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Milk and dairy products, post-harvest losses and food safety in sub-Saharan Africa and the Near East

TYPES, LEVELS AND CAUSES OF POST-HARVEST MILK AND DAIRY LOSSES IN SUB-SAHARAN AFRICA AND THE NEAR EAST

Phase Two Synthesis Report

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TABLE OF CONTENTS

Page

List of tables

List of acronyms

CBO	Community-based organization
DDA	Dairy Development Authority
ECAPAPA	Eastern and Central Africa Programme for Agricultural Policy Analysis
FAO	Food and Agriculture Organization of the United Nations
GAP	Good Agricultural Practice
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis Critical Control Point
ILCA	International Livestock Centre for Africa
ILRI	International Livestock Research Institute
KARI	Kenya Agricultural Research Institute
KDB	Kenya Dairy Board
KEMRI	Kenya Medical Research Institute
MoA	Ministry of Agriculture
LITI	Livestock Training Institute
LOL	Land O'Lakes
LPS	Lactoperoxidase system
MATI	Ministry of Agriculture Training Institute
NAADS	National Agricultural Advisory Services
NARO	National Agricultural Research Organization
NGO	Non-governmental organization
SDP	Smallholder Dairy (Research and Development) Project
UoN	University of Nairobi

Summary

The following is a synthesis report highlighting the results of rapid appraisals aimed at characterizing post-harvest milk and dairy losses in Ethiopia, Kenya, Syria, Tanzania and Uganda. In Kenya, Uganda and Tanzania, the rapid appraisals were undertaken during the dry month of July 2003, when milk yields were relatively low in the region[1]. Post-harvest milk losses have been quantified both in terms of quantity and monetary value lost. Specific links in the milk chain where significant losses are experienced, and those losses that have pragmatic solutions have been identified and targeted for appropriate interventions aimed at reducing or eliminating the losses.

Key findings showed that most post-harvest milk losses are experienced in the small-scale informal dairy sector; formal milk processors generally incur minimal losses. In terms of quantity, significant milk losses occur at the farm level (8.4, 28.6, 46.4 and 54.2 million litres of milk per year for Uganda, Ethiopia, Tanzania and Kenya, respectively) valued at approximately 0.9–11 million US dollars. Post-harvest losses of milk at the farm represented 1.3 to 6.4 percent of the value of available milk at the farm level. Poor road infrastructure and inadequate markets for raw milk are the main causes of farm-level losses, which are largely in form of spoilage, spillage, and "forced home consumption" (including by calves and humans) over and above normal household consumption. Although in quantity terms forced losses may seem to be high, in value terms they are less significant, because an estimated 70% of the value of the milk is still captured. Along the marketing chain, milk loss is mainly due to spillage and spoilage. These losses are occasioned by poor access to markets, poor milk handling practices as well as irregular power supply in milk processing plants. Based on the dry season rapid appraisal data, the total value of post-harvest milk losses per year amounted 9.9, 14.2, 17.8 and 23.9 million US dollars for Tanzania, Ethiopia, Kenya and Uganda, respectively.

[1] Similar information was not made available from Syria and Ethiopia.

Recommendations for interventions aimed at reducing milk losses have been targeted at the farm level and small-scale milk transporters. These are the two points in the chain where losses in value were found to be most significant. Four general areas of intervention are discussed: training, technology, policy/legislation and information.

This report represents the first systematic attempt to accurately quantify post-harvest milk losses in the countries studied. However, because of the small sample sizes, limited geographical coverage and the fact that the rapid appraisals were undertaken during the dry season only, the results obtained must be interpreted with caution, bearing in mind the limited scope of the study. Additionally, some of the data provided was not up to the standard required to make a complete valuation. Further comprehensive studies covering a wider scope are needed as a follow-up to the rapid appraisals in order to generate additional data on the levels of post-harvest milk and dairy losses at the national level and across seasons. Nevertheless, the information generated provides a useful basis for implementing the recommended interventions.

1. Introduction

Post-harvest losses of milk and dairy products are significant not only because of the resultant reduction in product availability but also due to the foregone income that would otherwise have accrued from sale of the lost product. When viewed at the wider national level, these losses have far-reaching economic implications.

In many countries of sub-Saharan Africa, significant post-harvest milk losses are incurred along the supply chain, largely due to lack of adequate markets and spoilage. The levels of these losses have not been accurately quantified and the few estimates available are not based on empirical evidence. An accurate assessment of the level of post-harvest milk and dairy product losses is necessary for identifying specific links in the milk chain where significant losses occur. This in turn will facilitate targeting of pragmatic solutions to the problem and justifying interventions aimed at reducing or eliminating these losses.

In 2003, the Food and Agriculture Organization of the United Nations (FAO) commissioned national studies in Ethiopia, Kenya, Syria, Tanzania and Uganda aimed at providing a clear assessment of the types, causes and levels of post-harvest milk and dairy losses in those countries. Five national consultants submitted comprehensive reports on the dairy sub-sectors of their respective countries. These reports were subsequently synthesized into a preliminary (Phase I) report.

Generally, the national studies were unable to identify reliable existing data on the level of milk market losses. This indicated a need for more accurate assessment of the causes and levels of post-harvest dairy losses at key stages of the milk distribution chain. The Phase I report came up with the following recommendations:

- Use of common approaches to facilitate cross-country comparisons.
- Quantification of post-harvest losses both in terms of quantity and value of milk lost.
- Prioritization among loss types based on the value of loss and applicability of pragmatic solutions.
- Linking of identified causes of loss to realistic solutions with clearly specified roles for stakeholders, particularly for those losses associated with inefficient quality control systems and poor transport and cooling infrastructure.
- Identification of appropriate intervention strategies for information, policy, technology and training at target loss areas.

Against this backdrop, a second phase of national assessments were undertaken in form of rapid appraisals aimed at more accurately quantifying the levels of post-harvest milk loss. An integrated milk chain approach—from producer to retailer—was used to characterize the dairy systems found in milk sheds around specific consumption centres and quantify the milk losses experienced at the main levels of the supply chain. Specific focus was on the value of post-harvest milk losses within the production, processing and marketing sub-systems. The national rapid appraisals constituted the basis for this synthesis report.

2. Methodology

2.1. Rapid appraisal

Data on milk losses along the milk chain from producer to retailer[2] were collected with the aid of a structured questionnaire and checklist. At least three representative producer-sellers and market agents of each type in each part of the major milk market channels were interviewed. In Kenya, Uganda and Tanzania the rapid appraisals were carried out during the dry season period of July 2003. The rapid appraisal reports from Ethiopia and Syria did not indicate in which season the respective studies were carried out.

