

Comparative analyses of the feasibility of cooling and LPS methods of milk preservation

Wanyoike, F.N.^a, Kutwa, J.^a, Mwambia, M.^b, Staal, S.^a and Omore, A.^{a,c}

^aInternational Livestock Research Institute, P.O. Box 30709, Nairobi, Kenya

^bMinistry of Livestock and Fisheries Development, P.O. Box 30028, Nairobi, Kenya

^cKenya Agricultural Research Institute, P.O. Box 58711, Nairobi, Kenya

Abstract

This study compared the cost and feasibility of alternative methods of milk preservation i.e. cooling and lactoperoxidase system (LPS) in Kenya. Data was collected from 4 milk coolers (3 large scale plants with potential chilling capacity $\geq 20,000$ L/day and one small-scale plant with capacity=1200L/day) and some milk market agents involved in LPS trials (2 farmers groups and 2 private milk collection agents) between 2002 and 2004. Capacity utilisation in milk cooling plants tended to be low (on average 48-71% in the large-scale coolers and only 25% in the small-scale plant). Costs of cooling were higher than those for preservation using LPS: Costs ranged from K.Sh1.10 - K.Sh1.30 per L in large-scale chilling plant to about K.Sh2.40 in the small-scale plant, compared costs of KSh1.02 - KSh1.09 per litre for LPS. The cost of cooling increased with decreasing capacity utilisation. Electricity costs were high accounting for up to 30% of the cost of cooling. The spoilage of milk in the small scale cooler accounted for 26% of the total variable costs compared to none in any of the large scale coolers.

Opportunities for using LPS were reduced by a preference by some farmers to keep the evening milk for home consumption. In some instances, women feared that they could lose the benefits of the evening milk to their husbands if it was delivered and sold through the milk marketing groups.

The trial groups used LPS to prevent spoilage of their morning milk only on occasions when they feared that it was likely to get spoilt. Milk market agents involved in the LPS trial viewed LPS as a better method of milk preservation than use of hydrogen peroxide that is common among some bulking agents because milk treated using LPS retains its physical properties such as density and appearance. Where cooling may be impractical due to lack of economies of scale or lack of electricity, it could be beneficial for farmers groups to use LPS. However, LPS use is unlikely to become widespread until a clause in the Codex Alimentarius Commission Guidelines that prohibits its use in milk intended for international trade is revised. Though that clause does not affect domestically marketed milk, it is of concern to regulatory authorities and stakeholders who do not wish to be excluded from the export trade should domestic regulations be amended to allow the use of LPS.

Introduction

Raw milk is a highly perishable product and has to be preserved awaiting processing or consumption. Many farmers in Kenya dwell in areas with poor roads, lack electricity or where cooling is uneconomical. Often, milk collected from areas with poor infrastructure can not reach processing plants within the recommended time of two to three hours culminating in spoilage. In some inaccessible areas, afternoon milk is not collected because doing so is unprofitable. In some of these areas, farmers cope with the lack of preservation facilities by prolonging the duration before milking by up to 16-18 hours. The use of the udder as storage for milk has high negative impacts on milk production. Furthermore, plenty of milk goes to waste in dairy farms, especially during the flush rainy season. In addition, some milk market agents in the remote areas resort to use of illegal chemical agents such as hydrogen peroxide to preserve milk.

Emerging evidence has shown that inadequate milk preservation facilities in Kenya undermines realisation of a significant potential in dairy production. It is estimated that farmers in Kenya loose

about 95 million liters of milk annually due to waste and spoilage in farms and along the market chain (ILRI/FAO, 2004). The MoARD/KARI/ILRI Smallholder Dairy (Research & Dev) Project (SDP) has demonstrated that the districts that would benefit from evening milk collection include Nyeri, Nyandarua, Kericho, Nakuru, Narok, Kajiado, Uasin Gishu, Baringo and Laikipia.

