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Assessing the effects of policy change on households and children's milk consumption in peri-urban Nairobi, Kenya

Master thesis

by

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Declaration

I hereby declare that I, Franziska Anna Schneider, born on 12th of November 1991, matriculation number 638278, completed the Master's thesis attached to this declaration independently and solely using the sources listed in the references and that it has not been submitted anywhere else. All passages of the thesis which were taken word-for-word or paraphrased from publications or other sources are marked appropriately.

Supervisor: Prof. Dr. Manfred Zeller
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Topic of Thesis: Assessing the effects of policy change on households and children's milk consumption in peri-urban Nairobi, Kenya
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ABSTRACT

Although 86% of the Kenyan milk is supplied through informal markets, policy makers aim to decrease the milk sold through informal markets due to safety and quality concerns. A potential decrease of the supply through the informal market would therefore increase its price. This study assesses the dairy product purchase and consumption patterns across income groups in peri-urban Nairobi with a special focus on children aged 6 to 48 months. It furthermore fits a demand system to examine the shift in demand of food items and dairy products driven by income and prices. Therefore, expenditure and cross-price elasticities of milk and other food items are estimated. It additionally fits a choice experiment on changes in purchase and consumption levels based on an increase in raw milk prices.

Results indicate that raw milk accounts for 83% of dairy consumption per households. Households spent on average 73% of their monthly income on food items. The lower the income, the more was spent on food items and on cheaper food items like grains.

Children aged 6 to 48 months consumed on average 42 liter of dairy products per year, out of which 36 liter were consumed in the form of raw milk.

The results of the demand system indicate that households would increase their demand for dairy products by 9.4% if the income increases by 10% and decrease their demand for dairy products by 6.3% if prices increase by 10%. On the non-aggregated level, results show that raw milk and Omena fish are most sensitive to changes in price. Raw milk will be mostly substituted with Omena fish, banana and eggs.

The results of the choice experiment show that households will either decrease raw milk consumption for all family members while replacing it with another product or keep the same quantity for children below 4 years and decrease it for the rest of the family if raw milk prices were to increase to 100 KES/ liter.

Keywords: Quadratic Almost Ideal Demand System, Elasticities, Nairobi, Raw milk consumers

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Table of content

Table of abbreviations

AFC	Agricultural Finance Corporation
AI	Artificial insemination
AIDS	Almost Ideal Demand System
ANOVA	Analysis of variance
ASF	Animal-source foods
CBO	Community-based organization
FAO	Food and Agriculture Organization
GADS	Generalized Addilog Demand System
GAIDS	Generalized Almost Ideal Demand System
GDP	Gross domestic product
ILRI	International Livestock Research Institute
KCC	Kenya Co-operative Creameries Limited
KDB	Kenya Dairy Board
KEBS	Kenya Bureau of Standards
KES	Kenyan Schilling
LA-AIDS	Linear Approximate Almost Ideal Demand System
LES	Linear Expenditure System
MoALF	Ministry of Agriculture, Livestock and Fisheries
MoH	Ministry of Health
NGO	Non-governmental organization
ODK	Open Data Kit
QUAIDS	Quadratic Almost Ideal Demand System
SSMV	Small scale milk vendors
UHT	Ultra-high-temperature

List of tables

List of figures

1 Introduction

Despite improvements in the reduction of malnutrition of children worldwide, 156 million children under 5 were still affected by malnutrition in 2015 (Unicef et al. 2014). In Kenya, 26% of under 5 years old are stunted and 11% are underweight (Worldbank 2016). Due to a rapid urban growth in combination with poor governance, many urban residents are living in so called informal settlements that are characterized by poor livelihood conditions, inadequate sanitation and water infrastructure, poor child feeding and high levels of food insecurity (Kimani-Murage et al. 2015). In informal settlements, the prevalence of stunting of under 5 year old children can be even higher. Dominguez-salas et al. (2016) reported that 41.5% of the children were stunted in low-income households in deprived areas of Dagoretti (Nairobi), and found that 74% of the children were anemic. Childhood malnutrition can have severe impacts including physical disabilities, impaired cognitive development and an increasing risk of morbidity and mortality. Mothers, who were underweight in their childhood, are furthermore more likely to have babies with a low birth weight and a greater risk of infant mortality. Those factors can uphold to the subsequent generations (James et al. 2015).

One way to improve the nutritional status of children is to increase their consumption of animal-source foods (ASF) which are often lacking or present in insufficient amounts in the diets of children in developing countries. Among the ASFs, milk plays a unique role in the development of children (Dror & Allen 2011). Studies have shown that an increase in the consumption of milk and other ASFs, such as meat and eggs, has a positive effect on the physical growth and cognition of children (James et al. 2015) as well as reducing morbidity and mortality (Cornelsen et al. 2016). James et al. (2015) found that a major constraint of an increase in the consumption of milk and other ASFs is the low purchasing power of households living in informal settlements. They also suggested that a small decrease in the price of milk would lead to a proportionally larger increase in the purchase and consumption of milk. This shows that, according to James et al. (2015), ASFs have generally high price elasticities in low-income populations. On the contrary, Cornelsen et al. (2016) reported low price elasticities for ASFs, and the Smallholder Dairy Project (2004b) determined that milk is considered a necessity among poor people with a low response in consumption of raw milk if the price rises. Furthermore, Pinstrup-Andersen (1985) showed that the price elasticities often increase as incomes decrease, which means that a given increase in milk price will lead to a higher percentage reduction in milk

demand among poor people. To deal with higher prices, poorer people might reduce their consumption of food items, with implications for health and nutritional intake (Smallholder Dairy Project 2004b).

The demand for milk and milk products in Kenya is among the highest in developing countries (Smallholder Dairy Project 2004b). Masembe Kasirye (2015) estimated that the annual per capita milk consumption accounts for 130 liters in Kenya which is more than five times higher compared to the milk consumption of other East African countries. In Kenya, most milk is consumed as raw milk because of its cheaper price compared to pasteurized milk (Smallholder Dairy Project 2004b). Furthermore, consumers often prefer the taste of the raw milk over pasteurized milk and it can be sold in variable quantities to suit every household's purchasing power (Blackmore et al. 2015). Raw milk is sold through informal milk markets, which accounts for about 86% of milk supplies to consumers (Kaitibie et al. 2010). Over the last years, many developing countries, including Kenya, are moving towards banning informal milk markets and therefore favor pasteurized milk over raw milk based on concerns on quality and safety of raw milk (Salasya et al. 2009). Countries aim to meet international standards of food safety by implementing policies that criminalize and try to repress the informal sector (Grace & Roesel 2015). However, Omore et al. (2004) found that packaged milk in supermarkets in Kenya is no more likely to meet safety standards than raw milk sold in informal markets. Moreover, most Kenyan households boil milk, which reduces biological foodborne hazards. Additionally, policies aiming to develop formal dairy processing and packaging while suppressing raw milk markets could potentially have a negative impact on the accessibility to milk by children in poor households (Blackmore et al. 2015).

There are many studies which show the importance of milk consumption by children especially in low income countries (Dror & Allen 2011; Dominguez-Salas et al. 2016; Abuya et al. 2012) as well as studies on the price elasticities of dairy products and other food groups in East Africa (Abdulai & Aubert 2004; Cornelsen et al. 2016; James et al. 2015). Yet, there are no studies that focus on the reaction of households´ (and children's) milk consumption and reallocation behaviors to a decrease in raw milk availability and therefore an increase in milk prices. To address these knowledge gaps, this study specifically focuses on (i) the dairy product purchase pattern across income groups and (ii) the investigation of the reaction of households' demand and reallocation for dairy products and raw milk when milk prices increase.

The aim of the study, which belongs to the overall project “MoreMilk: Making the most of milk” conducted by the International Livestock Research Institute, is to assess the effects of an increase in the price of milk sold through informal markets on the milk demand of households in a peri-urban settlement in Nairobi, Kenya, and milk consumption reallocation among households’ members. The increase in the milk price could result from policies promoting packed, pasteurized milk from the formal milk sector or a decrease in raw milk availability. This study will therefore contribute to informing researchers and policy makers about the effects of changes in raw milk availability. With this data, strategies aiming to address children undernutrition in peri-urban settlements can be developed and evaluated.

The concrete objectives of this study are twofold. The first one is to provide up-to-date data on dairy product purchase and consumption patterns across income groups in peri-urban Nairobi with a special focus on the consumption of children aged 6 to 48 months. Second, to measure the shifts in demand driven by income and prices, this study will fit a demand system and will assess food and milk price elasticities below the hypothesis that a ban in informal milk trade will decrease milk availability and therefore increase its price. It will furthermore estimate expenditure and cross-price elasticities of milk and other food items.

The research questions that will be addressed are the following:

- What is the current dairy product purchase pattern in low income households in peri-urban Nairobi? How is this associated with the income level?
- What is the current dairy products intake of children between 6 and 48 months in peri-urban Nairobi and how is this affected by the household income?
- How does the demand of raw milk change when milk prices increase? Will it lead to substitution effects?
- How does household and child consumption of raw milk change when milk prices increase?

The structure of this thesis is as follows: After the introduction, a literature review is conducted of the dairy market in Kenya and the most common demand systems. In chapter 3, data collection as well as the methods used are introduced, which is followed by the results and the discussion chapter. Chapter 5 brings the study to summary and conclusion.

2 Literature review

2.1 Dairy sector in Kenya

Since the introduction of commercial farming in Kenya in the early twentieth century, the production of milk has increased constantly to about 5 billion liters in 2014 (FAOSTAT 2017). The dairy sector plays a significant role in the nation's economy and has the potential to contribute to national development objectives (Muriuki 2011). In 2014, the dairy industry contributed to 14% of the agricultural gross domestic product (GDP) and to 4% of the national GDP with an average annual growth rate of 5 to 7% (KDB 2014). With more than 1.2 million Kenyans being employed in the dairy sector, it represents an important source of income generation, especially for smallholders. Dairy also plays a major role in assuring food and nutrition security in Kenya (Mukumbu & Diang' 2010).

The demand for milk products in Kenya is amongst the highest with a per capita consumption of about 130 liters per year (Masembe Kasirye 2015). Most of the milk is sold in the form of raw milk through informal markets. The demand for milk and dairy products is expected to grow driven by urbanization and a rising middle class. Quality and safety concerns of raw milk have fueled the Kenyan government to move towards the banning of informal milk markets, and promotion of pasteurization of all milk in the market (Salasya et al. 2009).

2.1.1 Dairy industry

The Kenyan dairy industry is one of the largest in sub-Saharan Africa and the second largest agricultural sector in Kenya after the meat sector, in terms of contribution to the GDP. As it employs more people than the meat sector (about 1 million families), it can be seen as the most important sub-sector (African Center for Economic Transformation 2015).

Numerous players are part of the Kenyan dairy sector. At the production level, smallholder dairy farmers dominate the industry (Muriuki 2011). According to Nassiuma & Nyoike (2014), about 1.8 million smallholder dairy farmers depend on the production and sale of milk. In Kenya, small-scale producers yield about 5 – 8 liters per cow per day, while large-scale farmers yield in general 17 – 19 liters per cow and day (African Center for Economic Transformation 2015). Most of the dairy production is performed in the former Rift Valley

Province and the highlands of Central Province. In Rift Valley, 53% of the dairy cattle can be found and in Central Province 25% (TechnoServe Kenya 2008). This distribution can be explained through the moderate temperatures by altitude and therefore a greater and more reliable rainfall than in lower altitudes. Furthermore, as forage production is highly related to rainfall, the risk of diseases is lower in higher altitudes (Reynolds et al. n.d.).
Besides smallholders, there are about 30 licensed milk processors. The four biggest ones combined (New KCC, Brookside, Githunguri and Spin Krit) process more than 80% of the total processed milk in the country. Other licensed milk traders include mini-dairies, producers, cottage industries and cooling plants (Muriuki 2011). The volume of milk processed increased in the last decade with an annual growth rate of about 7% (Gichohi 2014).

The total milk production amounts to about 5.2 billion liters (Kenya Markets Trust 2017) with an annual growth rate of 5.3% (African Center for Economic Transformation 2015). Figure 1 shows that most of the produced milk is cow milk, followed by camel milk and goat milk. Sheep milk plays a negligible role.

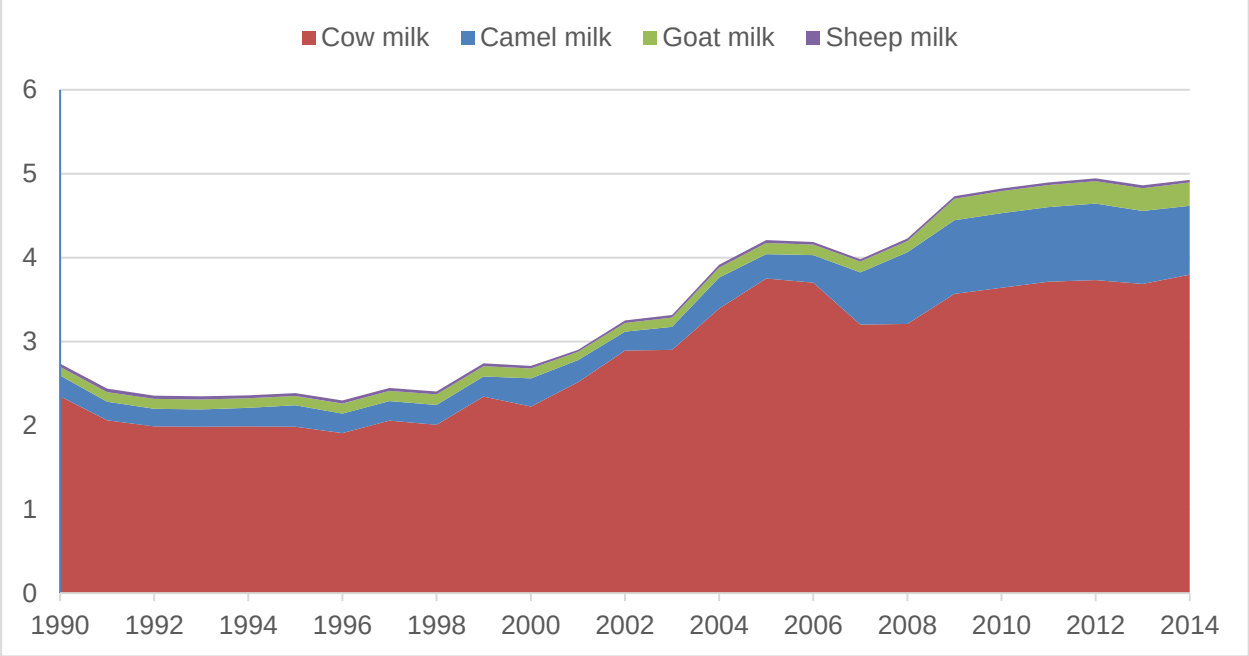

Figure 1: Production of dairy products in Kenya from 1990 to 2014 in billion liters.
Source: Data from FAOSTAT (2016)

Out of total milk production, only 55% are marketed. The other 45% are used for home-consumption, calf feeding and farmer-to-farmer sales (figure 2). Out of the marketed milk, only 20% is sold through the formal, licensed market. The rest reaches the consumer

through the informal market. The milk is sold either directly through farmers to the consumer or at milk bars, shops, kiosks, through mobile traders or dairy coop societies (Smallholder Dairy Project 2004a). Each of these traders sell on average 120 liters of raw milk per day, which enables them to earn twice the national average income (Omore et al. 2005).

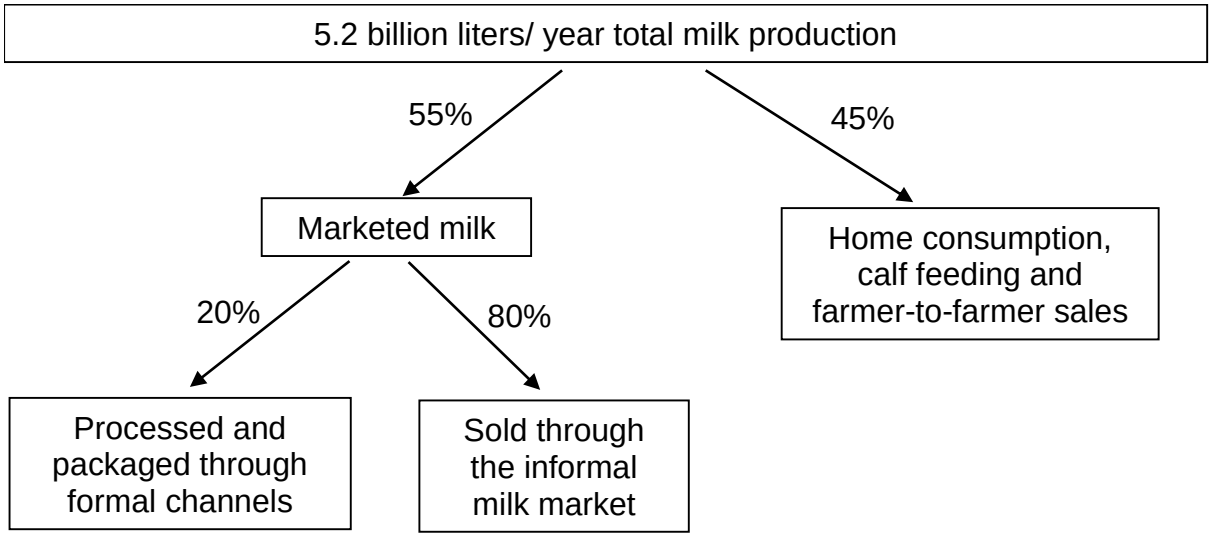

Figure 2: Marketing of milk in Kenya
Source: Based on Kenya Markets Trust (2017)

Informal markets exist in many countries throughout Asia and Africa. Common characteristics include (Grace & Roesel 2015):

- Many retailers do not pay taxes or have a legal status
- Food escapes effective safety and health regulations
- Preference is given to local products, traditional processing and retail practices
- Lack of infrastructure such as electricity, sanitation, water or refrigeration
- Provision of little support from the public or the governmental sector

Poor households and women are particularly involved in informal markets as both sellers and buyers. In Kenya and other countries in Sub-Saharan Africa, the informal milk market offers higher prices for producers and lower prices for consumers compared to the formal market (Grace & Roesel 2015). Therefore, the high share of raw milk which is sold through the informal markets is an indication of the consumers unwillingness to pay more for processed milk and shows furthermore their taste preferences for raw milk (Staal et al. 2008).

Most milk is sold either as raw milk or as its processed equivalent of fresh milk. In the informal market, only about 16% of the milk undergoes processing and is sold as homemade sour milk, butter milk or yoghurt. In the formal market, the same dynamics can be observed. Out of the total processed produce 85% is sold as fresh milk either as short life pasteurized milk or UHT milk. Fermented milk accounts for an additional 7%, powder milk for 3%, yoghurt for 3% and value-added products such as butter and cheese make another 2% (TechnoServe Kenya 2008).

Consumers in rural and suburban areas of Kenya buy mostly raw milk and this directly from producers, kiosks or milk bars. In urban centers, raw and processed milk compete, using mostly the same retail outlets. Kiosks and shops near residential areas sell both processed and raw milk (Muriuki 2011; African Center for Economic Transformation 2015). The consumers preference for unpacked milk has also been notified by supermarkets. The supermarket chain Tuskys started in 2010 to sell milk through milk dispensers in its chain stores. Naivas and other supermarket chains as well as some petrol stations followed Tuskys and sell now milk through milk dispensers (Njanja 2014). In August 2017, 275 milk vending machines (so-called ATMs) were already installed in Kenya which gives consumers the chance to access quality milk at a lower price than from processors (Andae 2017). However, although formal market outlets like supermarkets become more common and start selling milk through milk dispensers, the informal milk sector will remain important for decades to come. Currently, informal markets supply about 85 to 95% of market demand and are predicted to still supply 50 to 70% of market demand in 2040 (Tschirley et al. 2015).

2.1.2 Dairy consumption

The demand for milk and milk products in Kenya is among the highest in developing countries with an annual per capita milk consumption of about 130 liters (Masembe Kasirye 2015). This is more than five times higher compared to the milk consumption of other east African countries. A survey in Nairobi found that households spend on average 17% of their income on dairy products, of which 91% is spent on cow fresh milk (Cornelsen et al. 2016).

The figures of per capita milk consumption in Kenya vary between different studies. The Ministry of Agriculture, Livestock and Fisheries (MoALF 2013) as well as Argwings-Kodhek et al. (2005) reported the annual per capita consumption to be about 100 liters.

A study from Kaitibie et al. (2010) estimated the annual per capita milk consumption to be much higher at 145 liters. The KDB estimates the per capita annual milk consumption to be between 80 and 125 kg (Gichohi 2014). Although this is much higher than the average milk consumption in East Africa, it is still lower than the recommended annual per capita milk consumption of 220 liters from the FAO. Moreover, there is a huge discrepancy between urban and rural milk consumption as well as between different income groups. Njarui et al. (2011) documented an annual per capita milk consumption in rural areas for “milk-producing” households at 45 liters and for “milk-purchasing” households at 19 liters. Urban per capita milk consumption was estimated at 125 liters. Besides, 45% of the milk sold in urban areas was consumed by high income households and the remaining 55% by low-to middle income households. With a higher income, households tend to consume more milk, favor pasteurized milk over raw milk and consume more processed milk products (Staal et al. 2008). Furthermore, Melesse & Beyene (2009) showed that the education level has a great impact on the consumption of milk: the higher the educational level of the food budget manager, the higher the milk consumption of the household.

Many studies show that consumers in Kenya prefer raw milk over pasteurized milk (Mukumbu & Diang’ 2010; Staal et al. 2008; Thorpe et al. 2000). The Smallholder Dairy Project (2004c) identified the reasons why raw milk is so popular. First, raw milk is on average 20 to 50 percent less expensive than pasteurized milk and can be sold in different quantities. Therefore, even poor households can access small amounts of milk. Second, many households prefer the taste of raw milk because generally the cream is not removed from the milk. Third, especially in remote areas, raw milk is more accessible than pasteurized milk and most consumers are accustomed to the consumption of raw milk. Last, consumers feel that after boiling raw milk is safe for consumption. Nevertheless, the consumption of raw milk is of concern due to the potential health risks caused by its microbial load by the time it reaches the consumer, if not boiled before consumption (Muriuki 2011).

Projections about future supply and demand for milk in Kenya vary a lot. Kenya Markets Trust (2017) estimates the total milk production to grow from currently 5.2 billion liter/ year to 12.6 billion liter/ year by 2030. They also projected the per capita consumption to grow to 220 liters by 2030. Gichohi (2014) from the KDB expects that the demand for milk will

outstrip local milk production in the next few years unless the productivity per cow will increase and the post-harvest losses will decrease.

A study from James et al. (2015) showed that ASFs (including milk) have a high price elasticity in low-income populations, which means that a small decrease in the price of milk and other ASFs leads to a proportionally higher demand of the product. Cornelsen et al. (2016) estimated the price elasticity of demand of ASFs in low-income urban areas of Nairobi. According to them, a 10% increase in the price of dairy products would lead to a decrease in demand of dairy products by 9.5%. It would also lead to a decrease in the consumption of beef of 1.7%.

The Smallholder Dairy Project (2004c) showed that the price elasticity of milk in Nairobi and Nakuru in Kenya depends strongly on the type of milk (raw or pasteurized) and the income of the households (table 1). A value of 0 indicates that the consumers wouldn't change their demand of the product if the price increases. A positive value indicates that households would increase their demand of the product if the price increases while a negative value indicates that households would demand less of that product. The higher the absolute value, the stronger the demand response will be.

Table 1: Price elasticity of raw and pasteurized milk in Nairobi and Nakuru, Kenya

Commodity	Elasticity	
	Low-income group	High-income group
Raw milk	-0.12	-0.93
Pasteurized milk	-0.70	-0.21

Source: Edited from Smallholder Dairy Project (2004c)

Table 1 shows that milk is considered a necessary good with a low response to price changes. However, low-income groups wouldn't change their consumption of raw milk much but are more likely to reduce their amount of pasteurized milk. An increase in the price of raw milk of 10% would lead for low-income households to a decrease of raw milk demand of 1.2% and for pasteurized milk to a decrease in the demand of 7%. High-income groups show the opposite effect: they are more likely to reduce their amount of raw milk consumed due to an increase in its price, but would still buy about the same amount of pasteurized milk. Staal et al. (2008) added that the elasticity of highly processed dairy products like cheese or ghee are income elastic, which means that with a higher income the demand for such products will increase.

The preference and high consumption of raw milk implies that especially low-income households would not easily change their milk consumption patterns if raw milk prices would increase. According to the study of the Smallholder Dairy Project (2004c), poor households would rather reduce their consumption of other food products to deal with their budgetary constraints. However, there are no studies that assess with which products the households would substitute a decrease in raw milk consumption and that focus also on changes in the amount of raw milk given to children if milk prices increase.

2.1.3 Milk quality and safety

Milk and other dairy products are highly nutritious, especially for young children and pregnant woman. Milk contains calcium and animal protein, and is an important source of vitamin A, vitamin B12 and riboflavin. Along with other animal source foods, milk consumption has been found to promote children growth and development. It furthermore improves the bone development, reduces protein-deficiency malnutrition and improves cognitive functions of undernourished children (Dror & Allen 2011).

Compared to other animal source foods, milk plays a unique role particularly among poor and vulnerable populations because of its good nutritional value at affordable prices. Dairy is furthermore a primary source of livelihoods for rural populations in low income countries. Milk is also more suitable to children than other animal source foods. Nevertheless, compared to meat, milk has a lower content of iron and zinc (Allen & Dror 2011).

Although milk has a significant positive impact on children's and people's health and development, it can also be a major source of foodborne diseases. Most milk in Kenya is marketed unprocessed and is therefore typically accused of facing milk safety issues. Those include the presence of biological hazards, such as pathogens responsible for foodborne diseases (e.g. Salmonella, Listeria monocytogenes) as well as the presence of drug residues. A significant factor in the high counts of bacteria in raw milk has been identified in the use of plastic cans to transport and store milk which are hard to clean (Rademaker et al. 2016). A study from the Smallholder Dairy Project (2004b) found the bacterial quality of raw milk to be quite low compared to standards and to have some prevalence of brucellosis and tuberculosis. However, nearly all consumers of raw milk

reported boiling the milk before consumption which reduces the risk of infection from bacterial health hazards significantly.

Due to the weak monitoring of the milk market and a lack of efficient safety and quality control, adulteration of milk is a big challenge in Kenya. Adding water or other substances to milk can have negative impacts on the microbial quality, taste and market value (Omore et al. 2005). A study from the Smallholder Dairy Project (2004b) conducted in rural and urban areas of Kenya reported adulteration in raw milk to be on average 10%. Adulteration varied within season, site and location but with the most cases of adulteration to take place during the dry season. Because many consumers are not able to detect adulteration, this favors high levels of adulteration in raw milk (ILRI 2007).

