Supply and Value Chain Analyses of *Warqe* Food Products in Relation to Post-harvest Losses

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Licentiate Thesis
Swedish University of Agricultural Sciences
Uppsala 2016

Report (Department of Energy and Technology)
Licentiate thesis/Report 089
ISSN 1654-9406
ISBN (print version) 978-91-576-9389-1
ISBN (electronic version) 978-91-576-9390-7

Print: SLU Service/Repro, Uppsala 2016

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Abstract

Post-harvest losses are a global problem and are of critical importance in food-insecure countries such as Ethiopia. Losses of root and tuber crops are known to be high in developing countries, where many of the population are dependent on these crops. *Warqe* (*Ensete ventricosum* (Welw.) Cheesman) is a staple crop in Ethiopia. This banana-like plant is used as a food, mainly in the form of the products *kocho*, *bulla* and *amicho*, and also in non-food applications. The supply and value chain of *warqe* foods and associated post-harvest losses were analysed in this thesis and hotspots for losses were identified, based on two surveys conducted in Ethiopia in 2013 and 2015. The first survey targeted nine groups of farmers, four groups of traders and four research institutions throughout the country. Based on the results, the second survey concentrated on analysing two supply routes to central market. A total of 522 respondents, including producers, food processors, traders, transporters and consumers, were randomly selected for that survey. Value chain theory was employed to analyse the value chain, while post-harvest losses were assessed by adopting the Commodity System Assessment Methodology (CSAM).

The results indicated that farmers, collectors, processors, wholesalers, retailers and consumers are the principal value chain actors. In addition, some transporters and open market dealers are involved in the supply chain and logistics process. Product and information flows between actors in both the supply and value chains were found to be weak. The performance of the *kocho* value chain was not efficient and about 45.3% of the total marketed product of *kocho* and 45.6% of *bulla* was lost along the supply chain. The highest *kocho* (24.0%) and *bulla* (28.8%) losses were observed at retailer and processor level, respectively. Poor processing methods, use of perishable packaging material, poor transportation and inappropriate storage and market conditions were the main reasons for the losses. To minimise losses, it is important to work on value addition to *warqe* foods and improve processing, storage and packaging. Shared warehouses need to be built around producers and near marketplaces. Farmers and *bulla* processors could be supported by providing credit, developing and supplying improved *warqe* varieties, advisory services, market facilities and market information.

Keywords: Warqe, kocho, bulla, value and supply chain analyses, logistics, post-harvest losses, Ethiopia

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Dedication

Dedicated to my father Chaka Tuffa Medene

Contents

List of Publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I Chaka, A., Kenea, T. and Gebresenbet, G. (2016). Analysis of the supply chain and logistics practices of *warqe* food products in Ethiopia (Submitted to *Journal on Food System Dynamics*)

II Chaka, A., Kenea, T. and Gebresenbet, G. (2016). Value chain analysis of *warqe* food products in Central Ethiopia (manuscript)

III Chaka, A., Kenea, T., Balemi, T. and Gebresenbet, G. (2015). Post-harvest losses of *warqe* food products along the supply chain in central Ethiopia. (Submitted to *International Journal of Postharvest Technology and Innovation*)

The contributions of Ashenafi Chaka to the papers included in this thesis were:

I Planned the study, performed the data collection, analysis and paper writing together with the co-authors and prepared the data presentation (figures and table) and calculations.

II Planned the data collection method, performed the data analysis and paper writing together with the co-authors.

III Planned the data collection method, performed the data analysis and paper writing together with the co-authors.

Publications not included in the thesis:

I. Lemma, Z., Dawit, W., Negari, M., Chaka, A., Selvaraj, T. and Gebresenbet G. (2014). Identification of post-harvest rotting microorganisms from tomato fruits (*Solanum esculentum* Mill.) in Toke Kutaye District of West Shoa Zone, Ethiopia. *Journal of Stored Products and Postharvest Research* 5 (3), 14-9. DOI:10.5897/JSPPR2014.0171

Abbreviations

CSA	Central Statistics Agency of Ethiopia
CSAM	Commodity System Assessment Methodology
FAO	Food and Agriculture Organization of the United Nations
GMMP	Gross Marketing Margin of Producers
GTZ	German Technical Cooperation Agency
IBM	International Business Machines Corporation
LSD	Least Significant Difference
M4P	Making markets work better for the poor
MS	Microsoft
NMM	Net Marketing Margin
RELOAD	Reduction of Losses and Value Addition in East-African Food Value Chains
SE	Standard Error
SLU	Swedish University of Agricultural Sciences
SPSS	Software package used for statistical analysis
SWOT	Strengths, Weaknesses, Opportunities and Threats
TGMM	Total Gross Marketing Margin
US	United States

1 Introduction

1.1 Background

Post-harvest food losses are a global problem and are of critical importance in food-insecure countries such as Ethiopia. Food waste occurs at different levels in the food supply chain from production through post-harvest handling to consumption (Parfitt *et al*., 2010). The Food and Agriculture Organization of the United Nations (FAO) estimates that one-third of food produced for human consumption is wasted globally, which is equivalent to about 1.3 billion tons per year, and this loss leads to significant losses of resources used for food production (FAO, 2011). These include loss of land, water, energy and other inputs already used to grow these lost foods. Food losses are also the cause of unnecessary CO_2 emissions, in addition to the economic value of the foods produced. According to FAO (2013), the carbon footprint of this lost food is an estimated 3.3 Gigatonnes of CO_2 every year, without accounting for greenhouse gas emissions from land use change. The total cost is estimated to be about 750 billion US dollars every year when considering post-harvest losses throughout the supply chain (FAO, 2011).

Losses of food from farm to table through storage, transport, processing and retail and in the consumer stage are huge and associated water losses are significant and therefore reducing food losses and wastage would reduce water demands in agriculture (Lundqvist *et al*., 2008). Looking at the distribution of losses and waste, there is significant variation between developed and developing regions.

In developed countries, food losses tend to occur at the consumers level. However, in developing countries they tend to occur during production and

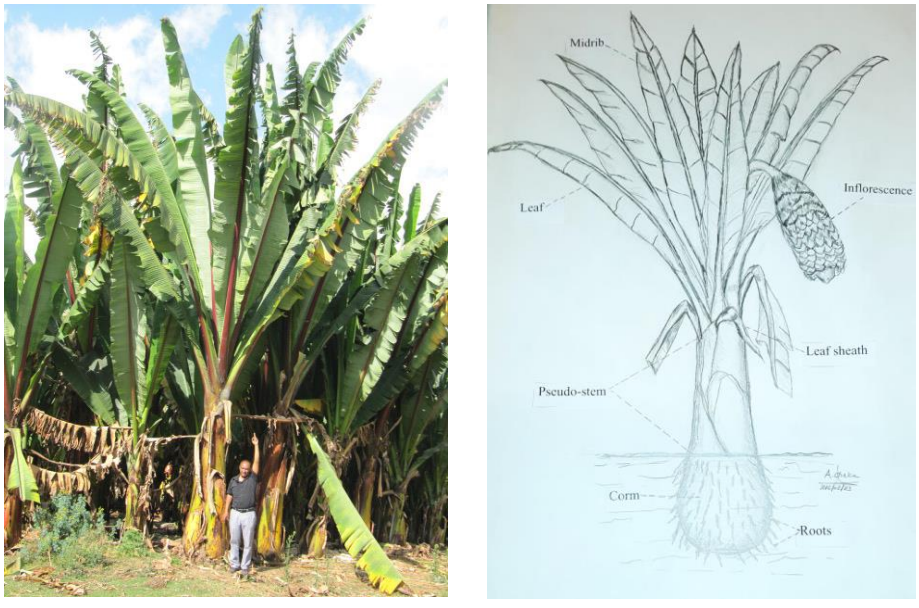
handling and storage (Lipinski *et al*., 2003). For instance in Tanzania, maize losses that occur in the field are of greater economic significance than those which occur during any other single activity from harvesting to marketing (Abass *et al*., 2014). The main causes of significant post-harvest losses in the early stage of the supply chain in developing countries include financial and structural limitations in harvest techniques, storage and transport infrastructure, combined with climate conditions favourable for food spoilage (FAO, 2013).

There are relatively high losses of fresh root and tubers at early stages of the food supply chain in developing countries (FAO, 2011). In fact, wastage of starchy roots is among the top ten food losses because of high wastage volumes in the growing and post-harvest phases (FAO, 2013). One reason for these high losses is the perishable nature of the crops, which results in them being easily damaged during harvesting and post-harvest activities, especially in warm and humid climates (FAO, 2011). However, a high proportion of the population in developing countries is highly dependent on root and tuber crops as a source of food, nutrition and cash income (Scott *et al*., 2000). In Ethiopia, root and tuber crops are the third largest national food commodity, after maize and wheat, in terms of quantity of production (CountrySTAT Ethiopia, 2016a). Cassava, potato, sweet potato and yam are the major root and tuber crops worldwide. Some other root and tuber crops are very specific to a certain country, for instance *warqe* is a staple food in Ethiopia.

1.2 *Warqe* plant and utilities

Warqe (*Ensete ventricosum* (Welw.) Cheesman) is a perennial plant that morphologically resembles the banana plant (Figure 1). The plant is sometimes known as *enset*. The edible parts of *warqe* are the pseudo-stem and the underground corm. *Warqe* plays a significant role in food security for Ethiopia and is an important source of income for growers in central, southern and western parts of the country. According to Seifu (1996), *warqe* grows mainly as a wild plant in sub-Saharan countries and Asia, and has only been domesticated in Ethiopia. As described by Brandt *et al.* (1997) *warqe* food products are used as staple and co-staple foods for millions of Ethiopians, but the exact number of people depending on *warqe* foods is not known. However, based on the 2014 agricultural sample survey report by the Central Statistics Agency of Ethiopia (CSA) and the 2012 population projection, it can be estimated that about 35% of Ethiopians live in areas where *warqe* is a very important food crop and *warqe* products are staple foods. In addition, *warqe* is commonly used as a food in major cities in Ethiopia such as Addis Ababa, Awassa, Dilla, Adama, Jimma, Wolayita Sodo, Hosaena, Wolkite, Woliso,

Bonga and Arba Minch and in other town and cities. Therefore more than 50% of the Ethiopian population may consume *warqe* regularly.



(a) (b)

Figure 1. a) Mature warqe plant and (b) its morphology

In Ethiopia, *warqe*-based farming plays an important role in food security. The complex *warqe* farming system is the most sustainable indigenous farming activity in southern and south-western Ethiopia and can support the densely populated highlands of these regions (Tsegaye and Struik, 2002). Ethiopia as a whole is strongly dependent on agriculture and over 84% of the population live in rural areas, where crop production and animal husbandry are their main livelihoods (CountrySTAT Ethiopia, 2016b).

Warqe cultivation is usually limited to homesteads. The natural habitat of this plant lies between 1500-3200 m above sea level (a.s.l), but it is extensively grown at altitudes between 2000 and 3200 m.a.s.l (Bezuneh, 2012). The optimum annual temperature range for *warqe* growth is 16 to 20 °C and the plant can withstand frost. *Warqe* prefers an even distribution of rainfall of about 1100 to 1500 mm per annum, but can withstand dry periods of up to five months. Moreover, *warqe* is not damaged by heavy rain. It prefers soil pH between 5.5 and 7.3 (Belehu, 1993). The reported acreage used for cultivation

of *warqe* was 300,000 hectares in 2013, which makes this the largest perennial food crop in Ethiopia (Olango *et al*., 2014). The major food products made from the *warqe* plant are *kocho, bulla* and *amicho* (Figure 2). Bread prepared from fermented *warqe* is also called *kocho*-bread, which is commonly served in restaurants with *kitfo* (a traditional Ethiopian food prepared from chopped red meat mixed with spiced butter).

Figure 2. *Warqe* food products: (left) *amicho*, (centre) *kocho* and (right) *bulla*

Warqe is a plant used for different purposes. In addition to human food, some parts of the plant are used for animal feed. Some *warqe* varieties are also used as traditional medicine, for example crushed fresh root is used to treat diseases such as abdominal pain and amoebic dysentery (Bekele and Reddy, 2015). Fibre and dried petiole parts of *warqe* are commonly used for the construction of houses and to make bags, ropes, twine, cordage, mats and wrapping material (Degu, 2012). Furthermore, *warqe* has potential for industrial applications, for example starch extracted from *bulla* can be used as a raw material for textile and paper industries. Fibre is used as a raw material for sack and string industries (Brant *et al*., 1997; Taye, 2012). The plant also helps protect the soil surface from erosion (Brant *et al*., 1997; Degu, 2012; Mulugeta and Adane, 2012).

According to CSA (2014), a total of 130,630,473 *warqe* plants were harvested in Ethiopia in 2014 and produced 34,723.6 tonnes of *kocho,* 12,259.4 tonnes of *bulla* and 311.3 tonnes of *amicho.* In that period, 1,169,348 *warqe* plants were harvested in the major *warqe* growing area of west Shoa and 1,929,028 in south-west Shoa. Some of the foods produced were supplied to local and central markets.