While cooling is the preferred method of bulk raw milk preservation, an alternative method preservation using the Lactoperoxidase system (LPS) has been proposed for groups of small-scale farmers in areas where cooling is not feasible (Björck et al, 1979). Use of LPS is approved by both the FAO/WHO Expert Committee on Food additives and the Codex Alimentarius Commission (Bennett, 2000). Field experiments carried out in Kenya, Sri Lanka, Mexico and Pakistan have demonstrated the economic benefits of using LPS under tropical conditions (IDF, 1988). In a creamery in Nakuru, it was found that although using LPS to preserve evening milk could cost about 5-8% of the farm gate price of the milk, its use could save about 66% of the fresh milk from spoilage (Claeson and Claeson, 2000).

Despite the potential for reducing losses due to milk spoilage by using LPS, little is known about the financial and institutional feasibility of using LPS under field conditions in most countries where it can be useful. This study aimed to fill this information gap. The objectives were:

1. To evaluate and compare the costs and benefits of using LPS, cooling and /or no preservation at all by milk marketing agents in Kenya
2. To establish the potential for use of LPS to replace the use of hydrogen peroxide
3. To determine the prospects for farmers in rural areas to increase their profits by using LPS to preserve and sell their evening milk.

Methodology

Case studies of four milk coolers were conducted. This included three large-scale plants and one small-scale plant (Table 1). The managers of the coolers were interviewed on costs of fixed inputs (buildings and equipment); variable costs (electricity, personnel, repairs and maintenance etc); and quantities of milk handled, spoilage and wastage.

Data on costs and benefits of LPS was collected using a questionnaire during trials conducted with two milk collection groups in Bomet District, that is, Olbutyo (300 members) and Gelegele (108 members) and two private milk collection agents in Nyandarua District. Focal group discussions were also held with the trial agents at the beginning and end of the trials. Bomet and Nyandarua districts were selected due to their relative high milk density and poor infrastructure, which are important factors contributing to post-harvest losses. A SWOT (strength, weaknesses, opportunities and threats) analyses was carried out to assess the potential for LPS use instead of illegal milk preservatives such as hydrogen peroxide.

Results

Characteristics of the study milk coolers and LPS trial agents

The survey included three large-scale coolers (potential capacity $\geq 20,000$ L of milk/day) and one small scale cooler (capacity=1200L/day) (Tables 1). The cooling plants often operated at considerably low capacities of their maximum potentials: 48-71% utilisation in the three large-scale plants and 25% utilisation in the small-scale plant). Quantities of milk handled by the LPS trial agents ranged from 200-400 L/day by the individual milk collection agents to 1000-2000 L/day by the groups (Table 2). The groups collected only the morning milk and it took an average of up to 7 hours between milking and delivering to the processor. They expressed a wish to sell their evening milk if spoilage of that milk could be avoided. The private agents collected both

morning and evening milk. It took up to 11 hours for the milk to be delivered to the bulking agent. The two independent milk collection agents routinely used hydrogen peroxide to preserve milk.

Comparison of cooling and the LPS methods of milk preservation

The cost of chilling milk ranged from KSh. 1.10 to KSh.1.30 per litre in the large-scale plants compared to about KSh. 2.40 in the small-scale plant (Figure 1). Electricity costs accounted for a significant percent of the variable costs (30 – 57%) in milk cooling plants. The cost of chilling was lower with higher levels of utilised capacity. Unfortunately, recall that the coolers often operated at very low capacities of their maximum potentials.

Milk losses due to spoilage accounted for a significant proportion (26%) of the total variable costs in the small scale cooling plant compared to none in any of the large scale coolers. The spoilage of milk in the small scale cooler was attributed to inadequate equipment including a standby generator and also equipments for advanced milk quality control tests such as acidity tests, milk keeping quality test (the resazurin test), and microbial counts.

The costs of capital inputs in the milk large-scale cooling centres were high. The replacement costs of the capital items ranged from a total of K.Sh.15m (US\$197 368) to KSh. 312m (US\$ 4 105 263) while the capital recovery costs (CRC)¹ ranged from over KSh. 2m (US\$26,316) to KSh. 11m (US\$144 737) per annum. In comparison, the small-scale cooling plant was estimated to have a replacement value of only KSh150 000 (US\$1 974) and a CRC of KSh. 34 126(US\$499) per annum. According to the milk cooler operators, high costs of equipment and electricity comprise some of the greatest constraints in milk cooling plants in Kenya. The owners of the small scale cooler however also complained that although chilling increased their operational costs they did

not get any premium for this from dairy processors since they lacked facilities to transport their milk to the dairy processing factories under chilled conditions.

