3R Kenya Project Research Brief 001

Private and public costs and benefits of implementing a quality-based milk payment system in Kenya

Asaah Ndambi, Ruth Njiru, Camee van Knippenberg, Jan van der Lee, Catherine Kilelu and Margaret Ngigi

WAGENINGEN UNIVERSITY & RESEARCH

3R Robust Reliable Resilient From Aid to Trade

Background

Assuring the quality and safety* of milk and dairy products has been a persistent issue in the Kenyan dairy sector, which is characterised by limited consumer awareness about quality and safety, processors and traders neglecting attention to quality as they compete for milk volumes, poor milk-handling practices along the chain, and lack of enforcement of quality and safety regulations. This has led to a situation where safety of dairy products cannot be guaranteed. Milk quality is important to the consumer in terms of taste and flavour attributes and its potential impact on health (Bernadette, 2008). Milk consumption in Kenya is increasing, and the annual per capita consumption is projected to reach 220 kg by 2030 (DMP, 2010). While this increase may improve nutritional outcomes, poor milk safety will mean consumers are more exposed to health risks.

Industry actors are now paying more attention to milk quality and the safety of dairy products in Kenya. This is important nationally, as better milk quality and safety reduce the costs to the health care system of milk-related illnesses. Milk quality is also important to processors and food companies due to its effect on product yields, taste, consistency and shelf life, thus affecting profit margins and (local and export) market access (Caswell, 1998). This is evidenced by the quality-based milk payment systems (QBMPSs) piloted by a few processors that consider food safety and other parameters to define quality.

In this study, **milk quality refers to a combination of characteristics that enhance the acceptability of the milk product: quality relates to chemical, physical, technological, bacteriological and aesthetic characteristics of milk and milk products; **milk safety** refers to a condition in which the risk of milk to harm and damage is limited to an acceptable level (Makerere University, 2018; p. 5, 7).*

Key messages

In cash terms, farmers are the greatest beneficiaries of a well-functioning QBMPS. This study identified a net profit of about 2 KES/kg milk if they produce Grade A milk.

The QBMPS also enables farmers to benefit from social inclusion, chain integration and productivity gains leading to business sustainability.

Collection and bulking enterprises (CBEs) and processors have a net additional cost of 2.5 KES/kg milk, mainly due to the significant initial costs of laboratory equipment, additional staffing and training of farmers.

Regarding public health, we estimate that milk-related infectious diseases currently cause an annual loss in Kenya of 53,000 healthy life years (Disability Adjusted Life Years), translating to about 850 full lives.

With a modest commitment from farmers, a QBMPS can generate health benefits of about 10 KES/kg milk in avoided health costs from milk-related illnesses.

These enormous public health benefits justify public and donor investment to support the set-up of a QBMPS, especially to subsidise costs of the CBEs and processors until the QBMPS can finance them.

1. Introduction

Consumption of poor quality and unsafe milk is known to be hazardous in various ways. It may contain foodborne pathogens that cause diseases in people (Tegegne & Tesfaye, 2017; Fernandez et al. 2017; Oliver et al. 2005). A number of studies have shown that public health could be compromised by uncontrolled and poor use of antibiotics and milk preservatives (such as hydrogen peroxide), and the presence of aflatoxins in milk, mainly from poorly stored or preserved concentrates and forages (Ahlberg et al., 2016; Darwish et al., 2013; Mutiga et al., 2015; Peng & Chen, 2009; Watt et al., 2004)

Quality-based milk payment systems (QBMPSs) have been successfully used in controlling and improving milk quality along the dairy chain (Pašić et al., 2016; Botaro et al., 2013). In order to produce good quality and safe dairy products, all actors along the dairy chain have an important role to play. These actors include input providers, who have to comply with standards, such as producing aflatoxin-free feed; dairy producers, who need to source inputs from approved suppliers and improve animal husbandry and milk-handling practices; cooperatives, who need to minimize collection time and install cooling facilities, build laboratory facilities for milk testing, and train milk graders; processors, who need to invest in laboratory facilities and staff as well as in training and extension; and regulators, who need to enforce quality standards along the chain. The many actors involved in a QBMPS supply chain each incur various costs and/or accrue various benefits, some of which are private (business) and others public good* in nature. The number and combination of quality parameters in a QBMPS may vary from country to country and from processor to processor, depending on the policies in place and the needs and ambitions of the actors. This study assesses the model of dairy processor Happy Cow Ltd as a pilot to introduce a QBMPS in Kenya that integrates smallholders as suppliers.

The assessment focuses on both the public and private good aspects of the pilot. This innovative approach is expected to offer unique lessons to those who wish to replicate it.

** Public goods are defined as goods that are non-rivalrous in consumption and non-excludable. This means that one person's consumption does not affect another person's opportunity to consume the good, and that consumers cannot deny each other the opportunity to consume the good. Health care is considered a public good because treating patients reduces their likelihood of spreading diseases. Good health care reduces the chance of getting sick during office/school hours and does not deprive anyone else from benefit of reduced risk of disease (Inge et al., 1999; Illingworth & Parmet, 2015).*

What is a quality-based milk payment system?

In a quality-based milk payment system (QBMPS), payment for milk is based not only on volume, but also on a number of quality standards, be they microbial and/or physicochemical. The QBMPS applied by Happy Cow Ltd, which includes food safety parameters, gives smallholder farmers an opportunity to earn bonuses on top of the normal prices for milk that meets the set standards. Parameters used are total bacterial count, presence of antibiotics residues, adulteration (measured by the freezing point), and total solids (including fat and protein). Happy Cow works with milk collection and bulking enterprises (CBEs; sometimes also referred to as cooperatives) that collect milk from their smallholder members in Nakuru and Nyandarua counties. Happy Cow developed its own standards, which were less stringent than those of the Kenya Bureau of Standards (KEBS) but were considered more realistic and attainable by smallholder farmers and CBEs (see **Table 1** for details).