1.3 Food loss, wastage and post-harvest losses

In order to assess the magnitude of the food waste problem, it is first essential to define what food waste means. Losses of food are described using many different terms and there is no clear definition or demarcation between the

terms *food losses, food waste* and *post-harvest losses*. These terms are used in inconsistent ways in the literature and sometimes overlap. It is not easy to find one definition that combines all kinds of food waste. According to Grolleaud (2002), food losses are the losses in quantity which arise through food becoming unfit for human consumption. Food differs from other commodity flows in that it is subject to degradation in nutritional value during commodity flow, since it is a biological material (Parfitt *et al*., 2010). This fact led Lipinski *et al.* (2003) to define food losses and waste in depth as "*the edible parts of plants and animals produced or harvested for human consumption but not ultimately consumed by people. It represents a decrease in the mass, caloric, and/or nutritional value of edible food intended for human consumption at any stage in the food value chain*."

According to FAO (2013), food losses involve a decrease in the quantity or quality of food originally intended for human consumption. However, food waste is defined as food appropriate for human consumption being wasted, whether it has spoiled. The term food wastage includes both food losses and food waste and refers to any food lost by deterioration or waste. Food waste can occur at different points of the food supply chain and this wastage has a significant influence on the East-African situation of food shortage. Food security is a major concern in Ethiopia and it is becoming evident that reducing food wastage by improving post-harvest management is more crucial than production of more food by expansion of agriculture.

The main causes of post-harvest losses include inappropriate methods of harvesting, insufficient cooling and unhygienic handling, lack of infrastructure, and poor technical and managerial skill in food production and post-harvest. Post-harvest losses range from about 20% for cereals to 66% for fruits and vegetables in sub-Saharan Africa's food value chains (FAO, 2011).

1.4 Concept of supply chain and logistics analysis

According to the Council of Logistics Management (1998), logistics is defined as "*the part of the supply chain process that plans, implements and controls the efficient and effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption for the purpose of conforming to consumer requirements".* Hence, the main goal of logistics is to have the right product in the right place at the right time and at the right cost. The logistics analysis of *warqe* food products in this thesis focused mainly on logistics actors and their relationships in the chain, their responsibilities, warehouse practices, product flows, finance and information from producers to consumers and *vice versa*.

Effective supply of products to markets is one of the essential measurements for evaluating the performance of supply and logistics chains. At this point, it is important to make reference to the concept of supply chain and logistics, because it helps to understand the reasoning behind the concepts and apply them to *warqe* food products. According to Khatami *et al.* (2015), a supply chain is defined as "*a network of suppliers, manufacturers, transporters, warehouses, retailers and customers, systematized in such a way that it transforms raw materials into finished products and distributes the final products among customers through retailers*". In this thesis, supply chain refers to the sequential arrangement of different chain actors involved in the flow of *warqe* food products from producers to end consumers.

Based on the classical terms used in logistics and supply chain management, the appropriate term used for food products is 'food chain logistics'. Food chain logistics covers the production and distribution of fresh or processed vegetables or animal-based products (Soysal *et al*., 2012). According to that review, logistics has three key aims in the new concept of sustainable food logistics management: (1) cost reduction and responsiveness, (2) improved food quality and reduction of food waste and (3) improved sustainability and traceability.

1.5 Value chain analysis concept

Value chain analysis is important in determining the relationships and linkages between buyer and suppliers and a range of market actors in between (Wenz and Bokelmann, 2011). Thus value chain analysis of *warqe* is required to identify key players in the chain and to provide an understanding of their interactions and linkages within the chain. Food value chain analysis is a vital and flexible methodology to improve the value to producers and end consumers (Van Hoang, 2014). According to Kaplinsky and Morris (2001), value chain analysis is particularly useful for new producers in less developed countries trying to enter global markets in a manner which would provide for sustainable income growth. It is also useful as a systematic tool in understanding the policy environment which provides for efficient allocation of resources within the domestic economy and the firms and countries participating in the global economy.

The value chain can be defined in various ways. Kaplinsky (2000) and Kaplinsky and Morris (2001) define it as: "*the full range of activities which are required to bring a product or service from conception, through the different phase of production which involving a combination of physical transformation and the input of various producer services, delivery to final consumers, and*

final disposal after use. In the value chain system independent actors are performing a sequence of value adding activities from conception over to phase of production to final consumption." The value chain can also be defined as a "*sequence of related enterprises conducting activities so as to add value to a product from its primary production, through its processing and marketing to the final of the product to consumers*" (Macfadyen *et al*., 2012).

According to Kaplinsky and Morris (2001), a value chain consists of chain actors from input suppliers, producers and processors to exporters and buyers engaged in the activities required to bring agricultural products from their conception to their end use. However, in this description, the activities of value chain actors create confusion with the definition of supply chain and the objective of the value chain. According to Trienekens (2011), the main objective of a value chain is to produce value-added products or services for a market, by transforming resources and by the use of available physical infrastructure in available opportunities and within the constraints of the institutional environment.

Value chain analysis is an excellent means to assess growth distribution issues and gender equitable growth, to analyse the relative importance of factors affecting competitiveness and the cost and earnings of those involved in the value chain, to identify weaknesses in value chain performance and to improve value chain performance (Macfadyen *et al*., 2012). Thus, in order to reduce post-harvest losses of *warqe* food products, improve the quality of *warqe*-based foods and gain a competitive advantage from the production of *warqe*, value chain analysis is needed at every stage of the food supply chain. This could also provide important insights into value addition and creation activities. Thus this thesis focused on supply and value chain analysis of *warqe* food products and the role of value chain actors for improving product value.

1.6 Research questions

Supply and value chain analyses were performed in this thesis in order to quantify the post-harvest losses of *warqe* food products. While *warqe* is one of the major food crops in Ethiopia, no previous supply and value chains analysis had been undertaken and food losses along the supply chain had not been studied comprehensively to obtain basic knowledge. Such knowledge could be used to reduce food losses at each level of the supply chain and help develop loss reduction technologies, thereby improving *warqe*-based food quality and adding value. Some previous studies have examined *warqe* storage losses at producer level, *e.g*. Ashenafi and Abebe (1996) reported that about 33% of *warqe* product spoilage happens during storage. Traditional *warqe*

fermentation and extended periods of storage in pits have been shown to cause spoilage problems and to create a bad smell (Brandt *et al*., 1997; Hunduma, 2012). Hunduma (2012) concluded that work on post-fermentation losses of *warqe* primary food products has been very limited and that no scientific attempts have been made to improve storage facilities for products. This indicates that unlike other crops, this important crop has been poorly investigated throughout the whole supply chain. Much research has been conducted on the value chain and supply chain of major staple food crops and associated losses. However, in the case of *warqe* foods, no previous study has analysed the value chain and supply chain in relation to post-harvest losses.

Three core research questions were formulated to guide the work in this thesis to assess post-harvest food losses of *kocho* and *bulla* in relation to the supply chain and value chain concepts.

- What are the main supply chain and logistics practices for the main *warqe* food products? Who are the principal actors involved in the supply chain and logistics process? What are the possibilities for improving logistics practices along the supply chain of *warqe* food products in Ethiopia?
- What kind of value-adding activities and performances are currently being used in the *kocho* and *bulla* production and supply chains?
- What is the total amount of losses of *warqe* products such as *kocho* and *bulla* along the supply chain and at what stage do the main losses occur? What are the main factors responsible for the losses?

2 Objectives and structure of the thesis

Overall aim

The overall aim of this licentiate thesis was to describe and analyse the supply chain and value chain of *warqe* food products in relation to post-harvest losses and to identify hotspots for these losses.

Specific objectives were to describe/map and analyse:

- The supply chain and logistics practices for *warqe* food products in Ethiopia (Paper I)
- The value chain of *warqe* food products in Central Ethiopia (Paper II)
- The post-harvest losses of *warqe* food products along the supply chain and loss hotspots in the chain in Central Ethiopia (Papers I and III)

Structure of the work

The intended outcome of the thesis work was suggestions on ways to reduce post-harvest losses and improve *warqe*-based food quality. The structure of the work performed in Paper I-III is presented in Figure 3. In Paper I, a supply chain analysis was performed and the logistics practices for *kocho* and *bulla* were described by identifying the chain actors and their activities. Moreover, the transportation system and its constraints were analysed and logistics infrastructure was evaluated. In Paper II, value chain analysis was performed and the value chain performance of *kocho* and *bulla* was assessed using survey and field observation methods and stakeholder analysis and performance-measuring models. Value addition and value creation activities of the products and the competitiveness of the value chain were also analysed. In Paper III, post-harvest losses were quantified and hotspot of losses of *kocho* and *bulla*

along the supply chain were identified. Knowledge of these losses and hotspots enabled suggestions to be made on further research to reduce post-harvest losses and to improve the quality of the *warqe* foods *kocho* and *bulla*.

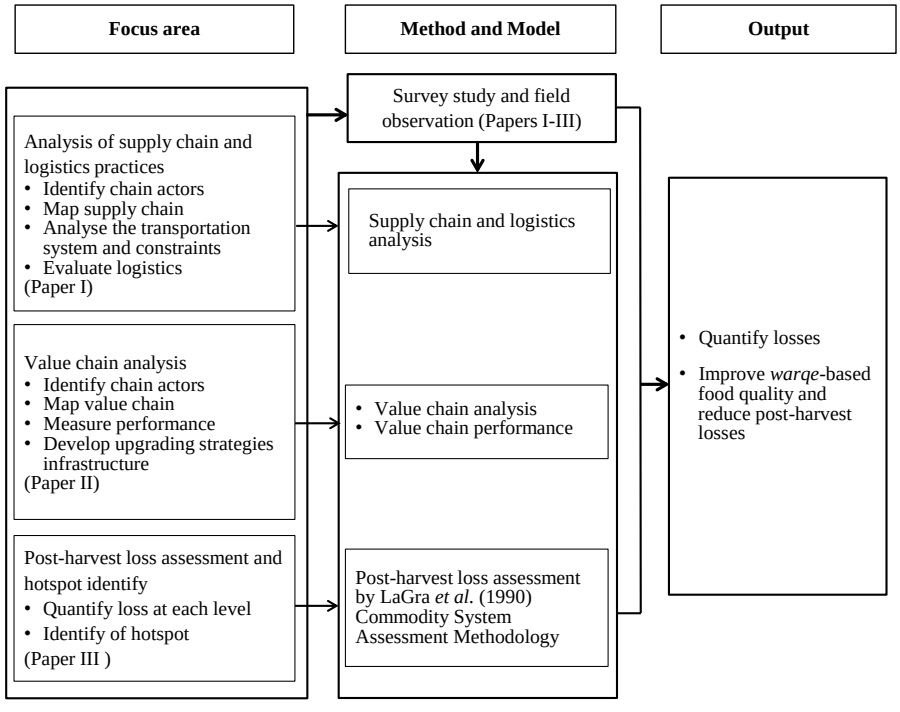


Figure 3. Scope of the work performed in Papers I-III of this thesis

3 Material and methods

3.1 General approach of studies

Two surveys were conducted in Ethiopia, during 2013 and 2015, in order to analyse the supply chain and value chain of *warqe* food products in relation to post-harvest losses and identify hotspots for these losses. The first (preliminary) survey was conducted in the major *warqe*-growing areas of Ethiopia, using semi-structured questionnaires. During this survey, a critical discussion was conducted with selected farmers, traders, researchers and technology developers on aspects of the *warqe* value chain, *warqe* logistics, the *warqe* supply chain, *warqe* varieties used, *warqe*-related problems and *warqe* food and non-food products.

A national workshop on the *warqe* value chain, logistics and processing was held at Ambo University on 4-6 February 2014. The participants at the workshop were the national coordinator of *warqe* research in Ethiopia from the Areka Research Centre, a technical expert within *warqe* research, a senior expert in the field of food microbiology from Ambo Plant Protection Research Centre, two experts working at *warqe* processing equipment development centres (Bako and Sodo Rural Technology Development Centres), three *warqe* traders, four farmers, three post-harvest technology experts from Jimma and Ambo Universities and a senior horticultural scientist from Ambo University. The results of the preliminary survey were presented at the workshop, which focused on identification of chain actors in the *warqe* value chain, mapping the *warqe* value chain, identification of constraints to *warqe* production and suggesting possible intervention options. The problems were further classified as production constraints and market-related, transport-related and finance-related constraints.

Based on the results of this preliminary survey, workshop discussion and literature reviews, the main study was designed and conducted. It comprised

value chain and supply chain analysis to assess post-harvest losses of *warqe* food products. For this, a survey and field observation approach was used as the main methods of data collection in the study areas. Five separate questionnaires were designed, to collect data from *warqe* farmers, traders, processors, transporters and consumers, respectively. The questionnaires were pre-tested and modified based on the results of this pre-testing. The questionnaire survey was mainly intended to collect information about *warqe* production, trading, transport, marketing, linkage, value addition, value creation and related information. In addition, focus group discussions with key informants were conducted to gain additional insights into the sector.