A study from Fadiga & Makokha (2014) assessed the importance of quality and safety attributes of milk as well as the willingness to pay for them. They found that price is the most important attribute of milk, followed by smell, hygiene and color for low-income households. They were willing to pay more for not smelly, creamy and clean milk but not for milk in sealed package. These results agree with the study from Walke et al. (2014), which found that the majority of the Kenyan study population is willing to pay more for improved quality.
There are many laws and regulations on milk safety. Regulations include licensing, certification, authorization and permits required by those involved in the dairy value chain. The KDB states that “The Kenya dairy industry does its utmost to supply products that meet all its customers’ expectations, high quality, healthy and safe” (Muriuki 2011).

The justification for previous policies favoring processed milk over raw milk was the assumption that raw milk is unsafe, and that pasteurized milk is safe for consumption. However, a study from Omore et al. (2005) showed that the quality of raw milk is not any worse than the quality of pasteurized milk. Furthermore, a study from Walke et al. (2014) found that 99% of raw milk consumers boil their milk prior to consumption. The justification from policies to shut down the informal sector due to safety concerns of raw milk does not seem to be supported by the available evidence up to date. Furthermore, Grace (2014) showed that there could also be an unintended consequence of safer milk. Safer milk involves more costs and may therefore be too expensive for the poor, which could lead to micronutrient deficiencies and stunting.

2.1.4 Access to finance, inputs and services

The availability of agricultural credit institutions is critical for a positive development of the dairy sector. In Kenya, the most important but not most popular one is the Agricultural Finance Corporation (AFC). Furthermore, there are commercial banks as a source for credit and micro-finance institutions. However, commercial bank credits are mostly unsuitable for farming. In addition, cost of credit, inadequate grace periods and collateral requirements make it difficult for smallholders to access commercial bank credits. Smallholders rather use credits in form of dairy value chain financing – which means that farmers can be paid before they deliver the milk or get credits on inputs (Muriuki 2011; Rademaker et al. 2016).

In order to address the problem of limited access of subsistence farmers to both farm inputs and outputs, the International Livestock Research Institute (ILRI) partnered with Heifer International and other organizations to implement a hub approach in East Africa in 2008. It aims to increase the dairy income of subsistence farmers through interventions along the dairy value chain like improvement of farm productivity and market access. The dairy hubs itself serve as community anchors for industry knowledge sharing, market access and business services. In the beginning, the hub approach strengthens or implements a network of inputs and services providers as well as a setup of a credit facility mechanism. It will then become a platform where other service providers and input suppliers can reach smallholder families. The dairy hub is, when fully functioning, a dynamic cluster of activities and services that generate a greater income for dairy smallholders and a successful triangulation between business delivery services, milk traders and milk producers (Worsley 2012). Results show, that smallholders who registered in such a hub have a greater household dairy income (Baltenweck 2014).

The dairy sector in Kenya faces many challenges. Constraints to an increase in the milk production include the seasonality of production, inadequate quantity and quality of the feed and a lack of good farming practices (Nassiuma & Nyoike 2014). Inadequate access to AI services due to high costs, high-cost animal health care and inefficient input supply are other identified challenges. Together with a poor infrastructure in some parts of Kenya, inadequate marketing system and milk collection, limited farmers' involvement in the output market, fluctuations in the milk supply and a lack of quality up-to-date data on the dairy sector hinders the successful development of the dairy sector in Kenya. To

mitigate the challenges the dairy industry is facing, the Kenyan government has taken several intervening steps. Those steps include tax incentives and investments in research and policy development (Muriuki 2011; Nassiuma & Nyoike 2014).

2.1.5 Policy and regulatory environment

The Kenyan dairy sector is characterized by the involvement of several institutions, partners and enablers. Value chain participants include regulators, input suppliers, market agents and service providers. Moreover, partners and enablers like research and development organizations, farmers and their groups/ organizations, non-governmental organizations (NGOs), community-based organizations (CBOs), and development partners belong to it (Muriuki 2011).

The Kenya Dairy Board (KDB) plays the lead role in dairy regulatory institutions in Kenya. It was established in 1958 under the Dairy Industry Act Cap 336 of the laws of Kenya. The aim of the KDB is the regulation, organization and development of the efficient production, marketing, distribution and supply of safe and high-quality dairy products (KDB 2014). It furthermore aims to ensure fair competition among the operators in the industry and the organization and capacity building of the stakeholders in the dairy industry to enhance efficiency and self-regulation (Nassiuma & Nyoike 2014).

Besides the KDB, the Ministry of Agriculture, Livestock and Fisheries (MoALF) plays a role in regulation and policy direction of the sector as well as the Kenya Bureau of Standards (KEBS) (Rademaker et al. 2016). The role of KEBS is to set and enforce standards for dairy products (and all other products and services). Furthermore, the Public Health Division which operates within both the Ministry of Health (MoH) and local authorities, controls and ensures the maintenance of hygiene in milk handling activities (Muriuki 2011). However, these regulations are not working properly to ensure milk quality and safety. Muriuki (2011) pointed out, that problems in the regulation arise because of a lack of personnel, equipment and other resources required to promote activities. Instead of focusing on solving these problems, most effort is put into the collection of fees and enforcement of regulations. Therefore, milk quality is of a big concern in Kenya. The African Center for Economic Transformation (2015) added that the KDB does not seem to recognize the consumers preferences for raw milk and that it sees the future of the dairy market to be rather in the processed milk sector. On the other hand, the Ministry of Agriculture, Livestock and Fishery (MoALF 2013) emphasizes that the KDB has

increased the producer price of milk in the recent years as well as increased the milk intake by processors. The volume of processed milk has increased by 7% per year with about 600 million liters sold in 2016 (Gichohi 2014). However, the KDB recognizes the need to look at the informal sector more closely for public health risks.

In the past, dairy cooperatives have played a significant role in the dairy sector in Kenya. They contributed to the development of the smallholder milk marketing through the provision of inputs and services and reduced the costs of milk marketing through bulking. However, nowadays cooperatives play a minor role in the dairy sector due to poor management, corruption and the inability to adapt to change (Muriuki 2011; MoALF 2013).

Before 1992, the dairy industry in Kenya was regulated by the government, which set the milk prices, gave policy guidelines, set the market rules and determined the players in the industry. KCC was a monopoly processing and marketing milk and dairy products. After liberalization in 1992, KCC lost its monopoly and milk prices were deregulated (MAFAP 2013). This reform led to a rapid growth of the informal market with a huge increase in the sale of raw milk (Wambugu et al. 2011).

However, up to 2004 under the old dairy policy, informal vendors and milk transporters were not officially recognized. They frequently got into trouble because powerful dairy market players wanted to increase their market share and the government expressed safety concerns over informal marketed milk. Since 2004, the Dairy Policy now acknowledges the role of small scale milk vendors (SSMVs) and KDB offers a training and certification scheme for those SSMVs (Wambugu et al. 2011). After completing the training and paying a fee the traders get licensed (Johnson et al. 2015). KDB adds, that since 2003 the Kenyan government took several additional measures to improve the milk production and marketing. Those steps include among others the revival of the New KCC and other farmer organizations and cooperatives, review of dairy policies and regulations, encouragement of private sector and development partners to invest in the dairy sector and a better use of resources (Wambugu et al. 2011).

Still, most of the policies implemented are in favor of pasteurized milk. To meet international standards of food safety, the government of Kenya launched in 2015 a campaign to promote the consumption of packed, pasteurized milk. KDB managing

director Margret Kibogi said, that “unpasteurized milk is very dangerous to the lives of the public and causes diseases” (Gikundi 2016). Further current public health interventions include the promotion of the selling of boiled milk and a ban of raw milk value chain (Alonso 2017). MoALF (2013) further proposes policy interventions that support the investment in long-life milk products and that encourage milk processors to engage in milk collection in the rural areas.

The Kenya National Dairy Master Plan sets a vision for the growth of the dairy sector. Its strategic vision is “to transform milk production and trade into an innovative, commercially oriented and globally competitive dairy value chain by 2030” (Ministry of Livestock Development 2010). The focus is to increase the productivity and competitiveness of the dairy sector. By 2030 it aims to increase the share of marketed milk to 75% and to reduce the milk sold through informal channels to 35%. However, given the popularity of raw milk in Kenya, it is not clear how this strategy will be implemented (African Center for Economic Transformation 2015; Rademaker et al. 2016).

The milk market in Kenya is clearly separated in a formal and an informal market with consumers preference given to raw milk, especially among poorer households. KDB has partly acknowledged these preferences through the licensing of informal milk traders. However, according to the Kenya National Dairy Master Plan, the KDB plans a future in which over half of the marketed milk is processed/ pasteurized. Policies move towards banning raw milk commercialization which will likely decrease the raw milk availability and likely subsequently increase milk prices. This could lead to negative effects on the food and nutrition security of poor households and especially of children due to inability to purchase enough milk. However, the impacts of such policies on the diets of children in poor families have been rarely studied. It is therefore important to investigate the contribution of the informal milk sector to the diet and nutrition security of poor households and especially of poor children and the effect that decreases in milk availability and increases in prices may have in the milk purchasing behavior of poor households (Smallholder Dairy Project 2004d; African Center for Economic Transformation 2015).

2.2 Demand systems

Consumers make choices every day on what and how much to buy and consume. Therefore, the main purpose of demand theory is to explain how a rational consumer would choose what to consume (Sadoulet & De Janvry 1995). A rational consumer refers to a consumer who seeks to maximize satisfaction or utility in spending his or her income (Salvatore 2008). However, the more of an identical item an individual acquires, the less he or she will desire more units of this specific product. This law of diminishing marginal utility is one of the fundamental principles of consumer demand behavior. The overall maximum utility from one individual is reached when all “last goods” consumed have the same marginal utility (Simple Economist 2017).

One can consider an individual with its utility function *u(q, z)* where *q* is the vector of quantities of *n* commodities on which a consumption decision must be made and *z* are individual characteristics like education, family size or area. The budget constraint is *p´q = y*, where *y* is the amount of money the individual can spend and *p´* is an *n*-dimensional row-vector of prices. The individual seeks to maximize utility with respect to *q*, subject to the budget constraint *p´q = y.* This can be written as:

$$\max u(q,z) + \lambda(y - p'q) \tag{1}$$

where λ is a Lagrange multiplier. To solve this maximization problem, a set of *n* demand equations can be used (Sadoulet & De Janvry 1995)

$$q_i = g_i\,(p,y,z),\ i = 1, \ldots, n \tag{2}$$

The estimation of single demand functions involves some constraints. The quantity projections obtained may not satisfy the requirements of demand theory, especially the budget constraint. Therefore, complete systems of demand equations need to be specified and estimated. Those must be able to take into account the mutual interdependence of large number of commodities in the choices made by consumers (Sadoulet & De Janvry 1995).

The first complete demand system was developed by Stone in 1954 and called the Linear Expenditure System. Since then, several new demand systems have been developed

and applied in empirical analysis. The price and income elasticities obtained from these empirical analyses have been used for policy interventions and projections. Because of the existence of many demand systems, it is important to know about the advantages and disadvantages of each system, as different demand systems could result in different estimations. Hence, the choice of the right demand system is an important step and determines the outcome of the study (Meyer et al. 2011).

The current chapter will provide an overview of five of the most common demand systems used in research. Each of the demand systems will be briefly introduced, their methods will be presented and the advantages and disadvantages highlighted.

2.2.1 Linear Expenditure System (LES)

The Linear Expenditure System (LES) was introduced by Richard Stone in 1954. It is the first empirical demand system that fulfills all general conditions of demand theory (Meyer et al. 2011).
The equations are linear in expenditure and the LES can be estimated with the formula:

$$p_i q_i = p_i \alpha_i + b_i \left(m - \sum_{j=1}^{n} p_j \alpha_j \right) \tag{3}$$

where p_i, q_i and m are the price, quantity and expenditure of product *i*, respectively. α_j is the subsistence parameter. This means that the individual first purchases α_j units of good *i* at a cost of $p_j \alpha_j$ which is called subsistence consumption. With the total cost of subsistence being $\sum_{j=1}^{n} p_j \alpha_j$, it leaves $m - \sum_{j=1}^{n} p_j \alpha_j$ as a supernumerary expenditure. b_i is therefore the parameter of how a consumer allocates his supernumerary expenditure over different commodities (Chang & Fawson 1994).

Because of the underlying utility function, the following assumption is necessary:

$$q_i > \alpha_i \tag{4}$$

It is essential to add the following restrictions, to satisfy adding up and symmetry conditions:

$$\sum_{i=1}^{n} b_i = 1 \text{ and } b_i > 0 \tag{5}$$

The LES assumes independence of the marginal utility of consumption of one commodity of the quantities consumed from other commodities. It is unlikely that this assumption will hold across all consumers and commodities. The LES is therefore a more reliable model where the level of aggregation is very high and where separate estimations for separate income classes can be done (Williamson & Shah 1981). Another weakness of the LES is that the Engel-flexibility is restricted because of constant marginal budget share (Meyer et al. 2011). Nevertheless, part of the disadvantages is offset by the advantages that the LES imposes. For instance, the LES only needs a limited number of independent parameters (2*k*-1, where *k* is the number of commodities), which makes its application easy (Meyer et al. 2011). It furthermore satisfies the theoretical restrictions of adding up, symmetry and homogeneity, parameters are ready to be interpreted and it is relatively easy to estimate (Williamson & Shah 1981).

Williamson & Shah (1981) used the LES in their study to estimate expenditure and price elasticities of demand for different food items in Kenya. In their study, all price elasticities were negative because of the strict specification of the model. For dairy products, the own-price elasticity added up to -0.382 and the expenditure elasticity to 0.745. The average budget share was 4.2% among all expenditures, food and non-food items. However, the study mentions a limitation of the LES which could have potentially impacts on their results. They mention, that substitution effects between substitutes or complementary commodities are not part of the formulas for the price elasticities of the LES. Therefore, the LES lacks flexible substitution effects. Nevertheless, Phlips (1983) concluded that the LES is a practical model if the goods are broadly grouped and the price variations within these groups are restricted.

2.2.2 Translog model

The “Transcendental Logarithmic” or “translog” demand system was developed in 1975 by Christensen, Jorgenson and Lau. The translog model is a generalization of the Cobb-Douglas function. It is a flexible functional form providing a second order approximation (Sadoulet & De Janvry 1995). The logarithmic form of the translog production function is the following:

$$\ln y = \ln \alpha_O + \sum_{i=1}^{n} \alpha_i \ln x_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} \ln x_i \ln x_j \qquad (6)$$

where α_O is the efficiency parameter, x_j input j, and α_i and β_{ij} (all *i, j* = 1, …, n) are unknown parameters to be estimated.

The biggest advantage of the translog model is that it has a functional form with less restrictions on production elasticities and substitution elasticities. However, compared for example to the LES, it is more difficult to interpret and requires the estimation of many parameters (K+3+K(K+1)/2, with K being the number of inputs) (Holt & Goodwin 2009).

Agbola et al. (2003) used the translog system to estimate the household food demand in South Africa. Food items were therefore grouped into six broad food groups, including dairy products. The compensated own-price elasticity was estimated to be -0.55 with the translog system and the expenditure elasticity 1.277. However, the authors question the reliability of those elasticities, because most of the calculated elasticities were contrary to expectations. They conclude, that the choice of the demand system has an impact on the elasticity estimates.

2.2.3 Rotterdam model

The Rotterdam model was first proposed by Theil (1965) and Barten (1964). According to Clements & Gao (2014) it was a breath-taking innovation because "this system of demand equations allowed for the first time rigorous testing of the theory of the utility-maximizing consumer".

The Rotterdam model starts with demand functions. It then takes the total differential and uses utility-maximization theory to impose restrictions (Clements & Gao 2014). The conditional absolute price version of the Rotterdam model is given by:

$$\bar{w}_{it} Dq_{it} = \mu_i DQ_t + \sum_{j=1}^{n} \pi_{ij} Dp_{jt} + v_{it} \qquad (7)$$

where $\bar{w}_{it} = {}^{1}/_{2}\left(w_{i,t} + w_{i,t-1}\right)$ is the average budget share of good i between the periods t – 1 and t, v_{it} is stochastic disturbance, and $DQ_t = \sum_{i=1}^{n} \bar{w}_{it} Dq_{it}$ is the log-change in real income (Barnett & Seck 2008). Furthermore, q_i is the quantity consumed of item i in the time period t and p_j is the price of item j in the time period t (Kinnucan et al. 1997). μ_i is a parameter known as the marginal share of a good *i*. π_{ij} is the substitution effect of a change in the price of good *j* on the demand for good *i* when real income is held constant, also known as the Slutsky parameter (Clements & Gao 2014).

The Rotterdam model has been widely adopted because of its simplicity and transparency (Clements & Gao 2014). It can be estimated in a linearized form where theoretical restrictions can be easily imposed and tested (Barnett & Seck 2008). Furthermore, it

allows for the estimation of substitutes and complements. Because total expenditure can be divided into groups of goods, preferences in one group can be analyzed independent of the quantities in other groups (Seale et al. 2003). Together with its consistency within the demand theory and the same flexibility as any other local approximation form, it became a prominent position in demand analysis (Kinnucan et al. 1997).
However, the Rotterdam model also possesses some limitations. According to Seale et al. (2003), the Rotterdam model yields counterintuitive results in terms of changes in income because it produces constant marginal shares. In their study, Meyer et al. (2011) found that the Rotterdam model performs well when the substitution between goods are low but with a high substitution of goods the model performed poor. Further limitations include generality, tractability and ease of interpretation (Clements & Gao 2014). It is also limited in its application with cross-sectional data because of its first difference approach (Gao et al. 1994).

Anwar et al. (2012) applied the Rotterdam model to major food items in Pakistan, including milk. They used cross-sectional data from household expenditures surveys. To estimate own price elasticities, cross price elasticities and expenditure elasticities a complete demand function was computed by estimating a system of share equation subject to the restriction with the help of Seemingly Unrelated Regressions (SUR). Because there was no availability of data on food prices, they used the ratio of expenditure to purchased quantity as a proxy for prices. The compensated own-price elasticity for milk in Pakistan was -0.648 and the expenditure elasticity 0.682 and in accordance with their theoretical expectations. In terms of compensation the authors found that milk is compensated only with fruits.

2.2.4 Almost Ideal Demand System (AIDS)

In the field of agricultural economics, both the Rotterdam model and the AIDS, developed by Angus Deaton and John Muellbauer in 1980, are frequently used in demand analysis. They are attractive because of inter alia their flexibility, compatibility with demand theory, plausibility and ease of use (Alston & Chalfant 1993). Nevertheless, according to Taljaard et al. (2004), the AIDS appears to be the most popular one out of all demand systems.
The i^{th} equation in the AIDS is given by (Taljaard et al. 2004):

$$w_{it} = \alpha_i + \sum_j^n \gamma_{ij} \ln p_{jt} + \beta_i \ln\left(\frac{m}{a(\mathbf{p})}\right) + u_{it} \quad \text{i = 1,…,n} \tag{8}$$

where, in observation t, w_{it} is the budget (expenditure) share of the i[th] good; p_{jt} is the nominal price of the j[th] good, $\ln m$ is total expenditure; u_{it} is the error term and $\ln a(\mathbf{p})$ is the translog price index which is defined by:

$$\ln a(\mathbf{p}) = \alpha_0 + \sum \alpha_j \ln p_j + \frac{1}{2}\sum_i^n \sum_j^n \gamma_{it} \ln p_{it} \ln p_{jt} \quad \text{t = 1,…,T} \tag{9}$$

However, this price index makes the system non-linear. This complicates in most cases the estimation process. Therefore, Deaton & Muellbauer (1980) suggested to use the linear price index. In the so-called linear approximate (LA) version of the AIDS the translog price index is replaced by the Stone's price index:

$$\log a(\mathbf{p}) = \sum_{i=1}^{n} w_{i,t} \log p_{i,t} \tag{10}$$

The LA-AIDS can be then written as (Akinbode 2015):

$$w_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_{jt} + \beta_i \ln\left(\frac{m}{a(\mathbf{p})}\right) + \sum_{k-1}^{m} \lambda_k D_k + u_{it} \tag{11}$$

Another shortcoming of the AIDS includes the limitation of the flexibility in expenditure. Therefore, Banks et al. (1997) proposed the Quadratic Almost Ideal Demand System (QUAIDS). They added a quadratic term to the AIDS equation:

$$w_{ij} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{m}{a(\mathbf{p})}\right) + \frac{\lambda_i}{b(\mathbf{p})}\left\{\ln\left[\frac{m}{a(\mathbf{p})}\right]\right\}^2 \tag{12}$$

where $b(\mathbf{p})$ is the Cobb-Douglas price aggregator.

Because the QUAIDS has rank three, it is more adequate to approximate non-linear Engel curves in empirical analysis. Furthermore, it is flexible in the representation of income effects and, compared to the regular AIDS and translog models, it has the same degree of price flexibility (Xi et al. 2004).

Another further development of the AIDS is the Generalized Almost Ideal Demand System (GAIDS). The GAIDS is a combination of the LES and AIDS and was developed by Bollino in 1990. It uses the concept of committed and supernumerary expenditures of the LES while adding flexibility to the estimated elasticities (Sadoulet & De Janvry 1995). It replaces the fixed proportions in the LES (b_i) by an AIDS specification to make it a function of income and price. The GAIDS in share form can be then expressed as:

$$w_i = \frac{p_i c_i}{M} + \frac{M^*}{M}\left[\alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln(p_j) + \beta_i \ln\left(\frac{M^*}{P}\right)\right] \quad \text{i, j = 1,…,N} \tag{13}$$

where w_i is the budget share associated with the i[th] good; p_i represents the price of the i[th] good, c_i is the quantity of good i; M is the total expenditure; M^* represents supernumerary expenditure; $\ln P$ is a non-linear price index; and α_i, γ_{ij} and β_i are parameters to be estimated (Zheng & Henneberry 2009).

The AIDS as well as its further developments has been widely used in demand analysis due to its linearity, flexibility and because it satisfies the axioms of choice exactly. Other advantages include that it is as flexible as other locally functional forms but is additionally compatible with aggregation over consumers. It can therefore be used in terms of economic models of consumer behavior when estimated with both disaggregated (household survey) and aggregated (microdata) data. It furthermore has a functional form which is consistent with known household-budget data (Taljaard et al. 2004).

However, to estimate the AIDS a big sample size is most often required because a large number of parameters has to be estimated (Williamson & Shah 1981). Therefore, many studies applying the AIDS/ LA-AIDS/ QUAIDS use national survey data with big sample sizes (for example Weliwita et al. 2003; Heien et al. 1990; Xi et al. 2004). Nevertheless, recent studies from Akinbode (2015) and Cornelsen et al. (2016) showed, that the estimation of the AIDS is also possible with a small sample size of less than 350 households. Cornelsen et al. (2016) used data from a cross-sectional household survey among 205 randomly chosen households in two settlements in Nairobi to estimate the demand for ASFs using the AIDS. The results of the AIDS provided measures of demand elasticity for changes in food expenditure and food prices. Because their data included many zero-observations (i.e. non-purchases), they employed a two-step sample selection approach. The own-price elasticity for dairy products was -0.955. According to the study, the beef consumption would increase if prices for dairy products increase.
Williamson & Shah (1981) not only used the LES to estimate expenditure and price elasticities of demand for different food items in Kenya, but also the AIDS. They only found for dairy products, vegetables and fruits an elastic price response. Although they had poor price data, they could estimate the effect of income changes on consumption using the AIDS. In comparison with the LES, the authors recommend using the AIDS, because it better fills the needs of a general equilibrium model.

2.2.5 Generalized Addilog Demand System (GADS)

The specific form of the GADS was developed by Bewley & Young in (1987). According to Bewley (1987), the GADS makes sure that the sum of the component demand is identical to total expenditure. Additionally, due to the nature of the functional form, it ensures that the implied demands for all goods are positive. The GADS equation is specified by:

$$\overline{w_{it}} \ln\left(\frac{q_{it}}{w_t^+}\right) = \alpha_i + \theta_i \ln\left(\frac{y_t}{P_t}\right) + \sum_{j=1}^{n} \pi_{ij} \ln p_{jt} \qquad (14)$$

where $\bar{w}_{it}$ represents the average budget share of the i[th] good in period t; q_{it} is the quantity of the i[th] good in period t; θ_i is the marginal budget share and π_{ij} the Slutsky parameters (Gracia et al. 1998).

Bewley (1987) argued that the GADS has not a flexible functional form like the AIDS or the translog model because it does not have an arbitrary second-order approximation to the utility or cost function. However, empirical comparisons of functional forms suggest that the GADS performs well in an empirical sense. It can also outperform more conventionally based models.

Gracia et al. (1998) estimated the Spanish food demand using the GADS as well as price elasticities and expenditure for six food groups. The expenditure elasticity for the food group milk/ eggs was estimated to be 0.64 and the own-price elasticity to be -0.56. The change in the price of milk/ eggs has therefore a negative effect on the milk/ eggs consumption.

3 Materials and methods

3.1 Description of study population

A structured household survey was carried out in May and June 2017 in Dagoretti, a peri-urban area in Nairobi, Kenya. Dagoretti sub-county has a total population of 360,000 (as of 2009), which is about 11.5% of the total population of Nairobi (InfotrackEA 2009). It is characterized by high unemployment rate of about 60%, high prevalence of HIV/ AIDS and crime (Kang'ethe et al. 2012). It has furthermore a large proportion of low-income urban slums and a high migrant population (Kang'ethe et al. 2012).

Dagoretti sub-county is divided into 10 wards, whereof 8 were covered in this study as shown in figure 3: Gatina, Kabiro, Kawangware, Mutu-ini, Ngando, Riruta, Uthiru/ Ruthimitu, and Waithaka. Two wards were excluded (Kileleshwa and Kilimani) because they are primarily high-income areas, so excluded based on the study target.

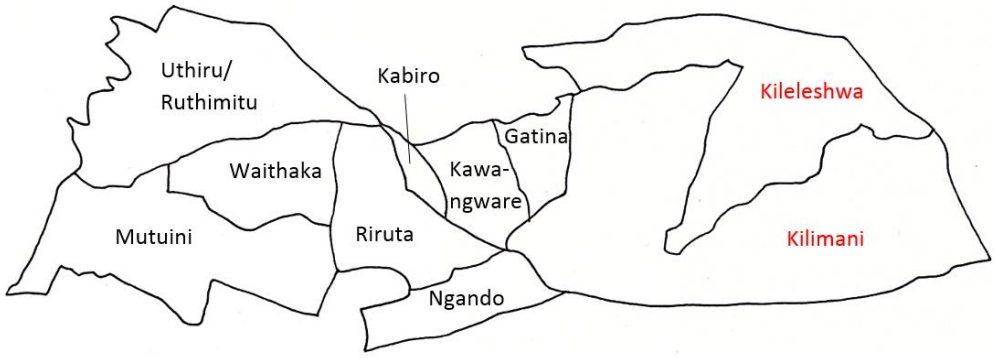

Figure 3: The study site in Dagoretti Division. Wards marked in red were not covered in the study.

