

Quality and safety control in Tanzania milk chains: current practices and interventions



LIQUID Project Progress Report

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List of abbreviations

BDS	Business Development Service
HACCP	Hazard Analysis Critical Control Points
ILRI	International Livestock Research Institute –Tanzania
MCCs	Milk Collection Centres
MLFD	Ministry of Livestock and Fisheries Development
NGO's	Non-governmental organisations
TALIRI	Tanzania Livestock Research Institute
TAMPRODA	Tanzania Milk Producers Association
TAMPA	Tanzania Milk Processors Association
TBS	Tanzania Bureau of Standards
TDB	Tanzania Dairy Board
TFDA	Tanzania Food and Drugs Board
SNV	Netherlands Development Organisation
SUA	Sokoine University of Agriculture

Introduction

The dairy sector in Tanzania is still evolving with potential for increased production of safe and consistent quality milk. Meanwhile, existing challenges along the dairy chain threatens the actualization of this potential. A prominent challenge in Tanzania is a dominant informal dairy chain, which channels most of the milk. However, the informal chain is characterized by limited enforcement and less advanced milking technology. Consequently, inconsistent quality persists for locally produced milk products such as pasteurized milk, ultra-high treated milk and raw milk. In addition, poor safety of raw milk at the point of consumption remains a concern.

Part of the unsatisfactory performance often seen along the dairy chain in Tanzania can be attributed to the emergence of small-scale milk processing companies without hygienically designed equipment and facilities. In addition, large-scale companies have no or poorly implemented HACCP-based food safety management systems. These challenges point to limitations in the quality control system in the raw milk chain.

Meanwhile, on-going initiatives in the Tanzania dairy chain involve interventions meant to increase milk production, improve livelihood and nutrition security. Such interventions include breed improvement of dairy animals, training and certification services to dairy farmers, provision of milk collection centres to facilitate milk collection and marketing, testing and promotion of feed supplements, and access to dairy equipment and inputs. Unfortunately, these interventions have been lacking in making huge impact in alleviating existing challenges.

In Tanzania, some dairy companies support the building of milk collection centres and provide cooling tanks to facilitate milk collection every two days. Ultimately, the dairy company benefits from regular supply of quality raw milk for processing while the farmers are assured of regular market for their milk. However, understanding how these implemented intervention support models relate to actual quality control practices of farmers in the dairy chain in Tanzania is yet limited. Furthermore, concerns about how inclusive these intervention support models are of women and youth also exist.

The aim of this study is to investigate the supportiveness and inclusiveness of intervention support models in quality control practices along the fresh milk chain in Tanzania. The main research questions are:

1. How is the raw milk value chain structured, and which actors have influence in setting milk quality requirements and ensuring quality control practices along the fresh milk chain in Tanzania?
2. What are current quality and safety control practices at the various stages of the milk value chain to ensure safe and quality milk in Tanzania?
3. What intervention support models are currently being applied in the raw milk value chain in Tanzania?
4. How supportive and inclusive are these intervention support models toward quality and safety control practices of farmers at farm level in Tanzania?

Methodology

Study design

We adopted an explorative approach. The first part involved a milk value chain analysis specifically tailored to understand the key actors involved in the chain. Furthermore, the actors with influence to determine milk quality requirements and enforcement, and how information on milk quality requirements are passed on to different actors along the formal and informal milk chain was explored. The second part involved exploring current quality and safety control practices implemented by different actors along the chain. In the third part, the supportiveness and inclusiveness of implemented intervention support models were investigated. In addition, two current interventions models were analysed to understand how beneficiary farmers and intervention owners perceive their supportiveness and inclusiveness. Two villages from one selected district in each of the regions (i.e. Morogoro and Tanga) were chosen as study sites. The villages were chosen based on producer organisation sustainability assessment strengths conducted by International Livestock Research Institute (ILRI, 2016). Three of the villages were at lower levels while one was at a higher level of sustainability in terms of financial health, engagement with output market, effective and transparent leadership, access to dairy inputs and services, relationship with external environment and membership loyalty.

