farmers who sold their milk directly to consumers. For those who had no such opportunities, returns were split by about half with intermediaries. As the number of intermediaries increased, the price received by farmers generally declined; in Ghana this effect was very small. In many cases, the market margins were shared among intermediaries. An important result was that there was no systematic difference in profitability between large- and small-scale market agents. Instead, unit returns differed according to volume handled and the value added in terms of labour. For example, large-scale wholesalers showed low unit profits, while retailers exhibited the highest unit profits in both countries, reflecting the market service and provision of refrigeration or premises at the retail level. Assemblers who travelled longer distances to collect milk also showed higher returns. Statistical analysis comparing volume of milk with profitability showed very little effect, suggesting that there are few economies of scale in milk marketing. This finding points towards strong continued viability of small-scale market agents and the consequent creation of employment opportunities in both rural and urban areas. In both countries, the policy environment was favourable in that small-scale milk agents did not require licences and experienced few regulatory constraints. However, another key finding, although expected, was the universal lack of any formal training in milk handling, except in some cooperatives. This often resulted, as shown below, in low quality milk.

Public health

Unlike in other such milk market studies, the project also gathered information on the quality of milk, using milk samples taken from the respondents interviewed. Samples were taken in both the dry and wet seasons to capture seasonal variability in quality. The samples were tested for bacterial counts (both coliform and total counts), for anti-microbial drug residue such as antibiotics (for adulteration), and for the zoonotic diseases *Brucella abortus* and *Mycobacterium bovis* (in Tanzania only). Haemorrhagic *Escherichia coli* strain O157:H7 was also assessed.

Overall, milk quality was often found to be quite low. Adulteration with water was found in 20% to 60% of samples in Tanzania (highest in Mwanza) and some 30% to 45% of samples in Ghana. This varied particularly by season and site of sampling. Adulteration was highest during the dry season, when milk supply was lowest, prices were highest and the economic incentives to add volume were also at their highest. Bacterial counts were similarly high. In Tanzania, 67% of the samples had unacceptable levels of coliform counts in Mwanza, compared with about 50% in Dar es Salaam. These figures are closely related to the high rate of adulteration in Mwanza seen above, since coliform counts reflect both adulteration and poor hygiene. Total bacterial counts, reflective mainly of time since milking, were also poor, with over 60% showing unacceptably high levels, and did not significantly differ between the urban areas. In Ghana, bacterial counts were somewhat lower, with only 25% of milk with unacceptable levels of either coliforms or total counts, although this differed by season. This probably reflects the lack of intermediaries in most milk market pathways in Ghana, where the majority were producer-sellers. The key finding from these milk quality tests was that small-scale milk market agents, often targeted by the public as being the greatest threat to public health, did not show significantly worse milk quality than other market agents. Indeed, in some cases such as wholesalers in Ghana, the worst milk quality was found among larger-scale market

agents. Again the issue of lack of training in hygiene became evident, as coliform counts were seen to generally increase as one moved down the chain to retailers, and milk was repeatedly handled. The use of inappropriate plastic containers was also found to contribute to low milk quality.

Antimicrobial drug residues were found in a significant number of samples, some 35–40% of samples in Tanzania and 35% of samples in Ghana. These residues usually result from farmers using antimicrobials to treat cattle. They may also be from preservatives added to the milk by market agents. Such residues are not degraded by pasteurization and will therefore be present in processed milk. This may pose a long-term public health threat to human beings.

Antibodies for *Brucella* were found in some 15% to 35% of samples in both countries, depending on which test procedures were used. This suggests potential health threats from drinking this milk unless it is boiled to destroy the pathogens.

The common practice by consumers of boiling milk before consumption shields them from most of these health hazards. However, the observed lack of training, coupled with the lack of policy support in terms of regulation, is clearly contributing to low milk quality. Training modules were developed and implemented to address the milk quality issues.

Processing of indigenous dairy products

In Ghana, considerable attention was given to the processing of a traditional fresh soft cheese product, known locally as *wagashi*. It is a cottage industry product, made in homes by individual processors, nearly all women. *Wagashi* is generally made when there is surplus milk for which no market is available. An extract from the plant *Calotropis procera*, which grows naturally in the area, is universally used as a coagulant for *wagashi* production. Initial investigation found the cheese had shelf-life constraints; the product had to be re-boiled and dried daily if it could not be sold, with consequent costs in terms of firewood/fuel and possible nutrient losses. The *wagashi* makers handled less than 15 litres of milk per day and had no formal training—the technique was learned from family members. Another constraint to *wagashi* production was a lack of clear knowledge on the amount of coagulant to use; this varied widely between different cheese makers. Inefficient use would further exacerbate the problem of increasing scarcity of *Calotropis* in some areas. Experiments were thus conducted to identify the optimum quantity for use, and the relative proportions of stem and leaf. These trials showed that 20 g of *C. procera* stem or 30 g of leaves are sufficient to coagulate 2 litres of milk. These quantities were converted into typical local measures. Several means of increasing shelf life were explored. Trials were conducted on the use of *Xylopia aethiopica,* a local plant thought to have anti-microbial properties. However, no preservative effect on the *wagashi* was observed. Brining trials found that soaking in brine concentrations over 10% overnight led to a significant reduction in bacterial growth.

These refined techniques, designed to be easily adopted by the cheese makers and to be acceptable to consumers, were then incorporated into a training module and a dissemination leaflet. Basic economic analysis showed that reasonable returns were available to these household cheese makers, and that improved shelf life would reduce their costs and increase their market opportunities.

Overall findings

This research project, one of the first to systematically address economic and public heath issues in indigenous dairy markets in Africa, found that important opportunities for livelihoods continue to be created in such markets. Further, the small-scale market agents (normally thought to pose public health threats) were not found to offer significantly lower quality products than larger-scale market agents, some of whom work within the regulated environment. Lack of training was found to be a systematic contributing factor to both low quality milk, and to variability in economic returns. The training materials and modules developed by the project address these problems. Policy recommendations from the project are aimed at bridging the gap between the regulated and unregulated dairy markets, thus reducing public health risks through targeted training of market agents coupled with licensing where appropriate.

Linkages

The dissemination materials and reports produced have formed the basis for several new initiatives and linkages. In Ghana, the findings were taken up by a new Food and Agriculture Organization of the United Nations (FAO) project (entitled 'The training programme for the small-scale dairy sector') and related livestock sector development efforts being funded by the African Development Bank. In Tanzania, close linkages initiated at the beginning of the project with Austroproject, a local dairy development non-governmental organization, and the national Dairy Task Force (of which the Tanzania Project Coordinator is a member) continue to ensure direct use of the findings. Internationally and regionally, the training materials developed are already being promoted in various ways by FAO and the Eastern and Central Africa Programme on Agricultural Policy Analysis (ECAPAPA) and formed the basis for a generic training manual being developed for eastern Africa.

Relevance to sustainable livelihoods

Market-oriented smallholder dairying in developing economies has higher returns than many traditional agricultural activities. It therefore offers income opportunities for resource-poor producer households and for rural and urban poor through their participation in processing and marketing. This research provides one of the first sets of evidence that systematically address the economic and milk-borne public health issues in Africa. It has documented that important livelihoods continue to be created in such markets, providing comprehensive evidence for greater policy attention to the markets. The policy recommendations are aimed at bridging the gap between the regulated and unregulated dairy markets, and reducing public health risks, through targeted training of market agents coupled with licensing where appropriate.

1   Background

This research report presents an analysis of the problems encountered in the milk markets in Ghana and Tanzania. It is based on a study carried out during 1999 and 2000 to identify and quantify the public health risks and economic performance in dairy product markets in these two countries.

The study was led by the International Livestock Research Institute (ILRI). Scientists from The University and Technology (Kumasi, Ghana), the Animal Research Institute (Accra, Ghana), Sokoine University of Agriculture (Morogoro, Tanzania) and the Natural Resources Institute (UK) collaborated in implementing the study. Funding was obtained from the UK Department for International Development-Livestock Production Programme (DFID-LPP).

This report is divided into an executive summary and a main section. The summary highlights the key findings and achievements of the study. The main report gives a detailed account of the methodology used and the main outcomes of the research. Chapter 2 addresses market mechanisms and efficiency, and contains the results of the economic and structural analysis of the markets. Chapter 3 deals with the milk-borne public health risks, and focuses on the results of laboratory testing of milk and dairy product samples; this chapter also uses some of the economic results in the analysis. Processing of traditional dairy products is the topic addressed in Chapter 4, with a focus on the traditional fresh cheese, *wagashi,* in Ghana. Chapter 5 presents the impacts of the training activities conducted during the study while Chapter 6 indicates ways in which the project contributed to meeting the research goal. The project team hopes that the technologies and strategies developed in this study will inform development in other similar production and market systems.

Introduction

Milk production and marketing contributes to the livelihoods of many smallholder farmers in sub-Saharan Africa. The increasing demand for dairy products associated with the growth in human population, rising incomes and urbanization offers an opportunity for poor smallholder farmers and other intermediaries in the milk value chains to realize higher incomes. Market-oriented smallholder dairying therefore offers an important pathway out of poverty to these farmers and other stakeholders in milk production and marketing, but this will only happen if constraints to market access are addressed.

Efforts to improve market access for small-scale dairy operators require a good understanding of the existing marketing mechanisms. In many countries in sub-Saharan Africa milk is mostly sold through informal marketing channels which deal mainly with raw milk and traditional dairy products. This is because of the unwillingness of many consumers to pay for the extra costs of pasteurization in the formal marketing sector, and also because of their tastes and preferences for traditional dairy products. Unfortunately, policy in many of these countries has traditionally discouraged informal milk marketing and this has had some undesirable effects, including:

- informal milk marketing agents are forced to operate at limited levels of scale and with increased inefficiency
- marketing channels are unreliable and have high transaction costs

- high milk prices (relative to world prices) to consumers

- low milk prices received by farmers.

Owing to systematic inattention, not much is known about how to improve the efficiency of informal milk marketing. The objective of this project was to contribute to the welfare of smallholder milk producers, small-scale processors and marketing agents and consumers. The study was therefor designed to identify efficient and viable market mechanisms and processes which deliver safe, consumer-preferred dairy products at low cost, and which provide higher and more reliable returns to resource poor small-scale dairy producers. To achieve this objective, studies were conducted in Ghana and Tanzania to quantify actual public health risks and economic performance in indigenous dairy product markets and to determine how these two aspects relate to market agent practices and government policies.

The studies in Ghana and Tanzania came after a similar study in Kenya. The idea was to generate a set of more widely-applicable recommendations based on evidence from countries with contrasting dairy production and marketing sub-sectors. Availability of dairy products in Tanzania is relatively higher (21 kg LME (liquid milk equivalent) per person) than in Ghana (5 kg LME). Milk availability in both countries is lower than the average level in sub-Saharan Africa (25 kg LME per person) and in most western countries (over 100 kg LME/person). A large proportion of the milk consumed in Ghana is imported. Much of the milk in Tanzania is produced from exotic or crossbred (with *Bos taurus*) dairy cattle, unlike in Ghana where most of the milk produced comes from zebu cattle mainly kept by the Fulani community. Consumption of cheese and other processed dairy products is common in Ghana and much of West Africa, whereas fresh and fermented liquid milk consumption dominates in Tanzania and East Africa in general.

Main research questions

1. What is the structure, conduct and performance of small-scale informal milk markets?

2. How can small-scale informal milk market mechanisms be differentiated by level of performance and safety?

3. Can the efficiency of informal markets be improved?

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

5. Do the hazards pose significant health risks?

6. What risk factors are involved?

7. How can milk-borne public health risks be alleviated without impeding the efficient marketing of milk?

Methodology

The study sites in Ghana and Tanzania are shown in Figures 1 and 2 respectively. Information was collected from milk producers who sell milk and from other milk marketing agents (small-scale milk product traders, wholesalers, assemblers of milk from rural areas, retailers, group collection centres, processors and sellers of traditional products) in and around the cities of Dar es Salaam and Mwanza in Tanzania, and Kumasi and Accra in Ghana (Table 1). These study sites represent contrasting patterns of dairy products supply, market access and consumer demand in the respective countries.

Table 1. *Type, number and gender of milk marketing agents interviewed*

Market agent	Tanzania		Ghana		Total
	Dar es Salaam	Mwanza	Accra	Kumasi	
Coops/collection centres	7	0	1	0	8
Producer-sellers	116	116	49	82	363
Wagashi processors	NA	NA	7	16	23
Wholesalers/assemblers	17	0	22	5	44
Vendors/mobile traders	77	185	0	8	270
Retailers	222	18	15	24	279
Total	**316**	**203**	**94**	**135**	**748**
Per cent female	36	14	44	54	33

Analytical approach used

This study used the structure, conduct and performance (SCP) framework of market analysis. This is a method of market analysis that looks at certain characteristics of the market, including specific behaviours of market agents and the outcomes of these in the market as influenced by the said characteristics (Box 1). In the case of milk marketing in Ghana and Tanzania, the characteristics included:

- nature and type of milk marketing channels
- types of dairy products
- sizes of market shares commanded by marketing agents
- legal, institutional and infrastructural environment
- location and distances of marketing agents
- capital requirements by marketing agents
- economies of scale.

The performance indicators included:

- selling and purchase prices of milk
- market margins in milk marketing
- marketing costs and net returns.