3.2 Data collection

Households were chosen through spatial random sampling, where the household nearest to the selected geospatial point and meeting the study inclusion criteria was identified and invited to participate. The inclusion criteria were: households with the presence of at least one child between 6 and 48 months, that had bought unpacked/ unprocessed milk or dairy products the week previous to the interview and that have a disposable household income under 30,000 KES were interviewed. If a first identified household was not eligible for the survey or refused to participate, the next household to the right was screened and invited to participate in the survey. The process was repeated until a consenting eligible household was identified. The survey was conducted with the person more

knowledgeable on food purchases. In total 200 households participated in the survey. All interviews were conducted by trained enumerators in Kiswahili. The responses were captured electronically with the help of Open Data Kit (ODK).

Before the start of the survey, a questionnaire pretesting was conducted in the same area where the survey was carried out. Pretesting helped to adjust some wording and phrasing of the questions in the questionnaire.

The questionnaire was divided into 6 sections. The first section captured general information from the household members. For this survey, a household was defined as a group of people that take food from the same pot or food basket. In addition, only persons who have eaten in the household the past 6 months for at least half of the week in each week of those months were considered households members. This could also include non-family members like servants or agricultural members. The second section of the questionnaire addressed the purchase, consumption and production of milk and other dairy products by the household. Following this, a choice experiment was conducted on changes in purchase and consumption levels based on an increase in milk prices. Thereafter, perceptions of milk quality and safety were captured, followed by a section on expenditure on other food items consumed at home (Muunda upcoming). The last section addressed information on the household income and expenditure on food and non-food items.

3.3 Data analysis

To describe the socio-economic and other relevant variables in this study, means, standard deviations and standard errors were calculated for continuous variables. For comparisons between nominal data a Chi-square test was applied. To test the null hypothesis that more than two sample means are equal, analysis of variance (ANOVA) was applied. ANOVA was done to compare the mean of the dependent variable with the income group of the households.

To analyze the demand for food and dairy products, the QUAIDS model from Banks et al. (1997) was applied. The QUAIDS maintains the desirable demand properties of the AIDS model which are a) it satisfies the axioms of choice exactly; b) to any demand system it gives an arbitrary first-order approximation; c) it is compatible with aggregation over consumers; d) it has a functional form and is therefore consistent with previous household budget data and e) it can be used to test for the restrictions of symmetry and

homogeneity (Jiang & Davis 2007). In addition, the QUAIDS adds a quadratic term to the AIDS to overcome the limitation of the flexibility in expenditure (Meyer et al. 2011). It also facilitates the comparison with other studies who used the AIDS to estimate the demand for milk and other dairy products in Africa (Agbola et al. 2003; Akaichi & Revoredo-Giha 2014; Cornelsen et al. 2016).

The expenditure share equation of the QUAIDS for good i is given in chapter 2.2.4 with the equation (12) and the translog price index in equation (9).
Restrictions imposed by demand theory on the model's parameters are implied because of adding up, homogeneity of degree zero in prices and total expenditure, and the Slutsky symmetry:

$$\sum_i \alpha_i = 1 \quad \sum_i \beta_i = 0 \quad \sum_i \gamma_{ij} = 0 \quad \text{(adding up)} \tag{15}$$

$$\sum_j \gamma_{ij} = 0 \quad \forall i \quad \text{(homogeneity)} \tag{16}$$

$$\gamma_{ij} = \gamma_{ji} \quad \forall i, j \quad \text{(symmetry)} \tag{17}$$

The QUAIDS model was carried out accounting also for demographic effects. According to Kane et al. (2015), demographic effects can have an impact on the household's behavior in terms of demand and allocation of expenditure of goods. Therefore, the approach as shown in Poi (2012) by Ray (1983) was applied. Using $\boldsymbol{z}$ as a vector of s household characteristics, $\boldsymbol{z}$ could be the scalar representing the household size in the simplest case. Let $e^R(\mathbf{p}, u)$ be the expenditure function of a reference household with just a single adult. Ray (1983) uses for each household an expenditure function of the form:

$$e(\mathbf{p}, \mathbf{z}, u) = m_0(\mathbf{p}, \mathbf{z}, u) \times e^R(\mathbf{p}, u) \tag{18}$$

Furthermore, Ray decomposes the scaling function as

$$m_0(\mathbf{p}, \mathbf{z}, u) = \bar{m}_0(\mathbf{z}) \times \varphi(\mathbf{p}, \mathbf{z}, u) \tag{19}$$

where the first term measures the increase in a household's expenditure as a function of $\mathbf{z}$ and the second term controls for changes in relative prices and the actual goods consumed.
Incorporating Ray's method into (12), the expenditure share equations take the form

$$w_i = \alpha_i + \sum_{j=1}^{k} \gamma_{ij} \ln p_j + (\beta_i + \boldsymbol{\eta}'_i \mathbf{z}) \ln\left(\frac{m}{\bar{m}_0(\mathbf{z}) a(\mathbf{p})}\right) + \frac{\lambda_i}{b(\mathbf{p}) c(\mathbf{p}, \mathbf{z})} \left\{\ln\left[\frac{m}{\bar{m}_0(\mathbf{z}) a(\mathbf{p})}\right]\right\}^2 \quad (20)$$

where $c(p, z) = \prod_{j=1}^{k} p_j^{\eta' j z}$

Due to the adding-up condition, it is required that $\sum_{j=1}^{k} \eta_{rj} = 0$ for $r = 1, \ldots, s$.

Price elasticities are calculated following Poi's (2012) approach. The uncompensated price elasticity of good i with respect to changes in the price of good j is

$$\epsilon_{ij} = -\delta_{ij} + \frac{1}{w_i}\left(y_{ij} - \left[\beta_i + \boldsymbol{\eta}'_i \mathbf{z} + \frac{2\lambda_i}{b(\mathbf{p}) c(\mathbf{p}, \mathbf{z})} \ln\left\{\frac{m}{\bar{m}_0(\mathbf{z}) a(\mathbf{p})}\right\}\right] \times \left(\alpha_j + \sum_l y_{jl} \ln p_l\right) - \frac{(\beta_j + \boldsymbol{\eta}'_j \mathbf{z})\lambda_i}{b(\mathbf{p}) c(\mathbf{p}, \mathbf{z})} \left[\ln\left\{\frac{m}{\bar{m}_0(\mathbf{z}) a(\mathbf{p})}\right\}\right]^2\right) \quad (21)$$

The expenditure (income) elasticity of good i is computed as

$$\mu_i = 1 + \frac{1}{w_i}\left[\beta_i + \boldsymbol{\eta}'_i \mathbf{z} + \frac{2\lambda_i}{b(\mathbf{p}) c(\mathbf{p}, \mathbf{z})} \ln\left\{\frac{m}{\bar{m}_0(\mathbf{z}) a(\mathbf{p})}\right\}\right] \quad (22)$$

Finally, compensated (Hicksian) price elasticities are obtained from the Slutsky equation

$$\epsilon_{ij}^{C} = \epsilon_{ij} + \mu_i w_j \quad (23)$$

The parameters were estimated using the quaids command from Poi (2012) in Stata version 13. Demographic variables used in this study were: gender, marital status, primary activity (i.e. job) and education level of the household head; number of household members; income group. Wald tests were performed on the demographic variables to determine if the variable is explanatory of the expenditure patterns.

In order to reduce the number of parameters that has to be estimated, food items were grouped into 7 food groups according to the USDA Food Pattern Food Groups (USDA 2010). The food expenditure share of the respective food group was estimated by summing the expenditures of all food items purchased the previous week and dividing it by the expenditure of the respective food group. Whenever unit prices (i.e. KES per kg) were not reported for the food items, the unit prices were derived by dividing the expenditure reported on the respective food item by the amount purchased in kilogram the week previous to the study. Because many quantities were reported in different non-

standardized units, conversion factors were obtained from USDA Food Composition Databases (USDA 2017), the Malawi Third Integrated Household Survey (2011), from ILRI nutritionists and from studies on the local market in Dagoretti. The studies on the local market were done by weighing the amount of food items provided in a non-standardized unit (for example 1 bunch of carrots or 1 piece of water melon). Households that reported the unit to be “other”, “don’t know” “bottle big > 330 ml” or “bottle small < 330 ml” could not be converted to a unit price (i.e. KES per kg) and were therefore substituted with the mean price as calculated from the survey data of the respective food item. Calculated unit prices that were more than 2.5 times higher than the mean unit price of the respective food item were also substituted with the mean unit price. Following Rizov et al. (2015), price indices for the food groups were calculated using the expenditure share as weights and calculating the price as the sum of the respective expenditure share times the respective unit price. Deaton (1988) adds that the price indices are effectively a value to quantity ratio, which is therefore called “unit price”. The calculated price is furthermore household specific and therefore represents the households’ purchase decisions. The variations in food group prices between households is thus due to differences in the consumption of food items consumed in each group and price differences of each food item across households. This difference is due to seasonal effects, regional market conditions and quality differences (Rizov et al. 2014). The study contains few zero observations (i.e. food groups not consumed in a household), which could result due to non-consumptions of food items of a specific food group. Because of the zero observations no specific food group price could have been estimated. Therefore, the prices of the food groups that were not consumed were substituted with the mean price of the respecting food group.

To calculate both the expenditure and price elasticities for raw milk and possible substitutes, a further QUAIDS was applied. However, all other dairy products except for raw milk had many zero-observations, many products were even purchased by less than 5% of the households. To fit a QUAIDS model with only 10 or less observations from some goods is not possible. Therefore, the QUAIDS was only fitted with raw milk as a dairy product. One possible substitute for raw milk is eggs. According to a recent study from Cornelsen et al. (2016), poor households in Dagoretti replace dairy products mainly with eggs. Thus, eggs were included in the QUAIDS. Additionally, raw milk is an important source of calcium. Therefore, a possible further substitute is Omena fish, with which an adequate protein quality can be achieved (Maina et al. 2007). During the survey,

households were furthermore asked, with which product they would substitute raw milk. Because the most common answer was “fruits” and an accessible and nutritive fruit is banana, the yellow banana was furthermore added to the model. Therefore, the QUAIDS was fitted with the four goods raw milk, eggs, Omena fish and yellow banana.

However, with those four goods still many zero-observations can be observed, which could lead to significantly biased results without adjusting the demand model for it (Cornelsen et al. 2016). Therefore, the two-step estimation of a censored system approach proposed by Shonkwiler and Yen (1999) was applied for the estimation of the demand model and elasticities for these products. In the first step, a probit model was estimated to determine the probability whether a given household would consume a food item in question. It is modelled as a dichotomous choice problem: The endogenous variable is $Y_{iht} = 1$ if household *h* consumes the *i*-th food item in period *t* and is $Y_{iht} = 0$ if the household does not consume the item in question (Jonas & Roosen 2008). Household’s socioeconomic variables are used as independent variables. The variables selected were the number of children aged 6 to 48 months per households, the household income group a dummy variable whether households paid for rent or not, total food expenditure and total number of household members. From the probit model, the normal probability density function ϕ_{ih} as well as the normal cumulative distribution function Φ_{ih} were estimated.

To reduce the number of parameters that have to be estimated, only two household demographics were included in the QUAIDS: household income group and the number of household members. Those household demographics were highly significant in the aggregated version of the QUAIDS and were therefore being chosen.

For the second step, the normal probability density function and the normal cumulative distribution function were incorporated into the QUAIDS. Equation (12) is therefore replaced by the following equation (Akaichi & Revoredo-Giha 2014):

$$w_i^* = \Phi_{ih}\left[a_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_{jt} + \beta_i \ln\left({}^{x_t}/_{p_t}\right)\right] + \lambda_i \phi_{ih} \qquad (24)$$

The parameters were estimated using the nlsur command as shown in Poi (2008).

To assess the behavior of households in terms of changes in purchase and consumption based on raw milk prices, the survey included a choice experiment exercise (Muunda upcoming). The hypothetical scenario chosen was that raw milk prices increase by about 40% because of a drought to a price of 100 KES/ liter. Households were presented a set of 9 choice cards, and each card included a set of 4 alternatives. The households were asked to choose their most (best) and least (worst) preferred alternatives that best describe respectively the most likely decision and the least likely decision they would make. All cards were presented as a graphic to facilitate the decision of the respondents. Table 2 below includes the list of 9 attributes/statements used to develop the choice cards.

Table 2: The attributes used in the choice experiment

1	Decrease raw milk quantities for all family members without replacing it by any other food product
2	Decrease raw milk quantities for all family members, and replace it with another food product only for children <4 years
3	Decrease raw milk quantities for all family members, and replace it with another food product for all family members EXCEPT for children <4 years
4	Decrease raw milk quantities for all family members, and replacing it with another food product for all family members
5	Keep raw milk quantities the same for children < 4years and decrease it for the rest of family members
6	Decrease the quantities of raw milk I give to the children <4 years, without replacing it by other food products. Will keep the same quantities of raw milk for adults
7	Decrease the amount of raw milk I give to the children <4 years, while replacing it by other products. Will keep the same amount of raw milk for adults
8	Keep buying the same quantities of raw milk by increasing milk budget
9	Stop buying raw milk

The number of attributes (9) and the number of choice alternatives (4) will lead to a high number of choice cards. To reduce this number, we used a balanced incomplete block design (BIBD) using SAS software. In total 9 choice cards were presented to each participant. Figure 4 shows an example of a choice experiment card.

If **raw milk** price increases by **40%** compared to high season prices, which corresponds to new raw milk price around **KES 100/litre**, from the 4 alternatives/actions below please indicate which is the most likely alternative/action you will choose/do and the least likely alternative/action you will not choose/do? (Tick only one case as most important and one case as least important)

Most likely	Alternatives	Least likely
☐	Decrease raw milk quantities for all family members, and replace it with another food product only for children <4 years	☐
☐	Keep raw milk quantities the same for children < 4years and decrease it for the rest of family members	☐
☐	Decrease the quantities of raw milk I give to the children <4 years, without replacing it by other food products. Will keep the same quantities of raw milk for adults	☐
☐	Decrease raw milk quantities for all family members, and replace it with another food product for all family members EXCEPT for children <4 years	☐

Figure 4: Example of a choice experiment card

To analyze the choice experiment, standardized Most-Least scores were calculated to assess respondents' stated importance of the alternatives (Rao et al. 2016). The standardized scores are calculated as follows:

$$\textit{Standardized Most – Least Score} = (M - L) / (m*n) \quad (25)$$

Where:

M = Number of times where the alternative was chosen as most important

L = Number of times where the alternative was chosen as least important

m = Number of respondents

n = Number of times the alternative was presented to the respondent

4 Results and discussion

4.1 Sample characteristics

In total 200 households were surveyed. The main characteristics of the sample are presented in table 3. Most of the households had a male head (83%). Women were the head of the household only if being single, divorced, widower or living separately. Except for 4 households, the household head was male if the household head was married. 11% of the households reported to be single households. Compared to the national housing survey of Kenya (Ministry of Land Housing and Development 2013), where 70% of the peri-urban households were headed by males, and the survey from Cornelsen et al. (2016) where 75% of the households in Dagoretti and Korochogo had a male head, this survey came to a noticeably higher result of 83%.

The majority of the household heads were between 18 and 39 years old (80%). The national housing survey reported only 48% of the household heads being between 20 and 39 years old nationwide (Ministry of Land Housing and Development 2013). From the heads of the households, 29% had primary education only and out of those 29% only 73% finished primary school. Most household heads went to secondary school and 71% finished it. Four didn't attend school and 2 respondents didn't know about the education of the household head. Majority of the heads of households were employed (69%) or self-employed (28%). Only 6 household heads were unemployed. The average number of members in a household was 4.33 (SD = 1.53, min. = 2, max. = 12) and therefore about the same compared to the national housing survey of 2012/ 2013 with an average household size of 4.3 in peri-urban areas (Ministry of Land Housing and Development 2013) but slightly lower compared to the survey from Cornelsen et al. (2016) who reported 5 household members. Most households (85%) had only one child between 6 and 48 months with an average of 1.16 (SD = 0.44, min. = 0, max. = 3) and 1.05 children between 4 and 18 years (SD = 1.174, min. = 0, max. = 6) which makes a mean of 2.2 household members under the age of 18 years.

As previously explained in the data collection section, we have deliberately chosen household income as one of the selection criteria (only households reporting earnings of less than 30,000 KES per month were included in the study). One household reported to earn less than 3,000 KES per month whereas about a quarter of sampled households earned between 25,001 and 30,000 KES per month. The average gross monthly national

income per capita was in 2013 7,572 KES/ capita. This survey revealed a slightly lower number, which is not surprising given our selection criteria to include only low- and middle-income households.

Households were furthermore asked if they think that raw milk is of better, worse or the same quality compared to packaged milk. Forty-eight percent responded that raw milk is of worse quality, 46% said that it is of better quality and 6% said that the quality is the same for raw and packed milk. Out of those households that answered that the quality of raw milk is the same compared to packed milk, 64% would purchase packaged milk if the quality would be the same for both. Further 18% would purchase raw milk and another 18% said, it depends on other factors. Ultimately households were asked if they would buy raw or packaged milk, if the price of raw milk was the same as that of packaged milk. Fifty-four percent would then purchase packaged milk, 44% raw milk and 5 households said it depends on other factors.

Table 3: Socio-economic and demographic characteristics of the sample *(n = 200)*

Variable	Categories	%
Sex of the household head	Female	17.0
	Male	83.0
Age of the household head	18 – 29 years	36.0
	30 – 39 years	44.5
	40 – 49 years	13.0
	50 – 59 years	3.5
	60 – 69 years	1.5
	Above 70 years	0.5
	Don't know	1.0
Education of the household head	Primary school (class 1-8)	28.9
	Vocational school	3.1
	Secondary school (form 1-4)	47.4
	Technical college / Diploma	18.6
	University / Degree	2.1
Marital status of the household head	Married living with spouse	84.0
	Married living separately	2.5
	Single/ divorced	11.5
	Widow/ widower	2.0
Primary activity of the household head	Unemployed/ Retired	3.5
	Employed/ laborer	69.0
	Self-employed	27.5
Household members	Two	3.5
	Three	30.0
	Four	31.0
	Five	18.0
	More than five	17.5
Children 6 – 48 months living in the household	Zero	1.0
	One	84.5
	Two	12.5
	Three	2.0
Household monthly income (KES)	Less than 3,000	0.5
	Between 3,000 and 6,000	4.0
	Between 6,001 and 10,000	14.5
	Between 10,001 and 15,000	18.5
	Between 15,001 and 20,000	18.5
	Between 20,001 and 25,000	17.0
	Between 25,001 and 30,000	27.0

4.2 Households' income and its effect on household demographics

Table 4 shows the education level of the household head by income group. Therefore, the households were classified into three different income groups, so that they contain approximately the same percentage of households (T1: 37.5% with an income of less than 15,000 KES/ month; T2: 35.5% with an income between 15,001 and 25,000 KES/ month; T3: 27.0% with an income between 25,001 and 30,000 KES/ month). Because the households only stated their household income as a range (for example between 3,001 and 6,000 KES/ month), the groups contain a different percentage in each group. The threshold between the poorest and middle group was set according to the current minimum wage of Kenya (about 13,000 KES/ month in July 2017, Daily Monitor 2017). The threshold between the middle and the wealthiest group was set at 25,000 KES/ month to divide the remaining households almost equally.

The Chi-square test revealed, that the education level of the household head was overall not associated with the household income, because the Null-hypothesis the education of the household head has no impact on the income has to be accepted (table 4). The gender of the household head was furthermore not associated with the income group (p-value = 0.076, annex A1). Eighty percent of the surveyed households paid rent for their house, 72% for the education of their children and almost all households paid for medical expenses (98%).

Table 4: Education of the household head in percent, by income group*

	G1	G2	G3
Primary school/ Vocational school	40.3 (25)	38.7 (24)	21.0 (13)
Secondary school	38.0 (35)	32.6 (30)	29.4 (27)
Technical college/ University/ Degree	27.5 (11)	40.0 (16)	32.5 (13)
Total	36.6 (71)	36.1 (70)	27.3 (53)

Pearson chi2(4) = 3.2357 Pr = 0.519
*Count in between brackets

Table 5 characterizes the households according to their income. The poorest group had a higher percentage of female household heads, though without a significant difference between the income groups (p-value = 0.076, annex A1). The poorest group had furthermore a higher percentage of younger household heads compared to the other income groups and less people went to technical college or university. Ninety-three percent of the household heads of the wealthiest group lived with a spouse and only 4% were single compared to the poorest group where 19% were single, which may also explain the higher percentage of female headed households in the poorest group. The wealthiest group had more household members (4.9 on average) compared to the middle group (4.3 on average) and the poorest group (4 on average). This agrees with other studies which also reported that the household size increased with an increase in the income (for example Argwings-Kodhek et al. (2005), Musyoka et al. (2010)). However, according to a chi-square test, there was no statistically significant difference between the different income groups relating to the number of children aged 6 to 48 months in the household (p-value = 0.517, annex A2).

Table 5: Socio-economic characteristics of the sample in percent, by household income group (*n=200*)

Variable	Categories	G1	G2	G3
Sex of the household head	Female	22.7	16.9	9.3
	Male	77.3	83.1	90.7
Age of the household head	18-29 years	48.0	29.6	27.8
	30-39 years	37.3	49.3	48.2
	40-49 years	8.0	15.5	16.7
	50-59 years	2.7	2.8	5.6
	60-69 years	1.3	1.4	1.9
	70 years and above	0.0	1.4	0.0
	Don't know	2.7	0.0	0.0
Education of the household head	Primary/ Vocational school	35.2	34.3	24.5
	Secondary school	49.3	42.9	50.9
	Technical college/ University/ Degree	15.5	22.9	24.5
Marital status of the household head	Married living with spouse	76.0	85.9	92.6
	Married living separately	2.7	2.8	1.9
	Single	18.7	8.5	3.7
	Divorced/separated	0.0	1.4	0.0
	Widow/ widower	2.7	1.4	1.9
Primary activity of the household head	Unemployed/ Retired	1.3	5.6	3.7
	Employed/ laborer	74.7	76.1	51.9
	Self-employed	24.0	18.3	44.4
Household members	mean	4.0	4.3	4.9
	SD	1.39	1.38	1.76
Children 6 – 48 months living in the household	mean	1.2	1.2	1.1
	SD	0.44	0.41	0.47

G1 = Poorest group with an income of less than 15,000 KES/ month, G2 = Middle group with an income between 15,001 and 25,000 KES/ month, G3 = Wealthiest group with an income between 25,001 and 30,000 KES/ month, error bars indicate standard error of the mean.

4.3 Expenditure on food and dairy products

The higher the income of the households, the higher was the weekly expenditure as a percentage of the total expenditure on dairy items and food products in general of the surveyed households (figure 5). The wealthiest group spent on average more than double the amount on dairy products compared to the poorest group and more than 1.5 times the amount on food items in general. Obviously, the lower the income the less can be spend on food items because households still have to pay for rent, education, medical bills and non-food items.

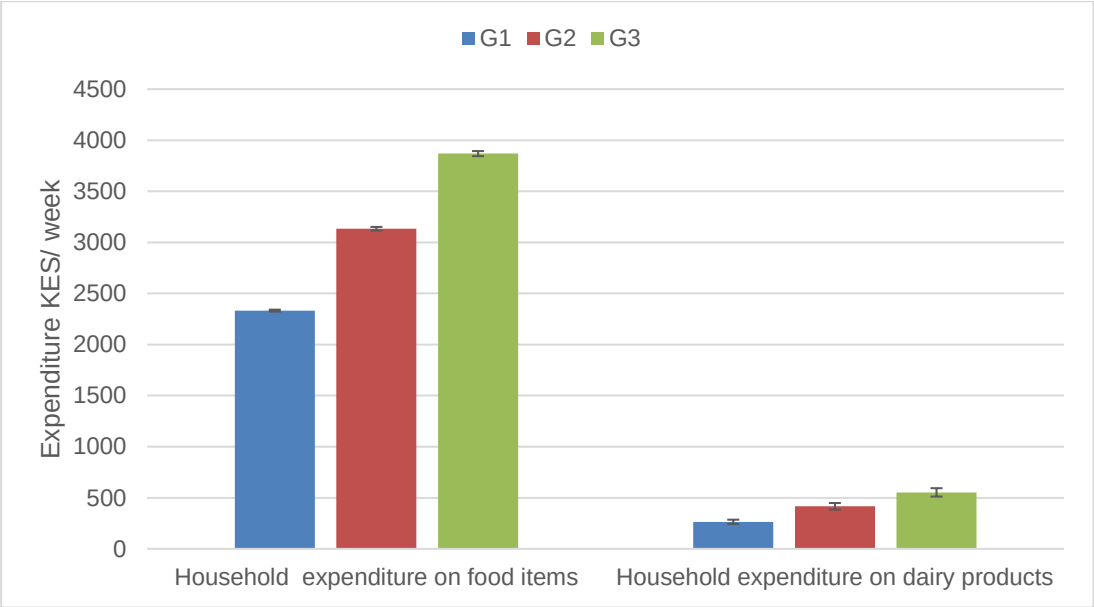

Figure 5: Household weekly expenditure on food items and dairy products, by income group (*n=200*)
G1 = Poorest group with an income of less than 15,000 KES/ month, G2 = Middle group with an income between 15,001 and 25,000 KES/ month, G3 = Wealthiest group with an income between 25,001 and 30,000 KES/ month, error bars indicate standard error of the mean.

Households were asked to report their expenditure on 100 food items in addition to their expenditure on 9 dairy products. For the purpose of the analysis, the food items (excluding dairy products) were grouped into 6 food groups according to the USDA Food Pattern Food Groups (USDA 2010) plus an additional group for other food items not listed in these groups.

Households spent the highest amount on grains (on average 780 KES/ week), followed by vegetables (578 KES/ week), meat (493 KES/ week) and dairy products (396 KES/ week). The lowest expenditure was done on oils and solid fats (180 KES/ week). In total, the average household expenditure on food products during the last seven days was 3,031 KES (SD 1524.41, min. 633, max. 11769), which translates to an average daily per capita food expenditure of 100 KES. Kamau et al. (2011) found a similar daily per capita expenditure among urban households in Kenya, whereas Cornelsen et al. (2016) estimated it at only 40 KES/ capita/ day. The big differences could be that Cornelsen et al. only included households up to a monthly income of 20,000 KES and only asked the households to estimate their total food expenditure without asking for the specific components. Households may therefore have underestimated their food expenditure.

Figure 6 provides an overview of how monthly income effects the expenditure on the different food groups. Except for the food group “other food items”, households from the wealthiest group spent the highest amount compared to the other income groups on the different food groups. The poorest group always spent the least amount on food groups. The total expenditure on food items was also significantly lower compared to the other income groups. The null hypothesis that there is no significant difference in total food expenditure between the poorest group and the middle and wealthiest group from the ANOVA was rejected ($p < 0.001$, annex A3).

