

Analysis of the Supply Chain and Logistics Practices of Warqe Food Products in Ethiopia

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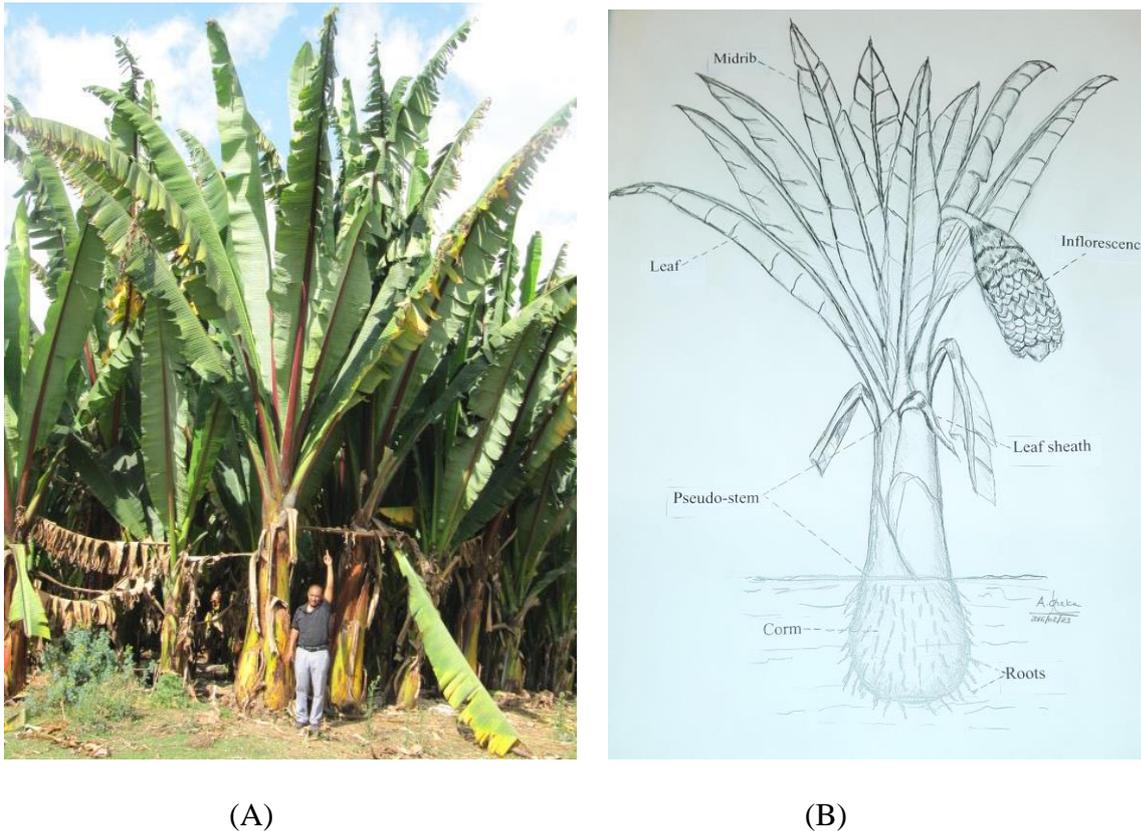
ABSTRACT

Warqe (Enset) is a multipurpose perennial plant, domesticated and grown as a food crop only in Ethiopia. *Kocho*, *bulla*, and *amicho* are food products of *warqe*. This study analysed the supply chain and logistics practices of *warqe* foods. Supply chain management concept was used to analyse the *warqe*-based food chain. Eight supply chain actors were identified. It was observed that the supply chain of *warqe* foods and the relationship between chain actors was very complex, long and overlapping. The major constraints identified in the chain were poor information flow, poor transportation system, using perishable packaging, lack of cooperation between actors, a poor infrastructure such as road and warehouse services, and poor policies concerning the *warqe* market. There is a need for cooperation and coordination between the chain actors to create an effective information sharing system. Shared warehouses need to be built near producers and market places. Transportation, packaging and handling need to be improved. Research is required to develop an integrated, efficient and effective logistics for *warqe* supply and marketing chain.

Keywords. Warqe, supply chain, logistics, Ethiopia

1 Introduction

Warqe (sometimes known as “*Enset*”) is domesticated and grown as a food crop in Ethiopia alone. However, Mesfin and Gebremedhin (2008) reported the existence of about 25 species of *Ensete* across Asia and Africa as wild plants. *Warqe* plant (Fig. 1) is primarily grown for its starchy food products in southern and south-western parts of Ethiopia. From the three food products of the *warqe* only *kocho* and *bulla*, are supplied to central markets from different production sites. Due to its perishable nature, *amicho* is not possible to deliver it to markets that are located far away from the production points. *Amicho* is the fleshy inner portion of the *warqe* corm, which is eaten as a root and tuber crop after being boiled. *Kocho* is the bulk of the fermented starch obtained from a mixture of the decorticated leaf sheaths and pulverised corm. The bread prepared from fermented *warqe* is also known as *kocho* bread. *Bulla* is a white dry powder or a semi-liquid that is produced by squeezing the decorticated leaf sheaths and pulverised corm and then decanting the liquid.



(A)

(B)

Figure 1. Mature *warqe* plants (A) and its morphology parts (B)

Warqe is a plant that has different uses. In addition to human food, the plant is used for animal feed. Some *warqe* varieties are used as traditional medicine, for example, the crushed fresh root is used to treat illnesses such as abdominal pain and amoebic dysentery (Bekele and Reddy, 2015). The fibre and dried petiole parts of *warqe* are commonly used in house building and to make bags, ropes, twines cordage, mats and wrapping material (Degu, 2012). *Warqe* also has potential in industrial applications as a raw material for adhesives in the textile and paper industries, with its fibre being used as a raw material in the manufacture of sacking and string (Brant *et al.*, 1997; Bezuneh, 2012). The plant also helps protect the soil surface from erosion (Brant *et al.*, 1997; Degu, 2012; Teamir and Tilahun, 2012).

According to the 2014 report by the Ethiopian Central Statistical Agency (CSA), a total of 130,630,473 *warqe* plants were harvested in the country in 2014 and produced 34,723.6 tonnes of *kocho*, 12,259.4 tonnes of *bulla* and 311.3 tonnes of *amicho*. For the same period, 1,169,348 *warqe* plants were harvested in west Shoa and 1,929,028 in south-west Shoa. Some of the foods produced were supplied to local and central markets. The two main supply routes for *kocho* and *bulla* to the central market in Addis Ababa are the Woliso and Guder-Ambo routes.