The cost of milk preservation using LPS ranged from KSh1.02 to KSh1.09 per litre. Use of LPS required only minimal investments in additional equipment by the trial agents. During the study, each market agent participating in the trial was provided with a stainless steel stirrer and a lactometer each set costing a sum of KSh 2,750. Variable costs of the trial agents were also expected to increase marginally as the agents adopted the ethanol test of milk quality. The Gelegele trial group failed to do the recommended ethanol alcohol test of milk quality while the two independent collection agents used methylated spirit. The trial group that used the alcohol test spent an average of 10 cents per litre on quality testing compared to about one cent by the agents who used methylated spirit.

Financial effect of LPS in the trial groups

None of the groups used LPS to preserve and sell their evening milk as initially expected. During some group discussions members of the trial groups said that during the dry season they used their evening milk for domestic consumption and sold the surplus to informal traders who offered better prices. Female members of the milk marketing group at Gelegele expressed unwillingness to have the evening milk delivered to the group because they would lose the benefits to men. The two groups also expressed fear over a frequent problem of delayed payment to farmers for milk sold to dairy processors through the groups. During the flush season, dairy processors imposed quotas on milk intakes. For these reasons the groups used LPS strategically only on morning milk and only when they feared that it was likely to get spoilt. During the dry season, the milk marketing group at Olbutyo procured milk from non-member farmers residing in more distant locations and this

¹A 10% interest rate was assumed in calculating the CRC. One of the coolers had been rented and the operator was unaware of the initial costs of capital items. In this case, total rent paid out per year was used as an estimate of the CRC capital items.

took relatively more time. They therefore used LPS to prevent spoilage for milk collected early in the morning. During the wet season when milk supply is high, the queue at selling point occasionally got very long making it necessary to use LPS to avoid spoilage. The group at Gelegele often used LPS only on milk collected from farmers who milked very early in the morning (at 5:00am). However, all the milk was treated in an occasion when their delivery truck broke down. In contrast to the groups, the private collection agents used LPS routinely on all their milk.

Milk spoilage when the market agents started using LPS was lower than before. No spoilage was reported in Olbutyo during the trials compared to a mean of 1.25% before. Spoilage was also lower for the two independent collection agents during the trials (0.2% and 0.1%) than before (2% and 1%, respectively). In the few cases where LPS treated milk got spoilt, the cause was traced to poor quality control measures. For instance, the spoilage in Gelegele (0.7%) involved milk not preserved with LPS nor tested using alcohol test. One of the private collection agents who reported spoilage during trials said that this happened only once when his buyer (a large milk collection agent) failed to turn up for 2 days. The other agent traced the spoilage of his milk during the trials to milk from a cow with mastitis and his failure to check the quality of the milk.

Table 3 shows the total cost of milk preservation using LPS during the trials and the estimated increase in incomes due to reduced spoilage. The incremental incomes were computed by subtracting revenue losses due to spoilage or non sale of milk preserved with LPS from the projected potential revenue loss due to spoilage if LPS was not being used. The potential spoilage without the use of LPS was estimated to be the same as the percentage spoilage recorded just before the trials. The incremental revenue during the trials was only greater than the cost of preservation in Gelegele where LPS was mainly used strategically to prevent spoilage. Conversely, in all the other three cases where LPS was used routinely, the costs exceeded the increase in

revenue. In Olbutyo, the increase in revenue could have been higher was it not for the case when milk preserved with LPS was refused at the processing factory when some other milk transported by the group on behalf of another milk collection agent tested positive for hydrogen peroxide. These results suggest that while routine use of LPS in morning milk may be uneconomical, strategic use when conditions arise that can occasion spoilage can boost profitability. The results among the independent milk collection agents in Nyandarua should however be interpreted carefully since these agents' routinely added illegal chemicals in their milk to preserve it before the trials. Substitution of LPS for the illegal chemicals by these agents entails huge social benefits not captured in the financial analyses.

