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Integrated food safety and nutrition assessments in the dairy cattle value chain in Tanzania

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ABSTRACT

The consumption of even small amounts of animal-source foods has the potential to improve nutrition, especially in vulnerable households. However, scaling up their production bears food safety risks that are often overlooked due to a disconnect between human nutrition and animal sciences. The aim of this scoping study in Tanzania was to identify opportunities for nutritional and food safety benefits from cow milk.

Questionnaires were administered to 156 producers and 157 consumers in 10 villages in Lushoto and Mvomero districts. Farmers reported that veterinary medicines such as oxytetracyclines, penicillin and streptomycin were frequently given to cattle, and a majority did not discard milk during or after treatment. Less than half of the producers boiled milk, although sale of fermented milk, made by spontaneous fermentation of raw milk, was common. Cattle management was characterised by low levels of biosecurity, hygienic practices and disease control. A majority of consumers reported not to have enough food to meet their family needs. The Food Consumption Score was acceptable for all households, but significantly higher for households with dairy cattle. When making purchasing decisions, the appearance of milk and trust in the supplier were more important considerations than hygiene practices observed. A total of 26% of consumers reported to consume raw milk "usually" or "sometimes" and 54% of consumers reported to drink fermented milk "usually" or "sometimes". Consumers had a positive attitude towards milk and concern for quality but most thought there was no risk of illness from milk consumption.

The findings promote understanding of the complexity surrounding the local food environment and practices related to the production and consumption of dairy products and allow shaping recommendations for nutrition-sensitive livestock interventions.

1. Introduction

Livestock value chains support the livelihoods of millions of rural and urban poor and can act as pathways out of poverty (Hawkes and Ruel, 2006; Randolph et al., 2007; Upton, 2004). Animal source foods (ASF) are important sources of micro and macro nutrients and even regular consumption of only small amounts have been shown to improve growth, physical activity and cognitive function (Neumann et al., 2003). But at the same time ASF can be an important source of foodborne disease (Grace, 2015). Interventions to develop ASF value chains need to consider explicitly impacts on food safety and quality, nutrition and livelihoods to avoid policies that improve one aspect, but negatively impact another. Food quality can be defined as "all those characteristics of excellence that make it acceptable to the food buyer" (Ferree, 1973), encompassing both objective and subjective factors (Grunert, 2005). Food safety is concerned with the production of food that does not pose a threat to human health (Henson and Traill, 1993), traditionally considering biological (e.g. bacteria, viruses), chemical (e.g. veterinary drug residues, disinfectants), or physical hazards (e.g. plastic, metal, bone) that can cause adverse effects in humans if consumed (FSA, 2009).

In Sub-Saharan Africa, the majority of meat, milk, eggs and fish is sold in informal markets, where food safety regulation is not available or often poorly enforced. Consequently, microbial and chemical

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hazards in food (e.g. brucellosis, tuberculosis, salmonellosis, chemicals, mycotoxins, antimicrobial residues) are commonly identified in studies investigating them (Alonso et al., 2011; Kikuvi et al., 2010; Namanda et al., 2009; Paudyal et al., 2017), even though the risk to consumers is not always high due to mitigating practices such as cooking (Grace et al., 2010). Diarrhoeal diseases are one of the main causes of morbidity and mortality from infectious diseases (Murray et al., 2012); in 2010 the global burden of foodborne disease was estimated at 33 million Disability Adjusted Life Years with the highest burden falling on the African, South-East Asian and "Eastern Mediterranean D"[1] sub-regions (Havelaar et al., 2015). Many food-borne diseases go under-reported without laboratory confirmation. The full extent of the burden and cost of unsafe food is therefore unknown. It is estimated that diarrhoea alone is the cause of mortality in 1.9 million children a year, with a significant proportion of these cases due to food- and water-borne disease (WHO, 2008).

Concerns over food safety among consumers in low income countries can lead to reducing ASF consumption with marked structural changes in elasticity (Kraipornsak, 2010), changing to outlets perceived as safer (ILRI, 2010) or cleaner (Otieno and Kerubo, 2016), asking retailers for health certificates (ILRI and DVS, 2008), or a willingness to pay for safer food products (Alphonce and Alfnes, 2012). On the other hand, improving availability and accessibility of even small amounts of ASF helps to ensure that diets include sufficient quality protein and micronutrients particularly for vulnerable populations (Iannotti et al., 2017, 2014; Randolph et al., 2007). These population groups often depend on the competitive prices offered by the informal sector. Consequently, common calls to tackle problems of food safety and disease by moving to Northern-style agro-food systems that are commonly characterised by processing and cold chains, can create unintended consequences in that they may decrease the availability and affordability of ASF for poor population groups (Grace, 2015). Moreover, large numbers of small informal sectors actors who are difficult to monitor or train in combination with ineffective rules, regulations, and governance hinder upgrading of informal sectors (Grace, 2015).