Table 1: QBMPS and KEBS standards‡

Test	Grade	QBMPS standard‡	KEBS standards	Premium / penalty Scoreæ
Total plate count (units in cfu/ml)	A	0–2,000,000	<200,000	50
	B	2,000,001–10,000,000	200,001–1,000,000	0
	C	>10,000,000	≤ 2,000,000	−50
Antibiotic residues	All	Negative	Negative	15*
Freezing point	All	−0.500	−0.525 to −0.565	20#
Total solids	All	>11%	>11.75%	15#

*æ Premium or penalty score given to milk of the corresponding QBMPS standard (column 3); *milk positive for antibiotic residues is discarded; #otherwise a 0 score; ‡Source: Happy Cow Ltd.*

In the QBMPS, the bulk milk is analysed daily for all of the parameters mentioned in Table 1. To reduce the costs for testing individual milk samples, about 5–10 farmers are grouped such that their supplied volumes add up to fill a 50 kg can. These farmers are maintained in the same groups to assure continuity and consistency in the payment system. Sampling is done randomly to ensure that each can is tested twice a month for the above-mentioned parameters. The payment module is based on a summation of the scores obtained from the last column of Table 1, as shown in **Table 2**.

Table 2: Payment modules used

Grade	*Total score	Payment	Amount (KES)
A	70–100	Premium	+2
B	40–69	Standard	+1
C	<40	Penalty	0

** Calculated by summing the scores from Table 1*

1.1 Objectives of the study

The main objective of the study is to quantify the public and private costs and benefits of the implementation of the QBMPS piloted by processor Happy Cow Ltd.

Specifically, the research aims to:

1. Calculate the costs and associated benefits to farmers, cooperatives and processors of improving the quality of milk;
2. Assess the public health benefits related to reduced incidence of milk-related illnesses as a result of improved milk quality;
3. Provide recommendations about what is needed to upscale the QBMPS pilot.

1.2 Piloting the QBMPS

Happy Cow Ltd, founded in 1994, is a dairy manufacturer based in Nakuru, Kenya and is focused on producing a diverse portfolio of quality, value added dairy products. Happy Cow is supplied by 2,000 small-scale dairy farmers, each supplying an average of about 8 - 10 kg of milk daily, which is collected through two collection and bulking enterprises (CBEs, also known as cooperatives): New **Ngorika** Milk Producers Ltd in Nyandarua County and **Olenguruone** Dairy Farmers Cooperative Society in Nakuru County.

In November 2014, Happy Cow started the Milk Quality Tracking & Tracing and Quality-Based Milk Payment pilot project together with Ngorika and Olenguruone. This was facilitated by SNV's Kenya Market-led Dairy Programme and funded by the Embassy of the Kingdom of the Netherlands in Nairobi.

Happy Cow advocates and raises awareness among farmers and other chain actors about the benefits of quality milk. The farmers are further motivated, through a bonus payment scheme, to invest in various ways (see section 2.1.1) to assure quality.

This study seeks to quantify the public and private costs and benefits of a QBMPS to the major actors in the dairy value chain – farmers, cooperatives and processors as well as the consumers – so as to determine the prospects of its being scaled up in Kenya.

To do this, the project aimed to improve the quality of raw milk sourced from the two CBEs, Ngorika and Olenguruone. In Phase 1, Happy Cow introduced the parameters mentioned in **Table 1**, while in Phase 2 (starting from 1 January 2017), Happy Cow started testing on somatic cells and aflatoxins. These two extra parameters have not yet been included in the bonus system.

2. Overview of costs and benefits of the QBMPS

The costs and benefits of the QBMPS were calculated using data collected from secondary sources combined with interviews and additional information collected from farmers, CBEs, processors, consumers, health workers and researchers. These were analysed using various methods that were extensively discussed by experienced researchers. The methods are further described in **Annexes 1–4.**

2.1 Private costs and benefits

Private costs and benefits apply to farmers, CBEs and the processors as business entities.

2.1.1 Costs and benefits for farmers

In analysing the costs and benefits it was assumed that farmers would differ in their level of investment into, and therefore receive dissimilar benefits from, the QBMPS. Four levels of milk quality were considered: Grades A, B and C milk (described in **Tables 1 and 2**); and mixed milk. The additional costs (investments) and benefits to farmers linked to each quality level are shown in **Table 3.** Mixed milk describes the quality of milk supplied by farmers who venture into but never fully commit to implementing the changes required for the QBMPS.

The revenue from foregone milk rejection considers farmers' benefits due to reduced rejection of milk by the processor. It should be noted that all milk rejected by the processor is discarded and never returned to the CBE. It is estimated that farmers targeting Grade A milk can reduce milk rejection rates to 0.5% compared to 5.8% for those who produce Grade C milk. If this is applied to the average daily sales of 10.71 kg (based on this survey), farmers can make additional income of 19.87 KES per day from the milk that is sold rather than rejected due to poor quality.

Key benefits per milk category

- At the current market price (of 35 KES/kg), an average farmer incurs an additional cost of 1.55 KES/kg of milk in order to continuously meet the standards for a premium payment of +2 KES (Grade A milk). The same farmer also gets an additional 1.86 KES/kg as revenue from foregone milk rejection, for a total profit of 2.31 KES/kg of milk.

- A farmer who continuously meets the standard for Grade B milk incurs an additional cost of 1.17 KES/kg and gets a benefit of 2.09 KES/kg, which comes from 1 KES/kg for quality payment and 1.09 KES/kg made by a foregone loss of income due to milk rejection. This results in a net profit of 0.84 KES/kg of milk.

- Because there is no extra payment for farmers with Grade C milk, they make a net loss of 0.20 KES/kg of milk due to costs they incur in order to be paid under the QBMPS scheme. Therefore, being part of a QBMPS without being committed results in a net loss.

- Most farmers are not consistent with their investment in the QBMPS and have fluctuating milk quality that ranges from Grade A to Grade C, represented by the column Mixed in **Table 3**. Their limited investment in the QBMPS means they do not always get the premium price. It is possible for them to be inconsistent because they can sell their milk in alternative markets where milk quality is not tested. These farmers have a net profit of 0.27 KES/kg of milk, which is less attractive than the profits made by farmers constantly supplying Grade A and Grade B milk. Because this amount is small, farmers receiving it may feel the investment is not worth the cost and may become dissatisfied with the system.

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Milk transportation by motor bike

Farmers who commit to consistent investment in the QBMPS receive higher profits and more benefits.

Additional benefits

- **Social/business inclusion:** Another benefit of this form of QBMPS designed for smallholders, is that it can enhance their inclusion into higher value (more profitable) dairy supply chains. Due to the small quantities they produce and the quality issues of their milk, smallholders are likely to be excluded from a formal dairy chain. The QBMPS gives them a chance to improve their production and sell their milk competitively through a reliable market channel instead of in the informal market, where prices are highly volatile and milk collection is irregular or even absent during peak production periods, leading to possible loss of revenue for the farmer.