Potential for LPS to replace Illegal milk preservatives

During the SWOT analysis, all the trial agents said that LPS prevented milk spoilage (Table 4). The private collection agents said that milk preserved with LPS remains fresh with density and organoleptic properties unchanged. They were happy that LPS has a scientific backing as a milk preservative.

The market agents involved in the trial saw the opportunities for uptake of LPS to preserve milk as increased demand for LPS milk due to good quality retention, reduced milk rejections of due to spoilage, preservation of evening milk for sale in the morning, and replacement of potentially harmful preservatives used by some agents. The private collection agents said that reduced milk rejections encourages farmers to continue selling to them even during the dry season when milk supply is low. All the trial agents however observed that LPS is limited by unavailability and also high cost compared to that of hydrogen peroxide of about 6 cents/litre of milk treated. There was also concern over lack of information about LPS by most farmers, processors and consumers. The trial groups felt that the process of LPS treatment was laborious and time consuming. Lack of LPS

packages for quantities of milk of <40L was also given by the trial groups as a constraint to its widespread adoption.

Discussion

Results from this study have showed that electric power expenses contribute a large share of the cost of milk cooling. The electricity power tariffs in Kenya are among the highest in Africa (Tino, 2003). A reduction in price of electricity could enhance the development of a cold chain in milk processing milk in Kenya.

It is evident that there are opportunities for using LPS in milk preservation in Kenya. First, large-scale coolers are heavy investment ventures feasibly operational only in areas with electricity power supply. Constructing coolers may therefore not be possible where financial resources are limiting or in areas with no electric power supply. Secondly, the unit cost of using an inadequately equipped and underutilised small-scale cooler seems rather high than if LPS is used. Milk preservation using LPS may therefore be a cheaper method than cooling when quantities of milk are rather small.

Use of LPS was expected to lead to increased profitability through increased milk sales and reduced spoilage. The results from the study however indicate that the scope for farmers realise higher returns through increased milk sales is limited by poor productivity of animals during the dry season and lack of milk markets during the flush season. There is also potential that adoption of the LPS may lead to a shift in sharing of benefits from dairying across gender in the dairy farm households.

LPS seems to be more preferable to other illegal chemicals currently being used to preserve milk-by-milk collection agents. It is however important to note that most dairy processors are reluctant to promote the use of LPS by their raw milk suppliers due to a clause in the Codex guidelines that

prohibits LPS use on milk intended for international trade. A similar opinion on the clause was also recently expressed by participants in the annual meeting of lactoperoxidase groups of experts in China (FAO, 2002).

Recommendations

- There is need to strive for a reduction of electricity tariffs for reduced cost of milk cooling
- Prohibition of use of LPS in milk and milk products intended for international trade should be reviewed so as to cultivate greater acceptability of the innovation by regulators and other stakeholders who participate in both local and international trade on milk and milk products.
- Gender issues should be considered in promotion of LPS since its adoption may lead to a shift in control of benefits from milk sales from women to men.
- If use of LPS is eventually legitimised as a way of raw milk preservation in Kenya, it will be important to investigate prospects of procuring it from countries selling it at a cheaper price than the current cost of KSh1 per litre of milk so as to enhance the competitiveness of using it relative to the illegal chemicals.
- Promotion of LPS should be backed up with efforts to ensure availability of milk markets during the wet season and promotion of innovations that could foster dairy productivity during the dry season. Important regulatory framework should also be put in place to prevent abuse of LPS once it is allowed.

Acknowledgements

The authors wish to thank the FAO and DFID for providing the funds for this study. Many thanks also go to the managers of dairy cooling centres visited and also the milk marketing agents for their cooperation during data collection.

