

Food losses in the value chain of potatoes in Kenya

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Abstract

Potatoes are the most important staple food after maize in Kenya. They are predominantly grown by small-scale farmers. Because certified seed and other inputs are too expensive their yields are relatively low. Additionally the poorly developed value chain offers no particular incentives for investors, and marketing of the final product is difficult. As part of a series of studies, GIZ has conducted a survey and analysed the losses of potatoes along the value chain from harvesting to marketing in Kenya. The lack of good processing, storage and transport facilities as well as diseases and pests contribute to high losses in the post-harvest sector. The damages and losses recorded are caused to a certain extent by inappropriate harvesting tools and insufficiently trained labour. The retail level with a market share of up to 90 per cent is mostly affected since low quality produce is supplied to the markets. In addition, missing market signals, in terms of “better prices for better quality tubers” contribute to a low performance in potato production and processing. Damages and losses occur in every stage of the value chain (farmers, processors, marketers). A major challenge in improving on-and off-farm usage of storage and storage technology is the improvement of seed and ware potato varieties and quality. Diffused Light Stores and improved traditional stores (charcoal-coated wall) have proved to be useful low cost storage alternatives, in particular to store seed potatoes. Results have shown that it is feasible to store healthy seed tubers of currently available potato varieties in Kenya under low-cost, on-farm conditions. In addition, Kenya’s expanding food processing industry requires potato varieties with better processing qualities.

Keywords: potatoes, post-harvest, food losses, Kenya, value chain

1. Introduction

Potato (commonly referred to as Irish potato) is the second most important food crop in Kenya after maize. Potato production in Kenya is expected to grow and could even take the number one spot as food crops like maize become affected by climate change, e.g. due to insufficient rainfall. Faced with droughts, farmers are being encouraged by the government to diversify food production. The Ministry of Agriculture reported that many farmers are opting to grow potato because it is fast-maturing compared to maize and can be used to bridge the gap during shortages of the staple grain. According to the Ministry, the number of potato farmers has grown from 500,000 farmers in 2003 to 800,000 in 2011 (Thompson Reuters Foundation, 2011). In spite of this popularity, several studies have reported major constraints in potato production, such as diseases and pests mainly spread by diseased seed and the lack of crop rotation. Other problems include climate (drought, heavy rains), the costs of inputs for smallholders, seed quality, soil quality and (post-) harvest losses.

The issue of food loss is a highly important factor in efforts to combat hunger and raise incomes. However, food loss also represents wasted production resources such as land, water, energy and inputs. These additional environmental impacts of food loss were not included in

the study but were evaluated as part of the GIZ study on ‘The Ecological Footprint of Cassava and Maize Post-Harvest Losses in Nigeria’ (2013)¹, which showed that food loss has a significant impact on the environment.

According to the FAO, food loss refers to a decrease in edible food mass throughout the part of the supply chain that specifically provides edible food for human consumption. Therefore, food destined for human consumption that falls out of the human food chain is considered as food loss or waste. This approach distinguishes between ‘planned’ non-food uses and ‘unplanned’ non-food uses, with the latter being counted as loss. Food loss occurring at the end of the food chain (retail and final consumption) is called ‘food waste’ and is the result of retailer and consumer behaviour.

Losses include:

- *physical losses* – products that are not marketable/consumable, e.g. spoiled, rotten, damaged, green potatoes
- *financial losses* – lower prices paid due to insufficient quality or loss of value due to bad storage facilities

Critical loss points can occur all along the value chain (Table 1). Given that at certain points not all damaged produce is lost, specifications have been drawn up to distinguish between losses and other uses.

2. Materials and Methods

The chosen methodology was based on a five-step approach following that of the FAO (van Otterdijk, 2012).

1. Screening of food losses including rapid appraisal.
2. Survey on food loss assessment.
3. Sampling including load-tracking assessment.
4. Data analysis, verification workshop and reporting.
5. Synthesis: recommendations and solution finding.

The farmer survey was conducted in four main potato growing counties in Kenya, namely Bomet and Nakuru Counties in the Rift Valley area, Nyandarua County in Central Kenya and Meru County in Eastern Kenya. These four were purposively selected to provide a representative overview of potato production, postharvest handling and marketing practices in the country. In Bomet and Nyandarua counties contract farming is already underway. General data for the study were collected from published sources and through key informants, and specific data through questionnaires and group discussions. Conducting a rapid appraisal to determine specific issues during the preparatory stage proved to be crucial for getting a better understanding of the context and for better preparing the survey.