Data collection methods

Focus group discussion: In order to understand the milk value chain organisation, two focus group discussions were held in each village targeting farmers who supplied milk through formal and informal milk chains. Each session of focus group discussion was led by two researchers with one acting as a facilitator and note-taker. The questions were prepared in advance (Curry et al., 2009) to cover three sections of milk value chain analysis. The first section involve questions related to milk quality requirements in the milk chain, flow of milk and specific roles of each milk chain actor. The second section involved questions on agreements used in transacting production and supply activities, information flow on milk quality requirements and the influence of each actor toward milk quality setting and enforcement. The third section involved questions on constrains and opportunities to produce and supply safe quality milk. On average, each session of focus group discussion took two hours. Each focus group discussion was treated as a unit of analysis but individual contributions and gestures during discussions were noted such that responses reflect the majority view (Onwuegbuzie et al., 2009). Seven farmers participated in each focus group discussion. Collectively, fifty-six farmers took part in the focus group discussions.



Figure 1: Focus group discussion in Manyinga (A), Mvomero district in Morogoro region and Mwangoi (B), Lushoto district in Tanga region

Key informant interviews: Key informants were identified among milk traders, milk collection centre managers, milk shop operators, dairy processing companies, and research experts to be interviewed using open-ended questions. The questions for the key informant interviews were structured to cover the same aspects as the focus group discussions in order to get a consistent partner on the milk value chain. In all, four milk traders, three milk collection centre supervisors, two dairy company managers, four milk shop/bars operators, two district livestock officers and an academic expert with thirty years' experience in dairy chain research were interviewed.



Figure 2:Key informant interviews with different actors in Morogor region, Tanzania

Face-to-face interviews and observations: Farmers, milk traders, milk collections centre managers, dairy processing mangers of milk quality and milk shop/bar operators were interviewed to understand current practices to ensure milk is of acceptable quality and safety. Onsite observations was done during the interviews to verify and confirm practices being carried out. Furthermore, to evaluate the supportiveness and inclusiveness of intervention support models, farmers who benefited from two selected intervention support models were interviewed as well as a representative of each of the selected intervention.



Figure 3: Field data collection activities: PhD student conducting one-on-one interview with milk collection centre supervisor in Mwangoi, Lushoto district (A) and quality manager of dairy company (D) in Tanga region. Interview with farmers in Wamidakawa (B) and Manyinga (C), Mvomero district in Morogoro