References

- Bennett A., 2000. The Lactoperoxidase System (LPS) of preservation. A poster presented in an E-mail conference on “Small Scale Milk Collection and Processing in developing Countries” FAO Rome.
- Björck, L., Claesson, O., Schulthess, W. 1979. The lactoperoxidase/thiocyanate/hydrogen peroxide system as a temporary preservative for raw milk in developing countries. *Milchwissenschaft* 34(12): 726-729.
- FAO. 2002. The Lactoperoxidase System of milk preservation: Proceedings of the fourth annual meeting of the lactoperoxidase group of experts in Tongshan, Jiangsu province China. FAO
- FAO/ILRI. 2004. Post-harvest food losses: Synthesis of post harvest milk losses in East Africa and Syria. Draft report. ILRI.
- IDF. 1988. Bulletin of the International Dairy Federation No. 234/1988. *Code of practice for preservation of raw milk by lactoperoxidase system*. IDF, Brussels, Belgium.
- Tino, E. 2003. Electricity tariffs in southern Africa. SAD-ELEC in ESI Africa Issue 3

Table 1: Surveyed milk coolers

Cooler	Large scale coolers			Small scale
	A	B*	C	D
Installed capacity (L /day)	100,000	42,000	20,000	1,200
Utilised capacity of the potential	48%	71%	68%	25%
Main milk market outlet	Dairy processors	Dairy processors	Dairy processors	Informal milk market agents

Source: Authors Survey

Table 2: Baseline Information about the different LPS trial agents

Trial Agent	Groups		Private agents	
	Gelegele	Olbutyo	NY-N02	NY-N03
Milk quantities handled (L/day)	942	2000	400	200
Milk Collected (AM or PM milk)	AM	AM	AM & PM	AM & PM
Time to reach buyer (hrs)	6	8	12	10
Frequency of spoilage (Number of times/Month)	4.5	3.0	3.0	5.0
Method of preservation before trials	-	H ₂ O ₂	H ₂ O ₂	H ₂ O ₂
Main cause of Spoilage as reported by agents	Mixing AM & PM milk	Lack of preservation	Poor preservation	Mastitis

Source: Authors Survey, 2003

Table 3: Total costs and incremental incomes in milk preservation using LPS

	Gelegele	Olbutyo	NY-N02	NY-N03
Strategy of LPS use	Mostly Strategic	Routine and latter strategic	Routine	Routine
Potential revenue loss without LPS	8646	1800	1725	1300
Revenue loss during LPS trials	6050	0	790	790
Incremental revenue during LPS trials	2596	1800	1535	1140
Cost of LPS preservation	2180	3468	10200	10815
Benefit cost ratio	1.2	0.5	0.2	0.11

Table 4: Results of SWOT analyses on LPS method of milk preservation

Groups	
Strengths	Weakness
1. Reduced milk rejections due to spoilage 2. Enabled sourcing milk from distant places 3. Simple method to learn and implement	1. Laborious, tiresome and time consuming 2. Lack of smaller packages e.g. for 20 litres 3. Unavailability of LPS 4. High cost 5. Only effective for up to one day 6. Can not be used on poor quality milk
Opportunities	Threats
1. Useful to farmers with surplus evening milk 2. Need for time to take milk to another processor incase main buyer institutes quotas 3. Substitute for H ₂ O ₂ as milk preservative	1. Lack of information processors o 2. Quotas in milk supply to processors 3. Curiosity by farmers during application 4. Delay milk delivery 5. Alternative technologies e.g. skimming
Private milk collection agents	
Strengths	Weakness
1. Milk flavour and odour milk and density remain unchanged 2. Easy to use 3. Effective in preventing spoilage hence no rejections 4. Milk passes the litmus test for hydrogen peroxide 5. LPS has scientific backing of safety as a milk preservative 4. LPS treated is usable sooner than if H ₂ O ₂ is used.	1. Can not be used on poor quality milk 2. Prescribed dose of LPS is best effective on 40L of milk compared to the recommended 50L
Opportunities	Threats
1. Retained good quality of milk leads to increased sales 2. No rejection of LPS treated milk by processors 3. Increased milk suppliers to milk agent due to reduced rejections 4. Milk retains it odour even when LPS is added twice unlike H ₂ O ₂ 5. LPS passes all milk quality tests unlike H ₂ O ₂ 6. Higher potential for acceptability because of scientific backing	1. Not readily available 2. More costly than H ₂ O ₂ 3. lack of knowledge about by most potential buyers

Figure 1: Costs of Chilling milk