Data was collected during the survey from the major participants along the value chain and on the major sources, causes and also quantities of loss and waste. A randomised survey was used so that statistically reliable quantitative data could be obtained on losses at the defined critical points. Multi-stage sampling was adopted so that different regions and types of farmers, brokers and traders were included in the survey. In total, 247 potato farmers, 54 marketers (brokers, traders, retailers and supermarkets), 3 processors and 22 restaurants were interviewed. The survey results were discussed in a verification workshop, which provided further input to the reporting.

¹For further reading please see GIZ 2013b.

Table 1 Critical loss points along the potato value chain.

Stages	Critical loss points	Specifications of loss according to the PHL study
Production	Energy Audit Subsidy	Small potatoes are losses if they are not for used for home consumption or for seed.
	Capital Cost Subsidy	
Harvest	Planting and harvesting techniques that leave remnants on the fields (volunteer crops)	Volunteer crops (those left on the field and harvested early the following year) are lost if not used for home consumption.
	Harvesting tools cause damage	Damaged/cut potatoes: partly for home consumption, with the rest being losses.
	Harvest timing – premature harvesting (green potatoes) or harvesting in wet weather	Green potatoes are losses if they are not used for seed.
Packing	Quantity and quality of produce packed into extended bags	
	Size of extended bags	
	Material of extended bags	
Transportation and handling	Weight of extended bags does not allow careful handling	
	Extended bags become heated (affecting sugar content)	
	Several stages of loading and unloading prior to reaching the end customer	
	Losses due to a lack of access roads or poor road conditions	
	Inadequate means of transport	
Storage	Lack of storage facilities or simple stores	
	Unsuitable varieties for storage	
	Stored products are immature, not disease-free	
Market conditions	Wet markets (dirt, contamination, weather)	Lower prices due to market oversupply/fluctuations are not losses.
		Losses caused by lack of sales are incorporated.
	Green potatoes due to sunlight and inadequate packaging material (nylon)	Reduction of prices due to low quality (green/cut potatoes) cause financial losses.
Processing	Wrong varieties for processing	
	Sorting and grading losses	Additional labour required to sort/cut potatoes causes financial losses.
	Forced to process by-products	Potato peel is not a loss.

3. Results and Discussion

Potato is the second most important staple food in Kenya after maize. The most favourable climatic conditions for potato cultivation in Kenya are found in areas at altitudes between 1,500 and 3,000 metres above sea level, where the country's main staple food, maize, has no comparative advantage. At this altitude, potatoes grow faster than maize and produce more energy and protein per hectare per day. Potato production areas are found mainly in the highlands of the Central, Eastern and Rift Valley regions and on the slopes of Mount Kenya. Also, other regions like Mount Elgon (Bungoma County) in Western Kenya are prominent production areas. Potatoes are grown by up to 800,000 farmers, who are mainly smallholders². It is estimated that 83% of the land under potato cultivation belongs to smallholders dedicating 0.2 to 0.4 hectares to potato production, while approximately 17% of

²The exact number is not known. 'The National Root and Tuber Crops Policy' published by the Ministry of Agriculture in 2010 estimates the number of farmers to be 790,000. In 2011, the Ministry reported 800,000 farmers.

Potato plots belong to larger-scale farmers dedicating 2 to 10 hectares to the crop (Janssens et al., 2013). Average production in Kenya is estimated at 7 to 10 tonnes per hectare (Muthoni et al., 2014), compared to a global average yield of 17 tonnes per hectare (FAO STAT 2011).

Kenyan farmers achieve up to two harvests per year. The total production area has increased in recent years and is estimated to have reached 150,000 to 160,000 hectares to date.

3.1. Mapping the chain

The ware potato value chain is structured rather simply (Figure 1) given that most of the potatoes marketed are bought and consumed as fresh produce by end-consumers. Farmers sell their produce mostly via brokers to local traders. Local traders take the produce to the wholesale markets where, again, brokers organise sales on behalf of the traders. Only farmers engaged in contract farming for the processing industry sell directly to their customers. Processing accounts for only around 9% of marketed produce³, although a trend towards increasing demand for processed products has been observed.