Elaboration on findings

Milk chain actors and organisation

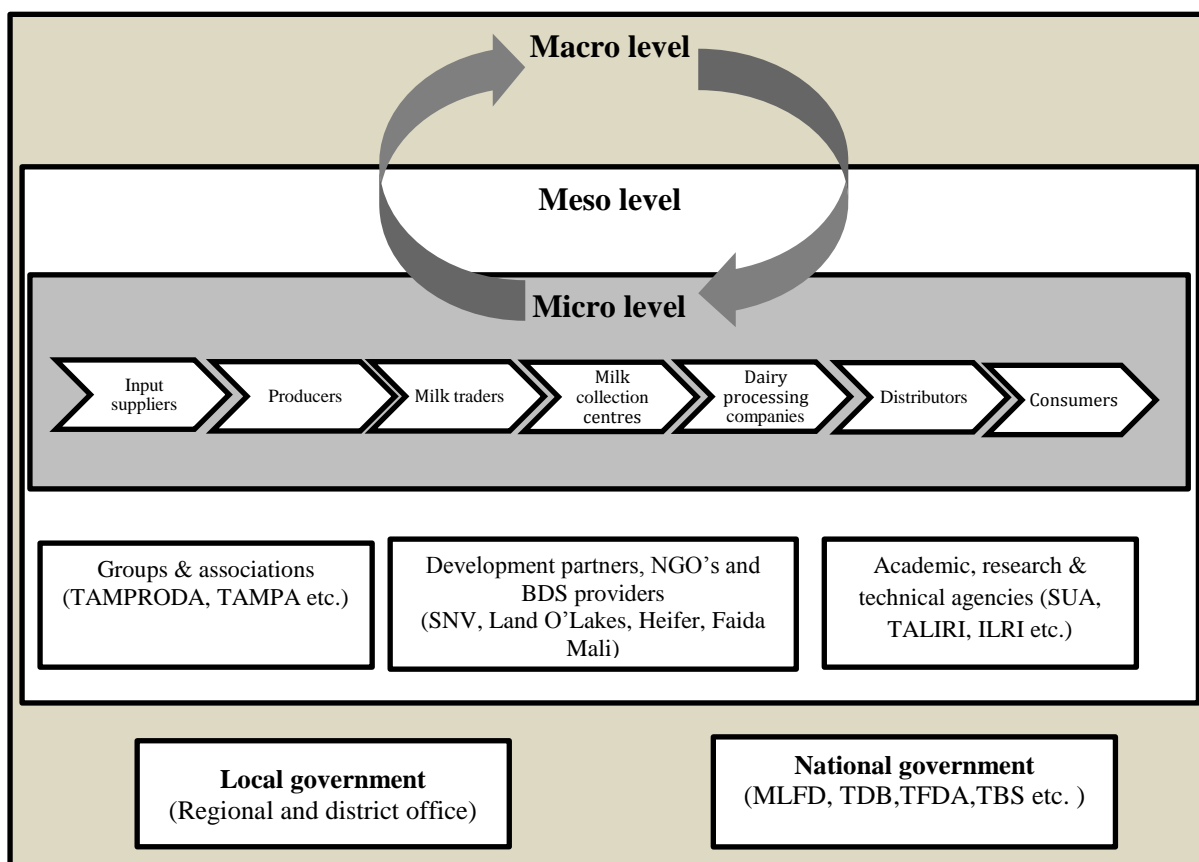


Figure 4: Milk chain actors and levels of organisation

Figure 4 shows micro, meso and macro level actors, products and information flow on milk quality requirements. At the micro level, farmers, milk traders, milk shop operators, milk collection centres, dairy companies, distribution agents, retailers and consumers are involved in milk production, collection, processing, marketing and consumption activities. Written and unwritten agreements are used to facilitate product flow and information on milk quality requirements. Written agreements are common in the formalized milk chain where dairy companies source milk from milk collection centres. In the informal milk chain, where there is direct sale of milk to customers, unwritten agreements and informal communication channels are used to transact and enforce milk quality.

Meso level actors involve groups and associations, business organisations, development partners, non-governmental organisations (NGO), academic and research institutions which provide support services in the milk chain. For example, Tanzania Milk Producers Association (TAMPRODA) and Tanzania Milk Processors Association (TAMPA) are groups which represent the interest of farmers and processors respectively. At this level, development partners (e.g. SNV, Irish aid, ILRI etc.), NGO's (e.g. Land O'lakes, Heifer international, Etc.) and business (e.g. Faida Mali) organisations are often involved in collaborative and independent milk chain interventions to improve milk chain effectiveness. Macro level actors provide enabling conditions for the overall operation of the milk chain in Tanzania. This level include government ministries and agencies involved in developing policies which spearhead the operations of the milk sector. It also includes regulatory bodies

such as Tanzania Bureau of Standards (TBS) and Tanzania Food and Drug Authority (TFDA). An important agency at this level is the Tanzania Dairy Board (TDB) which is mandated to develop, regulate and promote dairy industry activities in Tanzania.

Influence in setting and enforcing milk quality and safety requirements

The influence of actors in the formal and informal milk chains differ. In the formal milk chain, the Tanzania Bureau of Standards sets requirements on milk and milk products. These are passed on to milk processing companies in the chain. The requirements set on milk processing companies by TBS is used as basis to contract milk collection centres which are responsible for bulking of milk from farmers. Some milk collection centres receive milk directly from farmers or through milk traders. The requirements in the agreement between the milk processing company and milk collection centre is used as basis for accepting or rejecting milk. While individual farmers are not in direct consultation with standard authority, their requirements are passed on through the chain to the farmers. Therefore, enforcement of milk requirements are carried out at each point of the milk chain where transaction is made for milk. Milk traders, milk collection centres and milk processing plant use basic tools like alcohol tests to advance analytic methods such Resazurin, lactometer and laboratory tests applied to verify the quality of the milk. In the informal chain, customers sourcing milk determine the requirement. This is passed on to the suppliers and enforced using informal means such as personal discretion which is largely variable from one customer to the other (figure 5).