The Kenya rapid appraisal was carried out in six districts (Kiambu, Nakuru, Nandi, Nyandarua, Thika and Vihiga) representing the diversity of Kenya's milk production and processing potential. The Tanzania survey covered the Coast, Dar es Salaam and Morogoro milk shed areas where small-scale improved dairy cattle smallholder farmers and traditional pastoralists dominate. In Uganda, the Kampala milk shed was taken as the focus of the study, being the main market for milk and dairy products in that country. In Ethiopia, the major milk shed areas in six regions of the country (Addis Ababa, Amhara, Oromiya, Tigray, SNNP and Afar) were studied. These regions represent the diversity in Ethiopia's dairy production and marketing. The Syria study was carried out in three representative regions—Aleppo, Hama and Homs.

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[2] Losses at consumer level were not quantified.

Secondary data on national milk production, processing and marketing were used to extrapolate the rapid appraisal data on milk losses to the national level. The sources of the secondary data were Dairy Development Authority (Uganda), Smallholder Dairy Project (Kenya), the Ministry of Agriculture and Food Security (Tanzania) and the National Agricultural Sample Census on national milk production for 2001/2002 (Ethiopia).

2.2. Quantification of post-harvest milk losses

The rapid appraisal gave rise to figures on the percentage losses at the main levels of the milk chain; these are primarily dry season figures. Using secondary data on annual milk production and milk flows from producer to consumer, the proportions of milk available at the major levels of the milk chain were established. The data on percentage losses and quantities of milk available at each level of the milk chain were then used to calculate the quantities of milk lost at each level.[3]

A distinction has been made between forced consumption (economic) and spillage/spoilage (both physical and economic) losses. Because the former cannot be calculated directly in terms of quantity of milk lost but both loss types can be calculated in terms of value loss, the value losses for forced consumption and spillage/spoilage were quantified separately then summed to get the total value loss (expressed in US dollars for ease of cross-country comparison). Based on the percentage value loss of the total value of milk available, the implied quantity of milk lost was calculated.

2.2.1. Discounting of forced consumption loss

For a more accurate measure of farm-level losses, the value of forced consumption losses as reported by the country consultants was discounted to 30 per cent. This means that only 30 per cent of the value of what was reported was considered to be 'actual' forced consumption loss, which is solely a loss in

[3] Quantities of milk available along the milk chain not available for Uganda.

value. Forced consumption arises when milk that would otherwise be sold has to be consumed at the farm because of lack of markets. The seller does not get the full value of the milk had it been sold but retains some value (e.g. nutritive value). It has been postulated that 70 per cent of the value is retained so there is a 30 per cent loss in value through forced consumption of milk at the farm level.

2.2.2. Seasonal variation in milk losses

In order to get some idea of the seasonal variation in the value of milk losses, a seasonal weighting of the rapid appraisal data was done based on increased milk availability and lower prices during the wet season. It was assumed that during the wet season there is a 30 per cent increase in milk availability (based seasonal changes seen in detailed data from the Smallholder Dairy Project in Kenya) and 6 per cent decrease in milk price per litre (based on data provided by the Austroproject in Tanzania and regular milk prices monitoring in Kenya available at www.eadairy.com). Thus the value of milk lost was calculated for each season separately, based on quantities of milk lost at the farm and market chain as determined in the rapid appraisals.

2.3. Limitations of the study

Despite the usefulness of the rapid appraisals in providing quantified estimates of the level of post-harvest milk losses, the study has a few limitations that need to be considered while interpreting the results obtained.

First, most of the rapid appraisals were carried out during the dry season and data collected on seasonality did not provide reliable information on the quantity of milk produced during wet and dry seasons. For this reason, it was difficult to accurately assign losses for the wet season[4] and the seasonal variation in milk losses could only be estimated based on assumptions as discussed in section 2.2.2.

[4] National consultants arbitrarily estimated wet season losses as follows: Tanzania 25 percent; Uganda 42.8 per cent.

Second, the small sample sizes (range: 15–66 respondents) and the limited geographical coverage within each country somewhat limits the extent to which the results can be viewed as being representative of milk losses in each country and across seasons. This is because the actual level of post-harvest milk losses incurred will differ from one region to another depending on factors such as road conditions, access to markets and seasonal changes in milk supply. Therefore, the results of national-level milk losses must be interpreted taking into account this potential variation in losses over a wider area.

Finally, in some cases, particularly Uganda, Ethiopia and Syria, the consultants provided only limited details on the data, which limited the ability to make accurate differentiation of forced losses from market losses. In some cases there were evident contradictions in the data. For these reasons as well, the results should be taken as only broadly indicative.

3. Results and discussion

3.1. Country-level losses along the milk chain

3.1.1. Kenya

Most milk losses are incurred at the farm level, mainly as a result of spillage and spoilage. Total farm-level losses were quantified as 4.5 per cent of milk value available at the farm; this includes physical loss of milk through spillage and spoilage (3.8 per cent of milk production) and economic loss through "forced consumption" of evening milk and surplus milk above normal household requirements (2.4 per cent). Direct suckling by calves was not observed in most farms.

Poor handling of milk at the farm and long distances to market result in significant losses due to spoilage. This is often compounded by the poor road infrastructure that hinders timely access to markets, especially in the wet season. Losses arising from forced consumption result in reduced value of liquid milk and the level of loss fluctuates depending on changes in milk supply and demand. It has previously been postulated (though not accurately determined) that up to 40–50 per cent of farm milk goes to forced consumption during the wet season, mainly due to insufficient market outlets for the excess milk.

Along the market chain, almost all the milk lost is due to spillage during transport and within premises. Other causes of loss are adulteration and spoilage. Proportions of milk lost by the three major groups of market agents were relatively lower than farm losses: co-operatives and self-help groups (2.8 per cent of milk handled), small- and large-scale traders (1.3 per cent) and milk bars, kiosks, shops and retailers (2.3 per cent).

3.1.2. Tanzania

At the farm level, the total post-harvest milk loss was quantified at 6.5 per cent of milk available (spoilage and spillage, 6.3 percent; forced consumption, 0.2 per cent). Forced consumption of milk is usually associated with the rainy season when milk production peaks and market outlets for milk are limited. Since the study was carried out during the dry season, it may be reasonably assumed that most of the quantified farm losses were due to spillage and spoilage.

During transportation of milk by vendors to collection centres, spillage is the most significant type of loss. Vendors transport milk by bicycle over an average distance of 12 kilometres. Because of the low levels of milk supply experienced during the study period, spoilage losses incurred by milk vendors were minimal because the little milk available was readily sold.

Milk is routinely chilled at collection centres and processing plants, thus spoilage losses at these two levels were somewhat minimal (0.44 per cent and 1.5 per cent, respectively). Generally, spoilage losses at this stage of the milk chain are associated with irregular electricity supply at the premises. Retailers recorded minimal losses due to spillage (0.7 per cent) and spoilage (0.62 per cent), with spoilage losses being largely due to electricity failure. Unsold leftover milk at the end of the day is sold later at the same price, thus is not considered "lost" *per se* although this practice may result in a partial loss in value if the leftover milk is retailed at a lower price (for instance, if it has began to sour). Leftover milk arises mainly because of lack of market for fresh milk.