The household expenditure on food products ranged in this study from 2,332 KES/ week (SD 841.61, min. 633, max. 4422) for the poorest group to 3,134 KES/ week (SD 1491.40, min. 1404, max. 9729) for the middle group to 3,869 KES/ week (SD 1837.88, min. 1466, max. 11769) for the wealthiest group. These figures are higher compared to other studies, but those studies also show that the expenditure on food increased over the last years. For example Kamau et al. (2011) showed that expenditures on food increased by over 100% between 2003 and 2009 for low and middle income households. A comparison with older studies is therefore not meaningful.

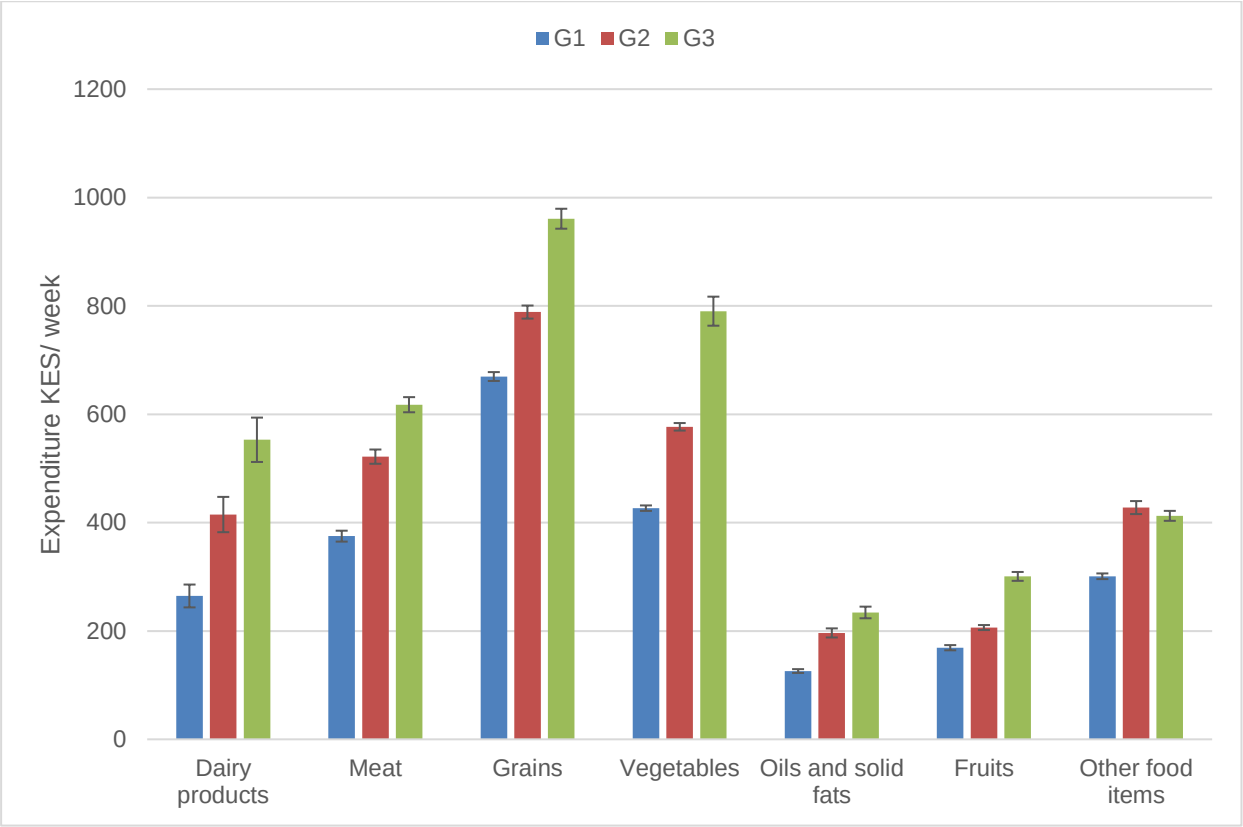

Figure 6: Household weekly expenditure on different food groups, by household income (*n=200*)
G1 = Poorest group with an income of less than 15,000 KES/ month, G2 = Middle group with an income between 15,001 and 25,000 KES/ month, G3 = Wealthiest group with an income between 25,001 and 30,000 KES/ month, error bars indicate standard error of the mean.

When looking at the expenditures in percent of the monthly income, one can observe a different picture. According to the results, the poorest group spends almost all their income on food items (95.6%). Reasons for this might be that during the time of the survey food prices were higher compared to the average food price (Ngotho 2017; Trading Economics 2018). Households may therefore have spent more money on food items than usually. Respondents may also have underestimated their household income.

The middle-income group spent on average 63% on food items and the wealthiest group 56%. The poorest group spent a significantly higher percentage on all food groups compared to the other income groups (p-value < 0.001, annex A4). In general, the higher the income of the households, the lower was the percentage spent on food items, confirming Engel's law that as income rises, the proportion of income spent on food falls (Kamau et al. 2011).

Because households only indicated their monthly household income as a range, the percentage spent on food might be over- or underestimated. A study from Argwings-Kodhek et al. (2005) estimated the expenditure on food to be 34% among households in

Nairobi with an income of up to 55,000 KES/ month. Kamau et al. (2011) came to a higher result with households in Nairobi earning up to 25,000 KES/ month spending 44% of their income on food items. Staal et al. (2008) found that Kenyan households spend on average 56% of their budget on foods. Because these studies use different thresholds for the income and were done in different parts of Nairobi or Kenya, a meaningful comparison is difficult to make. However, this study reveals that households in peri-urban Nairobi spend a big portion of their monthly budget on foods. This might be because households in peri-urban Nairobi have good access to food. Furthermore, the consumer price index increased by 85% from 2010 to 2016 (FAOSTAT 2017), showing that prices increased substantially over the last years. If the income of the households didn't increase in the same percentage, households have to spend more on food from their budget.

The households were also asked to estimate their monthly expenditure on food. The estimated household monthly expenditure on food items was in every income group clearly lower compared to the total food expenditure calculated from the details of the questionnaire. On average, households estimated their monthly food expenditure to be 8,526 KES compared to 13,138 KES calculated. Reasons therefore might be that the respondents, in their estimation of an average expenditure in food, accounted for expenditures they didn't do during the last seven days or that the week (which was the recall period for the detailed food expenditure survey) wasn't representative for the month. Thirty-two percent of the households received their income only once per month and further 17% irregularly. This means that about half of the study population have money available at a given point of time in the month. Because the recall period of this study was only seven days, households may have spent already most of their money earlier in time or spent more the previous week. Therefore, expenditures in food may be higher the previous week compared to the average weekly food expenditure.
Furthermore, during the survey, food prices were higher compared to other periods of the year (Ngotho 2017; Trading Economics 2018). Respondents may also not have an accurate perception of how much they really spend on food per month, whereas when asking for specific food items during a short amount of time, respondents were able to remember their food expenditures more accurately. This all together may explain the difference found between the calculated monthly food expenditure and the estimation the households gave.

All the households allocated most of their food budget to grains, followed by vegetables and meat (figure 7). The poorest group spent a significantly higher percentage of their weekly food budget on grains compared to the wealthier groups ($p<0.001$, annex A5) and a significantly lower percentage on dairy products ($p<0.001$, annex A6). This indicates that poorer households substitute dairy with grains most probably due to its cheaper price. The study from Staal et al. (2008) confirms these results by showing that grains take the largest share in the household food budget, followed by dairy products with 17% of food expenditure. In this study on average 13% was spent on dairy products from the total weekly food budget, which might be slightly lower compared to the study from Staal et al. (2008) because of the lower income of the households. Kamau et al. (2011) also showed in their study, that the share in the household food budget decreases for grains with an increase in the income. Although grains are a staple and households will purchase it also with an increase in the income, there is a maximum needed. Households will therefore stop purchasing more grains after a certain point as their income grows. The opposite behavior can be seen for dairy products and meat, which have a higher price compared to grains. All the households from this study still have a low income and the amounts consumed are far below the maximum threshold. They will therefore increase their consumption of meat and dairy as their income rises.

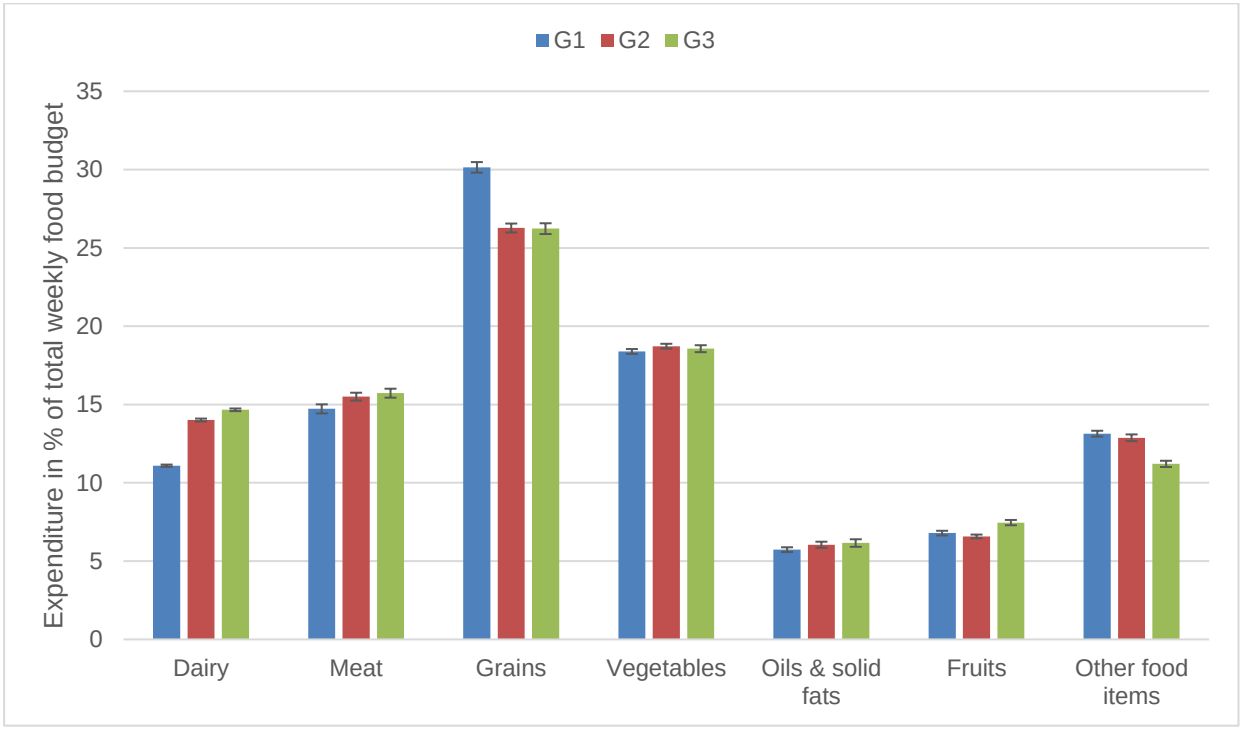

Figure 7: Food budget allocation in percent, by income group
G1 = Poorest group with an income of less than 15,000 KES/ month, G2 = Middle group with an income between 15,001 and 25,000 KES/ month, G3 = Wealthiest group with an income between 25,001 and 30,000 KES/ month, error bars indicate standard error of the mean.

Average expenditure on dairy products amounted to almost 400 KES per week (13% of total food expenditure) with a maximum household dairy expenditure of 1,400 KES (table 6). On average, households purchased 1.7 (SD 0.701, min. 0, max. 4) dairy products the previous week. The questionnaire asked for the following 9 dairy products: unpacked raw milk, unpacked boiled whole milk, unpacked fermented milk (mala), packed fermented milk (mala), unpacked yoghurt, packed yoghurt, packed pasteurized whole fresh milk, UHT milk, powdered milk.

Due to the sampling strategy (i.e. targeting households that consume raw milk), almost all households (99%) purchased unpacked raw milk during the previous week. The households who did not purchase unpacked raw milk produced their own milk. Around 40% of the households purchased packed yoghurt, 17% purchased packed pasteurized whole fresh milk and 7% purchased UHT milk. Unpacked and packed fermented milk (mala) as well as unpacked yoghurt and powdered milk were bought by less than 4 households only. Other dairy products like ghee, butter, cream or cheese were not purchased by the participating households (table 6).

Table 6: Dairy product purchase pattern of the sample (*n=200*)

	Mean quantity purchased last 7 days in liter*	Mean price per unit in KES/ liter*	Total expendi-ture KES/ week *	Purchase frequency days/ week*	% of households purchasing dairy products**
Unpacked raw milk	3.8 (2.77)	76.0 (15.09)	287.5 (207.30)	5.6 (2.07)	98.5 (197)
Unpacked boiled whole milk	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0)
Unpacked fermented milk (mala)	0.01 (0.10)	100.8 (27.54)	1.3 (9.68)	1.0 (0.00)	2.0 (4)
Unpacked yoghurt	0.0 (0.04)	170.0 (42.43)	0.6 (6.07)	1.0 (0.00)	1.0 (2)
Packed pasteurized whole fresh milk	0.3 (0.86)	117.7 (16.70)	35.1 (103.44)	3.4 (2.10)	17.0 (34)
Packed fermented milk (mala)	0.02 (0.22)	210.0 (77.46)	3.5 (31.58)	1.5 (1.00)	2.0 (4)
Packed yoghurt	0.3 (0.68)	188.9 (70.08)	61.4 (127.84)	2.2 (1.84)	39.0 (78)
UHT milk	0.1 (0.50)	135.4 (15.75)	15.0 (69.52)	3.6 (2.53)	7.0 (14)
Powdered milk (kg)	0.0 (0.01)	1000 (0.00)	0.4 (5.35)	1.0 (0.00)	1.0 (2)
Total dairy household expenditure KES/ week			397.03 (276.130)		

* Standard deviation between brackets
** Count between brackets

Two households reported to produce and consume their own raw milk (2 and 10.5 liter/ day) and three households received dairy products as a gift (the week before) from their relatives or friends.

The participants in the study relied heavily on raw milk for their dairy needs and bought not many other dairy products, unlike other studies, where households purchased in particular more pasteurized milk. Although only 7 out of the 200 households reported to

keep their milk in the fridge, not much UHT milk was bought. Reasons therefore could be the different taste of the UHT milk and the higher price. Many studies found that consumers in Kenya prefer raw milk because of its better taste compared to other milk products as well as the preference for raw milk due to its lower price (Blackmore et al. 2015; Smallholder Dairy Project 2004b). Furthermore, households purchase of unpacked raw milk is almost done on a daily basis: on average, 5.6 times per week for an average quantity of 3.8 liter per week (SD = 2.72, min. = 0, max. = 14). Per purchase households bought on average 0.66 liter (SD = 0.48, min. = 0, max. = 5). Packed yoghurt was, after raw milk, the second-most purchased dairy product (39% of the households) followed by packed pasteurized whole fresh milk (17% of the households). The mean quantity purchased of both dairy products in the last seven days was 0.3 liter. Half of the households purchased packed yoghurt only once per week and on average about 0.4 liter per purchase (SD = 0.24, min. = 0, max. = 1), whereas packed pasteurized whole milk was purchased irregularly, with on average 3.4 purchases per week. The other dairy products were purchased by less than 10% of the participating households. In general, the higher the degree of processing, the lower the purchasing frequency and the lower the proportion of consuming households.

In total, households purchased on average 4.53 liters of dairy products per week, which amounts to 236 liters per year and household. With an average household size of 4.33, the per capita consumption per year of dairy products of this study population is 54.4 liters and therefore clearly lower compared to other studies. For example, Argwings-Kodhek et al. (2005) found a per capita consumption of 101 liter per year in Nairobi, Njarui et al. (2011) estimated the yearly per consumption to be 125 liter per capita in urban areas of Kenya and Kaitibie et al. (2010) estimated it at even 145 liter per capita and year. Official figures from the Kenya Dairy Board set the annual per capita consumption between 80 and 125 liter (Gichohi 2014). However, those official data are most likely calculated by dividing the estimated production quantity by the official number of inhabitants and therefore bears some risks of an overestimation of the per capita consumption. Higher processed dairy products require more liters of milk to produce them. The production quantity is furthermore just an estimate and can be lower especially during drought years. Further reasons for the lower consumption compared to the other studies could be the higher prices during the survey period, which could have reduced the purchasing power of the households. Indeed, sixteen percent of the households indicated a lower consumption of dairy products the surveyed week compared to the rest of the year. Also, one inclusion criterion was to have a household member between the age of 6 and 48

months. Dominguez-Salas et al. (2016) showed that more than 50% of the children aged one to three years are still breastfed in Dagoretti which may therefore decrease the consumption of other dairy products.

According to the survey, powdered milk had the highest unit price, followed by packed fermented milk (mala), yoghurt, UHT milk and unpacked fermented milk. Unpacked raw milk was the cheapest dairy product with an average price of 76 KES/ liter, ranging from 26 KES/ liter to 130 KES/ liter. Compared to packed pasteurized whole fresh milk, raw milk was on average 36% cheaper, which agrees with studies done by TechnoServe Kenya (2008) and The Smallholder Dairy Project (2004b). Unpacked dairy products were in general cheaper than packed dairy products. Due to the high amount of unpacked raw milk purchased during the previous week, households spent most of their total dairy expenditure on it, followed by packed yoghurt and packed pasteurized whole fresh milk.

Households were furthermore asked from which market outlet they primarily bought their dairy product during the last 7 days. Primarily, they bought their dairy products from a corner shop or kiosk (40%), milk dispenser in a milk bar (16%), directly at the producer gate (12%) or from a milk bar in a dairy shop (11%). Most households only bought from one market outlet (79%), whereas 2 households bought their dairy product every day from a different market outlet. The time spent to travel to the market outlet accounted on average for 6.6 minutes (SD 7.343, min. 0, max. 40). Households therefore have good access to the milk market.

Households from the poorest group purchased a significantly lower number of dairy products in the previous week (on average 1.5, SD = 0.58, min. = 1, max. = 3) compared to the wealthiest group (on average 1.9, SD = 0.76, min. = 1, max. = 4; p-value = 0.001, annex A7), whereas there was no significant difference between the middle (on average 1.7, SD = 0.71, min. = 0, max. = 4) and the wealthiest group (p-value = 0.222, annex A7). This means, that poorer households can only afford the cheaper products.
Households of the wealthiest group purchased a higher amount of each dairy product the previous week compared to the other groups (figure 8). The poorest group purchased in total a significantly lower amount than the middle (p-value = 0.038, annex A8) and the wealthiest group (p-value < 0.001 annex A8). They also purchased a significantly lower amount of unpacked raw milk (p-value < 0.001, annex A9). Surprisingly, there was no significant difference in the purchasing behavior of packed pasteurized whole fresh milk

and UHT milk between the poorest and the wealthier groups. One reason is that poorer households have less household members and therefore need less dairy products. Per capita, households from the poorer group purchase 0.76 liter/ week, the middle group purchases 1.15 liter/ week and the wealthiest group 1.29 liter/ week. The biggest difference is therefore between the poorest and the other groups, showing that household from the poorer group have less income that they can spend on food and dairy products.

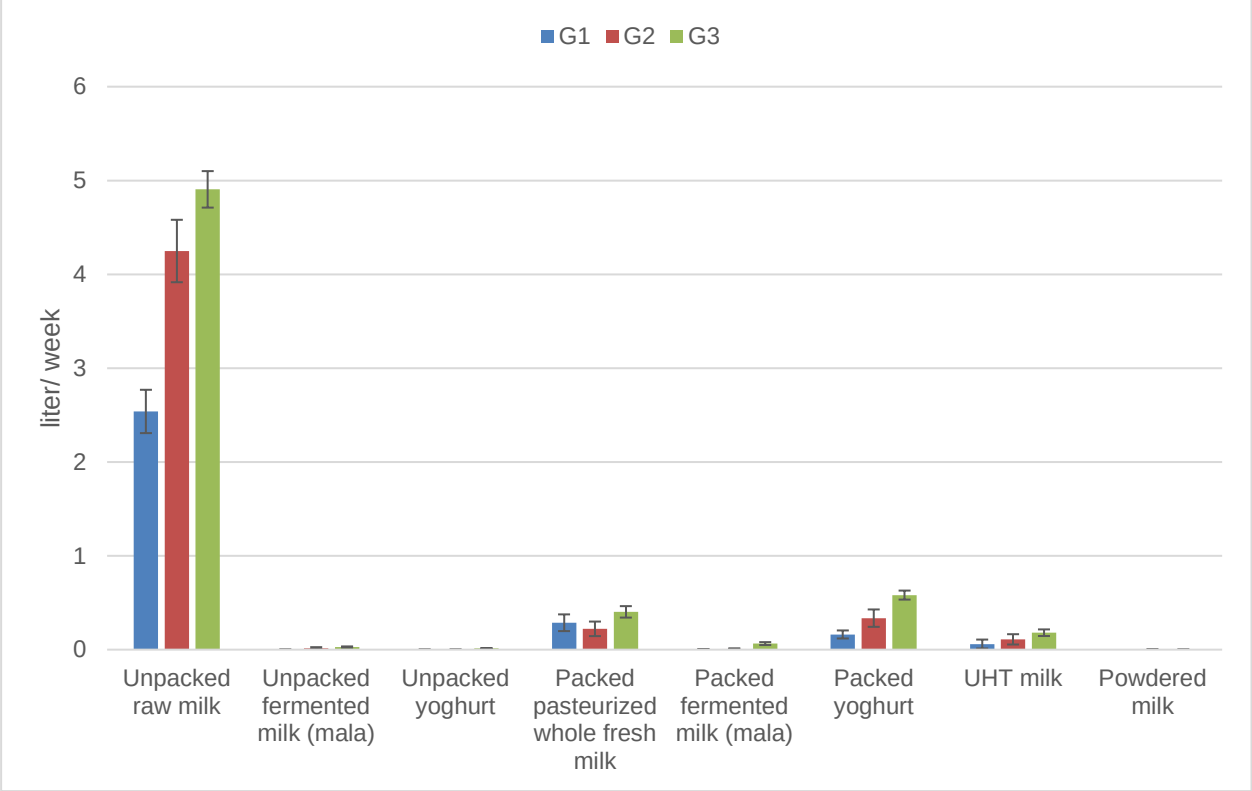

Figure 8: Average purchase of dairy products per household and week, by income group
G1 = Poorest group with an income of less than 15,000 KES/ month, G2 = Middle group with an income between 15,001 and 25,000 KES/ month, G3 = Wealthiest group with an income between 25,001 and 30,000 KES/ month, error bars indicate standard error of the mean.

With the possibility of an implementation of policies that criminalize the informal milk sector and therefore a decrease in the availability of raw milk, consumers would have to substitute raw milk with other products. Argwings-Kodhek et al. (2005) calculated that if all households who consume raw milk would have to substitute raw milk with pasteurized milk without reducing their quantity, about 13.5 million KES per day would be transferred from relatively poor households to distributors, processors and retailers promoting pasteurized milk. On the other hand, if those households would reduce their consumption to the average pasteurized milk consumption, the demand will fall by about 15,000 liters per day due to the price difference. This would lead to a reduction in nutrient intake,

possibly also among children, with its associated negative impacts on especially the development of children.

Taking the prices and consumption levels of raw and pasteurized milk determined in this study, the 200 surveyed households alone would transfer 4,170 KES/ day to distributors et cetera if they were to substitute raw milk with pasteurized milk. If the prices and consumption level were at the same level as from this study for the whole population of Kenya with an income of less than 30,000 KES/ month, those 40% of the population (Worldbank 2018) would transfer about 94 million KES per day to retailers, distributors and processors promoting pasteurized milk. Although this is unrealistic, because the households from this study consumed less pasteurized milk than the average Kenyan population, it shows how important raw milk is. And because most households from this income group could not afford the additional expenses, this would reduce the milk intake of households and children with the negative impacts on child development.

4.4 Dairy products intake of children aged 6 to 48 months

Children were defined according to their age. For this study, children refer to household members aged 6 to 48 months. This age group was targeted because it covers an age group for which feeding is critical for growth and development. According to the sampling strategy, every household had at least one child in this age range. In total, 231 children aged 6 to 48 months were reported and 734 between 6 months and 18 years. This implies that more than half of the household members are less than 18 years old, with an average number of children below 18 years per household of 2.2 (SD = 1.303, min. = 1, max. = 8).

Ninety-nine percent of the children aged 6 to 48 months consumed unpacked raw milk the week previous to the survey visit. Packed yoghurt was consumed by 40% and 17% consumed packed pasteurized whole fresh milk (table 7). Most children who consumed dairy products "*as it is"* consumed it either as unpacked raw milk or packed yoghurt (43% and 42%, respectively). "*As it is"* means that the product was consumed in the way the households bought it, without using it as an ingredient of a dish or a drink. Only 7% consumed packed pasteurized whole fresh milk "*as it is"*.

All children aged 6 to 48 months consumed on average 0.8 liter/ child of dairy products in the previous week, which means a total consumption per year of 42 liter per child. Most

children consumed raw milk (99%) with an average weekly consumption of about 700 ml. Packed yoghurt was consumed by 40% of the children aged 6 to 48 months with an average weekly consumption of 60 ml of it. Packed pasteurized whole fresh milk and UHT milk were consumed in a quantity of 30 ml and 13 ml, respectively.

Compared to household members above the age of 4 years, children aged 6 to 48 months consumed on average 0.06 liter of dairy products less the week previous to the study. Except for powdered milk, UHT milk and unpacked yoghurt, each household member above 4 years of age consumed on average a higher quantity of dairy products compared to children up to 4 years of age. The biggest difference can be observed in the consumption of raw milk, where household members above the age of 4 years consumed on average per person 80ml more raw milk (total consumption 780 ml, SD = 649.31, min. = 60.8, max. = 6285.7). Many of the children between 6 and 48 months are still breastfed, which could explain the lower average consumption as well as the general lower consumption of children below the age of four compared to older children.

Only three dairy products were consumed as part of a dish by children aged 6 to 48 months. In the majority of cases (84%) it was consumed using unpacked raw milk, 11% used packed pasteurized whole fresh milk and 5% used UHT milk. The respondents were asked for which dish or drink they used the respective dairy product and if the children consumed this dish or drink. The responses show that most of the children aged 6 to 48 months consumed the dairy products as part of a tea or coffee (85%). The second most common answer was as part of porridge (23%). Consumption with cereals (6%), vegetables (1%) and in other forms (2%), represented the other further answers.