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 concepts of supply chain and logistics. 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 the present study, supply chain refers to the sequential arrangement of different chain actors who are involved in the flow of *warqe* food products from producers to end consumers.

Meanwhile, according to 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 analysis of the logistics of *warqe* food products in this study focused mainly on logistics actors and their relationship in the chain, their responsibilities, warehouse practices, product flows, finance and information from producers to consumers and vice versa.

In addition to the classical terms of logistics and supply chain management, the appropriate term used in 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.

It is important to study what the logistics and supply chains of warqe food products look like and how efficient they are. To the authors' knowledge, little information is available in the literature about warqe food logistics and supply chain. The only related study identified was the description made by Degu (2012) who reported on market channels of bulla in the southern part of Ethiopia. This indicates that there is a knowledge gap in the warqe supply chain and logistics practices. The research questions formulated were: 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 main constraints in the chain and possibilities for improving logistics practices along the supply chain of warqe food products in Ethiopia?

The objective of the study was to analyse the supply chain and logistics practices for warqe food products in Ethiopia. More specifically, the study aimed to (i) analyse the transportation system and its constraints, (ii) evaluate the logistics infrastructure and assets employed along the chains, and (iii) identify possibilities for improving logistics practices along the supply chain of warqe food products in the study area.

2 Materials and methods

Supply chain management concept was used to analyse supply chain and logistics practices of *warqe* foods. In this analysis, the *stages-wise methodology* was developed; describing and defining supply chain actors; mapping supply chain; analysing activities and relationships of the actors; describing logistics practices and identified its constraints and pointing out upgrading strategies.

2.1 Selection of the study area

Two survey studies were conducted in Ethiopia during 2014 and 2015 in order to analyse the supply chain and logistics practise of *warqe* foods. The first survey was conducted in the major *warqe*-growing areas of the country. During this survey, a critical discussion was conducted with selected farmers, traders, and researcher on aspects of the *warqe* supply chain and logistics. Based on the result of a first survey and literature reviews, the second survey was designed and conducted. The second survey study was conducted in two major *warqe* food production areas that supply *warqe* foods to the central market in Addis Ababa (Fig. 2). The market routes begin in the towns of Haro Wonchi and Guder towns as the source or farmers' market and are linked to the central market in Addis Ababa through traders. Based on data collected about *warqe* food products, details about the routes taken from their source to the central market are given in Figure 2.

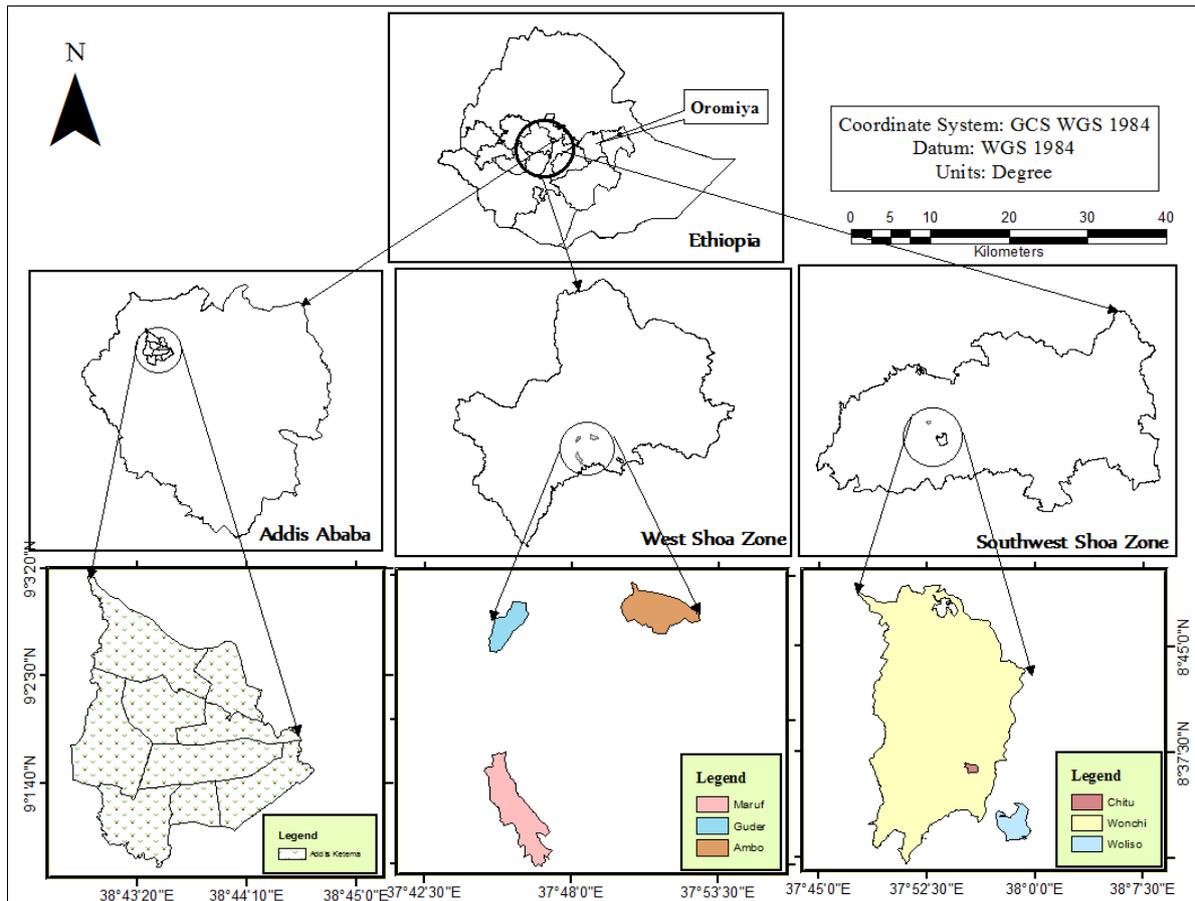


Figure 2. Location of the study areas

2.2 Sampling technique and sample size

Data were collected using semi-structured questionnaires and field observations. 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. Five types interview questionnaires were developed for the second survey to analyse supply chain logistics practices. A total of 522 respondents were selected along the supply chain. Of the respondents, 209 were farmers: 91 from the Maruf area and 118 households from the Haro Wonchi area. Of the remaining respondents included in the study, 56 were traders, 15 were transport operators, 8 were small-scale *bulla* processing enterprises, 11 were traditional Ethiopian restaurants and 223 were household consumers.