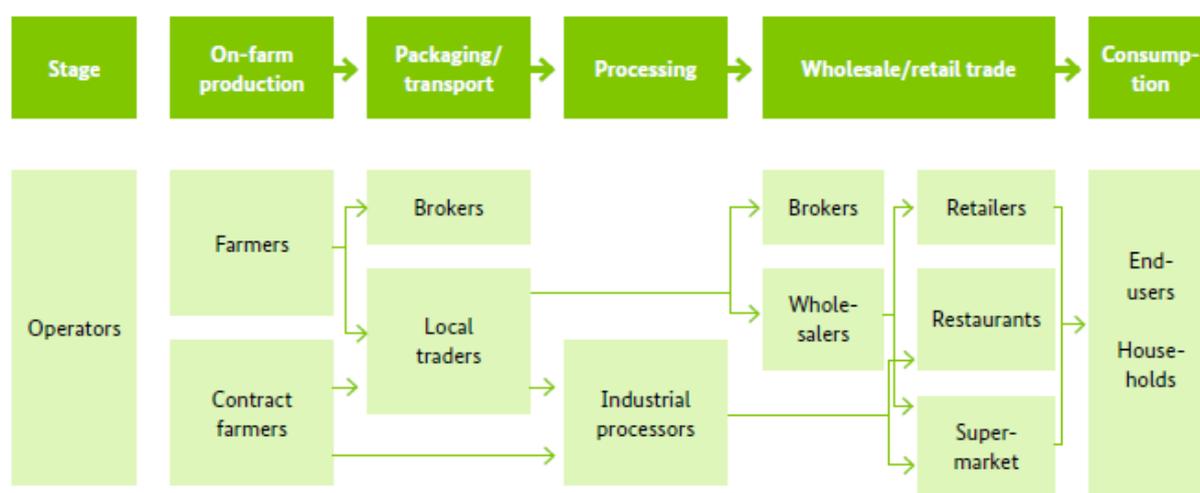


Figure 1 Ware potato value chain.

Average per capita consumption is estimated at 30 kg and is expected to rise due to increases in potato consumption by urban populations (FAO, 2013) and rapid population growth. Present estimates indicate that around 1 to 1.5 million tonnes of potatoes are marketed in Kenya per season. Currently, potatoes contribute over KES 40 billion or EUR 339 million (1%) to the national economy (Kasina & Nderitu, 2010). In addition to the 800,000 potato farmers, another 2.5 million people work in the potato value chain (Kaguongo et al., 2013). Potato is ideal as a food security crop as it has a short season and provides food within just 2.5 to 3 months, especially when planting fast-maturing varieties. Farmers are assured of a harvest as the crop is drought resistant and will provide some produce, even with little rain.

³According to National Potato Council of Kenya (NPCK) estimates.

3.2. Assessment of quantitative and financial losses in the potato value chain

3.2.1. Quantitative Losses

At farm level

Loss and damage reported at the farm level in the survey are summarised in Table 2. All quantities shown represent the overall average for surveyed farms in one season. Potatoes left in the field (volunteer plants) amount to about 650.1 kg per hectare and are added to the harvested potatoes. Since around 53% of these volunteer stocks are later used for home consumption, only 47% (304.2 kg) of these potatoes are ultimately lost.

With regard to the other listed forms of damage/loss, it is difficult to define the real losses at the farm level because, as Table 3 shows, large quantities of damaged potatoes still leave the farm and are sold on to traders and retailers. In this context, 12.8% of potatoes produced can be classified as lost or damaged. Harvesting tools caused the highest amount of damage on farms, followed by harvesting labour and harvesting during the rain⁴. Losses occurring during the storage of seed potatoes are of minor importance.

Table 2 Farmers' experienced losses during production and harvest.

	Bomet n=52	Meru n=53	Nakuru n=69	Nyandarua n=73	All n=247
Potato yield (kg/ha)	13,243.8	11,888.6	14,950.3	13,629.4	13,551.6
Farmers experiencing losses (%)	94.2	100.0	97.1	100.0	98.0
<i>Stages at which losses occur (%)</i>					
Production	77.6	81.1	74.6	55.6	71.0
Harvesting	53.1	56.6	44.8	45.8	49.4
Sales	28.6	39.6	26.9	36.1	32.8
Storage	8.2	15.1	10.4	15.3	12.4
<i>Damage caused during harvest</i>					
Harvesting in rain (kg/ha)	179.9	185.1	633.6	261.5	344.2
Harvesting tools (kg/ha)	430.3	525.1	759.2	528.7	568.2
Harvesting labour (kg/ha)	213.1	537.5	631.0	514.7	488.2

Transportation

The difference between the percentage of damage and loss found at the farm gate (15.6%) and at the retail point (24.4%) (Table 3) can be attributed to bag handling, packaging and transportation. Because they are so heavy, large bags are dragged and dropped. This results in splitting and bruising tubers, which eventually rot. Also, because of the packing methods used, potatoes can be exposed to sunlight, which turns them green.