- **Chain integration:** The QBMPS encourages grouping of farmers; this organization of the system strengthens both horizontal and vertical integration along the dairy chain so that it becomes more robust. This also makes the farmers more attractive as business partners to other actors, such as input suppliers and financial institutions.

- **Productivity gains:** Farmers practising the QBMPS receive a lot of training, including in animal husbandry and feeding. The resulting good practices contribute to improved milk quality and may also lead to higher production volumes.

Table 3: Variation in costs and benefits for farmers involved in the QBMPS

	Unit	Additional costs and revenue per kg for different milk grades (based on interviews with 90 farmers)				Per farm per day
		Grade A	Grade B	Grade C	Mixed	Grade A
Milk quantity considered	kg	1	1	1	1	10.71
QBMPS payment	KES	2	1	0	0.50	21.42
Revenue from foregone milk rejection	KES	1.86	1.09	0	0.60	19.87
TOTAL ADDITIONAL REVENUE	**KES**	**3.86**	**2.09**	**0**	**1.10**	**41.29**
Feed costs*	KES	0.15	0.15	0	0.07	1.56
Milk equipment costs	KES	0.08	0.08	0.08	0.08	0.85
Water costs	KES	0.17	0.08	0.08	0.08	1.80
Housing costs	KES	0.53	0.53	0	0.35	5.71
Additional time for cleaning and attending training	KES	0.62	0.33	0.04	0.25	6.64
TOTAL ADDITIONAL COST	**KES**	**1.55**	**1.17**	**0.20**	**0.83**	**16.56**
PROFIT/LOSS (net additional cost)	**KES**	**2.31**	**0.92**	**-0.20**	**0.27**	**24.73**

**Costs of including a mycotoxin binder in the feed*

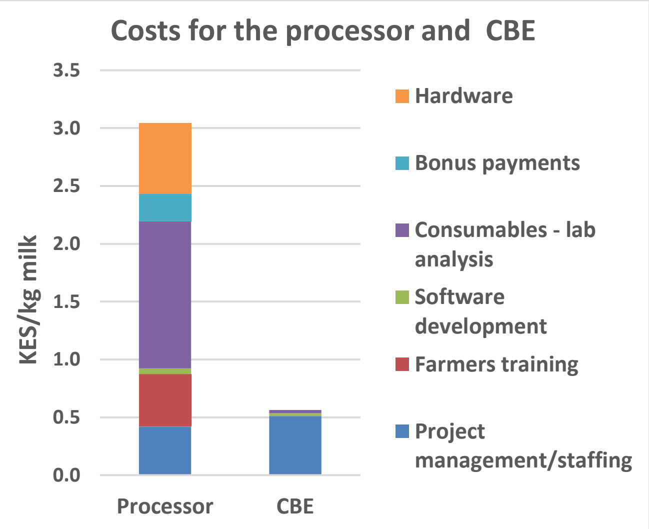
2.1.2 Costs and benefits for CBEs and processor

Costs for CBEs and processor

Figure 1 shows the costs/kg of milk for various investments made by the processor and the CBEs in the QBMPS (without considering subsidies). Annual depreciation was used as a cost for fixed investments. All total annual costs were divided by an average daily milk intake of 9,000 kg (based on 2016 intake levels) to get the cost/kg. The processor spends an average of 3.05 KES/kg and the CBE about 0.56 KES/kg of milk that goes through the QBMPS.

About 40% of the processor's total costs were used for consumables in the laboratory, while 20% were used for hardware and about 15% each for training of farmers and benefits for project staff. Interestingly, only 8% of the total cost was used to make bonus payments to farmers. For the CBEs, 90% of costs were on staffing, while the other 10% was almost equally distributed between laboratory consumables and software development. These figures show that in terms of costs, in the Kenyan context involving smallholders, building a QBMPS is a lot more about equipping laboratories, paying for lab consumables, training farmers and paying staff, rather than about paying bonuses to farmers.

Figure 1: Costs for the processor and CBE



Benefits to the CBEs and processor

Based on the 2016 situation, an average of 41 KES/kg of (bulk) milk collected was paid to the CBEs by the processor. It should be noted that the bulk milk will be a mixture of Grades A–C and that the CBE charges a fixed amount of about 6 KES/kg on top of the farmer's milk price, which is independent of the milk quality.

The CBEs confirmed that the QBMPS brought about significant reductions in the proportion of milk that was rejected by the processor. Milk rejected by the processor is not paid for, leading to a loss of 35 KES to the farmer and about 6 KES to the CBE per kg of rejected milk. The milk rejection levels for different grades of milk were estimated using information from the CBEs. **Table 4** shows the losses the CBE would make if all the daily milk collected were of a target grade (e.g. Grade A) compared to if all the daily milk were Grade C. If the CBE's farmers only provide Grade A milk instead of Grade C milk, the CBE would make an extra benefit of 0.32 KES/kg of milk. In the same way, the CBE will make a benefit of 0.19 KES/kg if all farmers deliver Grade B milk and 0.10 KES/kg for mixed milk.

The increased milk production from productivity gains will also be translated into higher milk intake by the CBE, leading to a higher total daily margin to the CBE.

When poor quality milk is processed, the chances of losing batches of the product are higher than when good quality milk is used. For example, the fermentation of yogurt and cheese may be hindered by the presence of antibiotics in milk. Also, products from milk of poor quality might spoil before their envisaged shelf life and will be returned to the processor. The QBMPS has the potential to reduce such occurrences, thus giving the processor an average benefit of 0.93 KES/kg of received milk (**Table 4**). Summing up the cost values for the processor and CBE in Table 4, shows that they have a net additional cost of 2.5 KES/kg milk, mainly due to the significant initial costs of laboratory equipment, additional staffing and training of farmers. It should be noted that the start-up costs for this pilot were subsidised by the project; the long-term plan would be to recover these costs through efficiency gains along the dairy chain and increased sales of premium milk.