2.3 Method of data collection

Data were collected after identifying the main stakeholders in a pilot survey. Focus group discussions were held to gather information that could not be obtained during interviews. All the respondents were interviewed face to face. To increase the reliability of the data collection, discussions were held with key informants.

2.4 Data analysis

The collected data were analysed both quantitatively and qualitatively. Descriptive statistics (means, standard deviations 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.

2.5 Defining supply chain actors

The following terms were used to describe the supply chain actors and their main activities in the chain:

- **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* food 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 sharing market, and production information.
- **Wholesalers:** large traders who operate in rural markets and urban markets. They have a permanent place 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:** have permanent shops and purchase products in bulk from their suppliers and sell them in small amounts to their clients.
- **Food processors:** involved in the processing of *warqe* food products, particularly *bulla*. They purchase fresh *bulla* in large amounts, process it into dried products, pack them and then sell them to customers in bulk or in small quantities.
- **Transporters:** 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 permanent sites in urban open markets. They purchase small amounts of products from retailers or processors. They run their 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 Results

3.1 Activities and relationships of supply chain and logistics actors

Eight supply chain and logistics actors were identified in the *kocho* and *bulla* supply chain: producers, collectors, wholesalers, retailers, processors, transporters, open market dealers and consumers (households and restaurant). Three groups of logistics and supply chain actors were identified and their activities and relationships are presented in Table 1. Two actors were in the upstream group – *warqe*-producing farmers and collectors – who have a strong relationship in the exchange of information about the market situation. The midstream features wholesalers, retailers, transporters, processors and open market dealers and these actors have a relationship around transport, finances and sharing market information. Downstream is where the consumers are found. They buy, store and prepare various forms of foods and consumers such as restaurants to sell the food that is prepared from *warqe* products to their customers.

Table 1.
Logistics and supply chain actors of *warqe* food supply and their activities

	Upstream	Midstream	Downstream
Actors	<ul style="list-style-type: none"> • <i>Warqe</i> producers and collectors 	<ul style="list-style-type: none"> • Wholesaler, retailer, transporters, processor and open market dealers 	<ul style="list-style-type: none"> • Consumers: households and restaurants
Major activities	<ul style="list-style-type: none"> • Growing <i>warqe</i> plant, producing <i>warqe</i> foods (<i>kocho</i> and <i>bulla</i>), packaging, transporting and selling the products • Collectors: buying and transporting the products, and sharing and picking up market and production information 	<ul style="list-style-type: none"> • Buying, storing, repacking, transporting and selling • Food processors: buying, processing, drying, packaging, storing and selling 	<ul style="list-style-type: none"> • Buying, storing, preparing various forms of food and selling
Relationship	<ul style="list-style-type: none"> • Exchanging market information 	<ul style="list-style-type: none"> • Exchanging market information, products and finances and collaboration in the transport of their products 	<ul style="list-style-type: none"> • Providing feedback about product quality

3.2 *Warqe* production, market supply, and income contribution

Warqe production is one of the main farming activities in the areas of Maruf and Haro Wonchi. As shown in Table 2, each household has on average around 1.45 hectares of land. The land size per household varies between 0.13 and 10 hectares. The proportion of land covered by *warqe* plants ranges from 0.10 to 0.50 hectares per household, with on average around 0.29 hectares of land covered by *warqe* plants. The results of the interviews revealed that about 74 % of the respondent farmers produce *warqe* for market purposes other than home consumption while the remaining 26 % of farmers grow *warqe* for home consumption only. The results also indicated that on average a family produces 678 kg/year of *warqe* food products (*kocho* and *bulla*), of which about 275 kg is sold per year. *Warqe* production is the main source of revenue for households in both areas, contributing about 75 % of their income for 39 % of farmer respondents. *Warqe* production is a major farming activity in both study areas, with the plant covering about 20.14 % of the family land. The farmers' livelihoods are heavily dependent on *warqe* production in the study areas.

As indicated in Table 2, 81.73 % of farmers use farm inputs such as organic fertilisers and planting materials from their own sources, 10.58 % of the farmers use inputs purchased from local markets, while 7.69 % of farmers are given farm inputs by relatives as a gift. With regard to fertilisers, all the farmers only use organic fertiliser such as animal manure available from their own livestock yard and household waste. These results indicated that farmers do not use chemical fertilisers such as DAP or urea for *warqe* cultivation. All the farmers use local varieties of *warqe*. This indicated that *warqe*-producing farmers depend on their own farm inputs. There are no external farm input supplier organisations or institutions in the study areas that supply improved planting materials for *warqe* production.

Table 2.Farm size, *warqe* acreage, production and sales quantity, and contribution of *warqe* products to household income

Farm information	Parameters	Value
Farm size (hectare)	Minimum	0.13
	Maximum	10.00
	Mean	1.45
Land cover by <i>warqe</i> plants (hectare)	Minimum	0.10
	Maximum	0.50
	Mean	0.29
Source of farm input (fertiliser and seedling) (%)	Own source	81.73
	Purchase	10.58
	Gift from relatives	7.69
Farmers producing <i>warqe</i> for the market	Yes	73.70
	No	26.30
Total <i>warqe</i> 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
<i>Warqe</i> 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 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 3. Woliso *kocho* market is one of the biggest *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 a cost of 25.80 Ethiopian Birr per 100 kg per 74 km distance on average (1 US dollar \approx 21 Ethiopian Birr), as observed during the study. It was difficult to obtain monthly records of the *warqe* food supply in other markets compared to 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 3, in 2014 the highest supply of *kocho* and *bulla* to the market was recorded in April, at about 204 and 8 tonnes respectively. In 2015, the highest supply of *kocho* and *bulla* was recorded as being 145 and 6 tonnes respectively. For both food products, there was a slight reduction in terms of the maximum amount supplied in 2015 as compared to 2014. The results indicated that supply and demand were highest in the months of September, December, January, and April. This is because *warqe* foods are in high demand during the Ethiopian holidays.