⁴The figures used here for the quantities of stock damaged through harvesting in the rain represent the average levels of damage expected on farms overall.

Table 3 Weight and losses at the trader level in kg and % per bag.

Weights and losses at the trader level	Weight (kg)	Per cent (%)
Weight of the bag	198.6	
Cut and bruised when buying at the farm gate	23	11.6
Greening tubers at the point of purchase	5.5	2.8
Rotten tubers at the point of purchase	2.5	1.3
Loss/damage at the farm gate	31 kg	15.6%
Cut and bruised at the retail point	36	18.1
Greening tubers at the retail point	10	5.0
Rotten tubers at the retail point	2.5	1.3
Total damage/loss at the retail point	48.5 kg	24.4%
Percentage change in damage during transportation		13
Percentage change in greening during transportation		4.5
Percentage change in rotten tubers during transportation		0.0
Total damage/loss during transportation		17.5 kg

Marketing

Load tracking, where bags were opened at the farm gate and then at the retail level, showed that the underlying cause of damage/loss recorded at the retail level is due to the treatment of produce on farms. This being the case, it is possible to attribute around 95% of damage/loss to problems occurring on farms (with three quarters of this damage being caused by harvesting tools and labour), along with a small share of post-harvest losses at the farm level (2.9%). Furthermore, most loss/damage recorded by supermarkets or processors is rooted in issues occurring at the production level, such as diseased potatoes, inappropriate varieties, the lack of sorting and grading, etc. Around 30% of harvested potatoes remain on the farm for home consumption, for use as seed potato, or due to on-farm loss (3%). That said, during the offseason when the survey was conducted, nearly all retail potatoes reaching the markets were sold, though often at lower prices. Of the 71% of potatoes marketed, 16% were damaged or lost⁵. Therefore, retailers in particular (and, ultimately, consumers) are left with potatoes that are perhaps cheaper but of low quality.

3.2.2. Financial assessment

The financial assessment of the damage and loss of potatoes along the value chain, as described in Table 4, shows the economic impact of low performance in potato production. Per season, 2,760 kg or 19.4% of production per hectare is damaged or lost, resulting in a loss of value of KES 42,824 (EUR 363) per hectare. Extrapolating these losses per hectare to the level of national yearly production (two seasons) on 150,000 hectares, we can assume that 815,000 tonnes are damaged or lost, with a value of about KES 12.9 billion (EUR 109 million). As outlined, most of this loss could be prevented with better agricultural practices and careful handling. To quantify the financial losses, prices at each level of the value chain were collected. The average farm gate price in October during the survey was KES 13.2 per kg and the recorded retail market sale price was KES 30 per kg. Consumer prices at supermarkets were significantly higher reaching up to KES 80 per kg.

⁵Marketed produce includes supplies to supermarkets and the processing industry.

The prices collected at each stage form the basis for subsequent calculations. The average farm-gate price is KES 13.2 (EUR 0.11), the average consumer price is calculated as KES 30 per kg (EUR 0.25) and the consumer price at supermarkets is based on an average of KES 50 per kg (EUR 0.42). Losses at the processing level are calculated using purchase prices of KES 20 per kg (EUR 0.17) – the additional costs of extra labour employed to cut oversize tubers are not included due to the lack of cost prices. The losses are calculated according to the market share of the different actors in the value chain. The total quantities are estimated based on a production area of 150,000 hectares per season (losses per hectare) and do not take into consideration the share of larger-scale farms that produce under better conditions.

Table 4 Financial calculation of damage and loss occurring along the ware potato value chain.