Table 4: Benefits to the CBEs and processor due to reduced milk rejection and misproduction

	Grade A	Grade B	Grade C	Mixed
CBE				
Total CBE cost/kg of milk (KES)	-0.56	-0.56	-0.56	-0.56
CBE benefit per kg of milk as foregone milk rejection (compared to Grade C milk) (KES)	0.32	0.19	0.00	0.10
Profit/loss (net additional cost) of CBE	**-0.24**	**-0.37**	**-0.56**	**-0.46**
Processor				
Total processor cost per kg of milk (KES)	-3.05	-3.05	-3.05	-3.05
Processor benefit per kg of milk as foregone misproduction and milk returns* (KES)	0.93	0.54	0.00	0.30
Profit/loss (net additional cost) of processor	**-2.12**	**-2.51**	**-3.05**	**-2.75**

** Calculated as additional revenue from sales of finished products, which the processor will get due to foregone product returns and misproduction when using the target grade of milk compared to Grade C milk. These costs occur when the final product is not of desired quality and is not marketed or when it expires before the expected lifespan and is returned to the processor.*

2.2 Public health costs and benefits

2.2.1 DALYs

To determine the burden of various milk-borne diseases on public health, Disability Adjusted Life Years (DALYs) were calculated from the incidence of the disease and the average productive time lost due to the disease (as shown in **Annex 1**).

Table 5 shows the incidences of milk-related infectious diseases per year. These are based on the current population of 48.46 million and on an estimation of the cases of infectious diseases caused by poor milk quality (KDB, 2017; World Bank, 2017).

The table shows that the impact of brucellosis is especially substantial. This is mainly because brucellosis is transmitted to many people at the same time and because the duration of the illness is relatively long. The DALYs for brucellosis are 19,259, which means that each year in the total population 19,259 healthy life years are lost due to brucellosis. In contrast, although salmonellosis occurs almost as frequently, it has a low mortality rate and only a short duration, so only 563 healthy life years are lost each year. Campylobacter has a high DALY primarily because young children are vulnerable to this illness and the mortality rate is high. Tuberculosis also occurs relatively less frequent and has a relatively high DALY, particularly due to the higher severity for HIV-positive patients.

In total, an estimated 53,093 healthy life years are lost annually in Kenya due to milk-related infectious diseases. Considering an average lifespan of 62.13 (World Bank, 2017), this gives an average loss of 855 full lives per year due to milk-related infectious diseases. It should be noted that due to the lack of reliable information on the losses due to use of antibiotics, mycotoxins and harmful preservatives like hydrogen peroxide, they have not been considered in the above calculations.

Table 5: Incidences and DALYs of infectious diseases derived from milk consumption in Kenya

	Incidence * (cases/year)	DALY # (years)
Tuberculosis	3,392	16,045
Brucellosis	28,107	19,259
Listeriosis	8,238	3,521
Salmonellosis	26,653	563
E. coli infections	23,745	2,089
Campylobacter infections	2,423	10,694
Coxiella burnetti	1,890	922
Total		**53,093**

**Source: KDB, 2017; #Source: Own calculations (Annex 1).*

Note: These incidences are based on an estimation of incidences of infectious diseases caused by poor milk safety. However, since proper microbiological research on the cause of infectious diseases is often lacking, it cannot be said with certainty that all these incidences are indeed caused by poor milk quality.

2.2.2 Direct and indirect health costs

The direct costs of being ill "represent the value of goods, services and other resources consumed in providing care due to an illness", while the indirect costs result from output lost because of reduced productivity due to illness (McLinden et al., 2014, p. 2). More details on the calculation of these costs are shown in **Annex 2**. **Table 6** shows the indirect costs and the total (direct and indirect) costs per year due to milk-related health hazards. These total costs are estimated at 436 billion KES. However, actual costs may differ, because of the missing costs due to hydrogen peroxide adulteration.

The cost variation is mainly due to the different medicines needed to treat each illness and different durations of treatment. Treatment of brucellosis and listeria is especially costly, as they require expensive antibiotics for a long time.

Milk collection and transportation

Milk being received at the CBE

Table 6: Estimated total annual costs of milk-related health hazards in Kenya (1,000,000 KES)

Illness	*Cost per case	Total direct costs	Total indirect costs	Total costs
Tuberculosis	0.02	76.36	2,381.85	2,458.21
Brucellosis	1.21	33,945.69	2,858.92	36,804.61
Listeriosis	43.02	354,384.74	522.67	354,907.40
Salmonellosis	0.44	11,609.13	83.59	11,692.72
E. coli infections	1.00	23,767.21	310.17	24,077.38
Campylobacter	0.16	397.69	1,587.54	1,985.23
Coxiella burnetti	0.001	1.95	136.86	138.82
Antibiotics	-	4,346.51	-	4,346.51
Aflatoxins	-	8.73	2.49	11.22
Total		**428,538.00**	**7,884.09**	**436,422.09**

*Exchange rate: 1 USD = 102 KES; * Source: KDB, 2017*

Costs due to antibiotic resistance and due to aflatoxins require some additional explanation:

Costs due to antibiotic resistance

As discussed before, antibiotics residues in milk may cause antibiotics resistance, which makes treatment of illness more difficult. Antibiotics are often used to treat diseases common in developing countries, such as tuberculosis, malaria, HIV/AIDS, food poisoning, pneumonia and sexually transmitted diseases. If the standard antibiotics do not work anymore, doctors have to prescribe "last-resort" medicines, which have more adverse side effects, are far more costly and are often not easily available in low-income countries. Sometimes bacteria become resistant to the last-resort medicines, leaving the patient with no other treatment possibility. Although it is hard to estimate the costs related to antibiotic resistance, it certainly causes economic losses due to higher rates of illness, increased duration, decreased productivity and higher costs of treatment (Cosgrove & Carmeli, 2003; Levy & Marshall, 2004; Okeke et al., 2005; World Bank, 2016; World Health Organization, 2015). The Kenya Dairy Board made an attempt to quantify the costs caused by antibiotics resistance linked to milk and estimated them at 4.3 billion KES each year (KDB, 2017).