3.1.3. Uganda

In Uganda, most of the reported farm-level losses were due to spillage and forced home consumption by calves and humans. Total farm level losses (spillage, spoilage and forced consumption combined) amounted to 2.7 per cent of the value of available milk. The primary cause of forced consumption is lack of adequate market outlets for liquid milk especially in the more remote areas. Sometimes scarcity of other food sources compels rural milk producer households to drink more milk than usual. During the wet season, losses reportedly more than double because timely collection of milk from farms is hindered by the poor road conditions, which are made even worse by the rains. It is estimated that during the wet season, up to 42.8 per cent[5] of milk produced remains on the farm unsold due to failure of buyers to access remote farms. Spoilage losses at the farm are mainly attributed to unhygienic milk handling.

Along the milk supply chain, up to 18 per cent of milk is lost through spillage and spoilage. As is the case at the farm level, losses along the milk chain increase during the wet season supply glut due to lack of adequate markets for liquid milk.

Milk from several farms is pooled at collection centres before being transported to processors and/or retailers. Most collection centres in urban/peri-urban areas have electrically-operated coolers, while others (mainly those in remote areas) lack electricity and cannot easily cool their milk. Even so, spoilage losses associated with electricity failure average 2 per cent of incoming milk per day.

[5] This level of loss was not determined during the study but is an arbitrary estimate given by the national consultant.

Transport delays and unhygienic handling of the milk at the farm also contribute significantly to milk spoilage.

Pasteurization and refrigeration of milk at processing plants help to minimize spoilage losses at this level of the supply chain. However, unhygienic handling of milk at the farm influences spoilage of milk at the processor level. Damages due to poor handling and packaging also rank as important causes of milk losses. The most significant retailer-level loss is spillage due to poor handling. Erratic electricity supply and lack of cooling facilities also contribute to milk spoilage.

3.1.4. Ethiopia

Farm losses in Ethiopia were quantified at 1.3 per cent and this was mainly due to spillage during milking and transportation, and spoilage caused by poor hygiene and use of inappropriate containers for milk storage. Another factor contributing to milk losses at the farm was the low level of technology application for milk preservation through conversion of liquid milk to value-added dairy products. However, farm losses represent only a partial loss in value since in many cases unsold fresh milk that goes sour is sold later at a lower price. The sour milk may also be consumed by the farmer's family, thus retaining the nutritive value of the milk. When milk is surplus to market or family needs and also during Lent and other fasting periods when up to 50 per cent of the population abstains from consuming dairy products any surplus liquid milk is routinely converted into butter and cottage cheese (*ayib*).

Off-farm losses were largely due to spillage during transportation and at retailers' premises due to poor handling and use of inappropriate containers. Transporters delivering milk from farms to private processors reported spillage losses of up to 2 per cent of milk handled. Informal sector transporters who usually deliver milk door-to-door reported 1.5 per cent of milk lost through spillage.

The formal sector experiences minimal spoilage losses because an established cold chain exists and milk is collected efficiently. In case of power failure at processing plants, milk is soured and processed into butter or cheese instead of being pasteurized.

3.1.5. Syria

Although detailed data of milk flows and post-harvest losses along the supply chain were unavailable for Syria, most losses were reported to occur during manufacture of cheese and yoghurt at the farm level and during transportation and marketing. The lack of quality controls, use of inappropriate containers and high temperatures during summer contribute to spoilage of raw milk, particularly in the semi-arid steppe region. Long distances between farms and markets also contribute to spoilage losses.

Unlike in the other countries surveyed, milk supply chains in Syria are very short with either one or two intermediaries (processors or retailers) before the milk or farm-produced dairy products reach the consumer. Another distinguishing feature, based on geographical and cultural differences, is the contribution of sheep and goat milk to Syria's per capita milk consumption. Culturally, yoghurt and cottage cheese (*labneh*) made from sheep milk are an important part of the Syrian diet and often, these products are manufactured at the household level.

3.2. Summary of causes of post-harvest milk losses

Results from the five countries revealed that the most significant loss in milk value occurs at the farm due to spillage, spoilage and forced consumption. Table 3.1 summarizes the types and causes of loss along the different levels of the milk chain. Causes and influencing factors of milk losses at the **farm** may be grouped as:

- *Marketing constraints*: Inadequate markets, failure to access remote markets and market rejection;

- *Poor rural infrastructure*: Poor roads, lack of cooling facilities and unreliable or non-existent electricity supply; and
- *Poor farm practices*: Excess calf suckling; lack of technical knowledge on safe handling of milk; use of inappropriate milk containers.

Along the distribution and marketing chain, losses are mainly in form of spillage and spoilage and are experienced mostly by informal marketing agents, in particular mobile bicycle milk traders. The major causes and influencing factors of milk losses along the **distribution chain** are:

- *Poor milk handling*: Low standards of milk hygiene, use of inappropriate containers; lack of training;
- *Infrastructure constraints*: Poor roads, lack of cooling facilities, irregular electricity supply; and
- *Marketing constraints*: Lack of access to markets.

Table 3.1.: Summary of types and causes of post-harvest milk losses

Country	Level of milk chain	Type of loss	Causes & influencing factors
Tanzania	Farm	Spillage; spoilage; forced consumption	Lack of market; poor roads
	Vendors (bicycle)	Spillage	Poor roads; inappropriate containers
	Collection centres	Spoilage	Electricity failure
	Processors	Spoilage	Electricity failure
	Retailers	Spillage; spoilage	Electricity failure; lack of market
Kenya	Farm	Spoilage; spillage; forced consumption	Lack of markets; poor handling; long distances to markets; poor roads; market rejection
	Small/large-scale traders	Spillage during transport & within premises (main type); adulteration; microbial spoilage	Poor handling (use of non-food grade containers)
Uganda	Farm	Forced consumption; calf/other animals' consumption; spoilage; spillage	Lack of markets; failure to access remote markets; poor roads; excess calf suckling; unhygienic handling; lack of cooling facilities
	Milk collectors (bicycle)	Spoilage	Transport delays
	Village collection points, milk collection & pooling centres	Spillage during transport & within premises (main type); adulteration; microbial spoilage	Poor handling & leakages; transport delays; lack of markets; irregular or no power supply
	Milk transporters (private vehicle)	Spillage; spoilage	Transport delays; lack of market
	Bulk pasteurizing centres & processors	Spillage; spoilage	Poor packaging; power cuts; unhygienic handling at farm
	Wholesalers, retailers, agents & sub-agents	Spoilage	Lack of market, irregular power supply
	Retailers	Spillage; spoilage	Poor handling & leakages; irregular power supply
Ethiopia	Farm	Spillage; spoilage; forced consumption	Inappropriate containers; poor hygiene; adulteration
	Rural transporters	Spillage; spoilage	Inappropriate containers; poor handling when transferring milk
	Milk collectors /retailers	Spillage; spoilage	Poor handling; milk contaminated at farm; collection delays
	Formal processors	Spillage	Power failure
Syria	Farm	Spoilage; spillage	Lack of quality controls; inappropriate containers; high summer temperatures
	Transporters	Spoilage	Long distances to market; high summer temperatures; lack of cooling facilities

3.3. Quantification and valuation of post-harvest milk losses

Table 3.2 summarizes the total value of post-harvest milk losses—in form of forced consumption, spillage and spoilage—for four countries. Results for Uganda are incomplete because information was lacking on the quantities of milk available at the major levels of the milk chain. Data from Syria was unavailable.