The factors affecting performance were also evaluated.
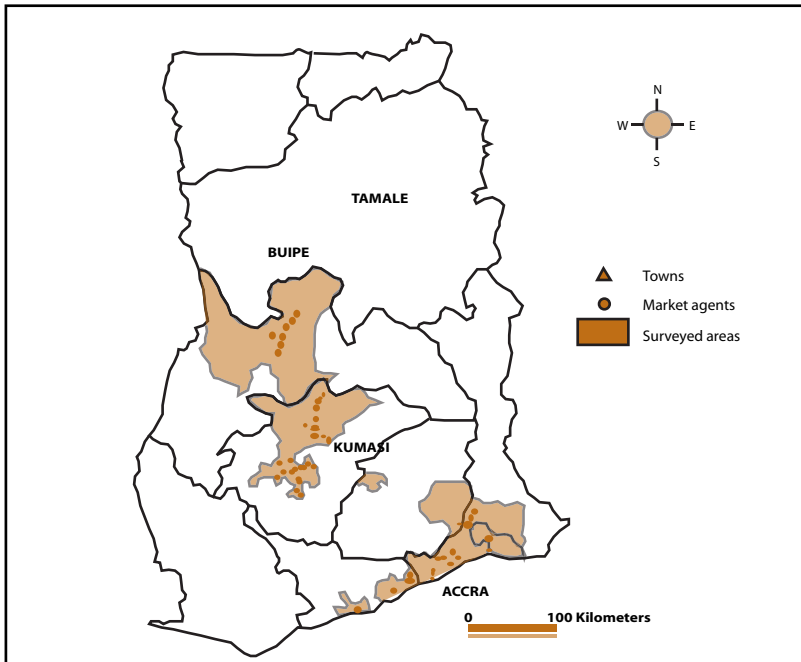
Figure 1. *A map of the study sites in selected milk sheds in Tanzania.*
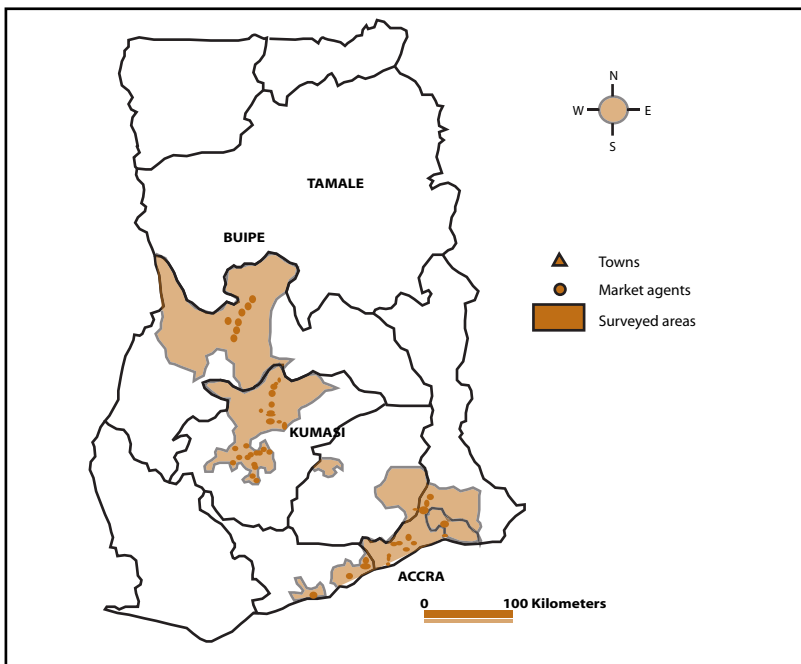
Figure 2. *A map of the study sites in selected milk sheds in Ghana.*

4

Box 1. The structure, conduct and performance (SCP) framework of market analysis

Market structure

The structure of an industry or market refers to the characteristics of the organization of the market that seem to exercise strategic influence on the nature of competition and pricing in the market (Bain 1968). Some of the characteristics most stressed are:

- **Marketing channels:** This refers to the alternative routes of product flows from producers to consumers. During the process, the ownership of the product changes from time to time among the marketing participants and in each case marketing costs are incurred. Thus in analysing marketing costs and margins, attention has to be focused on the nature and marketing channels involved.

- **Market concentration:** This is measured as the proportion of the market in a particular industry that is controlled by a particular firm. Market concentration greatly influences behaviour as it tends to affect the interdependencies among market agents and bargaining power to influence prices and transactions. Non-competitive behaviour such as collusion is normally a result of high market concentration.

- **Product differentiation:** Product differentiation is said to be there in an industry when there exists significant basis for distinguishing the products of one seller from those of another. Sellers differentiate their products in order to increase their appeal to buyers, reduce the substitutability for their products and increase the latitude in pricing. Typical differentiation factors include product typology, product handling and preservation and advertisement.

- **Entry conditions:** This refers to conditions that deter potential entrants in an industry thus impeding competition and market efficiency. Barriers to entry usually revolve around institutional, technological and financial factors. Existing agents usually enjoy a cost advantage over potential competitors through command over financial resources, access to raw materials, technical know how or existence of economies of scale.

Conduct

Conduct refers to the behaviour of and action programmes by market agents given the structure within which they operate. The salient features of conduct can be grouped into two:

- Buying and selling behaviour: This relates to source of products, selling/procurement modes, market channels, moral hazards and terms of payment.

- Pricing behaviour: This relates to price formation, collusion, price setting, price differentiation, price movement and location effects on prices.

Performance

Market performance is largely the outcome of market structure and conduct, but all are affected by policy and other factors. Basic performance variables include prices, costs and volume of outputs. These variables are the building blocks of market margins and net returns. Thus by analysing the level of market margins, net returns and their cost components, it becomes possible to evaluate the impact of structure and conduct characteristics on market performance.

2   Dairy product mechanisms and efficiency

Milk marketing agents and channels

The main types of milk marketing agents and channels in Ghana and Tanzania are presented in Table 2 and in Figures 3 and 4. The informal milk markets in these countries comprise numerous types of market intermediaries, who often play slightly different but often overlapping roles. These roles often are distinguished by scale of operation and the buyer/seller clients they serve. The markets exhibit different degrees of vertical integration, with some serving the same functions that two or more other intermediaries may be simultaneously performing.

Table 2. *Main types of market agents in traditional milk product markets in Ghana and Tanzania*

Type of seller	Description
Producer-seller	Producers who also sell their milk. In Ghana, these are herdsmen or their wives who sell their own milk at the farm/kraal or in the village, rural town or roadside. They are differentiated from processor-sellers, who sell home manufactured soft cheese, and are included among processors below. In Tanzania, producer-sellers include both rural and intra-urban farmers using mainly crossbred cattle. However, milk from traditional cattle is also increasingly entering the market, especially in Dar es Salaam.
Processors	These types of sellers procure milk to process into other products like yoghurt, ice cream and cheese. In Ghana, these include home processors of soft cheese known as *wagashi*, generally wives of stockmen/producers. In Tanzania, liquid milk dominates the market, with less than 5% reaching the consumer after pasteurization.
Private wholesalers/ assemblers	Wholesalers buy milk in bulk from producers and/or rural assemblers and sell it to retailers. Assemblers sell generally to other wholesalers. In Tanzania, some wholesalers operate milk collection/cooling centres, while in Ghana no chilling is generally used. They therefore play the role of bulkers in the marketing system.
Collection centres/dairy cooperatives	Dairy cooperatives facilitate milk collection and marketing; this activity is located around collection centres. Most dairy cooperatives have cooling facilities. They collect milk from members and vendors and resell to wholesale processors, vendors and household consumers.
Hawkers/vendors	Vendors collect milk from producers and/or milk collectors and sell directly to consumers and other market agents. In Ghana, they may also be the wives of stockmen/producers. Vendors play an important role in collecting milk and delivering it to other market participants, consumers and/or retail outlets such as milk bars, kiosks and hotels. Vendors normally trade in fresh milk unless there is unsold milk which can be fermented and sold as *mtindi* (soured milk) on the following day in the case of Tanzania. Vendors have more or less permanent customers and may sometimes deliver milk on credit, while hawkers are those vendors that hawk milk to any customers they may find, often using small volume selling units such as a cup. In Tanzania, hawkers may sell *mtindi,* particularly during the dry season when hot weather creates demand for this beverage.
Retailers	Retailers present milk to the consumer in the smallest quantities desired, and in a convenient form and location. In Ghana these are largely open-air roadside sellers, while in Tanzania (Dar es Salaam only) they are mainly specialized milk bars selling a variety of milk products to consumers, particularly consumers away from home.
Fura seller (Ghana only)	These are individual food-drink sellers mainly in urban centres of Ghana. They buy milk from the kraal, assembly market or from the sedentary wholesalers and retail it combined with balls of cooked cereal, the *fura*, as a snack or meal.
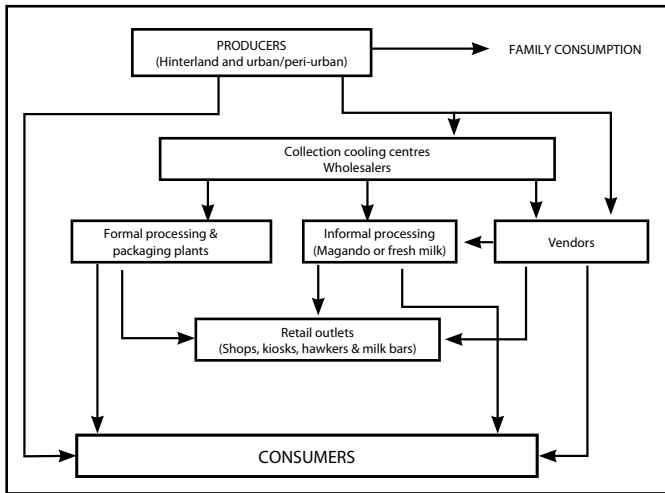
Figure 3. *Milk marketing channels in Tanzania.*

Points to note on milk marketing channels in Tanzania:

- Direct sales by producers to consumers, either at the farm gate or local market in producing areas, is the oldest of all channels in the milk marketing system. The popularity of this channel is, however, dwindling because more households are keeping dairy cattle in the producing areas and the number of alternative market channels and intermediaries is increasing.

- Currently most of the producers dispose of their milk through intermediaries who often deliver the milk directly or indirectly to consumers in the cities.

- The study found that there are fewer and less complex milk marketing channels in Mwanza than there were in Dar es Salaam, as cooperatives and milk wholesalers are virtually non-existent in Mwanza.
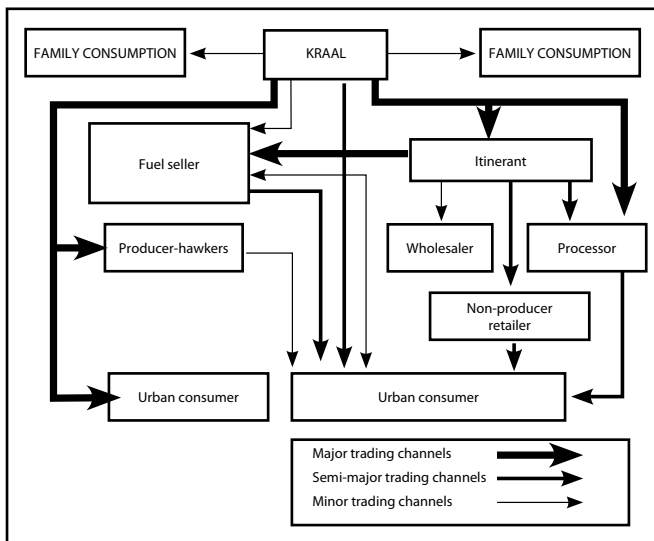
Figure 4. *Milk marketing channels in Ghana.*

Point to note on milk marketing channels in Ghana:

Milk is often taken to other sale points when customers do not buy all of it at the farm-gate. It is delivered to established customers including processors of traditional dairy products and milk bars, or it is hawked or delivered to a common market in the centre of town where milk sellers assemble to sell their milk.

Milk quantities handled

The quantities of milk handled by the different types of market agents vary (Table 3). Agents who perform bulking or processing roles (i.e. assemblers and *wagashi* processors in Ghana and dairy cooperatives and wholesalers in Tanzania) handle the most milk. In Dar es Salaam, wholesalers and cooperatives, who form only 7% of the intermediaries, handle about 43% of the traded milk. In comparison, vendors in Mwanza who are the majority there (85% of respondents) handle most of the milk (81%). This suggests that there may be oligopolistic conditions in the Dar es Salaam market that are not present in the Mwanza market at the milk procurement level. In contrast in Ghana, no specific market agent type dominates the dairy products in Accra, while in Kumasi wholesalers followed by *wagashi* processors, are the larger players.

In general, the study found that agents in relatively larger towns, i.e. Dar es Salaam in Tanzania and Accra in Ghana, where the dairy business is relatively more developed handle much more milk.

Table 3. *Mean quantities of milk (litres) handled by different marketing agents*

Country and site	Tanzania		Ghana	
	Dar es Salaam	Mwanza	Accra	Kumasi
Coop/collection centres	23,205	NA	2,760	NA
Producers	1,133	252	659	344
Processors	NA	NA	3,281	1,398
Wholesalers/assemblers	21,995	NA	2,465	2,447
Retailers	1,839	887	2,578	216
Vendors/mobile traders	1,564	711	NA	233
Others	980	NA	300	615

Product differentiation

Most of the milk in both countries is sold in raw fresh form (Figures 5 and 6). Nevertheless, there is a relatively higher degree of product differentiation in Ghana. Here, milk producers, dairy cooperatives and wholesalers mainly handle raw fresh milk. Some of the fresh milk that cannot be marketed by these agents is, however, processed into *wagashi* cheese or boiled. There are also some traditional processors who specialize in the production of *wagashi* for sale. *Wagashi* cheese—fresh and dry—was sold by 25% of the hawkers and 19% of retailers in Ghana. Other processed dairy products in Ghana included natural fermented milk sold by 24% of the retailers and 31% of the hawkers; fermented cultured milk sold by about 8% of the processors; and ghee sold by about 3% of retailers and by processors.