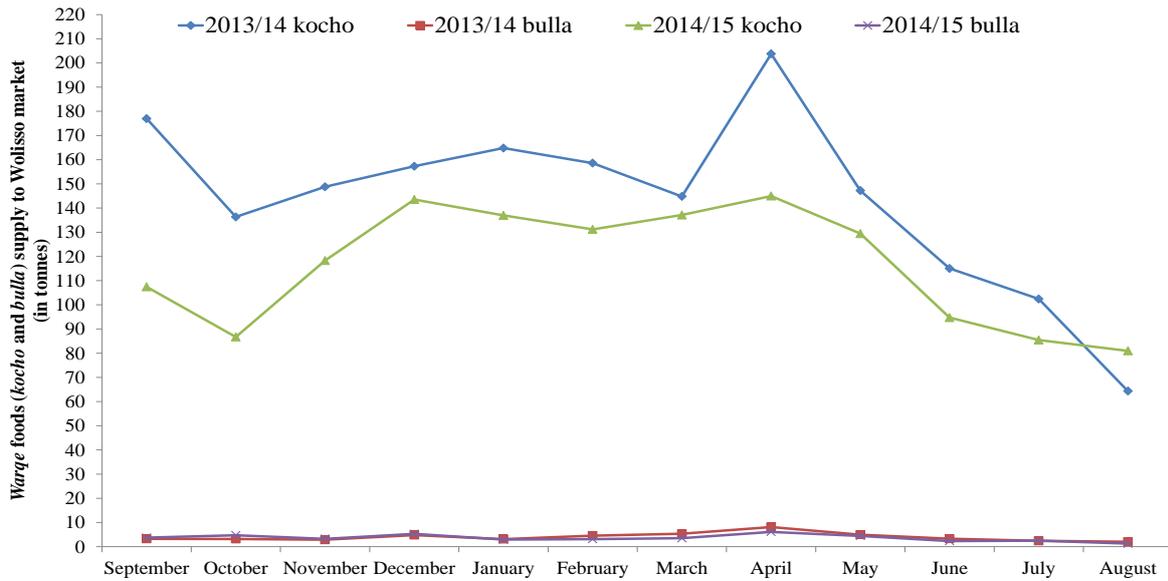


Figure 3. Quantity (tonnes) of kocho and bulla supplied to Woliso market in the period September 2013 to August 2015

3.3 Analysis of the supply chain and logistics practices of warqe food products

3.3.1 Analysis of the supply chain

The supply chain of *kocho* and *bulla* is illustrated in Figures 4 and 5 respectively. The numbers in the figures are the percentages of *kocho* and *bulla* delivered from one supply chain actor to the next. The results revealed that about 45 % of *kocho* is sold by producers to wholesalers, and 41 % is sold directly to consumers. Only 9 % and 5 % of the total production is as sold to collectors and retailers respectively. Wholesalers in rural areas purchase *warqe* products from producers and then sell it to urban wholesalers (67 %), retailers (21 %) and consumers (8 %). Collectors buy *kocho* from producers and wholesalers in the local market and then resell it to urban wholesalers. Urban wholesalers sell 40 % *kocho* to retailers and 60 % directly to consumers. Retailers buy from wholesalers and then resell in larger quantities to consumers (88 %) and the rest to open market dealers (12 %). Open market dealers only buy from retailers and sell to consumers.

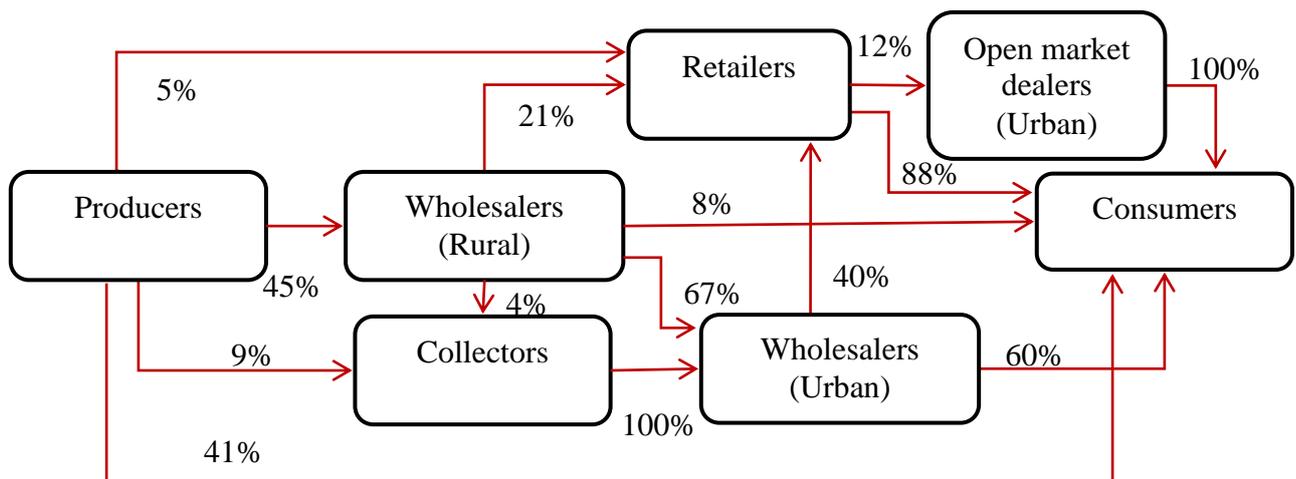


Figure 4. Supply chain of *kocho* in the central part of Ethiopia. Arrows indicate the physical flow of *kocho* and percentages indicate the quantity delivered to the next chain actor

The supply chain of *bulla* showed a more complex supply chain than the *kocho* chain (see Fig. 5). There are

two *warqe* products involved in the *bulla* supply chain: fresh *bulla* and processed or dried *bulla*. Producers sell 45 % fresh *bulla* to wholesalers, 41 % to consumers, 9 % to collectors and 5 % to retailers. 81 % of the fresh *bulla* purchased by rural wholesalers from producers is sold to urban wholesalers while 13 % and 6 % goes to consumers and retailers respectively. All the *bulla* purchased by collectors from producers and wholesalers in the local market is sold to urban wholesalers. Urban wholesalers buy fresh *bulla* from collectors and wholesalers and then sell 60 % to consumers and 40 % to retailers. Retailers purchase fresh *bulla* from wholesalers and then sell a large proportion to consumers (88 %) and a small proportion to open market dealers (12 %). Retailers purchase fresh *bulla* from wholesalers and then sell a large proportion to consumers (88 %) and a small proportion to open market dealers (12 %). Processors collect 63 % of the product from wholesalers, 25 % from producers and 13 % from retailers. Fresh *bulla* is processed into dried powder and processed *bulla* is mainly sold to open market dealers (34 %), about 27 % directly to final consumers, an equal amount sold to urban wholesalers and 13 % exported mainly to supply Ethiopian traditional restaurants and shops. Thus, consumers can get hold of *kocho* and fresh and processed *bulla* from different suppliers through a number of market channels. Consumers in rural areas buy the products from producers or wholesalers in local markets while consumers in urban areas acquire the products from different traders: from retailers, open market dealers or directly from processors.