Table 7: Intake of dairy products by children between 6 and 48 months

	% of children 6-48 months consuming dairy products*	Mean consump-tion per children in ml/ week**	% of children 6 - 48 months consuming dairy products as it is*	% of children consuming dairy product as part of a dish*
Unpacked raw milk	98.7 (228)	693.0 (585.34)	36.8 (85)	77.5 (179)
Unpacked fermented milk (mala)	1.7 (4)	0.6 (0.74)	0.9 (2)	0 (0)
Unpacked yoghurt	0.9 (2)	0.2 (0.3)	0.4 (1)	0 (0)
Packed pasteurized whole fresh milk	16.5 (38)	29.2 (31.80)	6.1 (14)	10.0 (23)
Packed fermented milk (mala)	2.6 (6)	0.8 (1.03)	2.2 (5)	0 (0)
Packed yoghurt	39.4 (91)	58.2 (147.27)	35.5 (82)	0 (0)
UHT milk	6.5 (15)	12.9 (11.59)	3.0 (7)	4.8 (11)
Powdered milk	1.3 (3)	0.00 (0.01)	0.4 (1)	0 (0)

* Count between brackets
** Standard deviation between brackets

Figure 9 provides an overview of the intake of dairy products by children aged 6 to 48 months in the previous week. The estimated average dairy products intake of children from the wealthiest group (956 ml/ week, SD = 674.56, min. = 95.12, max. = 3560.93) was higher than the one in the middle group (787 ml/ week, SD = 633.3, min. = 49.49, max. = 2301.6) and the poorest group (679 ml/ week, SD = 626.34, min. = 60.71, max. = 3365.79). However, the ANOVA revealed that there is no statistically significant difference, because the null hypothesis of equal means has to be accepted (p-value = 0.856, annex A10). Only one child consumed unpacked yoghurt and 2 consumed unpacked fermented milk (mala) and powdered milk, each from the wealthiest households. There was no statistically significant difference in the consumption of packed yoghurt (p-value = 0.463, annex A11), UHT milk (p-value = 0.887, annex A12) and packed pasteurized whole fresh milk (p-value = 0.253, annex A13) across income groups.

Guidelines from the FAO recommend that a diet from children aged six months to 5 years should contain at least 200 – 250ml of milk and other dairy products per day (Muehlhoff et al. 2013). The poorest group of this survey consumes on average less than 100 ml per day and child, which is clearly lower compared to the guidelines from the FAO. Nevertheless, because milk and other dairy products are an important source of energy, protein, vitamins and minerals, the low consumption without an adequate substitution could hinder the proper development of the children. A survey done in 2016 by Dominguez-Salas et al. (2016) in the same study area, revealed that 41.5% of the children between 1 and 3 years were stunted and 4.4% showed acute malnutrition. This could be due to the low intake of dairy. But because the two studies are not connected, a direct connection cannot be drawn.

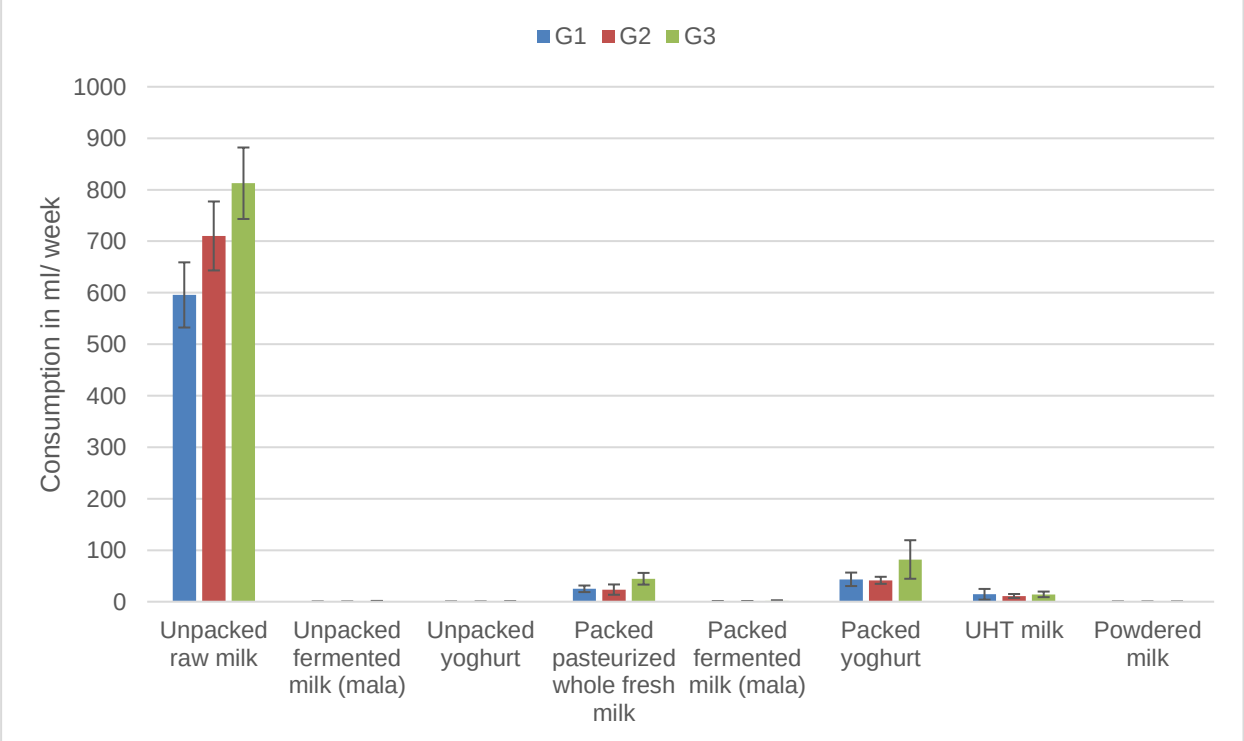

Figure 9: Average consumption of dairy products of children per week, by income group
G1 = Poorest group with an income of less than 15,000 KES/ month, G2 = Middle group with an income between 15,001 and 25,000 KES/ month, G3 = Wealthiest group with an income between 25,001 and 30,000 KES/ month, error bars indicate standard error of the mean.

4.5 Elasticities

Table 8 shows the expenditure elasticities (with respect to total food expenditure) for the different food groups from the QUAIDS model, as an approximation to the income elasticities. The coefficients from the QUAIDS are summarized in Annex B1. All expenditure elasticities are considered significant at 1% and are positive. The product

with a largest elasticity is meat with 1.405, followed by fruits with 1.333, while the lowest one is grains with 0.767. Because all the values are positive, the expenditure on all food groups will increase with an increasing income, for which expenditure is a proxy. However, a value below 1 indicates that the households demand for this food group will increase less than proportionally to the income, because it is considered a necessity good. For example, an increase in the income/ expenditure by 10% will increase the demand for grains by only 7.7%. On the other hand, a value above 1 indicates that the demand for this food group increases more than proportionally to the income. Those items are considered luxury goods. The demand for meat will increase by 14.1% if the income/ expenditure increases by 10%. The low expenditure elasticity for grains and the high one for fruits and meat point to a shift in the diet from grains to fruits and meat when income increases. These household expenditure elasticities are in line with other studies from Kenya. Cornelsen et al. (2016) found the expenditure elasticity for dairy to be 0.95 and Musyoka et al. (2010) found it to be 0.99. Expenditure elasticities for vegetables range from 0.877 (Abdulai & Aubert 2004) to 1.01 (Musyoka et al. 2010) and the expenditure elasticity for grains was found to be 0.738 (Abdulai & Aubert 2004). The expenditure elasticities from the other food group are difficult to compare, because the studies used a different grouping of the food items.

Table 8: Households expenditure elasticities from the QUAIDS model

	Dairy	**Meat**	**Grains**	**Vegetables**	**Oils & Solid fats**	**Fruits**	**Other food items**
Coefficient	0.939***	1.405***	0.767***	0.984***	0.902***	1.333***	1.005***

Significant at least *p < 0.1; **p < 0.05; ***p < 0.01

Households compensated (Hicksian) own- and cross-price elasticities from the QUAIDS model are summarized in table 9. All the own-price elasticities (in bold) have the expected negative sign, showing that an increase in the price of the product will lead to a reduction in its demand. Furthermore, all the own-price elasticities are significant at 1% level. Demand for meat is least sensitive to price changes with a 10% price change leading to a reduction in demand of 4.1%, followed by dairy with a demand reduction of 5.1%. The demand for oils & solid fats is most sensitive to price changes with a reduction in demand by 8.9% for an increase in its price by 10%. This means that households put a high value on meat and dairy products and would try to preserve consumption when prices increase.

It could also be that households will limit the reduction in their demand on meat and dairy, because their consumption is already very low, especially for meat.

Cross-price elasticities indicate by how much the demand for one product will change if the price for another product will increase. In this study, all significant cross-price elasticities have positive values. Those show substitution effects, meaning that if the price from one product increases, the demand for the other product will increase. For instance, if the price for grains increases by 10%, the demand for oils and solid fats will increase by 5.3%, dairy will increase by 3.3%, vegetables by 2.3% and other food items by 1.5%. Dairy products (1% of price increase) will be mainly substituted by grains (1.5%) and meat (1%) and are substitution goods for those products. In case the price of one category will increase, households still have alternative substitutes.

Table 9: Households compensated own- and cross-price elasticities from the QUAIDS model

	Dairy	**Meat**	**Grains**	**Vegeta-bles**	**Oils & Solid fats**	**Fruits**	**Other food items**
Dairy	**-0.505*** **	0.117**	0.333***	0.031	-0.064	0.057	0.031
Meat	0.099*	**-0.412*** **	0.076	-0.043	0.023	0.063*	0.194***
Grains	0.154***	0.042	**-0.555*** **	0.147***	0.109***	0.036	0.067**
Vegetables	0.022	-0.035	0.225***	**-0.508*** **	0.099**	0.047	0.150***
Oils & Solid fats	-0.140	0.055	0.527***	0.309***	**-0.885*** **	-0.016	0.151**
Fruits	0.120	0.155*	0.162	0.141	-0.015	**-0.688*** **	0.123*
Other food items	0.033	0.235***	0.154**	0.223***	0.072**	0.060*	**-0.776*** **

Significant at least *p < 0.1; **p < 0.05; ***p < 0.01

Table 10 displays the uncompensated (Marshallian) own- and cross-price elasticities from the same model. For the uncompensated price elasticities, consumers' money income is held constant (maximize utility given income), whereas for the calculation of the compensated price elasticities consumers' real income is held constant (Clements & Si 2016). All uncompensated own-price elasticities are like the compensated ones negative and significant at 1%. The demand for oils and solid fats is most sensitive to a change in price, followed by other food items, grains and fruits. Meat and dairy products are least sensitive to price changes. An increase in its prices by 10% reduces the demand by 6.3% for each group of products.

Nineteen coefficients show different signs between the uncompensated and compensated cross-price elasticities. According to Rizov et al. (2014) this suggests that the income effects are very important in the demand decision of the consumers (both

types of elasticities are linked through the Slutsky equation that include income/ expenditure elasticity). In other words, if the uncompensated cross-price elasticity is negative and the compensated cross-price elasticity positive (for example for meat with dairy), the income effect outweighs the substitution effects (Musyoka et al. 2010).
Substitution effects are better measured using the compensated cross-price elasticities, because they measure only substitution effects devoid of income effects (Musyoka et al. 2010).

Table 10: Households uncompensated own- and cross-price elasticities from the QUAIDS model

	Dairy	Meat	Grains	Vegeta-bles	Oils & Solid fats	Fruits	Other food items
Dairy	**-0.628*** **	-0.026	0.066	-0.144*	-0.120**	-0.001	-0.086*
Meat	-0.085	**-0.627*** **	-0.32***	-0.303***	-0.061	-0.024	0.018
Grains	0.053	-0.075*	**-0.772*** **	0.005	0.064*	-0.012	-0.029
Vegetables	-0.107**	-0.185***	-0.054	**-0.691*** **	0.041	-0.014	0.027
Oils & Solid fats	-0.258*	-0.083	0.270	0.142	**-0.938*** **	-0.072	0.038
Fruits	-0.054	-0.048	-0.217	-0.106	-0.094	**-0.770*** **	-0.044
Other food items	-0.099*	0.082	-0.132*	0.036	0.012	-0.002	**-0.902*** **

Significant at least *p < 0.1; **p < 0.05; ***p < 0.01

Table 11 shows the compensated own-price elasticities for the different food groups by income group. Significant differences can be observed between the poorest and wealthiest group for the food groups dairy, grains and oils & solid fats. With an increase of 10% in the price of dairy products, households from the poorest group will reduce their demand by 4.5%, whereas the wealthiest group will reduce it even more (by 5.4%). For grains and oils & solid fats the poorest households will reduce their demand significantly more when the prices increase compared to the wealthiest group. The biggest difference can be observed for oils & solid fats, where an increase in price by 10% leads to a reduction in quantities by 9.7% for the poorest group and by 7.9% for the wealthiest group.

Table 11: Households compensated own-price elasticities from the QUAIDS model, by income group

	Dairy	Meat	Grains	Vegetab-les	Oils & Solid fats	Fruits	Other food items
G1	-0.448a	-0.396a	-0.574a	-0.508a	-0.966a	-0.689a	-0.773a
G2	-0.522ab	-0.422a	-0.566ab	-0.509a	-0.887ab	-0.671a	-0.776a
G3	-0.538b	-0.419a	-0.508b	-0.508a	-0.788b	-0.703a	-0.781a

Different characters represent a significant difference at $p < 0.05$,
G1 = Poorest group with an income of less than 15,000 KES/ month, G2 = Middle group with an income between 15,001 and 25,000 KES/ month, G3 = Wealthiest group with an income between 25,001 and 30,000 KES/ month

On a second step, another QUAIDS model was fitted on a disaggregated level, to calculate elasticities for raw milk and its possible substitutes. Households expenditure for raw milk, eggs and Omena fish are summarized in table 12. The coefficients for the QUAIDS model are presented in Annex B2. All expenditure elasticities are significant. With an increase in the income, the demand for raw milk will increase more than proportionally to the income, while the demand for eggs, Omena fish and banana will increase marginally less than proportionally to the income. Those results are in line with other studies. Salasya et al. (2009) found the raw milk expenditure elasticity to be 1.15 and Cornelsen et al. (2016) estimated it for fish in general to be 0.87. However, for eggs they found an expenditure elasticity of 0.48 without being statistically significant.
Because all expenditure elasticities are very close to one, which means that the demand for these products will increase proportionally to the income, an increase in the income will lead to a proportional increase in the demand of these products with no big preference for one or the other product. Compared to the expenditure elasticities on the aggregated level (table 8), eggs, Omena fish and banana show a clearly lower expenditure elasticity. Reasons could be in the slightly different method to calculate the elasticities and that households put a higher emphasis on other food items from that food groups like beef. The expenditure elasticity for raw milk is higher compared to “dairy products”. Households are therefore more likely to increase their raw milk consumption with an increase in the income and increase the consumption of other dairy products less compared to raw milk. This shows how important raw milk for households of this study population is.

Table 12: Households expenditure elasticity for raw milk, eggs, Omena fish and banana

	Raw milk	Eggs	Omena fish	Banana (yellow)
Coefficient	1.136***	0.930***	0.991***	0.943***

Significant at least *p < 0.1; **p < 0.05; ***p < 0.01

Table 13 shows the compensated own- and cross-price elasticities. The results for the own-price elasticities (in bold) show, that the demand for raw milk will decrease less than proportionally when its price increases, meaning that the households from this survey put a high value on raw milk and will therefore decrease its consumption the least possible by possibly increasing their milk budget. An increase in the price by 10% for raw milk will decrease its demand by 4.8%. The own-price elasticity for eggs and banana showed no significant effect, while the demand for Omena fish will decrease by 6.2%.

As previously explained, compensated cross-price elasticities are a better measure for the explanation of substitutes than uncompensated elasticities (table 14). Most compensated cross-price elasticities are significant and positive, showing substitution effects. If the price of raw milk increases by 10%, households will substitute their raw milk consumption with banana, eggs and Omena fish by increasing their demand by 10.9%, 10.2% and 7.9%, respectively. Eggs will be substituted by banana, while Omena fish and banana will be substituted with eggs. There is only one statistically significant negative cross-price elasticity. With an increase of the price of Omena fish by 10%, households will not only substitute it with eggs, but will also reduce their raw milk consumption. This might indicate income effects, meaning that the higher price of Omena fish leaves less budget left for buying raw milk.

Table 13: Households compensated own- and cross-price elasticity from the QUAIDS model

	Raw milk	**Eggs**	**Omena fish**	**Banana**
Raw milk	**-0.481*** **	-0.039	-0.130*	-0.022
Eggs	1.016***	**-0.101**	0.434***	0.631***
Omena fish	0.787***	-0.017	**-0.617*** **	0.208
Banana	1.093***	0.499***	0.384	**-0.323**

Significant at least *p < 0.1; **p < 0.05; ***p < 0.01

Table 14 displays households' uncompensated own- and cross-price elasticity for raw milk, eggs and Omena fish. The own-price elasticity of raw milk shows an elastic behavior because the demand for it will decrease more than proportionally than an increase in its price. Eggs, Omena fish and banana are inelastic, but only the Omena fish own-price elasticity is statistically significant.

The findings for the own-price elasticity of raw milk are higher (in absolute value) compared to other studies. Salasya et al. (2009) found it to be -0.97 and Cornelsen et al. (2016) found it to be -0.955. This means that this study population decreases the raw milk

consumption more than proportionally, if money income is held constant. Cornelsen et al. (2016) furthermore estimated the uncompensated own-price elasticity for eggs and found it to be -0.736, which is higher (in absolute value) than the estimate from this study. Due to a different model, the comparison is difficult to make.

Table 14: Households uncompensated own- and cross-price elasticity

	Raw milk	**Eggs**	**Omena fish**	**Banana**
Raw milk	**-1.215*** **	-0.195***	-0.209***	-0.189**
Eggs	0.416	**-0.228**	0.369***	0.494***
Omena fish	0.147	-0.154	**-0.686*** **	0.062
Banana	0.484**	0.370***	0.319	**-0.462**

Significant at least *p < 0.1; **p < 0.05; ***p < 0.01

The results from the compensated own-price elasticity for dairy products on the aggregated level show, that households substitute dairy with grains and meat products, if the price of dairy increases. The estimation on the non-aggregated level confirms this first part of the analysis partly, indicating that households will substitute raw milk (which is the biggest proportion in dairy) primarily with Omena fish and banana, but also with eggs. Dairy products are furthermore used as substitutes for grains and meat. However, on the non-aggregated level, raw milk showed no significant substitution effect for the compensated cross-price elasticities. Even without any statistically significance, the values are very close to zero, showing that the analyzed goods are substituted with other goods than raw milk. However, the expenditure elasticity for raw milk, eggs, Omena fish and banana indicate that preference is given to raw milk when income increases.

The biggest difference between compensated and uncompensated price elasticities can be seen by raw milk. For the compensated own-price elasticity it is -0.481, while for the compensated one it is -1.215. Uncompensated elasticities are generally lower compared to the compensated elasticities, because they are linked through the Slutsky equation (equation 23 in the material and methods chapter).

4.6 Household choice decisions to an increase in milk price

During the survey, the households were asked to make choices on how they would change their purchase or consumption behavior when the price of raw milk increases. For each of the cards that were presented to the respondent, they had to indicate their most and least likely decision. Table 15 and figure 8 show the attribute level scores for the nine different attributes or statements. Figure 8 shows the attribute level scores by household

income group and for each attribute graphically the relative association between different attributes and the choice of alternatives as least or most preferred. Positive values indicate an increased preference for the attribute while negative scores indicate a lower preference (Rao et al. 2016).

The two most preferred options were to decrease the quantities for all family members and replace it by other food items for either all the family members or only for children below the age of 4 years. Decreasing the raw milk quantities only for adults is also associated with a higher preference as well as decreasing the raw milk quantities for children below the age of 4 and replace it by other food items while keeping the same amounts of raw milk for adults. Possible reasons could be that adults can easily replace the raw milk for children with porridge.

The lowest score and therefore the least preferred option for the households is to stop buying raw milk. Households seem to put such a high value on raw milk, that even with an increase in the price of raw milk by 40%, they would continue to buy raw milk through opting for other options with a positive score. Other options with a negative score include the reduced consumption of raw milk quantities without replacing it for children below the age of 4 years, without replacing it for any family members or to just decrease the raw milk quantities for children without replacing it by other food items.

According to the scores, households prefer to decrease raw milk quantities and replace it by other food items instead of stop buying raw milk, increasing the milk budget or decrease the raw milk quantities without replacing it by other food items. This can be also seen from the relative importance, where a decrease of the raw milk quantities for all family members and a replacement with other food items only for children under the age of 4 years is ranked highest, followed by a decrease in the consumption of raw milk and replacement with other food items for all family members with a relative importance of 89%.

Table 15: Attributes score and relative importance

Attributes	Best	Worst	Score	Std.*	Rel. Importance**
A1	45	205	-0.2000	0.3070	12.7%
A2	494	13	0.6013	0.2870	100.0%
A3	24	235	-0.2638	0.2713	9.1%
A4	518	17	0.6263	0.3666	89.2%
A5	305	45	0.3250	0.3850	48.6%
A6	12	319	-0.3838	0.2651	6.3%
A7	239	48	0.2388	0.3556	43.8%
A8	146	217	-0.0888	0.5074	19.2%
A9	17	699	-0.8525	0.3392	6.0%

*Standard deviation from the individual scores
**Calculated from the square root of the ratio of the attribute best frequency by the attribute worst frequency and taking the highest attribute (A2) as the reference level (100%) (Mtimet et al. 2015)
A1: Decrease raw milk quantities for all family members without replacing it by any other food product
A2: Decrease raw milk quantities for all family members, and replace it with another food product only for children <4 years
A3: Decrease raw milk quantities for all family members, and replace it with another food product for all family members except for children <4 years
A4: Decrease raw milk quantities for all family members, and replacing it with another food product for all family members
A5: Keep raw milk quantities the same for children < 4years and decrease it for the rest of family members
A6: Decrease the quantities of raw milk I give to the children <4 years, without replacing it by other food products. Will keep the same quantities of raw milk for adults
A7: Decrease the amount of raw milk I give to the children <4 years, while replacing it by other products. Will keep the same amount of raw milk for adults
A8: Keep buying the same quantities of raw milk by increasing milk budget
A9: Stop buying raw milk

Figure 10 also shows the scores according to the income level of the households. The biggest difference can be seen for the option “Stop buying raw milk”. Although still the least preferred option, it is more negative for households with a higher income. Poorer households have a lower budget which they could spend on raw milk. Therefore, an increase in the price of raw milk by 40% affects them more compared to wealthier households. Some of them therefore may consider to stop buying raw milk and replace it with other products.

The score for the option “Keep buying the same quantities of raw milk by increasing the milk budget” for the wealthiest group is zero, while the score for the middle and poorest group is negative. For the poorer households it is therefore least likely that they can increase their milk budget, probably because of low diet diversity and low options for substitution effects.

The results show that households are more likely to either decrease the raw milk quantities for adults and keep the same amounts for children below the age of 4 years or decrease the raw milk quantities for all family members but replace it with other food items for all family members or at least for their children. This means that the caregiver puts a specific emphasis on the nutrition of the children or knows of the importance of milk in the diet for children.

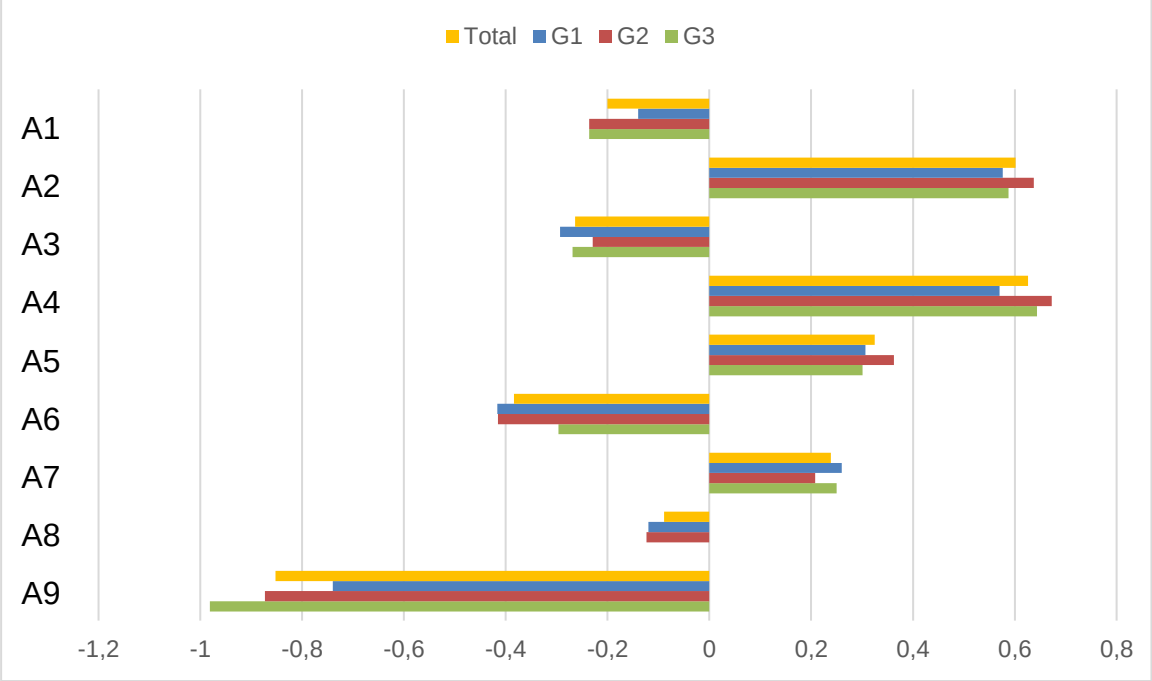

Figure 10: Attributes level scores

G1 = Poorest group with an income of less than 15,000 KES/ month, G2 = Middle group with an income between 15,001 and 25,000 KES/ month, G3 = Wealthiest group with an income between 25,001 and 30,000 KES/ month

A1: Decrease raw milk quantities for all family members without replacing it by any other food product

A2: Decrease raw milk quantities for all family members, and replace it with another food product only for children <4 years

A3: Decrease raw milk quantities for all family members, and replace it with another food product for all family members except for children <4 years

A4: Decrease raw milk quantities for all family members, and replacing it with another food product for all family members

A5: Keep raw milk quantities the same for children < 4years and decrease it for the rest of family members

A6: Decrease the quantities of raw milk I give to the children <4 years, without replacing it by other food products. Will keep the same quantities of raw milk for adults

A7: Decrease the amount of raw milk I give to the children <4 years, while replacing it by other products. Will keep the same amount of raw milk for adults

A8: Keep buying the same quantities of raw milk by increasing milk budget

A9: Stop buying raw milk

Households were furthermore asked for their behavior during the time of the survey, where the prices of raw milk were higher compared to other periods of the year. Figure 11 shows the percentage of households that made each decision. One out of two households decided to buy the same amount of raw milk by increasing their milk budget.

The higher the income of the households, the more households made this decision. The choice experiment, however, revealed a different view. There, the option for buying the same quantities of raw milk by increasing the milk budget had a neutral or negative score, which means that households would prefer another option. Reasons therefore could be that the raw milk price during the study period was about 76 KES/ liter, and the choice experiment asked for a price of around 100 KES/ liter. This could mean that households are willing to increase their milk budget up to a certain point, after which they opt for other options. The results from the calculation of the elasticities show that the increase in the dairy and therefore milk budget will be mostly achieved by decreasing the budget for meat and grains.