8

In Tanzania, most of the milk sold is either unprocessed or informally processed liquid milk. For instance, over 90% of the surveyed traders in the Dar es Salaam milk shed[1] cited raw milk as their major sale product. Producers and vendors in Mwanza also mainly traded in raw milk. About 57% of all the retailers in Dar es Salaam and Mwanza cited either fresh boiled cool or warm milk as the main products they sold. Other milk products at the retail level in Tanzania included naturally fermented milk, fermented cultured milk, packaged pasteurized milk and packaged fermented milk.
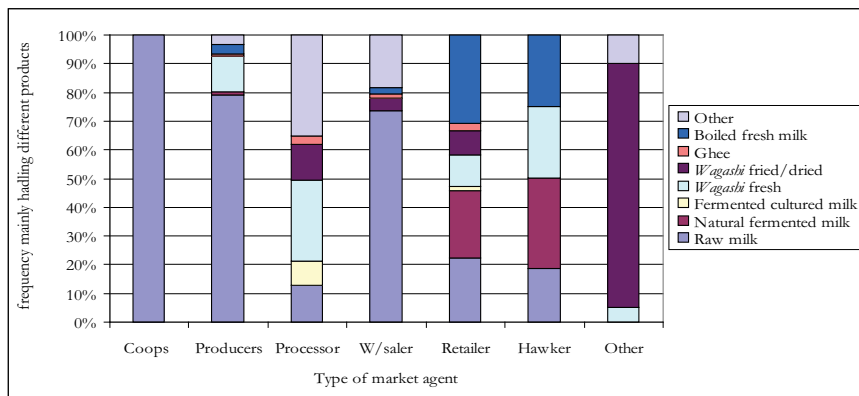
Figure 5. *Frequency of market agents dealing with diffrent types of dairy products in Ghana.*
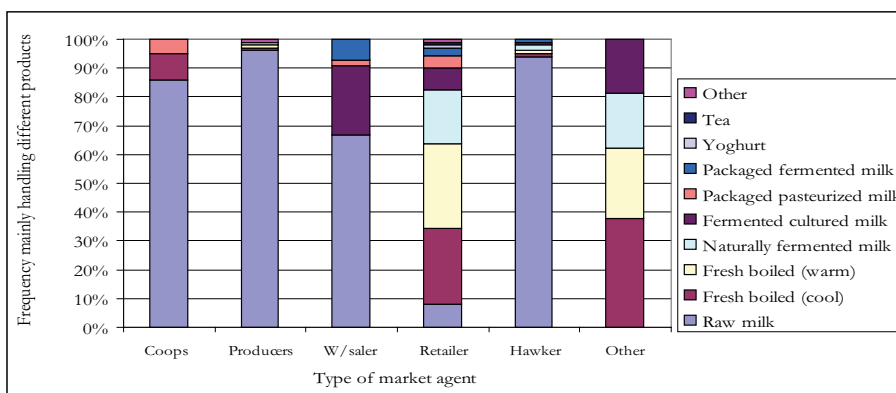
Figure 6. *Frequency of market agents dealing with diffrent types of dairy products in Tanzania.*

Quantities of milk collected per farm

The amount of milk collected each day per producer is presented in Figure 7. The results show that milk quantities collected per producer are generally higher in Tanzania than in Ghana largely due to the higher levels of consumption in Tanzania. The quantities collected tend to be higher during the wet season than in the dry season. The seasonal differences in milk quantities collected are, however, much larger in Tanzania than they are in Ghana. The quantities collected per farm in the Dar es Salaam area are much higher than those in Mwanza. Most likely, this is due to increased intensification and the use of higher yielding crossbred cattle in Dar es Salaam.

_____

1. A milk shed refers to a given milk production and consumption area. See Figures 1 and 2 for the milk sheds in both countries included in this study.
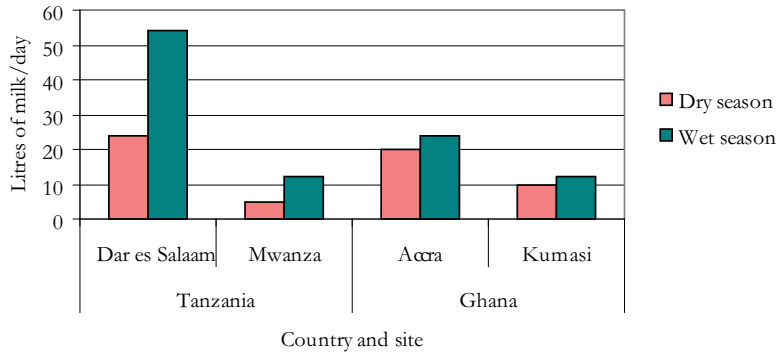
Figure 7. *Milk quantities (litres) procured per day from producers.*

Milk transportation

Milk producers and marketing agents demonstrated a higher use of mechanized transport in Tanzania than in Ghana. In Ghana, most herdsmen-producers normally sold their milk at the kraal (farm gate) or in their homes and only 12% transported it to a sale point. The milk was transported on foot. Most market intermediaries in Ghana (72%) also transported their milk from the collection point on foot; 21% used public transport, 6% used bicycles, 1% used their own vehicles, and only 1% of market agents hired vehicles. In Tanzania, 56% and 47% of the market agents relied mostly on bicycles to procure and to deliver milk to sales points respectively; 30% of market agents used vehicles to procure milk while 30% of the sales deliveries were done on foot—usually by hawkers. Producers and vendors in Tanzania usually transported milk to selling points on bicycles or public transport and in some cases they carried it on their heads. Transportation of milk from the collection centres to the urban areas was mainly done using hired or own private vehicles. The higher frequency of vehicle use in Tanzania is likely to be related to larger average volumes, and to much greater distances between supply and demand areas. Supply close to urban demand areas is not enough to meet demand, requiring procurement from more distant areas.

Contractual arrangements in milk sales and purchases

Milk purchases and sales mostly took place either under no contract or under informal unwritten contractual terms—often stipulating time of delivery, price and timing of payment. Some instances of informal written contracts were also found. Formal contracts—defined as 'lawyer assisted'—were not found.

In Ghana, 80% of the transactions were made without any form of business contract while 20% were made under unwritten informal contracts (Figure 8). The unwritten informal contracts were mainly made between milk processors and/or milk assemblers and herdsmen. In Tanzania, 41% of the producers and marketing agents indicated that they did not practise any form of contractual arrangements while 58% indicated use of informal unwritten contracts. Only 2% indicated the use of written but informal contracts. The higher number of informal written contracts in Tanzania compared to Ghana may reflect the generally more developed nature of the dairy industry in Tanzania. At the same time, the absence of formal contractual arrangements implies that informal milk marketing may be prone to business risks and uncertainties, particularly in Ghana.
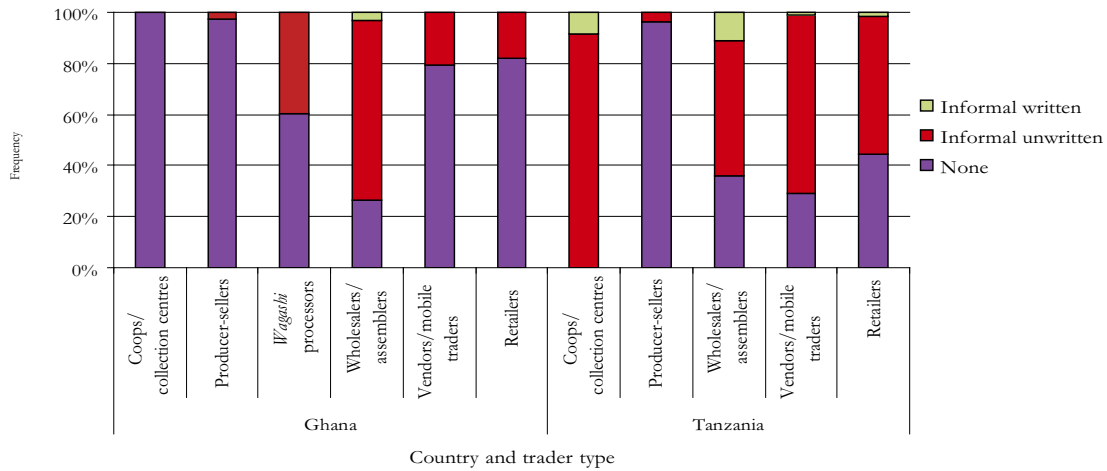
Figure 8. *Frequency and nature of contractual arrangements with suppliers by market agents.*

Milk handling vessels

In both Ghana and Tanzania, milk is most often handled using plastic containers; these are prone to bacterial contamination (Figure 9). Use of plastic containers by the milk marketing agents is, however, much more entrenched in Ghana (81%) than it is in Tanzania (61%). Moreover, only 1% of the marketing agents in Ghana were using the recommended aluminium milk cans/churns compared with about 23% of the traders in Tanzania. Milk handling problems coupled with lack of quality assurance of milk delivered to most of the retailers and household consumers, are potential sources of public health risks to consumers, and may contribute to low consumption of milk. One way to encourage the use of the recommended aluminium cans/churns in Ghana may be to encourage local aluminium manufacturing companies to produce such containers.
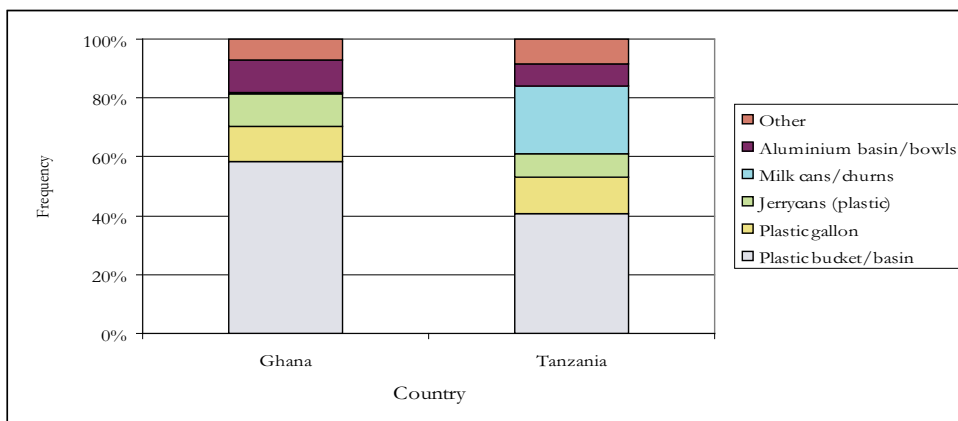
Figure 9. *Milk handling vessels used by traders: proportion of responses.*

Performance

Milk prices and marketing margins

Analyses of price variability among market agents enables an assessment of market efficiency by shedding light on how prices in different places move together and therefore how well the pricing system in the market does or does not perform its functions.[2] Market margins are not by themselves a measure of profitability of a marketing business. Conspicuously high market margins may imply high marketing costs and/or profits. The results of milk prices and market margins received by different marketing agents are shown in Figures 10 and 11. To enable comparison among agents selling different products, all products such as *wagashi* were converted into liquid milk equivalents. An exchange rate of USD 1 to 800 Tanzania shillings, and to 4050 Ghana cedis was used.

In Ghana, milk producers in the Kumasi zone receive higher prices than in Accra (which is a larger consumption area) most certainly due to the general milk scarcity in Kumasi. Conversely, consumers in Accra pay more as retailers there receive USD 0.46 per litre against USD 0.44 per litre in Kumasi most likely because of higher incomes and greater urbanization in Accra. *Wagashi* and other product processors in Accra and Kumasi receive the highest prices of all market agents. This is because these processors deal in value added products such as *wagashi* and *fura*, which fetch higher prices. The processors in Accra receive the highest margins, apparently due to limited supply of the *wagashi*, which is generally produced only by members of the Fulani ethnic group, who are a small minority in the Accra area.

In Tanzania, agents in the Dar es Salaam milk shed generally have higher marketing margins than in Mwanza. Retailers (especially in Dar es Salaam) get the largest market margins (USD 0.25), as would be expected given their higher costs. Conversely, collection centres have the lowest margins (USD 0.06), contributing to their lack of profitability. On average, producers and retailers in the Dar es Salaam milk shed receive higher prices (USD 0.29 and USD 0.62 respectively) than in Mwanza (USD 0.23 and USD 0.43 respectively). Moreover, the difference between producer prices and retail prices is also higher in the Dar es Salaam milk shed than in the Mwanza milk shed (USD 0.33 and USD 0.20 respectively) suggesting that marketing costs are lower in the Mwanza milk shed. Milk prices are also generally higher closer to the urban centres reflecting centres of demand and the costs associated with moving milk to those centres. For instance in the Dar es Salaam milk shed the producer and retail prices are higher in Dar es Salaam District than in other areas such as Tanga, Coast and Morogoro. Likewise in the Mwanza milk shed, producer prices were highest in Mwanza urban and peri-urban and lowest in more distant places where demand is relatively low.

The results of an assessment of the distribution of market margins by marketing channels indicated: (a) producers receive higher market margins in shorter milk marketing channels, and (b) the longer the marketing chain the smaller the proportion of the market margin enjoyed by a market agent.