Food loss according to production per ha	Produced and marketed produce	Quantity damaged in tonnes	Quantity lost	Cost of losses per kg	Value of losses per ha
On-farm production	14,202 kg				
Harvested	13,552 kg				
Left in field	650 kg				
On-farm consumption	-1,395 kg				
Left in field for home use	-346 kg				
Potatoes for seed	-2,000 kg				
Losses in storage			-119 kg	KES 13	KES 1,547
Losses left over in the field			-304 kg	KES 13	KES 3,952
Marketed produce	10,038 kg				
Retail market (90%)	9,034 kg				
Transport/packaging damage (50% lower retail price)			-795 kg	KES 15	KES 11,925
Losses			-117 kg (rotten)	KES 30	KES 3,510
Damages (50% lower retail price)		-1,292 kg		KES 15	KES 19,380
Supermarkets (1%)	100 kg				
Losses			-25 kg	KES 50	KES 1,250
Processing (9%)	903 kg				
Loss			-63 kg	KES 20	KES 1,260
Damage (extra costs for cutting)		-45 kg		not available	not available
Value of losses per ha in one season					KES 42,824 EUR 363
Value of losses per year (two seasons) for a total production area of 150,000 ha					KES 12,850 billion EUR 109 million

4. Challenges and options for food loss reductions

The report sets out the challenges and options for delivering improvements along the ware potato value chain, summarised as follows:

- Seed improvements – new varieties and rapid multiplication;
- Improved production and harvesting technologies;
- Improved post-harvest handling;
- Improved packaging;
- Improved conditions for the processing industry;
- Human capacity development.

As outlined in the World Resource Institute's working paper (Lipinski et al., 2013), it is important to note that technical solutions, for example, can only be effective when deployed in close coordination with other parts of the value chain. For example, improved on-farm storage will not ultimately lead to reductions in food loss if market prices do not provide profit gains from storage. Therefore, progress in reducing food loss and waste will require an integrated value-chain approach.

4.1. Seed improvements

4.1.1. New varieties and rapid multiplication

Seed potato research is dominated by KARI-Tigoni (National Potato Research Centre) and supported by the CIP. Along with being the main bodies involved in potato research in the country, these two organisations constitute the major sources of breeding materials and pre-basic seed potatoes. Until 2008, the only source of mini-tubers in Kenya was a conventional soil-based production system at KARI-Tigoni. In 2008, aeroponics technology for mini-tuber production was introduced in order to speed up the distribution of newly released varieties to farmers.

Due to Kenya's very strict quarantine regulations, importing high-quality seed potatoes has been difficult and, over the past 30 years, no certified seed potatoes have been imported. However, after a long period during which Kenya barred seed imports, the Kenyan Ministry of Agriculture, Livestock and Fisheries has begun cooperating with the Dutch Government and private companies on a fast-track system for the rapid multiplication of certified seed. After an agreement between the Kenyan and Dutch phytosanitary authorities was reached, Dutch seed potatoes of the Désirée variety (a variety registered in Kenya) were imported.

The limited availability and use of quality seed potato is a key barrier to increasing productivity in Kenya's potato sector. As such, seed potatoes need to be made available and affordable for small-scale growers. A survey conducted as part of a study on the 'Value of seed potatoes from four systems in Kenya' (Kaguongo et al., 2014) showed that farmers were aware of the importance of using high quality seed and were willing to pay higher prices for quality. On average, farmers were willing to pay 190 per cent of the price of farmer seed for certified seed and 170 per cent of the price of farmer seed for clean seed. This indicates that farmers recognise the importance of good quality seed in potato production and are willing to pay a premium price for quality.

4.1.2. Improved distribution network

The major weakness in seed potato production is the absence of a distribution system for certified seed output. Farmers wishing to buy seed potatoes must travel to, for example, KARI centres, which are sometimes located more than 200 km away. Improving the seed potato distribution network is therefore of the utmost importance if more farmers are to have access to certified seed.

4.2. Improved production and harvesting technologies

4.2.1. Improved soil fertility, soil analysis and crop husbandry

Soil fertility is one of the major problems for potato farming in Kenya. The poor yields that farmers achieve are directly linked to the poor state of their soils and a lack of crop rotation. Although interviewed farmers reported that they carry out crop rotation, the frequency of their rotations is low. According to CIP (Kaguongo et al., 2008), 21% of farmers indicate that they grow potatoes in the same plot continuously, with another 24% indicating that they grow potatoes in the same plot in three out of every four seasons. Only 55% of farmers practice

some form of regular rotation, with at least two out of every four seasons being given over to crops other than potato.