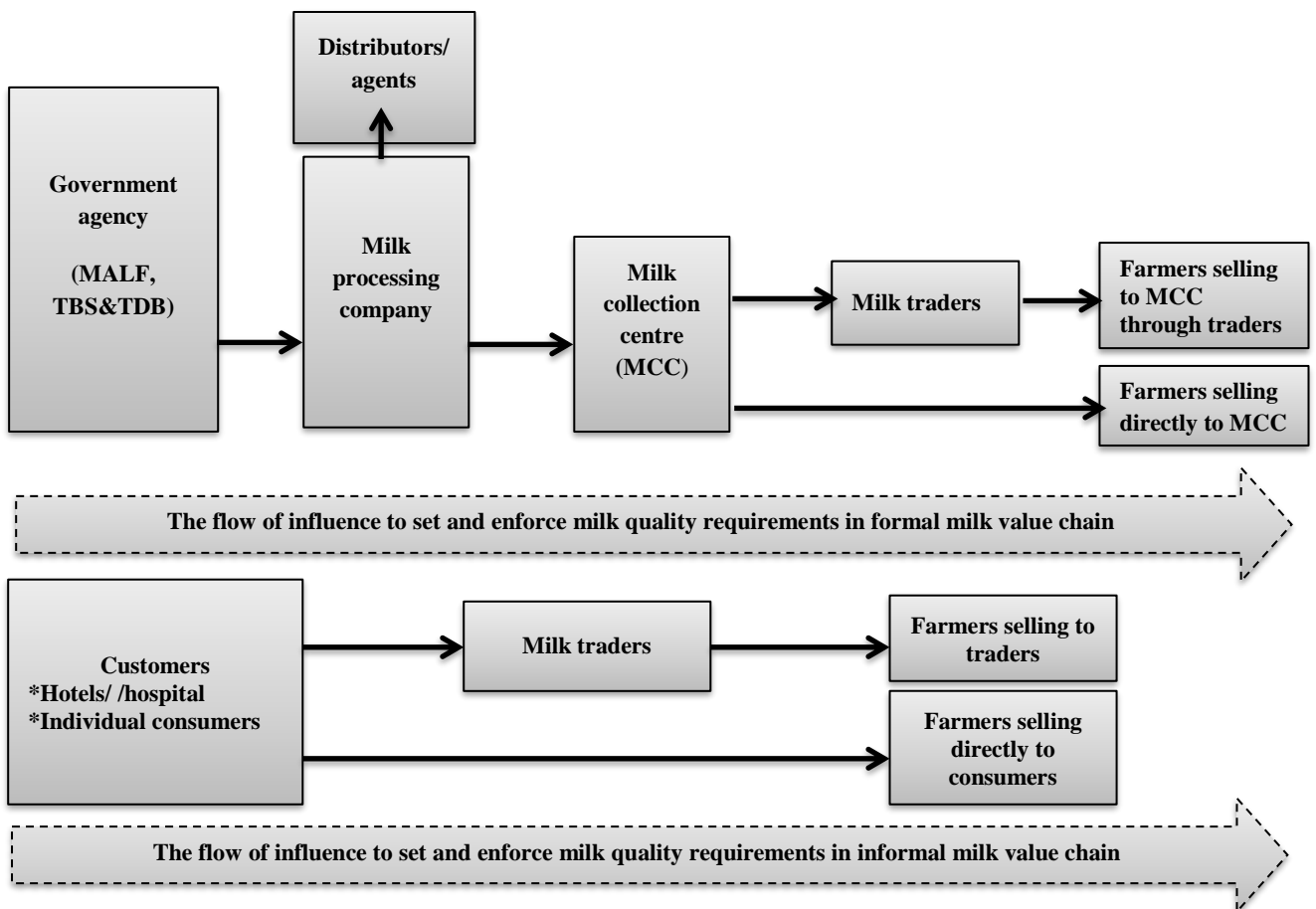


Figure 5: Flow of influence to set and enforce milk quality requirements in formal and informal milk value chains