---

2. However, transport and transactions costs will create price differences spatially. Also, product differentiation particularly in terms of value addition create differences in margins which do not reflect costs.
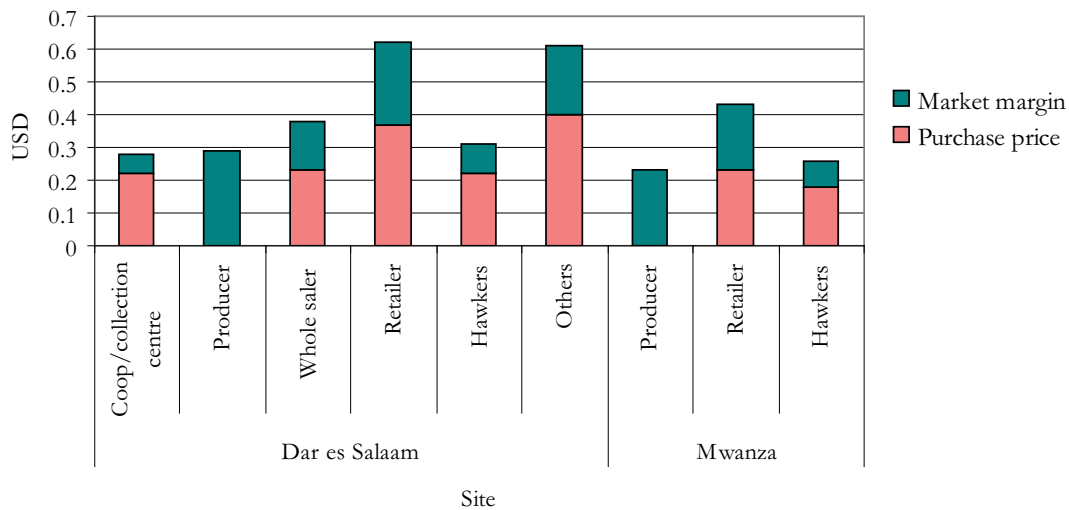
Note: Market margin = selling price - buying price

Figure 10. *Market margins (USD per litre) given the levels of purchase and selling prices among milk marketing agents in Tanzania.*
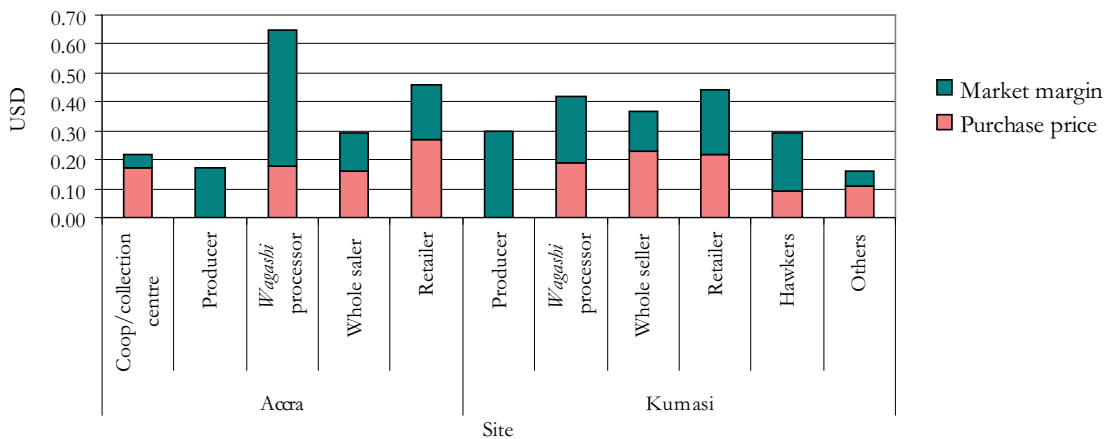
Note: Market margin = selling price - buying price

Figure 11. *Market margins (USD per litre) given the levels of purchase and selling prices among milk marketing agents in Ghana.*

Market agent profits

The results on profitability suggest that milk marketing can yield substantial income to many entrepreneurs in the study areas (Figures 12 and 13). The profit margins for vendors and retailers, most of whom are sole proprietors, are significantly higher than the country's per capita income for Tanzania (USD 270) and Ghana (USD 290) (World Bank 2005). Results on returns to working capital for cooperatives, wholesalers and vendors were adequate to allow them to accumulate and re-invest.

13

Figure 12. *Net returns (USD/month) given levels of revenue and costs among the milk marketing agents in Tanzania.*
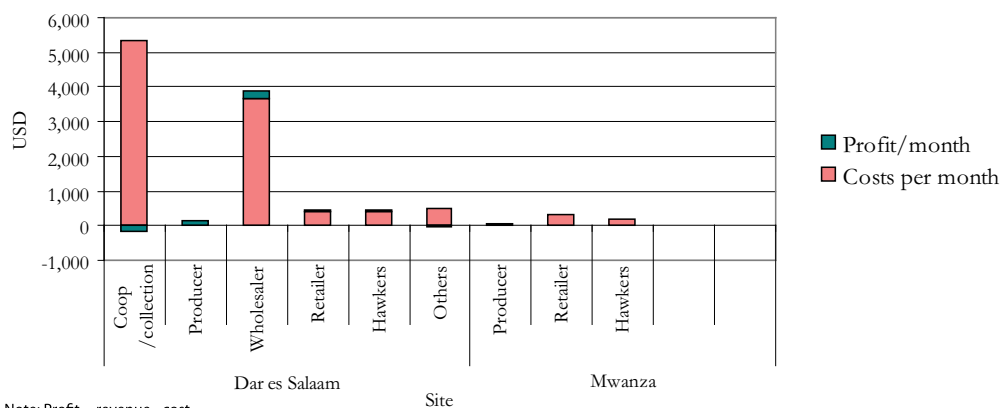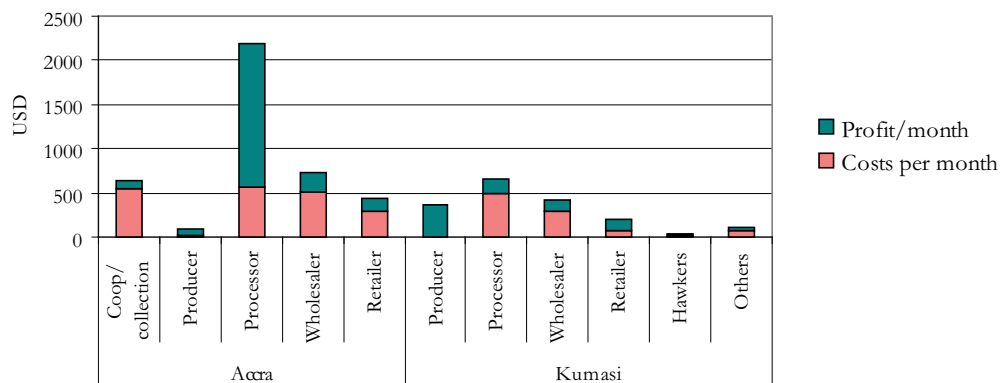
Note: Profit = revenue - cost

Figure 13. *Net returns (USD/month) given levels of revenue and costs among the milk marketing agents in Ghana.*

In general, unit profits are much lower in Tanzania (Table 4) where the milk market is much larger, with a greater range and number of market agents, and therefore where competitive forces may be stronger. In Ghana, *wagashi* processors make the highest profit in Accra while the producers make the highest profits in Kumasi for each litre of milk sold. *Wagashi* is more widely produced in the Kumasi zone, where many ethnic Fulani live, resulting in a lower price than in Accra. In addition, milk producers in Kumasi were able to charge higher prices due to shortages there.

Table 4. *Profitability (USD per litre) among the milk marketing agents in Ghana*

	Ghana		Tanzania	
	Accra	Kumasi	Dar es Salaam	Mwanza
Coop/collection centre	0.04	NA	-0.01	NA
Producers	0.15	0.27	0.22	0.22
Processor	0.44	0.02	NA	NA
Wholesaler	0.07	0.11	0.02	NA
Retailer	0.12	0.08	0.01	0.03
Hawkers	NA	0.12	0.05	0.001
Others	NA	0.03	-0.04	NA

14

Results of econometric analyses

Determinants of profitability

A quantitative analysis was conducted to determine the factors influencing the levels of profitability and the financial efficiency among different groupings of milk marketing agents in Ghana ((a) producer sellers; (b) wholesalers/milk assemblers and *wagashi* processors; and (c) vendors, hawkers, *fura*, *lekri* and *wagashi* sellers), and in Tanzania ((a) producer sellers; (b) retailers; and (c) vendors and hawkers). The grouping together of the different types of milk marketing agents was done to ensure a sufficient number of observations during the analysis and was based on the similarity of marketing roles performed, scale of operation and types of buyer/seller clients served so as to ensure that radically different types of marketing agents were not grouped together. Results indicated that inefficiency undermines profitability in all cases in both countries. On average, milk marketing agents in Ghana suffer higher losses in potential profitability (52–48%) due to inefficiency than in Tanzania where the milk market is more competitive (26–18%).

In Ghana, profitability among wholesalers/milk assemblers and *wagashi* processors tends to be higher with higher investments in the recommended aluminium milk cans and transportation equipment. Conversely, Ghanaian producer-sellers owning expensive milk transportation equipment realize less profitability. However, having more labour among the producer-sellers enhances profitability. The effect of aluminium milk cans on profitability among the wholesalers/milk assemblers and *wagashi* processors is attributable to the relatively large quantities of milk often handled by these traders which renders problems with quality more likely. This makes improved hygiene through the use of the recommended aluminium cans to reduce the risk of spoilage economically worthwhile. Likewise, while it is economically worthwhile for the wholesalers/milk assemblers and *wagashi* processors to invest in transportation equipment, this is counter-productive among producer-sellers who handle small volumes of milk and who are better off using labour intensive methods.

In Tanzania, the results of the effect of type and numbers of milk containers owned also demonstrate the positive effects of good hygiene standards on financial performance in the milk marketing business. Producer-sellers who invest more in the recommended metal containers realize higher profits. Metal cans help reduce milk spoilage as opposed to plastic containers which are prone to bacterial contamination. Nevertheless, Tanzanian producer-sellers and Ghanaian vendors/hawkers, *fura*/*lekri* and *wagashi* sellers who have many plastic containers also realize high profitability because they re-use containers less frequently thus reducing the build up of microbial load.

Determinants of efficiency

Results across the different groupings of milk marketing agents in both countries indicate that efficiency tends to be high when volumes of milk handled are high suggesting that economies of scale exist in milk marketing (Tables 5 and 6). A possible way to enable small-scale traders (producer-sellers, vendors and hawkers)—who commonly operate individually and handle limited quantities of milk—tap into more of these economies of scale and therefore gain more

competitiveness is through horizontal coordination through institutions such as milk marketing groups. The process of initiating formation and management of the milk marketing groups may require policy guidelines from a government authority to ensure sustainability.

The results in both countries also show that proximity to large town centres in addition to source and sale areas has important implications on efficiency. In Tanzania, levels of efficiency among producer-sellers and vendors and hawkers tend to be low with increasing distance away from the main town centres of Dar es Salaam and Mwanza. Similarly in Ghana, traders in urban and peri-urban areas have significantly higher levels of efficiency than in the rural areas. Conversely, wholesalers/milk assemblers and *wagashi* processors in Ghana tend to be more efficient in cases where distances between milk source and sale areas on murram roads are long. Low milk prices that usually prevail in less market access areas coupled with the relatively large volumes of milk handled by the wholesalers/milk assemblers and *wagashi* processors enable them save enough to offset the high costs of transporting milk over the long distances on murram roads.

Tanzanian milk retailers, and vendors and hawkers who source milk directly from producers tend to be more efficient. Nevertheless, retailers who also source milk from wholesalers realize high efficiency. These results reflect conditions that make it economically worthwhile for small-scale traders to either procure milk directly from producers or from wholesalers. For instance, when distances from source to sale areas are short, retailers gain by procuring directly from producers as savings gained from lower prices for milk offered by producers are sufficient to cover for the transportation and other transaction costs. However, procuring from wholesalers may be financially advantageous to the retailers in cases where transaction costs including transportation, quality control and contract enforcement costs are prohibitive due to long distances from the source to sale areas coupled with the small volumes of milk they handle compared to the wholesalers.

Milk procurement and sales contracts often enhanced efficiency among milk vendors and hawkers in Tanzania but was not significant among the small-scale marketing agents in Ghana. These results demonstrate the financial benefits of vertical coordination to small-scale milk marketing agents in a highly competitive market such as is the case of milk hawking and vending in Tanzania. Since individual milk vendors tend to have minimal market power, they may suffer due to fluctuations in supply and prices of milk. Having milk supply and sales contracts reduces the risk of financial loss due to the fluctuations in market conditions.

Surprisingly in Tanzania, training in milk quality control and testing was found to have no significant effect on inefficiency. Conversely, in Ghana where traders had never received any training, years of experience render traders more efficient. Since none of the reported training in Tanzania was formal, it is likely that the training was inappropriate or ineffective in imparting the intended skills to the market agents. Loose enforcement of standards by government monitoring agencies may also dampen the motivation to apply strict quality control by the market agents.