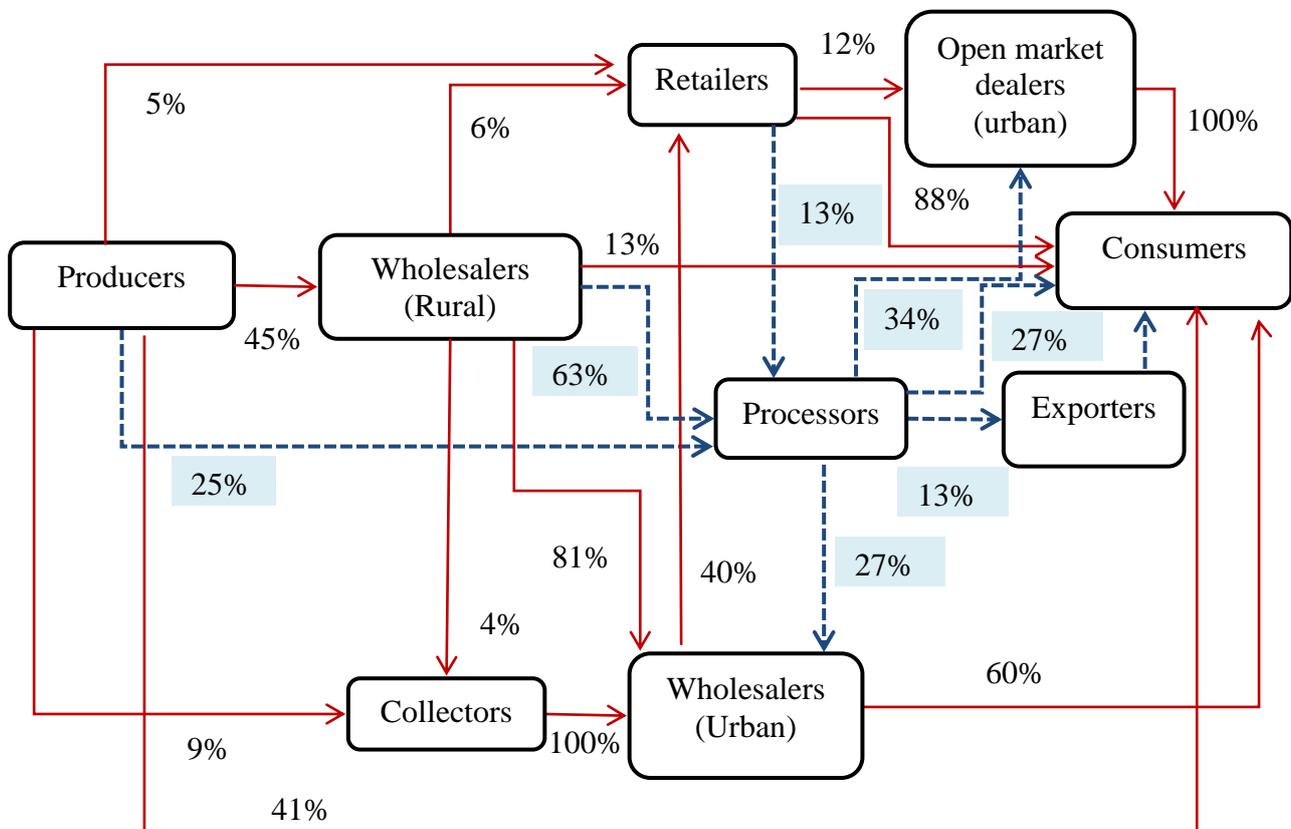


Figure 5. Supply chain of *bulla* in the central part of Ethiopia. Solid arrows indicate the physical flow of fresh *bulla* and the percentages indicate the quantity delivered to the next chain actor. Dash arrows indicate the physical flow of *bulla* for processing and the shaded numbers indicate the quantity delivered to the next chain actor

3.3.2 Supply chain and logistics

The product, finance and information flow in logistics chain of *warqe* is illustrated in Figure 6. *Warqe* food products flow upstream from producers and end downstream with consumers. However, finances flow in reverse, starting with consumers (downstream) to *warqe* producers (upstream). In both cases, traders are involved to facilitate the information flow in both directions and information sharing across the chain.

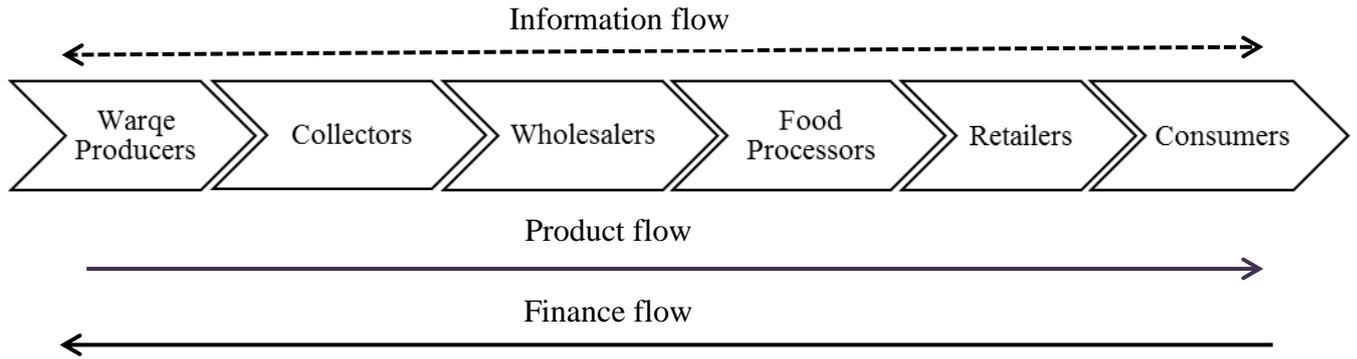


Figure 6. Product, finance, and information flow in logistic chain of *warqe* foods in the central part of Ethiopia