3.2 Selection of the study area

The preliminary survey was carried out in the main *warqe* production areas and at *warqe*-related technology development and research institutes in the Ambo, Guder, Tikur Enchini, Haro Wonchi, Melkassa, Bako, Wolayita Sodo and Areka areas of Ethiopia. The main study was conducted across the major *warqe*-growing areas of West Shoa and Southwest Shoa Zones in Oromia Region, Ethiopia (Figure 4). Two major *warqe*-growing areas, namely Haro Wonchi and Maruf, were purposely selected for the main study, in consultation with relevant agricultural officials and based on preliminary survey results. These areas are known as major sources of *kocho* and *bulla* supplies to the central market in Addis Ababa (the capital city of Ethiopia). Haro *kocho* market, Haro open market, and Haroj and Woliso *kocho* main market were selected by following the *kocho* and *bulla* supply chains in Haro Wonchi area. Guder Odo-Bari *Kocho* open market and Guder *bulla* market were selected by following the supply chain from Maruf area. All these markets are feeders to Addis Merkato market, which was also included in the study. To collect data regarding *bulla* processing, Addis Ababa and Woliso were selected as cities. Consumer-related information was collected from Haro Wonchi, Guder, Ambo and Addis Ababa.

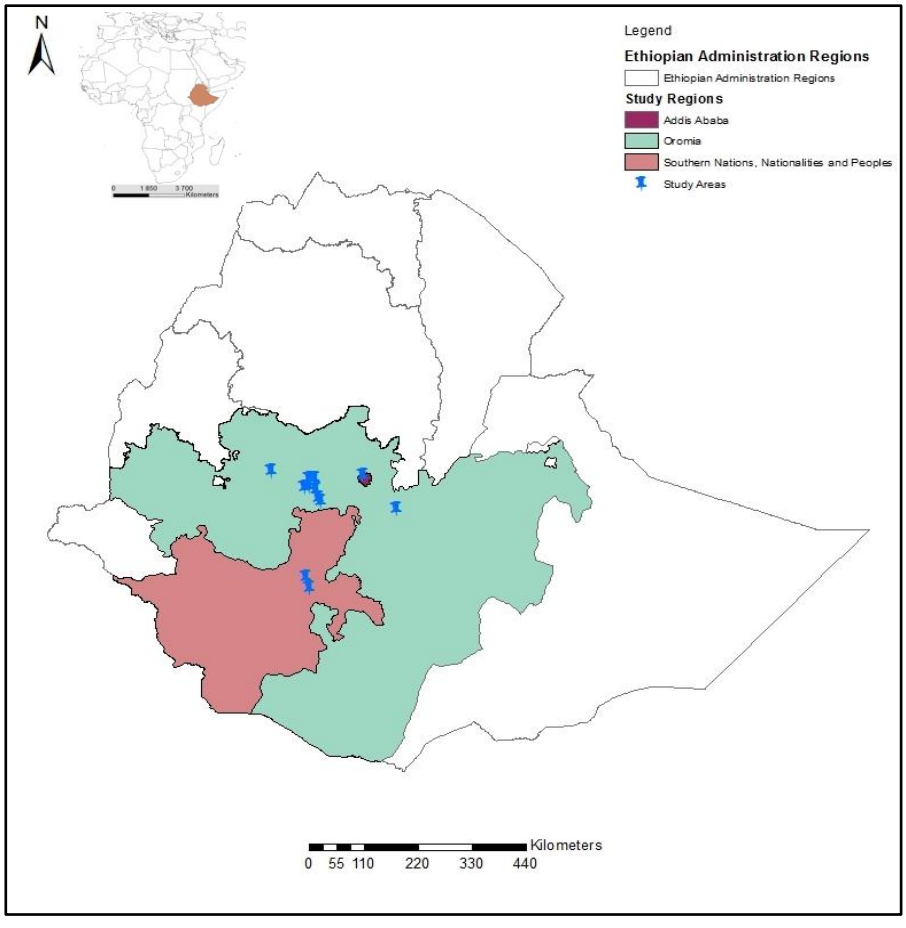


Figure 4. Map of the study areas

3.3 Sampling and sample size

Three types of survey questionnaires were developed for the preliminary survey. These questionnaires targeted, respectively, nine groups of *warqe*-producing farmers, four groups of traders, particularly wholesalers and retailers, and four research and technology development institutions.

In order to analyse the value chain, supply chain and post-harvest losses of *warqe* foods in the main study, a total of 522 respondents were randomly selected for collection of primary data and information from producers, small-scale food processors, traders and consumers. Among the 522 respondents interviewed, a total of 209 were *warqe*-growing households, of which 91 households were from the Maruf area and 118 were from Haro Wonchi.

A total of 56 *kocho* and *bulla* traders were interviewed in the selected markets. About 15 respondents were randomly selected from *kocho* and *bulla* transport operators. Eight small-scale *bulla* processing enterprises were included in this survey. Interviews were also held with *warqe* food products consumers, both at household and restaurant level, to assess post-harvest losses of *warqe*. A total of 223 *warqe* food consumers at household level were randomly selected and interviewed, while 11 traditional Ethiopian restaurants were randomly selected from Addis Ababa city and included in the study.

3.4 Identification and defining value and supply chain actors

In this thesis, actors were defined as stakeholders involved in the value chain and supply chain of *warqe* food products and who perform a certain function in the chain. Principal actors involved in the chains were identified in field observations and key informant interviews. All value-adding activities in the chain were identified and the roles of different actors were mapped. The mapping started from production site and continued through local markets to the final destination of the products at the central market. It also included distribution routes from the central market. Value chain mapping and actor identification were directed at the supply chains for *kocho* and *bulla*. The method used for actor identification in this work was in line with the methodology developed by Lelea *et al*. (2014) for stakeholder analysis for application in transdisciplinary research projects focusing on actors in food supply chains. Grimble and Wellard (1997) define stakeholders as "*any group of people organized, who share a common interest or stake in a particular issue or system; they can be at any level or position in society*". They also point out the importance of stakeholder analysis for understanding a system and effecting changes in it by identifying key actors and assessing their respective interests in the system.

The following terms defining supply chain and value chain actors and describing their main activities in the chain are used in this thesis:

- ***Producers***: *Warqe*-growing farmers who manage all farm and post-harvest activities. All farmers in the study area grow *warqe* plants and process them into *warqe* foods and non-food products. *Warqe* producers are also the main farm input suppliers. They have key responsibility for production activities such as supplying organic fertiliser and planting materials, producing *kocho* and *bulla*, packaging the products, transporting them to their local market and selling them to their clients.

- ***Collectors***: Non-licensed traders who operate in the local market. They are one of the basic key players and generally run their business with wholesalers. They buy *warqe* products directly from producers who are in the vicinity of growers and sometimes from local markets, before transporting them to markets and selling the collected products in large quantities to wholesalers at local markets. Collectors are also used as channels for information flow, such as sharing market and production information.
- ***Wholesalers***: Large traders who operate between rural markets and urban markets. They have a permanent site in the market with short-term storage facilities, and they purchase a large amount of *warqe* products from producers or through collectors. They sell a large amount of *warqe* to retailers and large consumers such as restaurant owners.
- ***Retailers***: Owners of permanent shops who purchase products in bulk from their suppliers and sell them in small amounts to their clients.
- ***Food processors***: All those involved in the processing of *warqe* food products, particularly *bulla*. They purchase fresh *bulla* in large amounts, process it into dried products, pack these and then sell them to customers in bulk or in small quantities.
- ***Transporters***: Agents involved in transporting *warqe* products in vehicles from the local market to the central market and, in some cases, from the market to processing sites or *vice versa*.
- ***Open market dealers***: Retailers who have a permanent site in an urban open market. They purchase small amounts of products from retailers or processors. They run their food business alongside other commodities and sell their products to consumers in urban markets.
- ***Consumers***: All those who make foods from *kocho* and *bulla* for direct use or to sell to customers in restaurants.

3.5 Value chain analysis

The frameworks of value chain analysis developed by M4P (2008) and GIZ (2007) were used in this thesis work. These frameworks were previously used as a method in value chain analysis of the pomelo sector in Vietnam by van Hoang (2014). M4P (Making market work better for the poor) has a manual called "*Toolbook*" developed for analysis of value chains with the focus on poverty reduction. This manual has eight practical value chain analysis tools that can be used to analyse different dimensions within value chains. A manual developed by GtZ, called "*ValueLinks*", describes this methodology of value chain promotion, which involves systematic compilation of action-orientated

methods for promoting economic development with a value chain perspective. The framework used for analysing the value chain of *warqe* food products in this thesis focused on planting, processing and marketing of the products and comparing the performance of the chain.

Analysis of the value chain in six steps:

Step 1: Describing and defining *warqe* food products
Step 2: Identifying actors
Step 3: Mapping major processing steps
Step 4: Mapping the value chain
Step 5: Analysing market margin share
Step 6: Strengths, weaknesses, opportunities and threats (SWOT) analysis and upgrading strategies.

3.5.1 Describing and defining terms used for *warqe* food products

There are three primary food products of the *warqe* plant: *kocho*, *bulla* and *amicho*. From these three food products, different kinds of foods are produced. Thus, it is necessary to provide a clear definition of the terms used for *warqe* products: *kocho*, *qummusi*, *holeta*, *bulla* or *hamtiti* and *amicho*.

Kocho is a dough-like material made from bulk fermented starch obtained from a mixture of decorticated leaf sheaths and pulverised corm. *Qummusi* is bread made from *kocho* mixed with cereal flour. *Holeta* is a white, high-quality *kocho* product that differs from ordinary *kocho* in that it is made from the innermost parts of leaf sheaths and corm and in that a different treatment is used during the fermentation period. *Holeta* is highly appreciated among *kocho*-loving consumers because it does not contain fibres and its high-quality bread. Food made from *holeta* is served to highly respected guests and it is usually prepared on special occasions.

Bulla or *hamtiti* is a white dry powder or semi-liquid food *warqe* product extracted from freshly decorticated pseudo-stem or pulverised corm mass. According to Hunduma and Ashenafi (2011), *bulla* extraction is commonly practised only in high-altitude environments. *Bulla* is also the name of the food (porridge) made from *bulla*. There are two types of *bulla* available in markets: fresh *bulla*, which is a semi-liquid cream like the product, and processed or dried, powdered *bulla*. From *bulla*, porridge and soup are commonly prepared, with or without mixing with wheat flour. *Amicho* is the non-fermented corm of the *warqe* plant, which is consumed after boiling just like other root and tuber crops. *Amicho* from younger plants is usually preferred and it is mostly consumed during shortage of food.

3.5.2 Mapping major processing steps

Main processing steps, starting from mature plant selection to final *warqe* food products, were mapped, followed by on-site verification of the flow diagram. Each step in *kocho* and *bulla* processing was described and analysed. Different maturity indices that farmers use for harvesting of *warqe*, the time required for *kocho* fermentation and the *bulla* drying process were described.

3.5.3 Mapping value chain

Mapping of the value chain was carried out after principal actor identification. This mapping included all activities, starting from farm input supply through product delivery to final consumers. The work focused on obtaining detailed information about the range of value-adding activities along a chain, the role of actors in each level and the governing environment in the chain.

3.5.4 Analysis of market margin share

Value chain performance of *kocho* and processed *bulla* was analysed by estimating the marketing margin, by taking into consideration the associated marketing cost for key marketing channels. Based on prices charged by the major market participants along the chain, margins at producer, collector, processor, wholesaler and retailer level were estimated and analysed. Value chain performance was analysed using the commodity subsystem approach based on market cost and margin devised by Mendoza (1995). The marketing margin was compared with marketing service costs and the results were interpreted. Margins at each stage were calculated and the shares were also compared. Estimated marketing margin, calculated as the difference between producer and retail prices, was the tool used to analysis performance of the value chain. The retail price, *i.e*. the end consumer price, was then considered as the base, or the common denominator, for all marketing margins. Comparisons of total gross marketing margin are always related to the final price, or the price paid by the end consumer, expressed as a percentage (Mendoza, 1995). The producers' share is the commonly employed ratio calculated mathematically, as the ratio of producer price to consumer price.

Mathematically, the producers' share (PS) can be expressed as:

$$PS = \frac{Px}{Pr} = 1 - \frac{MM}{Pr} \qquad (1)$$

where in the present case Px is the producers' price for *kocho* or *bulla*, Pr is the retail price of *kocho* or *bulla*, *i.e*. the consumer price, and MM is the marketing margin.

As equation (1) indicates, a higher market margin diminishes the producers' share and *vice versa*. It also shows welfare distribution among production and marketing agent. The total market margin was calculated using equation (2). The Total Gross Marketing Margin (TGMM) is always related to the final price paid by the end buyer, expressed as a percentage (Mendoza, 1995).

$$\text{TGMM} = \frac{Pr - Px}{Pr} \text{ x } 100 \qquad (2)$$

where in the present case Px and Pr are as defined for equation (1).

Producer's gross margin (GMM_p) is the proportion of the price paid by the end consumer that is received by the farmer as the producer. It should be emphasised that growers who act as middlemen also receive an additional marketing margin. GMM_p is calculated by difference as:

$$\text{GMMP} = \frac{Pr - MM}{Pr} \text{ x } 100 \qquad (3)$$

where in the present case Px, Pr and MM are as defined for equation (1).

Net Marketing Margin (NMM) is the percentage of the final price earned by the intermediary as net income once marketing costs are deducted. It is thus the percentage of net income that can be classified as pure profit (*i.e*. return on capital). As equation (4) indicates, a higher NMM diminishes the producers' share and *vice versa*. Equation (4) also provides an indication of welfare distribution among production and marketing agents.

$$\text{NMM} = \frac{\text{GMM} - MC}{Pr} \text{ x } 100 \qquad (4)$$

where GMM is gross margin, MC is marketing costs and Pr is the retail price of *kocho* or *bulla* in the present case.