Total value loss ranged from approximately 10 to 24 million US dollars per year, but this was mainly attributable to spillage and spoilage losses. Recorded forced consumption value losses were notably low (less than 1 per cent of total value loss) in Tanzania, Ethiopia and Kenya primarily because the surveys were carried out during the dry season when there was adequate access for the available milk. These value losses translated to an implied quantity loss of 40 to 66 million litres of liquid milk per year.

Detailed tables showing the disaggregation of losses along the market chain and seasonal variation in milk losses are in the appendices.

Table 3.2.: Quantified losses in value through spillage, spoilage and forced consumption of liquid milk

	Total value loss (forced consumption plus spill/spoil, million US$)	% forced consumption value loss of total	% spill and spoil value loss of total	% value loss of total	Implied quantity loss based on % value loss (million litres)
Tanzania	**9.9**	0.0%	5.6%	5.6%	**56.4**
Ethiopia	**14.2**	0.6%	1.0%	1.5%	**39.90**
Kenya	**17.8**	0.3%	2.7%	3.0%	**66.5**
Uganda[6]	**23.9**	-	-	-	-

[6] Quantities of milk available along the milk chain not available for Uganda.

Comparing the calculated implied quantity of milk lost with current FAO statistics (FAOStats 2004) shows that the FAO figures for milk wastage are significantly higher for Kenya and Ethiopia but lower for Tanzania (Table 3.3). This discrepancy is probably due to the fact that prior to this rapid appraisal study, there was no accurate quantification of milk losses at the national level and the methods used were not harmonized across countries.

Table 3.3.: FAO data on milk production and wastage in East Africa

	Milk production, year 2002 (metric tons)	Milk waste, year 2002 (metric tons)	% waste
Tanzania	935,000	18,719	2.0%
Ethiopia	1,518,125	44,624	2.9%
Kenya	2,841,000	144,574	5.1%
Uganda	700,000	35,004	5.0%

Source: FAOSTAT data, 2004

3.4. Interventions for reduction of post-harvest milk losses

In order to identify appropriate interventions to reduce or eliminate post-harvest dairy losses, priority targeting has been used to pinpoint those links in the milk chain where significant losses in value occur and the losses that are most amenable to pragmatic solutions. Proposed interventions at identified target areas and specified stakeholder roles are summarized in Table 3.4.

Based on the above criteria, the two major target areas for intervention are the farm level and informal sector small-scale milk traders and transporters. This section of the report will highlight possible interventions in training, technology, policy and information targeted at reducing post-harvest milk losses at these links in the milk chain.

3.4.1. Training

Training of farmers, informal market agents and retailers on hygienic milk handling can contribute significantly to lower incidences of milk spillage, contamination and microbial spoilage. This has recently been shown by pilot studies carried out in Kenya among groups of small-scale milk traders (Omore *et al.*, 2002). The studies revealed that significant improvements in the microbial quality of raw milk could be realized through training in hygienic milk handling and quality testing, coupled with the use of better milk containers.

Nonetheless, it was noted that the benefit of training could best be maximized if it is implemented along certification or licensing of milk handlers. This would greatly facilitate standardized training and allow for greater control of the informal sector by providing a framework within which the quality of milk sold can be monitored and controlled. Since the informal milk sector sells most of the milk in all study countries, an important first step in implementing milk hygiene training would be formal recognition of the sector by national regulatory authorities.

At the farm level, where milk losses are highest, training of farmers should be targeted towards ensuring better milk handling practices, which would go a long way in reducing spillage and spoilage losses. This is because the quality of raw milk at the farm directly affects the quality of milk down the chain and thus has a bearing on the overall magnitude of spoilage losses. For instance, in Uganda unhygienic milk handling at the farm was a key influencing factor of milk losses at bulk pasteurizing centres and processing plants (Kasirye, 2003). Thus, the range of extension services to dairy farmers should be extended to include appropriate training in milk hygiene and proper handling of raw milk.

Development of programmes for training of the predominant small traders on milk hygiene that is facilitated through trainers who are private business service providers, such as currently being piloted in Kenya, is likely to significantly reduce the levels of raw milk spoilage. The course content should be subject to review from time to time in order to remain up-to-date with changing conditions in the respective national dairy sectors. Parallel training-of-trainers courses are also needed for the training facilitators, who are likely to comprise government training and extension officers, NGOs and CBOs associated with the dairy industry. National dairy development organizations should be at the centre stage in supporting such training, and monitoring the effectiveness of the same. In the long term, a multi-level approach to training in milk quality assurance (e.g. GMP, HACCP) should be aimed at in order to appropriately address the quality issue at all levels of the milk chain.

3.4.2. Technology

Fermentation and milk processing technology

Fermentation offers a cheap way of preserving milk by converting it into value-added fermented products that are more shelf-stable than fresh milk, which has a limited storage life at ambient temperature. The lactic acid produced during fermentation inhibits the growth of spoilage bacteria and some pathogens.

Spontaneous fermentation of milk by the natural milk microflora has been practised traditionally at household level in many communities. However, milk processing at community level has not been historically recorded in Africa and for this reason the technology, equipment and vessels used have remained fairly simple and quantities of milk processed are low (FAO, 1990).

Fermentation of evening milk, which forms a large part of “forced consumption” losses, is one feasible way of adding value to fresh milk. Some of the excess milk produced during the wet season could also be fermented to prevent losses of fresh milk due to failure to access markets.

Another approach to using fermentation to reduce post-harvest milk losses would be to adapt the small-scale household-level technologies into medium- and large-scale community-based operations that will allow efficient and more economic processing of larger quantities of milk. Community-based dairy processing units are in line with the historical role of creameries in the development of the dairy industry in many developed countries (FAO, 1990).

This can be done through collaborative efforts of governmental and private sector dairy stakeholders. In addition to scaling up of traditional milk production, other improvements to the process include the use of starter cultures for fermentation and packaging in heat-sealed plastic pouches.

For medium-scale operations, simple milk coolers based on refrigerated brine may be used to chill raw milk before processing and to preserve processed dairy products such as yoghurt, cheese and butter before sale. Because of the associated costs of electricity, refrigerated storage of milk is unlikely to be economical for very small-scale operations.