Eighteen percent of the households decided to decrease the raw milk quantities for all family members without replacing it by other food products. This option was chosen more often from the poorest group compared to the wealthier groups. Decreasing raw milk quantities for all family members and replacing it with another food product for all family members was chosen the third most. Further 13% of the households would replace raw milk with other food items only for household members above the age of 4 years. The middle group chose this option more often compared to the other groups, while from the wealthiest group only 9% chose this option.

Seven percent chose the option “other”. Some households felt that the price increase was not different from the normal situation and therefore kept buying the same amounts of raw milk without increasing the milk budget. Others changed from buying packed raw milk to buying unpacked raw milk or changed from buying packed pasteurized milk to unpacked raw milk. This means that households decided to go for the cheapest option possible (unpacked raw milk).

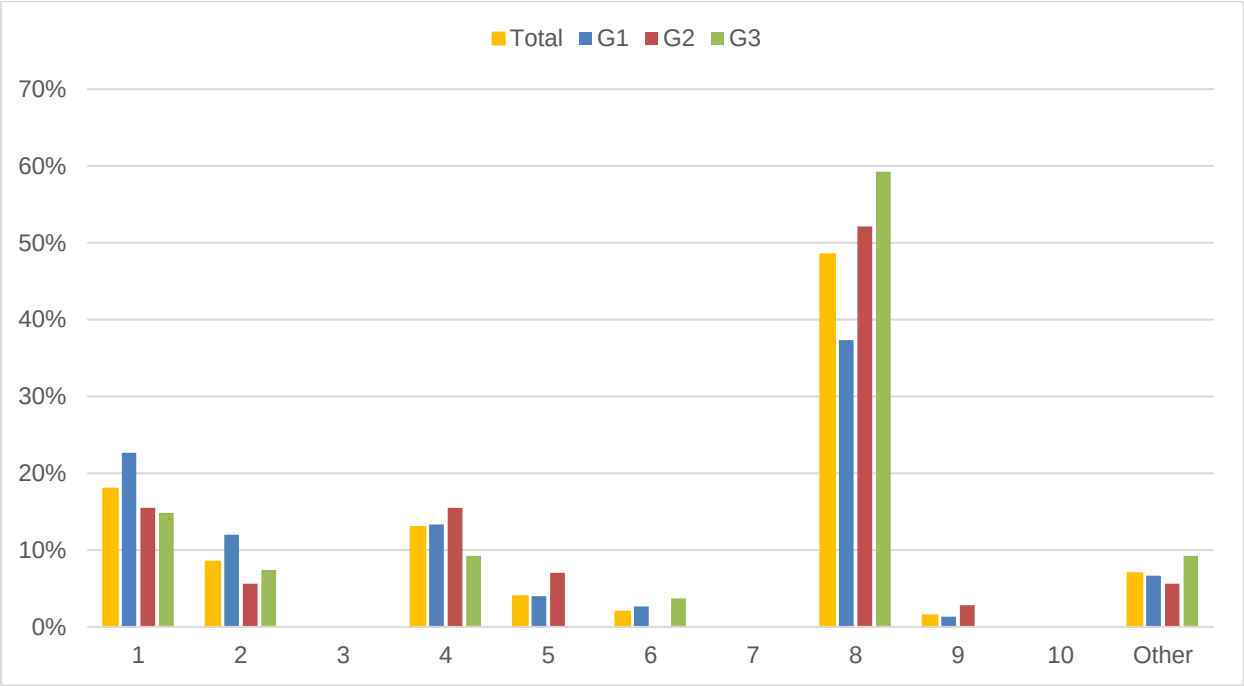

Figure 11: Decision households took during a time of high raw milk prices in percent, by income group

G1 = Poorest group with an income of less than 15,000 KES/ month, G2 = Middle group with an income between 15,001 and 25,000 KES/ month, G3 = Wealthiest group with an income between 25,001 and 30,000 KES/ month, error bars indicate standard error of the mean.

1: Decreased raw milk quantities for all family members without replacing it by any other food product

2: Decreased raw milk quantities for all family members, and replaced it with another food product only for children <4 years

3: Decreased raw milk quantities for all family members, and replaced it with another food product for all family members except for children <4 years

4: Decreased raw milk quantities for all family members, and replaced it with another food product for all family members

5: Kept raw milk quantities the same for children < 4years and decreased it for the rest of family members

6: Decreased the quantities of raw milk I give to the children <4 years, without replacing it by other food products. I kept the same quantities of raw milk for adults

7: Decreased the amount of raw milk I give to the children <4 years, while replacing it by other products. I kept the same amount of raw milk for adults

8: Kept buying the same quantities of raw milk by increasing milk budget

9: Stopped buying raw milk and replaced by other food product(s)

10: Stopped buying raw milk without replacing it by another food product

Households were asked to specify by which food items they would replace raw milk, if they choose to replace it. The only answers were either porridge or fruits. Porridge is made of millet, water and/ or milk, sometimes honey or sugar is added. Affordable and most consumed fruits could be either banana or mango, whereby mango is a seasonal fruit and therefore only eaten during the season. Bananas are a good source of potassium, vitamins and various antioxidants and phytonutrients, but with a significantly lower calcium content compared to milk (USDA 2017). The QUAIDS revealed that households would substitute raw milk with banana, eggs and Omena fish. Because not enough households purchased millet the week previous to the study, it could not be included in the model. The choice experiment exercise revealed that households are likely

to reduce the amount of raw milk consumed if prices increase and replace it with other food products if the prices are very high or keep buying the same amounts of raw milk by increasing the milk budget when prices increase, but less compared to the other scenarios. The result from the QUAIDS confirm those results partly. There, households would decrease their raw milk consumption and substitute it with banana, eggs and Omena fish. Furthermore, they would reduce their raw milk consumption less than proportionally when raw milk prices increase, indicating that they have to increase their milk budget to buy the desired amount of raw milk. But still households would reduce their raw milk consumption, they will not keep buying the same amounts as households did during the time of the survey where prices were higher compared to other times of the year.

5 Conclusion

Given the high prevalence of stunting and wasting among children worldwide, this study helps understanding dairy consumption among poor urban communities in Kenya and provides evidence that can be used to formulate food and nutrition policies. It reveals the changing patterns of food, and especially raw milk, demand as prices and income increase and shows the interaction between the demand of dairy products with the income level.

The purpose of this study was to assess the effects of an increase in the price of milk sold through informal markets on the milk consumption of households in a peri-urban settlement in Nairobi (Kenya). The study was conducted in an area in Nairobi, where previous studies found that malnutrition rates are high among children. One way to improve the nutritional status of children (as well as other household members), is to improve their intake of ASFs. As the literature review has shown, milk plays a unique role among ASFs due to its high prevalence of calcium, animal protein and vitamins while being offered at affordable prices.

Although consumers prefer raw milk in Kenya, the vision in the “Kenyan National Dairy Master Plan” aims at a reduction of the milk sold through informal markets due to concerns over quality and safety of the milk sold through these channels. Because pasteurized milk is in general more expensive compared to raw milk (in this study 55% more expensive on average), a reduction of milk availability in the form of raw milk may result in reduced accessibility of dairy products to poor households. Subsequently, it is important to study the consequences of an increase in the price of raw milk due to policies favoring pasteurized over raw milk and by which products households would substitute raw milk.

This study has shown that households who buy raw milk are very dependent on it. It accounts on average for 83% of dairy consumption per household and has the lowest unit price of 76 KES/ liter. Besides raw milk, packed yoghurt was consumed the second most dairy product, followed by packed pasteurized whole fresh milk. Households with a higher income consumed a higher amount of raw milk and other dairy products compared to households with a lower income. Raw, pasteurized and UHT milk was purchased more frequently compared to other dairy products (5.6, 3.4 and 3.6 times per week,

respectively) and the consumption of it declined with an increase in processing of the dairy products, which corresponds equally to an increase in price of product. If prices were to be the same for raw and pasteurized milk, households stated that they would buy more pasteurized milk than raw milk. However, for many households the taste is also of a big concern, so that they would prefer raw milk over pasteurized milk. This shows that there is both a market for raw and pasteurized milk but that the price is of a big constraint.

Children aged 6 to 48 months consumed on average 0.8 liter of dairy products per week, which sums up to a total consumption of 42 liter per child and year. Out of the 42 liters of dairy products, children consumed 36 liters in the form of raw milk. With an increase in the income of the households, the children consumed a higher quantity of dairy products. Nevertheless, children from the surveyed households consumed considerably less compared to the national average and only about 25% of recommended levels. Reasons for the different estimates might be the low income and different ways of the estimation of the quantity. Still, there is potential to increase the consumption of dairy products. UHT milk has especially in more remote areas the potential to boost the intake by those households because it doesn't need to be stored in a refrigerator. With only seven households who reported to use a refrigerator in this study, this can be of great importance. However, due to the higher price (almost twice as expensive compared to raw milk) and other factors like the taste, freshness or smell, UHT milk is likely to be consumed less compared to raw milk if the prices remain the same.

Household expenditure on dairy products increased with an increase in the income as well as a percentage of the total weekly food budget, mostly due to the higher price of dairy products compared to for example grains. On average, households spent 73% of their income on food products. Because households still have to pay for their rent, school fees, medical insurance and other expenses, these results imply that households are becoming food insecure and that those households need protection against food insecurity.

Households with a monthly income of less than 15,000 KES spent more of their food budget on grains compared to households with a higher income. Because of their lower budget, those households eat more of the cheaper foods. Policies aiming to increase the nutritional intake of the poorer households should take this into account.

To examine the effects of a price increase on the demand of raw milk and other food products, a Quadratic Almost Ideal Demand System was fitted, both on an aggregated and a non-aggregated level. On the aggregated level, both the uncompensated and compensated own-price elasticities are negative, showing a decrease in the demand if the price of food were to be increased. In absolute numbers, the expenditure elasticity is always higher compared to the compensated own-price elasticity, showing that income policies might be more effective than price policies in influencing consumption patterns. A policy aiming to increase the income of the households by 10% would increase the demand for dairy by 9.4% with its positive effects on, among others, child development and household nutrition, whereas a price policy might influence the consumption pattern less because of the lower elasticity compared to the expenditure elasticity.
The analysis of the elasticities on the non-aggregated level was done for raw milk, eggs, Omena fish and Banana. Demand for eggs was least price sensitive, both for the compensated and the uncompensated elasticities, which is likely to reflect households' preference for it. This is followed by banana. Raw milk and Omena fish were most sensitive to changes in prices. Households will mostly substitute raw milk with Omena fish, banana and eggs if its price increases. Expenditure elasticity in this model was highest for raw milk, indicating a preference towards raw milk if the income were to be increased.

During the time of the survey, where the prices of raw milk were higher compared to other periods of the year, households mostly kept buying the same amount of raw milk by increasing their milk budget. The choice experiment, asking households what they would do if prices were to be increased up to 100 KES/ liter, revealed a different view where households would rather replace raw milk with other food items. This shows that households are willing to increase their milk budget up to a certain point (in this case 76 KES/ liter), after what they will substitute raw milk. This aspect of the work however needs further examination and ongoing analysis will help understand more deeply decision making around food consumption and intra-household food allocation in resource limited contexts (Muunda upcoming).

The results of this study should be interpreted taking its limitations into account. First, this study focused only on households that consumed raw milk on regular basis the week previous to the study, that have a child between the age of 6 and 48 months and that have a disposable income of less than 30,000 KES per month. Therefore, the scope for

comparison with other studies is limited and should be done carefully. Second, the study showed that households that rely heavily on raw milk consume only a limited amount of other dairy products. Due to the low consumption of dairy products other than raw milk, the demand for all dairy products could not be calculated. This is also due to the small sample size of only 200 households. Third, the survey was done only once during a period of high food prices, which could lead to a different purchasing behavior from the respondents. The study was also restricted to a specific region of Kenya, and therefore the results apply to a restricted population. For broader policy recommendations, a bigger sample size would be necessary as well as a repetition of the study (both spatially and temporally) to capture seasonal and regional differences (Cornelsen et al. 2016).
Further limitations include that the accuracy of the data relies on the respondents' ability to recall their households' consumption and expenditure on food items. Respondents also stated their amount of consumption or purchase in non-standardized units. The conversion of those units could have led to potential bias.

To enrich the information obtained in this study it would be interesting to conduct a repetition of this survey during a time of lower milk prices. A survey with a higher sample size would furthermore be beneficial, so that the QUAIDS could be estimated with more products. To make statements on the impact of raw milk consumption on the development of children, the prevalence of stunting and wasting should be furthermore assessed.

From the policy perspective, interventions should focus on raising incomes to increase the milk consumption because of the high value of the expenditure elasticity. This could include raising the minimum wage, creating new job opportunities or reducing corruption. Similarly, social security should be addressed by the policy makers. An increase in the disposable income will improve the affordability of raw milk and other food items and therefore also improve the nutritional intake of children and other household members.
Other interventions could focus on the reduction of milk prices through an improved efficiency in transport and cooling systems, a reduction of the food waste along the value chain, an increase in the market competition or the support of small businesses. Because only two households of this sample were producers of milk, most households will benefit directly from lower prices.

With household's preference for raw milk, policy initiatives should focus on an improvement in the licensing of raw milk sellers and therefore in an improvement of the

quality and safety of raw milk. As the study has shown, higher prices which could result from policies favoring pasteurized over raw milk, will lead to a reduction in its demand with its negative effects on the nutrition of especially children.

6 References

Abdulai, A. & Aubert, D., 2004. A cross-section analysis of household demand for food and nutrients in Tanzania. *Agricultural Economics*, 31(1), pp.67–79.

Abuya, B.A., Ciera, J. & Kimani-Murage, E., 2012. Effect of mother's education on child's nutritional status in the slums of Nairobi. *BMC Pediatrics*, 12(80).

African Center for Economic Transformation, 2015. *Promoting Sustainable Rural Development and Transformation in Africa*, Accra.

Agbola, F.W., Maitra, P. & Mclaren, K., 2003. *On the estimation of demand systems with large number of goods: an application to South Africa household food demand*, Pretoria.

Akaichi, F. & Revoredo-Giha, C., 2014. The Demand for Dairy Products in Malawi. *African Journal of Agricultural and Resource Economics*, 9(3), pp.214–225. Available at: https://cgspace.cgiar.org/bitstream/handle/10568/1915/SDP Brief 1.pdf?sequence=1&isAllowed=y.

Akinbode, S.O., 2015. A linear approximation almost ideal demand system of food among households in South-West Nigeria. *International Journal of Social Economics*, 42(6), pp.530–542. Available at: https://doi.org/10.1108/IJSE-08-2014-0165 [Accessed June 8, 2017].

Allen, L.H. & Dror, D.K., 2011. Effects of Animal Source Foods , with Emphasis on Milk , in the Diet of Children in Low-Income Countries. *Nestlé Nutrition Institute Workshop Series*, 67, pp.113–130.

Alonso, S., 2017. Improving markets to protect food access: an intervention in informal dairy markets in Kenya. Available at: https://cgspace.cgiar.org/bitstream/handle/10568/79778/AgrilinksInformalDairyKenya.pdf?sequence=1&isAllowed=y [Accessed April 4, 2017].

Alston, J.M. & Chalfant, J.A., 1993. The Silence of the Lambdas: A Test of the Almost Ideal and Rotterdam Models. *American Journal of Agricultural Economics*, 75(2), pp.304–313. Available at: http://www.jstor.org/stable/1242914 [Accessed June 7, 2017].

Andae, G., 2017. Nairobi accounts for 62pc of milk vending machines - Daily Nation. Available at: http://www.nation.co.ke/business/Nairobi-accounts-for-62pc-of-milk-vending-machines/996-4059122-7kvphh/index.html [Accessed August 16, 2017].

Anwar, A., Aziz, B. & Ali, S., 2012. The Rotterdam Demand Model and its Applicaiton to major Food Items in Pakistan. *Journal of Basic and Applied Scientific Research*, 2(3), pp.5081–5087.

Argwings-Kodhek, G. et al., 2005. *Consumption Patterns of Dairy Products in Kenya's Urban Centres: Report from an Urban Household Survey*, Available at: www.tegemeo.org [Accessed May 15, 2017].

Baltenweck, I., 2014. Lessons from facilitating dairy producers organizations development in East Africa. *Presented at the 10th African Dairy Conference, Nairobi, Kenya, 24 September 2014.* Nairobi, Kenya: ILRI.

Banks, J., Blundell, R. & Lewbel, A., 1997. Quadratic Engel Curves and Consumer Demand. *The Review of Economics and Statistics*, 79(4), pp.527–539. Available at: http://links.jstor.org/sici?sici=0034-6535%28199711%2979%3A4%3C527%3AQECACD%3E2.0.CO%3B2-Z [Accessed June 8, 2017].

Barnett, W.A. & Seck, O., 2008. Rotterdam Model versus Almost Ideal Demand System: Will the best Specification please stand up? *Journal of Applied Econometrics*, 23, pp.795–824.

Barten, A.P., 1964. Consumer Demand Functions under Conditions of Almost Additive

Preferences. *Econometrica*, 32(1), pp.1–38. Available at: http://www.jstor.org/stable/pdf/1913731.pdf?refreqid=excelsior%3A1684446454733dc47ec0d16fe7bc2a86 [Accessed June 7, 2017].
Bewley, R.A., 1987. The Demand for Milk in Australia - Estimation of Price and Income Effects from the 1984 Household Expenditure Survey. *Australian Journal of Agricultural Economics*, 31(3), pp.204–218. Available at: http://doi.wiley.com/10.1111/j.1467-8489.1987.tb00465.x.
Bewley, R.A. & Young, T., 1987. Applying Multinomial Extension of theLlinear Logit Model to Meat Expenditure Data. *American Journal of Agricultural Economics*, 69, pp.151–157.
Blackmore, E., Alonso, S. & Grace, D., 2015. *Legitimising informal markets: a case study of the dairy sector in Kenya*,
Bollino, C., 1990. A Generalized Version of the Almost Ideal and Translog Demand Systems. *Economics Letters*, 34, pp.127–129.
Chang, T. & Fawson, C., 1994. *An Application of the Linear Expenditure Systems to the Pattern of Consumer Behavior in Taiwan*, Available at: http://digitalcommons.usu.edu/eri [Accessed July 31, 2017].
Christensen, L.R., Jorgenson, D.W. & Lau, L.J., 1975. Transcendental Logarithmic Utility Functions. *The American Economic Review*, 65(3), pp.367–383. Available at: http://www.jstor.org/stable/1804840 [Accessed June 6, 2017].
Clements, K.W. & Gao, G., 2014. The Rotterdam Demand Model Half a Century on. *University of Western Australia Discussion Paper Series*, (14.34).
Clements, K.W. & Si, J., 2016. Price Elasticities of Food Demand: Compensated vs Uncompensated. *Health economics*, 25, pp.1403–1408.
Cornelsen, L. et al., 2016. Cross-sectional study of price and other drivers of demand for animal source foods in low-income urban areas of Nairobi, Kenya. *BMC Nutrition*, 2(70), pp.1–13. Available at: http://dx.doi.org/10.1186/s40795-016-0109-z.
Daily Monitor, 2017. Kenyan workers get 18 percent minimum wage rise - Daily Monitor. Available at: http://www.monitor.co.ug/News/National/Kenyan-workers-get-18-percent-minimum-wage-rise/688334-3910638-8e4vtk/index.html [Accessed July 11, 2017].
Deaton, A., 1988. Quality, Quantity, and Spatial Variation of Price. *The American Economic Review*, 78(3), pp.418–430. Available at: http://www.jstor.org/stable/1809142 [Accessed January 3, 2018].
Deaton, A. & Muellbauer, J., 1980. An Almost Ideal Demand System. *The American Economic Review*, 70(3), pp.312–326.
Dominguez-Salas, P. et al., 2016. Nutritional characterisation of low-income households of Nairobi: socioeconomic, livestock and gender considerations and predictors of malnutrition from a cross- sectional survey. *BMC Nutrition*, 2(47), pp.1–20.
Dror, D.K. & Allen, L.H., 2011. The importance of milk and other animal-source foods for children in low-income countries. *Food and Nutrition Bulletin*, 32(3), pp.227–243.
Fadiga, M.L. & Makokha, S., 2014. Consumer valuations of the quality and safety attributes of milk and meat in Kenya. *African Journal of Agricultural and Resource Economics*, 9(2), pp.91–105.
FAOSTAT, 2016. Food and agriculture data. Available at: http://www.fao.org/faostat/en/#home [Accessed December 12, 2016].
FAOSTAT, 2017. Food and Agriculture Data. Available at: http://www.fao.org/faostat/en/#data/QL [Accessed April 11, 2017].
Gao, X.M., Wailes, E.J. & Cramer, G.L., 1994. A Synthetic Demand System : An Application to U . S . Consumer Demand for Rice and Selected Rice Substitutes. *Review of Agricultural Economics*, 16(1), pp.27–38.

Gichohi, M., 2014. Enhancing Milk Quality, Safety and Traceability: Key step in driving the Kenyan Dairy industry, *Presentation during the Food Safety in Dairy Development Workshop, held on 3rd Nov 2014 at ILRI's Campus*, Nairobi.
Gikundi, K., 2016. Drink pasteurized milk, urges KDB director. Available at: http://theslopes.co.ke/drink-pasteurized-milk-urges-kdb-director/ [Accessed May 30, 2017].
Grace, D., 2014. Food Safety in East Africa. *Presentation*.
Grace, D. & Roesel, K., 2015. *Food Safety and Informal Markets - Animal products in sub-Saharan Africa* 1st ed., Available at: https://cgspace.cgiar.org/bitstream/handle/10568/42438/Food Safety and Informal Markets.pdf?sequence=4&isAllowed=y [Accessed April 4, 2017].
Gracia, A., Gil, J.M. & Angulo, A.M., 1998. Spanish food demand : a dynamic approach. *Applied Economics*, 30(10), pp.1399–1405.
Heien, D., Wessells, C.R. & Helen, D., 1990. Demand Systems Estimation with Microdata: A Censored Regression Approach. *Journal of Business & Economic Statistics*, 8(3), pp.365–371. Available at: http://www.jstor.org/stable/1391973 [Accessed January 18, 2017].
Holt, M.T. & Goodwin, B.K., 2009. *The Almost Ideal and Translog Demand Systems*, Available at: http://mpra.ub.uni-muenchen.de/15092/ [Accessed June 6, 2017].
ILRI, 2007. *Comprehensive study of the Assam dairy sector - Action plan for pro-poor dairy development*, Nairobi, Kenya: ILRI.
InfotrackEA, 2009. Constituency Information. Available at: http://www.infotrackea.co.ke/services/leadership/constituencyinfo.php?cinf=wards&t=275 [Accessed June 13, 2017].
James, A.E., Palmer, G.H. & Allen, P.G., 2015. The Role of Animal Source Foods in Improving Nutritional Health in Urban Informal Settlements: Identification of Knowledge Gaps and Implementation Barriers. *International Journal of Child Health and Nutrition*, 4, pp.94–102.
Jiang, B. & Davis, J., 2007. Household food demand in rural China. *Applied Economics*, 39, pp.373–380. Available at: http://www.tandfonline.com/doi/pdf/10.1080/00036840500428013?needAccess=true [Accessed June 14, 2017].
Johnson, N. et al., 2015. How will training traders contribute to improved food safety in informal markets for meat and milk? A theory of change analysis. *IFPRI - Discussion Papers*, (1451). Available at: https://login.proxy.library.msstate.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=lbh&AN=20153390495&login.asp&site=ehost-live%5Cnhttp://www.ifpri.org/cdmref/p15738coll2/id/129293/filename/129504.pdf%5Cnemail: n.johnson@cgiar.org.
Jonas, A. & Roosen, J., 2008. Demand for Milk Labels in Germany: Organic Milk, Conventional Brands, and Retail Labels. *Agribusiness*, 24(2), pp.192–206. Available at: http://www3.interscience.wiley.com/journal/35917/issueyear?year=2006.
Kaitibie, S. et al., 2010. Kenyan Dairy Policy Change : Influence Pathways and Economic Impacts. *World Development*, 38(10), pp.1494–1505. Available at: http://dx.doi.org/10.1016/j.worlddev.2010.06.008.
Kamau, M., Olwande, J. & Githuku, J., 2011. *Consumption and Expenditures on Key Food Commodities in Urban Households: The Case of Nairobi*, Nairobi, Kenya. Available at: http://ageconsearch.umn.edu/bitstream/202602/2/WP41a-Consumption-and-Expenditures-on-Key-Food-Commodities-i.pdf [Accessed July 27, 2017].
Kane, G.Q. et al., 2015. *The impact of food price volatility on consumer welfare in*

Cameroon, Available at: https://www.wider.unu.edu/sites/default/files/wp2015-013.pdf [Accessed August 14, 2017].
Kang'ethe, E.K. et al., 2012. A trans-disciplinary study on the health risks of cryptosporidiosis from dairy systems in Dagoretti, Nairobi, Kenya: Study background and farming system characteristics. *Tropical Animal Health and Production*, 44(SUPPL.1), pp.3–10.
KDB, 2014. *Annual Report 2014*, Available at: http://www.kdb.co.ke/press/publications/reports/21-kdb-2014-annual-report/file.html [Accessed April 11, 2017].
Kenya Markets Trust, 2017. Dairy - Sector at a glance. Available at: http://www.kenyamarkets.org/current-sectors/dairy/ [Accessed July 28, 2017].
Kimani-Murage, E.W. et al., 2015. Evidence of a Double Burden of Malnutrition in Urban Poor Settings in Nairobi, Kenya. *PloS One*, 10(6).
Kinnucan, H.W. et al., 1997. Effects of Health' Information and Generic Advertising on U.S. Meat Demand. *American Agricultural Economics Association*, 79, pp.13–23. Available at: https://oup.silverchair-cdn.com/oup/backfile/Content_public/Journal/ajae/79/1/10.2307/1243939/2/79-1-13.pdf?Expires=1496907282&Signature=AK1YIlybS4~Z7~E42YixtGdwifS4uvuVldhKpQCPq7LrLAkit521hptViU7Ge~gN-PwievQ13Idd72A7nX5hB8ysDzAg8v1VZrN2HYs97G6ytCVT2ESvlX [Accessed June 7, 2017].
MAFAP, 2013. *Review of Food and Agricultural Policies in Kenya*, Rome. Available at: https://agriknowledge.org/downloads/5712m655z [Accessed May 15, 2017].
Maina, J.G. et al., 2007. The feeding value and protein quality in high-fibre and fibre-reduced sunflower cakes and Kenya's "omena" fishmeal for tilapia (Oreochromis niloticus). *Livestock Research for Rural Development*, 19.
Malawi Third Integrated Household Survey, 2011. Note on Conversion Factors for Food Item-Non-standard Measurement Unit Combinations in the Malawi Third Integrated Household Survey (IHS3) 2010/11 Data. Available at: http://siteresources.worldbank.org/INTLSMS/Resources/3358986-1233781970982/5800988-1271185595871/Malawi_IHS3_Food_Item_Conversion_Factors.pdf [Accessed August 29, 2017].
Masembe Kasirye, D.F.N., 2015. Milk Consumption Status and Trends. Available at: https://agriprofocus.com/upload/Microsoft_Word_-_MIlk_Consumption_Key_Note_Address_150920151442908714.pdf [Accessed June 28, 2017].
Melesse, K. & Beyene, F., 2009. Consumption pattern of milk and milk products in Ada a woreda , East Shoa Zone , central Ethiopia. *Livestock Research for Rural Development*, 21(4), pp.1–11.
Meyer, S., Yu, X. & Abler, D., 2011. Comparison of several demand systems. Available at: http://ageconsearch.umn.edu/record/103736/files/Meyer_Yu_Abler_simulation1.pdf [Accessed June 5, 2017].
Ministry of Land Housing and Development, 2013. *Kenya National Housing Survey 2012/2013 - Basic Report*, Nairobi, Kenya.
Ministry of Livestock Development, 2010. Kenya National Dairy Master Plan. Available at: http://kdb.co.ke/press/publications/reports/5-kenya-national-dairy-master-plan/file.html [Accessed May 18, 2017].
MoALF, 2013. Towards a Competitive and Sustainable Dairy Industry for Economic Growth in the 21 st Century and Beyond. Available at: http://kdb.co.ke/press/publications/acts/22-national-dairy-development-policy-of-