From the NMM, it is possible to see the locative efficiency of markets. Higher NMM or profit of the marketing intermediaries reflects reduced downward and unfair income distribution, which depresses market participation by producers. An efficient marketing system is where the net margin is near to reasonable profit.

3.5.5 SWOT analysis and upgrading strategies

To identify the challenges and opportunities of the sector, a SWOT analysis was performed during focus group discussions with key informants. SWOT analysis is essential to recognise internal strengths and weaknesses, as well as external opportunities and threats to a company (Houben *et al*., 1999). The SWOT analysis in this thesis was based on interviews conducted in the two survey studies and a summary of major points raised in group discussions with key informants. The analysis to upgrade the value chain of *warqe* food products adopted the Kaplinsky and Morris (2001) four trajectory areas of: process upgrading, product upgrading, functional upgrading and chain upgrading. Suggestions were devised for upgrading *kocho* and *bulla* value chain performance in three strategic areas: 1) input supply; 2) production, post-harvest and processing development; and 3) product distribution and marketing factors.

3.6 Method for estimation of different post-harvest food losses

Post-harvest food losses in this thesis refer to measured quantitative and qualitative losses occurring at each level in the supply chain. Quantitative losses comprise losses of physical substance of the products, which are reflected in weight loss. Qualitative losses of *warqe* foods in this thesis comprised changes in colour, taste and odour of *kocho, bulla* and their food products. However, these qualitative losses are more difficult to measure because of a lack of readily measurable quality criteria.

Post-harvest losses were assessed using the Commodity System Assessment Methodology (CSAM) originally developed by LaGra (1990), but modified during implementation over the course of many years. CSAM is made up of 26 components in four subsections that together account for all the steps associated with the pre-production, production, post-harvest handling and marketing of any given commodity. CSAM helps to quantify the losses and identify the causes of losses at different points of the food supply chain. In this thesis, field data from different respondents (farmers, transporters, traders, food processors and consumers) were collected on a quantity basis and data on post-harvest losses were obtained for different operations and different levels. *Warqe* growers were asked in questionnaire-based interviews about the quantity of *kocho* and/or *bulla* they produced during 2014. To assess post-harvest losses, farmers were also asked about the quantity of *kocho* and/or *bulla* products lost during each operation (harvesting, sorting, processing, fermentation, storage and transport to market).

Trader-level losses were estimated as the quantity of *warqe* products lost during trading in the same period. During interviews, the traders were asked about the quantity of *kocho* and/or *bulla* they bought and sold. The losses at different levels of trading (transportation, handling *etc*.) were then estimated in terms of the quantity bought.

Losses at consumer level were estimated on the basis of the quantity lost at households and restaurants. Post-harvest losses were also estimated for different types of losses, such as weight loss, rot or spoilage, physical losses *etc*. The characteristics of different types of loss symptom were explained to the respondents and this helped them to identify and quantify the losses they experienced. The individual losses were then calculated with reference to the total quantity of *warqe* produced and expressed as a percentage. For the calculation of total losses in terms of percentage, it should be noted that the total cannot be taken as the sum of the percentages at each loss stage. Thus, if the producer losses, wholesaler losses, food processing losses, retailer losses and consumer losses were x_1, x_2, and x_3, ...,x_n, then total losses was calculated as: $x_1 + (100 - x_1) \times x_2/100 + [100-(100-x_1) \times x_2/100] \times x_3/100 + \ldots$

3.7 Data analysis

The collected data were analysed both quantitatively and qualitatively. Descriptive statistics (means, standard deviation and/or frequencies) were computed using MS Excel and IBM SPSS Statistics software version 22. The data collected in interviews with key informants, focus group discussions and observations were narrated qualitatively. T-test and least significant difference (LSD) test were used to identify significant differences between *warqe*-growing areas and value chain stage at 95% confidence level ($P<0.05$).

4 Results

This results chapter is structured into five sections describing: identification of actors involved in chains; *warqe* production and importance; analysis of supply chain and logistics; analysis of value chain; and post-harvest food losses. Sections 4.1 and 4.2 mainly present the results from Papers I-III, while section 4.3 presents results from Paper I describing the supply chain and logistics practices for *warqe* foods. Section 4.4 presents the results of the *kocho* and *bulla* value chain analysis, mainly from Paper II. Section 4.5 describes post-harvest losses of *kocho* and *bulla* along the supply chain and hotspots for these losses mainly based on results from Papers I and III.

4.1 Identification and mapping of the main actors involved in the value and supply chains

It was found that there are two main routes of *kocho* and *bulla* supply to central market (Figure 5). The more important of these is the Woliso to Addis Merkato route. The Woliso *kocho* market is fed by major *warqe*-growing areas such as Chebo, Darian or Chitu, Haro Wonchi, Merega, Shegege and Tepi. The second supply route is the Guder to Addis Merkato route. The Guder market is supplied by the Tikur Enchi, Ginbi Bila, Maruf and Melke areas. The majority of products from Addis Merkato are supplied to Addis Ababa consumers and a small amount to towns outside Addis Ababa, such as Dire Dawa and Adma. A very small amount of *bulla* is exported from Wiliso and Addis Ababa through purchasing from *bulla* processors. By following these two *kocho* and *bulla* supply routes, value chain actors were identified.

Based on the preliminary survey results, six principal value chain actors were identified along the *warqe* supply chain in Ethiopia. These were *warqe*-rowing farmers, collectors, processors, wholesalers, retailers and consumers. In

addition to these six actors in the value chain, two more actors were identified in the supply chain. These were transporters and open market dealers. Other supporting actors identified in the value chain and supply chain included market infrastructure owners, local retailer shops and agricultural development agents, who supply packaging materials for processors, market information and technical services.

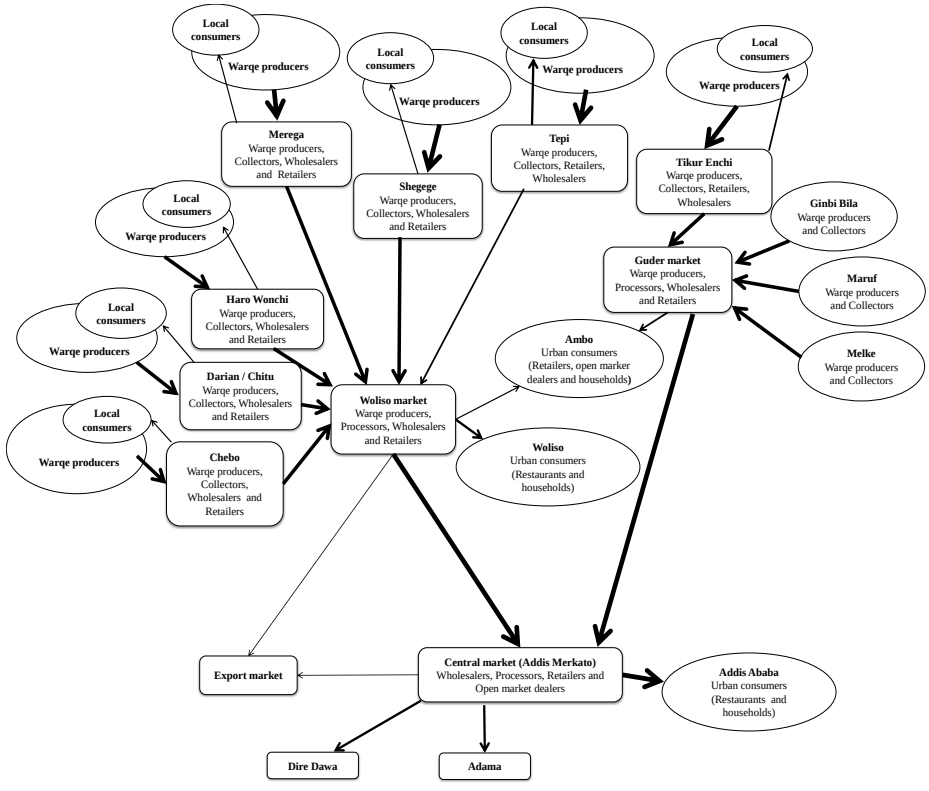


Figure 5. Supply routes of *kocho* and *bulla* to the central market and actors identified in the *warqe* food supply chain in Ethiopia, based on results of a preliminary survey in 2013

4.2 *Warqe* production and utilities

Warqe production is one of the main farming activities in the areas of Maruf and Haro Wonchi. As shown in Table 1, the survey found that each household had on average around 1.45 hectares of land, although the actual amount owned per household varied between 0.13 and 10 hectares. The proportion of land cropped with *warqe* ranged from 0.10 to 0.50 hectares per household, with on average around 0.29 hectares of land occupied by *warqe* plants. The results also indicated that on average, each family produced 678 kg/year of *warqe*

food products (*kocho* and *bulla*), of which about 275 kg were sold. Overall, about 41% of *warqe* food products produced per household were supplied to the market. *Warqe* production was the main source of revenue for households in both survey areas, contributing about 75% of income for 39% of farmer respondents. *Warqe* production was a major farming activity in both study areas, with the crop occupying about 20% of household land. The livelihood of farmers in the study areas was heavily dependent on *warqe* production.

Table 1. *Farm size,* warqe *acreage, production and sales quantity, and contribution of* warqe *products to household income*

Farm information per household	Parameter	Value
Farm size (hectares)	Minimum	0.13
	Maximum	10.00
	Mean	1.45
Land occupied by *warqe* crops (hectares)	Minimum	0.10
	Maximum	0.50
	Mean	0.29
Source of farm input (fertiliser and seedlings) (%)	Own source	81.73
	Purchase	10.58
	Gift from relatives	7.69
Farmers producing *warqe* for the market	Yes	73.70
	No	26.30
Total *warqe* production (kg/year)	Minimum	300.00
	Maximum	1400.00
	Mean	677.64
Quantity sold/year (kg)	Minimum	20.00
	Maximum	700.00
	Mean	275.17
Warqe contribution to household income	16 to 30 %	5.82
	31 to 45 %	11.65
	46 to 60 %	24.27
	61 to 75 %	19.41
	More than 75	38.83

The survey results indicated that *warqe* is the major food and non-food crop in the Haro Wonchi and Maruf areas. Almost all respondents (94%) who were *warqe*-growing farmers reported that *warqe* makes up an integral part of their livelihood, while the remaining 6% of farmer respondents considered it less important for their livelihood. All responding farmers mentioned that they

mainly grow *warqe* for multiple purposes. These multiple purposes of *warqe* crop production in the study areas are presented in Figure 6. *Warqe* growers ranked these in order of importance as: food production for the family livelihood, construction purposes, leaves used for bread making, the plant used in soil conservation, to make household utilities, for income generation, medicinal value for humans and animals, as animal feed, as compost and as fuel.

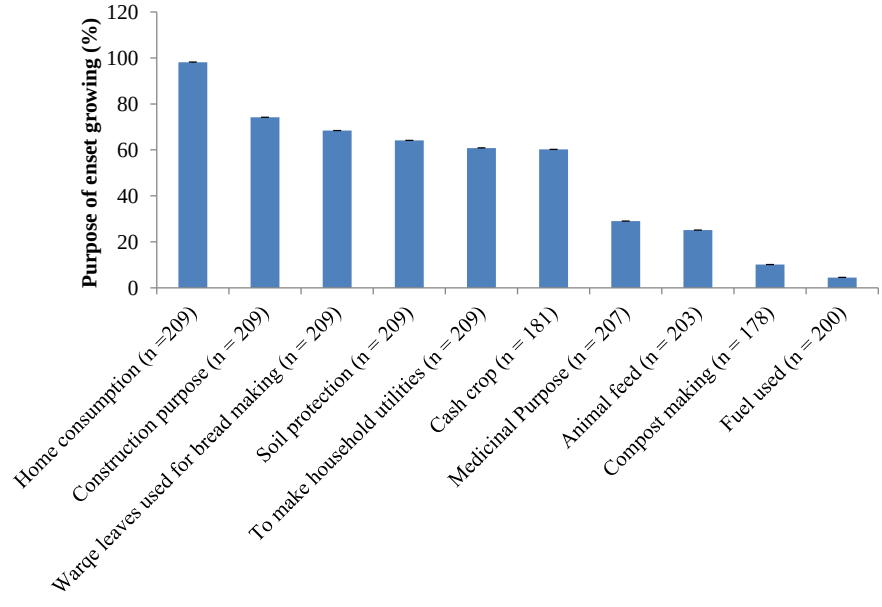


Figure 6. The multiple purposes of *warqe* crop production in the study areas (n is number of respondents and error bars show standard error)

The quantity of *kocho* and *bulla* supplied to Woliso *kocho* market (in metric tonnes) over the two years between September 2013 and August 2015 is shown in Figure 7. Woliso *kocho* market is one of the largest *kocho* markets in Ethiopia and is the major supplier of *warqe* foods to the market in Addis Ababa. The market is well-organised in a privately owned market compound with temporary storage facilities and transportation services at an observed cost of 25.80 Ethiopian Birr per 100 kg per 74 km distance on average (1 US dollar ≈ 21 Ethiopian Birr) during the study. It was difficult to obtain monthly records on *warqe* food supply to other markets compared with Woliso market. *Kocho* and *bulla* are supplied to Woliso market weekly from Haro, Dariyan, Chitu and Haroji *kocho* markets and the surrounding areas. As shown in Figure 7, in 2014 the highest supply of *kocho* and *bulla* to the market was recorded in April and comprised 204 and 8 tonnes, respectively. In 2015, the highest supply of *kocho*

and *bulla* was recorded as being 145 and 6 tonnes, respectively. Thus for both food products, there was a slight reduction in terms of the maximum amount supplied in 2015 compared with 2014. Supply and demand were found to be highest in the months of September, December, January and April. This is because *warqe* foods are in high demand during Ethiopian holidays.