Costs due to aflatoxins

The costs of aflatoxins are equally difficult to estimate, as their effects are not yet fully understood. Research to date mainly focuses on the market-related costs of aflatoxin exposure, such as lost harvest. Aflatoxin can have four major effects on human health: acute poisoning, stunting, immunosuppression and increased risk of liver cancer. Because Kenyans consume more milk than the average African population, they have a higher risk of consuming aflatoxin-contaminated milk (Karaimu, 2014). Although causality is not yet confirmed, it is widely assumed that aflatoxin exposure has an effect on stunting in children, which can cause adverse health outcomes beyond childhood (Wu, 2013). The link between aflatoxins and immunosuppression is shown in several studies; however, the exact impact of immunosuppression on health has not yet been studied (Wu, 2013). More is known about the relationship between aflatoxins and liver cancer. Wu (2015) estimated that 23% of all liver cancer cases can be attributed to aflatoxins. Assuming rates of aflatoxin shown in Van Eijkeren et al. (2006) and applying this to Kenyan milk gives the costs shown in **Table 6**.

Although liver cancer is the third-leading cause of cancer deaths worldwide and mortality follows in most cases within three months, the DALY is not that high because people are most vulnerable around the age of 60 (Wu, 2013). This means that relatively few healthy years of life are lost.

2.2.3 Health cost-reduction scenarios

The QBMPS was introduced to improve the quality of milk and therefore to reduce health risks and costs and to enhance business benefits for various dairy supply chain actors. However, when this study was undertaken, the system was not yet working optimally and milk quality had not yet substantially improved. Once this occurs, there should be a reduction in the incidence of milk-related health hazards and this could lead to a reduction in related health costs.

Previous studies estimate that disease incidences will reduce by 50% annually when interventions are introduced (Government of New Zealand, 2010; KDB, 2017). However, this rate of reduction seems unlikely with the current status of the QBMPS. With mixed milk (**Table 3**), perhaps only a 10% reduction of incidences of milk-related illnesses will be attained. The system is still being improved to meet its optimal potential. Therefore, in **Table 7**, different rates of reduction for incidences are applied. The reduction rates of 10%, 20% and 50% are used to reflect improving effectiveness of the QBMPS.

Table 7: Cost-reduction scenarios (1,000,000 KES)

Costs	Current	10% reduction	20% reduction	50% reduction
Total direct	428,538	381,775	302,324	149,630
Total indirect	7,884	7,024	5,562	2,753
Total costs	436,422	388,799	307,886	152,383
Total avoided costs	**-**	**47,624**	**128,536**	**284,040**
Avoided costs/ kg of milk		**9.52**	**18.17**	**44.10**

Table 7 shows the costs for these different scenarios. Costs per year will decrease rapidly if a reduction in incidence cases is accomplished, to a reduction of 284 billion KES per year where there is a 50% reduction of incidences. When calculated per kg of milk, this scenario will result in 44 KES in avoided costs per kg of milk.

However, a scenario of mixed milk is more likely, in which the average milk quality is somewhere between Grades B and C. In this scenario, farmers' profit reduces to 0.27 KES/kg, and the CBEs and processor make a loss totalling 3.2 KES/kg. The public health benefits from the QBMPS in this scenario of mixed milk will still amount to almost 10 KES/kg milk, which is considerably higher than the cost of the QBMPS. This justifies an initial allocation of public/donor funds into development of QBMPSs, but these costs would be reduced over time once the initial fixed investments are made. If funds of 3.2 KES/kg milk were allocated to QBMPSs, they would cover the net losses to the CBE and processor and would stimulate set up of QBMPSs.

Weighing of milk at collection point

3 Conclusions and recommendations

Table 8 summarizes the costs and benefits of various actors. It shows that among the milk value chain actors, farmers benefit the most from a well-functioning QBMPS. Farmers producing Grade A milk will have extra profit of 2.3 KES/kg of milk, being the difference between the additional costs and benefits per kg of milk. Meanwhile, the CBEs and processors have additional costs which, if not passed on to the consumer, will give them a loss (0.46 and 2.75 respectively) for mixed milk. This is likely to influence their commitment to the QBMPS.

Table 8: Summary of costs and benefits per kg of milk

Grade	A	B	C	Mixed
Farmers				
Costs	1.55	1.17	0.20	0.83
Benefits	3.86	2.09	0	1.1
Profit/loss	2.31	0.92	-0.20	0.27
CBEs				
Costs	0.56	0.56	0.56	0.56
Benefits	0.32	0.19	0.00	0.10
Profit/loss	-0.24	-0.37	-0.56	-0.46
Processor				
Costs	3.05	3.05	3.05	3.05
Benefits	0.93	0.54	0.00	0.30
Profit/loss	-2.12	-2.51	-3.05	-2.75
Public				
Costs	*Public investment*			
Benefits	44.10	18.17	0.00	9.52
Profit/loss	44.10	18.17	0.00	9.52

3.1 Progress of the Happy Cow project to date

Since 2015, a number of investments have been made in this project. These covered milk-testing equipment and laboratories, milk cans and can-washing facilities, the cold chain, collection points in the routes, motorbike racks, software for data storage, processing and bonus payments, and KENAS (Kenya Accreditation Service) accreditation of the Happy Cow laboratory. These and other investments have improved the efficiency of milk collection. Due to better testing, the average quality of milk delivered at Happy Cow's factory has improved (antibiotic residues have been particularly reduced). Although the project has made progress, change has been slow and only a few farmers qualified for bonus payment.

Major challenges proved to be:

External factors

- Lack of enforcement by relevant authorities of hygienic milk-handling practices and quality standards
- Lack of common strategy towards milk quality among the processors; i.e. a market that is driven by volumes

instead of by quality

- No level playing field of processors and CBEs in regard to hawkers who buy milk directly from farmers; frequent side-selling and low level of farmer loyalty to CBEs
- Prolonged drought in 2017, resulting in significant financial setbacks

Internal factors

- Low awareness, skill level and weak governance of the dairy value chain actors, all of which are necessary to produce quality milk
- Basic infrastructure (e.g. potable water, cold chain, food-grade milk cans) and milk quality policies at CBEs are inadequate in places. This results in unhygienic milk handling, milk being cooled too slowly, unethical behaviour of some individuals (e.g. adulteration with hydrogen peroxide) and high bacteria loads.