Table 5. *Determinants of profitability and inefficiency among milk marketing agents in Tanzania*

Determinants of profitability		Producer-sellers	Vendors and hawkers	Retailers
	Constant	7.84***	6.06***	7.14***
	Ln normalized CRC of transportation equipment	0.005	-0.02	0.00
	Ln normalized CRC of aluminium standard milk cans	0.09***	0.00	-0.04
	Ln normalized CRC of aluminium local milk cans	0.00	-0.04**	0.03
	Ln normalized CRC of plastic milk containers	0.06**	-	0.02
Levels of physical inputs and input prices	Ln normalized CRC of milk quality checking equipment	0.05	-0.01	0.02
	Ln normalized CRC of milk processing equipment	-0.02	-0.01	0.01
	Ln normalized CRC of furniture	0.04	-0.23	-0.03
	Ln normalized total labour	0.12	-0.08	-0.06
	Ln normalized wage	0.03	-	-0.18***
Determinants of inefficiency in profitability				
	Constant	-5.17***	-4.97***	0.45***
	Farming	1.01	2.39***	0.09
Other occupations (base for comparison = no other occupation)	Herding	-0.80	-	-
	Employment	-0.48	-	-
	Retired with pension	-1.42	-	-
	Other business activities	-0.16	-0.63	0.03
	Milk producers (0,1)	-	-2.12***	-0.08**
Source of milk	Wholesaler (0,1)	-	-	-0.92***
	Milk vendors (0,1)	-	-	-0.12
Milk procurement contracts	Milk procurement contract (informal verbal) (0,1)	-	1.60***	-0.07
	Milk procurement contract (informal written) (0,1)	-	-4.63***	-
	Milk procurement contract (formal)	-	-8.67***	-
Milk sale contract	Milk sales contract (informal verbal)	0.19	-2.75***	-0.04
	Milk sales contract (informal written)	-0.69	-0.21***	-
	Used own savings to start the business	0.95	1.58***	-
	Training in milk quality control and testing	-0.49	-	-0.02
Other business characteristics	Distance in km from to Dar es Salaam/Mwanza	0.01***	0.02***	-0.0001
	Quantity of milk dealt with (litres/month)	-0.002***	0.00***	-0.00017***
	Proportion of hired labour	0.12	1.09	-
	Sigma-squared	1.92***	1.55***	0.16***
	Gamma	0.96***	0.96***	0.09***
Model size (observations)		155	236	211
Mean efficiency		74%	76%	82%
Number of iterations		42	23	43
Log-likelihood function		-93	-107	-115

17

Table 6. *Determinants of profitability and inefficiency among milk marketing agents in Ghana*

	Determinants of profitability	Producer-sellers	Wholesalers and processors	Vendors, hawkers, fura, lekri and wagashi sellers
	Constant	7.83***	7.21***	6.85***
Levels of physical inputs and input prices	Ln normalized CRC of aluminum milk cans/containers	-0.003	0.06*	0.01
	Ln normalized CRC of utensils for handling milk	0.002	0.02	0.04
	Ln normalized CRC of plastic milk containers	-0.004	-0.01	0.08**
	Ln normalized CRC of glass milk containers	-0.002	-0.01	-0.03
	Ln normalized CRC of milk processing equipment	0.001	0.00	0.04*
	Ln normalized CRC of transportation equipment	-0.04**	0.03**	-
	In normalized CRC other equipments for handling milk	-0.01	-	-0.01
	Ln normalized wage	0.04	0.08	0.10
	Ln normalized total labour	0.04*	-	-
Determinants of inefficiency in profitability				
	Constant***	1.02***	1.95	0.86***
Other occupations	Farmer (0,1)	-	1.57	-
	Other business (0,1)	-	-0.71	-0.003
Business location (Base of comparison=rural)	Municipal (0,1)	-0.07*	-3.66*	-0.38**
	Peri-urban (0,1)	-0.06	-0.25	-0.58**
	Urban (0,1)	-0.05*	-0.25	0.16
GIS weighted distances from the procurement to sales area	Km of tarmac from source to sale area	0.001	0.00	-
	Km of murram from source to sale area	-0.01	-0.3**	-
	Km of earth from source to sale area	-0.01	-0.04	-
Other agent and business characteristics	Age of trader (yr)	0.001	-0.01	-0.01
	Gender of traders (1=male, 0=otherwise)	0.0002	-1.89	0.33
	Traders years of experience	-0.0005***	-0.001**	-
	Quantity of milk dealt with (litres/month)	-0.0007***	-0.001**	-
	Milk procurement contract (informal verbal) (0,1)	-	-0.56	-0.05
	Milk sales contract (informal verbal) (0,1)	-	-0.28	0.04
	Sigma-squared	0.008***	1.67***	0.04**
	Gamma	1.000**	0.98***	1.00***
Model size (observations)		125	48	35
Mean efficiency		48%	66%	56%
Number of iterations		54	41	28
Log-likelihood function		-126	-29	12

Conclusions

Generally, Tanzania has a much more complex and developed informal milk market. It is characterized by: a) a greater degree of market concentration than in Ghana (at least in the case of Dar es Salaam); b) more use of mechanized transport; c) longer distances for liquid milk delivery (although *wagashi* in Ghana is also transported over long distances); and d) greater use of contracts.

In both countries, a large proportion of milk is often not handled by intermediaries, but is sold directly from producer to consumer suggesting that in many cases market intermediaries are not needed. Transportation is also often either on foot or by bicycle, demonstrating sustainable low reliance on mechanization. Use of both plastic and metal containers is common in both countries. However, use of better quality metal containers is more common in Tanzania. There are clear opportunities to raise quality and food safety by increased use of metal containers.

While product differentiation is important in Ghana (due to a need to convert milk to a form with longer shelf life or to add value), liquid milk remains the most important product in both countries. In addition, although value addition through *wagashi* making helps generate higher profits, opportunities for this are limited by the demand for differentiated products. In Tanzania for example, where demand is currently almost all for liquid milk, shifts in demand to other products would be needed to create such opportunities.

Milk prices are not necessarily higher in and around urban demand areas. Relatively low producer prices in Accra compared to Kumasi demonstrates that local supply conditions partially influence prices, and that opportunities for producers and traders can occur even in hinterland areas. On average, however, more remote rural areas generally display lower prices at all levels of the market, reflecting supply/demand and transport costs in reaching demand centres.

Good profits are available to market agents from producer-sellers, traders and wholesalers, and retailers, most of whom are small scale. This demonstrates that informal milk markets could be a mechanism for rural and urban income generation.

There do not seem to be many instances of market agent 'exploitation' of farmers and/or consumers demonstrated by excessive profits. In a few cases, such as wholesalers in Ghana, profit margins per litre of over USD 0.10 suggest that there may be some undue market power. Greater participation by producers in the market would reduce that, as demonstrated by the Tanzanian examples.

Profitability is shown to be associated with higher investments in capital equipment including metal cans and transportation and processing equipment. Also, efficiency increases with scale of operation. Overall, these suggest favourable opportunities in more intensive enterprises can be achieved with investment in more intensive, sophisticated enterprises, pointing at opportunities for those agents who are particularly entrepreneurial. Among small-scale milk sellers, formation of milk marketing institutions such as groups may be one policy goal with the aim of improving efficiency in the system overall.

Training seemingly has no significant effect on efficiency. However, years of experience of traders, is shown to be very significantly associated with greater efficiency. This suggests that existing training, which is informal, does not impart the knowledge needed, but only comes with experience. This clearly points towards opportunities for improved training of market agents, which is likely to improve both efficiency and food safety.

3 Milk-borne public health risks

Context and issues

When this study was carried out, informal milk markets in both Ghana and Tanzania lacked policy support in terms of regulation.[3] There were also justifiable public health concerns regarding milk-borne diseases and hygiene in raw milk and traditional dairy products. Greater concerns are associated with milk from extensive production systems due to the higher risk of transmission of milk-borne zoonotic diseases. Informed policy making regarding informal milk markets cannot occur without quantitative information on these milk-borne public health hazards.

This part of the study quantified the main public health hazards and the magnitude of the risks associated with specific hazards in informal milk markets. The principles of the Hazard Analysis Critical Control Point (HACCP)[4] quality assurance system were used as a tool and guideline to identify critical control points (CCPs) associated with each hazard. CCPs are specific areas in the milk marketing chain where the identified hazards can be controlled or eliminated. Based on this analysis, recommendations are given on how the risks can be reduced or eliminated.

The approach taken to analyse milk-borne public health risks conformed to the model that became widely accepted for analysing food safety and setting standards in the early 1990s and was adopted by the Codex Alimentarius Commission in 1995 (FAO/WHO 1995). This participatory approach involves three stages: (1) risk assessment; (2) risk management; and (3) risk communication. Workshops were held before, during and after the studies to get inputs from stakeholders and begin the process of risk communication. Market agents and extension workers also received training in methods to reduce milk-borne public health risks.

Sampling

Information from participatory rural appraisals was used to select areas that key informants indicated had dairy marketing as an important activity within each site. Data were then collected from randomly selected traders in these areas using questionnaires during the wet and dry seasons. Sampling of market agents varied by location and by type. All bulking centres (large cooperative societies and assemblers and wholesalers) were sampled. Smaller-scale market agents, producer-sellers, vendors and retailers were identified through local informants and up to 30 traders were sampled at a selected area (or along a route in the case of Mwanza). For areas or routes with more than 30 milk traders, the selection was made to cover all major urban and retail sites in the area. Market agents were sampled in eight areas in greater Dar es Salaam (including Tanga and Morogoro), five in Mwanza, five in Accra and seven in Kumasi.

---

3. Tanzania has since enacted a Dairy Act and created a regulatory authority, the Tanzania Dairy Board.
4. 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 used 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.

During the dry and wet seasons of 1999 and 2000, a total of 1686 milk and dairy product samples (419 and 1267 from Ghana and Tanzania respectively) were collected from dairy producers, cooperatives, processors, wholesalers, mobile milk vendors and retailers (Table 7). The samples were analysed in the laboratory as described in Annex 1 for:

- adulteration with water

- microbial counts (total viable counts and coliforms)

- *Escherichia coli* O157:H7 (a coliform species)

- *Brucella* and *Mycobacterium bovis* (disease-causing micro-organisms that can be passed to humans via infected milk)

- antibiotic residues.

Table 7. *Number of milk and dairy products samples collected from various cadres of market agents*

	Ghana		Tanzania	
	Accra	**Kumasi**	**Dar es Salaam**	**Mwanza**
Dry season	97	133	397	163
Wet season	80	109	522	185

Findings

Adulteration with water

Adulteration of milk with water lowers its specific gravity towards that of water. Conversely, adding solids such as flour or sugar and removing butterfat increases the milk's specific gravity. Such interference may introduce chemical and microbial hazards into the milk, besides affecting its nutritional and processing quality, taste and market value. The specific gravity depends on the solids content of the milk; the respective values for specific gravity of fat, solids-not-fat (SNF) and water are 0.93, 1.6 and 1.0.

Incidents of adulteration of milk with water did not vary widely between seasons except in Mwanza. The proportion of adulterated milk samples also did not vary widely between Dar es Salaam, Kumasi and Accra where added water was detected in 13% to 20% of raw milk samples. Of the four towns, Mwanza was noted to have significantly higher proportions of adulterated milk samples, and this was highest (61%) in the dry season (Figure 14). However, there was no apparent difference in the proportion of adulterated milk samples between different types of milk market agents.

With respect to milk solids, the average values for butterfat, SNF and total solids were within normal ranges for bovine milk. However, the average butterfat content of milk samples from Ghana was relatively lower than that of samples from Tanzania. This may indicate removal of cream by traders because milk from zebu cows often has more butterfat than that from other bovine breeds.

22
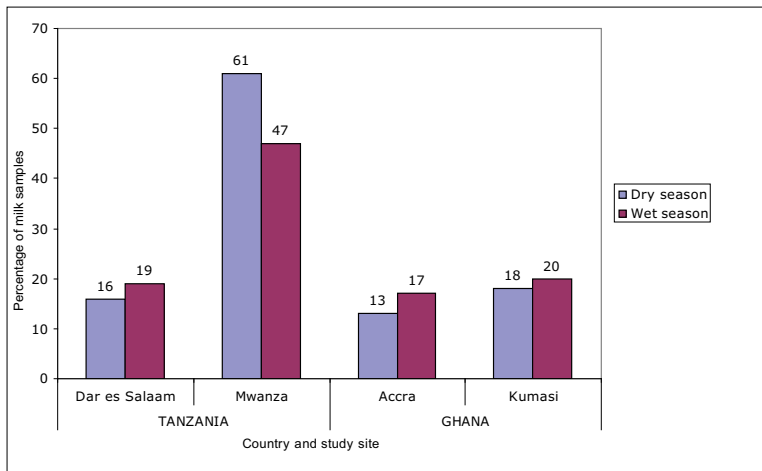
Figure 14. *Survey of adulteration of milk by addition of water.*

Counts of total bacteria and coliforms

Quality standards set by the Tanzania Bureau of Standards (http://www.tbstz.org/tbs_publication) were used to assess the microbial quality of raw milk samples since similar standards were not identified in Ghana. Tanzania had a higher proportion of samples of low microbial quality than Ghana did (Figures 15 and 16).