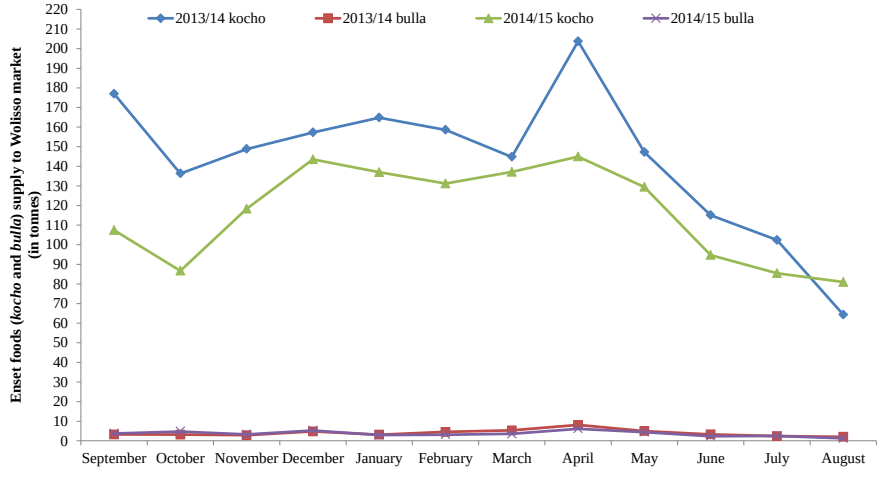


Figure 7. Quantity (tonnes) of *kocho* and *bulla* supplied to Woliso market in the period September 2013 to August 2015

4.3 Analysis of the supply chain and logistics practices

4.3.1 Supply chain analysis

The supply chain of *warqe* food products is illustrated in Figure 8. Eight main supply chain actors were found to be involved in the chain, which was observed to be long and often overlapping. The relationships between *warqe* supply chain actors proved to be complex. Producers reported that they sold their products to wholesalers, retailers, collectors and/or to consumers, with the proportion of the total amount sold to each depending on the availability of buyers and proximity to the market. Collectors purchased a large amount of *kocho* and fresh *bulla* from producers and wholesalers in the vicinity of farms and at the local market. They sold directly to urban wholesalers. Wholesalers bought *kocho* and fresh *bulla* from producers and then sold to urban wholesalers, retailers and consumers. Urban wholesalers sold their *kocho* and fresh *bulla* to retailers and directly to consumers. Retailers bought from wholesalers and sold a large proportion to consumers and the rest to open

market dealers in urban areas. Open market dealers bought from retailers and sold directly to consumers.

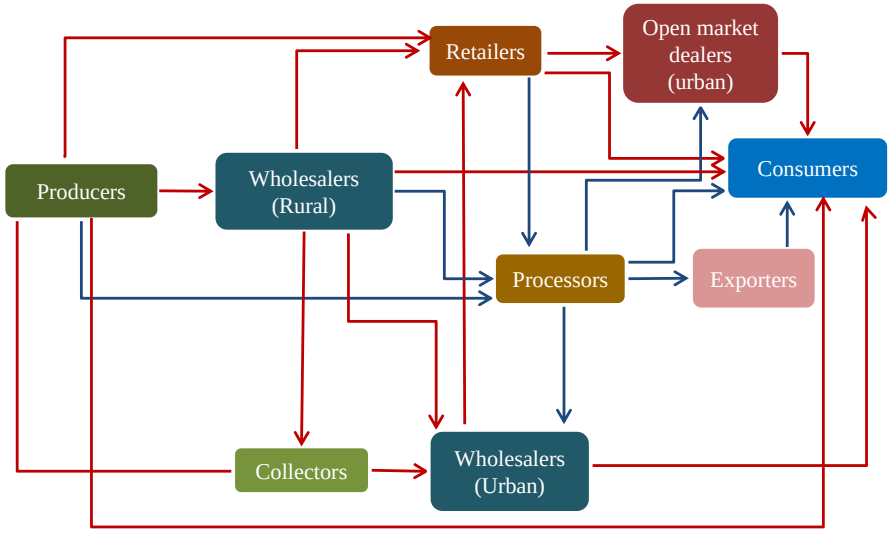


Figure 8. Schematic mapping of the *kocho* and *bulla* supply chain in central Ethiopia, based on survey results. Red arrows indicate physical flows of *kocho* and fresh *bulla*. Blue arrows indicate physical flows of processed *bulla*

The supply chain of *bulla* was found to be more complex than that of *kocho*. In the *bulla* supply chain, there were two distinct products involved, fresh *bulla* and processed (dried) *bulla*. The supply chain of fresh *bulla* was similar to that of *kocho* described above. Fresh *bulla* intended for processing was reported to be purchased by processors from three different suppliers: producers, wholesalers and retailers. Processed *bulla* was mostly sold to wholesalers, retailers and open market dealers and some amount directly to final consumers. A very small amount of processed *bulla* was sold to exporters. Exporters reported that they exported their products to different countries, mainly to Ethiopian traditional restaurants and shops abroad. Thus, final consumers could get *kocho* and fresh and processed *bulla* from different suppliers through a number of chains.

4.3.2 Packaging and storage methods for *warqe* food products

In all areas surveyed, it was observed that *kocho* and fresh *bulla* were packed in fresh *warqe* leaves and dried leaf sheaths (*koba* and *woficho*) before sale and storage. Repacking was also undertaken in local markets using the same packaging materials (Figure 9). However, the processed (dried) *bulla* products were packed in large polypropylene bags with plastic bags inside containing

100 kg amounts and in small packages of small plastic bags containing amounts of 250 g, 500 g or 1 kg. The plastic and polypropylene bags used as packaging materials by processors for the processed products were reported to be supplied by retailers and wholesalers in local shops.

Figure 9. (Left) Packed *kocho* and (right) processed *bulla*

Different storage methods were identified during the course of the survey. The main storage areas for *warqe* food products were pits, living rooms, marketplaces or shops and warehouses. At the producer level, the majority of farmers (50%) used a pit for *kocho* storage and their living room for *bulla* storage. Among traders, the majority (74%) used the marketplace or their shop as the storage place. At processor level, the processing site was mainly used for storage (63%). At consumer level, consumers in rural areas generally used pits (45%), whereas urban consumers mainly used their living rooms to store *kocho* and *bulla*.

Warqe products can be stored for long periods using different storage methods along the supply chain (Figure 10). It was concluded that *kocho* was stored on average for 186, 7, 8, 29 and 185 days in the hand of producers, collectors, wholesalers, retailers and consumers, respectively. In the case of *bulla*, it was stored on average for 100, 7, 114, 65, 99 and 104 days in the hands of producers, collectors, wholesalers, retailer and consumers, respectively. The duration of *kocho* storage in the entire chain from producer to consumer was thus 415 days, while for *bulla* it was 489 days. Therefore, *warqe* foods can be stored for long periods using traditional storage methods.

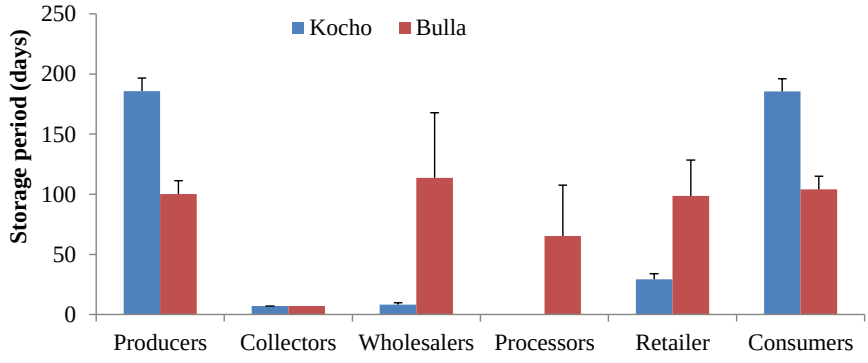


Figure 10. Storage periods (days) for *kocho* and *bulla* at different levels along the supply chain

4.3.3 Transportation

Warqe foods were reported to reach end consumers using different modes of transport (Figure 11). It was observed that human power, pack animals, animal carts and vehicles were the main means of transport in the study areas. The majority (85%) of *warqe* farmers stated that they used human power to transport their products from the processing area to their homes. About 47% of farmers used pack animals with human power to transport their products to local markets. The means of transport used by traders to transport goods to market were mainly vehicles (39%), pack animals (34%) and animal carts combined with pack animals (7%). Processors primarily used vehicles (50%) to transport their products.

Donkeys and horses were mainly used as pack animals. It was observed that one pack animal could carry on average 40-50 kg of goods from farmers' villages to local markets. A single horse-drawn cart was another method of transportation observed in local market areas. These carts can carry a load up to 300 kg of *warqe* products. Two types of vehicle were observed in the transport of *warqe* foods: a small-sized lorry (2-axle, 6-tyre single unit) with a maximum load capacity of 3.52 tonnes, but observed to carry 5.23 tonnes, implying 148.58% loading rate; and a medium-sized lorry (2-axle, 6-tyre single unit) with a capacity of 12 tonnes, but observed to carry up to 15 tonnes, resulting in around 125% loading rate. These vehicles were observed to be carrying *warqe* products alongside other goods such as vegetables, wood, charcoal and cereals. Thus, it was observed that the transportation system for *warqe* food products in the study areas was multimodal, starting with human-based transportation, then pack animals, then animal carts and finally vehicles.

Figure 11. Different methods of *warqe* food transport: (Top left) on donkeys, (top right) on an animal cart, (bottom left) on a small lorry and (bottom right) on a medium-sized lorry

4.4 Value chain analysis

4.4.1 Mapping the core processes for *warqe* products

Warqe food products were found to be processed in traditional processing procedures using local-made tools. The main processing steps, starting from selection of a mature plant and ending with final food product made from *warqe*, are presented in Figure 12. These results were obtained in the main survey, where a slight difference in *warqe* processing steps between the Haro Wonchi and Maruf areas was observed. However, the steps presented in Figure 12 were the common steps employed in both areas. The main steps in traditional *warqe* processing started with identification and selection of mature plants. This was followed by preparation of the working area and fermentation pit, removal of leaves from the plant and excavation of the plant by removing all parts and the corm at the site. The plants were then divided or cut into three parts. The main processing method was pulverisation, decortication and fibre separation (fibre is a by-product). *Bulla* was extracted from freshly decorticated pseudo-stem or pulverised corm mass. Preparation of fermentation

starter (*gamma* or *racheta*) was the next step in the operation. The following step involved mixing the pulverised and decorticated mass thoroughly with starter and putting the mixture into concave-shaped empty corms in the fermentation pit.

Respondents indicated that *kocho* processing involved a two-stage fermentation process, primary and secondary fermentation stages. In the primary fermentation stage, the mass in the concave-shaped corm and in the pit was fermented separately for one month. In the second fermentation stage, the contents of the corms were mixed together with the pit mass and left in the pit for a further approximately two months of fermentation. The mass was turned and checked and the leaves were changed or the mass was remixed and wrapped with new leaves as necessary during the fermentation period.

After two or three months, fully fermented *kocho* was obtained. It underwent further processing steps to break down tiny fibres by tamping (*tumuu*) to upgrade the quality, and finally *holeta* was obtained. Similarly, *bulla* was serially further processed by *bulla* processors to produce dried *bulla* product (Figure 12). In this process, fresh *bulla* was mixed with pure water and stirred to dissolve it completely in water, after which unwanted materials were removed by filtering. The filtrate was left for one day to sediment and the supernatant was then removed, mixed again with pure water and stirred to dissolve, left for one more day to sediment and then decanted and finally sun-dried. This yielded a sediment or crystalline deposit which was dried further under continual turning and crushing of aggregated particles to produce dry, very fine powdered *bulla*.