2013/file [Accessed May 15, 2017].
Mtimet, N. et al., 2015. Effect of quality attributes on prices of small ruminants in Somaliland: A farmers' perspective using Best-Worst approach.
Muehlhoff, E., Bennett, A. & Mcmahon, D., 2013. *Milk and dairy products in human nutrition*, Rome. Available at: http://www.nzo.nl/sites/default/files/page/attachment/milk_and_dairy_products_in_human_nutrition_fao.pdf [Accessed January 6, 2018].
Mukumbu, M. & Diang', D., 2010. *USAID Kenya Dairy Sector Competitiveness Program Annual Report*, Available at: http://pdf.usaid.gov/pdf_docs/Pdacs668.pdf [Accessed April 3, 2017].
Muriuki, H.G., 2011. *Dairy development in Kenya*, Rome. Available at: http://www.fao.org/docrep/013/al745e/al745e00.pdf [Accessed April 3, 2017].
Musyoka, M.P. et al., 2010. Structure and properties of urban household food demand in Nairobi, Kenya: implications for urban food security. *Food Security*, 2, pp.179–193.
Nassiuma, D. & Nyoike, N., 2014. *Milk production and marketing in Kenya: A preliminary survey 2013 Report*,
Ngotho, A., 2017. Kenya food prices among the highest in the world – researcher | The Star, Kenya. Available at: https://www.the-star.co.ke/news/2017/05/26/kenya-food-prices-among-the-highest-in-the-world-researcher_c1568154 [Accessed January 5, 2018].
Njanja, A., 2014. Milk machines that are generous to the pocket - Nairobi News. Available at: http://nairobinews.nation.co.ke/money-spinner/milk-machines-that-are-generous-to-the-pocket/ [Accessed July 5, 2017].
Njarui, D.M.G. et al., 2011. Consumption Patterns and Preference of Milk and Milk Products among Rural and Urban Consumers in Semi-Arid Kenya. *Ecology of Food and Nutrition*, 50(3), pp.240–262. Available at: http://www.tandfonline.com/doi/pdf/10.1080/03670244.2011.568908?needAccess=true [Accessed April 4, 2017].
Omore, A. et al., 2005. *Addressing the public health and quality concerns towards marketed milk in Kenya*, Nairobi. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.547.3149&rep=rep1&type=pdf.
Omore, A.O. et al., 2004. Analysis of Public Health Risks from Consumption of Informally Marketed Milk in Sub-Saharan African Countries. *Kenyan Veterinarian*, 40, pp.15–17. Available at: https://cgspace.cgiar.org/bitstream/handle/10568/1597/Omore et al-2000-Public health risks of raw milK sub Sahara-ISVEE.pdf?sequence=1 [Accessed April 6, 2017].
Phlips, L., 1983. *Applied Consumption Analysis* 1st ed., Amsterdam: Elsevier Science Ltd.
Pinstrup-Andersen, P., 1985. Food Prices and the Poor in Developing Countries. *European Review of Agricultural Economics*, 12(12).
Poi, B.P., 2008. Demand-system estimation: Update. *The Stata Journal*, 8(4), pp.554–556. Available at: http://ageconsearch.umn.edu/bitstream/122621/2/sjart_st0029_1.pdf [Accessed September 12, 2017].
Poi, B.P., 2012. Easy demand-system estimation with quaids. *The Stata Journal*, 12(3), pp.433–446. Available at: http://www.stata-journal.com/sjpdf.html?articlenum=st0268 [Accessed June 8, 2017].
Rademaker, C.J. et al., 2016. *Sustainable growth ot the Kenyan dairy sector - A quick scan of robustness, reliability and resilience*, Wageningen. Available at:

http://edepot.wur.nl/391018 [Accessed May 15, 2017].
Rao, J. et al., 2016. Farmers' preference for bundled input -output markets and implications for adapted dairy hubs in Tanzania – a choice experiment. *Invited paper presented at the 5th International Conference of the African Association of Agricultural Economists, September 2.* In International Livestock Research Institute.
Ray, R., 1983. Measuring the costs of children. An alternative approach. *Journal of Public Economics*, 22(1), pp.89–102.
Reynolds, L., Metz, T. & Kiptarus, J., WAR 87 Smallholder dairy production in Kenya. *FAO Corporate Document Repository*. Available at: http://www.fao.org/docrep/W2650T/w2650t07.htm [Accessed July 4, 2017].
Rizov, M. et al., 2014. Food demand and consumption patterns in the new EU member states: The case of Slovakia. *Paper prepared for presentation at the EAAE 2014 Congress "Agri-Food and Rural Innovations for Healthier Societies" August 26 to 29, 2014 Ljubljana, Slovenia.* Available at: http://ageconsearch.umn.edu/bitstream/182825/2/Food_demand_Slovakia_3_eaae 2014.pdf [Accessed September 6, 2017].
Rizov, M., Cupak, A. & Pokrivcak, J., 2015. Food security and household consumption patterns in Slovakia. Available at: http://www.econ.kuleuven.be/licos [Accessed August 14, 2017].
Sadoulet, E. & De Janvry, A., 1995. *Quantitative Development Policy Analysis*, Baltimore and London: The Johns Hopkins University Press. Available at: http://caoye.lzu.edu.cn/upload/news/N20141106111536.pdf [Accessed April 3, 2017].
Salasya, B. et al., 2009. Quantifying the economic impacts of a policy shift towards legalizing informal milk trade in Kenya*. Discussion Paper No. 1*, International Livestock Research Institute.
Salvatore, D., 2008. Consumer Preferences and Choice. In *Microeconomics*. pp. 57–86. Available at: http://global.oup.com/us/companion.websites/9780195336108/pdf/Salvatore_Chapter_3.pdf [Accessed August 2, 2017].
Seale, J., Regmi, A. & Bernstein, J., 2003. *International Evidence on Food Consumption Patterns*, Available at: http://ageconsearch.umn.edu/bitstream/184321/2/tb1904_1_.pdf [Accessed June 2, 2017].
Shonkwiler, J.S. & Yen, S.T., 1999. Two-Step Estimation of a Censored System of Equations. *American Journal of Agricultural Economics*, 81(4), pp.972–982. Available at: http://www.jstor.org/stable/1244339 [Accessed August 3, 2017].
Simple Economist, 2017. Consumer Demand Theory. Available at: http://simpleeconomist.com/consumer-demand-theory/ [Accessed August 2, 2017].
Smallholder Dairy Project, 2004a. *Public Health Issues in Kenyan Milk Markets*, Available at: https://cgspace.cgiar.org/bitstream/handle/10568/1581/SDP Brief 4.pdf?sequence=1&isAllowed=y [Accessed April 13, 2017].
Smallholder Dairy Project, 2004b. *The Demand for Dairy Products in Kenya*, Available at: https://cgspace.cgiar.org/handle/10568/1915 [Accessed January 19, 2017].
Smallholder Dairy Project, 2004c. *The Policy Environment of Kenya's Dairy Sector*, Available at: https://cgspace.cgiar.org/bitstream/handle/10568/1750/SDP Brief 6.pdf?sequence=1&isAllowed=y [Accessed April 13, 2017].
Staal, S.J., Pratt, A.N. & Jabbar, M., 2008. *Dairy Development for the Resource-Poor*, Available at: https://cgspace.cgiar.org/bitstream/handle/10568/1314/Dairy development wp44_2.pdf?sequence=1&isAllowed=y [Accessed April 11, 2017].
Stone, R., 1954. Linear Expenditure Systems and Demand Analysis: An Application to the Pattern of British Demand. *The Economic Journal*, 64(255), pp.511–527.

Available at: http://www.jstor.org/stable/pdf/2227743.pdf?refreqid=excelsior%3Ad05c5d9681eef3d6fbe71f4b41f0028c [Accessed June 5, 2017].
Taljaard, P., Alemu, Z. & Van Schalkwyk, H., 2004. The demand for Meat in South Africa: An almost ideal estimation. *Agrekon*, 43(4), pp.430–443.
TechnoServe Kenya, 2008. *The Dairy Value Chain in Kenya - A report by TechnoServe Kenya for the East Africa Dairy Development Program*, Available at: https://cgspace.cgiar.org/bitstream/handle/10568/2407/Dairy Value Chain Kenya Report.pdf;jsessionid=196A7D6BB1184428753F29303FB73958?sequence=1 [Accessed April 13, 2017].
Theil, H., 1965. The Information Approach to Demand Analysis. *Econometrica*, 33(1), pp.67–87. Available at: http://www.jstor.org/stable/1911889 [Accessed June 6, 2017].
Thorpe, W. et al., 2000. Dairy development in Kenya: the past, the present and the future. *Paper prepared for the Annual Symposium of the Animal Production Society of Kenya, March 22nd-23rd, 2000*, KARI Headquarters, Nairobi.
Trading Economics, 2018. Kenya Consumer Price Index. Available at: https://tradingeconomics.com/kenya/consumer-price-index-cpi [Accessed January 5, 2018].
Tschirley, D. et al., 2015. The Rise of a Middle Class in East and Southern Africa: Implications for Food System Transformation. *Journal of International Development*, 27, pp.628–646.
Unicef, WHO & World Bank, 2014. Levels and Trends in Child malnutrition. *Midwifery*, p.4.
USDA, 2017. Food Composition Databases. Available at: https://ndb.nal.usda.gov/ndb/search/list [Accessed September 6, 2017].
USDA, 2010. *Item Clusters, Percent of Consumption, and Representative Foods for USDA Food Pattern Food Groups and Subgroups*,
Walke, M. et al., 2014. Kenyan Perceptions of Aflatoxin: An Analysis of Raw Milk Consumption. *Paper prepared for presentation at the EAAE 2014 Congress "Agri-Food and Rural Innovations for Healthier Societies"*, August 26 to 29, 2014, Ljubljana, Slovenia. Available at: http://ageconsearch.umn.edu/record/182729/files/Walke-Kenyan_perceptions_of_aflatoxin-435_a.pdf [Accessed June 28, 2017].
Wambugu, S., Kirimi, L. & Opiyo, J., 2011. *Productivity Trends and Performance of Dairy Farming in Kenya*, Nairobi.
Weliwita, A., Nyange, D. & Tsujii, H., 2003. Food Demand Patterns in Tanzania : A Censored Regression Analysis of Microdata. *Sri Lankan Journal of Agricultural Economics*, 5(1), pp.9–34.
Williamson, C. & Shah, M.M., 1981. *Models of Expenditure Systems for Kenya*, Laxanburg. Available at: http://pure.iiasa.ac.at/1690/1/WP-81-071.pdf [Accessed June 2, 2017].
Worldbank, 2016. Data | The World Bank. Available at: http://data.worldbank.org/ [Accessed December 12, 2016].
Worldbank, 2018. Poverty and Equity Data Portal. Available at: http://povertydata.worldbank.org/poverty/country/KEN [Accessed January 10, 2018].
Worsley, S., 2012. Bringing Policy to Practice The Concept of Dairy Hubs. Available at: http://www.fao.org/fileadmin/user_upload/drought/docs/2 ILRI dairy EADD hubs Final.pdf [Accessed July 28, 2017].
Xi, J., Mittelhammer, R. & Heckelei, T., 2004. A QUAIDS Model of Japanese Meat Demand. *Selected Paper American Agricultural Economics Association. Denver,*

Colorado, USA. Available at: http://ageconsearch.umn.edu/bitstream/20120/1/sp04xi02.pdf [Accessed June 8, 2017].

Zheng, Z. & Henneberry, S.R., 2009. An Analysis of Food Demand in China: A Case Study of Urban Households in Jiangsu Province. *Review of Agricultural Economics*, 31(4), pp.873–893. Available at: http://www.jstor.org/stable/40588533 [Accessed June 12, 2017].

Appendix A: Significance tests

A1: Chi-square test to test the null hypothesis that the gender of the household head has no influence on the income group

Gender of the household head	Income group G1	G2	G3	Total
Male	38	38	38	114
Female	17	11	5	33
Total	55	49	43	147

Pearson chi2(2) = 5.1533 Pr = 0.076

A2: Chi-square test to test the null hypothesis that

Frequency of Children 6-48 months	G1	G2	G3	Total
0	0	1	1	2
1	65	50	54	169
2	8	11	6	25
3	2	0	2	4
Total	75	62	63	200

Pearson chi2(6) = 5.2142 Pr = 0.517

A3: Analysis of Variance to test the null hypothesis that the mean food expenditure in the three income groups are not different

Source	SS	df	MS	F	Prob > F
Between groups	7.53E+09	2	3.77E+09	1944.88	0
Within groups	3.87E+10	19997	1935975.55		
Total	4.62E+10	19999	2312325.36		

Bartlett's test for equal variances: chi2(2) = 3.80E+03 Prob>chi2 = 0

Comparison of total hh food expenditure by hh income group (Bonferroni)

Row Mean - Col Mean	G1	G2
G2	801.8660	
G3	1536.860	734.9960

A4: Analysis of variance to test the null hypothesis that the mean expenditure of households on food groups in the three income groups is not different

Source	SS	df	MS	F	Prob>F
Between groups	178600383	2	89300191.7	409	0
Within groups	4.37E+09	19997	218338.589		
Total	4.54E+09	19999	227247.22		

Bartlett's test for equal variances: chi2(2) = 4.90E+03 Prob>chi2 = 0

Comparison of expenditure per hh per food group by hh income group (Bonferroni)

Row Mean - Col Mean	G1	G2
G2	118.30	
G3	237.4140	119.1140

A5: Analysis of variance to test the null hypothesis that the mean expenditure on grains in percent in the three income groups is not different

Source	SS	df	MS	F	Prob>F
Between groups	9929.68415	2	4964.84207	50.71	0
Within groups	273825.346	2797	97.8996588		
Total	283755.03	2799	101.377288		

Bartlett's test for equal variances: chi2(2) = 41.6751 Prob>chi2 = 0

Comparison of expenditure on food group grains of total food expenditure in % by hh income group (Bonferroni)

Row Mean - Col Mean	G1	G2
G2	-3.872790	
G3	-3.911990	-0.0391951

A6: Analysis of variance to test the null hypothesis that the mean expenditure on dairy in percent in the three income groups is not different

Source	SS	df	MS	F	Prob>F
Between groups	49223.1707	2	24611.5853	532.32	0
Within groups	924553.974	19997	46.2346339		
Total	973777.145	19999	48.6912918		

Bartlett's test for equal variances: chi2(2) = 523.5899 Prob>chi2 = 0

Comparison of expenditure on dairy of total food expenditure in % by hh income group (Bonferroni)

Row Mean - Col Mean	G1	G2
G2	2.914540	
	0	
G3	3.568490	0.653957
	0	0

A7: Analysis of variance to test the null hypothesis that the mean number of dairy products purchased the week previous to the study in the three income groups is not different

Source	SS	df	MS	F	Prob>F
Between groups	6.77237089	2	3.38618545	7.32	0.0009
Within groups	91.1026291	197	0.46244989		
Total	97.875	199	0.49183417		

Bartlett's test for equal variances: chi2(2) = 5.311 Prob>chi2 = 0.07

Comparison of number of dairy products purchased last week by hh income group (Scheffe)

Row Mean - Col Mean	G1	G2
G2	0.196056	
	0.222	
G3	0.464444	0.268388
	0.001	0.094

A8: Analysis of variance to test the null hypothesis that the mean purchase of dairy products in liter of the three income groups is not different

Source	SS	df	MS	F	Prob>F
Between groups	35.8101475	2	17.9050738	7.7	0.0005
Within groups	4179.46045	1797	2.3257988		
Total	4215.27059	1799	2.34311873		

Bartlett's test for equal variances: chi2(2) = 183.4083 Prob>chi2 = 0

Comparison of purchase in liter by hh income group (Bonferroni)

Row Mean - Col Mean	G1	G2
G2	0.209902 0.038	
G3	0.347374 0	0.137472 0.403

A9: Analysis of variance to test the null hypothesis that the mean raw milk purchase of the three income groups is not different

Source	SS	df	MS	F	Prob>F
Between groups	199.564931	2	99.7824656	15.48	0
Within groups	1269.98108	197	6.44660444		
Total	1469.54601	199	7.3846533		

Bartlett's test for equal variances: chi2(2) = 10.0057 Prob>chi2 = 0.007

Comparison of raw milk purchase in liter by hh income group (Scheffe)

Row Mean - Col Mean	G1	G2
G2	1.70992 0	
G3	2.36689 0	0.656964 0.36

A10: Analysis of variance to test the null hypothesis that mean dairy consumption from children of the three income groups is not different

Source	SS	df	MS	F	Prob > F
Between groups	96799.317	2	48399.6585	0.16	0.8562
Within groups	119333854	383	311576.642		
Total	119430653	385	310209.488		

A11: Analysis of variance to test the null hypothesis that the mean consumption of packed yoghurt from children of the three income groups is not different

Source	SS	df	MS	F	Prob > F
Between groups	33919.9102	2	16959.9551	0.78	0.4625
Within groups	1896327.47	87	21796.8675		
Total	1930247.38	89	21688.1728		

A12: Analysis of variance to test the null hypothesis that the mean consumption of UHT milk from children of the three income groups is not different

Source	SS	df	MS	F	Prob > F
Between groups	37.0925088	2	18.5462544	0.12	0.8873
Within groups	1843.431	12	153.61925		
Total	1880.52351	14	134.323108		

A13: Analysis of variance to test the null hypothesis that the mean consumption of packed pasteurized whole fresh milk from children of the three income groups is not different

Source	SS	df	MS	F	Prob > F
Between groups	2825.19092	2	1412.59546	1.43	0.2532
Within groups	34598.8104	35	988.53744		
Total	37424.0013	37	1011.4595		

Appendix B: Coefficients from the QUAIDS model

B1: Coefficients from the QUAIDS model. The conditions adding-up, homogeneity and symmetry are satisfied.

	Dairy	Meat	Grains	Vegetables	Oils and Solid fats	Fruits	Other food items
Alpha	0.0564	0.2434	-0.2068	0.2581	0.3064	0.1330	0.2096
Standard Error	0.0901	0.0757	0.1430	0.0880	0.0867	0.0587	0.0559
P>z	0.5310	0.0010	0.1480	0.0030	0.0000	0.0240	0.0000
Beta	-0.0586	0.0777	-0.3728	0.0314	0.2163	0.0269	0.0792
Standard Error	0.0779	0.0671	0.0866	0.0725	0.0563	0.0495	0.0480
P>z	0.4520	0.2470	0.0000	0.6650	0.0000	0.5870	0.0990
Gamma 1	0.0592	-	-	-	-	-	-
Standard Error	0.0265	-	-	-	-	-	-
P>z	0.0260	-	-	-	-	-	-
Gamma 2	-0.0174	0.0856	-	-	-	-	-
Standard Error	0.0191	0.0258	-	-	-	-	-
P>z	0.3630	0.0010	-	-	-	-	-
Gamma 3	0.0603	-0.0940	0.3008	-	-	-	-
Standard Error	0.0482	0.0533	0.1212	-	-	-	-
P>z	0.2110	0.0780	0.0130	-	-	-	-
Gamma 4	-0.0239	-0.0313	-0.0279	0.0580	-	-	-
Standard Error	0.0146	0.0147	0.0508	0.0138	-	-	-
P>z	0.1000	0.0320	0.5830	0.0000	-	-	-
Gamma 5	-0.0476	0.0262	-0.1317	0.0177	0.0906	-	-
Standard Error	0.0352	0.0289	0.0578	0.0298	0.0500	-	-
P>z	0.1770	0.3650	0.0230	0.5520	0.0700	-	-
Gamma 6	-0.0040	0.0057	-0.0246	-0.0018	0.0038	0.0171	-
Standard Error	0.0101	0.0098	0.0335	0.0069	0.0195	0.0072	-
P>z	0.6900	0.5590	0.4630	0.7900	0.8450	0.0170	-
Gamma 7	-0.0266	0.0252	-0.0829	0.0093	0.0410	0.0038	0.0302
Standard Error	0.0173	0.0155	0.0382	0.0143	0.0227	0.0096	0.0188
P>z	0.1240	0.1050	0.0300	0.5160	0.0710	0.6960	0.1080
Lambda	-0.0137	0.0038	-0.0583	0.0056	0.0434	0.0002	0.0190
Standard Error	0.0154	0.0136	0.0191	0.0137	0.0124	0.0096	0.0106
P>z	0.3720	0.7770	0.0020	0.6850	0.0000	0.9830	0.0730

Eta_genderhhhead	0.0001	0.0182	-0.0010	-0.0104	-0.0050	-0.0046	0.0028
Standard Error	0.0058	0.0092	0.0088	0.0067	0.0040	0.0039	0.0055
P>z	0.9880	0.0490	0.9060	0.1210	0.2050	0.2340	0.6120
Eta_maritalhhhead	0.0024	-0.0081	-0.0015	0.0023	0.0032	0.0011	0.0007
Standard Error	0.0025	0.0038	0.0036	0.0028	0.0017	0.0017	0.0024
P>z	0.3460	0.0320	0.6700	0.4220	0.0680	0.5180	0.7560
Eta_activityhhhead	-0.0041	-0.0022	0.0000	0.0012	0.0006	0.0006	0.0040
Standard Error	0.0023	0.0034	0.0033	0.0026	0.0015	0.0015	0.0022
P>z	0.0800	0.5230	0.9980	0.6420	0.7100	0.7190	0.0660
Eta_eduhhhead	-0.0020	-0.0008	0.0006	0.0012	0.0008	-0.0001	0.0003
Standard Error	0.0009	0.0013	0.0013	0.0010	0.0006	0.0006	0.0008
P>z	0.0290	0.5450	0.6280	0.2340	0.1840	0.8290	0.7360
Eta_nohhmembers	0.0029	0.0005	-0.0018	-0.0017	-0.0002	0.0007	-0.0003
Standard Error	0.0011	0.0015	0.0015	0.0012	0.0007	0.0007	0.0009
P>z	0.0070	0.7260	0.2170	0.1440	0.7480	0.3340	0.7410
Eta_hhincomegroup	-0.0059	0.0018	0.0031	-0.0005	-0.0015	-0.0001	0.0030
Standard Error	0.0020	0.0028	0.0028	0.0021	0.0013	0.0013	0.0018
P>z	0.0040	0.5270	0.2710	0.8200	0.2550	0.9480	0.0880
Eta_frequchild	-0.0056	-0.0032	0.0076	0.0031	0.0017	-0.0040	0.0004
Standard Error	0.0032	0.0047	0.0045	0.0035	0.0021	0.0021	0.0028
P>z	0.0770	0.4990	0.0930	0.3700	0.4370	0.0550	0.8810

A2: Coefficients from the Quaids model with raw milk, eggs, Omena fish, banana

	Raw milk	**Eggs**	**Omena fish**	**Banana**
Alpha	1.068	0.242	-0.018	-0.292
Standard Error	0.077	0.046	0.016	0.097
P>z	0.000	0.000	0.237	0.003
Beta	0.136	-0.070	-0.009	-0.057
Standard Error	0.044	0.020	0.014	0.040
P>z	0.002	0.000	0.518	0.151
Gamma 1	-0.002	0.010	0.001	0.014
Standard Error	0.006	0.016	0.009	0.012
P>z	0.708	0.524	0.886	1.180
Gamma 2	-0.013	0.036	-0.020	-0.003
Standard Error	0.022	0.014	0.007	0.029
P>z	0.539	0.013	0.003	0.930

Gamma 3	0.001	-0.020	0.013	-0.005
Standard Error	0.009	0.007	0.004	0.010
P>z	0.886	0.003	0.000	0.646
Gamma 4	0.014	-0.003	-0.010	0.022
Standard Error	0.012	0.029	0.005	0.030
P>z	0.238	0.930	0.053	0.466
eta_hhincomegroup	0.000	0.000	0.000	0.000
Standard Error	(omitted)	(omitted)	(omitted)	(omitted)
P>z				
eta_nohhmembers	0.029	0.033	-0.0116399	-0.0506507
Standard Error	0.008	0.005	0.016707	0.0181956
P>z	0.001	0.000	0.486	0.005

Appendix C: Questionnaire for the household survey

Section 1: General information about the household

s01q01. For how many years has the household lived in this area? [_____] years [put 0 if < 1 year] (if 0 – go to s01q01_01)

s01q01_01, If less than 1 years, is it more or less than 6 months? (1=more, 2=less, 98=don't know)

I will now ask you to give me some details of all the individuals living in this house; that is all those individuals, children included, who **usually** shared the same meals in the last 6 months, and for more than half the week in those 6 months. This may include even your maids or others who shared the meals.

s01q02	s01q03	s01q04	s01q05	s01q06	s01q07	s01q08	s01q09	s01q010	s01q011	s01q012
Please give me the names of all the household members	What is [NAME]'s relation to the HH head? (code a)	Male or Female? (1=male; 2=female)	**In the last 7 days**, how many days did [NAME] eat both main meals away from the household? (days)	**During the past 6 months**, how many months did [NAME] eat away from the household? (months)	What is [name]'s age? (in completed years) (code e) (if <3 - go to Q13)	What is [name]'s marital status? (code b)	Has (name) attended school (1=yes; 2=no; 98=don't know) (if 2 or 98, move to Q12)	What is the highest level of education attended by [name]? (code c)	Did [NAME] complete that highest level of education? (1=yes; 2=no; 98=don't know)	What is [name]'s primary activity? (code d)
1.	[_____]	[___]								[_____]
2.	[_____]	[___]								[_____]
3.	[_____]	[___]								[_____]
4.	[_____]	[___]								[_____]
5.	[_____]	[___]								[_____]
6.	[_____]	[___]								[_____]
7.	[_____]	[___]								[_____]
8.	[_____]	[___]								[_____]