Aside from fermented milks, cottage cheese and butter are important dairy products in Syria and Ethiopia, respectively. Traditional butter-making in Ethiopia is an important form of extending the storage life of milk particularly during the fasting periods when dairy products are not consumed by Orthodox Christians who form the majority of the population. A recent technological improvement to the traditional practice of butter-making is the internal agitator designed by dairy researchers in ILCA, Ethiopia. The paddles of the agitator fit inside the traditional churning pot and consistently agitate the milk into butter. The use of the agitator improves the efficiency of butter-making by significantly reducing the churning time and improving the recovery of butterfat from the milk thereby reducing product losses. This results in better economic returns to smallholder producers (O'Connor *et al.*, 1993). Since this technological intervention has already yielded desirable results, its wider adoption among Ethiopian dairy smallholders should be encouraged.

Improved milk handling technology

Spillage and spoilage losses incurred during transportation of milk from the farm to milk collection centres may be minimized by the use of well-designed appropriate milk churns. Often in the informal sector, milk is transported in non-foodgrade plastic containers by bicycle over poor rural roads from the farm to rural milk collecting centres. Plastic containers are difficult to sterilize and thus their use for milk handling contributes to milk spoilage. For this reason, the regulatory authorities do not approve of using plastic containers in marketing milk.

Omore *et al.* (2002) report that most mobile milk traders in Kenya (who are often unlicensed because they lack fixed premises) use cheaper plastic containers partly because of the risk of confiscation of containers used for unlicensed milk trade. However, because of the shortcomings associated with use of plastic containers for transporting milk, Kenya's Smallholder Dairy Project (SDP) recently developed foodgrade aluminium milk cans (5- and 10-litre capacity) that can be easily transported on a bicycle carrier. Results of a pilot study carried out by SDP among a group of small-scale milk traders in Kenya showed that using the metal cans combined with training in hygienic milk handling and testing caused a significant improvement in the microbial quality of raw milk. In addition, the leak-proof design of the improved container reduced spillage losses during transportation of milk. Since many small-scale mobile milk vendors in Uganda and Tanzania also use bicycles to transport milk to market, there is great potential for this new milk handling technology to be extended regionally.

Lactoperoxidase system of milk preservation (LPS)

In instances where refrigeration of milk is unavailable or not economically feasible, FAO has proposed that LPS[7] can be used for preserving raw milk at tropical ambient temperatures for up to eight or more hours. This milk preservation technology stands to greatly benefit smallholder farmers located far away from feeder roads or milk collection points by reducing spoilage losses arising due to inability to access markets in a timely manner.

Toxicological studies have shown that the use of LPS in accordance with the Code of Practice will not result in adverse health problems to consumers. The LPS method is thus fully effective and safe, and in countries with warm climates it has great potential for widespread field application as an alternative method of prolonging the shelf-life of unrefrigerated milk. A recent study by the SDP in Kenya shows that LPS can be beneficial to many small-scale dairy farmers not only where there are no cooling facilities, but also in cases where costs of cooling are prohibitive.

However, incorporation of the LPS technology into the national legislation of many developing countries is currently hindered by Codex Alimentarius restrictions on international trade of milk and dairy products treated with LPS. As with any new technology, the introduction of LPS must be backed not only by training of milk handling personnel but also consumer education on the safety of LPS so that the technology may be successfully adopted.

3.4.3. Policy and legislation

Regulations governing the dairy industry in some of the countries, such as Kenya, predate independence and are based on those operating in western countries with more developed dairy industries based on pasteurization and 'cold chain' systems. As a result, there has been a wide gap in policy governing the formal and informal components of dairy sectors. Often, these laws are at variance with the current situation of milk marketing where almost all the milk is sold 'raw' in the absence of a cold chain. In the Kenyan situation, several policy changes have taken place in the dairy sub-sector since it was liberalized in 1992 but the legislative framework has not kept pace with the changing policy environment. This often creates disharmony between various policies and legislations that affect the handling and sale of milk. For instance, the Dairy Industry Act of 1958 (last revised in 1984) does not allow the sale of unpasteurized milk yet currently most of the milk sold in Kenya is not processed. Thus any interventions to address the issue of post-harvest milk losses should be more legislative- than policy-oriented, geared towards pushing

[7] The LPS is a natural antibacterial system that occurs naturally in raw milk but only inhibits spoilage bacteria for 1-2 hours. LPS kills most pathogens but is bacteriostatic to the milk lactobacilli, allowing milk to be held for up to eight hours without souring. After 15 years of field experimentation, Codex Alimentarius approved the use of LPS in 1991 along with a code of practice. FAO recommends that only trained personnel at milk collection centres use the LPS technology.

for a revised Dairy Industry Act that is in line with the changes that have occurred in the industry since milk marketing was liberalized.

An example of the needed effort to achieve desired reforms in such circumstances was recently demonstrated in the country. To address this and other policy-related issues affecting Kenya's dairy sector, a national dairy policy forum was facilitated by a number of partners in Kenya in May 2004, bringing together various dairy sector stakeholders and NGO partners. Following the forum, the process of enacting a new Dairy Industry Bill—which has stalled since 1997—has regained momentum with the Minister for Livestock Development committing to push for the enactment of the Bill, which is aimed at creating a more favourable environment for the informal dairy sector. Official recognition of the informal dairy sector will greatly facilitate the institution of appropriate measures to address the issue of post-harvest losses experienced by milk traders in the sector.

It is noteworthy that Tanzania has taken the lead in dairy legislation reform in the region, following the passing of a new Dairy Industry Act in April 2004 and the establishment of an autonomous dairy development board with greater stakeholder representation, including smallholder dairy farmers. However, additional effort is still needed to pro-actively engage small-scale traders in improving the quality of the milk that they sell.

The sort of pro-action that is needed from dairy regulatory authorities to reduce post-harvest milk losses, contamination and spoilage is to link licensing of informal sector small-scale milk traders to appropriate training in milk hygiene and hygienic milk handling. The licensing would act as an effective incentive not only in reducing spoilage, and associated losses, but also in reducing public health risks associated with sale of unwholesome milk.

In addition to the above mentioned policy interventions, a comprehensive rural infrastructure development policy is needed to ensure adequate development and maintenance of feeder roads to facilitate timely transportation of milk to market outlets. In most of the rural milk-producing areas, the road networks are in poor condition and the situation worsens during the rainy season, which coincides with a glut of milk production. This makes it difficult for farmers to access markets to sell their surplus milk, often resulting in significant losses due to forced consumption or spoilage. Likewise, policies to support the provision of training to dairy farmers on hygienic methods of milk handling and Good Agricultural Practice (GAP) can contribute to reducing farm-level losses arising due to milk spoilage.