Constrains and opportunities in the milk chain

Table 1: Constrains and opportunities in the milk chain

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Parameter	Farmers	Milk traders	Milk collection centres	Dairy company	Milk bar operators
Milk quality requirements and participation in milk chain	Positive impact *Quality guarantees available market which supports their participation *Customers demand for high quality milk creates market *Supports them to get more customers *Supports them to get bulk money which enables them to buy feeds and other needs	Positive impact *Makes me get more customers *Allows for good price for the milk *Customers accept the milk when quality is met * Able to meet demands of MCC * Helps to maintain reliable market for the milk	Positive impact *Have a permanent market as a result *Ensures the growth of their market * Makes MCC to meet market demand of dairy companies	Positive impact * In the downstream, it helps companies to stay in business because they collect quality milk *Demand is growing because of good quality of products *Serves as an advertising tool for the company	Positive impact * Good milk quality sustains the business since more quality milk is sourced * Helps to meet customers demand for assured market *Helps to get more customers
	Negative impact *Quality requirements prevent farmers to participate in the value chain due to rejection at collection centre *Prevent farmers to produce because of low income to meet quality demands	N/A	N/A	Negative impact: *Too much quality requirements are set and too many regulatory bodies doing the same thing which does not support companies to exist *Regulation does not favour participation of small scale processing companies	Negative impact: * It is difficult for farmers to meet these requirements because of high cost of feed.
Challenges affecting ability to collect and supply quality milk?	*Milking person/labourer sometimes are not trustworthy because they add water to the milk during milking *Low purchasing power to get inputs which are expensive *Unsustainable market as a result of seasons. *Poor quality of the breeds	*Drought reduces the milk supply *Heavy rain reduces the demand for milk *Transport used by farmers affect the time of milk delivery and this affects the milk quality	*Poor quality of testing materials e.g. Alcohol *Poor feeding of animals e.g. feeding cows with toxic grass *Poor infrastructure *Poor government policy on milk industry	*Level of education of producers on awareness on quality of milk *Scale of operation of the farmers which is small-scale *Weather such as dry and wet seasons which affect milk production volumes *Not reliable power	* Only when milk prices go up such that customers won't be able to buy *Drought *Presence of many diseases *Lack of extension services *Poor government policy which disturbs livestock keepers all the time

	<ul style="list-style-type: none"> *Unsupported policy from government for livestock keeper *Lack of financial support because of high interest rates *Drought which affects feeding the cows *Poor road infrastructure to transport milk *Unattractive milk price *Inadequate industries for processing the milk *Lack of education of farmers on good animal husbandry 	<ul style="list-style-type: none"> *Road infrastructure is poor especially during raining season *Low price of milk compared to other markets like direct sale to consumers *Milk equipment are expensive like milk cans 	<ul style="list-style-type: none"> *Poor transportation mechanism e.g. use bicycles and motorbikes *Dirtiness of milk utensils *One market channel i.e. Tangafresh *Low price of milk *Expensive feed concentrate to farmers 	<ul style="list-style-type: none"> *Poor road conditions *Power fluctuations *Infrastructure challenges like accessible roads 	<ul style="list-style-type: none"> *Low price of milk to direct customers *lack of storage containers to keep the milk for long *MCC's assurance on quality
<p>Future opportunities to continue producing and supplying milk</p>	<ul style="list-style-type: none"> *Availability of support in the form of training from stakeholders like Heifer international, Faida Mali and Maziwa Zaidi *Source of income to get inputs for farming *Availability of customers/customer demand *Consumption at the farmers household *Need for more milk collection centres *Continuous Source of income *Cows are used as asset 	<ul style="list-style-type: none"> *Unavailability of MCC allows milk traders to proceed in business *Low price from MCC for the milk will allows milk traders to continue to do business *Continuous demand from consumers for health purposes *MCC that are still operating keeps her in business because of continuous income *Continuous source of income 	<ul style="list-style-type: none"> *Demand for milk is still high *Opportunity to generate profit although still small *Part of economic activities *Market demand is still high *The business keeps growing 	<ul style="list-style-type: none"> *97% of the milk is unprocessed in Tanzania *Increased tendency to take healthy milk products *Potential exist to invest in dairy infrastructure due to increasing demand. *Having more dairy plants in the country will help in milk processing 	<ul style="list-style-type: none"> *Customers demand for milk *Opportunity to continue to get good quality milk from farmers *Important income source *Opportunity to educate farmers that milk production is a brings money not only selling the cattle