Fertilizer use in Kenya is low compared to the recommended rates of application, which results in the rapid decline of soil fertility. The biggest complaint farmers make is about increasing input costs and this factor results in the limited use of agro-inputs. About 38% of farmers in Kenya stated that the costs of fertilizer, fungicide and employee wages have been rising and that this affects their incomes. Consequently, the lack of funds to buy inputs was reported as the second most important problem affecting potato production in Kenya (Kaguongo et al., 2008). In short, plant diseases and access to inputs and seed are the major challenges farmers face in their production activities. The situation is further aggravated by the fact that remnant tubers remain in the soil after harvest and produce volunteer plants in the next crop. Farmers reported up to 304 kg/ha remain in the field and these allow diseases to carry over from one season to the next.

KARI performed a cost-benefit analysis on different seed types under current and target conditions which showed that, although yields from certified seeds were the highest (12.7 tonnes/ha), they still fell well short of the expected yields of 25 tonnes/ha envisaged by KARI-Tigoni. Although seed quality is important in determining yields, other factors such as management practices, disease prevalence and control methods play equally important roles.

Therefore, both small-scale and larger-scale farmers should be supported in developing good agricultural practices to improve soil fertility, seed quality, fertilizing and spraying. At present, NPCK and CIP are working on guidelines for good agricultural practices (GAP) in the potato sub-sector in cooperation with Kenya-GAP⁶, a GLOBAL GAP-benchmarked GAP initiative in Kenya for fruits, vegetables and flowers (Muthoni et al., 2013).

4.2.2. Adequate harvesting tools

The level of mechanization on medium-size and large-scale farms is medium to low and machinery is often fairly old. On smallholdings, most work is performed manually, which results in significant damage to and losses of potatoes. As the survey shows, damage caused by casual labour and harvesting tools like the *fork jembe* equals 7.3% of on-farm losses.

An ongoing challenge for reducing damage is the presence of farms that are too small for mechanization. The size of machinery supplied for potato production in Kenya should be tailored to local needs and take into account the workforce involved in harvesting. Smallholders can also combine to share equipment and thereby generate economies of scale.

4.3. Improved post-harvest handling

4.3.1. Traditional storage alternatives

A major challenge in improving the on- and off-farm use of storage and storage technology is the improvement of seed and ware potato varieties and quality. Diffused light stores (DLS) and improved traditional stores (with charcoal-coated walls) have proved to be useful low-cost storage alternatives, in particular for storing seed potatoes. However, neither of these storage technologies is widely used in Kenya because the provision of information and

⁶Kenya GAP is a trademark registered to the Fresh Produce Exporters Association of Kenya (FPEAK). Kenya GAP is a quality assurance scheme based on: the principles of good agricultural practice, hazard analysis critical control point principles for food handling and marketing, local regulations, and ILO conventions ratified by the Government of Kenya.

training on the use of these technologies is limited. A further aspect limiting the use of and investment in storage is the current preference for growing Shangi potatoes, which are not suitable for storage. KARI recently conducted an on-farm storage trial in Nyandarua County using seed tubers of eight officially recognised Kenyan potato varieties as well as farmers' preferred variety, Shangi. The seeds were stored for up to eight months under DLS conditions in low-cost structures to test the feasibility of prolonged seed storage on farms.

The results of this study have shown that it is feasible to store healthy seed tubers of currently available potato varieties in Kenya on farms and at low cost. Varieties selected for long-term storage should have a long dormancy and be in high demand, either for the market (such as the Kenya Mpya) or for processing (such as the Dutch Robjijn or Désirée). The unofficial variety, Shangi, which is the most popular on the market, showed poor levels of storability but could be planted two to three months after harvest. That said, KARI still favours the Shangi variety due to its short dormancy periods. According to KARI, the variety Shangi should be officially recognised as a quick sprouting variety, which is a good characteristic for complementing on-farm storage and mitigating climate change.

4.3.2. Cold storage for seed potatoes

According to the Dutch study 'Value chain of seed and ware potatoes in Kenya' (Janssens et al., 2013), modern cooled storage facilities should have a minimum capacity of 100 tonnes, given that costs decrease the more storage capacity is increased. The costs of storing seed potato long term are calculated to be EUR 0.33 per kg in a 100-tonne store and drop to EUR 0.13 per kg in a 400-tonne store. Investments required per tonne are rather high for storage capacities of 400 tonnes or less. Thus, small cold storage facilities are relatively expensive and will substantially raise seed prices. Consequently, professional modern storage is more attractive for farmers, farmer groups or processors who store big quantities.