A significant finding was the high proportion of samples of ready-to-consume dairy products (*wagashi* cheese and boiled or fermented milk) that failed to meet the quality standards for coliform counts. In Ghana, this was notably high where all 85 samples of boiled chilled milk and all 28 samples of *wagashi* had coliform counts greater than 50,000 per ml of milk (Figure 17). Since coliforms are micro-organisms of faecal origin, this indicates poor hygiene during handling of milk resulting in contamination of processed milk products.
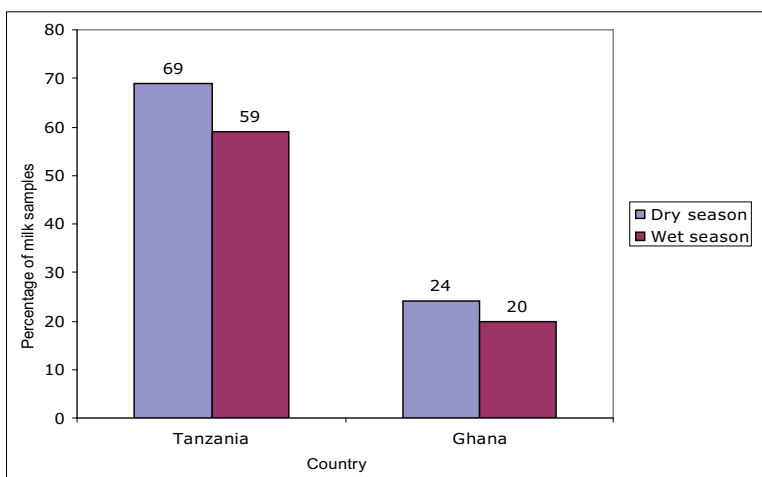
Figure 15. *Seasonal variation in proportion of raw milk samples with total viable counts above 2 million colony forming units (cfu) per ml.*

23
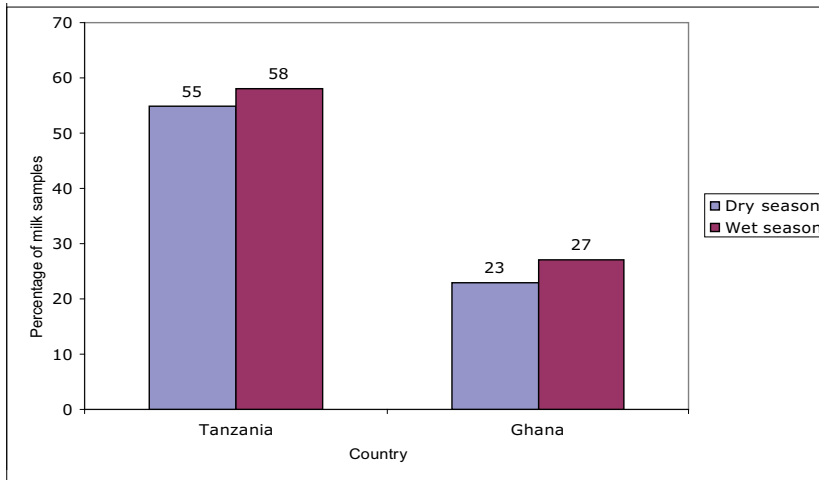
Figure 16. *Seasonal variation in proportion of raw milk samples with coliform counts above 50,000 colony forming units (cfu) per ml.*
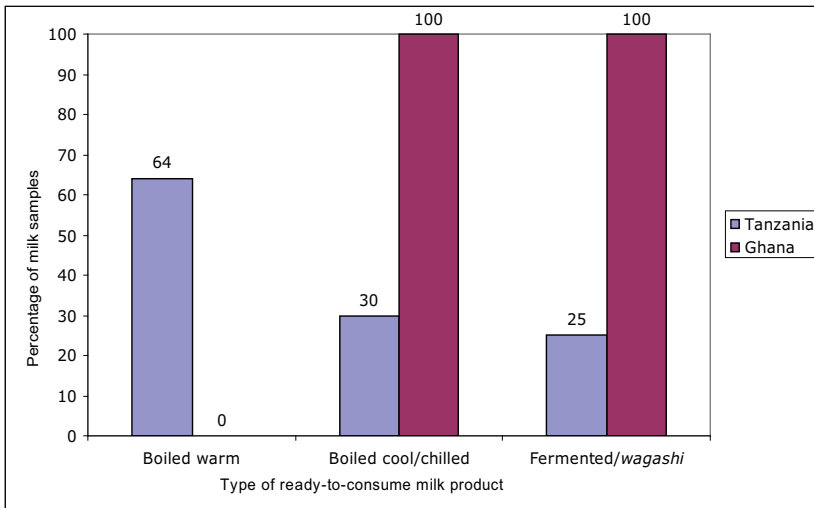
Figure 17. *Ready-to-consume milk samples with coliform counts above 50,000 colony forming units (cfu) per ml.*

Antibodies of *Brucella abortus*

B. abortus is a pathogen that causes brucellosis in animals and humans. The disease manifests as a type of flu-like fever in humans. *Brucella* is associated with raw milk hence the risk of brucellosis is a major reason for promoting heat treatment of milk before consumption. *Brucella* antibodies were isolated from 13% to 39% of samples in both countries and during both seasons (Figures 18 and 19). In Tanzania, a higher prevalence of *Brucella* antibodies was recorded in milk procured from farmers keeping extensively grazed zebu animals. In addition, samples from traders who bulked milk, such as cooperatives and wholesalers, had a higher prevalence of *Brucella* antibodies. However, in Ghana, there was no distinct pattern in prevalence of *Brucella* antibodies in milk sampled from various groups of traders.

24
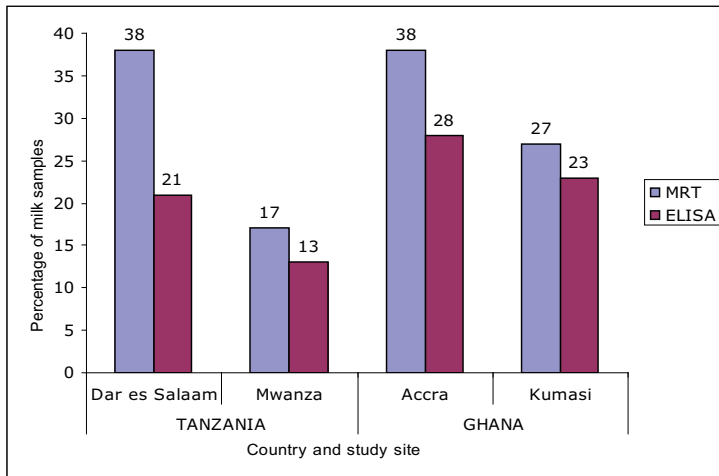
Note: MRT = milk ring test; ELISA = enzyme-linked immunosorbent assay.

Figure 18. *Proportion of raw milk samples testing positive for* Brucella *antibodies during the dry season.*
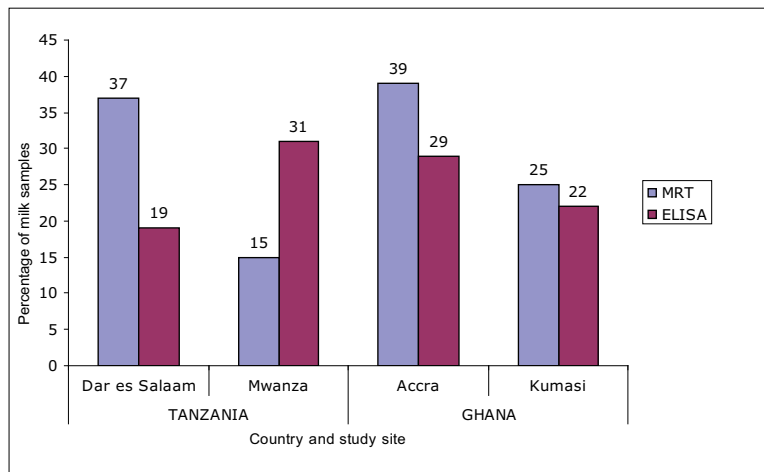
Note: MRT = milk ring test; ELISA = enzyme-linked immunosorbent assay.

Figure 19. *Proportion of raw milk samples testing positive for* Brucella *antibodies during the wet season.*

Escherichia 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 be contaminated with *E. coli* O157:H7 through contact with cow faeces or unhygienic handling.

In all four towns, *E. coli* O157:H7 was isolated from less than 1% of the samples that were tested for coliforms (Table 8). However, 20% of all the milk samples analysed for coliforms were positive for *E. coli*.

Table 8. *Number of milk samples tested for* E. coli *and the strain O157:H7*

	Dar es Salaam	**Mwanza**	**Accra**	**Kumasi**
Tested for coliforms	383	239	170	250
Positive for *E. coli*	69	43	51	50
Positive for *E. coli* O157:H7	2	1	1	2

Mycobacterium bovis

M. bovis is the milk-borne micro-organism that causes bovine tuberculosis. In Tanzania, 64 out of the 641 milk samples tested were positive for the genus *Mycobacterium* but none of these was positive for *M. bovis*. Likewise in Ghana, *M. bovis* was not isolated from the 40 milk samples that were analysed.

Antibiotic residues

Antibiotic residues are found in milk when farmers do not observe the specified milk withdrawal periods after treating dairy cows with antibiotics. When human beings are exposed to antibiotic residues over a long period, they risk developing bacterial resistance and allergies.

Between 33% and 42% of milk samples had antibiotic residues (Figure 20). Seasonal variation was low in all four towns. In Tanzania, 40% of raw milk samples from pastoralists contained antibiotic residues compared with 33% of samples from individual dairy farmers with crossbred cattle.
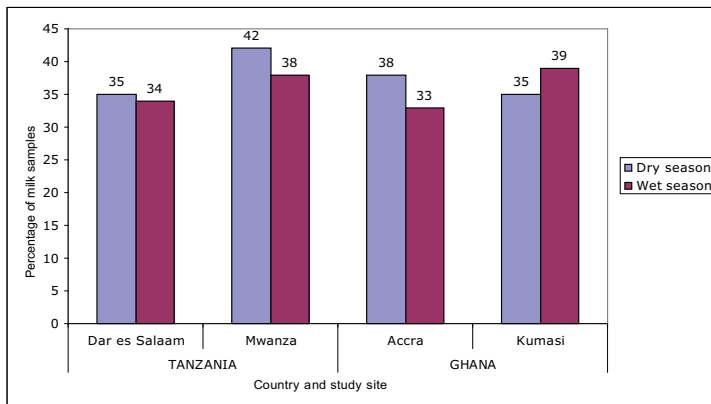
Figure 20. *Proportion of milk samples containing antibiotic residues.*

Identification of critical control points

CCPs are specific links in the milk market pathways where identified potential public health risks can be reduced or eliminated to protect the health of consumers. The CCPs can therefore be used as target points for interventions aimed at minimizing risks.

In Tanzania, the market agents involved in milk market pathways were farmer groups/cooperatives, producer-sellers, wholesalers, vendors and retailers. In Ghana, the milk market agents for these pathways were producer-sellers, processors, wholesalers and retailers.

Observed practices and factors that pose risks to public health

Adulteration

This practice was notably widespread in Mwanza despite random checks by municipal public health authorities and a requirement for vendors and retailers to use lactometers to check raw milk for adulteration. This suggests that it is not enough merely to enforce the ownership and use of lactometers, but rather there is need to advocate for effective quality improvements by associating profitable business practice with high milk quality. Failure to comply with quality regulations should result in strong punitive measures to discourage unfair business practices.

Use of plastic containers or sub-standard metal containers

Plastic milk containers were used by 83% and 99% of sampled market agents in Tanzania and Ghana respectively. Where aluminium cans were used, they were mostly poorly fabricated from scrap vehicle parts; they were therefore not up to standard. Plastic containers are difficult to sterilize and thus are often associated with low milk quality. These milk handling practices contributed to the observed general low microbiological quality of traded milk.

Low use of milk preservation methods

Three-quarters of sampled market agents in both countries did not take any measures to preserve milk before resale. Among those traders who preserved their milk, the most common methods were boiling (in Ghana) or refrigeration (in Tanzania). Preservation by either method slows down the rate of microbial growth in the milk and consequent spoilage by souring.

Low levels of training

In Tanzania, only 5% of the milk market agents interviewed had received any training in milk handling and quality control, and this was mostly for less than a month. None of the respondents in Ghana had received formal training in hygienic milk handling and processing. They mostly learned how to process milk from friends or older family members. These strikingly low levels of training can be linked to the observed high prevalence of public health hazards associated with poor milk hygiene.

Regression, multivariate and descriptive analyses identified CCPs associated with informal milk marketing pathways in the two countries. A summary of the CCPs associated with the major milk-borne public health hazards that were identified is given in Table 9. These CCPs indicate areas where interventions may be targeted to eliminate or reduce the identified hazards and thereby improve milk quality and assure consumer safety.

Table 9. *Milk-borne hazards and critical control points in informal milk markets in Ghana and Tanzania*

Hazard	Critical control point
Adulteration with water	Milk vendors in Mwanza and herdsmen in Ghana
Coliforms	Milk vendors in Mwanza and herdsmen in Ghana
Total bacteria	Herdsmen in Ghana
Antibiotic residues	Pastoralists (in Tanzania) and dairy farmers
Brucella antibodies	Milk vendors in Mwanza (especially in the dry season)

Conclusions and recommendations

Adulteration

The higher proportion of milk samples of low microbial quality in Tanzania were linked to location-specific milk handling practices, e.g. the numerous cases of milk adulteration in Mwanza. This suggests general poor hygiene or even the possibility that unscrupulous vendors adulterated their milk with contaminated water.

It would appear that the health regulations put in place by municipal authorities in Mwanza are not effective in minimizing the risks of milk-borne hazards. It is therefore recommended that a more effective approach be considered, such as training and public intervention with incentives to promote self-regulation. For longer-term training, community development centres may be ideal for institutionalizing simple training programmes. In addition, the use of hygienic metal containers that can be sterilized (as opposed to the commonly used plastic containers) has the potential to improve the microbial quality of raw milk.

Coliforms

The isolation of coliforms from boiled and fermented milk products suggests that these products were not being handled hygienically after processing, since coliforms are primarily organisms of faecal origin. This observation reinforces the need to train milk handlers and traders in personal hygiene and good manufacturing practices to avoid the potential public health risk of coliforms in processed products. This is especially so for fermented milk products and cheeses which are not normally re-heated before consumption.

Brucella

The average occurrence of *B. abortus* antibodies in raw milk in the four towns was 20%. This means that one in every five people who drinks milk that is not boiled in these areas risks being exposed to *B. abortus*. However, boiling milk before drinking it effectively destroys *Brucella*. This practice—already common among many milk consumers in Ghana and Tanzania—should therefore be reinforced through public education and media campaigns. In addition, market agents and consumers should be educated to ensure that milk products offered for direct consumption have been appropriately heated beforehand. This applies especially to milk intended for fermentation, since the acidity developed during fermentation is not in itself sufficient to inhibit milk-borne pathogens.

E. coli O157:H7

The low prevalence of *E. coli* O157:H7 in the milk samples from both countries implies that someone who drinks informally marketed milk daily risks being exposed to *E. coli* O157:H7 up to three days a year. However, the high prevalence of *E. coli* in milk samples reinforces the need to educate milk traders on the need to handle milk hygienically.

Mycobacterium bovis

The results show that there are no milk-borne risks of infection of bovine tuberculosis in the two countries. However, there is still the risk of infections (e.g. leprosy, pulmonary disease) caused by other species of *Mycobacterium* if infected milk is consumed without first being boiled or pasteurized.