On farm quality and safety control practices in the milk chain

The results revealed that there was no distinct difference in preventive practices of farmers supplying in both formal and informal chains. Farmers supplying milk through both formal and informal chains tended to rely on preventive medication by using de-wormers and vaccination to preventive diseases. Some farmers also use insecticides spray to prevent diseases. The use of dipping was rare among informal farmers. However, various less popular methods are used by farmers. The reason for the varied pattern of practices among farmers could be because of lack of clear guidelines for preventing diseases. Most farmers depend on own knowledge or experience of other farmers to instead of following specific guidelines. Feed storage practices range from no storage control to semi-control. These situation exposes the feed to possible bacterial and fungal growth which are major risk for the quality and safety of the milk.

The use of non-food grade containers was common in both formal and informal chain farmers (figure 6). This type of containers are known to be difficult to clean and cross-contamination of the milk due to poor cleaning practices can occur. Furthermore, majority of the farmers use sandy floors (figure 7) instead of acceptable clean cement floors (Gachuiriri et al., 2012; Morgan, 2004). The use of cement floors require more capital investment and most farmers kept small number of cows with limited returns from the sale of milk.



Figure 6: Milk storage containers of farmers; Non-food grade containers used by farmers (1), Stainless-steel storage containers used by farmers (2), Traditional calabash used by farmers for home consumption (3)

The results reveal that most farmers rely on physical observable and behavioural changes to detect diseases in the milking cow. They lack of confirmatory tests to verify the presence of specific diseases was noted. Although, majority of farmers consult the veterinarian and have no ability to use confirmatory tests to detect specific diseases. Consequently, the risk of contamination of the milk from diseased cows is high. Furthermore, monitoring of feed in storage is also by physical means. In addition, most farmers also use physical characteristics of smell and colour to judge the quality of the milk. The use of simple standard instruments such lactometer and alcohol test for acidity of milk were absent. The preventive and monitoring practices of farmers point to high quality and safety risk for the milk. This is situation is even more precarious because of the direct sale of milk to consumers without any further quality and safety checks.



Figure 7: Hygienic design of milking floors on farms; Cement milking floor of some farms (1) and a typical milking floor in Wami dakawa (2)

Quality and safety control practices by other milk chain actors

The results revealed that the use of hygienically designed milk containers is limited among traders and milk bars operators. This could increase risk of cross contamination from inadequate cleaning of plastic containers. Furthermore, the use of written protocols for sanitation practices was absent except in dairy companies where sanitation procedures were documented. Milk traders and milk bar operators clean based on personal instincts rather than document sanitation plans. Pest control practices tend to focus on insects but not rodents, which are also major pests in milk handling and processing. Across the milk chain, there is a general lack of coherence in preventive practices. This lack of coherence can be attributed to the fragmented nature of the chain which does not favour the enforcement of uniform standards.

The result on monitoring activities reveal that milk quality parameters check increased in dairy company practices. The activities of national regulatory bodies such as Tanzania Bureau of Standards and Tanzania Food and Drugs Authority on established processing companies can be a crucial motivation for the dairy companies to comply with acceptable standards. However, checks for specific pathogenic bacteria are absent at the dairy company. At the milk trader and milk collection centre level, quality checks are supported by basic instruments such as lactometers to check for density and temperature. In addition, milk acidity and total bacteria presence are also check at the milk collection centre to accept and reject milk coming from farmers. However, at the milk bar, milk quality checks are largely based on physical characteristics such as smell and colour. This is a major concern since most milk bars serve milk directly to consumers. Although, some milk bars source milk from milk collection centres, this is common in very few cases.