4.3.3. Improved packaging

Sorting and grading of potatoes is not performed in earnest because the fresh produce market currently fails to reward good quality. The market offers no price incentives for quality potatoes – potatoes are traded on a per-bag basis with no price differential for mature, large tubers. Farmers are, therefore, not motivated to grade potatoes or to pack well-matured potatoes. The Kenyan Government attempted to improve packaging in 2005 and again in 2008. Legal Notice No 113 of 2008 and No 44 of 2005 specified that potato must be marketed in a standard 110 kg bag. However, the implementation of this law did not affect real change as it was not properly enforced. Recently, the Government, NPCK and counties have kick-started a new initiative to introduce a maximum 50 kg bag in line with the requirements of the International Labour Organization (ILO).

A study conducted by KARI in 2009/2010 (Kasina & Ndritu 2010) analysing the low levels of adoption of the 2008 Legal Notice showed that 92% of interviewed traders were aware of the new potato packaging regulations, though only 16% implemented them. Lack of enforcement and the absence of additional benefits/incentives are the main reasons traders fail to comply with the regulation. Traders reported good profits from trading with extended-size bags (with 53% gains) compared with standard bags (with 44% gains). The key challenge for implementing the regulations is market competition (24%), since demand for extended bags among



Figure 2 Extended-sized bags used for trading.

retailers remains high. The reason extended bags are popular is that using a fixed bag size and weight results in sales being charged according to weight. The advantage of using extended bags is, conversely, the vague definition of bag sizes, which can be used to exploit farmers. Damage/losses are accounted for and mean lower prices for traders, thus, traders offering standard-size bags fear losing out to competitors offering extended ones. About, 97% of the farmers' interviewed were aware of the new regulations but competition (63%) and the lack of enforcement by Government agencies (27%) were cited as barriers to implementation.

As the survey shows, extended bags have a severe impact on the quality of produce marketed. The fact that payments for large volumes are inadequate encourages farmers (and brokers) to pack all potato stocks regardless of their quality. Furthermore, the packaging material and difficulty in handling the large bags cause additional losses. An agreement on smaller bag sizes would be a first step towards better quality and would send an important market signal to farmers. To ensure the law is enforced, any process to improve packaging should involve brokers, traders, wholesalers, retailers and local authorities so that the resulting agreement is supported by all participants along the value chain⁷. In general, standards should be established for general measurement according to weight.

4.3.4. Market infrastructure

The major markets for potatoes are in large urban areas like Nairobi, Mombasa, Nakuru and Kisumu. The Wakulima Market in Nairobi is the largest terminal market handling over 50% of all potatoes traded in urban markets. However, the 2.4-hectare market can no longer cope with supply and demand. This situation has resulted in high levels of congestion and market activities spilling over into surrounding areas where conditions are very unhygienic. The physical improvement of Nairobi Market is decades overdue but the efforts of the international donor community to convince the Government and Nairobi City Council to set up a new wholesale market outside the city centre have so far failed. The same applies for other marketplaces in the country and only a few market sites have been refurbished in recent years. Improving the marketing system, and in particular market infrastructure, would help to reduce losses as it is reasonable to assume that modern infrastructure would also have an impact on quality awareness.

4.4. Improved conditions for the processing industry

4.4.1. Varieties

Kenya has an expanding food processing industry, driven by its growing urban population, changing population structure, new eating habits and increased tourism. The industry requires potato varieties with better processing qualities (for example, Dutch Robjin, which is suitable for crisps) to replace the traditional varieties that are susceptible to bacterial and viral diseases. Processors are calling for suitable varieties that meet their needs for better-quality raw material for processing. There is a need for a concerted effort from all stakeholders to introduce new processing varieties in the country in order to improve the competitiveness of the industry. Furthermore, processors should be supported in developing stable business relationships with farmers to ensure the provision of suitable varieties, appropriate sorting and constant supply. The production of properly sorted suitable varieties would, in particular, have a notable impact on reducing losses and, hence, on the competitiveness of the industry.