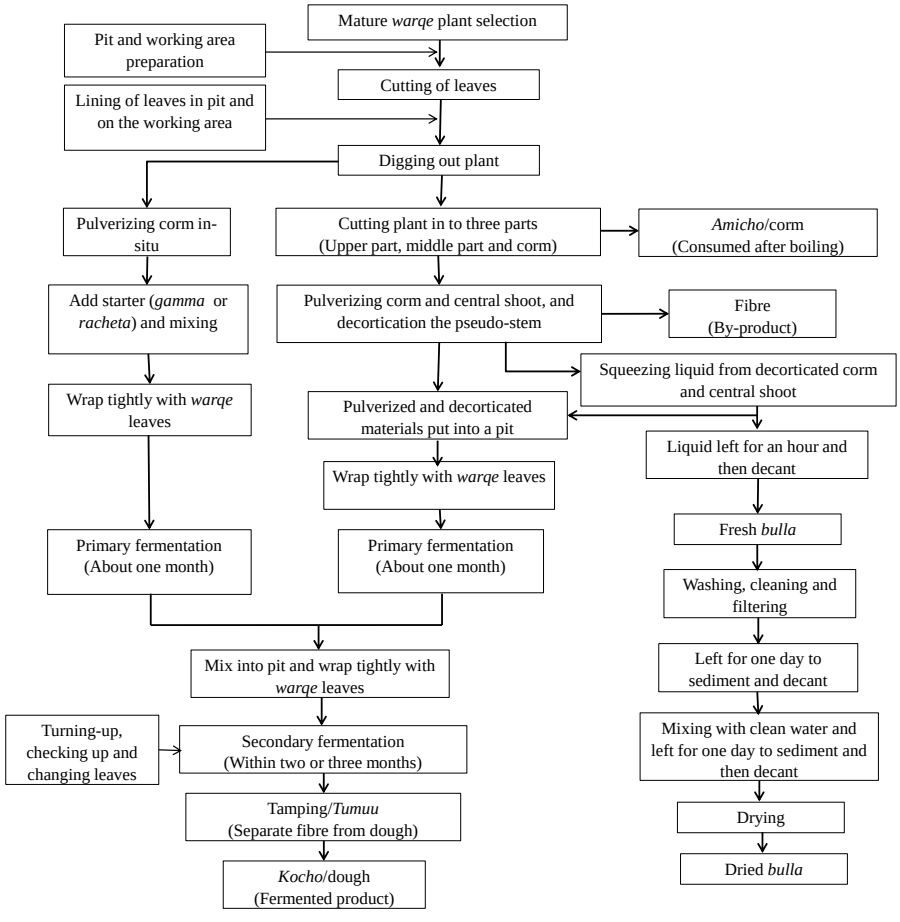


Figure 12. Flow chart of traditional *warqe* food processing in the Haro Wonchi, Maruf and Woliso areas based on survey results

4.4.2 Mapping the *kocho* and *bulla* value chains

The value chain of *kocho* (Figures 13) and that of *bulla* (Figure 15) were mapped based on data obtained in interviews conducted in the main survey study. It was found that a weak coordination existed in product flow and information exchange between value chain actors within and across different levels of the chain. The chains depended on links between farmers, processors, collectors, wholesalers, retailers and consumers. The value chain of *kocho* and *bulla* started with farming input suppliers. *Warqe*-growing farmers and *bulla* processors were found to be the basic actors and created the most value in the chain. Actors such as collectors, wholesalers and retailers mainly worked in

trading activities and value addition. Collectors linked farmers to wholesalers in rural and urban markets. *Bulla* processors were the largest actors in the *bulla* value chain and supplied to wholesalers, retailers and export markets. Wholesalers supplied mostly to retailers and consumers/restaurants. Retailers sold *warqe* foods to end users. The value chain of *kocho* and *bulla* proved to be very complex, *e.g*. besides the main supply chain, *warqe*-growing farmers also sold to consumers at the local market. However, this thesis focused mainly on analysis of the value chain for the main supply chain only.

Input supply

About 82% of *warqe*-producing farmers used their own farming inputs, such as planting materials and organic fertiliser, mainly farmyard manure (Table 1). A further 10% of *warqe*-growing farmers used purchased planting materials from the local market and the remaining 8% of farmers used planting materials which they obtained free from relatives. The farmers mainly used labour supplied by their own family, but some farmers used locally hired workers for hard work like digging planting holes, transplanting to permanent planting fields and weeding. Traditional and cultural cooperation among male and female farmers, which are called "*Daboo*" and "*Daadoo*", during peak harvesting and processing was another labour source used. In "*Daboo*" individual come together and contribute labour and skills without payment. "*Daadoo"* is a system of group work cooperation where the people work together one day on one person's and the other day on other person's job; it is a kind labour lending to be repaid by the same labour time/day. In this cooperation, farmers work in groups to share labour and experiences.

Local market trading

Local market trading has been part of the Ethiopian agricultural sector for a long time. In the case of *kocho* and *bulla*, the main actors in the local market were found to be farmers, collectors, wholesalers and rural retailers. The local market had the important role of linking *warqe*-producing farmers to market. It was observed that traders in the local market had long-term and trusted relationships with their client farmers. Traders did business with certain farmers based on long-term business relations and trust development. Core value-adding activities in the local market were grading and sorting based on quality parameters, mixing, repacking, transport, storage and selling. Traders usually employed other workers to carry out these value-adding activities and to transport their commodities to central markets.

Bulla processors

Bulla processors pursued their business by processing fresh *bulla* into dried powder form. The main value-adding and value-creating activities in *bulla* processing were washing, cleaning, dehydrating, drying, packaging, storage and selling. Products were dried on plastic sheeting on unlevelled ground using sun heat on an irregular basis. This was the main food processing activity observed in the *bulla* value chain. Processors used simple, locally made and traditional tools and generally specialised in dried *bulla* processing and packaging. The organisational structure of this actor was small-scale, family-based enterprises and family members occupied the key management positions in the enterprise. Most of the workers were hired but some work was done by family members. In both cases, all activities were performed by women.

Central market

The central market Merkato is located in Addis Ababa city, the capital of Ethiopia. Merkato is the largest market in Africa, covering several square miles, and the primary merchandise passing through it is locally-grown agricultural products. In Merkato market, there is a special section for *warqe* foods called "*kocho tera*" or "*kocho berenda*", which is very well-known to traders in *warqe* food products (Figure 14). The main actors in this market were found to be wholesalers, retailers and open market dealers. The central market had the important role of linking wholesalers, retailers, open market dealers, processors and consumers to market. Traders generally specialised in *kocho* and *bulla* trading. The main value-adding activities in this value chain were sorting and grading, weighing and packaging, storage and selling of both *kocho* and *bulla*. For *kocho*, separation of fibre from the products was performed to improve the quality of *kocho*. All value-adding activities were reported to be done by women. However, for transporting and arranging the products in shops and stores, male workers were hired. The survey results indicated that all owners in the central market were women. The employees in market activities were usually relatives and without labour contracts.

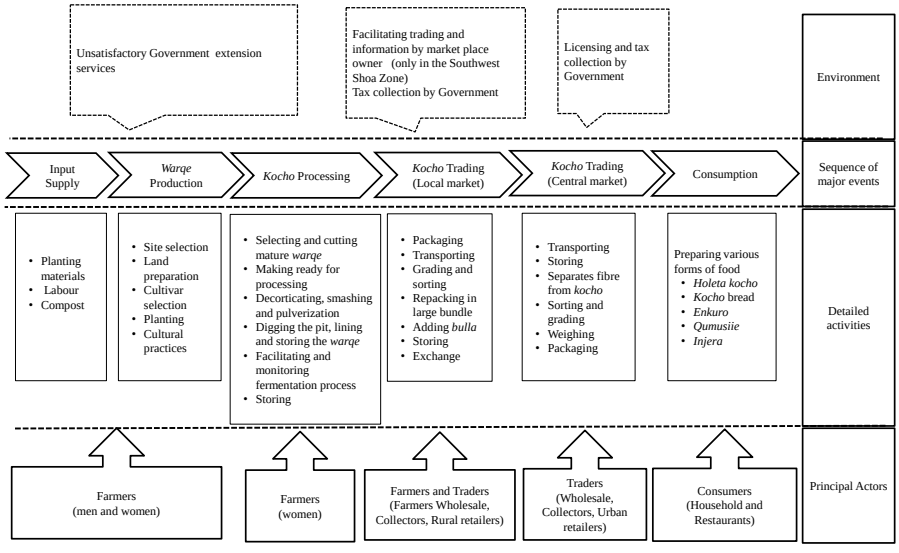


Figure 13. *Kocho* value chain in Central Ethiopia

Figure 14. Part of the *kocho berenda* at Addis Merkato market

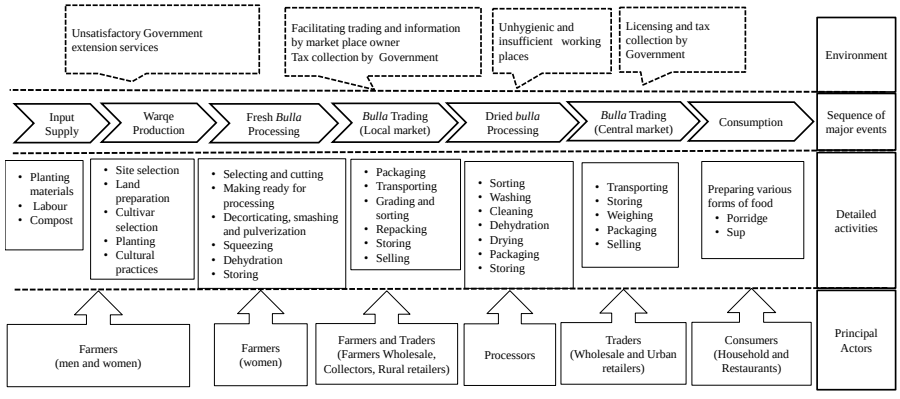


Figure 15. Bulla value chain in Central Ethiopia

4.4.3 Analysis of market margin share

The market margins of *kocho* and processed *bulla* marketing along the value chain are presented in Table 2 and Figure 16. The main survey found that *kocho* and *bulla* production in the Maruf and Haro Wonchi areas did not rely on external costs for purchase of chemical fertilisers, herbicides and packaging materials. The main external costs of the *kocho* and *bulla* value chain were labour and market costs.

The total gross marketing margin that was added to *kocho* while passing through the marketing system to reach final consumers was 73% and thus *warqe* growers receive only 27% of the final consumer price. Within the total gross marketing margin of *kocho*, retailers received the highest marketing margin (37%), while 31% was received by wholesalers and the remaining 5% of marketing margin by collectors along the value chain. Similarly, the total gross marketing margin added to processed *bulla* while passing through marketing system to reach final consumers was 63%. The highest gross margin was received by processors (31%) and wholesalers (23%), while the remaining 9% of marketing margin was received by retailers. The farmers' share of the final consumer price of processed *bulla* was 37%.

Table 2. *Marketing cost (Birr ⁎) and average margin per kg for kocho and processed bulla*

Cost and margin	*Kocho*			Processed *bulla*		
	Collectors	Wholesalers	Retailers	Wholesalers	Processors	Retailers
Marketing cost						
Purchase cost	5.97	6.97	13.77	14.94	24.29	37.14
Processing cost	-	0.06	1.50	0.10	3.00	-
Transport cost	0.20	0.41	0.38	0.33	0.45	0.38
Loading and unloading	-	0.06	0.13	0.06	0.06	0.13
Tax and licensing fee	-	0.19	0.25	0.30	0.49	0.57
Transaction cost						
Opportunity cost of labour	0.25	0.55	0.4	0.55	0.4	0.4
Opportunity cost of capital	0.30	0.48	0.69	0.75	1.21	1.86
Total cost	6.72	8.72	17.12	17.03	29.90	40.48
Sales	6.97	13.77	21.74	24.29	37.14	40.96
Gross margins	0.25	5.05	4.62	7.26	7.24	0.48
Total gross margins	4.60%	31.28%	36.66%	22.83%	31.37%	9.33%
Producer's gross margin	98.85%	76.77%	78.75%	82.28%	82.32%	98.83%
Net marketing margin	1.15%	23.23%	21.25%	17.72%	17.68%	1.17%

⁎Price of *kocho* and *bulla* based on 2014 price in Ethiopian Birr (1 US dollar ≈ 21 Ethiopian Birr).

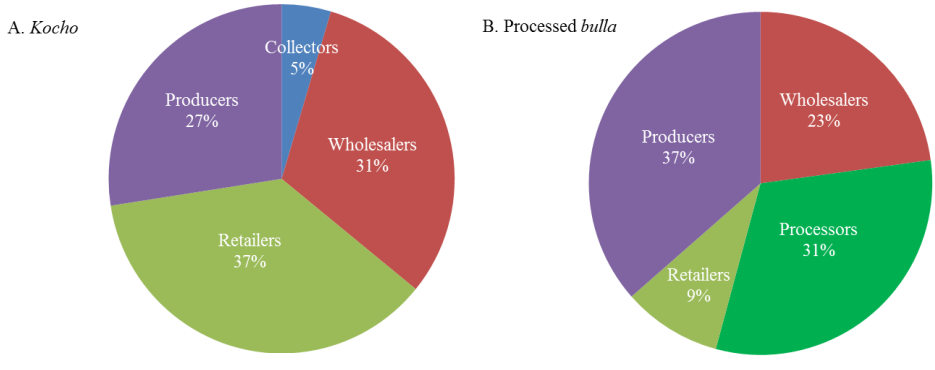


Figure 16. Producers' profit share and total gross marketing margin for (A) *kocho* and (B) processed *bulla* while passing through the marketing system to reach final consumers

4.5 Post-harvest food losses along the supply chain

Substantial losses were observed in the whole supply chain of *warqe* food products. There was a highly significant ($P<0.01$) difference in the extent of losses between the chain actors for both *kocho* and *bulla* (Figures 17 and 18). About 45% of *kocho* and 46% of *bulla* was lost from the total marketed product along the supply chain. In the *kocho* supply chain, the highest losses were estimated to occur at retailer level and were 24% of the total losses of the product at all supply chain levels. Figure 19 shows *kocho* and *bulla* spoiled at market due to damage by rodents and poor display and exposure to the air. The lowest *kocho* losses (about 6%) were estimated to occur at producer and consumer level. Similarly, in the *bulla* supply chain, the highest losses (29%) were reported at processor level (see Figure 18). The lowest losses of *bulla*, about 1% of the total amount produced, were found at producer level. In general, the losses of *bulla* and *kocho* in the respective chains were similar in the trend along the supply chain, however, the hotspot for *kocho* at retailer level whereas processors level is for *bulla*.