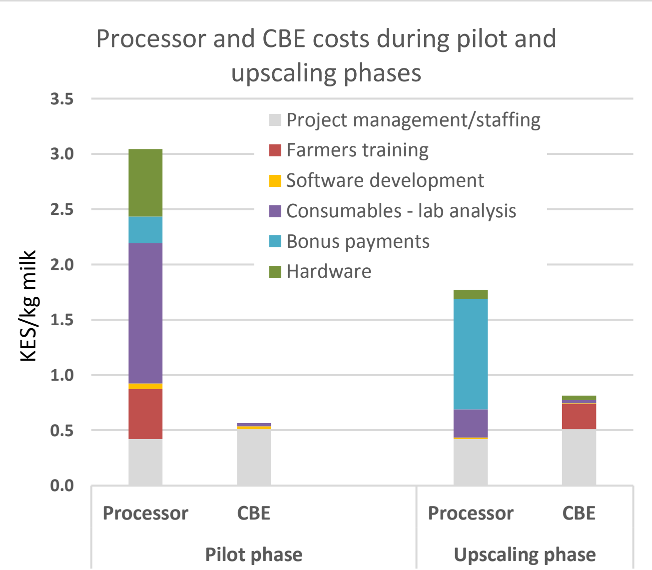


Figure 2: Costs of the processor and CBEs during pilot and scaling-up phases

3.2 Considerations for upscaling

To scale up the QBMPS, some further considerations on costs and benefits need to be articulated. Some initial investments were made to meet the basic infrastructure requirements for a good milk collection system according to Kenyan regulations, irrespective of whether there is a QBMPS implemented or not. Based on the current case, we calculated an additional cost of **1.73 KES/kg** of milk for putting basic systems in place (See **Annex 1**). This includes simple laboratories, clean water and can-cleaning facilities, cooling tanks with instant cooling (ice banks/plate heat exchanger) and using aluminium cans in all milk collection centres. It is expected that these extra costs will be required, in addition to the costs shown in **Figure 2**, during the pilot phase and during scaling up of the QBMPS.

Compared to the pilot phase, the processor's and CBEs' costs during the scaling-up phase are expected to fall. Both hardware and software costs will decrease, as they will become mainly maintenance costs. The cost for laboratory consumables is expected to decrease during scaling up as well. It is assumed that when scaling up, sampling will be from larger units, such as 150 kg collected by a motor bike transporter or 500 kg collected per route by a tractor/lorry, instead of the 50 kg cans of milk currently sampled. Such scaling up of the sampling unit will substantially reduce sampling and labour costs.

Most importantly, bonus payments will increase during the scaling-up phase, because more farmers will comply with better milk standards, justifying a bonus payment.

3.3. Conclusions

Sustainable development of the dairy sector in Kenya is important in order to meet the growing consumer demand. It is projected that the annual per capita consumption of milk in Kenya will reach 220 kg by 2030. The dominance of an informal sector coupled with weak enforcement of quality regulations has raised concerns about milk quality and safety in the country. The current payment structure of milk emphasizes quantity rather than quality in both the formal and informal sectors. In this structure, actors do not have any incentive to improve milk quality; they receive the same payment, regardless of the investments made to improve milk quality.

A functional QBMPS gives incentives to all players along the dairy chain to improve the quality of milk. Based on the pilot programme implemented by Happy Cow, farmers delivering Grade A milk would receive an additional 3.86 KES/kg of milk delivered to the CBE. This would require that the farmers practise hygienic milking, observe withdrawal periods for antibiotics, separate morning and evening milk and attend training regularly. The costs incurred by the farmers amount to 1.55 KES/kg, resulting in an extra profit of 2.31 KES/kg. The CBEs would incur a cost of 0.56 KES/kg of milk and have a benefit of 0.32 KES/kg, leaving them with a net loss of 0.24 KES/kg. For the processor, the QBMPS requires him to equip a laboratory, employ quality control personnel, purchase good software, among others, at the cost of 3.05 KES/kg, for which he would accrue benefits of 0.93 KES/kg leading to a loss of 2.12 KES/kg of milk. This is not counting potentially higher prices for better products.

Apart from the private benefits to the value chain actors (farmers, CBEs and processor), the QBMPS would result in reduced public health costs amounting to 44.1 KES/kg of Grade A milk, 18.17 KES/kg of Grade B milk and 9.52 KES/kg of mixed milk. These are significant benefits, which justify public investment in the QBMPS.

Based on the information collected, the QBMPS clearly is a step in the right direction towards improving milk quality in Kenya. The processor and the CBEs incurred large costs in setting up the system and both made cash losses (if subsidies given were not taken into account). From the cost–benefit analysis it is evident that the QBMPS is not yet viable to finance itself under the current circumstances in Kenya. Since this was a pilot phase, some funding was received from the Embassy of the Kingdom of the Netherlands in Kenya to cover part of the processor and CBE costs, which compensated for the losses.

In conclusion, this study indicates that implementing a QBMPS provides a certain potential to address milk quality issues, leading to improved revenues for farmers and multiple benefits for various dairy chain actors in Kenya. Additionally, the QBMPS has much potential to improve public health by reducing the enormous health losses of 53,093 life years lost annually in Kenya due to milk-related diseases, with public health costs amounting to a total (direct and indirect) cost of 4.4 billion KES annually.

3.4 Recommendations

In order to fully integrate and replicate the system, this study makes the following recommendations to improve the implementation of a QBMPS:

Farm level: Full implementation of proper hygiene, adoption of aluminium cans and timely delivery of milk to the milk collection points. Farmers producing Grade B and Grade C milk can be encouraged to produce Grade A milk, as they need to invest only slightly more to get significantly more profit.

Cooperatives (CBEs): The CBEs should stringently check the quality of milk delivered, either at the milk collection point or at the CBE for farmers delivering to the CBE directly. All employees involved in handling and transporting milk must be trained in hygiene practices. This calls for development and enforcement of strict standard operating procedures. As much as its main objective is finding a market for its members' produce, the CBE must be willing to reject poor quality milk to ensure quality of milk supplied. CBEs should employ dependable transporters to assure an optimal quality of milk; outsourcing of milk collection and transportation increases the risk of receiving poor quality milk. CBEs should organise faster collection to ensure that milk is cooled within 3 hours after milking, and also switch into a two-times daily milk collection scheme. CBEs should also invest in cooling tanks that are equipped with an instant cooling device and in potable water and can-washing stations. They should only use aluminium cans for milk collection and transportation.

Processors: Like the CBE, processors must not accept poor quality milk. They should strictly and continuously monitor the milk collection process of the CBEs and implement a robust milk quality tracking and tracing system. Processors also incur losses at this stage, and we recommend that they get support during the first years of implementation of the QBMPS until it can finance itself.