In the logistics chain, the flow of information is both vertical and horizontal. Figure 7 demonstrates the vertical relationship and horizontal cooperation between chain actors and within levels of the logistics chain of *warqe* food products. At the producer level, farmers collaborate in farm activities and post-harvest operations. There is traditional cooperation between male and female farmers, known as “*Daboo*” and “*Daadoo*”, during peak harvesting and processing operations. Farmers work in groups to share labour and experience. Collectors cooperate with each other by sharing information about the supply of products and market demands. Wholesalers mainly cooperate in arranging transportation and sharing market information. Processors collaborate with each other in information sharing about the supply and demand of fresh and processed products and the availability of packaging materials. Collaboration between retailers is mainly focused on the integration of transportation and information sharing as regards the supply and demand of products in the market.

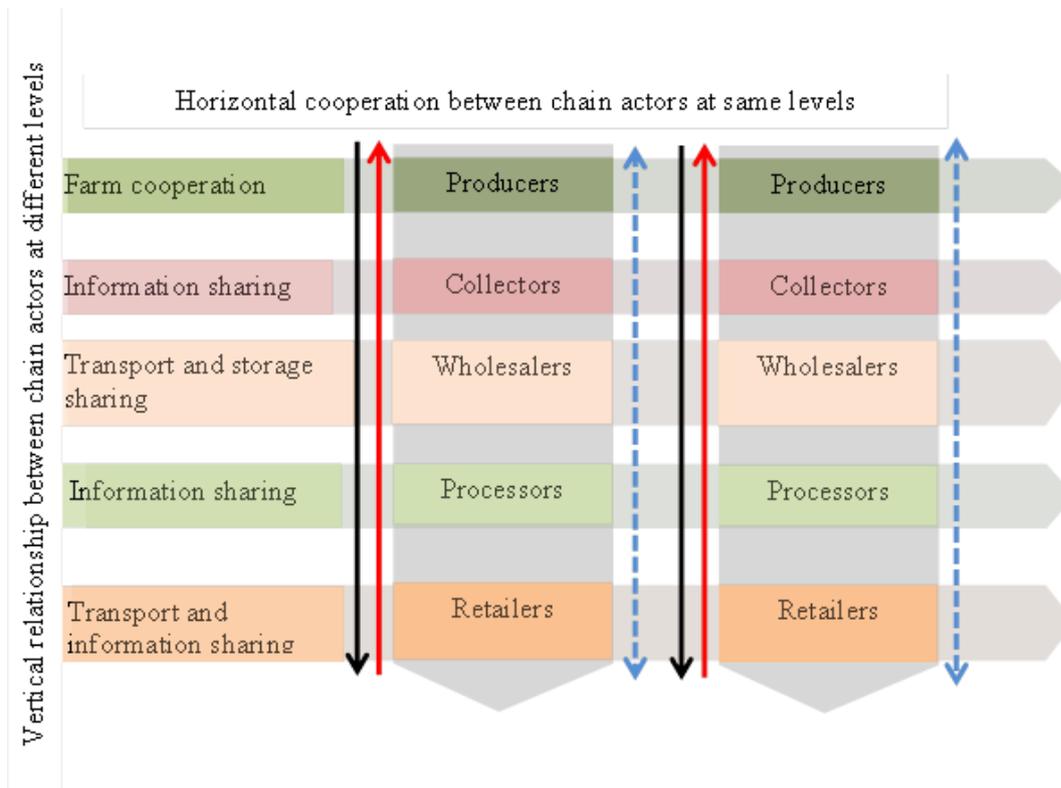


Figure 7. Vertical and horizontal cooperation between chain actors with and within levels of the logistics chain of *warqe* food products. Black and red solid arrows indicate the flow of products and finance respectively and dashed arrows indicate the information flow in the chain

3.3.3 Packaging and storage methods of warqe food products

In all the areas surveyed, it was observed that *kocho* and fresh *bulla* are packed in fresh *warqe* leaves and dried leaf sheaths (*koba* and *woficho*) before sale and storage. Repacking is also undertaken in local market places using the same packaging materials (Fig. 8). However, the processed (dried) *bulla* products are packed in large polypropylene bags, with a plastic bag inside in 100 kg amounts and small packages in small plastics bags in amounts of 250 g, 500 g or 1 kg. The packaging materials of plastic and polypropylene bags used by processors for the processed products are supplied by retailers and wholesalers in local shops.



Figure 8. Packed *kocho* (left) and processed *bulla* (right)

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

As described earlier, *warqe* products can be stored for long periods using different storage methods along the supply chain (Fig. 9). It was indicated that *kocho* is stored on average at each supply chain level for 186, 7, 8, 29 and 185 days in the hand of producers, collectors, wholesalers, retailers, and consumers respectively. In the case of the *bulla*, it is stored on average in each chain level for 100, 7, 114, 65, 99 and 104 days in the hand of producers, collectors, wholesalers, retailer, and consumers respectively. The duration of *kocho* storage in the entire chain from the producer until consumption is 415 days while for *bulla* it is 489 days. Thus, *warqe* foods can store for long periods using traditional storage methods.

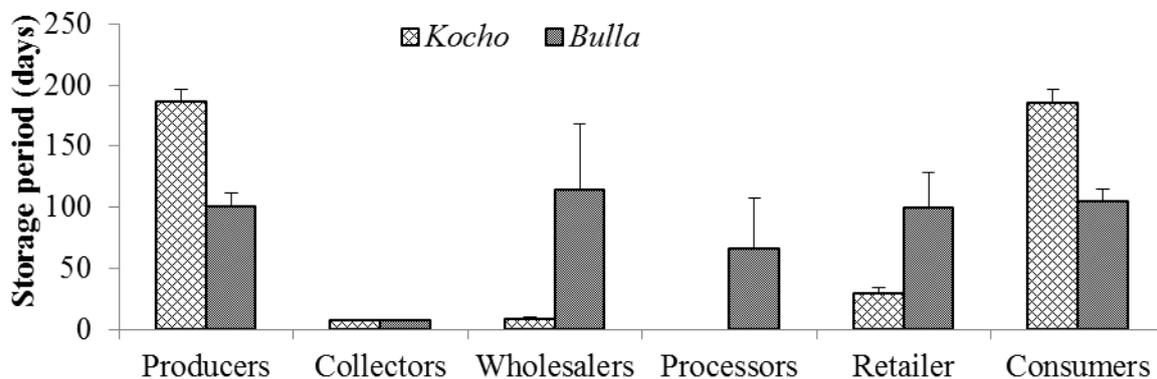


Figure 9. Storage periods (days) for *kocho* and *bulla* at different levels along the supply chain

3.3.4 Transportation and distance to market

Warqe foods were reported to reach end consumers using different modes of transport (Fig. 10). It was observed that human power, pack animals, animal carts and vehicles are the main means of transport in the study areas. The majority (85 %) of *warqe* farmers stated that they use human power to transport their products from the processing area to their homes. About 47 % of farmers use 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 use vehicles (50 %) to transport their products.