Codes

(a) Relation to HH head

1= Household head
2= Spouse
3= Son
4= Daughter
5= Daughter-in-law
6= Son-in-law
7= Niece
8= Nephew
9= Parent (incl. in-law)
10 = House help (maid/boy)
97 = Other
98 = I don't know

(b) Marital status

1= Married living with spouse
2= married living separately
3= Single (incl. children)
4= Divorced/Separated
5= Widow/ widower
97 = Other
98 = I don't know

(c) Level of education

1= Kindergarden (<6yr)
2= Adult literacy education
3 = Primary school (class 1-8)
4 = Vocational school (no secondary education)
5 = Secondary school (form 1-4)
6 = Technical college / Diploma
7 = Post-Secondary school ('A' level)
8 = University / Degree
9 = Post-graduate
97 = Other
98 = I don't know

(d) Primary activity /Main occupation

1= Unemployed
2= Employed/laborer
3= Self-employed (own business, family business)
4= Pupil/Student
5= Retired with pension
6= Retired without pension
97 = Other
98 = I don't know

(e) age in completed years

0=less than 6 months
1=6m-11months
2=1-3 years
3=4-12 years
4=13-17 years
5= 18-29years
6=30-39years
7=40-49years
8=50-59years
8= 60-69years
9= 70years and above
98=Don't know

Section 2: Milk and other dairy products purchase, consumption, and production by the household

Now I would like to talk with you about milk and dairy products from cow you and others in the household consumed and purchased in the past 7 days. I will go through a list of dairy products and ask you a few questions about each of them.

		s02q01_01	s02q01_02	s02q01_03	s02q01_04	s02q01_05	s02q01_06	s02q01_07	s02q01_08	s02q01_9	s02q01_10	s02q01_11	s02q01_12	s02q01_13	s02q01_14	s02q01_15
															(only if Q_13=1)	
		Did your household purchase [PRODUCT NAME] in last 7 days? (1=Yes; 2=No) **If "No", skip to next product**	How many days did you purchase [PRODUCT NAME] in last 7 days? (code b)	How was the purchase frequency of [product name] this week compared to previous weeks? (code c)	How much of [product name] did you purchase in total in the last 7 days?	Unit of purchase (code d)	How much did all this amount cost? (K. Sh.) (if answered, go to s02q01_9)	What was the price of [product name] per unit? (e.g. Ksh/ unit)	Unit (code d)	In which type of market outlet did you PRIMARILY purchase [product name] in the last 7 days? (code e)	(for PRODUCTS INDICATED WITH X) How long does it take you to travel from your home to [MARKET OUTLET FROM Q9] (one way)? (minutes)	(for PRODUCTS INDICATED WITH X) How many different market outlets did you purchase it from in the last 7 days?	In the last 7 days, did you obtain [PRODUCT NAME] from any other source for free? (1=Yes; 2=No) **If "No", skip to next product**	Which other **sources** did you obtain [PRODUCT NAME] from in the last 7 days? (code f) (if ≠1, skip to **next product**)	How much of [product name] did you consume from own production in the last 7 days?	Unit (code d)
s02q01	UNPACKED Raw Milk	[__]	[__]	[__]							**X**	**X**				
s02q02	UNPACKED Boiled whole milk	[__]	[__]	[__]							**X**	**X**				
s02q03	UNPACKED fermented milk (mala)	[__]	[__]	[__]							**X**	**X**				

s02q 04	UNPACKED yoghurt	[__]	[__]	[__]							X	X				
s02q 05	PACKED pasteurized whole fresh milk	[__]	[__]	[__]							X	X				
s02q 06	UHT milk	[__]	[__]	[__]							X	X				
s02q 07	PACKED fermented milk (mala)	[__]	[__]	[__]												
s02q 08	PACKED yoghurt	[__]	[__]	[__]												
s02q 09	Powdered milk	[__]	[__]	[__]												

Codes

(b) purchase frequency	**(c) Compare consumption frequency**	**(e) Market outlet/ source of product**	**(f) Other sources of consumption**
1= 1 day 2= 2 days 3= 3 days 4= 4 days 5= 5 days 6= 6 days 7= 7 days 98 = Don't know	1= Same 2= Higher 3= Lower 98 = Don't know **(d) Unit of consumption** 1= Liter 2= mL 3= grams 4=Kg 5 = cup 500mL 6= cup 300mL (large) 7= cup 250mL (small) 8= glass (200mL) 9= yoghurt unit (50-250mL) 10= packet 500mL 11= packet 250mL 97= Other (specify_____) 98 = Don't know	1= Milk dispenser in supermarket 2= Milk dispenser in milk bar 3=Milk dispenser in other location 4= Producer gate 5= Home delivery (door vendor) 6= Street vendor 7= Vendor in open market 8= Corner shop/kiosk (fix premise) 9= Milk bar (dairy shop) 10= Supermarket 11= Whole seller 97= Other 98 = Don't know	1= Own production 2= Gift from friend/relative 3= Government/NGO program 97= Other 98 = Don't know

s02q10. Are there any other dairy products that the household consumed over the last 7 days (prompt participants if needed)? [___] (1= yes /2= No). (if "no" go to s02q14)

s02q11. Which product did the household consume? (#) (code: 1=ghee, 2=butter, 3=cream, 4=cheese, 5=camel milk, 6=sheep/goat milk, 97=other, 98=don't know)

[FOR EACH PRODUCT INDICATED IN s02q11]:

s02q12. How much of the products did you consume? [___] Units (code d)

s02q13. Was it purchased, or from other sources? (1=purchased, 2=other sources, 3=both, 98=Don't know)

Now I will ask you, for each of the household members you named before and for each of the products that you told me you purchased last week, how much each of the household members consumed in the past 7 days.

	s02q14	**s02q15**		**s02q16**	**s02q17**	**s02 q18**	**s02q19**		**s02q20**	**s02 q21**	
(FOR PRODUCTS PURCHASED OVER THE LAST 7 DAYS)	Excluding today, when was the last time you purchased [PRODUCT NAME]? (record n. of days from today)	What amount of [PRODUCT NAME] did you purchase that last time you bought it?	Unit of purchase (code c)	Has any of the purchased [PRODUCT NAME] been consumed by now? (1=Yes, 2=No; 98=Don't Know) (If 2 or 98, go to next product)	Was any of it [PRODUCT NAME] consumed "as is"? (1=Yes, 2=No; 98=Don't Know) (If 2 OR 98 go to Qxx20)	Which household members consumed it as is? (list of household members) (#)	(FOR EACH HH MEMBER WHO CONSUMED AS IS) How much did [HH MEMBER] consume (*from the total amount)?*	Unit of consumption (code c)	Was any of the purchased [PRODUCT NAME] consumed "as part or ingredient of a dish or drink"? (1=Yes, 2=No; 98=Don't Know) (If 2 OR 98, go to next product)	Which dishes/ drinks did you prepare with that product? (#) (code a)	Which HH members consumed it? (present list of HH members)
UNPACKED Raw Milk						[___]	7	[___]			
UNPACKED Boiled whole milk						[___]		[___]			
UNPACKED fermented milk (mala)						[___]		[___]			
UNPACKED yoghurt		…						[___]			
PACKED pasteurized whole fresh milk						[___]		[___]			
UHT milk						[___]		[___]			
PACKED fermented milk (mala)						[___]		[___]			
PACKED yoghurt								[___]			
Powdered milk											

(a) dish/drink	(c) Unit
1= Tea/coffee 2= Porridge 3= cake 4= with vegetables 5= with cereals 97= other 98=Don't know	1= Liter 2= mL 3= grams 4=Kg 5 = cup 500mL 6= cup 300mL (large) 7= cup 250mL (small) 8= glass (200mL) 9= yoghurt unit (50-250mL) 10= packet 500mL 11= packet 250mL 97= Other 98 = Don't know

Now I would like to enquire about how the purchase of liquid milk (both packed and unpackaged) in the household changes over the year and why.

s02q21. Over one year, from January to December, which are the months in which your household purchases more liquid milk? [__] (1=Yes, 2=No) (if no, go to question s02q24)
s02q22. Which months? (#)
s02q23. And why? (code a) (#)

s02q24. which are the months in which your household purchases less liquid milk? (1=Yes, 2=No) (if no, go to question s03q01)
s02q25. Which months? (#)
s02q26. And why? (code a) (#)

Code a

1= more people in the house 2 = less people in the house 3= milk is cheaper 4= milk is more expensive	5= milk is higher quality 6 = milk is lower quality 7 = income is higher 8 = income is lower	9 = recent high non- food HH expenditure 10 = recent high HH expenditure 11 = less milk supply in the market 12=more milk supply in the market 97 = other 98 = I don't know

Section 3: Changes in purchase/consumption levels based on milk price

Suppose that, because of a longer drought situation, the prices of RAW milk will increase by 40% compared to the current price and go up to KES 100/litre. In the following exercise you will be shown a series of 9 cards. Each card contains 4 statements that describe different behaviours/ decisions that you might make or not. For each card, please indicate what is the most likely decision you would make, and the least likely decision you would make.

There are no wrong or correct answers. We only want you to describe what would be the decision you will make.

(code a)	
1	Decrease raw milk quantities for all family members without replacing it by any other food product
2	Decrease raw milk quantities for all family members, and replace it with another food product only for children <4 years
3	Decrease raw milk quantities for all family members, and replace it with another food product for all family members EXCEPT for children <4 years
4	Decrease raw milk quantities for all family members, and replacing it with another food product for all family members
5	Keep raw milk quantities the same for children < 4years and decrease it for the rest of family members
6	Decrease the quantities of raw milk I give to the children <4 years, without replacing it by other food products. Will keep the same quantities of raw milk for adults
7	Decrease the amount of raw milk I give to the children <4 years, while replacing it by other products. Will keep the same amount of raw milk for adults
8	Keep buying the same quantities of raw milk by increasing milk budget
9	Stop buying raw milk

S03q01. If **raw milk** price increases by **40%** compared to high season prices, which corresponds to new raw milk price around **KES 100/litre**, from the 4 alternatives/actions below please indicate which is the most likely alternative/action you will choose/do and the least likely alternative/action you will not choose/do? (Tick only one case as most important and one case as least important)

Most likely	Alternatives	Least likely
☐	2. Decrease raw milk quantities for all family members, and replace it with another food product only for children <4 years	☐
☐	5. Keep raw milk quantities the same for children < 4years and decrease it for the rest of family members	☐
☐	6. Decrease the quantities of raw milk I give to the children <4 years, without replacing it by other food products. Will keep the same quantities of raw milk for adults	☐
☐	3. Decrease raw milk quantities for all family members, and replace it with another food product for all family members EXCEPT for children <4 years	☐

S03q02. If **raw milk** price increases by **40%** compared to high season prices, which corresponds to new raw milk price around **KES 100/litre**, from the 4 alternatives/actions below please indicate which is the most likely alternative/action you will choose/do and the least likely alternative/action you will not choose/do? (Tick only one case as most important and one case as least important)

Most important	Alternatives	Least important
☐	Keep buying the same quantities of raw milk by increasing milk budget	☐
☐	Decrease raw milk quantities for all family members, and replace it with another food product only for children <4 years	☐
☐	Decrease raw milk quantities for all family members, and replace it with another food product for all family members EXCEPT for children <4 years	☐
☐	Stop buying raw milk	☐

S03q03. If **raw milk** price increases by **40%** compared to high season prices, which corresponds to new raw milk price around **KES 100/litre**, from the 4 alternatives/actions below please indicate which is the most likely alternative/action you will choose/do and the least likely alternative/action you will not choose/do? (Tick only one case as most important and one case as least important)

Most likely	Alternatives	Least likely
☐	Decrease the amount of raw milk I give to the children <4 years, while replacing it by other products. Will keep the same amount of raw milk for adults	☐
☐	Decrease the quantities of raw milk I give to the children <4 years, without replacing it by other food products. Will keep the same quantities of raw milk for adults	☐
☐	Decrease raw milk quantities for all family members, and replace it with another food product only for children <4 years	☐
☐	Decrease raw milk quantities for all family members without replacing it by any other food product	☐

S03q04. If **raw milk** price increases by **40%** compared to high season prices, which corresponds to new raw milk price around **KES 100/litre**, from the 4 alternatives/actions below please indicate which is the most likely alternative/action you will choose/do and the least likely alternative/action you will not choose/do? (Tick only one case as most important and one case as least important)

Most likely	Alternatives	Least likely
☐	Keep raw milk quantities the same for children < 4years and decrease it for the rest of family members	☐
☐	Keep buying the same quantities of raw milk by increasing milk budget	☐
☐	Stop buying raw milk	☐
☐	Decrease the amount of raw milk I give to the children <4 years, while replacing it by other products. Will keep the same amount of raw milk for adults	☐

S03q05. If **raw milk** price increases by **40%** compared to high season prices, which corresponds to new raw milk price around **KES 100/litre**, from the 4 alternatives/actions below please indicate which is the most likely alternative/action you will choose/do and the least likely alternative/action you will not choose/do? (Tick only one case as most important and one case as least important)

Most likely	Alternatives	Least likely
☐	Decrease raw milk quantities for all family members, and replace it with another food product for all family members EXCEPT for children <4 years	☐
☐	Decrease raw milk quantities for all family members without replacing it by any other food product	☐
☐	Decrease raw milk quantities for all family members, and replacing it with another food product for all family members	☐
☐	Keep buying the same quantities of raw milk by increasing milk budget	☐

S03q06. If **raw milk** price increases by **40%** compared to high season prices, which corresponds to new raw milk price around **KES 100/litre**, from the 4 alternatives/actions below please indicate which is the most likely alternative/action you will choose/do and the least likely alternative/action you will not choose/do? (Tick only one case as most important and one case as least important)

Most likely	Alternatives	Least likely
☐	Decrease raw milk quantities for all family members, and replacing it with another food product for all family members	☐
☐	Stop buying raw milk	☐
☐	Decrease raw milk quantities for all family members without replacing it by any other food product	☐
☐	Decrease raw milk quantities for all family members, and replace it with another food product only for children <4 years	☐

S03q07. If **raw milk** price increases by **40%** compared to high season prices, which corresponds to new raw milk price around **KES 100/litre**, from the 4 alternatives/actions below please indicate which is the most likely alternative/action you will choose/do and the least likely alternative/action you will not choose/do? (Tick only one case as most important and one case as least important)

Most likely	Alternatives	Least likely
☐	Stop buying raw milk	☐
☐	Decrease raw milk quantities for all family members, and replacing it with another food product for all family members	☐
☐	Keep raw milk quantities the same for children < 4years and decrease it for the rest of family members	☐
☐	Decrease the quantities of raw milk I give to the children <4 years, without replacing it by other food products. Will keep the same quantities of raw milk for adults	☐

S03q08. If **raw milk** price increases by **40%** compared to high season prices, which corresponds to new raw milk price around **KES 100/litre**, from the 4 alternatives/actions below please indicate which is the most likely alternative/action you will choose/do and the least likely alternative/action you will not choose/do? (Tick only one case as most important and one case as least important)

Most likely	Alternatives	Least likely
☐	Decrease raw milk quantities for all family members without replacing it by any other food product	☐
☐	Decrease raw milk quantities for all family members, and replace it with another food product for all family members EXCEPT for children <4 years	☐
☐	Decrease the amount of raw milk I give to the children <4 years, while replacing it by other products. Will keep the same amount of raw milk for adults	☐
☐	Keep raw milk quantities the same for children < 4years and decrease it for the rest of family members	☐

S03q09. If **raw milk** price increases by **40%** compared to high season prices, which corresponds to new raw milk price around **KES 100/litre**, from the 4 alternatives/actions below please indicate which is the most likely alternative/action you will choose/do and the least likely alternative/action you will not choose/do? (Tick only one case as most important and one case as least important)

Most likely	Alternatives	Least likely
☐	Decrease the quantities of raw milk I give to the children <4 years, without replacing it by other food products. Will keep the same quantities of raw milk for adults	☐
☐	Decrease the amount of raw milk I give to the children <4 years, while replacing it by other products. Will keep the same amount of raw milk for adults	☐
☐	Keep buying the same quantities of raw milk by increasing milk budget	☐
☐	Decrease raw milk quantities for all family members, and replacing it with another food product for all family members	☐

S03q10. Now, if you consider the current situation, with the current raw milk prices which are higher compared to the rainy/high production season, what decision/s have you taken in terms of raw milk purchase and household raw milk allocation: (enumerator will tick the corresponding case/s)

1	Decreased raw milk quantities for all family members without replacing it by any other food product	
2	Decreased raw milk quantities for all family members, and replaced it with another food product only for children <4 years. Specify the food product replacing raw milk:_____	
3	Decreased raw milk quantities for all family members, and replaced it with another food product for all family members EXCEPT for children <4 years. Specify the food product replacing raw milk:_____	
4	Decreased raw milk quantities for all family members, and replaced it with another food product for all family members. Specify the food product replacing raw milk:_____	
5	Kept raw milk quantities the same for children < 4years and decreased it for the rest of family members	
6	Decreased the quantities of raw milk I give to the children <4 years, without replacing it by other food products. I kept the same quantities of raw milk for adults	
7	Decreased the amount of raw milk I give to the children <4 years, while replacing it by other products. I kept the same amount of raw milk for adults. Specify the food product replacing raw milk:_____	
8	Kept buying the same quantities of raw milk by increasing milk budget	
9	Stopped buying raw milk and replaced by other food product(s). Specify the food product(s) replacing raw milk:_____	
10	Stopped buying raw milk without replacing it by another food product. Specify what have you done with the money unspent:_____	
11	Other specify: _____	

SECTION 4. PERCEPTIONS OF MILK QUALITY AND SAFETY

Now we are going to talk about how safe for consumption (**ni salama kwa afya yako**) the milk in this area is.

s04q01. Do you trust that the unpacked milk you buy from your usual market outlet is safe for consumption?

[_____] (1=Yes; 2=No, 98= don't know)

s04q02. And do you believe that packaged fresh milk is safe for consumption?

[_____] (1=Yes; 2=No, 98= don't know)

s04q03. And do you think that RAW milk is more safe, less safe or about the same compared to packaged fresh milk?

[_____] (1=safer; 2=less safe, 3=same, 98= don't know)

Now we are going to talk about the quality (**ubora**) of the milk in this area.

s04q04. Do you believe that raw/fresh milk purchased at your most frequent local market outlet is of high/good quality?

[_____] (1=Yes; 2=No, 98= don't know) (if 1, go to **s04q05**; if 2, go to **s04q06**; if 98, go to **s04q07**)

s04q05. What makes it of good quality? (#)
(code a)

s04q06. What makes it of bad quality? (#)
(code a)

s04q07. Do you think the raw milk is of better/worse/same quality compared to packaged milk?

[_____] (1=better; 2=worse, 3=same, 98= don't know)

(if they say 1 – "if both types of milk were of same quality, would you still purchase raw milk or would you purchase packaged milk?"

s04q08. If the price of raw milk was the same as that of packaged milk, would you buy raw milk, or would you buy packaged milk?

[_____] (1=raw; 2=packaged, 3= depends on other factors, 98=don't know)

(a) quality attributes
1= nutritive value
2= density
3= color
4= smell
5=taste
6=safety
7=amount of cream
8= price
9-=cleanliness
10=kept in a dispenser
11=is kept in a fridge/freezer
12= adulteration
97 = other
98 = Don't know

Section 5: Information on expenditure on other food items consumed at home

Now I will like to ask you about other food items the HH purchased and/or consumed last seven days, consumed in the house. I will first give you a list of products and ask you to tell me if your HH consumed any of them in the last 7 days. After that, I will ask you a few further questions for those products that you indicate the HH consumed.

	s05q01	(for products indicated Yes in s05q01						
Nature of food item	Did your household consume this product in the last 7 days? (1=Yes; 2=No)	How much did your household consume in the last 7 days?	Unit of consumption (code a)	How much of what you consumed YOU DIDN'T PURCHASE/ you obtained for free?	Did you purchase this product in the last 7 days? (1=Yes; 2=No) (if 2, go to next product)	How much did you buy in the last 7 days?	Unit of purchase (code a)	How much did you pay (total value over the 7 days) (KSh)
Beef meat	[____]					[____]		
Goat meat	[____]					[____]		
Sheep meat / mutton	[____]					[____]		
Pig meat / pork	[____]					[____]		
Sausages								
Smokies								
Chicken indigenous	[____]					[____]		
Chicken broiler	[____]					[____]		
Chicken neck, feet/legs, gizzard, head								
Duck	[____]					[____]		
Fish (Tilapia, Nile Perch, cat fish/obambla)	[____]					[____]		
Fish (omena)								
Fish ballskat								
Offal	[____]					[____]		
Liver/kidney/heart								
Other meat_____ _____	[____]					[____]		
Eggs	[____]					[____]		
Maize	[____]					[____]		
Maize meal/flour	[____]					[____]		
Wheat flour	[____]					[____]		
Unga mix (mixed maize flour)								
Green banana/matoke	[____]					[____]		
Bread	[____]					[____]		
Pasta								

	s05q01	(for products indicated Yes in s05q01						
Nature of food item	Did your household consume this product in the last 7 days? (1=Yes; 2=No)	How much did your household consume in the last 7 days?	Unit of consumption (code a)	How much of what you consumed YOU DIDN'T PURCHASE/ you obtained for free?	Did you purchase this product in the last 7 days? (1=Yes; 2=No) (if 2, go to next product)	How much did you buy in the last 7 days?	Unit of purchase (code a)	How much did you pay (total value over the 7 days) (KSh)
Noodles								
Millet	[___]					[___]		
Sorghum	[___]					[___]		
Rice	[___]					[___]		
Rice flour	[___]					[___]		
Chapatti								
mandazi								
Other cereals/staples	[___]					[___]		
Beans	[___]					[___]		
Lentil	[___]					[___]		
Chick pea	[___]					[___]		
Pea	[___]					[___]		
Other pulses	[___]					[___]		
Boiled beans								
Boiled green grams								
Githeri								
Groundnuts								
Other nuts _____ __								
Corn oil	[___]					[___]		
Sunflower oil	[___]					[___]		
Vegetable oil								
Soybean oil	[___]					[___]		
Fortified oil								
Margarine	[___]					[___]		
Other oil_____ _____	[___]					[___]		
Cooking fat								
Sweet potatoes	[___]					[___]		
Irish potatoes	[___]					[___]		
Arrowroots	[___]					[___]		
Cassava								

	s05q01	(for products indicated Yes in s05q01						
Nature of food item	Did your household consume this product in the last 7 days? (1=Yes; 2=No)	How much did your household consume in the last 7 days?	Unit of consumption (code a)	How much of what you consumed YOU DIDN'T PURCHASE/ you obtained for free?	Did you purchase this product in the last 7 days? (1=Yes; 2=No) (if 2, go to next product)	How much did you buy in the last 7 days?	Unit of purchase (code a)	How much did you pay (total value over the 7 days) (KSh)
Other roots/tubers_____ _____	[___]					[___]		
Tomato	[___]					[___]		
Carrot	[___]					[___]		
Spinach/Sukuma wiki/Kales	[___]					[___]		
Onion	[___]					[___]		
Green leaves (Mchicha, Managu, Murenda, etc)	[___]					[___]		
Cucumber	[___]					[___]		
Cabbage	[___]					[___]		
Lettuce								
Pumpkin	[___]					[___]		
Cauliflower	[___]					[___]		
Eggplant (Biringanya)	[___]					[___]		
Green pepper (hoho)								
Okra (Bamia)								
Radish	[___]					[___]		
Coriander (Dhania)								
Other vegetables_____ ____	[___]					[___]		
Mango	[___]					[___]		
Banana (yellow)	[___]					[___]		
Papaya	[___]					[___]		
Watermelon	[___]					[___]		
Avocado	[___]					[___]		
Passion fruit	[___]					[___]		
Apple	[___]					[___]		
Pineapple	[___]					[___]		
Orange	[___]					[___]		
Lemon								
Grapes	[___]					[___]		
Guava	[___]					[___]		

	s05q01	(for products indicated Yes in s05q01						
Nature of food item	Did your household consume this product in the last 7 days? (1=Yes; 2=No)	How much did your household consume in the last 7 days?	Unit of consumption (code a)	How much of what you consumed YOU DIDN'T PURCHASE/ you obtained for free?	Did you purchase this product in the last 7 days? (1=Yes; 2=No) (if 2, go to next product)	How much did you buy in the last 7 days?	Unit of purchase (code a)	How much did you pay (total value over the 7 days) (KSh)
Sugarcane	[___]					[___]		
Other fruit_____ _____	[___]					[___]		
Sugar	[___]					[___]		
Tea	[___]					[___]		
Drinking chocolate								
Coffee	[___]					[___]		
Milo	[___]					[___]		
Cocoa	[___]					[___]		
Honey	[___]					[___]		
Other_____ _____	[___]					[___]		
Biscuits	[___]					[___]		
Soft drinks	[___]					[___]		
Beer and alcoholic drinks	[___]					[___]		
Fruit juices								
Candies, chewing gum, minties, etc.								
Spices and condiments (salt, black pepper, Royco, etc.)								
Infant cereal/formula	[___]					[___]		
Other_____ _____								

(a) Unit

1= Liter
2= mL
3= grams
4=Kg
5 = cup 500mL
6= cup 300mL (large)
7= cup 250mL (small)
8= glass (200mL)
9= yoghurt unit (50-250mL)
10= packet 500mL
11= packet 250mL
12= bottle small (up to 330ml)
13=bottle big (>330ml)
14=bunch
15= Unit/piece
16=slices
17=sachets
97=Other
98=Don't know

Section 6: Household income and expenditure

S06.01 How much did you spend LAST MONTH on food?: _____ (Ksh/month)

S06.02. How much did you spend LAST MONTH on non-food expenditure (housing, health, education, leisure, etc.): _____ (Ksh/month)

S06.03. Do you pay for the rent of this house? (1=yes, 2=no, 98=Don't know)
S06.04. Do you pay for education for your household members? (1=yes, 2=no, 98=Don't know)
S06.05. Do you pay for medical expenses? (1=yes, 2=no, 98=Don't know)

S06.06. In which of the following groups do you estimate **your total household monthly income**, from all working members, business income, pensions and remittances from elsewhere? [_____] (insert code)

Household income (Ksh/month)			
1= Less than 3,000	3= Between 6,001 and 10,000	5= Between 15,001 and 20,000	7=25,001-30,000
2= Between 3,000 and 6,000	4= Between 10,001 and 15,000	6= Between 20,001 and 25,000	8=above 30,000

S06.07. When does your household usually receives MOST OF THE MONTHLY income? [_____]

Time of household income reception		
1= At the end of the month	3= Every week	5= Irregularly
2= Every day	4= Every 2 weeks	6= Other (specify)_____