Government/regulatory: The regulatory authority should ban the use of plastic cans completely. It must phase out the raw milk market and implement entry barriers for CBEs wishing to get into the business of milk collection and marketing: for example, a proper water supply, cleaning and cooling infrastructure and a lab with lab equipment, a qualified food technologist, and dedicated quality assurance staff. Policies and standard operating procedures for clean milk handling need to be in place.

The authorities should streamline the dairy sector towards a formal sector, since a QBMPS can only be implemented in these conditions. They should also invest in quality control staff who will enforce quality regulations in all counties. Part of the investment currently provided by the processor and CBEs could be made by the government. An example is in the training of farmers, which cost the processor 0.45 KES/kg of milk during the pilot phase. Because of the significant public health benefits, it is advisable for the government to allocate funds to support the dairy sector in building up sustainable QBMPSs that include food safety parameters.

Consumer organizations/consumers: Consumers should be duly informed about the difference in quality of milk that goes through a QBMPS; they may accept a higher price for products generated from it, which could (partly or entirely) compensate the costs borne by the processor.

Limitations to this study

- The calculations of benefits from the processor only consider yogurt and cheese as final products. Including other products might alter the results.
- Some costs might be required for regulation of feed in order to reduce aflatoxins to tolerable levels. These have not been considered.
- Improving milk quality might not necessarily translate into improved health impacts as assumed in this study because other factors, such as milk pasteurisation and human resistance, also play a role. Similarly, the impact of antimicrobial residues and aflatoxins in milk on human health is controversial in the literature.
- The benefits do not consider the trade benefits that might arise from marketing of a better quality milk.
- Environmental benefits arising from reduced loss (waste) of milk, more productive cows and a more efficient dairy industry have not been quantified.

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Annex 1: Approach for calculating private costs and benefits

The study applied both descriptive and econometric tools to analyse the empirical data collected. Descriptive statistics have been used to describe characteristics of the respondents and their cost and benefits in the QBMPS as described in **Annex 4**.

The study was undertaken in Nakuru and Nyandarua counties, based on the location of the different stakeholders who form part of the dairy value chain. Purposive sampling was carried out to permit an in-depth analysis of the costs and benefits. Data was collected through interviews with the stakeholders (**Table A1**) and through two focus group discussions with farmer groups to understand their perceptions of the QBMPS. For the costs and benefits a partial analysis was conducted focusing on the additional costs and benefits that would be incurred in a QBMPS system.

Table A1: Number of chain actors interviewed

Respondents	Number
Farmers/producers	90
Cooperatives	6
Milk transporters	12
Focus group discussions	2
Processors	2

Profit and loss is calculated as: *Profit/loss = Total Benefits/Revenue – Total costs* (1)

Empirically this model can be specified as outlined below:

$$\pi = \sum_{i=1}^{i=n} P_y Y - \sum_{i=1}^{i=n} P_x X \quad (2)$$

Where: π = profit or loss

P_y = Price of milk sold by the player.(for the processer, this will be the quantity of cheese and yoghurt sold)

Y = Quantity of milk sold

$\sum_{i=1}^{i=n} P_y Y$ = Total benefit from the sale of milk and milk products

P_x = Price of inputs (1, 2, 3…..n)

X = Quantity of inputs (1, 2, 3……n)

$\sum_{i=1}^{i=n} P_x X$ = Total costs incurred by the player

Equation (2) illustrates the situation the players would face every day. In order to find out the costs and benefits within the QBMPS pilot, the study considers the additional costs and benefits that would yield additional profit or loss to the player: $\Delta\pi = \Delta\sum_{i=1}^{i=n} P_y Y - \Delta\sum_{i=1}^{i=n} P_x X$ (3)

Where: $\Delta\pi$ = Additional profit/loss made from participation in the QBMPS

$\Delta\sum_{i=1}^{i=n} P_y Y$ = Additional revenue made by the player in the QBMPS

$\Delta\sum_{i=1}^{i=n} P_x X$ = Additional costs incurred by the player in the QBMPS

The partial cost and benefit analysis is broken down as $\frac{\Delta\pi}{Y} = \frac{\sum_{i=1}^{i=n} P_y Y}{Y} - \frac{\sum_{i=1}^{I=n} P_x X}{Y}$ (4)

Where: $\frac{\Delta\pi}{Y}$ = Additional profit/loss per litre of milk made from participation in the QBMPS

$\frac{\sum_{i=1}^{i=n} P_y Y}{Y}$ = Additional revenue per litre of milk made by the player in the QBMPS

$\frac{\sum_{i=1}^{I=n} P_x X}{Y}$ = Additional costs per litre of milk incurred by the player in the QBMPS

The model can be Specified as follows:

For the farmer: $\pi = (BONUSPAYMENT + LESSMILKREJECTION) - (\Delta FEEDCOST + \Delta MIKEQUIPMENTCOST + \Delta WATERCOST + \Delta HOUSINGCOST + \Delta CLEANING + \Delta TRAIN)$ (5)

For the CBE: $\pi = (LESSMILKREJECTION) - (STAFFCOST + SOFTWARECOSS + CONSUMEABLES)$ (6)

For the processor: $\pi = (YIELDGAINSINCOME + LESSRETURNS + LESSMISPRODUCTION) - (STAFF + TRAINING + SOFTWARE + CONSUMEABLES + BONUSPAY + HARDWARE)$ (7)

Annex 2: Approach for calculating public health costs and benefits

Three indicators were used to calculate the public health benefits of the QBMPS: *DALYs, direct costs* and *indirect costs*.

i) **DALYs -** Disability Adjusted Life Years (DALYs) were used to determine the burden of milk-related diseases. When people are born, they have a potential number of life years to live in optimal health. However, people may lose some of these years of optimal health due to illnesses or death before reaching their life expectancy. These losses are measured by DALYs. DALYs indicate the burden of disease across the population and indicate the gap between current health status and the ideal situation where people reach their life expectancy free from diseases or disabilities (Devleesschauwer et al., 2014; Larson, 2013; World Health Organization, 2017).