Donkeys and horses were mainly used for pack animal transportation. It was observed that one pack animal can carry on average 40 to 50 kg of goods from farmers' villages to local markets. A single horse-drawn cart is another means of transport used in local market areas. These carts can carry a load up of 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 a 148.58 % loading rate. The second type of vehicle used is 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 a 125 % loading rate. These vehicles were observed carrying *warqe* products alongside other goods such as vegetables, wood, charcoal, and cereals. In this study, it was observed that the mode of transport for *warqe* food products was a multimodal transportation system, starting with human-based transportation, then pack animals, then animal carts and finally vehicles.



Figure 10. Different modes of *warqe* food transportation: top left by human back, top right on donkeys, and bottom left on an animal cart and right on lorry respectively

The average distance covered by *warqe* food products to the point of sale in the supply chain is presented in Figure 11. Producers on average travel about 5 km to sell their products at the market. The products are then transported on about 20 km, 31 km, 79 km, and 62 km to reach collectors, wholesalers, processors, and retailers respectively. The results show that products cover the longer distance to reach processors.

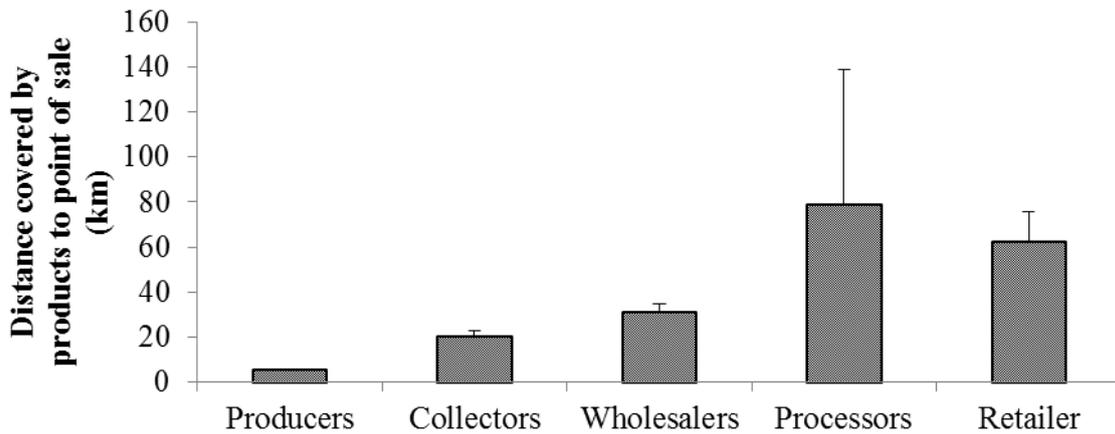


Figure 11. Distance covered by *warqe* food products to their point of sale (km) in the supply chain

3.3.5 Constraints in the *warqe* food product supply chain and logistics

A number of constraints were identified along the supply chain and logistics system of *warqe* food products. The major problems identified in the chain were as follows: producers have no information about potential market and prices in urban areas; poor transportation system and market facilities in both local and urban markets; lack of cooperation between producers regarding transportation, marketing and price determination; nature of products (bulkiness and perishability when exposed to air and light); lack of market access and poor policies around the *warqe* market; central market supplies are dominated by a few people and it is hard for producers to break into urban markets; poor infrastructures such as roads, communication and warehouse services; problems arise from the transportation of *warqe* products with other goods such as vegetables, wood, charcoal, and cereals.

4 Discussion

4.1 *Warqe* production and supply to market

This study indicated that *warqe* covers about 20.14 % of farmers' land and contributes up to 75 % of family income. These results are in agreement with the report by Olango *et al.* (2014) *Warqe* is a major perennial crop and one of the most important food security sources in southern Ethiopia, particularly in the area of Wolaita. This indicates that *warqe* is one of the major crops in the central part of Ethiopia and is also used as a staple food and source of income for families.

The results show that the majority (81.73 %) of farmers use farm inputs from their own source. A small number of farmers buy planting materials from local markets when they face a shortage of seedlings during the planting season, and in some cases obtain seedlings and organic fertilisers from their relatives or neighbours. However, both groups use local varieties of *warqe* seedlings. Farmers not only supply their own farm inputs but also provide packaging materials for their products. This indicates a lack of external input suppliers in the *warqe* production system. These findings support a previous report by Brant *et al.* (1997) showing that the *warqe* farming system allows long-term high productivity with minimum external inputs. Olango *et al.* (2014) report that *warqe* cultivation is an organic farming system using farmyard manures only, with no external chemical fertilisers, herbicides or insecticides. This implies that *warqe*-growing farmers do not have the option of using improved technologies such as planting materials and fertilisers and therefore still rely on their own sources of farm inputs and packaging materials. This may be one of the reasons for the low productivity of a crop that has considerable potential and offers high food security.

Farmers in the study areas grow *warqe* for a number of purposes, such as human food, feed for animals, medicines, packaging materials, plates, carpets, materials for house building and fences and even as a source of water for cattle during the dry season, in addition to its use as a source of income. Brant *et al.* (1997) classify *warqe*-based farming system into four groups. The first group is where *warqe* is a staple food and the main crop, the second is *warqe* as a co-staple with cereals and tuber crops, the third group is cereals as the most important crops with *warqe*, and root crops of secondary importance and the fourth group is where roots crops are of prime dietary importance, cereals of secondary importance and *warqe* of minor importance. The present study areas fall into the second group of *warqe*-based farming systems.