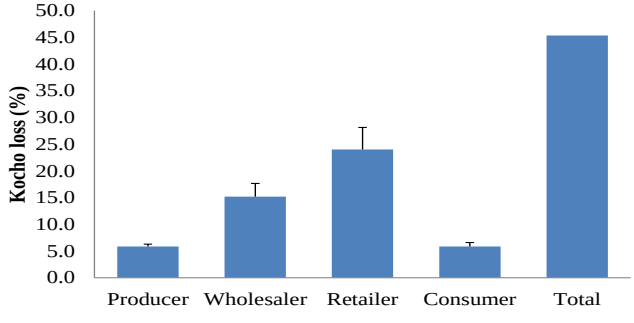


Figure 17. Kocho losses (%) at different stages of the *warqe* supply chain in Central Ethiopia (mean ± standard error)

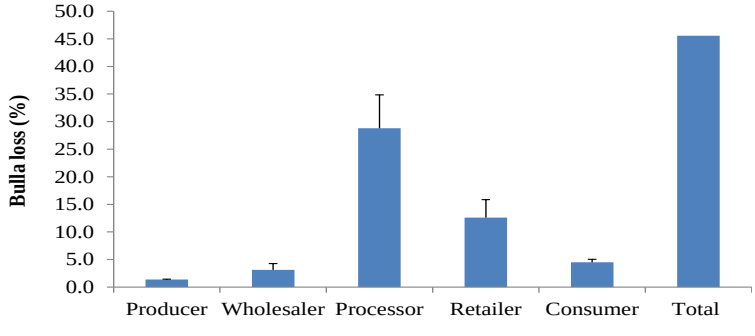


Figure 18. Bulla losses (%) at different stages of the *warqe* supply chain in Central Ethiopia (mean ± standard error)

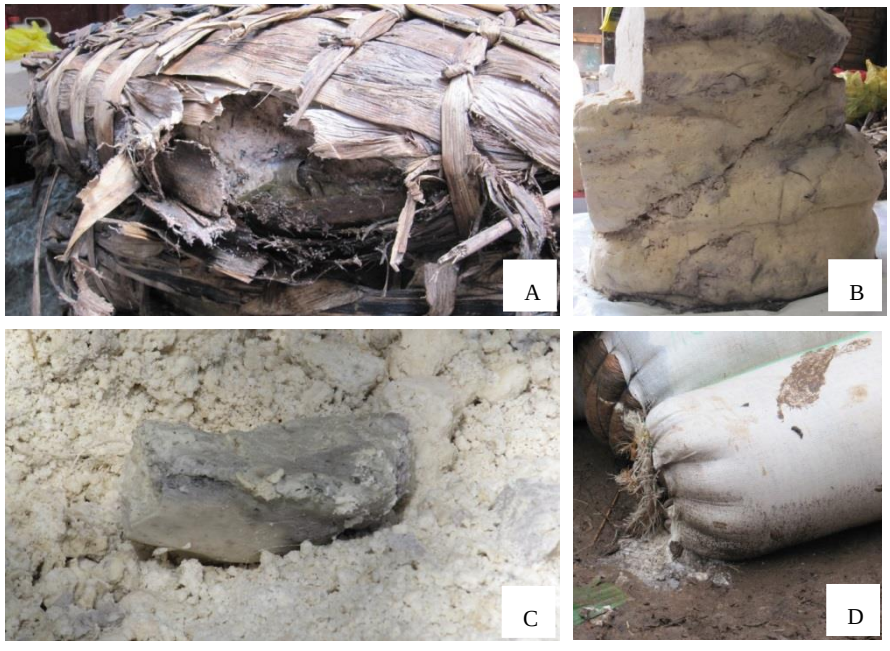


Figure 19. Spoiled *kocho* at market due to (A) damage by rodents and (B) poor display and exposure to the air. *Bulla* spoilage at the processing site due to (C) mould development and (D) physical losses due to poor packaging at processors stage

5 Discussion

In this thesis, the supply chain and value chain of *warqe* food products were analysed, post-harvest food losses of *kocho* and *bulla* were estimated and hotspots for these losses were identified. Many previous studies have been conducted on post-harvest food losses in different food crops along the supply chain. However, prior to the present study very limited information was available about post-harvest losses of *warqe* primary food products. Moreover, the causes of spoilage were not clearly known and the extent of losses in the supply chain of *warqe* had not been studied and documented. This discussion chapter focuses on the importance of *warqe* in the study areas, post-harvest food losses of *kocho* and *bulla* along the supply chain, the supply chains of *kocho* and *bulla* and value chain analysis of *warqe* food products.

5.1 *Warqe* production and utilities

Warqe production is unique compared with cereal crop production, as the *warqe* plant needs on average five to six years after final transplanting at its permanent planting site to reach final maturity for harvesting. Moreover, complex processing is required to produce *kocho* and *bulla*. To be fully fermented, *kocho* needs two to three months of fermentation in the pit. Farm and processing activities are carried out under a gender-based division of labour. It was observed in field studies that unlike other crops, all post-harvest and trading activities concerning *warqe* are mainly done by women. Moreover, men are not involved in the marketing activities even in the central market in Addis Ababa, where most of the *warqe* traders are women. A study by Abass *et al*. (2014) indicated that in Tanzania maize processing activities are mainly done by women. In line with observations in this thesis, Yeshi (2012) and Mac Entee *et al.* (2013) reported that women are solely responsible for decision

making regarding processing, marketing and controlling *warqe* income at the producer level. The roles of men and women in *warqe* cultivation and processing are clearly separated. Women have the responsibility for securing household food by transforming the *warqe* plant into food (Negash and Niehof, 2004). This indicates that tradition and cultural influence in *warqe* production and trading are very important, *e.g*. it is considered taboo for men to be involved in the processing and trading activities. This creates a heavy burden on women, as they are responsible for every post-harvest activity, which makes life very tough for women in *warqe*-growing areas throughout Ethiopia.

The main survey revealed that *warqe* grown in the Haro Wonchi and Maruf areas is used for multiple purposes (*cf*. Figure 6). Farmers reported that their *warqe* crop is their main livelihood; it is household food, animal feed, medicine, packaging material, platters, construction material to build houses and fences and even a source of water for cattle during the dry season. *Warqe* is also households' main income source, with the majority of farmers surveyed (39%) responding that more than 75% of their household income comes from *warqe* production. This implies that *warqe* production is a very crucial farm activity for their family livelihood. Similarly, previous studies have shown that the livelihood of families in the *warqe*-producing areas of Ethiopia depends heavily on the *warqe* crop (Barndt *et al*., 1997; Negash and Niehof, 2004; Degu, 2012; Mulugeta and Adane, 2012). *Warqe* production is the basis of household food security (Negash and Niehof, 2004) and an insurance against hunger (Barndt *et al*., 1997). Moreover, it is more than just a food crop (Brant *et al*., 1997; Degu, 2012; Mulugeta and Adane, 2012) and has potential to be used as an industrial raw material to produce fibre-related goods and starch for paper and adhesives (Brant *et al*., 1997; Taye, 2012).

Most previous studies cited above were conducted in southern Ethiopia and reported multiple uses of *warqe*, although focusing on family food security. Tsegaye and Struik (2002) clearly indicated that *warqe* produced in southern Ethiopia is used predominantly for home consumption, with only a very small proportion of *warqe* products being sold in the local market. However, this thesis showed that *warqe* is widely used as a cash crop in central Ethiopia, in addition to other uses. This difference could be due to two main reasons: i) The present study areas in central Ethiopia have a very suitable climate for growing *warqe* and this gives a high quality product with higher yield. In fact, *warqe* products from the Haro Wonchi and Maruf areas are known for their good quality and have a special brand name, "*Yechebo Kocho*", in the market. ii) Haro Wonchi and Maruf are located very close to the central market (Addis Merkato market) and thus the *warqe* products in these areas in high demand in the market. These factors result in *warqe* grown in the two areas being used not only for food, as they motivate farmers to supply non-food products and

multiple uses of *warqe* products for their livelihood, including use as a direct source of income.

Warqe foods supplied to the Addis Merkato market come in by different routes. This thesis identified the two major supply routes: Haro Wonchi to Addis Ababa and Guder to Addis Ababa. Similarly, Degu (2012) reported that high-quality *bulla* supplied to Addis Ababa originates from rural areas of Amaro in southern Ethiopia through the Hawassa and Shashemene market chains. The two-year analysis of *kocho* and *bulla* supply to Woliso *kocho* market and traders' experiences presented in this thesis indicate that supply is at its highest during religious holidays. This is because it is common to serve traditional foods during the holidays in Ethiopia, thus increasing the demand for *kocho* and *bulla*. Another reason is that *warqe* foods are usually consumed with animal products, resulting in high demand in non-fasting periods.

5.2 Post-harvest food losses

Significant amounts of *warqe* foods are wasted throughout the supply chain, from initial *warqe* growing down to final household and restaurant consumption (see Figures 17 and 18). The highest losses of *kocho* occur at retailer level and the highest losses of *bulla* at processor level. The lowest losses occur at the producer and consumer levels for both food types. According to FAO (2011), in low-income countries food losses mainly occur at early and middle levels of the food supply chain and less food is wasted at the consumer level. Moreover, FAO (2011) reports that the highest losses of roots and tubers in sub-Saharan African countries occur during post-harvest handling, storage and processing and packaging, with lower losses occurring at consumption. Thus *warqe* food losses in Ethiopia follow the same trends as losses in roots and tubers in sub-Saharan Africa.

The high losses of *kocho* (24.0%) and *bulla* (12.6%) observed at retailer level were due in particular to problems in market storage. These high losses reflect the fact that the *warqe* food products are traded in poor hygiene conditions in the market. Traders sell the products by displaying them in the open air. There is no proper storage place for products and traders use the same place for selling and storage. The markets are crowded and do not have a good ventilation system, so sales and storage conditions are poor. It was observed in the field studies that *kocho* and *bulla* are handled roughly during loading and unloading and are even stacked in storage. Compared with other stages of the supply chain, the marketing margin for *kocho* is highest at retailer level and for *bulla* at processor level. These price increments may be added by retailers and processors to compensate for losses and to maintain their profit. This shows

that losses in the chain are the cause of market price increments, with consumers being forced to pay for the losses indirectly.

The packaging material used for *kocho,* which is a wrapping consisting of *warqe* leaves applied at local markets, is not replaced until before the product reaches the final consumer. The leaves become dry over time and may deteriorate when they reach the central market because of rough handling during transport and due to the delicate nature of the leaves. Moreover, to check the quality of the products, it is common practice by traders in the marketing chain to pierce the packaging leaves and take out samples. This open hole may expose the product to the air and may even provide flies with access to lay their eggs, so that larvae may develop within the storage time. All these factors make a contribution to the deterioration of *kocho* at retailer level and may be the reason for *kocho* and *bulla* losses being high at retailer level. In the *bulla* supply chain, the highest losses were observed at processor level (28.8%). One of the causes of high food losses in developing countries is a lack of processing facilities (FAO 2011). The traditional method of processing, using inappropriate equipment, lack of quality products and a poor method of drying, is the most probable reason for the highest processing losses of *bulla*.

5.3 Supply chain analysis

This thesis found that there were eight actors in the *warqe* supply chain and logistics system, which can be grouped into three streams. Upstream actors comprise producers and collectors as the producers and initial suppliers of the products. Midstream actors are traders, transporters and processors, engaged in trading, transport and processing of *bulla*, respectively. The only downstream actors are consumers. This indicates that a large proportion of the logistics activities takes place in the midstream group, implying that there a number of parties involved in trading, transporting and processing *warqe* food products. The involvement of many actors in the supply chain may be one reason for the time taken to reach end consumers. It also implies a lack of communication between producers and consumers in urban areas. Similarly, Trienekens (2011) indicated that weak infrastructure hampers efficient flow of products to market and exchange of market information.

In the *kocho* and *bulla* supply chains in central Ethiopia, there are a number of chain actors involved. Producers are forced to supply their products directly to local wholesalers, rural consumers and collectors in the local market, due to a lack of transportation and lack of information about market demand in urban central markets. It was observed that collectors play a key role in the chain by collecting the products from producers and wholesalers in remote local

markets. Even though the collectors' share of the market supply is very small, they make a major contribution in taking *warqe* products from remote areas and supplying them to central markets because their commodities are sold to wholesalers who operate in urban markets. This means that collectors are the most important channel between rural and urban markets. Similarly, in a previous study Degu (2012) reported that 58.7% of the market supply of *bulla* produced in the rural Amaro area is taken outside the district by assemblers (collectors) and retailers.