3.4.4. Information

Creating awareness among dairy industry stakeholders on the causes and levels of post-harvest milk loss is another intervention that can contribute towards reducing the amount of milk lost along the market chain, by making available technology and training information to users. Avenues for information dissemination include field days, workshops and media campaigns. Informing dairy sector players and the general public of the economic impact of post-harvest milk losses can assist in directing the efforts of other interventions (e.g. training, improved milk handling technology) aimed at directly minimizing or eliminating the losses.

An increasingly effective medium of sharing information is through information networks or platforms. Establishment of a dairy information network, as has been agreed by stakeholders in countries that participated in this study, would help to consolidate relevant data on national dairy industries. Such networks are either lacking or inadequate to meet the requirements of industry stakeholders, particularly for small-scale producers, market agents and regulators that serve them.

The ideal dairy information network will also act as a comprehensive accurate electronic database and repository of national dairy-related statistics thereby providing a one-stop source of information on dairy issues. Links to the websites of national dairy boards/authorities (such as Kenya's KDB and Uganda's DDA) should also be provided to create a wider information pool. The development of the information network should therefore involve both national and international stakeholder cooperation (national agricultural research institutes, FAO) with lead roles being played by the national dairy boards.

Table 3.4.: Proposed stakeholder roles in reducing post-harvest milk losses

Country	Intervention	Focal areas	Stakeholders involved	Stakeholders' roles
Uganda	Training	Dairy hygiene, Good Agricultural Practices, record keeping, business management, quality assurance (HACCP), Good Manufacturing Practices (GMP)	Dairy Development Authority, Entebbe Dairy Training Unit, parastatal & NGOs, National Agricultural Advisory Services (NAADS) Programme	Training, extension services, monitoring quality of milk & dairy products, enforcement of quality regulations
	Technology	Promotion of small-scale rural based processing plants, transfer of bulk pasteurization units from peri-urban to rural producing areas	DDA, National Agricultural Research Organization (NARO)	Identification, validation & dissemination of technologies
Kenya	Training	Proper milk handling, Good Agricultural Practices, milk quality testing, appropriate preservation & processing technologies, milk hygiene, good business practices	Government extension officers, Kenya Dairy Board, NGOs & CBOs involved in dairy industry	Training and extension, training of trainers
	Information	Responsible business practices e.g. no adulteration of milk, safe disposal of dairy industry waste	Media, stakeholders involved in dairy training	Create awareness on extent causes and sources of milk losses
	Technology transfer	Preservation of liquid milk by cooling, small-scale milk processing, LPS, easy-to-use metal milk cans	Smallholder Dairy Project, Kenya Dairy Board, NGOs	Research and development, training
	Infrastructure	Development of rural feeder roads, power & water supply	Government, policy makers	Development of rural infrastructure policy
Tanzania	Training	Hygienic milk handling	LITI-Tengeru, MATI-Uyole	Training and creation of awareness on extent of milk loss
	Transfer of appropriate technologies	Processing of milk and dairy products	LITI-Tengeru, MATI-Uyole	Training and implementation of new technologies

Table 3.6 contd.

Ethiopia	Training	Hygienic milk handling	Ministry of Agriculture	Training and extension; monitoring and quality control
	Technology	Improved preservation technologies e.g. butter-making, fermentation, cooling, LPS; improved milk handling; quality assurance; establishment of a dairy technology training centre	Milk producer groups	Implementation of improved milk processing technologies
	Information	Quality control and assurance; hygienic milk handling and transportation; creation of a dairy information platform	National dairy development institution	Create awareness on extent of losses; instill quality consciousness
Syria	Training	Hygienic milk production	Government, development partners e.g. FAO	Organize training courses for farmers, village groups, small-scale processors and traders
	Technology	Low-cost appropriate technologies for milk preservation, e.g. LPS	Government, development partners e.g. FAO	Training and creation of awareness
	Information	Central repository of dairy information	National dairy development institution	Synthesis and dissemination of information on the dairy sector

4. Conclusions and recommendations

The results of the rapid appraisals have shown that significant post-harvest loss in value (up to 11 million US dollars) occur at the farm level. The annual farm-level value losses as combined forced consumption, spillage and spoilage ranged from 0.9 million US dollars for Uganda to 6.9, 10.1 and 11.0 million US dollars for Tanzania, Ethiopia and Kenya, respectively. Spillage and spoilage also give rise to significant losses during transportation by informal sector milk transporters. Annually, up to 24 million US dollars worth of liquid milk is lost along the entire milk market chain; 9.9 million US dollars worth of milk is lost in Tanzania while the total value of annual milk losses in Ethiopia, Kenya and Uganda is 14.2, 17.8 and 23.9 million US dollars, respectively.

Based on the rapid appraisal data, seasonal variations in these losses have been estimated but because the rapid appraisals did not come up with reliable data on the seasonality of milk losses, more comprehensive studies focusing on this are needed in future to generate more accurate estimates of wet-season losses. Nevertheless, the information already generated provides a useful basis for implementing the recommended interventions.

A comparison of the rapid appraisal data with current FAO statistics on annual milk wastage revealed that the FAO data for the year 2002 report significantly higher levels of quantity of milk wastage for Kenya and Ethiopia but markedly lower wastage levels for Tanzania. These differences point to the importance of using a harmonized methodology to quantify milk losses in different countries.

Considering the high economic value of the milk losses, there is an immediate need to institute the identified intervention measures in order to minimise or eliminate these losses. Training and use of appropriate milk preservation technologies could be undertaken as immediate options, provided there exists a favourable policy/legislative environment to support training efforts aimed at improving the operations of informal dairy sector.

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Appendix 1: Detailed quantification of dry-season milk losses

KENYA (annual production 2500 million litres)

	Forced Consumption Loss						Spillage/Spoilage Loss					Total Losses					
Level of milk chain	Total quantity of milk at level (million litres)	Forced consumption (%)	Forced consumption (million litres)	Forced consumption value loss per litre (30% of farm gate price in Ksh)	Total forced consumption value loss (Mill Ksh)	Total forced consumption value loss (Mill US$)	Spillage/spoilage (%)	Spillage/spoilage loss (million litres)	Spillage/spoilage value loss (Market price Ksh)	Total spillage/spoilage value loss (Mill Ksh)	Total spillage/spoilage value loss (Mill US$)	Total value (million US$)	Total value loss (forced consumption plus spill/spoil, million US$)	% forced consumption value loss of total	% spill and spoil value loss of total	% value loss of total	Implied quantity loss based on % value loss (Million litres)
farm	1,200	2.4%	28.8	4.86	139.97	1.75	3.8	45.6	16.2	738.7	9.2	243.0	11.0			4.5%	54.24
coops/groups	318	0					2.8	8.9	17.2	152.9	1.9	68.3	1.9			2.8%	8.89
small/large traders	268	0					1.3	3.5	25.0	87.0	1.1	83.7	1.1			1.3%	3.48
shops/kiosks/ milk bars/retailers	212	0					2.3	4.9	30.0	146.1	1.8	79.4	1.8			2.3%	4.87
processors	216	0					1.7	3.7	44.0	161.6	2.0	118.8	2.0			1.7%	3.67
TOTAL	2,213		28.8		140.0	1.75	3.0	66.51		1,286.3	16.1	593.1	17.8	0.3%	2.7%	3.0%	66.52