Supportiveness and inclusiveness of milk chain interventions

Perceived supportive of milk chain interventions

Two major types of milk chain interventions were identified; commercial and non-commercial driven. Commercial driven milk chain interventions are profit-oriented initiates by dairy companies in collaboration with farmers co-operatives. However, non-commercial driven milk chain interventions are philanthropic-oriented and aimed to bring development in milk production and boost value chain participation. The results show that non-commercial driven interventions were perceived to be more supportive of quality and safety control practices of farmers at farm level than commercial driven interventions. Majority of farmers who benefitted from non-commercial driven interventions perceived support for animal health care and hygiene, feed storage and, hygienic design, sanitation and milking practices through non-commercial driven interventions as strong compared to commercial interventions. The strong support perceived by farmers from non-commercial driven interventions was mainly explained

by the fact that farmers received training on those quality and safety control practices. For example, the animal health care was supported through training on the use of an anti-insect spray to control pests on the farm. In addition, farmers went on a study tour to Tanga and had interactions with a trained veterinarian. In response to the training, a farmer said: *'Now I am able to understand the problem and act upon that'*. Most farmers receiving support from the commercial driven intervention indicated no support whereas some farmers indicated strong support.

The perceived 'no support' can be explained by the fact that most farmers did not receive training and merely brought their milk to the MCCs provided by intervention provider. To illustrate, some farmers said: *'Intervention only collects our milk, we do not receive any training.'* and *'Tanga Fresh takes our milk through the milk collection centres, but they do not assist us in anything.'* Some farmers did perceive strong support from commercial driven intervention since they received training and seminars on the quality and safety control activities. However, checks indicate that these trainings are not consistent. The training was only available on demand which is a possible explanation for the perceived no support. This is contrary to the trainings provided by the non-commercial driven interventions, which were more consistent and regular. However, the sustainability of the non-commercial driven interventions was a concern since support financial support for the interventions will end in 2017.

Perceived inclusiveness of milk chain interventions

In this study we assessed the inclusiveness of women and youth in current interventions by using the following criteria; ownership, voice, risk and reward. Ownership is specified as whether the actor involved in the intervention owns any provided assets, services or facilities. For example, lands, processing facilities or cooling tanks. We assessed voice to mean the actors ability to influence key business decisions. In addition, the opportunities to review decisions made was assessed as part of voice (Vorley et al., 2009). We defined risk as the challenges that actors have to confront as a result of their participation or direct impact of intervention to women and youth in the milk chain. On the other hand, reward assessed the benefits as a result of the intervention. This was focused on how economic cost and benefits are shared women and youth.

From the results (Table 4), the non-commercial driven intervention actively supports the position of women and youth. This was carefully planned ahead by initiators of the intervention to include women and youth. This can be collaborated by a statement from a representative of non-commercial driven intervention *'Intervention made it compulsory to have women and youth in leadership positions. Women are also encouraged to execute certain tasks within the groups like being a chairperson.'* In the commercial driven intervention, women involvement has been planned as crucial goal prior to implementation. However, youth participation has not been substantial. As result, programmes were organised to inspire youth participation in the milk chain. This is emphasized by the statement of the intervention representative; *'There is relatively few youth working in the dairy chain, since they resist long-term plans and instead focus on short plans to earning direct money. Therefore, the intervention started a Youth program to involve the youth in the chain as, transporters or distributors.'* Due to the high participation of women in both interventions, they have major say in key decisions compared to young people who have limited influence due to their lack of participation.

The risk for both women and youth was not obvious since there was no discrimination in opportunities for women and youth. However, in some communities where cultural differences in the role of men and women, exposed the women to limited voice and ownership. This was not as a result of the intervention but the underlining cultural situation. This situation

was common among the Maasai community in Wami dakawa. The major reward in both intervention is the opportunity for women and youth to participate in trainings which increased their knowledge, improved their milk production and increased their income. A typical story was shared by one farmer in Wami dakawa who was both farmer and a milk trader. She narrated how her initial involvement in milk production and marketing was resisted by her husband because the activity took her away from home more often. However, as result of the business, she was able to buy a motorcycle which her husband now uses. This changed the husband's perception of her involvement in milk trading.