This thesis also identified rural wholesalers as central distributors of *warqe* products in the supply chain. They purchase large quantities of products from producers and distribute them to urban wholesalers, retailers, collectors and even end users such as restaurants. This clearly reveals that wholesalers are major buyers and the main distributors in the *kocho* and *bulla* supply chains. Retailers usually buy from wholesalers in rural and urban areas and then re-supply larger quantities to consumers directly and any remaining small quantities to open market dealers. High-quality but expensive products from the growing areas of Haro Wonchi and Maruf ultimately reach end consumers in a variety of ways. Rural consumers purchase the product directly from producers and rural wholesalers in local marketplaces. However, urban consumers in Ambo, Woliso and Addis Ababa purchase the products through wholesalers, retailers or open market dealers. This long and complex chain makes high-quality *warqe* products from Haro Wonchi and Maruf very expensive for urban consumers, which may be one of the reasons why *warqe* foods are very expensive in traditional restaurants in large cities.

There is a complex chain for processed *bulla* compared with the chain for fresh *bulla*. *Bulla* processors buy fresh *bulla* from a variety of suppliers such as producers, wholesalers and even retailers in local and distant markets. This is because of the shortage of sufficient amounts of the raw material. This is one indication of a lack of effective links with producers to supply sufficient quantities on demand. Moreover, processors also distribute to wholesalers, retailers, open market dealers, exporters and consumers. This is because processors are centrally located in Woliso and Addis Ababa, giving them access to the market and their clients. Thus, processors are the main buyers of fresh *bulla* and the main suppliers of processed *bulla*. This makes the processed *bulla* chain more complex than the fresh *bulla* chain.

It was also observed that the supply chain of *kocho* and *bulla* and the relationships between chain actors are very complex, very long and overlapping. Probable reasons for the complexity are the involvement of many chain actors, producers having no information about the potential market in urban areas, poor transportation and market facilities, a lack of cooperation

among producers, a lack of market access, poor policies concerning *warqe* markets, central market supplies being dominated by a few people and difficulties encountered by producers wanting to break into urban markets.

Kocho and fresh *bulla* are packed in large quantities in *warqe* leaves and dried leaf sheaths (*koba* and *woficho*). This packaging method is not reliable for long-term storage due to the perishable nature of the packaging materials and is not suitable for checking the quality of the product during trading. It also makes it difficult to handle during loading, unloading and storage. Moreover, *warqe* food products are stored for long periods of time: 415 days for *kocho* and 489 days for *bulla*. However, the methods of storage used are very traditional and liable to cause losses at each chain level. One area that requires further study is improvements to packaging and storage methods.

The survey results indicated that *warqe* foods reach final consumers *via* different modes of transport, starting with human labour and then pack animals, animal carts and lastly vehicles. In total, about 150 km are covered, starting with producers and ending with consumers. The lack of infrastructure such as roads and a proper transportation system that farmers are forced to sell to wholesalers or collectors at the farm gate or local *kocho* collection places at very low prices. *Warqe* food products are transported to distant markets by pack animals, mainly donkeys and horses. Traders transport *warqe* food products to urban markets in small lorries, mainly Isuzu light-duty commercial trucks, but these vehicles were observed to be frequently overloaded. A study by Degu (2012) showed similar modes of supply of fresh *bulla* in southern Ethiopia. It can be noted in the present case that the products cover relatively short distances to reach the final consumers, but require four different means of transportation. This indicates that the products are handled and transported by different chain actors over this small distance.

Overall, the major issues identified in the supply chain were weak information flow, poor infrastructure and transportation systems, a lack of links between producers and consumers and packaging problems. Market issues such as poor market policies, lack of market access, poor market facilities and inadequate warehouse services were also observed. Central market supplies are dominated by a few individuals, making it difficult for producers and processors to break into the urban market.

Logistics constraints were identified along the supply chain, such as poor warehouse services. It was also usual for *warqe* foods to be transported with other goods, such as vegetables, wood, charcoal and cereals. There is a common practice of using easily perishable packaging materials (fresh and dried *warqe* leaves) that are not suitable for long periods of storage, although

these packaging materials do have the advantage of being cheaper and preserving the flavour of the products.

5.4 Value chain analysis

A slight difference in the processing steps for *warqe* food products was observed between Maruf and Haro Wonchi areas. This is well in line with findings by Gebremariam (1993) indicating that the steps in traditional *warqe* processing techniques differ from region to region and also differ between areas within the same region. This difference in processing procedures for *warqe* food products is mainly due to the differing experiences of women (who perform all processing work) from place to place because they acquire the processing skills from their ancestors, differences in microclimate conditions between areas, the season of the year in which *warqe* is processed and cultural differences between areas.

This thesis mapped the value chain of *warqe* food products and found that six principal value chain actors were involved in the chain. It was observed that product information flows between value chain actors within and across different levels of the chain were weak. Analysis of benefit distribution along the value chain indicated unfair profit distribution in the *kocho* value chain (*cf.* Figure 16). Market margin analysis indicated that the highest total gross margin was received by retailers in the *kocho* marketing chain and processors in the processed *bulla* marketing chain. Therefore, *kocho* value chain performance is not efficient, since the farmers do not get a better share of the consumer price. Farmers generate the most added values in the chain, but they only gain a small share of the profit (27%). However, the processed *bulla* value chain has better efficiency than the *kocho* value chain because both farmers and *bulla* processors get a fair profit share (37% and 31%, respectively). Farmers and processors generate the most added values in the processed *bulla* value chain. The efficiency of any marketing system usually depends on the ratio of producer to consumer price. The better the efficiency of marketing, the better will be the farmers' share of the consumer price (Mendoza, 1995).

It was observed that farming practices and post-harvest tools used in *warqe* production and processing are still traditional, with low use efficiency. Similarly Hunduma and Ashenafi (2011) reported that *warqe* processing still uses age-old techniques without any scientific modifications. Moreover, the equipment used in *warqe* processing is very traditional and locally made. This indicates that much work is needed to improve processing methods. The gender-dependent work division in *warqe* processing also has a negative impact on productivity. *Warqe* plant and *kocho* losses to wild animals such as

mole rats and porcupines are also substantial. In addition, the traditional *kocho* storage methods and *bulla* drying method lead to losses of products. Marketing practices used for *kocho* and *bulla* in the local market are also very liable to cause losses and spoilage due to lack of storage and market facilities.

5.4.1 SWOT analysis and value chain upgrading strategies

A summary of the SWOT analysis for *warqe* supply is presented in Table 3. *Warqe* foods are one of the staple foods in Ethiopia and a major cash crop in the study areas chosen for this thesis work. A large amount of *kocho* and *bulla* produced from these areas is supplied to the central market. *Warqe* production and marketing thus have strong opportunities, but there are some weaknesses and threats facing this 'golden' crop, such as bacteria wilt disease (*Xanthomonas campestris*) and lack of improved production technologies, planting materials and post-harvest processing technologies. The lack of improved *warqe* varieties and absence of external farm inputs may affect production. Farmers mostly rely on organic farmyard manures to supply nutrients to the *warqe* plant, which may not sufficient for raising yield. Another problem is that *warqe* production is performed within subsistence farming systems that are not directly linked with the central market. There are thus several gaps and weaknesses in the production, processing and marketing of *kocho* and *bulla*.

Table 3. *SWOT analysis of warqe food products in Central Ethiopia*

Strengths (S)	**Weaknesses (W)**
• Valuable and multipurpose crop • High quality and delicious taste of *kocho* and *bulla* products • Hard-working, experienced and enduring farmers • Working culture of cooperation between male and female by different traditional associations like *Daboo* and *Daadoo* • Product very suitable for processing and upgrading, especially *bulla*	• Lack of improved cultivars and fertilisers • High labour inputs needed • Working culture places burden on women • Marketing facilities problems, *e.g.* lack of warehouses • Poor marketing policies • Passive market development • Small production scale and low specialisation • Underdeveloped farming and post-harvest processing technology • Weak support from the government and scientists
Opportunities (O)	**Threats (T)**
• Suitable climate for *warqe* production • Near to central marketplace • Availability of different kinds of *warqe* cultivars • High demand for products in local market • Potential export market, especially *bulla* • Potential raw material for textiles and paper industries	• New generation does not accept the hard work needed for production and processing of *warqe* and is migrating to cities • *Warqe* production requires much labour • Roads are poor and old • High disease incidence (bacterial wilt) • Shortage of land, poor soil fertility and unsuitable topography for agriculture

In upgrading the value chain of *warqe* food products, it is important to adopt the four trajectories listed by Kaplinsky and Morris (2001): Process upgrading; Product upgrading; Functional upgrading; and Chain upgrading. There are three strategic areas that can be suggested based on these four trajectory points for *kocho* and *bulla* value chain upgrading:

1) Input supply improvement, which can upgrade both process and product by developing high-yielding cultivars, and farming tools, which can help to produce high-quality *kocho* and *bulla* products.

2) Production, post-harvest and processing upgrading in a functional way, which can help save time and labour and reduce post-harvest losses.

3) Product distribution and marketing, which can facilitate marketing and information sharing among producers, processors, traders and consumers within the *warqe* value chain.

According to Trienekens (2011), the presence of adequate distribution and communication infrastructure is a basic precondition for value chain development and upgrading. On the other hand, weak infrastructure hampers efficient flows of products to market and exchange of market information, especially at upstream value chain level. Lack of favourable credit facilities for

warqe-growing farmers and *bulla* processors and no subsidy policy, lack of infrastructure, lack of government support in value addition for local products and weak enforcement of existing laws and regulations are the major problems observed in *warqe* production in the SWOT analysis. Thus, based on the results in this thesis, it can be argued that the role of *warqe* farmers should be improved through providing an enabling environment for producers and access to credit and supplying improved varieties, advisory services, market facilities, market information and disease control. All these efforts could improve *warqe*-based food quality and reduce post-harvest food losses at each stage of the supply chain, particularly the retailer and processor stages.

6 Conclusions

This thesis analysed the supply chain and value chain in relation to post-harvest losses of *warqe* food products. The results showed that there are six principal value chain actors and eight supply chain actors involved in the *warqe* foods value and supply chains. A weak coordination was observed in product and information flow between actors in both chains. Significant amounts of *warqe* foods were found to be wasted throughout the supply chain, from initial *warqe* growing down to the final consumer stage. The overall losses of *kocho* and *bulla* were 45.3% and 45.6%, respectively, of total marketed product along the supply chain. The highest losses of *kocho* (24.0%) were observed at the retailer level and the highest losses of *bulla* (28.8%) at the processor level. From the overall data presented, the following general conclusions can be drawn:

- There is a need for cooperation and coordination between supply chain actors to create an effective information system throughout the supply chain using modern information technology and to develop an effective transportation system. The construction of shared warehouses around producers and in the market and the creation of links between producers and consumers to shorten the supply and marketing chain are also required.
- The performance of the *kocho* value chain is not efficient for farmers, since they receive only a 27% share of the consumer price, despite generating the most added values in the chain. However, there are opportunities for further upgrading the performance of the *kocho* value chain. The role of farmers and of *bulla* processors could be improved by providing access to credit, developing and supplying improved *warqe* varieties, access to advisory services, better market facilities and market information.
- Lack of appropriate processing technology at producer and processor level, use of poor storage facilities, packaging materials and transport methods,

poor handling in the market and air exposure during market display, insect pests at producer level and rodent problems at farm and market level are the main causes of *kocho* and *bulla* losses. Therefore, it is important to work on value addition to *warqe* foods, improvement of processing technology, transportation, storage, packaging and handling, and improvement of market conditions to reduce post-harvest food losses of *warqe*.

7 Further work

Future studies could:

- Characterise and evaluate the performance of *warqe* processing devices/equipment and determine pertinent parameters for the development new *warqe* processing equipment.
- Develop value-adding activities (including upgrading the food value of *warqe*) in the *warqe* supply chain.
- Develop *warqe* handling, packaging and storage methods and technologies to minimise losses and improve the food quality.

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Acknowledgements

A number of people were involved in helping me in both my educational and personal life during the time I carried out these studies. I am very grateful for all their help and I wish to thank most sincerely all those involved. However, for reasons of space, only a few of them are mentioned by name in these acknowledgements.

To start with, I wish to express my deepest thanks to my supervisor Professor Girma Gebresenbet. I particularly appreciate his great ability in giving me guidance in all the work which I did. I thank him for his unwavering and unconditional love, inspiration and encouragement. I also would like to thank my assistant supervisors Dr. Rikard Landberg and Dr. Tesfaye Balemi for their support during the planning, as I executed the study and in developing this thesis.

I gratefully acknowledge the German Federal Ministry of Education and Research for funding the RELOAD project. My special thanks go to all RELOAD team leaders and management for their great idea of the RELOAD project working on the *warqe* plant. I would like to thank all my colleagues at the Department of Energy and Technology at SLU, who were supportive and provide me help whenever I needed it. Special thanks to Tadesse Kenea, Dr. Techane Bosona, Dr. Samuel Aradom, Dr. David Ljungberg and Dr. Fufa Sorri for their wonderful collaboration and encouragement.

I express my gratitude to my dear wife, Azeb Bekele, my daughter, Mahlet Ashenafi, and my mother, Mulunesh Anechamo, for their perpetual love and support throughout the time I was carrying out my studies.

Last but not least, I am grateful to my friends Wosene Gebreselassie, Dereje Belay, Daniel Belay, Dr. Ermias Habte, Ibrahim Hamza, Takele Enkossa and Motumma Teressa for their encouragement and support during both data collection and in writing the papers.