Exchange rate to US$: 80

Assumed value loss in forced consumption: 30 per cent

TANZANIA (annual production 1000 million litres)

	Forced Consumption Loss						Spillage/spoilage Loss					Total Losses					
Level of milk chain	Total quantity of milk at level (million litres)	Forced consumption (%)	Forced consumption (million litres)	Forced consumption value loss per litre (30% of farm gate price in Tsh)	Total forced consumption value loss (Mill Tsh)	Total forced consumption value loss (Mill US$)	Spillage/spoilage (%)	Spillage/spoilage loss (million litres)	Spillage/spoilage value loss (Market price Tsh)	Total spillage/spoilage value loss (Mill Tsh)	Total spillage/spoilage value loss (Mill US$)	Total value (million US$)	Total value loss (forced consumption plus spill/spoil, million US$)	% forced consumption value loss of total	% spill and spoil value loss of total	% value loss of total	Implied quantity loss based on % value loss (Million litres)
farm	729	0.2%	1.5	45	65.61	0.06	6.3	45.9	150	6889.1	6.8	108.3	6.9			6.4%	46.36
informal sector vendors	227	0					4.5	10.2	250	2553.8	2.5	56.2	2.5			4.5%	10.22
processors & retailers	44	0					4.4	1.9	250	484.0	0.5	10.9	0.5			4.4%	1.94
TOTAL	1,000		1.5		65.6	0.06	5.8	58.1		9,926.8	9.8	175.3	9.9	0.0%	5.6%	5.6%	56.42

Exchange rate to US$: 1010

Assumed value loss in forced consumption: 30 per cent

UGANDA (annual production 900 million litres)

	Forced Consumption Loss						Spillage/Spoilage Loss					Total Losses					
Level of milk chain	quantity available (million litres)	Forced consumption loss (%)	Forced consumption (million litres)	Forced consumption value loss per litre (30% of farm gate price in Ush)	Total forced consumption value loss (Mill Ush)	Total forced consumption value loss (Mill US$)	Spillage/spoilage (%)	Spillage/spoilage loss (million litres)	Spillage/spoilage value loss (Market price Ush)	Total spillage/spoilage value loss (Mill Ush)	Total spillage/spoilage value loss (Mill US$)	Total value (million US$)	Total value loss (forced consumption plus spill/spoil, million US$)	% forced consumption value loss of total	% spill and spoil value loss of total	% value loss of total	Implied quantity loss based on % value loss (Million litres)
farm	315	4.5%	14.2	60	850.50	0.47	1.3	4.1	200.0	819	0.5	35.0	0.9			2.7%	8.35
primary collector/door-to-door vendor		0					2.5		250.0	3,473	1.9		1.9				
secondary collector		0					0.6		300.0	975	0.5		0.5				
milk transporter		0					5.0		350.0	9,426	5.2		5.2				
bulk pasteurizing centre/small-scale processor		0					4.0		400.0	8,187	4.5		4.5				
wholesaler		0					2.7		450.0	5,968	3.3		3.3				
retailer (shop/bicycle)		0					4.0		500.0	13,382	7.4		7.4				
TOTAL	315		14.2		850.5	0.47				42,230	23.5		23.9				

Exchange rate to US$: 1800

Assumed value loss in forced consumption: 30 per cent

ETHIOPIA (annual production 2591 million litres)

	Forced Consumption Losses						Spillage/Spoilage Loss					Total Losses					
Level of milk chain	Total quantity of milk at level (million litres)	Forced consumption loss (%)	Forced consumption (million litres)	Forced consumption value loss per litre (30% of farm gate price in Birr)	Total forced consumption value loss (Million Birr)	Total forced consumption value loss (Mill US$)	Spillage/spoilage (%)	Spillage/spoilage loss (million litres)	Spillage/spoilage value loss (Market price Birr)	Total spillage/spoilage value loss (Mill Birr)	Total spillage/spoilage value loss (Mill US$)	Total value (million US$)	Total value loss (forced consumption plus spill/spoil, million US$)	% forced consumption value loss of total	% spill and spoil value loss of total	% value loss of total	Implied quantity loss based on % value loss (Million litres)
Farm	2213	2.3%	50.9	0.9	46.57	5.42	0.6	13.3	3.1	40.5	4.7	784.8	10.1			1.3%	28.55
rural milk transporters	116	0					5.6	6.5	3.1	19.9	2.3	41.3	2.3			5.6%	6.52
urban & peri-urban milk collectors/retailer s	243	0					1.8	4.4	3.1	13.4	1.6	86.3	1.6			1.8%	4.38
formal processors	18	0					2.5	0.5	3.1	1.4	0.2	6.5	0.2			2.5%	0.46
TOTAL	2,591		50.9		46.6	5.4	1.0	24.6		75.1	8.7	918.9	14.2	0.6%	1.0%	1.5%	39.90

Exchange rate to US$: 8.6

Assumed value loss in forced consumption: 30 per cent

Appendix 2: Seasonal variation in losses during the wet season

This analysis assumes: (1) a 30 per cent increase in milk availability during the wet season and (2) a 6 per cent decrease in milk price during the wet season.

KENYA

		Forced Consumption Loss					Spillage/Spoilage Loss					Total Losses					
	Total quantity of milk at level (million litres)	Forced consumption (%)	Forced consumption (million litres)	Forced consumption value loss per litre (30% of farm gate price in Ksh)	Total forced consumption value loss (Mill Ksh)	Total forced consumption value loss (Mill US$)	Spillage/spoilage (%)	Spillage/spoilage loss (million litres)	Spillage/spoilage value loss (Market price Ksh)	Total spillage/spoilage value loss (Mill Ksh)	Total spillage/spoilage value loss (Mill US$)	Total value (million US$)	Total value loss (forced consumption plus spill/spoil, million US$)	% forced consumption value loss of total	% spill and spoil value loss of total	% value loss of total	Implied quantity loss based on % value loss (Million litres)
Farm	**1200**	**2.4%**	**28.8**	**4.86**	**139.97**	**1.75**	**3.8**	**45.6**	**16.2**	**739**	**9.2**	**243.0**	**11.0**			**4.5%**	**54.2**
dry season	522	2.4%	12.5	4.86	60.86	0.76	3.8	19.8	16.2	321	4.0	105.7	4.8			4.5%	23.6
wet season	678	2.4%	16.3	4.57	74.37	0.93	3.8	25.8	15.2	392	4.9	129.1	5.8			4.5%	30.7
Market chain	**1013**	**0**	**0**	**0**	**0**	**0**	**2.1**	**20.9**	**29.1**	**608**	**7.6**	**367.8**	**7.6**			**2.1%**	**20.9**
dry season	440	0	0	0	0	0	2.1	9.1	29.1	264	3.3	159.9	3.3			2.1%	9.1
wet season	573	0	0	0	0	0	2.1	11.8	27.3	323	4.0	195.4	4.0			2.1%	11.8
Total	**2213**		**28.8**		**135.22**	**1.69**		**66.5**		**1301**	**16.3**	**590.1**	**17.9**	**0.3%**	**2.8%**	**3.0%**	**67.3**