However, the results show that *warqe* is not only used as a staple food but also as a cash crop because about 74 % of farmers grow the plant for the market in addition to feeding their family. Thus, the areas in the present study fall within the first group in the classification by Brant *et al.*

Warqe food supplied to the Addis Merkato market comes in on different routes and this study confirmed that there are two major supplier routes: Haro Wonchi to Addis Ababa and Guder to Addis Ababa. In line with this study, the report by Degu (2012) shows that high-quality *bullaa* supply to Addis Ababa originates from the rural areas of Amaro in southern Ethiopia through the Hawassa and Shashemene market chains. The present two-year analysis of *kocho* and *bullaa* market supply to Woliso's *kocho* market and traders' experience indicate that supply is very high during religious holidays. This is because it is common to serve traditional food serving during the holidays in Ethiopia, thus increasing the demand for *kocho* and *bullaa*. Another reason is that *warqe* foods are usually consumed with animal products, making it a high-demand product in non-fasting periods.

4.2 Analysis of the supply chain and logistics practice of *warqe* food products

The study found that there are eight actors in the *warqe* supply chain and logistics system, which can be grouped in three streams. Upstream involves producers and collectors as the producers and initial suppliers of the products. Midstream, traders, transporters and processors are engaged in trading, processors are involved in the processing of *bullaa* and transporters are engaged in transport services. Downstream only features consumers. This indicates that a large amount of the logistics activities takes place in the midstream groups, implying that there a number of parties are involved in trading, transporting and processing *warqe* food products. The involvement of several chain actors in the supply chain may be one reason for the time taken to reach end consumers. Also implicit is a lack of communication between producers and consumers in urban areas. Similarly, Trienekens (2011) indicates that weak infrastructures hamper efficient flows of products to markets and the exchange of market information.

The information flow in the supply chain was not efficient, particularly upstream. This indicates a lack of communication infrastructure at the producer level. Nevertheless, horizontal cooperation between chain actors, particularly at the producer level, is very strong. Since there is traditional cooperation between farmers, known as "*Daboo*" and "*Daadoo*", during harvesting and processing, labour, information, and experience are shared between the producers.

In the *kocho* and *bullaa* supply chain in central parts of Ethiopia, there are a number of chain actors. Producers are forced to supply their products directly to local wholesalers and retailers, rural consumers and collectors in the local market due to a lack of transportation and 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. This result is in agreement with Degu (2012) who reports that 58.7 % of the market supply of *bullaa* produced from the rural Amaro area is taken outside the district by assemblers (collectors) and retailers.

This study also identified that rural wholesalers are 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 revealed that wholesalers are big buyers and the main distributors in the *kocho* and *bullaa* supply chain. Retailers usually buy from wholesalers in rural and urban areas and then re-supply larger quantities to consumers directly and the remaining small quantities to open market dealers. High-quality but expensive products from the areas of Haro Wonchi and Maruf ultimately reach end consumers in a variety of ways. Rural consumers acquire the product directly from producers and rural wholesalers in local marketplaces. However, urban consumers in Ambo, Woliso, and Addis Ababa acquire 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 cultural restaurants in big cities.

Fresh *bullaa* is processed into dried powder form by being dried on plastic sheeting and exposing to sunlight. Processors buy fresh *bullaa* from three different suppliers: directly from producers or from wholesalers and retailers. Processed products are packed in large 100 kg bags or small packs of 250 g or 500 g or 1 kg depending on customers' preferences. There is a complex change involved with processed *bullaa* compared to the chain for fresh *bullaa*. *Bullaa* processors buy fresh *bullaa* 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, making them accessible for the market and their clients. Thus, processors are the main buyers of fresh *bullaa* and the main suppliers of processed *bullaa*. This makes the processed *bullaa* chain more complex than the fresh *bullaa* chain.

It was also observed that the supply chain of *warqe* food products and the relationship between chain actors are very complex, very long and overlapping. The 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 between producers, a lack of market access and 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 *bullaa* 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. On the other hand *warqe*, food products are stored for long periods of time: 415 days for *kocho* and 489 days in the case of the *bullaa*. However, the methods of storage used were 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 results indicate that *warqe* food reaches final consumers *via* different modes of transport. It starts with human labour, then pack animals, animal carts, and lastly vehicles. In total, it about 150 km are covered, starting with producers and ending with consumers. This indicates the lack of infrastructures such as roads and a proper transportation system and means 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 were transported to distant markets by pack animals, mainly donkeys, and horses. Traders transport *warqe* food product to urban markets in small lorries, mainly Isuzu light-duty commercial trucks, however, the vehicles were observed to be overloaded. A study by Degu (2012) shows similar modes of supply of fresh *bullaa* in the southern part of Ethiopia. It was observed that the products cover very small 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 to cover this small distance.

Logistics constraints were identified along the supply chain, such as poor road infrastructure, poor market facilities and a lack of transportation and 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, although the packaging materials do have the advantage of being cheaper and preserving the flavour of the products.

5 Conclusions

The present study provides insight into experiences and bottlenecks in the supply chain and logistics in *warqe* food products. Eight supply chain and logistics actors were identified and grouped into three streams. Producers and collectors are grouped upstream and are involved with the initial supply of the products. Midstream, traders, transporters and processors are engaged in the business of trade, transport and processing respectively. Downstream features consumers only. The relationship between these actors was observed to be very complex, long and overlapping. A lack of communication infrastructure results in an inefficient flow of information along the chain, particularly upstream. However, horizontal cooperation between producers is very strong, including traditional cooperation between farmers known as “*Daboo*” and “*Daadoo*” during harvesting and processing.

The major issues identified in the chain were weak information flow, poor infrastructures 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 and poor market facilities and warehouse services were also observed. Central market supplies are dominated by a few people, making it hard for producers and processors to break into the urban market. Finally, *warqe* products are commonly transported with other goods such as vegetables, wood, charcoal and cereals, which deteriorate quality of both *warqe* and vegetables. This leads to the conclusion that there is a need to develop an integrated (where all stakeholders are linked), efficient and effective logistic for *warqe* supply and marketing chain, with specific consideration of food quality and logistics costs. There is a need to coordinate the chain actors to create an effective information sharing system throughout the chain using

modern information technology and to develop an effective transportation system. The construction of shared warehouses, located near to producers and market places, improving packaging and handling. The creation of links between producers and consumers to shorten the supply and marketing chain could be recommended.

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