Table 3: Perceived inclusiveness by beneficiary farmers and representative of milk chain interventions

Criteria	Statement to reflect inclusiveness	Non-commercial driven				Commercial driven			
		Women		Youth		Women		Youth	
		F ²	R ³	F	R	F	R	F	R
Ownership	Equal opportunities between sexes	4	1	3	1	2	1	2	1
	Equal participation in e.g. training	5	1	4	1	6	1	5	1
	Participate in a leadership position	1	1		1	3	1	2	1
	Obtaining their own cross breed cattle					3		1	
	Supply milk to Tanga Fresh					1		1	
	Participate in farmer's association					1		1	
	Obtaining hands on skills					1			
Voice	Make decisions concerning the hubs/association	1	1		1	3	1	3	1
	Being elected and electing leaders	3	1		1	1	1		1
	Membership, all members have equal right	8		7		5		5	
	Equal payment for milk					2			
	More women compared to men	1							
	More women leaders	1							
	United voice in decision making involving men	1							
	Equal right to apply for a loan					1			
	Equal right in deciding issues concerning milk					1			
	Low influence since low participation								1
Risk	No risk	6		2		6	1	6	1
	Not owner of cattle		1	4	1	1			
	Youth prefer a job with direct money			7				6	
	Lack of education	3		1					
	Youth represents family			3	1				
	Unable to obtain improved breeds	1						2	
	Milking is a job for women, not for men			1					1
	Maasai culture discriminates women	4		3					
	Scared to join leadership contest	1							
	Low participation of youth			7					1
	No contribution to discussion			3					
	Long distance to reach MCC					1			
	Reward	Increased knowledge	4	1	3	1	4	1	
Increased income		8		1		4	1		1
Exchange of ideas with other farmers		1	1	1	1	1			
Increased awareness about dairy business		2		3		4		3	
Increased milk production		2				6		4	
No clear reward, youth participation was low				2				1	1
Improved milk quality						1		2	
Expand social network			1		1				
Form an advocacy group			1		1				
Receiving storage containers		1			1				
No reward, since youth did not participate				4					
Increased living standards							1		
Financial help among farmers			1						

1: Women, 2: Farmer, 3: Representative.

Conclusions on findings

Milk value chain organisation toward milk quality requirements in Tanzania

1. Milk quality requirements in formal milk value chains are formalized and backed by written agreements. The Tanzania Bureau of Standards leads the process of setting and enforcing milk quality requirements. These milk requirements are enforced through the operation of dairy processing companies. Based on the national milk quality requirements, dairy processing companies also set milk quality requirements in supply agreements with milk collection centres. Milk collection centres become points of assessing milk quality between farmers and dairy processing companies. Milk quality requirements in informal value chains are determined by direct customer and not backed by any written agreements. This varies from one customer to the other in informal chains.
2. The direct customer in informal chains has power to determine milk quality. In formal milk value chains, the Tanzania Bureau of Standards has power to determine quality requirements for milk. This is enforced at established milk processing companies.

Quality and safety control practices

3. There is no significant difference in implemented quality/safety control practices by farmers in formal and informal milk chains in Tanzania.

Identified milk value chain intervention models

4. Two major types of milk value chain intervention models were identified. These were commercial and non-commercial driven milk value chain interventions. Commercial driven milk value chain interventions are initiated by dairy processing companies in collaboration with farmer co-operative groups. This is profit-oriented and focused on getting raw milk from farmers through milk collection centres. The non-commercial driven milk value chain intervention is not-profit oriented. It is a collaboration between different development-oriented organisations with the primary aim to boost milk production and value chain participation through capacity building of actors along the milk value chain.

Supportiveness and inclusiveness of milk value chain intervention models

5. The non-commercial intervention was perceived to be more supportive of quality/safety control measures of farmers at the farm level in both the formal and informal value chain. The commercial intervention was perceived to be less supportive of quality/safety control practices of farmers at farm level in the formal chain compared to the non-commercial intervention.
6. Both commercial and non-commercial interventions were perceived to be inclusive of women and youth.

Future work: The findings provide a basis for further research to assess milk quality and safety (i.e. microbiological and chemical) of raw milk as an indication of the quality control system performance.

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