Exchange rate to US$: 80

Assumed value loss in forced consumption: 30 per cent

TANZANIA

	Forced Consumption Loss						Spillage/Spoilage Loss					Total Losses					
	Total quantity of milk at level (million litres)	Forced consumption (%)	Forced consumption (million litres)	Forced consumption value loss per litre (30% of farm gate price in Tsh)	Total forced consumption value loss (Mill Tsh)	Total forced consumption value loss (Mill US$)	Spillage/spoilage (%)	Spillage/spoilage loss (million litres)	Spillage/spoilage value loss (Market price Tsh)	Total spillage/spoilage value loss (Mill Tsh)	Total spillage/spoilage value loss (Mill US$)	Total value (million US$)	Total value loss (forced consumption plus spill/spoil, million US$)	% forced consumption value loss of total	% spill and spoil value loss of total	% value loss of total	Implied quantity loss based on % value loss (Million litres)
Farm	**729**	**0.2%**	**1.5**	**45.0**	**65.61**	**0.06**	**6.3**	**45.9**	**150.0**	**6889**	**6.8**	**108.3**	**6.9**			**6.4%**	**46.4**
dry season	317	0.2%	0.6	45.0	28.53	0.03	6.3	20.0	150.0	2995	3.0	47.1	3.0			6.4%	20.2
wet season	412	0.2%	0.8	42.3	34.86	0.03	6.3	26.0	141.0	3660	3.6	57.5	3.7			6.4%	26.2
Market chain	**271**	**0**	**0**	**0**	**0**	**0**	**4.5**	**12.2**	**250.0**	**3038**	**3.0**	**67.1**	**3.0**			**4.5%**	**12.2**
dry season	118	0	0	0	0	0	4.5	5.3	250.0	1321	1.3	29.2	1.3			4.5%	5.3
wet season	153	0	0	0	0	0	4.5	6.9	235.0	1614	1.6	35.6	1.6			4.5%	6.9
Total	**1000**		**1.5**		**63.38**	**0.06**		**58.1**		**9590**	**9.5**	**169.4**	**9.6**	**0.0%**	**5.6%**	**5.6%**	**56.4**

Exchange rate to US$: 1010

Assumed value loss in forced consumption: 30 per cent

UGANDA

Forced Consumption Losses

	Total quantity of milk at level (million litres)	Forced consumption (%)	Forced consumption (million litres)	Forced consumption value loss per litre (30% of farm gate price in Ush)	Total forced consumption value loss (Mill Ush)	Total forced consumption value loss (Mill US$)
Farm	**315**	**4.5%**	**14.2**	**60.0**	**850.50**	**0.47**
dry season	137	4.5%	6.2	60.0	369.78	0.21
wet season	178	4.5%	8.0	56.4	451.87	0.25
Market chain	**585**	**0**	**0**	**0**	**0**	**0**
dry season	254	0	0	0	0	0
wet season	331	0	0	0	0	0
Total	**900**		**14.2**		**821.66**	**0.46**

Spillage/Spoilage Losses

	Spillage/spoilage (%)	Spillage/spoilage loss (million litres)	Spillage/spoilage value loss (Market price Ush)	Total spillage/spoilage value loss (Mill Ush)	Total spillage/spoilage value loss (Mill US$)
Farm	**1.3**	**4.10**	**200.0**	**819**	**0.46**
dry season	1.3	1.8	200.0	356	0.20
wet season	1.3	2.3	188.0	435	0.24
Market chain			**250.0**	**41411**	**23.01**
dry season					
wet season					
Total					

Total Losses

	Total value (million US$)	Total value loss (forced consumption plus spill/spoil, million US$)	% forced consumption value loss of total	% spill and spoil value loss of total	% value loss of total	Implied quantity loss based on % value loss (Million litres)
Farm	**35.0**	**0.9**			**2.7%**	
dry season	15.2	0.4			2.7%	
wet season	18.6	0.5			2.7%	
Market chain	**81.3**	**23.0**				
dry season	35.3					
wet season	43.2					
Total	**112.3**					

Exchange rate to US$: 1800

Assumed value loss in forced consumption: 30 per cent

ETHIOPIA

	Forced Consumption Loss						Spillage/Spoilage Loss					Total Losses					
	Total quantity of milk at level (million litres)	Forced consumption loss (%)	Forced consumption (million litres)	Forced consumption value loss per litre (30% of farm gate price in Birr)	Total forced consumption value loss (million Birr)	Total forced consumption value loss (Mill US$)	Spillage/spoilage (%)	Spillage/spoilage loss (million litres)	Spillage/spoilage value loss (Market price Birr)	Total spillage/spoilage value loss (Mill Birr)	Total spillage/spoilage value loss (Mill US$)	Total value (million US$)	Total value loss (forced consumption plus spill/spoil, million US$)	% forced consumption value loss of total	% spill and spoil value loss of total	% value loss of total	Implied quantity loss based on % value loss (Million litres)
Farm	**2213**	**2.3%**	**50.9**	**0.9**	**46.57**	**5.42**	**0.6**	**13.3**	**3.05**	**40.5**	**4.7**	**784.8**	**10.1**			**1.3%**	**29**
dry season	962	2.3%	22.1	0.9	20.25	2.4	0.6	5.8	3.05	17.6	2.0	341.2	4.4			1.3%	12
wet season	1251	2.3%	28.8	0.9	24.74	2.9	0.6	7.5	2.87	21.5	2.5	417.0	5.4			1.3%	16
Market chain	**378**	**0**	**0**	**0**	**0**	**0**	**3.0**	**11.4**	**3.05**	**34.6**	**4.0**	**134.1**	**4.0**			**3.0%**	**11.36**
dry season	164	0	0	0	0	0	3.0	4.9	3.05	15.1	1.8	58.3	1.8			3.0%	4.94
wet season	214	0	0	0	0	0	3.0	6.4	2.87	18.4	2.1	71.2	2.1			3.0%	6.42
Total	**2591**		**50.90**		**44.99**	**5.23**		**24.6**		**73**	**8.4**	**887.7**	**13.7**	**0.6%**	**1.0%**	**1.5%**	**39.9**

Exchange rate to US$: 8.6

Assumed value loss in forced consumption: 30 per cent