Milk contains energy, readily-digestible protein and bio-available micronutrients such as calcium, magnesium, phosphorus, potassium, selenium, zinc, thiamin (vitamin B1), riboflavin (vitamin B2), and vitamin B12 (cobalamin) (Latham, 1997). Milk alone is a good source of many of these micronutrients and populations that consume large amounts of milk along with other foods seem to have fewer micronutrient deficiencies, as observed for example in pastoralist populations in Kenya (Fratkin et al., 2004; Fratkin et al., 1999) or in school children in Kenya where vitamin B12 plasma concentrations were improved with milk supplementation (McLean et al., 2007). While highly nutritious, it is at the same time highly perishable and an ideal growth medium for microorganisms (Schoder et al., 2013; Swai and Schoonman, 2011).

The dairy sub-sector in Tanzania, as in other East and Central African countries, is dominated by informal markets, which handle 80–90% of all milk sold (Swai and Schoonman, 2011). Milk production is pre-dominantly rural and is divided between two types of production systems, namely extensive and semi-intensive/intensive systems. Extensive systems are characterised by displacement of cattle from one place to another in search of fodder (seen in pastoralist or agropastoralist contexts), intensive systems by cutting and carrying of fodder and supplementation, and semi-intensive systems by a combination of grazing and stall feeding. Milk production is pre-dominantly rural with about 95% of all cattle in the country (predominant breed is the Tanzania shorthorn zebu) raised extensively by pastoral and agro-pastoral farmers (Msalya, 2017). Milk is sold either in rural areas, mainly to neighbours and local restaurants, or in the neighbouring urban centres to obtain additional income; the volume of milk imports match local production (Kurwijila et al., 2012). There is abundant feed during the "long", intense (March to May) and short, less intense (between October and December) rainy seasons, leading to high milk production and lower prices. The inverse trend is observed during the dry season (Kurwijila et al., 2012). Because of low fodder quality, scarcity of land for production, lack of technical knowledge, capital and market chains, feed preservation is limited (Lukuyu et al., 2016). Seasonal milk production, poorly organised marketing procedures, limited processing, transport and storage options, lack of inspection or disease control, and fluctuating prices constitute hindrances to the commercialisation of dairy products (Kurwijila et al., 2012; Msalya, 2017).

A range of studies reported on milk safety in Tanzania. They included concerns over milk hygiene because of a lack of clean water, inadequate transport containers, poor refrigeration and a lack of understanding of hygiene (Schoder et al., 2013); documentation of bacteria in milk samples from milk marketing agents in Tanga city (Swai and Schoonman, 2011), and from smallholder dairy farmers, street vendors and outlet shops in Arusha and Arumeru districts (Lubote et al., 2014). Schoder et al. (2013) tested milk in the regions of Dar es Salaam and Lake Victoria and isolated *E. coli O157:H7* as well as *Salmonella* spp. from a tenth of raw milk samples. However, these were absent in heat treated samples except for coliforms which were detected in 41% of processed milk samples possibly due to recontamination attributable to unhygienic packaging at the plants. In 54 milk samples from cattle owning households, milk collectors, and retailers in ten villages in Tanga region, more than 90% of all handled milk samples were above the East African Community maximum acceptable standard for bacterial total plate counts (Hyera, 2015). In a related study in Morogoro region, milk samples from 82 producers tested negative for *E.coli 0157:H7* and 17.1% were positive for *Brucella abortus* (Joseph, 2013). In another study, 238 out of 328 (73%) raw (fresh) milk samples from the regions Morogoro, Coast, and Tanga in Tanzania tested positive for ten groups or species of bacteria including a range of foodborne pathogens (Msalya, 2017).

Heat treatment is a common strategy to reduce bacterial contamination in milk. Commercial pasteurisation protocols improve milk safety considerably without perceptibly changing the nutritional value of milk (Claeys et al., 2013). However, boiling of milk at high temperatures for a prolonged period of time decreases the nutritional value as vitamins like B12, thiamin, B6 and C get destroyed or reduced; for example heat treatment of skimmed milk at 100 °C for 30 min caused a loss of vitamin B12 by 86% (Kilshaw et al., 1982). Many rural and urban populations in Tanzania consume raw milk, increasing their risk to zoonotic disease. In previous studies it was found that smallholder dairy farmers claimed to boil milk for home consumption but not the milk for sale; 80% of agro-pastoralists claimed to boil milk whilst the practice was uncommon among pastoralists (Shirima et al., 2003).

To the authors' knowledge, there are no studies available that look at food safety and nutritional gains in the informal dairy value chain in Tanzania in an integrated way. There are several studies that focus on single aspects, such as breeding performance or marketing studies that may affect food and nutrition security, or foodborne hazards at one node in the supply chain but none aims to link producer and consumer practices and perceptions that influence the relationships between food safety and nutrition and the availability and safety of milk. The aim of this scoping study therefore was to conduct a rapid integrated assessment looking explicitly at both food safety and nutritional risks and to get an understanding of trade-offs in the informal dairy value chain in Tanzania with a focus on major constraints to increasing production of milk (e.g. genetics, feed, disease). The objectives were (1) to characterise the production and consumption patterns of milk in the informal dairy value chain in Tanzania, (2) to identify factors influencing its availability and safety, and (3) to describe linkages between nutritional and food safety outcomes.

[1] Afghanistan; Djibouti; Egypt; Iraq; Morocco; Pakistan; Somalia; South Sudan; Sudan; Yemen.