DALYs were calculated using the following formulas:

$$DALY = YLL + YLD \quad (1)$$

$$YLL = N * L \quad (2)$$

$$YLD = I * DW * L \quad (3)$$

Where, *YLL* (Equation 2) corresponds to the number of deaths (*N*) multiplied by *L*, which is the difference between the life expectancy and the average age at which death occurs due to a particular milk-related illness. The *YLL* value thus indicates the number of years lost because of death. Calculation of the *YLL* was based on the incidences and number of deaths due to milk-related illnesses (adopted from the KDB data (KDB, 2017)), the average life expectancy (based on World Bank, 2017), and the average age at which death occurs (based on secondary data and expert interviews). *YLD* (Equation 3) is the number of milk-related incidences in a particular period multiplied by the duration of the illness and a weight factor. In this formula, *I* is the number of incidences, *L* is the average duration of the case until remission or death in years and *DW* is the disability weight, which reflects the severity of the disease on a scale from 0 (perfect health) to 1 (worst possible health state). The disability weight indicates the proportional reduction in good health due to an adverse health state (Devleesschauwer et al., 2014). In this study it was adopted from previous research (Salomon et al., 2012, 2015). For tuberculosis only, a differentiation was done between HIV-infected patients and non-HIV-infected patients, as the severity for these two types of patients differs and thus affects the disability weights.

ii) **Direct costs** Direct costs of being ill "represent the value of goods, services and other resources consumed in providing care due to an illness" (McLinden et al., 2014, p. 2). These costs include basic medical care expenditures, such as for diagnosis, treatment, continuing care, rehabilitation, terminal care and transportation costs (Hodgson & Meiners, 1982; McLinden et al., 2014). To estimate the direct costs of milk-related illnesses, the incidence-based costs approach was used; it is often used for analyses that "seek to measure the savings, or benefits, of preventing a new case of disease" (Hodgson & Meiners, 1982, p. 431).

The direct costs were calculated as: *Total direct costs = incidences of specific illnesses * direct costs per incidence* (4)

iii) **Indirect costs -** Economic indirect costs also exist, which result from output lost because of reduced productivity due to illness. Indirect costs account for losses in productivity due to an illness or death (McLinden et al., 2014). These indirect costs were measured using the human capital approach, which is commonly used to measure indirect costs of illness (Hodgson & Meiners, 1982). These losses were calculated by multiplying the life years lost (DALY) and the average productivity per year, as shown in Equation 5.

Total indirect costs = DALY for milk-related illnesses * average productivity / year / capita (5)

The total costs were calculated by summing direct and indirect costs for all milk-related illnesses.

Public investments

The set-up of the QBMPS at Happy Cow was supported by the Embassy of the Kingdom of the Netherlands in Kenya, in order to pilot sourcing quality milk from smallholder dairy farmers, who make up the majority (80%) of the producers in Kenya. This public investment was made in the form of a subsidy. Note that these costs have not been deducted in the calculations, and the above costs reflect the full cost of the QBMPS.

Annex 3: Milk hygiene and handling practices at the farm level

		Frequency (n = 75)	%
1.	Clean the shed and dispose of the dung away from the shed	6	8.0
2.	Wash the milking vessels with clean water and dry them	74	98.7
3.	Wash hands with soap and dry the hands with towel	72	96.0
4.	Wash the udder with clean warm water before milking	75	100.0
5.	Forestrip each quarter and observe signs of mastitis	16	21.3
6.	Wipe and dry the udder after washing using clean dry towel	47	62.7
7.	Apply milking jelly/lubricant after milking	60	80.0
8.	Disinfect the teats with teat dip	4	5.3

This table shows the hygiene practices of farmers from the two cooperatives that are paid using the QBMPS. It shows that 80% of the farmers applied milking jelly after milking. After milking, teats should be dipped in antiseptic solution to minimize risk of infection, but only 5.3% of farmers did so. Only 41.3% of the interviewed farmers had attended dairy training in the previous year. Out of those who attended training, 25.3% had gained knowledge about proper milking and clean milk handling, while the others attended training about dairy health, pasture establishment and feeding. Although the training offered by Happy Cow and the CBEs is free of charge and voluntary, very few farmers attended any training. Farmers who adopt these hygienic practices are more likely to produce Grade A milk and to receive bonuses.

Annex 4: Overview of costs and benefits from the QBMPS

	Costs incurred in a QBMPS	Benefits from a QBMPS
Producer	• Milk handling, storage and transportation • Infrastructure – housing, etc. • Sourcing quality and more expensive feed • Use of suitable milk containers for storage and transport • Disease prevention and proper treatment • Time for training and extension • Additional time for proper milk handling and hygiene	• Increased revenues from better quality milk • Greater incentive to invest in infrastructure • Move from the informal to the formal sector • Increased milk yield from improved feed quality • Faster milk collection • Less milk rejection • Safer milk for household consumption • Lower animal health costs
Cooperative	• Training, extension and supervision • Recruitment of new staff • Cost of software for the tracking and tracing system • Higher transportation costs • Investment in bulking and cooling facilities • Investment in suitable collection centres and milk quality monitoring	• Milk-testing facilities • Increased milk volumes • Better management practices by the farmers • Better quality milk from the farmers • Higher revenue from milk • Faster milk collection due to shortening of collection duration • Less milk rejection
Processor	• Training and extension • Training and supervision • Investment in adequate milk-testing facilities and products • Marketing costs • Investment in the quality tracking and tracing system • Recruitment of new staff • Investment in better storage and cold chain management	• Higher quality of the processed products and premium prices • Longer shelf life of products • Increased product volumes due to higher milk solid content • Less misproduction / rejected batches • Lower processing costs of shorter processing time • Shorter pasteurization time • Increased access to export markets and higher prices • Improved organoleptic quality, such as flavour, odour and appearance of products
Consumer	• Price of milk purchase	• Improved shelf life of the product • Safe milk • Higher quality and higher nutritional value • Lower medical bills • Longer shelf life of products • Higher product safety • Possibility of exporting or selling in niche markets • Possibility of increasing margins

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Photos: Asaah Ndambi and Ruth Njiru

Contact

Wageningen Livestock Research
Postbus 338
6700 AB Wageningen
The Netherlands

Asaah Ndambi
Senior International Animal Production Specialist
asaah.ndambi@wur.nl

3R Kenya project
c/o ACTS,
ICIPE, Nairobi, Kenya
www.3r-kenya.org/

Catherine Kilelu
3R Kenya project coordinator
C.Kilelu@acts-net.org