Antibiotic residues

The high prevalence (up to 40%) of antibiotic residues from raw milk samples in both countries points to the general need to educate dairy farmers—and pastoralists in particular—on the need to strictly observe the specified milk withdrawal periods after antibiotic treatment of dairy cows. There is also need to create more awareness of this problem among policy makers so that they can begin to address it.

4   Processing of traditional dairy products

This section covers the analysis of processing of *wagashi*, a traditional fresh cheese, in Ghana. Data were collected through three complementary research activities: rapid appraisals, a structured survey and laboratory analysis.

Data collection

Rapid appraisal

The rapid appraisals were carried out from April to June 1999 in 12 sites in Kumasi and 7 sites in Accra. The aim of these appraisals was to:

- characterize dairy production and marketing systems

- identify the main constraints to marketing and processing of dairy products

- provide baseline information for the design and conduct of a formal marketing survey.

Non-standardized interviews, group discussions and field observations were carried out among key informants from the following groups of people: cattle owners, herdsmen, producers, market agents, processors and consumers.

Structured survey

A structured survey was carried out to complement the rapid appraisals and generate more information on production processes and constraints faced by traditional dairy processors, with particular focus on *wagashi* (soft cheese) processors. Data were collected using a questionnaire administered to 33 *wagashi* processors in 5 locations in peri-urban Kumasi.

Laboratory analysis

Laboratory analysis was carried out to determine practical ways of improving the traditional processing of *wagashi* by optimizing the level of coagulant and increasing the yield and shelf life of the product.

Wagashi is a soft brined cheese that is mainly processed by women who are often the wives of cattle herdsmen. For this reason they often do not require a cash outlay to acquire milk for processing. The larger processors tend to operate as commercial businesses and purchase larger quantities of milk for which they are able to negotiate a favourable price. The traditional method of *wagashi* processing is shown in Figure 21.

Sap extracted from the Sodom apple (*Calotropis procera*) plant is commonly used to coagulate the milk during processing of the cheese. The whey is drained from the curds in perforated calabashes, but this process tends to be inefficient and often results in loss of product.

Experiments were carried out to investigate to what extent product yields may be increased by draining whey in calabashes lined with cheese cloth. Tests were also carried out to investigate ways

to improve the shelf life of the product through brining. Consumer acceptance tests were carried out among 102 panellists to establish the optimal level of brine that effectively preserves the cheese without adversely affecting its taste.

Results from the process optimization experiments were then used to train 51 *wagashi* processors on how to improve the efficiency of production by correct use of coagulant, draining whey with lined calabashes and preserving the cheese in brine solution. The processors were also taught how to carry out their operations using hygienic practices. A follow-up study was done six months after the training to assess the rate of adoption of improved practices during *wagashi* processing.
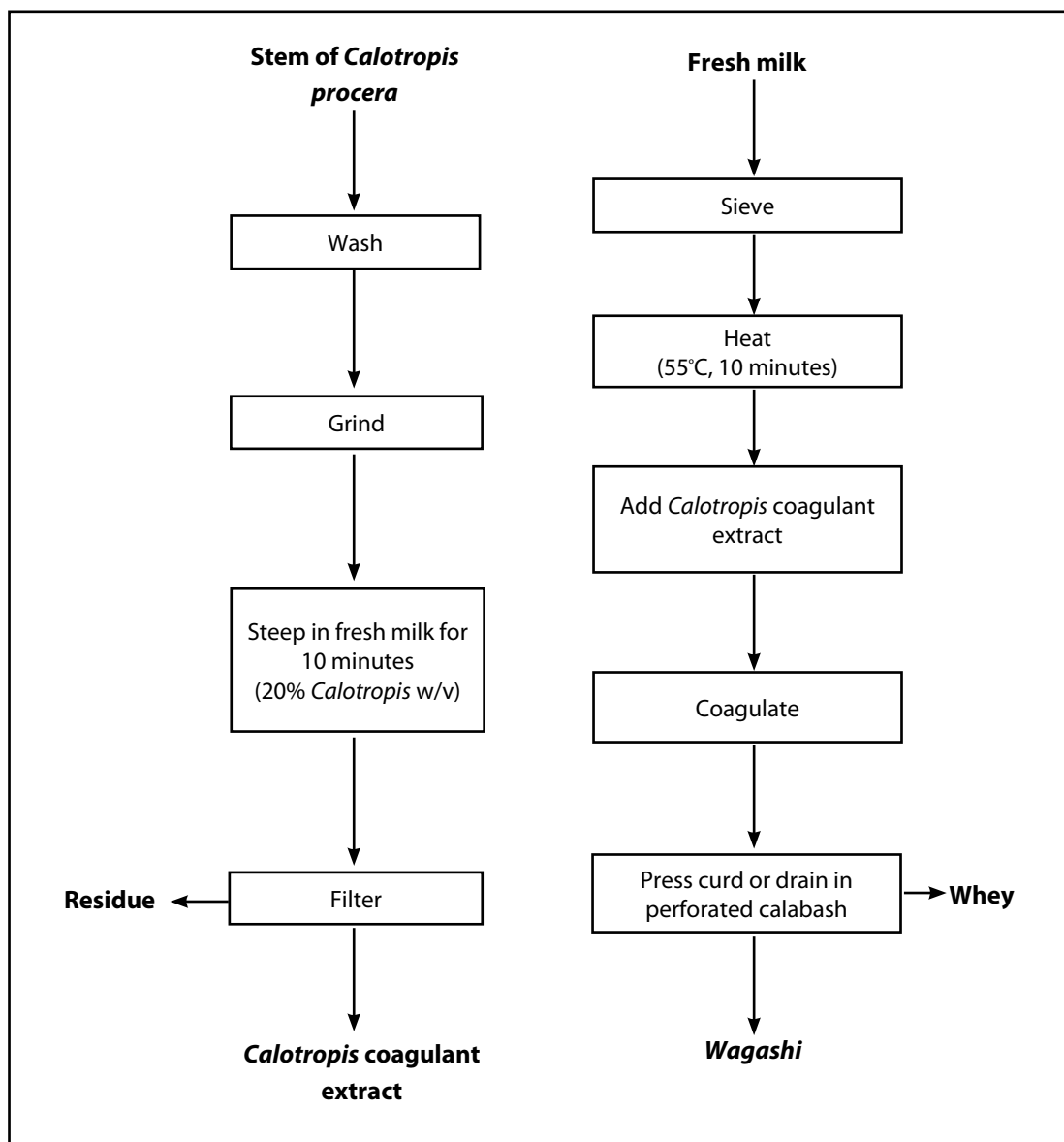
Figure 21. *Flow diagram of traditional method of* wagashi *processing and preparation of* Calotropis *coagulant.*

Findings

Rapid appraisal

The appraisal revealed the following:

- Most herdsmen preferred to sell fresh milk direct to consumers or market agents at the kraal.

- Kraal sales did not require any investment in marketing (transport, containers etc.).

- Farm gate milk prices were relatively high (USD 0.3/litre compared with USD 0.2 in East Africa).

- During periods of oversupply milk was converted to *wagashi*.

- *Wagashi* was marketed exclusively by women.

Wagashi was traded both nationally and internationally, though most consumers are located in northern Ghana, in Kumasi and in Accra. In some cases, *wagashi* was transported from Accra to neighbouring Togo.

- There were no formal contractual arrangements between suppliers, market agents or consumers of dairy products.

The main constraints facing the market agents were also identified:

- The short shelf life of fresh milk and *wagashi*.

- Some transport owners refused to carry *wagashi* due to its odour and because it is a wet product.

- Poor access to capital and credit by *wagashi* processors and high costs of production.

- The seasonal nature of *wagashi* processing.

- The quality of *wagashi* was not consistent.

Structured survey results

Nearly half (48%) of the *wagashi* processors interviewed had small-scale businesses, handling on average less than 15 litres of milk per day. Most had no formal training in milk processing and had learnt the skills of the trade from family members.

None of the processors reported using lactometers to test for adulteration of milk by addition of water; many merely used visual inspection of the milk and a few reported using the clot-on-boiling test to check for developed acidity in the raw milk. However, most of the processors interviewed said they normally strive to process the milk within one to four hours of purchase.

Most of the processors surveyed (87%) used firewood as their fuel source for boiling/heating the milk. The only other fuel used is charcoal. No processors had dedicated premises and used their kitchens or processed the cheese outside over an open fire, depending on weather conditions.

All the surveyed processors used the locally available *C. procera* as a coagulant for *wagashi* production. The older leaves were preferred to young leaves or bark as the best source of active ingredient. The actual quantity of coagulant used per litre of milk varied enormously between processors. The optimum amount was not known and was therefore considered worthy of further laboratory investigation.

Some processors used certain additives for both aesthetic reasons and to improve preservation/ shelf life. A red dye extracted from the sorghum sheath is used to colour the cheese once the curds have formed. The sorghum sheath is boiled with the cheese. Some processors believe that the sorghum sheath has both aesthetic and preservative qualities.

Salt was used as an additive by 45% of processors. In most cases the salt was added during the production of curds (during coagulation of the milk) to assist in separation of whey and impart a distinct taste to the product.

Only 4 out of 30 processors reported pressing curds, adding weights to the curds to expel moisture (excess whey). Most processors simply allow the curds to drain under their own weight in calabash moulds. Pressing is limited to 4 hours only, to ensure that the cheese retains the desired characteristics which the market demands (i.e. soft cheese).

Less than 10% of the processors reported regular failure of their milk to coagulate. Most failures are preventable as they are associated with over heating (boiling over) of the milk. This information suggests that there is little adulteration of milk, processors are skilled in *wagashi* production, milk is usually processed within the optimum period following purchase and that the coagulant has effective rennet properties.

The most common means of extending the shelf life of *wagashi* was boiling the cheese (in water) daily until sold. This method was used by 60% of the processors. The addition of salt was used by about 20% of the sample interviewed, but in very small quantities, usually during the processing procedure. Only 1 out of 30 processors had access to refrigeration. One processor reported using (unidentified) herbs as a preservative while two processors reported using drying as a preservation technique. Cheese is sun-dried or fried to expel moisture and extend shelf life. Visits to Kumasi market confirmed that one of the most popular products purchased by consumers is fried cheese. Frying produces a drier, harder product that is consumed as a snack or added to cooked dishes as an alternative to meat. Dyeing also takes place at the final point of sale (before frying).

Sixty-six per cent of processors stored their cheese before sale in covered (with a cloth or plastic) aluminium bowls or basins. Plastic bags were used in a small number of cases, mostly as a means of storage rather than as packaging. These methods of storage were used to minimize contamination and for their convenience. The containers and packages used are all locally available.

Discussions with processors established that their major constraints were associated with:

- shortages of milk during the dry season
- the time required for and cost (firewood and labour) of preservation (daily boiling)
- low prices and poor returns (profits).

Poor demand was not reported as a constraint, suggesting that there is a market for most of the cheese that is produced. Some processors pointed out that more could be sold during the dry season if more milk were available at this time. Some processors reported that they prefer to market fresh milk, as the returns are higher. Processing is therefore used as a method of preserving excess milk by these households rather than as a means of adding value. The processor who purchases milk daily is, however, a specialist cheese-maker providing cheese for the peri-urban consumer in both Kumasi and Accra.

The survey confirmed the need to optimize the procedure for processing of *wagashi*, in particular the amount of coagulant required. Another issue that arose was the importance of devising methods for improving shelf life and reducing spoilage to improve the quality of the product that processors and wholesalers deliver to the market and to ensure the delivery of a safe, fresh product for consumers.

Laboratory analysis

Following are the key findings of the laboratory experiments carried out to investigate ways of improving *wagashi* processing:

- The stem extract from *C. procera* was a better coagulant than leaf extract and gave a higher yield of cheese. The optimum quantity of stem was found to be 25 g/litre of milk.
- The traditional method of separating the curds from whey by pressing in perforated calabashes was significantly improved by lining the calabashes with muslin cheesecloth before pressing. An increase in cheese yields of up to 4% was noted with the use of cheesecloth while draining the whey.
- Dipping *wagashi* in a 10–15% brine solution for 12 hours resulted in a significant increase in the shelf life of the product. While daily boiling of the cheese preserved it for only 3 days, daily brining increased the storage life at ambient temperature to 14 days. Brining also retained the product's colour, odour and appearance and did not affect consumer acceptance of the product in terms of texture.

Conclusions and recommendations

Wagashi is produced mainly to preserve excess raw milk. However, the product is an important source of animal protein for poor urban families in the Kumasi and Accra metropolitan areas. *Wagashi* processing businesses are generally small operations with a limited turnover and with a limited amount of capital invested in production. Using simple innovations such as draining whey in lined calabashes and preserving the cheese in brine can reduce the costs of production and increase yields while producing a safer longer-lasting product. Processors should be trained and encouraged to adopt these simple yet effective processing improvements.

5 Testing the impact of training of informal sector traders in hygienic milk handling and quality control

Training in Tanzania
Training methodology

This section reports the results of indicative sampling and testimonies from trained market agents in Tanzania.[5] The follow-up survey of 22 trained market agents in Dar es Salaam and 17 in Mwanza was to assess the initial impact of the risk information communicated during the training and through meetings and leaflets produced during the course of the project. In November 2001, trainees were exposed to various skills including marketing, handling and processing of milk, and business management. Focus was on specific areas identified during the surveys as needing attention. Results obtained between 5 and 12 March 2002 are presented below. These results highlight practice changes and narrations of typical personal experiences of market agents related to milk hygiene.

Results
Practice changes

Nearly all the market agents interviewed in the indicative survey said that they had achieved significant improvements in their business performance in various areas including processing, milk handling/quality control and customer care. A subjective assessment ranked personal, equipment and premises hygiene of all trainees as being 'fair' or 'good'. In addition, a few traders had replaced their plastic containers with metal ones that are easier to clean and nearly all traders who previously did not have lactometers had bought them. Whereas only 6% of the milk traders were found to keep records during the main market surveys, virtually all of the trained traders kept records in the follow-up survey. Most kept records related to expenditure, but also sales, volumes handled and salaries.