4.4.2. Contract farming

Contract farming is already a well-known arrangement in Kenya. However, problems are arising in the cooperation between the potato processing industry and ware potato farmers. Farmers surveyed in Nyandarua had had their contract with the processing industry terminated because of issues arising from the strict sorting standards and they ended up

selling the bulk of their stock to local traders. Processors cooperating with farmers in Bomet encountered problems with side-selling and also terminated their agreement. Conversely, farmers complain about the high price or low quality of supplied inputs. The potato processing industry is still in its infancy and this is also true of the partnerships being developed between potato farmers and the industry.

Contract farming is a business model for the interface between farm supply and industrial procurement, linking the buyer's strategy with the suppliers' farming systems. It can be an appropriate tool for promoting inclusive business models, giving small-scale farmers an opportunity to join in the venture, an equal voice in contract negotiations, a fair reward and a reasonable approach to risk sharing. Contract farming is primarily characterised by the interdependency of the contracting parties and the risks involved should the contract farming arrangement not be appropriate for ensuring either partner fulfils their obligations. Default risks are high on both sides and are frequently reasons for failure, as outlined above. Therefore, sound planning, appropriate skills and adequate approaches are key to the success and sustainability of contract farming schemes.

4.5. Capacity building and agricultural finance

4.5.1. Human capacity development

The level of education of farmers, number of extension visits and access to credit are significant variables for improving the level of economic efficiency in potato production. It is, therefore, necessary to expand farmer training in improved agronomic and management practices, with the support of extension services. Priority should be given to innovative approaches that enhance extension and farmer training, such as: (i) the use of group approaches; (ii) farmer-led extension, such as farmer field schools with demonstration plots and on-farm trials; and (iii) the provision of communications technology (ICT) to support agricultural extension (Nyagaka 2009). In addition to farmers, traders are also in need of comprehensive training to improve the capacity of those involved in post-harvest handling and storage, and in processing and marketing. Training should also be provided to operators in the wholesale and retail markets on how to improve product handling and storage and thereby maintain quality and reduce physical losses.

4.5.2. Agricultural finance

A major problem also seen as affecting the financial situation of farmers is that of achieving economies of scale. When operating small potato plots of 0.2 to 0.6 hectares, it is difficult for an individual smallholder to earn enough income to cover the costs of the required inputs. The banking system in Kenya is well capitalized and is known to work well, even in rural areas. Access to short-term credit for input supply or working capital has improved and is increasingly being used. Yet, reaching the majority of smallholders needing to invest in their agriculture remains a challenge.

Given that enhanced access to credit will contribute to productivity gains, innovative ways need to be devised to ensure farmers can access credit at a reasonable cost. Contract farming can also play a role in opening up access to finance and achieving economies of scale – for instance, the economies of scale that a contractor (a large farm or processor) can achieve will cut the cost of inputs and transportation. Furthermore, the contract can be used as guarantee for the banks, resulting in a tripartite agreement between the bank, processor and farmer.

5. Conclusion

The Kenyan Government has recognised the critical role potato plays in alleviating food shortages in the context of the decreasing production of maize and other staples (Mwaura

2009). The development of potato production could form part of the solution for tackling food shortages given that potato has higher yields compared to maize⁷. As such, improvements in the potato sub-sector will also benefit food security in the country. Due to the increasing importance of the potato crop, a number of initiatives to improve performance in the potato subsector are now in place. Several international donor projects and local and international NGOs are working in cooperation with the International Potato Center (CIP) and Kenyan institutions like the Kenyan Agricultural Research Institute (KARI) and NPCK on the different challenges arising along the value chain.

Although the study focuses on post-harvest losses, the results indicate that a very high level of loss-causing factors occurs at the production level, because potato production practices in Kenya remain suboptimal. The problems identified as occurring on farms require capacity building and investment in order to change production patterns and improve harvesting techniques and on-farm infrastructure. Therefore, to make significant change happen, market signals involving better prices for better quality⁸ are required to stimulate farmers' interest in better production results. A starting point for improvements could be the introduction of standardized bags, allowing better handling and the fair payment of farmers.

A further market signal could come from contract farming, which helps farmers to exit the vicious circle of insecure markets and exploitation through extended bags. Capacity building of farmers – especially with the support of extension services – is the key for delivering on-farm improvements.

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⁷FAO (2009) established cereal and maize equivalents based on the calorie content of selected foods, which indicate that five units of potato can replace one unit of maize.

⁸Farmers cited market demand and pricing as important challenges.

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