Milk quality indicators

The high variability in milk quality indicators, particularly bacterial counts, did not allow for meaningful comparisons between the findings in the main survey and indicative sampling considering the small number of respondents in the indicative sampling. However, it was observed that in reaction to findings from the main survey that indicated a high prevalence of adulteration in Mwanza, municipal health officials became stricter in enforcing tests for adulteration. In one instance, the project team observed the officials ordering an offender to pour out adulterated milk. However, addition of water still occurred after traders passed checkpoints mounted by health officials. This practice was more common among employed traders.

Business plans

Only one in every six trainees had drawn up a business plan at the time of this survey. The specific reasons for this apparent lack of interest were not clear but could be attributed to perceptions that they could manage without preparing business plans. More information is required on the

---

5. Similar reports from Ghana were unavailable at the time of writing this report.

usefulness of drawing up such plans. Semi-literacy and the cost of engaging a skilled expert may also play a role in the traders' reluctance to prepare these plans.

Plans for the future

Most trainees expressed a desire to venture into more dairy-related business activities particularly processing of fermented milk, yoghurt and boiling of milk to lengthen shelf life.

Conclusions

The Tanzanian project leaders expect the traders to adopt more of the disseminated skills as they access the required capital to acquire necessary inputs, e.g. metal containers and inputs for processing. Punitive measures (e.g. being forced to pour out adulterated milk) do not seem to be adequate deterrents to adulteration. Alternative mechanisms to reduce the practice, such as self-regulation and quality seals, may be a better solution. Narrations of personal experiences provide some insights into personal benefits received by the market agent clients (see Annex 2).

6   Contribution of outputs

This study was undertaken to identify and quantify the problems in the milk markets in Ghana and Tanzania, and to develop recommendations for improving the performance of these markets. These outputs were achieved. They are aimed at improving the welfare of small-scale market agents and farmers as well as resource-poor consumers who are the main buyers of these indigenous products. The major factors enabling these outputs to contribute to the project goals are:

- the strong links developed for dissemination of training materials and information

- the important links established with policy makers in both countries

- links between project partners and long-term multilateral dairy development efforts, particularly the Food and Agriculture Organization of the United Nations (FAO), and with other non-project countries.

The three major sets of outputs are therefore:

1. Training and extension materials.
2. Policy influence/impact in the project countries.
3. Impact on the development agenda of multilateral dairy development efforts in other developing countries.

The extension materials have been widely disseminated nationally and have been the basis for several new initiatives and links. In Ghana, the findings were taken up by a new FAO project entitled 'The Training Programme for the Small-scale Dairy Sector' and related livestock sector development efforts being funded by the African Development Bank. In Tanzania, close links initiated at the beginning of the project with Austroproject, a local dairy development non-governmental organization, and the national Dairy Task Force (of which the Tanzania Project Coordinator is a member) continue to ensure direct use of the project findings. Internationally and regionally, the training materials developed are being promoted in various ways by FAO and the Eastern and Central Africa Programme on Agricultural Policy Analysis (ECAPAPA), a programme of ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa) and formed the basis for a generic training manual being developed for eastern Africa.

Market-oriented smallholder dairying in developing economies has higher returns than many traditional agricultural activities and thus offers important income opportunities for resource-poor producer households and for the rural and urban poor through their participation in processing and marketing. This research provides one of the first sets of evidence that systematically address the economic and milk-borne public health issues in Africa. It has documented that important livelihoods continue to be created in such markets, thus providing comprehensive evidence for greater policy attention to the markets. The policy recommendations are aimed at bridging the gap between the regulated and unregulated dairy markets, and reducing public health risks through targeted training of market agents coupled with licensing where appropriate.

Further studies needed

Economies of scale in marketing

The efficiency results from both Ghana and Tanzania showed clearly that efficiency declined with larger volumes of milk handled by market agents, suggesting dis-economies of scale in milk marketing. This suggests that small-scale agents are competitive and may not be threatened by increased industrialization or growth in milk markets for some time. However, this also creates a barrier to development, in that small-scale agents will be constrained from scaling up and developing their businesses. Further research is needed to better understand the reasons for these apparent scale barriers.

Technologies to improve milk quality

The project found significant problems with bacterial growth in many different market channels, even where appropriate containers were being used. This is simply because refrigeration/cooling is not economical or practical in most cases. Although this may not pose a health threat because consumers boil/heat products before consumption, it nevertheless is a main cause of spoilage and losses. There is need therefore to identify alternative practical and affordable technologies to reduce bacterial growth, such as the Lactoperoxidase Milk Preservation System (LPS), and to promote such technologies in areas where they can make a difference. Although LPS has been tested and proven technically, the economics remain uncertain as does the viability of the institutional and organizational arrangements needed to use it in a sustainable manner among small-scale farmers. Some research along these lines has already been conducted by ILRI and partners in Kenya. The results indicate potential viability of the technology in some settings (see SDP Brief No 8 at www.smallhoderdairy.org)

De-brining of *wagashi*

A primary constraint to the use of brining to extend the shelf life of *wagashi* was consumer acceptability of the resulting product. Further research is required to examine the potential for de-brining to make this brined product more acceptable to consumers while maintaining good preservation characteristics.

Understanding informal/traditional milk markets elsewhere

At a general level, the project was one of the first anywhere to closely examine the functioning of informal/traditional milk markets in developing countries. These markets remain by far the largest sector of the dairy industries in developing countries not just in sub-Saharan Africa, but also in South Asia and in Latin America. A great deal more research is needed to understand these markets in all their diversity, and to understand how the formal–informal gap can be bridged to retain small-scale agent participation while at the same time improving product quality and safety. This project has provided a sound starting point to addressing these issues, but further research is needed to look at similar markets in other countries. One indirect project outcome is a new project in India, using the same methods.

Through its Market-Oriented Smallholder Dairy Project and its Livestock Policy Analysis Programme, both of which contributed to this project, ILRI will build on the project outcomes to develop similar research in other countries. Having already completed similar studies in Kenya, research is being developed for South Asia, and potentially for sites in Central America. The aim is to provide a strategic overview of issues and potential solutions for the huge indigenous dairy markets that dominate the dairy sectors in developing countries, which to date have not been systematically studied. The frequent failure of dairy development efforts that assume a Western, pasteurized milk model is one consequence of this lack of strategic knowledge.

References

Bain, S.J. 1968. *Industrial Organization*. 2nd Edition. John Wiley and Sons Inc., New York, USA.

FAO (Food and Agriculture Organization of the United Nations)/WHO (World Health Organization). 1995. *Application of risk analysis to food standards issues.* Report of the Joint FAO/WHO Expert Consultation, WHO/FNU/FOS/95.3. Geneva, Switzerland.

FAO (Food and Agriculture Organization of the United Nations). 2007. FAOSTAT data. Available at: http://faostat.fao.org/.

Tanzania Bureau of Standards. Microbial standards for raw milk. Available at: http://www.tbstz.org/tbs_publication/.

USDA (United States Department of Agriculture). 1997. *Guidebook for the preparation of HACCP plans*. Food Safety Inspection Service. Washington, DC, USA.

World Bank 2005. Development Data & Statistics for 2002. Available at: http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS. Accessed December 2008.

Annex 1. Flow diagram summarizing laboratory analysis

Milk sample

250 ml (non-sterile sample)

50 ml (sterile sample)

1. Specific gravity
2. Peroxidase test
3. Butterfat determination

1 ml: *Brucella* MRT

1 ml: serial dilution
$10^{-1} – 10^{-8}$

REST OF SAMPLE FROZEN
FOR FURTHER TESTS (see text)
1. Brucella ELISA (Nielsen Techn.)
2. Drug residues (Charm AIM
   and ROSA text)

Sketch of test procedures

Specific gravity. Half fill 250 ml cylinder with milk at ~20°C. Insert lactometer, add milk to brim, read specific gravity and temperature.
Peroxidase milk boiling test. Make 2% p-phenylene-diamine and 1% H2O2, add 2 drops of each into 10 ml milk in a test tube. Shake. Observe colour. Result: blue (milk not boiled = negative); clear (milk boiled = positive).

Butterfat. Pipette 10 ml H2O2 into butryometer, then 11 ml milk and 1 ml amyl alcohol. Stopper, shake then centrifuge at 1200 rpm for 5 min before reading BF content.

Brucella milk *ring test.* Mix 1 ml milk sample and a drop of Brucella antigen in miniature test tube. Shake tube and incubate for 1 h at 37°C. Blue ring = positive (treat positive control similarly).

Add one drop of Brucella antigen to sample and mix

Incubate 1 h, 37°C

Blue ring = positive for Brucella

10^{-1} to 10^{-4} onto violet red bile agar

Incubate 24 h, 37°C

Coliform counts

6 colonies onto MacConkey agar, incubate 24 h, 37°C

Pick 6 pink colonies (lactose fermenters: *E. coli*, *Klesiella* etc.)

Tryptone soy agar slants for storage, 6 slants per sample; 24 h, 37°C

Characterisation; isolation of *E. coli* 0157:H7

$10^{-4} – 10^{-8}$ onto plate count agar

Incubate 48 h, 30°C

Total plate counts

Counts of total bacteria and coliforms

1. *Diluent preparation.* Prepare microbiologically suitable phosphated water (e.g. 0.2 M KH2PO4—dissolve 34 g of KH2PO4 in 1 litre of distilled water. Adjust pH to 7.2 with NaOH. To make stock solution, add 1.25 ml in a flask and make up to 1 litre, adjust pH to 7.2). Could also use peptone water.

2. Pipette 9 ml in culture tubes and autoclave at 121°C, 15 minutes. Add 1 ml sample into 9 ml diluent to get 10^{-1} dilution. Add 1 ml of 10^{-1} dilution into 9 ml diluent to get 10-2 dilution, and so on till 10^{-8}.

3. Pipette 1 ml of respective dilutions onto Petri dishes and add 15–20 ml molten sterile medium. Swirl plates to mix. Incubate inverted plates when media solidifies.

41

Annex 2. Narrations of personal experiences in Tanzania

Small-scale milk processor in Dar es Salaam

Mrs Bupe Muikambo, commonly called 'Mama Muikambo' because of the respect she has earned among her peers, is a small-scale milk processor selling about 30 litres of milk a day. She is also the chairperson of a self-help group comprising 12 women who engage in similar business. Asked how she had benefited from the Milk Marketing and Public Health project, Mama Muikambo replied, 'I have learnt many things including the need to maintain high standards of hygiene given that milk is a very perishable commodity. I have also understood why maintaining a high level of cleanliness reduces spoilage and wastage. Before the training, I never knew that heating milk to a specific temperature and cooling it quickly gives it the desired final quality. My customers prefer the milk that I sell now compared with previously.'

Mama Muikambo particularly likes two milk quality control tests that she learnt: use of a lactometer and the alcohol test. 'I would like it to be known that I was not the only one who was ignorant about these tests,' she said, adding that: 'Before training, I did not know that cows may have diseases that can be passed to human beings if the milk is not heat treated.' She was also able to cite nearly all the micronutrients in milk and their usefulness.

When asked about her future needs and plans, Mama Muikambo replied, 'I would like to know where I could receive more training for myself and those I work with. I also wish I could access more capital and various techniques to enable me compete more effectively in the liberalized dairy market.'

Milk vendor in Mwanza

John Maguta sells about 20 litres of milk per day in Mwanza. When John was asked about his experiences following training, he said: 'I am one of those lucky few who got an opportunity to be trained by the project at Sokoine University of Agriculture in Morogoro in November 2001. When the researchers first came to Mwanza in 2000, we were afraid that they would stop us from doing our business of selling milk. But after some time we realized they were on a mission to help us improve they way we handle the milk. This is important for us because sometimes we get losses when the milk gets spoilt.'

When asked to talk about any changes made after training, John said, 'From the knowledge gained, I can now be more emphatic when advising farmers who supply me with milk about the need to milk hygienically, including the need to wash the udder with warm water and to disinfect the teats in order to prevent mastitis. I have also changed the containers I use for transporting milk from plastic to aluminium cans. I am now able to distinguish poor quality milk using a lactometer and the alcohol test. And I am now selling more milk since my customers are more satisfied with the quality and I get less spoilage. I also now make safe sour milk.'

Producer-seller in Mwanza

Ms Mary Sumbya sells about 5 litres of raw milk daily. She narrated changes in her practices after being trained as:

- the need for a good environment for my cows

- hygienic milking

- hygienic storage and how I could improve milk sales.

'Since attending the training I have strived to improve the cow shed by putting up a better roof and drainage for the effluents. My milker is now provided with gumboots and an overcoat, and detergents for cleaning milk vessels. I have also instructed the milker on proper milking procedure.'

'My cows used to suffer a lot from mastitis but I now use a teat dip and the disease has reduced significantly. I now use aluminium cans and any milk not sold immediately is kept in a refrigerator.'

'I no longer receive complaints from my customers regarding spoilage of milk when it is heated. I used to sell only raw milk. After the training I am now selling part of my milk after fermenting it properly.'

Annex 3. Acronyms

ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CCP	Critical control point
CFU	Colony forming units
ECAPAPA	Eastern and Central Africa Programme on Agricultural Policy Analysis
DFID-LPP	Department for International Development-Livestock Production Programme (UK)
ELISA	Enzyme-linked immunosorbent assay
FAO	Food and Agriculture Organization of the United Nations
HACCP	Hazard Analysis Critical Control Point
LME	Liquid milk equivalent
LPS	Lactoperoxidase Milk Preservation System
MRT	Milk ring text
SCP	Structure, conduct and performance framework
SNF	Solids-not-fat